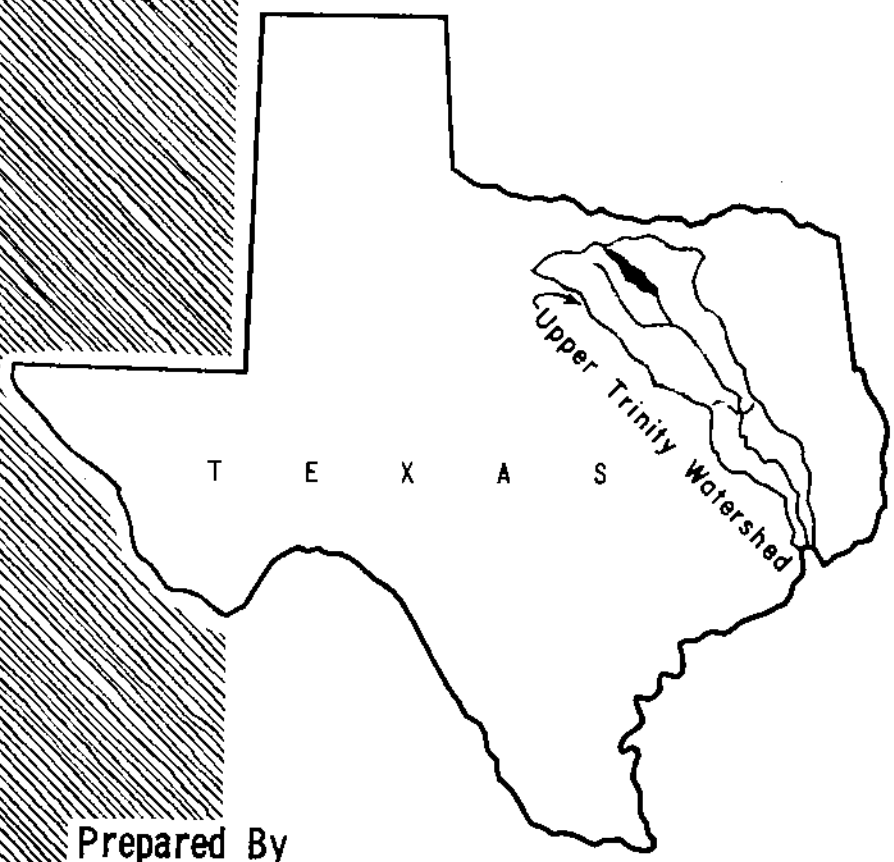
WORK PLAN

HICKORY CREEK WATERSHED

OF THE TRINITY RIVER WATERSHED

DENTON, WISE, TARRANT, AND DALLAS COUNTIES, TEXAS



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
OCTOBER 1966

4-23045 1-68
USDA-SCS-FORT WORTH, TEX. 1968

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WATERSHED WORK PLAN AGREEMENT

between the

Denton-Wise Soil and Water Conservation District
Local Organization

Dalworth Soil and Water Conservation District
Local Organization

Denton County Commissioners Court
Local Organization

City of Denton, Texas
Local Organization

of the

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

and the

SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
(hereinafter referred to as the Service)

Whereas, the Soil Conservation Districts have heretofore entered into a Flood Control Supplemental Memorandum of Understanding with the Soil Conservation Service for assistance in constructing works of improvement for prevention of floods in Hickory Creek Watershed, State of Texas, under the authority of the Flood Control Act of 1944 (58 Stat. 887); and

Whereas, the responsibility for carrying out a portion of the work of the United States Department of Agriculture on the watershed has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Local Organization and the Service a mutually satisfactory plan for works of improvement for the Hickory 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; and

Whereas, the County will benefit from installation of works of improvement through the reduction of damages to property, including county roads and bridges located in the flood plain of the watershed; and

Whereas, the City will benefit from installation of works of improvement through the reduction of damages to urban properties located in the flood plain of the watershed;

Now, therefore, in view of the foregoing considerations, the Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about eight years.

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

1. The Local Organization will acquire without cost to the Federal government such land, easements or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost $541,800). The percentages of this cost to be borne by the Local Organization and the Service are as follows:

Works of Improvement	Local Organization (percent)	Service (percent)	Estimated Land, Easements, and Rights-of-Way Cost (dollars)
Floodwater Retarding Structures Nos. 1 through 17	100.00	0	541,800 1/

1/ Includes $2,950 legal fees.

2. The Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.

3. The percentages of construction costs of structural measures to be paid by the Local Organization and by the Service are as follows:

Works of Improvement	Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
Floodwater Retarding Structures Nos. 1 through 17	0	100.00	1,136,180

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

Works of Improvement	Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
Floodwater Retarding Structures Nos. 1 through 17	0	100	280,360

5. The Service will award and administer the contracts covering construction of all structural works of improvement.

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

7. The Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to

this agreement if made with a corporation for its general benefit.

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

Denton-Wise Soil and Water Conservation District
Local Organization

By Tom L. Muir

Title Chairman

Date 8-15-67

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

adopted at a meeting held on 8-15-67

Lemon W Harper
(Secretary, Local Organization)

Date 8-15-67

Dalworth Soil and Water Conservation District
Local Organization

By Tom C. Layton

Title Chairman

Date 8-8-67

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

adopted at a meeting held on 8-8-67 O H Skinner

(Secretary, Local Organization)

Date 8-8-67

v

Denton County Commissioners Court
Local Organization

By H. R. Dressinger

Title County Judge

Date August 21, 1967

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

adopted at a meeting held on August 21 1967

Theta Parker Co. Clerk
(Secretary, Local Organization)

By Mary Jo Nichols Deputy

Date 8-21-67

City of Denton, Texas
Local Organization

By Zeke Mast

Title Mayor

Date 1-22-68

The signing of this agreement was authorized by a resolution of the governing body of the City of Denton, Texas
Local Organization

adopted at a meeting held on 1-9-68

Burke Hale
(Secretary, Local Organization)

Date 1-22-68

Soil Conservation Service
United States Department of Agriculture

By _____

Date _____

4-23045 1-68

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

HICKORY CREEK WATERSHED
Of the Trinity River Watershed
Denton, Wise, Tarrant, and Dallas Counties, Texas

Plan Prepared and Works of Improvement
to be Installed Under the Authority
of the Flood Control Act of 1944
as Amended and Supplemented

Participating Agencies

Denton-Wise Soil and Water Conservation District
Dalworth Soil and Water Conservation District
Denton County Commissioners Court
City of Denton, Texas

Prepared By:

Soil Conservation Service
U. S. Department of Agriculture

October 1966

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USDA SCS FORT WORTH, TEX. 1967

WATERSHED WORK PLAN

HICKORY CREEK WATERSHED
Of the Trinity River Watershed
Denton, Wise, Tarrant, and Dallas Counties, Texas
October 1966

SUMMARY OF PLAN

Hickory Creek watershed, a tributary of the Trinity River, comprising an area of 145,600 acres or 227.5 square miles, is located in Denton, Wise, Tarrant, and Dallas Counties, Texas. All planned structural measures are located in Denton County, Texas, where more than 95 percent of the drainage area of the watershed is located.

The Denton-Wise Soil and Water Conservation District, Dalworth Soil and Water Conservation District, Denton County Commissioners Court, and the Denton City Council, local sponsoring organizations, propose installing a project for watershed protection and flood prevention during an 8-year period. The total installation cost is estimated to be $3,874,326. The share to be borne by other than Flood Prevention funds is $2,416,936. In addition, local interests will bear the entire cost of operation and maintenance of structural measures estimated to be $1,760 annually.

The major land uses in the watershed are cropland, 36 percent; pastureland, 46 percent; rangeland, 11 percent; and miscellaneous, 7 percent. All of the agricultural land is privately owned.

The principal problem in the watershed is the frequent flooding of approximately 6,912 acres of flood plain, excluding stream channels. An average of two floods occur annually, with more than 50 percent of the flood plain inundated on the average of twice each five years. The City of Denton has urban developments on 120 acres of the flood plain along the Pecan Creek tributary where frequent flooding occurs.

The average annual floodwater damages without the project is estimated to be $67,109, including $27,100 in the urban area. In addition, sediment, scour, and indirect damages amount to $14,951 annually.

Land treatment measures are being established through the leadership of the Denton-Wise and Dalworth Soil and Water Conservation Districts. Landowners and operators will be encouraged to accelerate the installation of those land treatment measures which will contribute directly to watershed protection, flood prevention, and sediment control.

The cost of land treatment measures installed to date is $610,179. The work plan proposes the installation of land treatment measures at an accelerated rate for the 8-year period in the amount of $1,915,986. Of this

amount, $40,850 is to be borne by Flood Prevention funds for accelerated technical assistance and $1,875,136 from other funds.

Seventeen floodwater retarding structures will be installed at an estimated cost of $1,958,340. Of this amount, $1,416,540 will be borne by Flood Prevention funds and $541,800 from other funds. The sponsoring local organizations will furnish all needed land, easements, and rights-of-way for structural measures. It is expected that a major portion of the easements and rights-of-way will be donated for structural measures. If necessary, the Denton County Commissioners Court will use their rights of eminent domain to secure easements for floodwater retarding structure Sites 1 through 15, and the Denton City Council will use its rights to obtain easements for the remaining structure Sites 16 and 17. These structural measures will be installed during an 8-year period.

Storage capacity was not planned in any of the structure sites for purposes other than sediment storage and floodwater detention.

Eighty-five landowners and operators of 6,912 acres of flood plain land will benefit directly from the installation of this project. The average annual floodwater damage reduction benefits are estimated to be $52,376 with the project installed. In addition, flood plain scour, sediment, and indirect damage reductions will amount to $10,109 annually.

The ratio of the total annual benefits of $90,879, resulting from installation of structural works of improvement, to the annual cost of $65,640 is 1.4 to 1.

Landowners and operators will operate and maintain all land treatment measures installed in this watershed. Denton County Commissioners Court will operate and maintain floodwater retarding structure Sites 1 through 15 and the City of Denton, Texas will operate and maintain Sites 16 and 17. Monies for this purpose are available from general funds.

DESCRIPTION OF THE WATERSHED

Physical Data

Hickory Creek watershed encompasses an area of 145,600 acres (227.5 square miles) and is located in Denton, Wise, Tarrant, and Dallas Counties. Denton, the county seat of Denton County, is the principal municipality in the watershed. Other towns included are Slidell, Krum, Ponder, Argyle, Lake Dallas, and Lewisville.

Hickory Creek originates near the town of Slidell in Wise County and flows in a southeasterly direction for 27 miles, emptying into Garza-Little Elm Reservoir. Some of the larger tributaries are North Hickory, Middle Hickory, South Hickory Creeks, Dry Branch, and Roark Creek. Pecan Creek, Prairie Branch, Timber Creek, and Baker's Branch are also located within the watershed boundaries. Pecan Creek flows into Garza-Little Elm Reservoir. Prairie Branch and Timber Creek confluence with the Elm Fork of the Trinity River below the reservoir. Baker's Branch flows into Denton Creek

below Grapevine Dam. There are approximately 6,912 acres of flood plain in the watershed, including 1,600 acres of flood plain along the Elm Fork and Denton Creek.

The watershed ranges in width from six to nine miles. Elevations range from approximately 1,000 feet above mean sea level along the northwestern divide near Slidell to 532 feet where Hickory Creek enters the flood control pool of Garza-Little Elm Reservoir.

Surface rocks in the watershed are of Cretaceous age and dip normally to the southeast at 40 feet per mile. The formations of the Lower Cretaceous (Comanche series) are in the Fredericksburg and Washita groups. The Upper Cretaceous (Gulf series) is represented by the Woodbine and Eagle Ford groups.

The lowest unit of the Fredericksburg group occurring in the watershed is the Goodland formation. This formation is exposed along the watershed divide near Slidell and is composed of a hard, massively bedded limestone which has an average thickness of approximately 50 feet. The upper unit of the group is the Kiamichi formation. This formation consists of stratified and laminated clays with thin flagstone beds.

The Washita group is exposed in a broad belt extending from Slidell southeasterly for about 18 miles to U. S. Highway 377. The strata have a total thickness of approximately 500 feet and form a rolling upland prairie. Included in this group are marine shaly clays, marls, limestone, and sandstones of the Duck Creek, Fort Worth, Denton, Weno, Pawpaw, Mainstreet, and Grayson formations.

Rocks of the Pepper, Dexter, and Lewisville formations of the Woodbine group occur in the lower portion of the watershed. These formations are highly variable in composition and consist of crossbedded sandstones and laminated shaly clays forming gently rolling to hilly uplands.

Shales of the Eagle Ford group are exposed in the lower extremities of the watershed near Lewisville.

Soils of the Grand Prairie Land Resource Area are found in the upper 55 percent of the watershed. The principal soil series include Bolar, Burleson, Crawford, Heiden, Lindy, Payne, Houston Black, Trinity, and Frio. These are predominantly deep to moderately deep, clays, silty clays, and clay loams. Subsoils are similar in texture to the topsoils and are moderately to very slowly permeable. Fertility levels generally are moderate and erosion is low to moderate.

Soils of the Cross Timbers Land Resource Area are located in the central and lower portions of the watershed. Fertility levels are generally low. Soils are uneroded to slightly eroded on the nearly level to gently sloping areas and slightly to moderately eroded on the steeper areas. Some soils are severely eroded on formerly cultivated fields. These areas have been converted to pastureland and erosion has greatly reduced. The major soil series include the Konawa, Doughtery, Stidham, Travis, Axtell,

and Galey. These are predominantly fine sandy loams and loamy fine sands. Sandy clay loams, sandy clays, and heavy clays form the subsoils and are rapidly to very slowly permeable. Approximately 37 percent of the watershed lies in this land resource area.

The soil series of the Blackland Prairie Land Resource Area include the Houston Black, Heiden, Trinity, Gowen, Crockett, and Wilson. The textural range of the soils is comprised of clays, clay loams, and fine sandy loams. Subsoils are moderately to very slowly permeable and are composed of clays and clay loams. Fertility levels are moderate to high. They are limited to the extreme lower portions of the watershed near Lewisville and occupy eight percent of the drainage area.

Land use in the watershed is estimated to be:

Land Use	Acres	Percent
Cropland	52,300	36
Pastureland	67,176	46
Rangeland	15,700	11
Miscellaneous 1/	10,424	7
Total	145,600	100

1/ Includes roads, highways, railroads, urban areas, stream channels, etc.

The natural vegetation consists generally of a post oak and blackjack oak savannah in the Cross Timbers. The Grand Prairie and Blackland Prairies are true grass prairies with about a five percent cover of woody vegetation such as live oak, elm, and hackberry. Some of the climax grasses are little bluestem, Indiangrass, big bluestem, sand lovegrass, switchgrass, and Virginia wild rye. Increasers are tall dropseed, hairy grama, silver bluestem, sideoats grama, Texas wintergrass, Scribner panicum, and woody plants. Vegetation that invades as a result of overuse of rangeland includes sand dropseed, splitbeard bluestem, threeawns, fall witchgrass, buffalograss, windmill grasses, Texas grama, mesquite, prickly pear, nightshades, sumac, and all annuals. Range sites within the watershed are Rolling Prairie, Deep Upland, Bottomland, Stony Hills, Sandy Loam, and Sandy. The range condition classes of the watershed are as follows:

Class	Grand Prairie (percent)	Cross Timbers (percent)	Blackland Prairie (percent)
Excellent	10	8	5
Good	30	30	25
Fair	40	42	45
Poor	20	20	25
Total	100	100	100

The hydrologic cover on pastureland and rangeland, ranging from poor to good, is classified mostly as fair. Cropland produces somewhat less

effective hydrologic cover, but conservation practices such as cover and green manure crops, crop residue use, terracing, and contour farming have been effective in reducing erosion, sediment, and flood damages.

The mean annual precipitation of 31.56 inches, based on a 30-year record at Denton, Texas, is fairly well distributed throughout the year, with the greatest amounts of rainfall occurring in April and May. The minimum recorded rainfall was 18.49 inches in 1948 and the maximum was 58.35 inches in 1957. The mean annual temperature is 65 degrees. Temperatures range from a mean low of 34 in January to a mean high of 96 degrees in July. The normal growing season is 226 days.

Water for domestic and livestock uses in the rural areas is supplied largely by small ponds and shallow wells. Water for Denton is provided by wells and Garza-Little Elm Reservoir, while Lewisville, Slidell, Krum, Ponder, Argyle, and Lake Dallas obtain water from wells.

Economic Data

Agricultural production constitutes an important part in the economy of this watershed. Farm units, in the watershed as a whole, average about 280 acres in size. More than half of the farms are operated by tenants. The livestock enterprise consists primarily of beef cattle, dairying, and sheep production. Cash crops grown in the watershed are oats, wheat, grain sorghums, hay, and small acreages of cotton.

The flood plain formerly was used for production of cultivated crops, hay, and pasture. Because of frequent flooding, sediment, and erosion damages, most of the cultivated land has been diverted to hay crops and improved pastures. It is expected that more of the flood plain, once used for row crops, will be utilized for feed and hay production in connection with the growing livestock enterprises.

Ownership trends indicate a decreasing number of farms with more acres per farm. The tenure trends are toward an increase in farm managers. Land value and farm size have been influenced by the proximity of the watershed to the metropolitan Dallas-Fort Worth area. The current market price of land ranges generally from $150 to $300 per acre, although there are some areas where these values are so high that the land cannot be economically used for agricultural production.

Industries within the watershed include plants manufacturing bricks, business forms, clothing, flour, feed, highway signs, boats, trailers, and plastics. There are many businesses connected with water recreation.

The transportation needs in the area are served by approximately 450 miles of roads, of which an estimated 150 miles are paved. These roads provide adequate access to all parts of the watershed. Four railroads transverse the watershed and ample loading facilities are available at Denton.

The population of Denton County, in which more than 95 percent of the watershed is located, has increased from 47,432 in 1960 to 56,000 in 1965.

The 1960 census showed 1,863 farm families with a median family income of $6,370 per year. A large percent of the farmers and ranchers in the watershed supplement their income with employment in the nearby Dallas-Fort Worth metropolitan area. Approximately 11 percent of the total income for Denton County is derived from agricultural operations.

The City of Denton is a cultural center offering excellent educational and employment opportunities for the residents of the watershed and surrounding area. North Texas State University and Texas Woman's University, with a combined enrollment of approximately 15,000 students, add to the community's economy.

The watershed area is well suited for recreational development and is readily accessible to the Dallas-Fort Worth metropolitan area.

Denton, Dallas, Tarrant, and Wise Counties have not been designated as an area of underemployment under the Area Redevelopment or the Public Works and Economic Development Acts.

Approximately 40 of the family type farms use one and one-half or more man-years of hired labor.

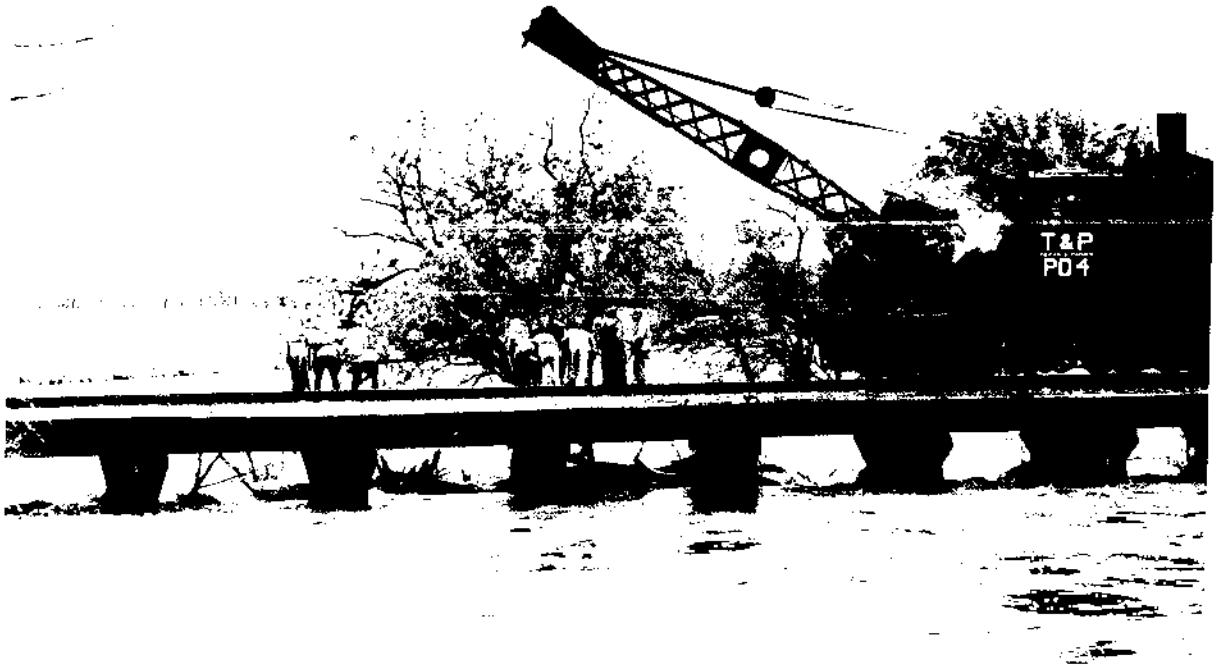
Land Treatment Data

The Soil Conservation Service work unit at Denton, Texas is assisting the Denton-Wise Soil and Water Conservation District which covers approximately 95 percent of the watershed. The work units at Dallas and Fort Worth are assisting the Dalworth Soil and Water Conservation District in the remaining five percent of the area. Technical assistance has been provided to cooperators of the districts in preparing 360 basic soil and water conservation plans on 98,280 acres and in establishing and maintaining the planned land treatment measures. Current revisions are expected on 167 basic conservation plans during the installation of the project. Soil surveys are complete on 30,670 acres. The remaining area, 114,930 acres, is scheduled for survey during the early part of the project installation period. More than 43 percent of the land treatment practices needed on cropland have been applied. Needed land treatment practices have been applied on approximately 70 percent of the pastureland. A total of 75 percent of the needed land treatment will be established by the end of the installation period.

WATERSHED PROBLEMS

Floodwater Damage

There are 6,912 acres of flood plain land, excluding stream channels, in the Hickory Creek watershed. Of this amount, there are 4,279 acres of flood plain along Hickory Creek and its tributaries above the 10-year frequency pool of Garza-Little Elm Reservoir at (mean sea level) elevation 525.0. There are 599 acres of flood plain land along the Timber Creek lateral, above its entrance at the bottomland common with the Elm Fork of the Trinity River. There are 434 acres of flood plain land along the Pecan



Rains of April and May 1957 resulted in extensive damage to crops and structures along the entire length of main stem Hickory Creek. Photo taken at Texas and Pacific railroad crossing south of Denton. Photo by Denton Record-Chronicle.

Flash floods of 1957 caused extensive fence damage, adjacent fields suffered scour damage, sediment and debris were deposited in channels. Photo of tributary of Hickory Creek.

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Highway and railroad damage caused by floods of September 1962. Texas and Pacific Railroad in center of photo and U. S. Highway 377 in background. Photo by Denton Record-Chronicle.

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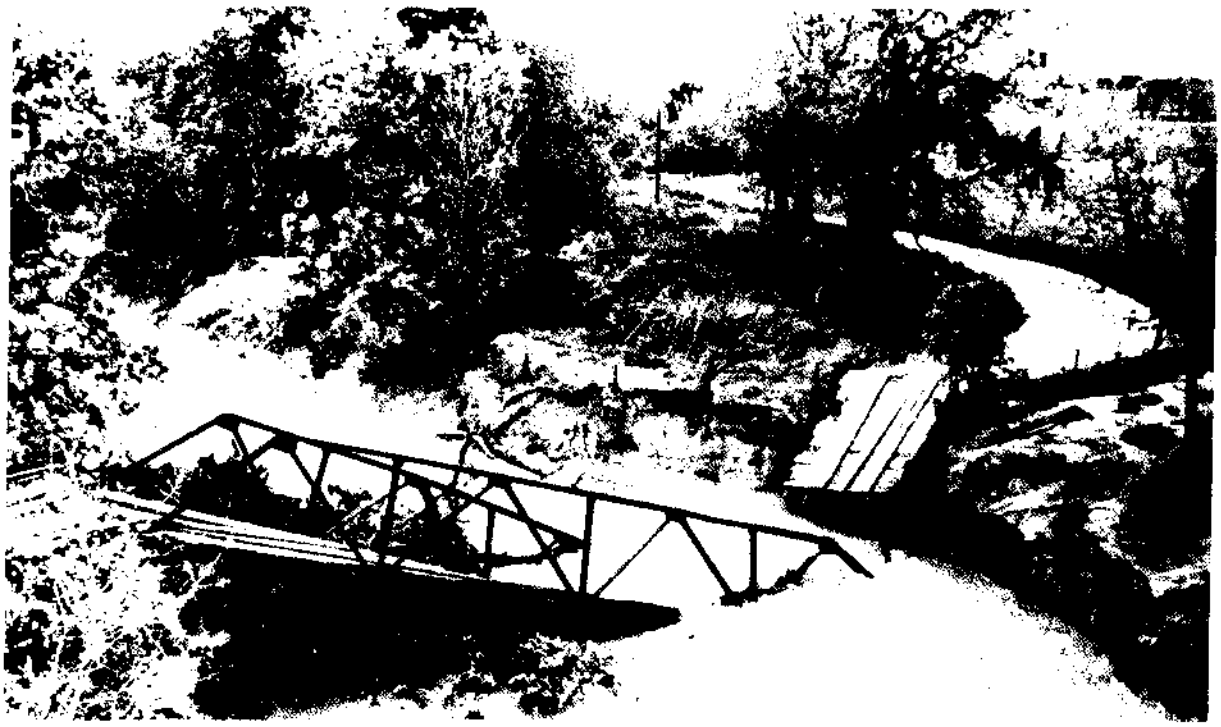

Road and bridge damages typical to these shown occur frequently in all portions of the watershed.

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Creek lateral, of which 120 acres are utilized in urban developments and 314 acres devoted to agricultural uses. Fifty-six acres of the agricultural land along Pecan Creek are located upstream from the urban area and 258 acres are downstream. The flood plain along Elm Fork, common to the Hickory Creek watershed, consists of 1,600 acres. The entire flood plain has been inundated by the runoff from the largest storm considered in the 20-year (1944 through 1963) evaluation series.

During the 20-year period there were 8 major floods covering more than half the flood plain and 36 minor floods. More than 46 percent of the floods have occurred during the months of April, May, and June. This is the season when crops are at a critical stage of growth and are very susceptible to damage from floodwater. An average of two floods occur annually on the Hickory Creek watershed. Floods that inundate more than 50 percent of the flood plain occur on the average of twice in five years.

The two largest floods occurred in 1957 and 1962. Runoff from the 1957 storm inundated the entire flood plain. Damage to county roads, State and Federal highways, bridges, and fences was extremely heavy.

The average annual flood damages without the program of land treatment and structural measures are estimated to total $82,060. These include $15,129 of crop and pasture damage, $7,806 of other agricultural damage, and $17,074 of road and bridge damage. Urban damages average approximately $27,100 annually. Sediment, erosion, and indirect damages amount to $14,951 annually.

At one time, about 80 percent of the flood plain was in cultivation. Frequent flooding has forced operators to retire all but about 25 percent to hay crops and improved pasture. Improved pastures are not being managed for maximum use due to loss of fertilizers and seeds from flooding. Noxious weed seed are washed in on flood plain land and film deposits of sediment are left on grasses. Livestock will not graze until another rain falls and cleans the grass of this sediment. Attempts have been made by individual landowners to levee bottomlands, but these efforts, generally, have not proved to be satisfactory.

Urban flood damages have been experienced in the City of Denton. Flooding in the past has caused extensive damage to approximately 150 private homes and 10 businesses. The City of Denton, Texas has installed a concrete lining along part of the channel of Pecan Creek through the urban area. It is estimated that the improved channel will carry the runoff from a storm expected to occur on the average of once every 10 years. Urban areas should be provided with a higher level of protection and additional flood prevention measures are needed.

Erosion Damage

Flood plain scour damage is generally low. This can be attributed to grassland which provides protective cover on a high percentage of the flood plain lands. The area of greatest damage occurs along a six mile section of Hickory Creek (Reach II, figure 5) extending two miles upstream

and four miles downstream from U. S. Highway 377. Flood plain scour damage by evaluation reach is as follows:

Evaluation Reach	Acres Damaged, Percent 10	20	30	40	Total
I, VII, VIII	NO DAMAGE				
II	37	119	13	13	182
III	-	13	4	5	22
IV	-	41	51	-	92
V	-	5	-	-	5
VI	-	78	9	-	87
IX	-	8	-	-	8
X	-	4	-	-	4
Total	37	268	77	18	400

The estimated average annual damage by flood plain scour is $3,232 (table 5). Channel entrenchment and lateral erosion are generally minor in the watershed, with the exception of the upper reaches of Timber Creek where these processes have been quite active. The estimated land loss by channel erosion in the watershed is less than three acres annually.

Erosion rates in the watershed range from low to moderate. Conversion of cropland to improved pastures and application of land treatment measures have significantly reduced erosion damage since 1950. This trend of converting cropland to pastureland has been particularly effective in reducing erosion in the Cross Timbers portion of the watershed.

Present annual erosion rates in the upland range from 4.4 to 13.2 tons per acre on cropland and from 1.0 to 2.2 tons per acre on rangeland and pastureland. The average annual erosion rate for the watershed under present conditions is 4.2 tons per acre. In the upland area, sheet erosion accounts for 92 percent and gully and streambank erosion for 8 percent of the annual soil loss.

Sediment Damage

Damage by overbank deposition is low. This results mainly from the low to moderate sediment production and the fine texture of the materials deposited. The most damaging deposition has occurred on the Timber Creek flood plain. Improved cover has resulted in a reduction in upland sediment sources of Timber Creek during the last 15 years and has permitted a high rate of recovery on the damaged flood plain.

Modern sediment deposits are mainly clays and silts with lesser amounts of silty sands. Under present conditions, the productive capacity of 585 acres of flood plan is being reduced 5 to 30 percent, as follows:

Evaluation Reach	Acres Damaged: Percent 5	10	20	30	Total
I, VII, VIII	NO DAMAGE				
II	157	56	-	-	213
III	77	9	-	-	86
IV	79	30	-	-	109
V	20	-	-	-	20
VI	43	8	-	-	51
IX	-	30	-	-	30
X	-	41	25	10	76
Total	376	174	25	10	585

The average annual damage from sediment deposition on flood plain lands is estimated to be $1,434 (table 5).

Stream channel aggradation is generally minor. Gravel deposits have reduced channel capacities of North Hickory and South Hickory Creeks approximately 10 percent. Aggradation also occurs in the middle reaches of Timber Creek where sand deposits have reduced channel capacities 10 to 20 percent.

It is estimated that 130 acre-feet of sediment is being deposited annually in Garza-Little Elm Reservoir from Hickory Creek watershed. The annual damage to this reservoir by depletion of its capacity is estimated to be $2,825 (table 5).

Problems Relating to Water Management

Problems relating to surface drainage and irrigation activity are insignificant in the watershed. According to the sponsoring local organization, there is no known local interest at the present time in providing storage for irrigation in any of the structures.

The towns of Lewisville, Slidell, Krum, Ponder, Argyle, and Lake Dallas obtain their water from wells. These towns are not interested in development of a multiple-purpose structure.

The City of Denton obtains its water from wells and Garza-Little Elm Reservoir. While acute water shortage is not a problem at the present time and plans have been made to assure adequate water for the immediate future, the City of Denton, cognizant of rapid growth and expansion, is vitally interested in any project that offers potential development of additional municipal and industrial water supplies.

Rural water supplies are obtained from shallow wells and ponds which furnish adequate amounts to satisfy daily needs.

The towns in the watershed do not create a pollution problem at the present time. The City of Denton has a modern sewage treatment plant which can handle 2,000,000 gallons per day. Plans are underway to triple this capacity by 1969. According to City officials, there are no industrial pollution problems at present. Chemical pollutants such as insecticides are not used extensively in the watershed.

There is no interest in the watershed to develop a water based recreational facility. Garza-Little Elm Reservoir provides an excellent area for water based recreational activities. Farm ponds within the watershed provide a source for fishing. Fishing along the intermittent streams of the watershed is limited to small water holes.

PROJECTS OF OTHER AGENCIES

Garza-Little Elm Reservoir, completed by the U. S. Corps of Engineers in 1954, and into which the major portion of Hickory Creek watershed drains, includes conservation storage for the municipalities of Denton and Dallas, Texas.

The planned works of improvement for Hickory Creek watershed will prolong the life of Garza-Little Elm Reservoir by reducing the rate of sedimentation. Structural and land treatment measures in this watershed will not produce any foreseeable detrimental effects to this or to any other project which may be developed in the future.

There are no known plans for additional works of improvements for water resource development which would affect or be affected by the program included in this work plan.

BASIS FOR PROJECT FORMULATION

Following a request for planning assistance, a reconnaissance of the watershed was made by staff specialists of the watershed planning staff. Meetings were held with the local sponsoring organizations to discuss existing problems and to formulate the objectives of a watershed protection and flood prevention project. Frequent flooding prevents intensive land use and causes damage to crops, pastures, and other agricultural properties. Urban damages have occurred frequently along the Pecan Creek tributary in the City of Denton.

The following specific objectives were agreed to:

1. Establish land treatment measures during the project installation period which contribute directly to watershed protection and flood prevention.

2. Attain a reduction of 65 to 75 percent in average annual floodwater and sediment damages along Hickory Creek and its tributaries.

3. Obtain complete protection from the 100-year frequency storm in the urban area of Denton along the Pecan Creek tributary.

Other objectives of the over-all watershed project are reduction of upland erosion and encouragement of owners to develop the structure sites as recreational areas. Recreational developments at sediment pools of floodwater retarding structures will provide landowners the opportunity to establish income producing enterprises.

Alternate systems of structural measures were evaluated to obtain the most economical system. Land treatment measures and floodwater retarding structures are the most feasible means of meeting project objectives.

The opportunities for including storage capacities for purposes other than flood prevention were explained. Denton is the only city in the watershed interested in additional storage. It was determined that their future needs for municipal water exceeds the storage permissible under the Flood Control Act. At the present time, Denton is obtaining water from wells and Garza-Little Elm Reservoir.

It was determined that a project for watershed protection and flood prevention meets local needs and that no other group or individual is interested in obtaining additional storage for other purposes.

In the selection of floodwater retarding structure sites, consideration was given to locations which would provide the desired level of flood protection. The location, size, number, and cost of structures were influenced by topographic and geologic conditions, existing roads, pipelines, powerlines, land use, and farmsteads. Alternate combinations of structural measures including stream channel improvement which would provide the desired level of flood protection were considered during the development of the work plan. The most efficient system was used to meet the project objectives.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Denton-Wise and Dalworth Soil and Water Conservation Districts, is essential to a sound and continuing program of flood prevention in the watershed. Basic to the attainment of this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices. Emphasis will be placed on accelerating the establishment of land treatment practices which have a measurable effect on the reduction of floodwater and sediment damages (table 1).

The extent of needed land treatment measures which have been applied to date within the project area represents an estimated expenditure by landowners and operators of $610,179, excluding reimbursements from Agricultural

The acreage of coastal bermudagrass is expanding rapidly in the watershed. A portion of the acreage was formerly cultivated.

Legumes grown on cultivated land as shown above is a very important phase in obtaining proper land treatment.

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Conservation Program (table 1A). Table 1 includes estimates of the acreage in each major land use which will receive accelerated land treatment during the 8-year installation period. These measures will be established and maintained by the landowners and operators in cooperation with the local soil and water conservation districts.

In addition to the presently available technical assistance, $40,850 will be made available to accelerate planning and establishment of needed practices and measures.

There are 360 basic conservation plans covering 98,280 acres. It is expected that during the 8-year installation period, 160 additional basic plans will be prepared and 167 revised.

Following is the schedule for completing the needed soil surveys during the installation period:

	Acres to be Surveyed
First Year	36,000
Second Year	40,000
Third Year	38,930
Total	114,930

	Man-Year Requirements
First Year	.61
Second Year	.68
Third Year	.66
Total	1.95

The accelerated application and maintenance of land treatment measures is particularly important for protection of the 38,971 acres draining into planned floodwater retarding structures. The applied land treatment measures will reduce the sediment which would be delivered to the floodwater retarding structures by about 18 percent. There are 106,629 acres of the watershed which do not have any control from floodwater retarding structures. On these lands, the establishment and maintenance of land treatment measures constitutes the only planned measures. Land treatment measures are important in reducing scour damages on the 6,912 acres of flood plain.

Conservation cropping systems including such land treatment practices as cover and green manure crops, contour cultivation, and improved residue-conserving tillage operations will be established on approximately 10,838 acres of cropland. These farming practices will improve water-holding capacity, increase infiltration rates, improve fertility levels, and reduce erosion of the soil. About 200,640 linear feet of gradient terraces will be built and provided with needed grassed waterways to control erosion and retard runoff from the more rolling lands. Establishment of needed waterways will precede construction of terraces.

The trend in upland farm areas is toward retirement of eroded areas from cropland use to hay or pasture. Pasture and hayland management will be practiced on 47,020 acres of improved pasture. Approximately 5,469 acres of this area will be renovated by seeding and fertilizing. Thirteen thousand four hundred acres will be improved or reestablished by either seeding or sodding to attain a good base grass cover. Special grazing control will be carried out and fertilizers applied as needed. Approximately 1,000 acres will be cleared of trees and brush.

Application of wildlife area improvement measures, including stocking of fish in farm ponds and sediment pools of floodwater retarding structures, will enhance upland game, fish, and waterfowl habitats. Plantings in field borders and on grassland will furnish food and cover for wildlife. Excellent cover will be established within the fenced areas on the dams and emergency spillways of floodwater retarding structures and will furnish additional areas of wildlife habitat.

The installation of land treatment measures will reduce the total annual erosion in the watershed by approximately 15 percent. Infiltration will be increased by the improvement of cover in the cultivated areas and increased density and growth in the pastured areas. Terraces, diversions, and waterways will slow the runoff from cultivated fields.

Structural Measures

A total of 17 floodwater retarding structures are required to provide the desired protection to the watershed and reduction in floodwater and sediment damages to flood plain lands (figure 6). All planned structural measures are located in Denton County.

Figure 1 shows a section of a typical floodwater retarding structure.

The capacity of the 15 floodwater retarding structures above U. S. Highway 377 totals 20,733 acre-feet. Of this total, 5,065 acre-feet is provided for sediment accumulation over a 100-year period and 15,668 acre-feet for floodwater detention. Runoff from 54 percent of the watershed above U. S. Highway 377 will be retarded. Floodwater detention in Sites 1 through 15 represents an average of 5.04 inches runoff from the area upstream from these structures. The amount of runoff controlled by each structure is shown in table 3.

The total capacity of the two floodwater retarding structures on Pecan Creek is 1,311 acre-feet. Of this total, 101 acre-feet is provided for sediment accumulation and 1,210 acre-feet for floodwater detention. Runoff from 56 percent of the watershed above State Highway 24 will be retarded. Floodwater detention in Sites 16 and 17 is the equivalent of 8.60 inches runoff.

No structural measures are planned on Timber Creek. Residential developments and high land value make it infeasible to install structural measures to obtain agricultural benefits.

All applicable State water laws regulating the appropriation of water or the diversion of streamflow will be complied with in the design and construction of structural measures.

Details on quantities, cost, and design features of structural measures are shown in tables 1, 2, and 3.

EXPLANATION OF INSTALLATION COSTS

The estimated cost of planning and installing land treatment measures during the 8-year installation period, including expected reimbursement from Agricultural Conservation Program funds, is $1,915,986 based on current program criteria. Accelerated technical assistance will be provided to landowners and operators through the soil and water conservation districts by the Soil Conservation Service at an estimated cost of $40,850 from flood prevention funds. These land treatment costs are based on present prices being paid by landowners and operators to establish the individual measures.

Estimates of the kinds, amounts, and costs of land treatment measures were furnished by the Denton-Wise and Dalworth Soil and Water Conservation Districts.

Land, easements, and rights-of-way for the floodwater retarding structures will be furnished by local interests at no cost to the Federal government. The local cost for the floodwater retarding structures, estimated to be $541,800, consists of land, easements, and rights-of-way ($532,650), relocating and clearing obstacles ($6,200), and legal fees ($2,950).

Construction costs for the 17 floodwater retarding structures, estimated to be $1,136,180, include the engineer's estimate and a 10 percent allowance for contingencies. The engineer's estimate was based on unit costs of structural measures constructed in similar areas and modified by special conditions inherent to each individual site location. The cost of installation services is estimated to be $280,360, including engineering and administrative costs. The total construction and installation services costs for these measures is $1,416,540 and will be borne by flood prevention funds. The total cost of installation of the structural measures is estimated to be $1,958,340.

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

Fiscal Year	Measures	Flood Prevention Funds (dollars)	Other Funds (dollars)	Total (dollars)
First	Floodwater Retarding Structures 1 through 5	526,370	109,250	635,620
	Land Treatment	5,106	234,392	239,498
	Subtotal	531,476	343,642	875,118
Second	Floodwater Retarding Structures 6, 15, 16, and 17	228,130	307,950	536,080
	Land Treatment	5,106	234,392	239,498
	Subtotal	233,236	542,342	775,578
Third	Floodwater Retarding Structures 7 through 14	662,040	124,600	786,640
	Land Treatment	5,107	234,392	239,499
	Subtotal	667,147	358,992	1,026,139
Fourth	Land Treatment	5,107	234,392	239,499
Fifth	Land Treatment	5,106	234,392	239,498
Sixth	Land Treatment	5,106	234,392	239,498
Seventh	Land Treatment	5,106	234,392	239,498
Eighth	Land Treatment	5,106	234,392	239,498
Total for Installation Period		1,457,390	2,416,936	3,874,326

EFFECTS OF WORKS OF IMPROVEMENT

With the project installed and functioning as planned, agricultural lands can be managed more efficiently. Marginal cropland will be removed from cultivation and the hazards of flooding will be reduced on the flood plain lands. Land treatment measures will materially reduce losses by erosion on the upland areas and losses by scour on the flood plains. Structural measures will reduce flood and sediment damages on the benefited areas.

It is expected that there will be an increase in the production of non-surplus crops such as grain sorghums, hay, and truck crops.

An increase in the amount of improved pasture is expected to result in more livestock production which will further diversify agricultural operations.

Development and preservation of wildlife measures will improve game habitat and result in greater incomes to landowners from hunting fees.

Increased net returns from more efficient operations and increased production will raise the standards of living of the local people. The improved living standards will stabilize the farm families and provide greater opportunities for advanced formal education.

With the installation and operation of the project, 5 of the 8 major floods such as those which occurred during the 20-year evaluation period, 1944-1963, would be reduced to minor floods. Average annual flooding on Hickory and Pecan Creeks would be reduced from 3,913 to 1,129 acres. Including recurrent flooding on Hickory and Pecan Creeks, the average annual area flooded three feet or more in depth without project is 435 acres. This is reduced to 135 acres after project installation.

The following table shows the acres flooded by storms of specified frequencies without and with the project:

Evaluation Reach (Figure 5)	Average Recurrence: 50 Percent Chance		10 Percent Chance		4 Percent Chance	
	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)
I	41	33	63	47	76	53
II	1,160	625	1,461	1,331	1,500	1,410
III	307	18	437	348	460	395
IV	115	23	554	111	625	185
V	35	34	106	96	140	135
VI	231	10	778	164	915	260
VII	45	3	94	18	103	11
VIII	77	54	123	77	137	88
IX	218	160	316	203	320	210
X 1/	206	-	427	-	470	-
Total	2,435	960	4,359	2,395	4,746	2,747

1/ Land treatment measures only.

Application of the planned land treatment practices is expected to reduce the total annual soil loss from 345 to 293 acre-feet, a reduction of 15 percent.

The annual flood plain scour damage on 406 acres is expected to be reduced 76 percent. Nine percent will be attributable to land treatment measures and 67 percent to structural measures.

After the project is installed, a 48 percent reduction in overbank deposition on 585 acres will be effected, with 15 percent resulting from land treatment measures and 33 percent from structural measures.

It is estimated that 130 acre-feet of sediment from this watershed is deposited annually in Garza-Little Elm Reservoir under present conditions. This damage will be reduced to 70 acre-feet annually with the project installed.

Without the project, a 48-hour 25-year frequency storm will produce 6.53 inches of runoff from the watershed. Such a storm occurred on May 24-25, 1957. The runoff from this storm on Hickory Creek and tributaries produced an estimated peak discharge of 28,990 cubic feet per second at the reference valley section No. 5 (figure 3). Runoff from this storm inundated 4,335 acres of flood plain land below the proposed floodwater retarding structure sites.

With the project installed, the peak discharge from this storm would have been reduced to 19,200 cubic feet per second. The area inundated with the project would have been reduced to 3,012 acres.

Figure 3 graphically illustrates the reduction at valley section No. 5 for the storm of May 29-30, 1946 (2.56 inches of rainfall, 2.03 inches of runoff), approximating a 2-year frequency storm.

Reduced flooding will make it possible for farmers to increase the productivity of flood plain land and to plan cropping systems which will result in greater net returns. The flood threat from a recurrence of the storms in the evaluation series would be eliminated from 1,323 acres on Hickory and Pecan Creeks, permitting more intensive use of this fertile land.

With the installation of floodwater retarding structures 16 and 17, the urban area along Pecan Creek tributary through Denton will be protected against flood damage from the runoff produced by a storm expected to occur on an average of once in 100 years. It is expected that with adequate flood protection, some relatively large tracts of land now idle or in low value agricultural use may be converted to high value residential, commercial and industrial uses. Opportunities will also exist for the development of other smaller scattered areas. No benefits were estimated for changes in land use which might take place following project installation.

It is expected that intensification will occur on about 1,000 acres of the agricultural flood plain on which flooding is expected not more often than once in three years on the average. A large amount of this change will be

from pasture and wooded pasture to improved pasture and hayland. Allotted crops are minor and no significant changes are expected.

Landowners of flood plain lands will be able to carry out a more diversified and intensified agricultural program. Shifts in land use will reduce the acreage of cropland in the watershed by about 13,439 acres, or 26 percent. An estimated 85 landowners and operators of 6,912 acres of flood plain will be benefited directly by the project.

The most severe damage to roads, bridges, and railroads is caused by floods that cover 75 percent or more of the flood plain. With the project in place, the number of floods included in the 20-year series that would inundate 75 percent or more of the flood plain would be reduced from 3 to 0. The reduction of these larger floods would decrease indirect losses resulting from traffic rerouting and marketing delays by approximately 76 percent.

Percent of Flood Plain Covered	Number of Floods in 20-Year Series	
	Without Project	With Project
50 - 75	8	3
75 - 100	3	0

Some loss of wildlife habitat will result from the clearing and inundation of sediment pool areas. All sites will offer opportunities for fish production and provide waterfowl habitat where none existed previously. Wildlife habitat in flood plain areas will be improved by reduction of frequency, depth, and duration of flooding. Upland habitat for wildlife will be enhanced by the application of land treatment.

The sediment pools of all floodwater retarding structures will be open for public use on a fee basis or by landowners' permission and will provide neighborhood recreational opportunities that would not be available locally. Facilities will be available for recreational uses such as fishing, swimming, picnicking, boating, camping, and hunting. Peak recreation use is expected to occur from May through September, with fishing and hunting continuing throughout the year. For these pools, it is estimated that there will be an additional 12,750 visitor-days annually with a peak daily use of 451 visitors.

The project will create additional employment opportunities for local residents. Firms contracting for installation of the structures will employ some of their help locally. The operation and maintenance of project measures over the life of the project will also provide employment opportunities for the local residents.

Secondary benefits, including increased business activity and improved economic conditions in the surrounding communities, will result from the installation of the project. In addition, increased farm production will provide a market for both labor and products used in farming. The increased production will provide added income for farm families, thereby

improving their standard of living. Economic activities will be stimulated by sales of fishing equipment and other items associated with improved recreational opportunities. These secondary benefits will have a favorable effect on the watershed and in the surrounding areas. In addition, there are intangible benefits such as increased sense of security and the opportunity to plan farm operations without consideration of frequent flooding. Local secondary benefits were considered to be equal to 10 percent of the direct primary benefits plus 10 percent on the increased costs that primary producers will incur in connection with increased production.

PROJECT BENEFITS

The estimated average annual flood damage (table 5) within the watershed will be reduced from $82,060 to $19,575, a reduction of 76 percent. Approximately 7 percent of the damage reduction benefits will result from land treatment measures; all the remainder will accrue to the structural program.

The total benefits from structural measures are estimated to be $90,879 annually. It is estimated that benefits from more intensive use of flood plain will be $15,160 annually after discounting for a 5-year lag in accomplishment.

It is estimated that the project will produce secondary benefits averaging $9,634 annually in the local area. This amount which excludes indirect benefits in any form, consists of $7,595 benefits stemming from the project and $2,039 benefits induced by the project. Secondary benefits of national significance were not considered pertinent to the evaluation. Therefore, only those benefits of a local or area nature were considered in the economic evaluation.

Incidental recreation benefits (picnicking, fishing, and hunting), based on an estimated value of 85 cents per visitor-day, will equal $7,881 annually for structures open for public recreational use. Facilities will be moderately developed. Allowance was made for associated costs of 15 cents per user-day for repairs, maintenance, and operation of facilities and liability insurance.

In addition to the monetary benefits, there are other substantial benefits which will accure to the project such as enhanced land values in the vicinity of floodwater retarding structures, an increased sense of security, better living conditions, and improved wildlife habitat. None of these additional benefits were evaluated in monetary terms; nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

Average annual benefits from structural measures, excluding secondary benefits, are estimated to be $81,245. The average annual cost of these structural measures (amortized from total installation cost plus operation and maintenance), is estimated to be $65,640 providing a benefit-cost ratio of 1.2 to 1.

Total benefits, including secondary benefits, from structural measures will provide a benefit-cost ratio of 1.4 to 1 (table 6).

PROJECT INSTALLATION

During the 8-year installation period, individual landowners and operators will establish land treatment measures. The land treatment practices are itemized in table 1, which shows acres to be treated. The goal is to have at least 75 percent of the land treatment applied at the end of the installation period.

Schedule for completion of planned land treatment during the installation period is as follows:

Fiscal Year	Cropland (acres)	Pastureland (acres)	Rangeland (acres)	Wildlife Land (acres)	Total (acres)
First	2,596	4,702	1,180	21	8,499
Second	2,855	5,172	1,298	22	9,347
Third	3,115	5,642	1,416	24	10,197
Fourth	3,115	5,642	1,416	24	10,197
Fifth	3,375	6,113	1,534	27	11,049
Sixth	3,635	6,583	1,652	28	11,898
Seventh	3,635	6,583	1,652	28	11,898
Eighth	3,635	6,583	1,652	28	11,898
Total	25,961	47,020	11,800	202	84,983

Technical assistance in the planning and application of land treatment is provided under the going programs of the soil and water conservation districts. A standard soil survey is in progress and adequate surveys have been completed on 30,670 acres. There are 114,930 additional acres in the watershed needing soil surveys. This work will be completed during the installation period.

The governing bodies of the Denton-Wise and Dalworth Soil and Water Conservation Districts will assume aggressive leadership in accelerating the land treatment program. The landowners and operators will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to landowners and operators in accordance with existing arrangements.

Additional flood prevention funds will be used for technical assistance to accelerate installation of land treatment measures during the 8-year installation period. These funds, estimated to be $40,850, will be used by the Soil Conservation Service to assign additional technicians to the local districts to accelerate the application of soil and water conservation measures.

The County Agricultural Stabilization and Conservation Service Committees will cooperate with governing bodies of the soil and water conservation

districts in selecting practices which will accomplish conservation objectives.

The Texas Extension Service will assist in the general educational phase of the program by furnishing information to landowners and operators in the watershed.

The Soil Conservation Service will contract for the construction of the 17 floodwater retarding structures, prepare plans and specifications, supervise construction, prepare contract payment estimates, make final inspections, certify completion, and perform related tasks for the installation of these structural measures.

The local sponsors will provide, at no cost to the Federal government, all the land, easements, rights-of-way, legal fees, and relocation of existing improvements as needed for the construction of the floodwater retarding structures.

The structural measures will be constructed pursuant to the following conditions:

1. The requirements for land treatment in the drainage area above structures have been satisfied.

2. Land, easements, and rights-of-way have been secured for all structural measures or for a group of structures in a hydrologic unit, or written statements are furnished by the appropriate sponsoring local organization(s) that their rights of eminent domain will be used, if needed, to secure any remaining easements within the project installation period, and that sufficient funds are available and will be used to pay for these easements, permits, and rights-of-way.

3. Operation and maintenance agreements have been executed.

4. Flood prevention 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 Flood Control Act of 1944, as amended and supplemented.

The needed land treatment measures will be installed by landowners and operators under agreements with the Denton-Wise and Dalworth Soil and Water Conservation Districts. Reimbursement under the Agricultural Conservation Program will be available for those measures which are eligible for payments based on present program criteria. Financing for the farmers and ranchers share of the cost can be arranged through local lending institutions and the Farmers Home Administration. The cost of technical assistance for land treatment measures will be borne by flood prevention funds.

Landowners were contacted by the local sponsors during development of the work plan, and it is expected that most of the easements and rights-of-way will be donated. Denton County Commissioners Court will exercise power of eminent domain as may be needed to secure rights-of-way necessary for installation of floodwater retarding structure Sites 1 through 15. Funds are available for this purpose in the County general fund for roads and bridges.

The City of Denton will exercise power of eminent domain as needed to secure the rights-of-way needed to install floodwater retarding structures 16 and 17. A bond election in the amount of $250,000 has been approved for this purpose.

The sponsoring local organizations do not plan to use a Farmers Home Administration loan for this project.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners and operators of farms and ranches on which the measures are applied. Representatives of the soil and water conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs. Landowners and operators will be encouraged to perform the management practices and needed maintenance.

Structural Measures

The estimated annual operation and maintenance cost is $1,760 for the 17 floodwater retarding structures.

Specific operation and maintenance agreements will be executed between the Soil Conservation Service and the responsible organization prior to the issuance of invitation to bid on construction of any of the structural measures included in this work plan.

The Denton County Commissioners Court will be responsible for the operation and maintenance of floodwater retarding structures 1 through 15. The two structures to be installed on Pecan Creek, Sites 16 and 17, will be maintained and operated by the City of Denton.

Both the Court and the City will budget each year sufficient funds for the operation and maintenance of the floodwater retarding structures of which they are responsible. The Court and the City will provide money for this purpose from the Denton County road and bridge fund and the city general fund respectively. Maintenance will be accomplished through the use of contributed labor and equipment, by contract, by force account, or by a combination of these methods.

The structural measures will be inspected jointly by representatives of the soil conservation district, the County Commissioners Court or the City

of Denton after each heavy streamflow. The Soil Conservation Service representative will participate in these inspections at least annually for the first three years following the installation of each structure and for successive years if unusual conditions warrant.

Inspection will include items such as the condition of the principal spillway and its appurtenances, the earth fill, the emergency spillway, the vegetative cover, and the fences and gates installed as a part of the structure.

The Soil Conservation Service will furnish technical guidance and information necessary for the operation and maintenance program. Provisions will be made for free access of representatives of sponsoring local organizations and Federal representatives to inspect and provide maintenance for all structural measures and their appurtenances at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Hickory Creek Watershed, Texas
(Trinity River Watershed)

Price Base: 1966

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) Federal 1/	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	25,961	-	928,111	928,111
Pastureland	Acre	47,020	-	660,780	660,780
Rangeland	Acre	11,800	-	283,435	283,435
Wildlife Land	Acre	202	-	2,810	2,810
Technical Assistance (Accelerated)		-	40,850	-	40,850
SCS Subtotal		84,983	40,850	1,875,136 2/	1,915,986
TOTAL LAND TREATMENT		84,983	40,850	1,875,136 2/	1,915,986
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	17	1,136,180	-	1,136,180
Subtotal - Construction			1,136,180	-	1,136,180
Installation Services					
Soil Conservation Service					
Engineering Services			180,210	-	180,210
Other			100,150	-	100,150
SCS Subtotal			280,360	-	280,360
Subtotal - Installation Services			280,360	-	280,360
Other Costs					
Land, Easements, and Rights-of-Way			-	538,850	538,850
Legal Fees			-	2,950	2,950
Subtotal - Other Costs			-	541,800	541,800
TOTAL STRUCTURAL MEASURES			1,416,540	541,800	1,958,340
TOTAL PROJECT			1,457,390	2,416,936	3,874,326
SUMMARY					
Subtotal - SCS			1,457,390	2,416,936	3,874,326
TOTAL PROJECT			1,457,390	2,416,936	3,874,326

1/ Flood prevention funds.
2/ Includes reimbursement from ACP funds under going program.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
Hickory Creek Watershed, Texas
(Trinity River Watershed)

Price Base: 1965

Measures	Unit	Applied to Date 1/	Total Cost (Dollars) 2/
LAND TREATMENT			
Cropland			
Conservation Cropping System	Acre	20,542	20,542
Contour Farming	Acre	1,640	820
Cover and Green Manure Crop	Acre	1,645	16,450
Crop Residue Use	Acre	12,859	12,859
Diversion	Foot	53,476	4,813
Grasses and Legumes in Rotation	Acre	3,266	24,495
Grassed Waterway or Outlet	Acre	275	19,250
Terrace, Gradient	Foot	432,960	17,318
Terrace, Parallel	Foot	5,280	317
Pastureland			
Brush Control	Acre	2,180	39,240
Farm Pond	No.	375	75,000
Land Clearing	Acre	1,490	52,150
Pasture and Hayland Management	Acre	37,900	18,950
Pasture and Hayland Planting	Acre	9,672	241,800
Pasture and Hayland Renovation	Acre	2,050	51,250
Range Deferred Grazing	Acre	8,840	4,420
Range Proper Use	Acre	9,200	4,600
Wildlife Land			
Wildlife Habitat Development	Acre	503	5,030
Wildlife Habitat Preservation	Acre	175	875
TOTAL LAND TREATMENT			610,179

1/ As of July 1964.
2/ Excludes reimbursement from ASCS funds under going programs.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Hickory Creek Watershed, Texas
(Trinity River Watershed)

(Dollars) 1/

Structure Site Number or Name	Installation Cost - Federal Funds				Total Non-Federal Installation Cost 2/	Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Total Federal		
Floodwater Retarding Structures						
1	91,030	11,540	7,650	110,220	24,100	134,320
2	56,170	10,220	5,060	71,450	13,050	84,500
3	137,240	17,840	11,820	166,900	33,700	200,600
4	65,850	9,880	5,770	81,500	11,000	92,500
5	77,810	11,670	6,820	96,300	27,400	123,700
6	35,980	7,910	3,350	47,240	21,950	69,190
7	45,890	8,350	4,130	58,370	9,950	68,320
8	132,690	17,250	11,430	161,370	36,850	198,220
9	73,320	11,000	6,430	90,750	13,450	104,200
10	92,180	13,830	8,080	114,090	11,850	125,940
11	51,400	9,350	4,630	65,380	13,650	79,030
12	49,500	9,010	4,450	62,960	17,550	80,510
13	27,970	6,990	2,660	37,620	4,200	41,820
14	56,210	10,230	5,060	71,500	17,100	88,600
15	34,110	7,510	3,170	44,790	5,650	50,440
16	67,820	10,170	5,950	83,940	154,200	238,140
17	41,010	7,460	3,690	52,160	126,150	178,310
GRAND TOTAL	1,136,180	180,210	100,150	1,416,540	541,800	1,958,340

1/ Based on 1966 prices.
2/ Includes land, easements, rights-of-way, legal fees, and removing obstacles.

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Hickory Creek Watershed, Texas

(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER										
		1	2	3	4	5	6	7	8	9	10	11
Drainage Area	Sq.Mi.	5.02	2.42	10.88	1.68	6.54	3.19	1.54	11.52 1/	3.25	1.85	2.43
Storage Capacity												
Sediment Pool 2/	Ac.Ft.	200	138	197	107	199	174	124	197	123	159	96
Sediment Reserve Below Riser	Ac.Ft.	64	-	342	-	112	-	-	387	-	-	-
Sediment in Detention Pool	Ac.Ft.	193	104	395	77	223	124	90	424	88	112	70
Floodwater Detention	Ac.Ft.	1,350	625	3,027	473	1,761	851	412	2,722	907	652	700
Total	Ac.Ft.	1,807	867	3,961	657	2,295	1,149	626	3,730	1,118	923	866
Surface Area												
Sediment Pool 2/	Acre	38	28	46	24	42	50	24	46	23	23	22
Sediment Reserve Below Riser	Acre	45	-	82	-	53	-	-	88	-	-	-
Floodwater Pool	Acre	170	101	288	85	230	158	71	320	115	88	86
Volume of Fill	Cu.Yd.	191,300	109,800	293,000	117,550	161,740	57,700	91,460	255,500	164,750	204,360	95,800
Elevation Top of Dam	Foot	841.8	836.3	804.8	784.0	729.8	698.2	889.7	762.5	769.2	713.7	671.6
Maximum Height of Dam 3/	Foot	40	30	47	29	40	25	29	46	36	44	34
Emergency Spillway												
Crest Elevation	Foot	838.0	833.0	800.0	781.5	726.0	695.0	886.5	756.6	765.5	710.0	668.0
Bottom Width	Foot	180	120	250	150	250	130	100	160	160	200	120
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		3.6	4.0	3.6	3.8	3.5	3.7	4.0	4.0	3.7	2.0	3.6
Average Curve No. - Condition II		82	82	83	83	82	82	84	81	83	82	83
Emergency Spillway Hydrograph												
Storm Rainfall (6-Hour) 5/	Inch	6.80	6.80	6.80	6.80	6.80	6.80	6.80	6.80	6.80	9.60	6.80
Storm Runoff	Inch	4.73	4.73	4.84	4.84	4.73	4.73	4.95	4.61	4.86	7.40	4.84
Velocity of Flow (V_r) 6/	Ft./Sec.	0	0	0	0	0	0	0	0	0	2	0
Discharge Rate 6/	C.F.S.	0	0	0	0	0	0	0	0	0	39	0
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	-	-	-	-	710.4	-
Freeboard Hydrograph												
Storm Rainfall (6-Hour) 7/	Inch	14.00	14.00	13.93	14.00	14.00	14.00	14.00	13.74	14.00	20.80	14.00
Storm Runoff	Inch	11.67	11.67	11.78	11.81	11.67	11.67	11.95	11.27	11.81	18.38	11.81
Velocity of Flow (V_r) 6/	Ft./Sec.	8.5	7.7	9.4	6.8	8.2	7.6	7.6	10.5	7.9	8.0	8.0
Discharge Rate 4/	C.F.S.	3,030	1,670	6,330	1,260	4,150	1,710	1,310	5,750	2,610	3,340	1,910
Maximum Water Surface Elevation 6/	Foot	841.8	836.3	804.8	784.0	729.8	698.2	889.7	762.5	769.2	713.7	671.6
Principal Spillway Capacity (Maximum)	C.F.S.	84	40	190	30	112	53	26	197	57	41	44
Capacity Equivalents												
Sediment Volume	Inch	1.71	1.88	1.61	2.05	1.53	1.75	2.60	1.64	1.22	2.75	1.28
Detention Volume	Inch	5.04	4.84	5.22	5.28	5.05	5.00	5.01	4.43	5.23	6.61	5.40
Spillway Storage 8/	Inch	2.80	3.02	2.77	2.65	3.02	3.55	3.50	3.75	2.65	3.93	2.72
Class of Structure		A	A	A	A	A	A	A	A	A	B	A

(See footnotes on last page table 3)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Hickory Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 12	13	14	15	16	17	Total
Drainage Area	Sq.Mi.	2.64	0.90	2.89	1.51	1.68	0.95	60.89:
Storage Capacity								:
Sediment Pool 2/	Ac.Ft.	123	28	117	48	37	23	2,090:
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	-	905:
Sediment in Detention Pool	Ac.Ft.	90	21	85	34	26	15	2,171:
Floodwater Detention	Ac.Ft.	724	229	845	390	777	433	16,878:
Total	Ac.Ft.	937	278	1,047	472	840	471	22,044:
Surface Area								:
Sediment Pool 2/	Acre	33	9	31	13	18	15	485:
Sediment Reserve Below Riser	Acre	-	-	-	-	-	-	268:
Floodwater Pool	Acre	142	33	145	42	119	90	3,048:
Volume of Fill	Cu.Yd.	89,600	44,400	114,300	56,800	125,100	64,840	2,236,300:
Elevation Top of Dam	Foot	648.6	625.7	674.1	619.9	685.5	681.8	xxx:
Maximum Height of Dam 3/	Foot	24	25	27	32	27	20	xxx:
Emergency Spillway								:
Crest Elevation	Foot	645.5	622.5	671.0	616.0	681.2	678.0	xxx:
Bottom Width	Foot	120	80	150	80	230	120	xxx:
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx:
Percent Chance of Use 4/		3.7	3.9	3.0	3.9	1.0	1.0	xxx:
Average Curve No. - Condition II		81	80	81	81	81	81	xxx:
Emergency Spillway Hydrograph								:
Storm Rainfall (6-Hour) 5/	Inch	6.80	6.80	6.80	6.80	13.00	13.00	xxx:
Storm Runoff	Inch	4.61	4.51	4.61	4.61	10.55	10.55	xxx:
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	3.0	3.1	xxx:
Discharge Rate 6/	C.F.S.	0	0	0	0	170	90	xxx:
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	681.9	678.8	xxx:
Freeboard Hydrograph								:
Storm Rainfall (6-Hour) 7/	Inth	14.00	14.00	14.00	14.00	30.50	30.50	xxx:
Storm Runoff	Inch	11.52	11.39	11.52	11.52	27.86	27.86	xxx:
Velocity of Flow (V_c) 6/	Ft./Sec.	7.3	7.7	7.5	8.6	8.8	8.2	xxx:
Discharge Rate 6/	C.F.S.	1,450	1,110	1,910	1,540	4,780	2,110	xxx:
Maximum Water Surfate Elevation 6/	Poot	648.6	625.7	674.1	619.9	685.5	681.8	xxx:
Principal Spillway Capacity (Maximum)	C.F.S.	46	14	53	24	50	27	xxx:
Capacity Equivalents								:
Sediment Volume	Inch	1.51	1.02	1.31	1.01	0.71	0.75	xxx:
Detention Volume	Inch	5.14	4.78	5.48	4.83	8.69	8.54	xxx:
Spillway Storage 8/	Inch	3.57	2.45	3.31	2.36	6.94	9.00	xxx:
Class of Structure		A	A	A	A	C	C	xxx:

Footnotes:

1/ Exclusive of area controlled by floodwater retarding structure No. 7.

2/ 50-year sediment accumulation or 200 acre-feet limitation.

3/ Measured from centerline of stream channel to effectlve top of dam.

4/ Based on regional analysis of stream gage runoff. All struttures equal or exceed minimum requirements given in Washington Engineering Memorandum SCS-27 (Revised March 19, 1965).

5/ Value of P equals values given on Figure 1 Class (A) structures, Figure 3 Class (B) structures, Figure 5 Class (C) structures, Spillway Design Storms, ENGINEERING-HYDROLOGY MEMORANDUM TX-1.

6/ Maximum during passage of hydrograph.

7/ Value of P equals values given on Figure 2 Class (A) structures, Figure 4 Class (B) structures, Figure 6 Class (C) structures, Freeboard Storms, ENGINEERING-HYDROLOGY MEMORANDUM TX-1.

8/ Storage from emergency spillway crest to effective top of dam.

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TABLE 4 - ANNUAL COST
Hickory Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures 1 through 15	50,240	1,580	51,820
Floodwater Retarding Structures 16 and 17	13,640	180	13,820
TOTAL	63,880	1,760	65,640

1/ Installation cost based on 1965 prices and amortized for 100 years at 3 1/8 percent.
2/ Long-term prices as projected by ARS, September 1957.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Hickory Creek Watershed, Texas
(Trinity River Watershed)

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	15,129	6,586	8,543
Other Agricultural	7,806	2,473	5,333
Nonagricultural			
Urban	27,100	-	27,100
Road and Bridge	17,074	5,674	11,400
Subtotal	67,109	14,733	52,376
Sediment			
Overbank Deposition	1,434	748	686
Garza-Little Elm Reservoir	2,825	1,521	1,304
Subtotal	4,259	2,269	1,990
Erosion			
Flood Plain Scour	3,232	793	2,439
Indirect	7,460	1,780	5,680
TOTAL	82,060	19,575	62,485

1/ Price Base: Adjusted Normalized Price Index, Advisory WS-17, May 1966.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Hickory Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost	Benefit-Cost Ratio
	Flood Prevention						
	Damage Reduction	More Intensive Use	Incidental Recreation	Secondary	Total		
Floodwater Retarding Structures 1 through 15	28,165	14,351	7,345	6,656	56,517	51,820	1.1:1.0
Floodwater Retarding Structures 16 and 17	30,039	809	536	2,978	34,362	13,820	2.5:1.0
TOTAL	58,204 2/	15,160	7,881	9,634	90,879	65,640	1.4:1.0

1/ Price Base: Adjusted Normalized Price Index, Advisory WS-17, May 1966.
2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $4,281 annually.

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TABLE 7 - CONSTRUCTION UNITS
Hickory Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Unit No.	Measures in Construction Unit	Annual Benefit 1/	Annual Cost 2/
1	Floodwater Retarding Structures Nos. 1 through 5	26,540	21,420
2	Floodwater Retarding Structures Nos. 7 through 11	21,355	19,420
3	Floodwater Retarding Structures Nos. 6 and 15	4,624	3,810
4	Floodwater Retarding Structures Nos. 12 through 14 plus Units 1, 2, and 3	56,517	51,820
5	Floodwater Retarding Structures Nos. 16 and 17	34,362	13,820

1/ Price Base: Adjusted Normalized Price Index, Advisory WS-17, May 1966.
2/ Installation costs based on 1966 prices and amortized for 100 years at 3 1/8 percent.

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INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment measures for the watershed was developed by the soil and water conservation districts with assistance from Soil Conservation Service work unit personnel at Denton, Dallas, and Fort Worth, Texas.

At a meeting held in Denton, the measures for land treatment required to establish a sound soil, water, and plant conservation program for the watershed were determined.

Trends in farming operations, expected changes in land use, soil condition, land tenure, and other pertinent data were used. From these data, land treatment measures expected to be applied during the 8-year installation period were selected. Past rates of application were examined, and the need for funds to be used for accelerated technical assistance was determined.

Land treatment practices that have been applied on farms under conservation plans obtained from accomplishment records maintained by the Soil Conservation Service, were expanded to represent those applied to date within the watershed.

The II-condition soil-cover complex numbers were computed under present conditions considering soils, land use, and hydrologic cover. These computations were based on land use, cover, and completed soil survey information which was expanded to represent the watershed area. Further computations with the land treatment measures assumed to be in place were completed to develop the after-project curve numbers.

Based on conservation needs, an estimate was made of the measures to be applied in the 8-year installation period. The acres to be treated and cost of treatment measures are shown in table 1.

Table 1A reflects the cost of land treatment measures applied prior to development of the work plan.

Engineering

The following steps were taken in making the engineering investigations:

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

2. A study of aerial photographs supplemented by field examinations was made to determine the limits of flood plain subject to flood damage.

3. Probable sites for floodwater retarding structures were located by study of U. S. Geological Survey topographic maps and stereoscopic photo study. A field examination was made of all possible floodwater retarding structure sites. Those sites which did not show sufficient storage possibilities or in which obstacles were encountered making the site unfeasible were dropped from further consideration. A base map was used to show locations of all structure sites that could possibly be used to evaluate alternate systems of structural measures needed to meet project objectives.

4. A system of 29 floodwater retarding structures was recommended to the sponsors for further consideration and detailed survey.

5. Engineering surveys were started after agreement was reached with the sponsoring local organizations on the locations of floodwater retarding structure sites to be studied. Surveys were carried out as follows:

   a. Horizontal control - The scale of aerial photographs was checked during mapping of the topography of the floodwater retarding structure sites.

   b. Vertical control - Existing U. S. Coast and Geodetic Surveys and U. S. Geological Survey bench marks were used to establish a system of temporary bench marks set at strategic locations. These were used in making surveys for proposed structural measures.

   c. Site surveys - Tentative capacity tables for the proposed structure sites were developed from USGS quadrangle sheets and used as a guide in determining the extent of surveys needed. Topographic maps of the reservoir areas with 4-foot contour intervals and a scale of 1 inch = 660 feet were developed on aerial photographs.

      Cross section and profile data were obtained at proposed floodwater retarding structure centerlines, pipelines, utility lines, and roads involved in each site. After preliminary reservoir plans were accepted by local sponsors, detailed topographic maps of the emergency spillway areas were prepared with a scale of one inch equals 100 feet and a contour interval of 2 feet. Contour lines at the elevation of the top of the riser, the emergency spillway crest, and two feet above the emergency spillway crest were located on the ground and plotted on the aerial photographs. These surveys were used to develop data to finalize design, determine estimated installation cost, determine land rights requirements, and to prepare final land rights work maps.

6. Design of floodwater retarding structures was initiated as soon as survey data was completed. Structure classification and detention and sediment storage requirements for each structure site were determined from criteria outlined in Engineering Memorandum SCS-27 (March 14, 1950) and Texas State Manual Supplement 2441. After storage tables and curves were developed from topographic maps, principal and emergency spillway crest elevations were determined. Alternate locations for each dam were analyzed to determine the most economical and feasible site.

   The elevations of the sediment and detention pools were determined from the storage curves. The top of the riser was set by providing capacity for the expected 50-year sediment accumulation. In the structure which the 50-year sediment accumulation exceeded 200 acre-feet, a lower pool was set at the 200 acre-feet volume. Storage of water is limited by State law to 200 acre-feet unless a special use permit is obtained. The elevations of the emergency spillways were set by providing capacity for the detention and the 100-year sediment volume. Detention volumes in all structure sites meet or exceed the minimum criteria set forth in Engineering Memorandum SCS-27 (Rev. March 19, 1965) and Texas State Manual Supplement 2441.

7. Floodwater detention capacity was provided in all structures according to structure classification as follows: For class "a" structures - detainment of expected runoff from a 25-year storm event; class "b" structures - detainment of expected runoff from a 50-year storm event; class "c" structures - detainment of expected runoff from a 100-year storm event. The expected runoff from these three storm events was determined from a regional analysis of stream gage records.

8. Appropriate emergency spillway design and freeboard storms for all structures were selected from figures 1 through 6 of Engineering-Hydrology Memorandum TX-1 as follows: Class "a" structures - figures 1 and 2; class "b" structures - figures 3 and 4; class "c" structures - figures 5 and 6.

   Spillway design and freeboard inflow hydrographs were developed by the distribution graph method. The appropriate inflow hydrographs were routed through each reservoir by the Goodrich floodrouting method either graphically or by digital computer to determine the width of emergency spillway and effective top of dam. Various combinations of spillway widths and depths were computed to determine the most economical structure.

9. Construction costs were determined from a preliminary design and cost estimate of significant individual items such as embankment, principal spillway, clearing, and fencing. Unit

prices were based on recent contracts of structures in sites with similar characteristics. Conditions peculiar to a particular site such as rock excavation are reflected in designs and cost estimates.

10. Structure data and cost distribution tables were developed to show for all proposed floodwater retarding structures, the drainage area, planned detention capacity, sediment volume, release rate for principal spillway, emergency spillway capacity, area inundated by the pools, volume of fill in the dam, estimated cost, and other pertinent data (tables 2 and 3).

Hydrologic and Hydraulic

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

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

2. Engineering surveys were made of valley cross sections, high water marks, bridges, and other data pertinent to determining flood and sediment damages. The cross sections were selected to represent the stream hydraulics and flood plain areas. Evaluation reaches were delineated in a joint study with the economist.

   Additional channel sections were surveyed within the urban area of Denton, Texas to determine channel and flood plain characteristics for purposes of making a detailed water surface profile study.

3. The watershed is divided into two parts for the purpose of determining runoff. The portion of the watershed draining into Timber Creek lateral includes a large amount of permeable soils of the Cross Timbers Land Resource Area. This area is considered separately from the remainder of the watershed.

   The area draining into Pecan Creek lateral is separated into two parts. Due to the high runoff characteristics of the urban area along Pecan Creek, this area is considered separately from the remainder of the drainage area of Pecan Creek lateral.

Hydrologic conditions of the watershed for both before and with project were determined on the basis of soil groups, land use, land treatment, and cover conditions.

The before-project II-condition soil-cover complex curve number of 81 and the with-project curve number of 80 were determined for use on the major portion of the watershed. Areas excepted are that drained by Timber Creek lateral and the urban area portion of Pecan Creek.

For Timber Creek lateral, the before-project II-condition curve number of 75 and the with-project curve number of 74 were used.

For the urban area only along Pecan Creek lateral, it was determined to use curve number 95. These curve numbers were determined from soil surveys with a combined acreage equal to 25 percent of the watershed area.

4. Cross section rating curves were computed from field survey data by the use of Manning's formula.

5. Runoff-peak discharge relationships were determined by flood routing four volumes of runoff in accordance with procedures set forth in Technical Release 20, "Computer Program for Project Formulation, Hydrology" (Central Technical Unit, Soil Conservation Service).

   Stage-discharge relationships along the concrete lined channel within the urban area of Denton, Texas were determined by making water surface profile studies. These studies revealed that floodwater retarding structures were needed to provide protection to the urban area from the runoff produced by a storm expected to occur on an average of once in 100 years (figure 4).

6. Stage-area inundated curves were developed from field survey data for each portion of the valley represented by a cross section. Stage runoff and stage area inundated curves were developed for each evaluation reach for existing watershed conditions.

7. The rainfall records from the Denton gage were studied for the period 1923 through 1963. From a tabulation of cumulative departure from normal precipitation, the 20-year period 1944 through 1963 was determined to be representative of normal precipitation on the watershed. The historical evaluation series was developed from those years, with individual events limited to a period of 2 days.

8. Determinations were made of the area that would have been inundated by each storm of the evaluation series under each of the following conditions:

   a. The without-project conditions.

   b. The installation of land treatment measures for watershed protection.

   c. The installation of land treatment measures and floodwater retarding structures.

9. The evaluation series contained 44 storms that would cause flood damage at the smallest cross section, an average of approximately two floods per year.

10. The runoff from the largest storm in the historical evaluation flood series was routed to determine the maximum flood plain area used in the computations of damages and benefits.

Sedimentation

Sedimentation investigations were made in accordance with procedures outlined in Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reservoirs," September 1959, U. S. Department of Agriculture, Soil Conservation Service, and "Guide to Sedimentation Investigations - South Regional Technical Service Area," March 1965, U. S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas.

Sediment Source Studies

Sediment source studies were made in the drainage areas of the 17 planned floodwater retarding structures to determine the 100-year sediment storage requirements. Detailed investigations were made in the drainage areas above 5 of the planned floodwater retarding structures and semidetailed studies were made for the remaining 12. Sediment source studies were also made in the drainage areas of 7 sites investigated but not included in the work plan. The following is a tabulation of the investigations and procedures used in determining sediment rates:

1. Detailed field surveys to determine soil loss by sheet erosion included: mapping of land use, cover conditions, land treatment, and slope lengths. Gully and streambank channel investigations included mapping lengths, depths, and estimated lateral erosion.

2. Utilization of soils and slope data from soil survey photographs.

3. Annual soil loss was computed in tons by sediment sources (sheet, gully, and streambank erosion). The Musgrave soil equation was used in sheet erosion calculations.

4. Semidetailed field surveys to determine soil loss rate consisted of mapping land use and studying soils, topography, and erosion. Computations were based on erosion rates determined by detailed studies of similar areas.

5. Erosion rates were adjusted to reflect the effect of planned land treatment.

6. Sediment storage requirements for all structures were determined by adjusting annual soil loss for expected delivery ratios and trap efficiency.

7. Allowance for density differences between soil in place and sediment were made for the required sediment storage volumes. These densities were based on volume weights ranging from 43 to 45 pounds per cubic foot (sediment) and 82 to 83 pounds per cubic foot (soil in place).

8. Allocations of sediment in structures were based on the following (all sites in the Grand Prairie Land Resource Area):

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
First 50 Years	Sediment	Submerged	85
	Detention	Aerated	15
Second 50 Years	Detention	Aerated	100

Flood Plain Sediment and Scour Damages

The following investigations were made to determine the physical damages to the flood plain.

1. Examinations were made along the valley cross sections (figure 3), making note of the depth and texture of deposits, soil conditions, scour channels, stream channel aggradation or degradation, and other pertinent factors contributing to flood plain damage.

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

3. Tables were developed to show percent damage by texture and depth increments for sediment and by depth and width for scour.

4. The areas of sediment and scour damages were measured and tabulated by percent damage categories.

5. The damage to the productive capacity of the flood plain was assessed by percent for each type damage.

6. Damages were summarized by evaluation reaches. Estimates of recoverability of productive capacities were developed from field studies and interviews with farmers.

7. Using the average annual erosion rates as a basis, sediment yields to the flood plain were estimated by sediment sources for present conditions, with land treatment measures installed, and with land treatment and structural measures installed.

8. Reductions in sediment yields were adjusted to reflect the relative importance of each sediment source as a contributor of damage. The reduction of monetary damage from overbank deposition was based on reduction in sediment yield. The reduction of scour damage is based on reductions in depth and area inundated.

Sediment Deposition to Garza-Little Elm Reservoir

That portion of Hickory Creek which drains into Garza-Little Elm constitutes ten percent of the total watershed area above the reservoir. The estimate of the present annual sediment yield from Hickory Creek watershed to the reservoir is based on a detailed study of sediment sources and the use of delivery ratio curves developed by the Soil Conservation Service. It is estimated that the present annual rate of deposition is 0.72 acre-foot per square mile. With the project installed in Hickory Creek watershed it is expected that the rate of deposition to the reservoir will be reduced to 0.39 acre-foot per square mile.

A sedimentation survey of Garza-Little Elm Reservoir made in September 1960 by the U. S. Army Corps of Engineers showed an annual rate of deposition of 1.46 acre-feet per square mile during the 5.88 year period of record. Preliminary data from the sedimentation resurvey of 1965 indicates an annual rate of deposition of 0.47 acre-foot per square mile for the five year period since the 1960 survey. The weighted average annual rate of deposition for the 10.88 year period of record is 0.97 acre-foot per square mile. The primary reason for the wide variation of sediment yield for the two periods is because of above normal runoff during the first period and below normal runoff for the second.

It is believed that the study of sediment sources in Hickory Creek watershed is more representative of its sediment contribution to Garza-Little Elm Reservoir than the 1960 and 1965 sedimentation surveys. The surveys reflect rates of deposition from a wide range of sediment sources in the 1,660 square mile drainage area of the reservoir. Additionally, the installation of land treatment measures, land stabilization measures, and 80 floodwater retarding structures (June 30, 1965) have materially reduced sediment contribution to the reservoir.

Geologic

Preliminary geologic investigations were made at each of the floodwater retarding structure sites to obtain information on the nature and extent of embankment materials, foundation conditions, and emergency spillway excavation that will be encountered in construction. These investigations included surface observations of valley slopes, alluvium, channel banks, and exposed geologic formations; seismic investigations; and hand auger borings.

Description of Problems

All structure sites are located on Lower Cretaceous strata of the Washita group. This group is composed of marine shaly clays, marls, and subordinate limestones, having a total thickness of approximately 500 feet in the watershed. Toward the top is one sandy formation, the Pawpaw, which is the only exception to the non-sandy character of the group. The following tabulation shows, in descending order, the geologic formations of the Washita group and the sites occurring within their outcrops:

Formation	Sites
Grayson	-
Main Street	12 through 17
Pawpaw	-
Weno	11
Denton	6
Fort Worth	5, 9, 10
Duck Creek	1 through 4, 7, 8

Site conditions are closely related for all formations within the group. Soils overlying the geologic strata are calcareous, silty clays, and gravelly clays. Seepage problems are considered minor because of the dominance of relatively impervious material and near positive cutoffs can be obtained at shallow depths at most site locations.

Preliminary estimates of borrow volumes within the sediment pool and emergency spillway areas of Sites 4, 10, and 13 closely approximate embankment requirements. Detailed core drill investigations may reveal that additional borrow will be needed from other sources. Construction materials are readily available within easement areas on these three sites. Adequate quantities of satisfactory materials are available within the sediment pool and emergency spillway areas on the remainder of the sites. The soils of the borrow areas are classified CL, CH, and GC.

Rock excavation is expected in the emergency spillways of Sites 3, 8, 9, and 11. The preliminary estimates are 10 percent of the total excavation on Sites 3, 9, and 11, and 25 percent for Site 8. All of the materials will be usable in the embankments.

Detailed investigations, including exploration with core drilling equipment, will be made at all sites prior to construction. Laboratory tests

will be performed to determine the suitability and handling of embankment and foundation materials.

Economic

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention," U. S. Department of Agriculture, Soil Conservation Service, March 1964.

Determination of Annual Benefits from Reduction in Damages

Agricultural damage schedules were obtained by interviewing landowners and operators of approximately 40 percent of the flood plain. These schedules covered past, present, and future land use, crop distribution under normal conditions, crop yields, other agricultural losses, and depth of flooding. Supplemental data on normal crop yields were obtained from agricultural workers in the area. The present land use on all of the flood plain was obtained by field mapping.

Analyses of this information formed the basis for determining the damageable value and damage rates for various depths and seasons of flooding. The proper rates of damage were applied to the floods in the historical series, covering the period 1944-1963, inclusive. An adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year.

Field studies indicated that land use, yields, frequency of flooding, and anticipated future use warranted the division of this watershed into ten reaches. Consequently, a different damageable value was used for each reach. Estimates of damage to other agricultural property such as fences, livestock, on-farm roads, and farm equipment were made from the analysis of information contained in the flood damage schedules. The monetary value of the physical damage to the flood plain land from erosion and sediment was based on the value of the production lost. The estimate took into account the lag in recovery of productivity and the cost of farm operations to speed recovery. Damage from flood plain scour was related to depth of flooding and velocity, giving greater weight to deeper flows.

Damage to Garza-Little Elm Reservoir for sediment deposition was determined by the straight line method. The total cost (adjusted to normalized prices) of Garza-Little Elm Reservoir was used to determine the cost per acre-foot of storage lost by sediment deposition.

Road and bridge damages were based on information from the County Commissioners, Texas Highway Department employees, and residents of the watershed.

Urban damages in the City of Denton were based on information collected in the field on damages experienced from the 1957 flood and from other more recent floods. An evaluation was made of the damage that would occur from a 100-year frequency flood with the present stream channel improvements.

The field investigation showed that much of the flood plain area on the upper end of the reach had been developed since 1957, both in the form of residential and commercial areas.

Indirect damages involve such items as additional travel time for farmers, rerouting of general traffic, school buses and mail deliveries, and costs of extra feed for livestock during and after floods. Based on information and data obtained from watersheds previously analyzed, it was determined that indirect damages approximate 10 percent of the direct damages.

Owners and operators were asked what changes they would make in their flood plain land use or cropping systems if flood protection were provided. They indicated that a shift would be made from pasture to hay, including alfalfa. Consequently, it is not expected that acreages of crops subject to allotments will be increased as a result of the project. Benefits from more intensive land use in protected areas have been estimated.

Evaluation of incidental recreation benefits was based on an economic analysis of existing structures and from past experience. This analysis indicated that the project will have an average of 12,750 visitor-days annually and net benefits of $0.85 per visitor-day, after allowances of $0.15 for associated costs. It was estimated that tne capacity of the sediment pools would remain adequate for recreational purposes for 40 years and decline to zero at the end of 50 years. The incidental recreational benefits were discounted to allow for this depletion in capacity.

The value of local secondary benefits stemming from the project was considered to be equal to 10 percent of the direct primary benefits. This excludes all indirect benefits. The value of local secondary bcnefits induced by the project was considered to be equal to 10 percent of the increased costs that primary producers will incur in connection with increased production.

The values of easements were determined through local appraisal, giving full consideration to current real estate market values. An estimate was made of the value of production lost in the pool areas after installation of the program. In this appraisal it was considered that the sediment pools would yield no production. Thc land covered by the detention pools would be used as pasture after installation of the structures. The average annual loss in production within the floodwater retarding structures plus secondary costs therefrom were compared with the amortized value of easements. The easement value was found to be greater and therefore was used in economic justification to assure a conservative benefit-cost analysis.

Fish and Wildlife

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Texas Parks and Wildlife Department, has completed a reconnaissance study of the Hickory Creek watershed and make the following observations and recommendations:

Fish habitat in the watershed is primarily in farm ponds. A small portion of the Garza-Little Elm Reservoir lies in the southeastern extremity of the watershed. The intermittent watershed streams support few fish.

Principal species of fish in farm ponds and Garza-Little Elm Reservoir are largemouth bass, white bass, bluegill, white crappie, redear sunfish, green sunfish, and channel catfish. Carp, gars, and gizzard shad also are common in Garza-Little Elm Reservoir. The streams have a few sunfish and channel catfish. Farm pond fishing is restricted to landowners and their invited guests. Garza-Little Elm Reservoir is open to public fishing. Fishing is insignificant in the project streams.

There is no commercial fishing in streams and farm ponds in the watershed, and none is expected to develop in the future. That part of Garza-Little Elm Reservoir occupying a small portion of the watershed supports a commercial fishery for buffalofish, carp, and gars. This fishing is done by State contract netters and is expected to continue.

With the project, the construction of 17 floodwater retarding structures and additional farm ponds would create good fish habitat in the watershed. These impoundments would reduce the amount of sediment deposited in Garza-Little Elm Reservoir thereby improving fish habitat and prolonging the life of that reservoir.

No commercial fishing would be expected to develop under with-the-project conditions, except for that in Garza-Little Elm Reservoir.

The principal wildlife species in the watershed are bobwhite, mourning dove, fox squirrel, cottontail, waterfowl, raccoon, opossum, armadillo, skunk, and mink. No big-game animals reside in the watershed, and none are expected to do so in the future.

Bobwhites, mourning doves, and cottontails are hunted intensively in the watershed. Hunting for fox squirrels and opossums is moderate to light. A few landowners lease a small amount of land for bobwhite hunting. These conditions would not be expected to change significantly without the project.

During periods of migration, waterfowl make extensive use of available water in the watershed. They are hunted heavily during the waterfowl season.

Raccoons are hunted for sport with dogs, but there is no fur trapping in the watershed.

With the project, planting legumes, cover and green manure crops, conservation cropping systems, wildlife habitat development, and wildlife habitat preservation would be beneficial for upland game. Flood protection below the floodwater retarding structures would improve wildlife habitat, particularly for ground-nesting species.

The floodwater retarding reservoirs and farm ponds would be of value to wildlife as a source of drinking water. Migrating waterfowl would use the impoundments as resting areas.

Brush control and land clearing would destroy wildlife habitat valuable to most upland game.

Construction of the floodwater retarding reservoirs with sediment pools that maintain water until silted in would benefit fishing and hunting in the watershed. However, to realize the full fishing and hunting potential of the project, provision should be made to provide public access to all of the structure sites.

There are certain measures that could be implemented in the project plan that would improve fish habitat and reduce the loss of wildlife habitat. To promote fertility and reduce turbidity, upon completion of the structures and prior to impoundment of water, the basins of the floodwater retarding reservoirs should be disked and planted to grasses or a small grain adaptable to the area. When practicable, the dams and selected reservoir areas should be fenced to prevent damage to the dam and muddying of the water by livestock. A watering device installed below the dam and outside of the enclosed area could be used to water livestock. If this is not feasible, watering lanes could be provided to a selected area of the reservoirs.

Clearing and charting of seining areas in the larger reservoirs to permit seining would be an aid to management of the reservoirs for fishing. Suitable seining areas could be provided at little additional cost if included in the project construction plans. Such cleared areas could be constructed in the process of securing fill for the dams.

The Texas Parks and Wildlife Department should be consulted regarding the reservoir stocking requirements. Indiscriminate stocking would be detrimental to the sport fishery. Where channel catfish are approved for stocking, suitable spawning devices should be installed. Sewer tiles, barrels, and old tires have been used successfully as channel catfish spawning shelters.

Consistent with project objectives, as much brush and timber as possible should be retained in the watershed for wildlife. Losses of brush and timber that result from project construction and inundation should be compensated for by planting appropriate vegetation at suitable locations such as on idle lands, eroded areas, stream banks, gullies, and along fencerows. The Texas Parks and Wildlife Department should be consulted prior to clearing for their recommendations relative to the retention of brush and timber.

With a minimum of planning and expense, many floodwater retarding, erosion prevention, and soil building practices can be made to improve fish and wildlife habitat. For example, hedgerow plantings provide excellent food and cover for various species of wildlife. They also delineate field boundaries, reduce erosion, establish contour guidelines, and serve as living fences or screens. Likewise, field border plantings help control

erosion, protect edges of fields that are used for turnrows or travel lanes for farm machinery, and also provide food and cover for wildlife. Appropriate plantings around reservoirs and ponds would enhance the beauty and scenic qualities of the watershed.

In view of the above, it is recommended that:

1. Public access be provided to the floodwater retarding reservoirs for fishing and hunting.

2. Upon completion of construction and prior to storage of water, the basins of the reservoirs be planted to grasses or small grains adaptable to the area.

3. Lands adjacent to the periphery of the floodwater retarding dams and reservoirs be planted to grasses and other beneficial vegetation to prevent soil erosion and runoff of sediment into the basins of the impoundments.

4. When practicable, the floodwater retarding reservoirs be fenced and watering devices installed below the dams and outside of the fenced enclosures or adequate watering lanes be provided to selected areas of the pools.

5. Planned clearing and grading to permit fish seining in the reservoirs be included in the project construction plans.

6. Only fish species recommended by the Texas Parks and Wildlife Department be stocked in the reservoirs.

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

8. Clearing of timber and brush be kept at a minimum during construction of the floodwater retarding reservoirs and farm ponds.

9. Losses of timber and brush be compensated for by planting trees and shrubs suitable for wildlife at appropriate locations such as idle lands, eroded areas, stream banks, gullies, and strips along fencerows and travel lanes.

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, additionally, 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.

4-23045 8-67

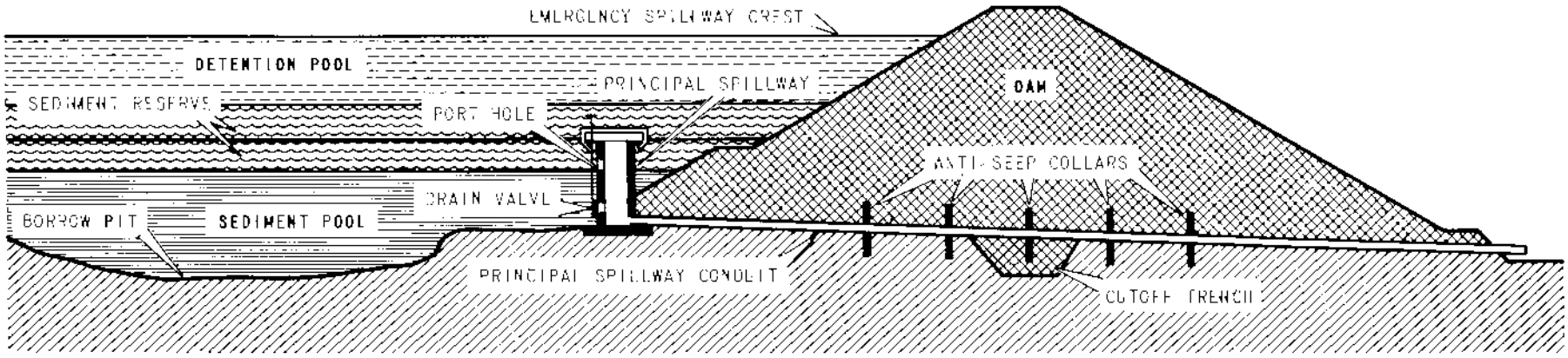


Figure 1

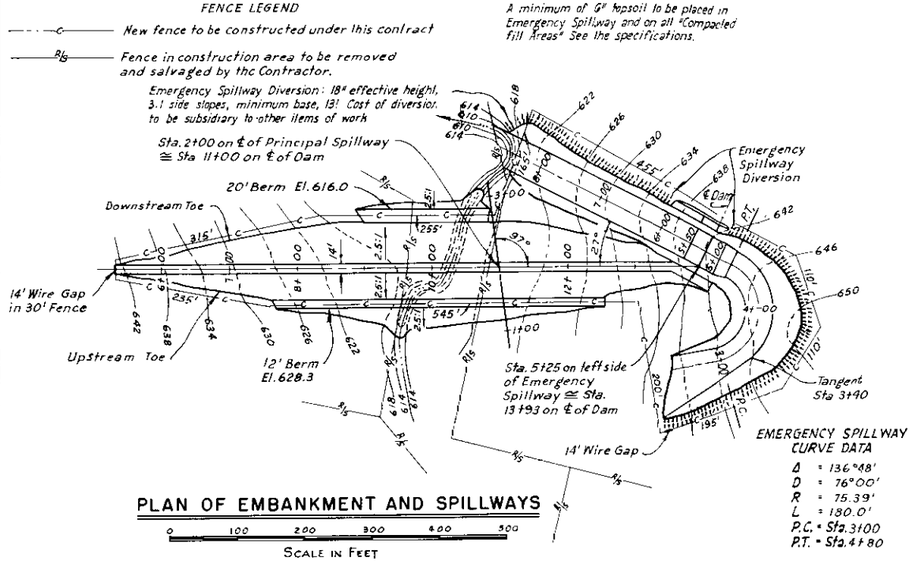
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

FENCE LEGEND

—c— New fence to be constructed under this contract

—R/S— Fence in construction area to be removed and salvaged by the Contractor.

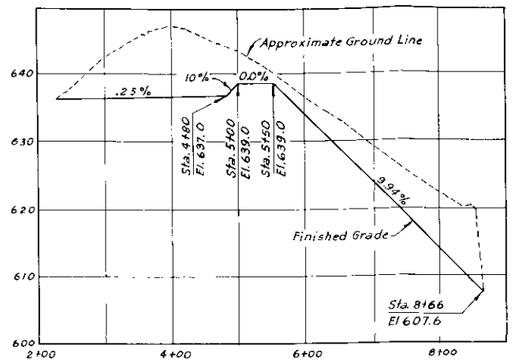
A minimum of 6" topsoil to be placed in Emergency Spillway and on all "Compacted fill Areas" See the specifications.



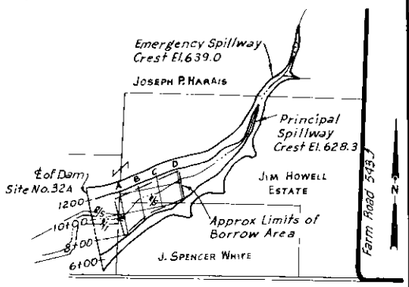
PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500

SCALE IN FEET



PROFILE ON ℄ OF EMERGENCY SPILLWAY



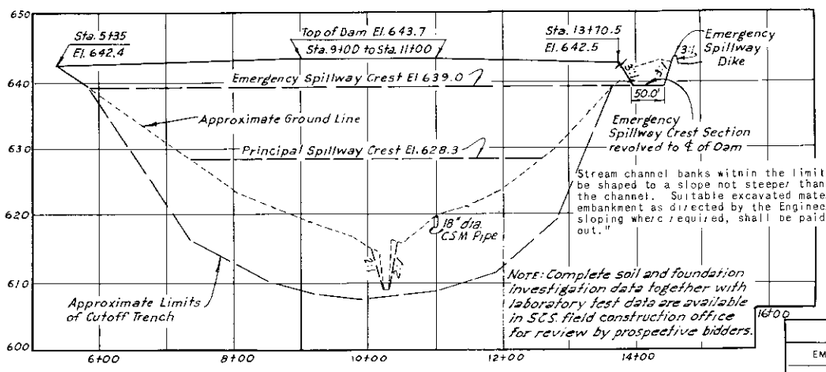
Structure Site No. 32A is located approximately 4.5 miles west of Anna, Collin County, Texas.

VICINITY MAP &

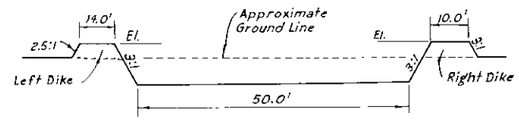
GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640

SCALE IN FEET



PROFILE ON ℄ OF DAM



Left Dike Note:

Approximate Sta. 5+00 to Embankment: El. 642.5.

Right Dike Note:

Approximate Sta. 5+10 to Sta. 5+50 El 642.5

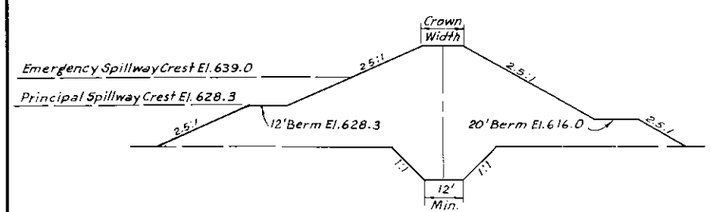
Grade top of Dike uniformly from El. 642.5 @ Sta. 5+50 to 3.0' above grade @ approximate Sta. 6+00.

Material forming Dike shall be placed and paid as "Compacted Fill."

TYPICAL SECTION EMERGENCY SPILLWAY

Elevation	Surface Acres	Storage	
		Acre Feet	Inches
618	0.5	1	.04
622	3.0	8	.28
626	7.0	28	.99
628.3	10.0	48	1.70
630	11.5	65	2.31
634	15.0	118	4.19
638	20.0	188	6.67
639	22.0	210	7.45
642	27.5	283	10.05

Top of Dam (Effective) Elev.	642.4
Emergency Spillway Crest Elev.	639.0
Principal Spillway Crest Elev.	628.3
Sediment Pool Elev.	628.3
Drainage Area, Acres	338
Sediment Storage, Acre Feet	54
Floodwater Storage, Acre Feet	156
Max. Emergency Spillway Cap., c.f.s.	722



TYPICAL SECTION

MATERIAL PLACEMENT DATA

Embankment Section	Source of Fill Material	Ave. Depth Feet		Lab Test		Compaction Requirements			Lab. Curve
				Modified		Min. Dry Density	Moisture Range		
Description	Location	From	To	Max Dry Den	Optm Moist	Lbs Per Cu Ft.	Percent From	To	No
Any Section	Borrow	0	6	111.5	15.5	100.5	16.0	Up	1
	Borrow	6	12	119.5	13.0	107.5	13.0	Up	2
	Borrow	7	12	111.5	15.5	100.5	16.0	Up	3

Notes

1. Material from required excavation may be used for "Compacted Fill," with compaction requirements and limits of placement moisture being the same as for similiar material from the borrow area.
2. Place weathered limestone from Emergency Spillway in upstream berm & use the same compactive effort as is used on adjacent materials.
3. No upward limits of placement moisture are established Upper limits of placement moisture will be established during construction by the engineer, based on the workability aspects of materials being placed in the fill and the densities reached.
4. Maximum dry density, optimum moisture, minimum acceptable dry density and moisture range shown are for material particles passing the number 4 sieve.

EMBANKMENT DATA

Figure 2

TYPICAL

FLOODWATER RETARDING STRUCTURE

GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

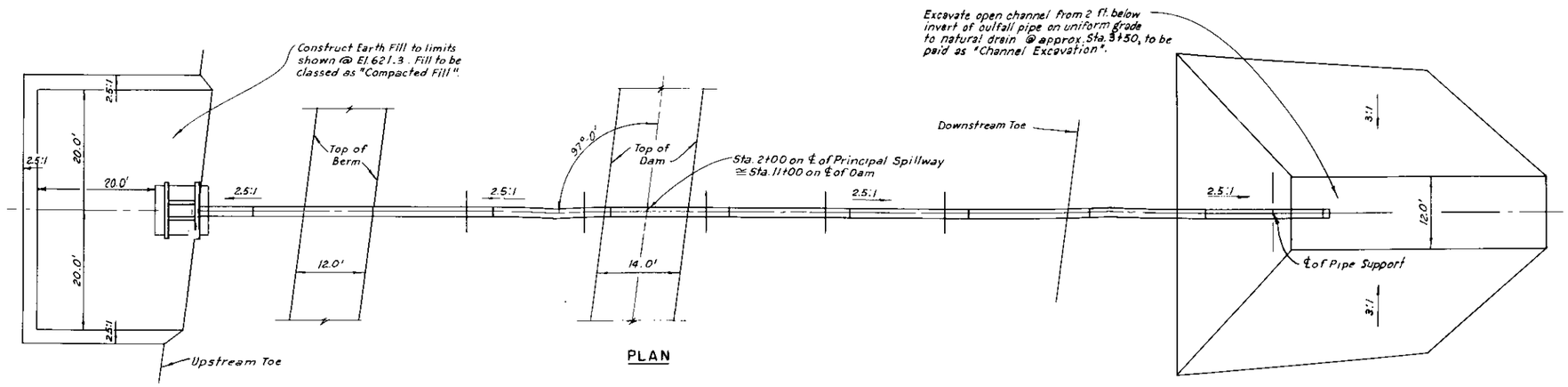
		Date
Designed	L.L.	10-64
Drawn	D.L.F. & M.G.C.	10-64
Traced	M.G.C.	11-64
Checked	L.L. & G.W.T.	11-64

Approved by SCS, TEMPLE AREA WATERSHED PLANNING UNIT, FORT WORTH, TEXAS

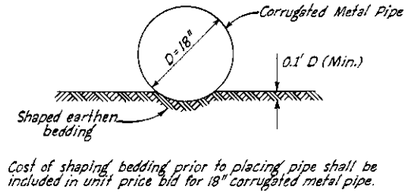
STATE CONSERVATIONIST, TEMPLE, TEXAS

Sheet No. 2 of 7

Drawing No. 4-E-19,480

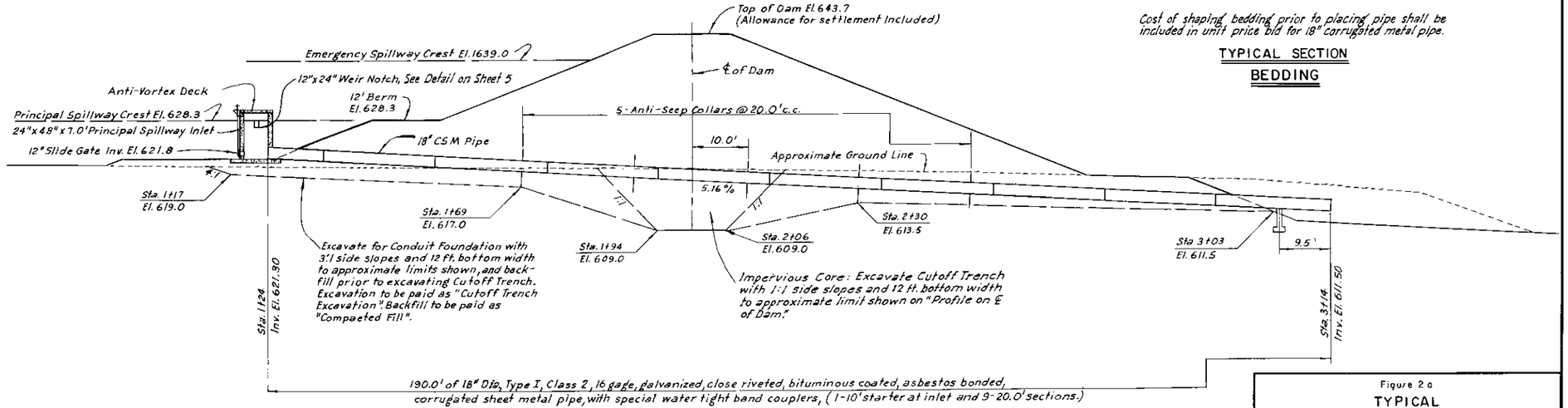


PLAN



Cost of shaping bedding prior to placing pipe shall be included in unit price bid for 18" corrugated metal pipe.

TYPICAL SECTION
BEDDING



SECTION
PRINCIPAL SPILLWAY

Figure 2 c
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.L.	Date 10-64	Approved by HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS	
Drawn L.L. & M.G.C.	10-64	STATE CONSERVATION ENGINEER S. C. S. TEMPLE, TEXAS	
Traced M.G.C.	11-64	Sheet No 3 of 7	Drawing No 4-E-19,480
Checked L.L. & G.W.T	11-64		

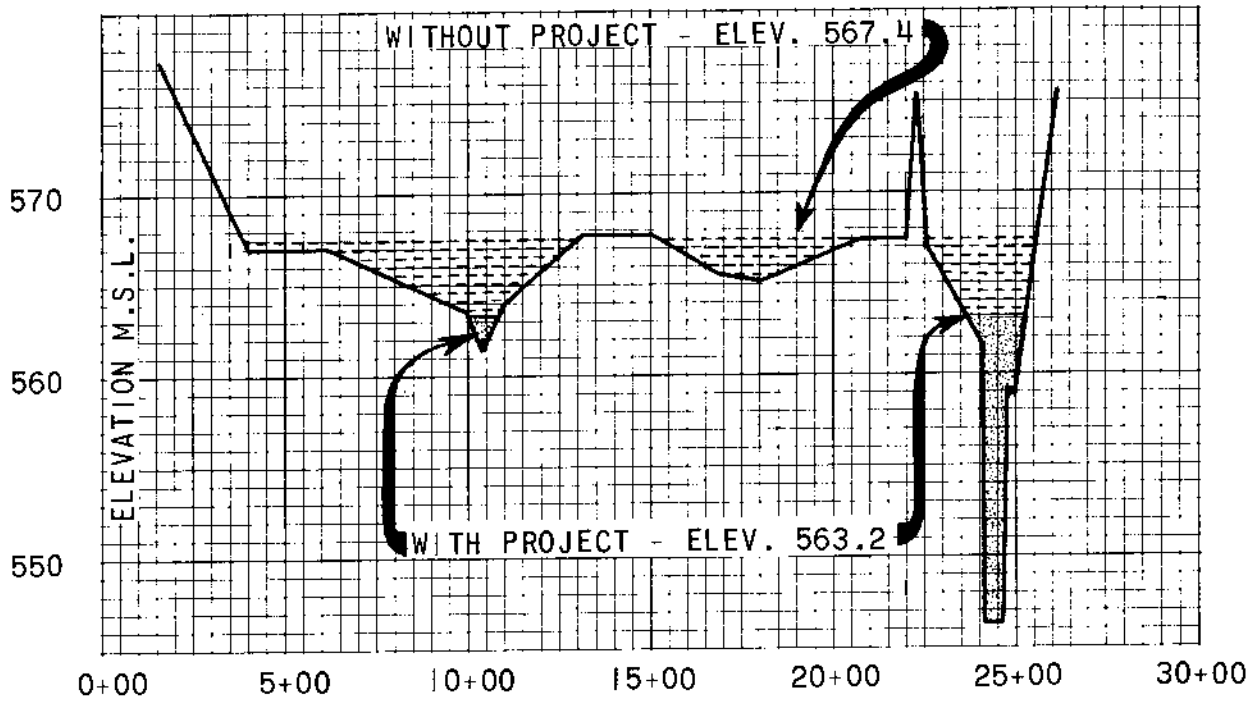
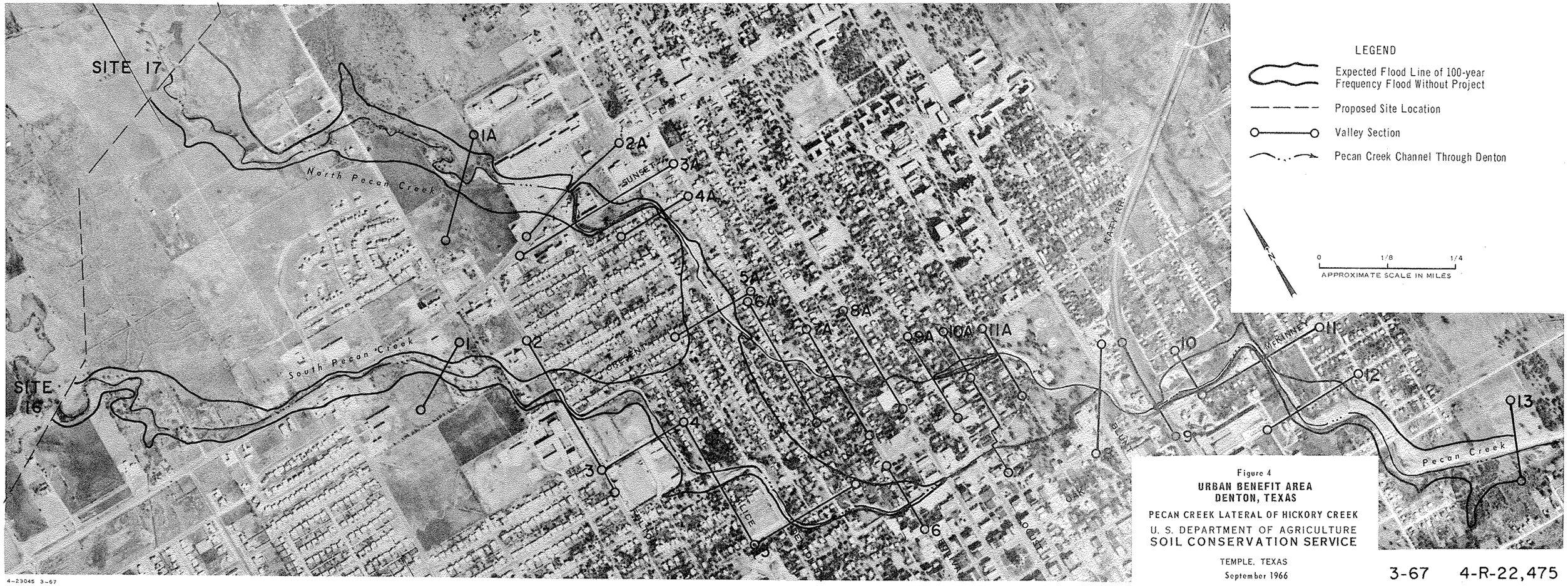


Figure 3

DEGREE OF FLOOD PROTECTION
HICKORY CREEK WATERSHED
(VALLEY SECTION 5)
TRINITY RIVER WATERSHED, TEXAS

STORM OF MAY 29-30, 1946
2.56" RAINFALL WITH 2.03" RUNOFF
APPROXIMATELY 2-YEAR FREQUENCY

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, TEMPLE, TEXAS
USDA-SCS FORT WORTH, TEX 1966
6-23065 11-66



LEGEND

- Expected Flood Line of 100-year Frequency Flood Without Project
- Proposed Site Location
- Valley Section
- Pecan Creek Channel Through Denton

0 1/8 1/4
APPROXIMATE SCALE IN MILES

Figure 4
URBAN BENEFIT AREA
DENTON, TEXAS
PECAN CREEK LATERAL OF HICKORY CREEK
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS
September 1966

3-67 4-R-22,475

4-23045 3-67

Figure 5

PROBLEM LOCATION MAP

HICKORY CREEK WATERSHED

DENTON, DALLAS, TARRANT AND WISE COUNTIES
TEXAS

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

Revised 11-66 4-R-22901
Revised 10-31-66 4-R-7557

O. Constructed

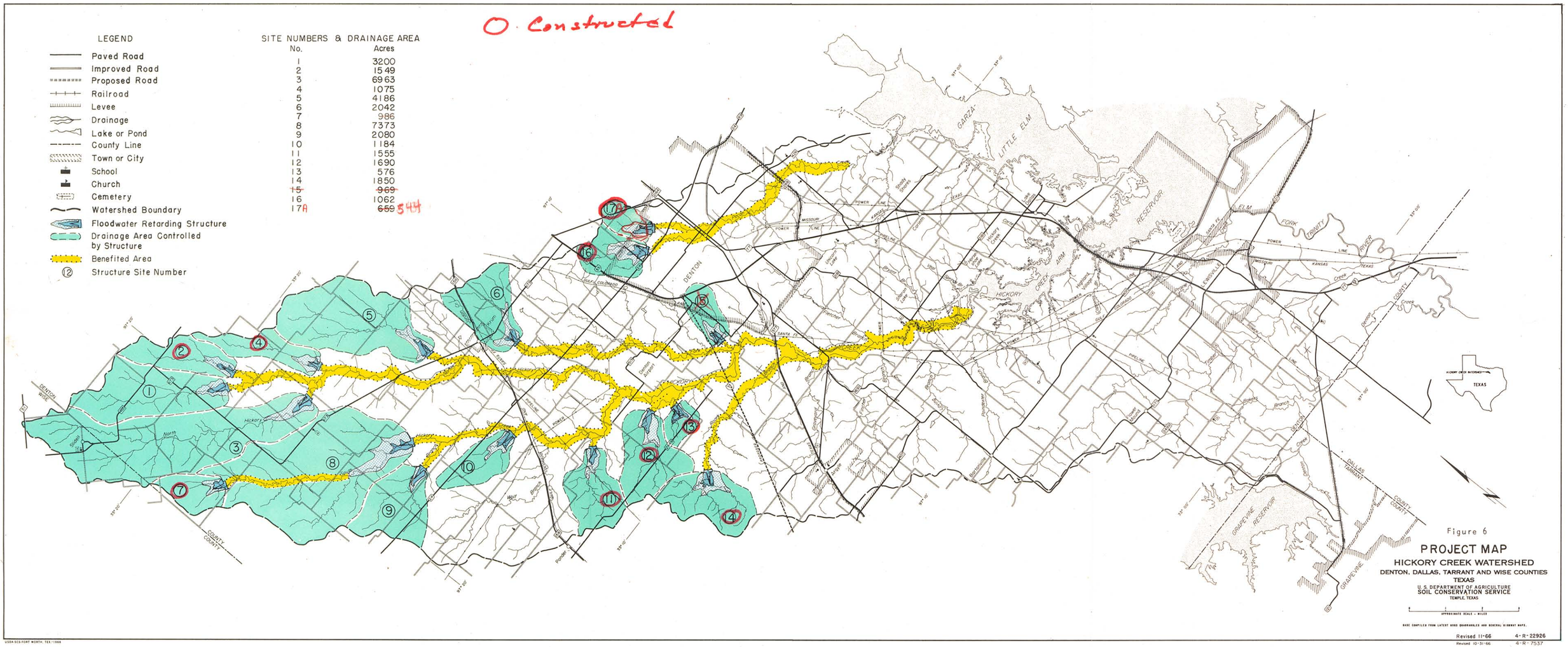


Figure 6

PROJECT MAP

HICKORY CREEK WATERSHED

DENTON, DALLAS, TARRANT AND WISE COUNTIES
TEXAS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

APPROXIMATE SCALE - MILES

BASE COMPILED FROM LATEST USGS QUADRANGLES AND GENERAL HIGHWAY MAPS.

USDA-SCS-FORT WORTH, TEX.-1966

Revised 11-66 4-R-22926
Revised 10-31-66 4-R-7537