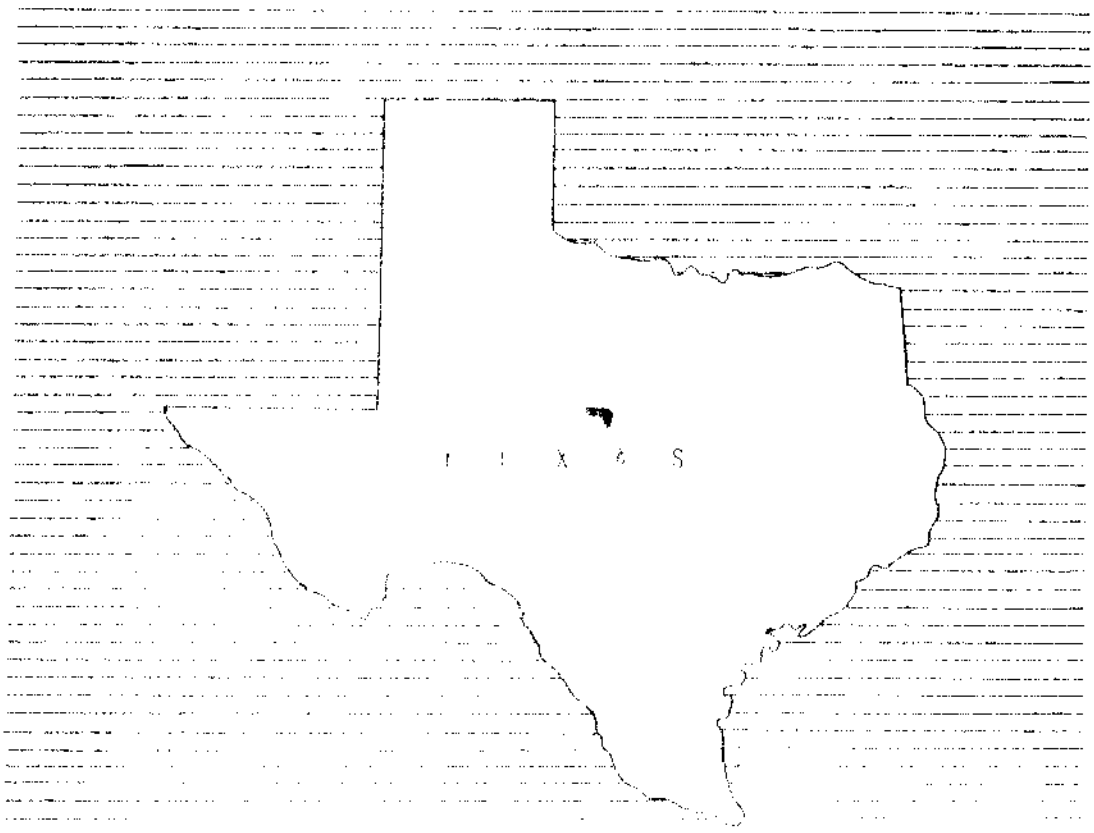
WORK PLAN

WATERSHED PROTECTION
FLOOD PREVENTION
AGRICULTURAL WATER MANAGEMENT

RUSH CREEK WATERSHED

COMANCHE, EASTLAND, AND BROWN COUNTIES, TEXAS



September 1965

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WATERSHED WORK PLAN AGREEMENT

between the

Comanche County Commissioners Court
Local Organization

Upper Leon Soil and Water Conservation District
Local Organization

Brown-Mills Soil and Water Conservation District
Local Organization

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

and the

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

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Rush Creek Watershed, State of Texas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

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

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

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 5 years.

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

1. The Sponsoring Local Organization will acquire such land, easements or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost $173,655). The percentages of this cost to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organizations (percent)	Service (percent)	Estimated Land, Easements, and Rights-of-Way Cost (dollars)
13 Floodwater Retarding Structures	100	0	155,054
1 Multiple-Purpose Structure	100	0	17,801
Stream Channel (South Copperas Creek)	100	0	800

2. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement. (Estimated cost- $600)

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
13 Floodwater Retarding Structures	0	100	1,477,023
1 Multiple-Purpose Structure	6.6	93.4	94,408
Stream Channel Improvement (South Copperas Creek)	0	100	9,421

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
13 Floodwater Retarding Structures	0	100	314,933
1 Multiple-Purpose Structure	0	100	22,434
Stream Channel Improvement (South Copperas Creek)	0	100	2,097

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 7,000 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 65% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

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

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

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

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

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

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

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

13. No member of Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

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

15. All references to specific Soil Conservation Districts (Upper Leon or Brown-Mills) in the work plan are changed to read Soil and Water Conservation Districts.

Comanche County Commissioners Court
Local Organization

By D. F. Caraway
D. F. Caraway

Title County Judge

Date 5/23/66

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

adopted at a meeting held on May 23, 1966

Fred Hall
(Secretary, Local Organization)
Fred Hall - County Clerk

Date 5/23/66

Upper Leon Soil & Water Conservation District
Local Organization

By Ory Beaty
Ory Beaty

Title Designated Representative

Date 5/23/66

The signing of this agreement was authorized by a resolution of the governing body of the Upper Leon Soil & Water Conservation District
Local Organization

adopted at a meeting held on May 13, 1966

[signature]
(Secretary, Local Organization)

Date 5/23/66

Brown-Mills Soil & Water Conservation District
Local Organization

By W. P. Morris

Title L.C.D. Supervisor

Date May 26, 1966

The signing of this agreement was authorized by a resolution of the governing body of the Brown-Mills Soil & Water Conservation District
Local Organization

adopted at a meeting held on May 26, 1966

W. G. Bishop
(Secretary, Local Organization)

Date May 26 - 1966

Brown & Mills S.C.D.
Local Organization

By _____

Title _____

Date _____

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

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION, FLOOD PREVENTION,

AND AGRICULTURAL WATER MANAGEMENT

RUSH CREEK WATERSHED

Comanche, Eastland, and Brown Counties, Texas

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

Prepared By:

Upper Leon and Brown-Mills Soil and Water Conservation Districts
(Sponsor)

Commissioners Court of Comanche County
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
September 1965

WATERSHED WORK PLAN

RUSH CREEK WATERSHED
Comanche, Eastland and Brown Counties, Texas
September, 1965

PREFACE

This work plan for watershed protection, flood prevention and agricultural water management on the Rush Creek watershed was prepared by the Upper Leon and Brown-Mills Soil and Water Conservation Districts and the Comanche County Commissioners Court, the sponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the U. S. Department of Agriculture. The Bureau of Sport Fisheries and Wildlife of the U. S. Department of Interior collaborsted with the Texas Parks and Wildlife Department in the preparation of a reconnaissance report of the fish and wildlife aspects of the project area.

Financial assistance in developing the work plan was furnished by the Texas State Soil and Water Conservation Board and the Soil Conservation Service.

The work of the Rush Creek Watershed Association, an informal local organization, has been outstanding throughout development of this plan. The cooperative effort by this organization has contributed immeasurably to timely completion of the work plan, and will be a motivating force during installation of the project.

WATERSHED WORK PLAN

RUSH CREEK WATERSHED

Comanche, Eastland, and Brown Counties, Texas
September 1965

SUMMARY OF PLAN

General Summary

The work plan for watershed protection, flood prevention, and agricultural water management for the Rush Creek watershed was prepared by the Upper Leon and Brown-Mills Soil and Water Conservation Districts, and the Commissioners Court of Comanche County as sponsoring local organizations. Assistance during planning was furnished by the Rush Creek Watershed Association. Technical assistance was provided by the Soil Conservation Service of the United States Department of Agriculture.

The watershed covers an area of 294 square miles, or 188,160 acres, in Comanche, Eastland, and Brown Counties, Texas. Approximately 40 percent of the watershed is cropland, 12 percent is pasture, 42 percent is rangeland, and 6 percent is in miscellaneous uses such as urban areas, farmsteads, roads, railroad rights-of-way, and stream channels.

There are approximately 152 acres of Federal land in the watershed. This is the area above elevation 1,172 (m.s.l.) in the vicinity of Rush and Duncan Creeks that was purchased by the U.S. Army Corps of Engineers in connection with the installation of Proctor Reservoir.

The principal problem is the occurrence of frequent floods that cause damage to crops, pastures, other agricultural property, and to some nonagricultural property. The cumulative area flooded during an average year of the 25-year evaluation period is 7,878 acres. The area inundated by the largest flood during this period is about 8,131 acres. The productive capacity of about 3,370 acres has been reduced about 20 percent by sediment deposits and flood plain scour. Frequent flooding also prevents efficient use of some flood plain land.

The objectives of the project are to provide proper land use and treatment in the interest of soil and water conservation, flood protection for the flood plain lands along Rush Creek and its tributaries, and additional water storage for irrigation. The project as formulated meets these objectives.

The work plan proposes installing, in a five-year period, a project for the protection and development of the watershed at a total estimated installation cost of $3,729,415. The share of this cost to be borne by Public Law 566 funds is $1,961,153. The share to be borne by other than Public Law 566 funds is $1,768,262. In addition, local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

Landowners and operators will establish land treatment, during the five-year installation period, which will help accomplish the project objectives. Primarily, this treatment will consist of measures, or combinations of measures, which contribute directly to watershed protection, flood prevention, and sediment control.

The cost for land treatment is estimated to be $1,627,904, of which $1,580,809 will be borne by other than Public Law 566 funds. This amount includes expected reimbursements from the Agricultural Conservation Program Service and $74,850 to be spent by the Soil Conservation Service for technical assistance under its going program during the project installation period. The Public Law 566 share, consisting entirely of accelerated technical assistance, is $47,095.

Structural Measures

The structural measures included in the plan consist of 13 floodwater retarding structures, 1 multiple-purpose structure, and about 3,570 feet of stream channel improvement. The 13 floodwater retarding structures and the multiple-purpose structure have a total storage capacity of 37,304 acre-feet, including 8,718 acre-feet for sediment accumulation, 28,133 acre-feet for floodwater detention, and 453 acre-feet for irrigation water to be used by an organized group of landowners and operators. Approximately 3,570 feet of the present channel, downstream from floodwater retarding structures Nos. 6 and 7, will be enlarged to insure sufficient capacity for the release flow of these two structures.

The estimated total installation cost of the structural measures is $2,101,511. The Public Law 566 share is $1,914,058; the local share is $187,453 which consists of land, easements, and rights-of-way ($171,130), construction ($6,198), and contract administration and legal fees including costs for water rights ($10,125). The structural measures will be installed during a five-year period.

Damages and Benefits

The estimated average annual floodwater, sediment, erosion, and indirect damages in the watershed, without a project will total $109,516 at long-term price levels. With the proposed land treatment and structural measures installed, these damages will be reduced to an estimated $33,018 annually. This will be a reduction of 70 percent.

The average annual primary benefits accruing to the structural measures are estimated to be $84,643 which include the following:

Damage Reduction	$70,246
More Intensive Use of Flood Plain Land	$ 5,118
Agricultural Water Management	$ 2,221
Incidental	$ 5,082
Proctor Reservoir	$ 1,976

There will be an estimated 165 landowners and operators and about 8,717 acres of agricultural land that will be directly benefited by the installation of the structural measures.

Local secondary benefits are estimated to be $7,826 annually.

The ratio of the total annual benefits ($92,469) resulting from the installation of the structural measures to the annual cost of these measures ($71,646) is 1.3:1 (table 6).

Provisions for Financing Local Share of Installation Cost

The Commissioners Court of Comanche County has powers of taxation and eminent domain under applicable State laws and will furnish the funds for financing the local share of installation costs of structural measures for flood prevention. Monies for the local share of project costs are available in the general fund of Comanche County which is supported by revenue from existing taxes and there is no need for a loan. The local share of the installation cost of multiple-purpose structure No. 9 allocated to irrigation water supply will be paid to the Commissioners Court of Comanche County by the organized group of landowners and operators concerned.

Operation and Maintenance

The Upper Leon Soil Conservation District and the Comanche County Commissioners Court will be responsible for the operation and maintenance of the structural measures. Maintenance will be accomplished through the use of contributed labor and equipment, by contract, by force account, or by a combination of these methods. Funds for this purpose will come from the General Fund of Comanche County. This fund is supported by existing taxes and is available and adequate. The value of annual operation and maintenance of installed structural measures is estimated to be $2,800.

DESCRIPTION OF WATERSHED

Physical Data

Rush Creek watershed is located in north central Texas and includes portions of Comanche, Eastland, and Brown Counties.

The Rush Creek drainage pattern consists of three large tributaries which merge in the middle and lower reaches of the watershed to form Rush Creek. Copperas Creek, the main tributary, heads in Eastland County about two miles west of Rising Star and flows in s meandering course toward the southeast through Comanche County. It is joined by South Copperas Creek about 16 miles downstream from its head and by Sweetwater Creek another 11 miles downstream. Rush Creek originates at the confluence of Sweetwater and Copperas Creeks, and flows about two miles to enter Proctor Reservoir. Proctor Dam is located across the Leon River immediately downstream from the Rush Creek-Leon River confluence.

The larger tributaries of Copperas Creek are Keys Branch, Nanny Branch, and Martins Creek. Stagg Creek is an important headwater tributary of South Copperas Creek, as is Jimmies Creek of Sweetwater Creek. Duncan Creak flows directly into Proctor Reservoir. The drainage area of the Rush Creek watershed is 294 square miles or 188,160 acres.

The watershed lies within three land resource areas. The nearly mountainous Grand Prairie, composed of Cretaceous limestones and shales of the Trinity and Fredericksburg groups, occupies 15 percent of the watershed along the southern and western divide. The West Cross Timbers, underlain by Cretaceous clays, shales, and poorly cemented sandstones and conglomerates of the Trinity group, is adjacent to the Grand Prairie and occurs as a broad gently rolling shelf which covers about 50 percent of the watershed. The North Central Prairie occupies about 35 percent of the watershed and occurs where the larger streams are entrenched through Cretaceous strata, exposing Pennsylvanian shales, limestones, sandstones, and conglomerates of the Strawn and Canyon groups.

Elevations range from 1950 feet above mean sea level along the southwestern watershed divide to 1172 feet on the flood plain where Rush Creek enters Proctor Reservoir at the five-year flood pool elevation.

The soils of the Grand Prairie are mostly shallow and rocky clays. The resistant limestones and thin stony soils retard accelerated erosion but are conducive of rapid runoff during intensive storm periods.

Soils of the West Cross Timbers are mostly deep fine sandy loams and loamy fine sands with sandy clay subsoils. Wind erosion is a major hazard to cultivation on deeper surfaced soils. Both wind and water erosion are hazards on the more shallow surfaced soils.

The North Central Prairie soils range from deep sands to deep fine textured soils. The steeper slopes are composed of shallow fine textured soils of low permeability and support only sparse vegetative cover. The runoff rate is moderately high in this area.

Flood plain in the watershed is well defined, level to nearly level, and ranges in width from 300 to 4400 feet. It is underlain by deep fertile clays, clay loams, and fine sandy loams with permeability rates ranging from very slow to moderate.

The dominant soil series are Denton, Tarrant, San Saba, and Crawford in the Grand Prairie; Nimrod, Winthorst, Stephenville, and May in the West Cross Timbers; and Renfrow and Kirkland in the North Central Prairie. Plood plain soils consist mostly of the Trinity, Frio, and Gowen series. Terrace soils of the Norge and Lewisville series also occur in the watershed.

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

Land Use	Acres	Percent
Cropland	74,559	39.6
Pastureland	23,223	12.3
Rangeland	78,984	42.0
Miscellaneous 1/	11,394	6.1
Total	188,160	100.0

1/ Includes roads, highways, railroad rights-of-way, towns, farmsteads, stream channels, etc.

Range sites within the watershed are Sandy, Deep Sandy, Sandy Loam, Rolling Prairie, Redland, Deep Upland, Shaly Hills, Tightland, and Bottomland. The climax vegetation of little bluestem, big bluestem, Indiangrass, switchgrass, tall dropseed, and sideoats grama once covered the entire watershed except on the deep deposits of Nimrod fine sand, where scrub post oak was the dominant vegetation. The West Cross Timbers and North Central Prairie had scattered post oak and blackjack oak, and live oak clumps dotted the Grand Prairie. Hackberry, elm, oak, and pecan grew along the streams.

At present, short grasses such as buffalograss and grama grasses and woody vegetation such as mesquite, oaks, juniper, elms, and sumac have replaced climax vegetation which was destroyed by overuse of grassland. The hydrologic cover condition on rangeland is mostly poor to fair.

Many acres of the cropland in the West Cross Timbers Land Resource Area are used for the production of peanuts. The coarser, deeper surfaced soils are highly susceptible to wind erosion when cultivated. The shallow surfaced soils also are easily eroded by both wind and water. These soils are generally of low fertility. Nearly 15,000 acres of this type of land are expected

to be converted to pasture and rangeland during the next five years.

The climate is warm and sub-humid. Mean monthly temperatures range from 46 degrees Fahrenheit in January to 82 degrees in July. The normal growing season, extending from March 22 through November 15, is 238 days. The average annual rainfall is 28.45 inches. Precipitation is fairly well distributed throughout the year, but is heaviest during April, May, June, September, and October.

Watershed streams are intermittent, and fishing is of little consequence. Wildlife species present include white-tailed deer, fox squirrel, turkey, bobwhite, and waterfowl. Hunting is of little significance under present land use. Several species of ducks migrate through the watershed, but there is little duck hunting at the present time.

Water for livestock and rural domestic use is obtained from wells and surface ponds. Wells are the source of municipal water for Rising Star. The most important aquifer is the Travis Peak formation (basal Trinity). The depth to the water table is 80 to 150 feet. Since the water bearing sand is fine grained, the ground water flow is very slow. The average production is 60 gallons per minute.

Proctor Reservoir will be the source of municipal water for some of the towns in the surrounding area.

Economic Data

The watershed economy depends to a large extent on agriculture. Most of the agricultural activities are associated with diversified livestock operations and with peanut production. Approximately two-thirds of the farm income is derived from livestock and the remaining one-third is derived mostly from peanuts, pecans, fruit crops, and grain sorghums. Farming operations are primarily connected with production of these crops along with forage crops for livestock feed and grazing.

This type of farming is expected to continue. The only significant changes expected are adjustments in acreages of feed and grazing crops to give greater efficiency in livestock operations. The principal types of livestock in the watershed are beef and dairy cattle. The beef cattle enterprise is primarily a cow-calf operation with the calves being sold as feeders. Some goats are used for brush control and mohair production.

The watershed formerly included smaller farms on which cash crops of cotton, wheat and peanuts were produced. The acreage devoted to these crops, except for peanuts, has declined as the operating units became larger and more land was planted to feed crops and pasture. Deterioration of some of the upland soils has brought about a need to convert the use of more land to permanent grass. The acreage now devoted to peanut production is significant to the watershed economy and to the producers who depend on this crop for a sizeable portion of the family income.

There are approximately 700 farms and ranches in the watershed. The average size operating unit is about 230 acres. Even though farm sizes are increasing, many of the smaller farmers will continue to have difficulty in providing a reasonable standard of living for their families without further expansion of off-farm employment. About 33 percent of ths farms are smaller than 140 acres. About 36 percent of the Comanche County farms, and an estimated 219 farm operators in the watershed, rsport less than $2,500 gross sales annually. There is a need for additional employment opportunities for many of these farmers and other workers to hold them in the area. Rural farm population has decreased from about 64 percent of the total population in 1940 to 39 percent at the present time. The small increase in urban population is expected to continue.

The average value of land and buildings is $25,881 per farm according to the 1959 United States Census of Agriculture. This amount is 26 percent higher than in 1954. Most of the land is valued at about $100 per acre. About 50 percent of the farms are owner-operated and a majority of the remaining farms are operated by neighboring landowners.

The cities of Comanche, DeLeon, and Rising Star are the principal market centers serving the watershed. Modern up-to-date transportation facilities consisting of bus, motor freight, and the Gulf, Colorado and Santa Fe Railroad provide service to the area. U. S. Highways 67, 183, and 377 and State Highways 16 and 36 enter the watershed. About 70 miles of farm-to-market roads provide good travel routes within the watershed. There is a total of about 97 miles of hard surface roads and about 262 miles of other county roads.

There are very few outdoor water-based recreation facilities available in the watershed other than at Proctor Reservoir which is located at the lower end.

Good opportunities will exist for development of better habitats for mourning dove, bobwhite, deer, and wild turkey in addition to improved fishing areas.

Land Treatment Data

The Upper Leon and Brown-Mills Soil Conservation Districts are assisting farmers and ranchers of the watershed in the preparation and application of basic soil and water conservation plans on their land.

The Soil Conservation Service work units at Comanche, Rising Star, and DeLeon are assisting these two soil conservation districts. There are 464 farms and ranches with a total of 113,522 acres under district agreement.

The work units have assisted Soil Conservation District cooperators in preparing 454 basic soil and water conservation plans, covering 112,705 acres, and have given technical assistance in establishing and maintaining planned measures. There are 399 active cooperators controlling 105,783 acres. Current revision is needed on 283 conservation plans.

Complete treatment has been accomplished on about 40 percent of the agricultural land. Approximately 70 percent of the needed land treatment practices on cropland and 35 percent on pasture and rangeland have been applied. Soil surveys have been completed on 81,054 acres, leaving 95,712 acres of agricultural land needing soil surveys.

It is estimated that the level of land treatment will reach at least 80 percent in five years as a result of the planned accelerated land treatment program.

Land treatment practices presently applied have been effective in reducing total erosion by an estimated 15 to 20 percent. Additional application of land treatment to take place during the five-year installation period is expected to reduce erosion another 10 percent.

WATERSHED PROBLEMS

Floodwater Damage

There are approximately 9,000 acres of flood plain land in the watershed. This is the estimated acres inundated by a 100-year frequency flood. The 8,131 acres inundated by runoff from the largest storm considered in the 25-year evaluation period is defined as the flood plain which is used in the economic evaluations. Included in this area are 1,141 acres of land along Rush Creek (reach 1); 2,148 acres along Copperas Creek (reach 2); 1,109 acres along North Copperas Creek (reach 3); 1,281 acres along South Copperas Creek (reach 4); 1,751 acres along Sweetwater Creek (reach 5); 124 acres along Little Sweetwater Creek (reach 5A); and 577 acres along Duncan Creek (reach 6). When recurrent flooding is considered, the cumulative area flooded during an average year is 7,878 acres. The value of the flood plain land is estimated to be $100 to $300 per acre.

Floods cause severe damage to crops, pastures, and other agricultural properties. Severe damage also is inflicted on roads and bridges in the flood plain. Erosion and sediment deposits have caused substantial acreage of cropland to be returned to grassland. Flooding has limited the use of the fertile bottomland soils so that much of its potential cannot be utilized for production of feed and hay crops which are necessary for efficient livestock operations. More efficient use of the flood plain will lessen the need for keeping marginal upland in cultivation.

During the 25-year period (1936 to 1960), there were 19 major floods, each inundating more than half the flood plain. In addition there were 46 minor floods covering less than half the flood plain. Floods often develop quickly because of the steep slopes on much of the drainage area in the upstream parts of the watershed. The rapid runoff from these areas cause peaks and high velocity of floodwater that is very destructive to crops, pastures, fences, and other agricultural properties. Some livestock, especially goats, are lost frequently. More than 100 head of goats were lost in the September 1964 flood. Floods occur most often during the months of April, May and June. This three-month period is the season when crops and pastures are at a critical stage in growth and very susceptible to damage

from floodwater. Fences are difficult to maintain, restricting diversified farming practices, especially in livestock farming. This results in inefficient use of time and resources of the farm operators. Noxious weeds scattered by floodwater add to the cost of crop production and pasture maintenance.

Recent major floods occurred in October 1959, April 1957, and May 1952, inundating most of the flood plain. In September 1964, a flood inundated most of the flood plain of Copperas and Rush Creeks. A recurrence of the 1957 storm which is considered about equal to a six-year frequency event for the entire watershed, would cause an estimated $119,298 in direct floodwater damages. Damage to crops and pastures with an average damageable value of $24.53 would amount to about $7.88 per acre on 7,428 acres.

Based on the floods that were considered in the 25-year historical series, average annual direct floodwater damages, without land treatment and structural measures applied, will total an estimated $89,227 (table 5). These damages, by individual evaluation reaches, are shown in the following tabulations:

Average Annual Direct Floodwater Damages without Project

Evaluation Reach (Figure 1)		Damage in Dollars (Based on Long-Term Prices)			
Number	Name	Crop and Pasture	Other Agricultural	Road and Bridge	Total
1	Rush Creek	12,488	6,555	-	19,043
2	Copperas Creek	12,961	7,803	2,430	23,194
3	North Copperas Creek	10,354	4,157	1,629	16,140
4	South Copperas Creek	5,286	4,728	1,507	11,521
5	Sweetwater Creek	7,634	4,038	3,651	15,323
5A	Little Sweetwater Creek	632	-	246	878
6	Duncan Creek	921	1,456	751	3,128
Total Watershed		50,276	28,737	10,214	89,227

County road bridge on Sweetwater Creek, a major tributary washed out during flood of April 26, 1957.

Flood plain scour along Sweetwater Creek caused by flood of April 26, 1957.

The indirect damages resulting from flooding are considered to involve such items as restriction in travel, delays and re-routing of school buses and mail deliveries, losses in business by business establishments, and inconvenience and delays in tending livestock. Indirect damages are estimated to average $9,957 annually.

Floodwater damage to the habitat of some species of wildlife, especially the nesting areas of mourning dove, bobwhite and turkey, has not been evaluated in monetary terms.

Erosion Damages

The estimated average annual rate of gross erosion is 2.55 acre-feet per square mile. Of this, sheet erosion accounts for 77 percent, gully erosion 4 percent, streambank erosion 4 percent, flood plain scour 13 percent, and streambed erosion 2 percent.

Sheet erosion and wind erosion are severe on the sandier cultivated fields which do not have adequate conservation treatment. Much of this type of land is to be converted to pasture and rangeland.

Gully erosion has been widespread in the past in the West Cross Timbers and North Central Prairie land resource areas. Proper land use and management has been highly effective in reducing gully erosion. At present, active gullies occur in small isolated areas and show evidence of healing.

There is an area in the lower reaches of Sweetwater Creek, where critical gullying has been stopped temporarily by a small dam installed by the landowner concerned. This dam, however, is cracking and is in danger of failing. Treatment will be needed in the near future to prevent rejuvenation of headward gully erosion and resultant sediment damages downstream.

A considerable volume of stream bedload moves downstream annually. However, the channels remain mostly in a stable condition since additional bedload is moved in to replace that which has been removed. There is a segment of stream channel, 1.5 miles long, in the upper reaches of South Copperas Creek which has lost nearly all of its capacity due to channel filling. This stream segment is very sinuous, and the aggradation was evidently started as logs and other debris clogged the channel.

Streambanks are relatively stable. Land loss from this type of erosion is very minor.

Although streambank and gully erosion account for a small percent of total erosion, they are important sources of damaging sediment deposited on flood plain lands.

Flood plain erosion is moderate to high. Most of the damaged areas range from broad sheet scour depressions to channels one to five feet deep and 50 to 200 feet wide. However, in a few isolated areas, scour channels are as deep as 10 feet and as narrow as 20 feet. This type of erosion is damaging because it reduces the productive capacity of flood plain soils

and makes farming operations difficult or impractical. It is estimated that flood plain scour causes some loss in productive capacity on about 1700 acres which is distributed as follows: 1537 acres, 10 percent; 147 acres, 20 percent; 15 acres, 30 percent; and 1 acre, 50 percent. The average annual monetary value of this damage is estimated to be $4,766 at long-term price levels (table 5).

Sediment Damages

Sediment damage is severe in the watershed. The most damaging sediment consists of fine to medium grained sand which originates primarily as sheet erosion of unprotected fields and rangeland of the Cross Timbers and North Central Prairie land resource areas. Movement and deposition of this sediment is evident as colluvium adjacent to and on the flood plain, as bedload in stream channels, and as overbank deposits on the flood plain.

A segment of the lower portion of the Sweetwater Creek flood plain is covered by one of the larger alluvial fans. A small, severely gullied area, adjacent to the flood plain, is the source of this sediment.

The meandering channel of South Copperas Creek has been almost completely filled with fine sand and silty sand for a length of 1.5 miles in its upper reaches. This has greatly increased flooding and created some swamping in this segment.

Overbank deposition of sediment occurs as deposits ranging in texture from medium grained sand to sandy clay and in depth from 0.5 to 7.0 feet. These deposits are generally very low in fertility and moisture holding capacity, causing some land to be converted from cropland to pasture. It is estimated that overbank deposition causes some loss in productive capacity on 1,690 acres of flood plain land which is distributed as follows: 513 acres, 10 percent; 162 acres, 20 percent; 543 acres, 30 percent; 225 acres, 40 percent; 147 acres, 50 percent; 15 acres, 60 percent; and 85 acres, 70 percent. The average annual monetary value of this damage is estimated to be $5,566 at long-term price levels (table 5).

It is estimated that Rush Creek watershed contributes an average of 154 acre-feet of sediment annually to Proctor Reservoir. This is the equivalent of an average annual sediment production rate of 0.53 acre-foot per square mile. The estimated average annual monetary value of the damage caused by loss of storage capacity is $5,968 at long-term price levels.

Flood plain damage from overbank deposition and scour is estimated to be in equilibrium in that additional acres damaged each year are about equal to the area which recovers from such damage annually.

Problems Relating to Water Management

Irrigation activity is of minor importance in the watershed because of the distance from larger streams and the low production of wells. Additional water is desired for irrigation in the area of some floodwater retarding

structures.

Drainage of agricultural land is not a problem in this watershed.

Proctor Reservoir, located at the eastern end of the watershed, provides waterbased recreation facilities for residents of thia watershed and the surrounding area. Local sponsors state there is no desire to incorporate storage capacity for municipal or industrial water supply.

PROJECTS OF OTHER AGENCIES

Proctor Dam, located on the Leon River immediately downstream from the Rush Creek-Leon River confluence, was constructed by the Corps of Engineers, U. S. Army, and was completed in 1963. It is designed to provide flood protection to the flood plain of the Leon River and to provide municipal water supply for towns in the surrounding area.

The works of improvement included in this plan will have no known detrimental effects on any existing or proposed downstream works of improvement. Conversely, the project will compliment Proctor Reservoir by decreasing sediment yield from Rush Creek watershed.

BASIS FOR PROJECT FORMULATION

An initial study was made by representatives of the Soil Conservation Service and sponsoring local organizations to determine wstershed problems and possible aolutions.

Meetings were held with the sponsoring local organizations to diacuss existing flood problems and water and related land resource development needs and to formulate project objectives. Watershed protection, flood prevention, and storage of water for irrigation were the primary objectives desired by the sponsors.

The following specific objectives were agreed to:

1. Establish land treatment measures which contribute directly to watershed protection and flood prevention and would make the watershed an outstanding example of soil and water conservation.

2. Attain a reduction of 70 to 75 percent in average annual flood damages through installation of atructural works of improvement to supplement land treatment on the watershed. Approximately 26 potential structure sites will be investigated in determining the most feasible system of measures.

3. Investigate feasiblity of including storage of water for municipal use for Rising Star. After estimated costs were available, city officials decided against addition of this storage.

4. Include storage of water for irrigation in a multiple-purpose structure with a 90 percent chance of meeting irrigation needs. This development would serve land already in agricultural production.

The land treatment program will include conversion of cropland to pasture and rangeland, resulting in a reduction in alloted crop production.

In selecting sites for floodwater retarding structures, consideration will be given to locations which would provide the agreed upon level of protection to areas subject to damage. The size, number, design, and cost of structures are influenced by physical, topographic, and geologic conditions.

The recommended works of improvement, including both land treatment and structural measures, meet the project objectives at least cost in providing the desired level of protection to agricultural flood plain lands. Storage of water for irrigation will be included in one of the floodwater retarding structures.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The Upper Leon and Brown-Mills Soil Conservation Districts are assisting farmers and ranchers of the watershed in the preparation and application of basic soil and water conservation plans on their land. The application of measures in these plans, based on the use of each acre within its capabilities and treatment in accordance with its needs, is an essential part of a sound program for watershed protection and flood prevention. The extent of needed land treatment measures which have been applied to date within the watershed represents an estimated expenditure by landowners and operators of $1,265,999, including reimbursements from ACPS (table 1A).

The accelerated application and continued maintenance of land treatment measures is particularly important for protection of the 83,475 acres which comprise the drainage areas above planned floodwater retarding structures.

The application and maintenance of land treatment measures will reduce the capacity required for sediment accumulation in planned structural measures. They also will reduce the rate of runoff into floodwater retarding structures. About 96,554 acres of upland below planned floodwater retarding structures contribute sediment and runoff to the flood plain areas. Land treatment measures on these lands will further reduce floodwater and sediment damages on 8,131 acres of flood plain.

Table 1 includes estimates of the acreage in each major land use on which land treatment measures will be established during the five-year project installation period. These messures will be established and maintained by landowners and operators in cooperation with the Upper Leon and Brown-Mills Soil Conservation Districts.

In addition to the technical assistance presently available, $47,095 will be made available from P. L. 566 funds to accelerate the establishment of these practices and measures. This amount includes $6,890 to complete standard soil surveys at an early date.

The local people under their going program will continue to install and maintain land treatment measures needed in the watershed after the five-year installation period.

About 14,000 acres of cultivated land will be treated with a combination of measures in keeping with a conservation cropping system for soil conditioning and protection from sheet erosion in the upland and scour in the flood plain. The conservation cropping systems in this watershed include cover and green manure crops, fertilizing, and crop residue use. About 323 miles of terraces provided with grassed waterways or outlets will be installed to control erosion and retard runoff from the more rolling areas.

There will be approximately six miles of diversions constructed to protect cropland, pasture, and rangeland from rapid runoff from steeper areas.

There is a trend toward conversion of deep, low fertility, sandy soils and rolling, eroded soils from cropland to pasture and rangeland. It is expected that this conversion will take place on nearly 15,000 acres during the five-year project installation period.

Pasture and hayland management will be practiced on about 18,000 acres, and about 9,500 acres of pasture and hayland will receive plantings of desirable forage plants to attain a good base cover.

Proper use will be practiced on about 33,000 acres of rangeland to maintain adequate cover for soil protection and improve quantity and quality of desirable vegetation. About 32,000 acres will be either bulldozed, chained, root plowed, or treated by aerial spray to control brush; and about 5,500 acres will be seeded with range grasses. Range rotation-deferred grazing will be practiced on about 8,500 acres to allow sufficient growth periods for range grasses.

The destruction of cover caused by overuse around present watering places will be reduced by establishing 263 farm ponds on pasture and rangeland.

The installation of land treatment measures will reduce average annual erosion and increase infiltration of rainfall as a result of improved ground cover in cultivated areas and increased grass density and vigor in pastured areas. Terraces, diversions, and waterways will have a measurable effect in slowing the runoff from cultivated fields and in reducing erosion damage and sediment production. Average annusl erosion will be reduced by about 10 percent as a result of the installation and maintenance of land treatment measures expected to take place during the five-year installation period. Also, the conversion of cropland to pasture and rangeland will result in a reduction of allotted crop production.

Strip Cropping - Peanut land stripped with Sudangrass and drilled to rye grass for winter cover crop.

Range Seeding - Native grass seeding of sideoats grama, Indiangrass, and switchgrass.

Good grass cover following brush and weed control and deferred grazing.

Structural Measures

A system of 13 floodwater retarding structures and 1 multiple-purpose structure will be installed and 3,570 feet of channel will be enlarged to provide the needed protection to flood plain lands that cannot be attained by land treatment measures alone. The multiple-purpose structure will include 453 acre-feet of storage for irrigation water. A section of the present stream channel, downstream from floodwater retarding structures Nos. 6 and 7, will be enlarged to insure sufficient capacity for the release flow of these two structures. The location of structural measures is shown on the project map (figure 5) and figure 2 shows a section of a typical floodwater retarding structure. Tables 1, 2, 3, and 3A show the details on quantities, costs and design of the structural measures.

The total storage capacity of the 13 floodwater retarding structures and the multiple-purpose structure will be 37,304 acre-feet. There will be 8,718 acre-feet for sediment accumulation during a 100-year period, 28,133 acre-feet for floodwater detention, and 453 acre-feet for irrigation water. Detention storage capacity will be sufficient to detain an average of 4.04 inches of runoff from 50.4 percent of the watershed upstream from valley section R-22 (figure 1). The capacity equivalents are shown for each structure in table 3.

The irrigation water supply in multiple-purpose structure No. 9 will be used by a group of landowners and operators who plan to irrigate forage crops with sprinkler type irrigation equipment.

The installation cost of the structural measures is estimated to be $2,101,511, including $1,953,310 for 13 floodwater retarding structures, $135,743 for the multiple-purpose structure, and $12,458 for stream channel improvement.

The detention storage of the floodwater retarding structures and the multiple-purpose structure will be sufficient to permit the use of vegetation for emergency spillway protection.

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

There will be a total of 422 surface acres and 2,289 acre-feet of initial storage capacity in the sediment pools for water that will be available for incidental uses such as recreation and supplemental irrigation. The quality of the water is considered to be good and will not restrict the use in any way except in floodwater retarding structure No. 1 where some sewage effluent may possibly make the pool undesirable for swimming.

EXPLANATION OF INSTALLATION COST

Public Law 566 funds, in the amount of $47,095 for technical assistance during the five-year installation period, will be provided to accelerate the application of planned land treatment for watershed protection. This amount includes $6,890 for completion of standard soil surveys. These

Public Lsw 566 funds will be in addition to $74,850 of Public Law 46 funds provided under the going program. Local interests will apply planned land treatment, including recurring practices, at an estimated cost of $1,505,959, which includes reimbursements from the Agricultural Conservation Program Service funds based on present program criteria (table 1). The costs are based on present prices being paid by landowners or operators to establish the individual measures in the area. The land treatment necessary to reach treatment goals and the unit cost of each measure were estimated by the Upper Leon and the Brown-Mills Soil Conservation Districts.

The total installation cost of the structural measures is estimated to be $2,101,511. Public Law 566 cost share is $1,914,058 which includes $1,574,654 for construction and $339,404 for installation services. Local cost share is $187,453 which includes $6,198 for construction, $171,130 for land, easements, and rights-of-way, and $10,125 for contract administration and legal fees, including costs for water rights. The cost of land, easements, and rights-of-way ($171,130) includes $161,530 land value and $9,600 relocation of improvements.

Construction costs include the engineer's estimates and contingencies. The engineer's estimates were based on the unit costs of floodwater retarding structures in similar areas modified by special conditions inherent to each individual site location. They include such items as permeable foundation conditions, rock excavation, wasting unsuitable material, and site preparation. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs.

Installation services include engineer and administrative costs. These estimates were based on analysis of previous work in similar sreas.

The costs of land, easements and rights-of-way, contract administration, and legal fees were determined by appraisal in cooperation with representatives of the sponsoring local organizations. Rights-of-way costs will include costs for relocating improvements and removing obstacles. The following will be involved: Telephone lines at sites Nos. 1, 6 and 12; county road at site No. 6; pipelines at sites Nos. 1 and 10; power lines at sites Nos. 1, 5, 6, 9, 10 and 12; and an abandoned oil well at site No. 9.

The installation cost of multiple-purpose structure No. 9 is estimated to be $135,743. Of this amount, $116,700 is allocated to flood prevention and $19,043 is allocated to agricultursl water management. Joint construction and installation services costs are allocated in accordance with the "Use of Facilities" Method as follows:

Purpose	Acre-Feet	Percent
Flood Prevention	2,996 1/	86.87
Agricultural Water Management	453	13.13
Total	3,449	100.00

1/ Includes 596 scre-feet of storage for sediment accumulation.

Cost for water rights is allocated to agricultural water management as a specific cost. Other joint installation costs of multiple-purpose structure No. 9 are allocated as follows:

Purpose	Surface Acres	Percent
Flood Prevention	250 1/	83.06
Agricultural Water Management	51	16.94
Total	301	100.00

1/ Includes 18 acres in dam and spillway.

Construction and installation services costs allocated to agricultural water management are $15,342. The local share is $6,198 which is 50 percent of the construction cost allocated to agricultural water management. Other local installation costs, allocated to agricultural water management, are $3,701 which includes $2,880 for value of land and easements, $600 for water rights, $68 for relocating improvements, $17 for clearing obstacles, and $136 for contract administration and legal fees.

A summary of cost allocation and cost sharing by project purpose is shown in table 2A.

In summary, Public Law 566 will bear the project construction costs for flood prevention, all installation services costs, 50 percent of the construction costs allocated to agricultural water management, and all cost for acceleration of technical assistance for land treatment. Other funds will bear all the remaining project installation costs.

The estimated schedule of obligations for the five-year installation period is as follows:

Schedule of Obligations

Fiscal Year	Measures	Public Law 566 Funds	Other Funds	Total
		(dollars)	(dollars)	(dollars)
First	Land Treatment	10,625	363,586	374,211
	Floodwater Retarding Structures Nos. 1 and 8 and Multiple-Purpose Structure No. 9	502,904	58,762	561,666
Second	Land Treatment	10,625	363,586	374,211
	Floodwater Retarding Structures Nos. 10, 11 and 13	413,231	39,226	452,457
Third	Land Treatment	8,615	284,546	293,161
	Floodwater Retarding Structures Nos. 2 and 3	353,617	25,675	379,292

Schedule of Obligations - Continued

Fiscal Year	Measures	Public Law 566 Funds	Other Funds	Total
		(dollars)	(dollars)	(dollars)
Fourth	Land Treatment	8,615	284,546	293,161
	Floodwater Retarding Structures Nos. 5, 12 and 14	273,733	29,889	303,622
Fifth	Land Treatment	8,615	284,545	293,160
	Floodwater Retarding Structures Nos. 4, 6, 7, and Stream Channel Improvement	370,573	33,901	404,474
	Total	1,961,153	1,768,262	3,729,415

This schedule may be adjusted from year to year to conform with appropriations, actual accomplishments and any significant mutually desirable changes.

EFFECTS OF WORKS OF IMPROVEMENT

The owners and operators of approximately 165 farm and ranch units and 8,717 acres of agricultural land will benefit directly from the installation of the structural measures.

The combined program of land treatment and structural measures will reduce the total average annual acres inundated by 56 percent. Flooding of areas more than three feet deep will be reduced by 75 percent. Cumulative totals of average annual recurrent flooding will be prevented on 4,406 acres, a reduction from 7,878 to 3,472 acres.

Reductions in flooding varies with respect to location within the watershed. The locations and reductions in flooding are shown in the following tabulations:

Evaluation Reach (Figure 1)		Average Annual Area Inundated		
Number	Name	Without Project (Acres)	With Project (Acres)	Reduction (Percent)
1	Rush Creek	1,700	1,015	40
2	Copperas Creek	2,067	900	56
3	North Copperas Creek	1,522	331	78
4	South Copperas Creek	1,452	731	50
5	Sweetwater Creek	737	196	73
5A	Little Sweetwater Creek	101	27	73
6	Duncan Creek 1/	299	272	9
	Total Watershed	7,878	3,472	56

1/ No structural control is planned on Duncan Creek.

The following tabulations show the effects the project will have on flood damages by evaluation reaches. All figures indicate average annual percent reductions.

Evaluation Reach (Figure 1)		Damage Reduction in Percent					
No.	Name	Crop and Pasture	Other Agricultural	Non-agricultural	Overbank Deposition	Flood Plain Scour	Total
1	Rush Creek	47	50	-	73	53	49
2	Copperas Creek	68	73	88	84	74	72
3	North Copperas Creek	86	91	92	97	91	88
4	South Copperas Creek	56	71	63	84	80	65
5	Sweetwater Creek	88	89	88	89	90	89
5A	Little Sweetwster Creek	70	-	99	88	99	81
6	Duncan Creek 1/	9	9	8	16	8	9
	Total Watershed	67	69	77	83	75	70

1/ No structural control planned on Duncan Creek.

With the installation and operation of the project, 10 of the 19 major floods that occurred during the 25-year evaluation period (1936-1960) would have been reduced to minor floods. In addition, flooding would have been completely eliminated during 21 of the 46 minor storms that occurred during the same period.

The largest storm in the evaluation series will produce 4.36 inches of runoff from the wstershed without the project. Such a storm occurred in September 1936. The volume of runoff, under without project conditions, would produce a peak discharge of 51,400 cubic feet per second at the reference valley section No. R-23 and would inundate 8,131 acres of flood plain land. The planned land treatment program will reduce the surface runoff from this storm to 4.25 inches (50,000 c.f.s.) and the area inundated to 8,086 acres. The installation of the floodwater retarding structures will further reduce the peak discharge to 24,400 c.f.s., and the area inundated to 5,817 acres.

Direct floodwater damages caused by a storm similar to the one that occurred in April 1957 will be reduced by an estimated 58 percent with the planned program of land treatment and structural measures in place.

The most severe damage to roads, bridges, other agricultural property like fences and farm roads, and from debris accumulation is caused by floods that cover 75 percent or more of the flood plain. With the project in place, the number of floods during the 25-year evaluation period that would inundate 75 percent or more of the flood plain would be reduced from 10 to 0.

Reduced flooding will make it possible for farmers to organize cropping systems and to operate more efficiently in the flood plain. The use of more fertile bottomland soils for the production of feed and hay crops will reduce the need for cultivating marginal upland. Considerable reduction in cropland is expected in the upland areas of the watershed during land treatment installation period. About 1,172 acres of pasture will be planted or renovated in the flood plain and about 15,000 acres of additional grassland is to be established in the remaining areas of the watershed. No significant change in acreage of grain sorghum and peanuts is expected but a continued decline in cotton and wheat acreage is anticipated.

The application of the planned land treatment program is expected to reduce the annual gross erosion from 743 acre-feet to 664 acre-feet, a reduction of 11 percent. The annual flood plain scour damage on 1,700 acres is expected to be reduced about 65 percent. Six percent will be attributable to land treatment measures and 59 percent to structural measures.

After the complete project is installed, a 60 percent reduction in overbank deposition on 1,690 acres will be effected, with 10 percent resulting from land treatment measures and the remaining 50 percent from structural measures.

It is estimated that 154 acre-feet of sediment from this watershed is deposited annually in Proctor Reservoir under present conditions. This deposition will be reduced to 89 acre-feet annually with the project installed.

The channel improvement downstream from floodwater retarding structures Nos. 6 and 7 will prevent prolonged flooding by the release flow from these structures in one area of the flood plain.

Some loss of wildlife habitat will result from the clearing of sediment pool areas, but the sediment pools of all structures will offer opportunities for fish production. Wildlife habitat on the flood plain areas will be improved by reduction of frequency, depth, and duration of flooding. Good opportunities for the development of on-farm income-producting recreation activities will become available at and in the vicinity of sediment pools.

Multiple-purpose structure No. 9 will include 453 acre-feet of storage for irrigation water that will be used to irrigate about 160 acres of forage crops.

The sediment pools of the floodwater retarding structures open to the general public will increase the opportunity for water based recreation activites, such as fishing, swimming, picnicking and camping, for many of the local inhabitants and for tourists who are visiting in the area. These activities will be enjoyed by an estimated 2,190 people, resulting in about 10,950 visitor-days use annually. The most intensive use will be during the period of June through August. Average use on peak days for the weekends is expected to be about 125 persons. The water in the sediment pools will be available also for domestic use and for supplemental irrigation when water permits are obtained. Water yield studies indicate an adequate water supply will be available for the planned uses. It is expected that about 260 acres of forage crops will receive supplemental irrigation water from the sediment pools of structures.

Secondary benefits steming from, and induced by, the project will accrue in the local area. The increased net income of farm families resulting from reduced flood damages and increased efficiency in farm operations will stimulate economic activities. As the farm family standard of living improves, sales of consumer goods can be expected to increase. Sales and services in connection with recreational activities will be increased. The operation and maintenance of the project measures will provide some employment opportunities for local residents. 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.

PROJECT BENEFITS

Total average annual project benefits are estimated to be $99,264 distributed as follows:

Benefits	Dollars
Damage Reduction	76,498
More Intensive Use of Flood Plain Land	5,118
Agricultural Water Management	2,221
Incidental	5,082
Proctor Reservoir	2,519
Secondary	7,826

Agricultural (crop, pasture, other, sediment, erosion) and non-agricultural (road and bridge) damages in the watershed, including indirect damages, will be reduced from an estimated $109,516 to $33,018 annually (table 5). Approximately eight percent of the damage reduction benefits will result from land treatment measures, with the remainder accruing to floodwater retarding structures. Annual benefits from damage reduction is estimated to be $33,676 (crops and pasture), $19,819 (other agricultural property), $7,858 (roads and bridges), $4,627 (overbank deposition), $3,564 (flood plain scour), and $6,954 (indirect).

The following tabulations show the location of damage reduction benefits attributed to the combined program of land treatment and structural measures:

Average Annual Damages and Benefits (Dollars)

Evaluation Reach (Figure 1)		Damages		
Number	Name	Without Project	With Project	Benefits
1	Rush Creek	23,295	11,819	11,476
2	Copperas Creek	28,966	8,206	20,760
3	North Copperas Creek	19,445	2,266	17,179
4	South Copperas Creek	14,232	5,000	9,232
5	Sweetwater Creek	18,743	2,153	16,590
5A	Little Sweetwater Creek	1,150	215	935
6	Duncan Creek 1/	3,685	3,359	326
	Total	109,516	33,018	76,498

1/ No structural control is planned for Duncan Creek.

Annual net income of owners and operators will increase an estimated $5,118 from more intensive use of flood plain land. An estimated 1,172 acres will be renovated and established to improved pasture.

The agricultural water management benefits will result from increased net income to landowners and operators who plan to use water stored in multiple-purpose structure No. 9 for irrigation of forage crops. Approximately 160 acres will be irrigated from this site. Benefits will amount to $2,221 annually after discounting to allow for a five-year lag in accrual.

The annual monetary value of the incidental benefits from recreation ($2,234) and from irrigation ($2,848) will total an estimated $5,082. The recreation benefits, derived from activities such as fishing, picnicking, camping, swimming and hunting, are based on a value of 50 cents per visitor-day. Approximately 10,950 visitors are expected to utilize the sites annually for recreation during the years of useful life of the pools. Allowances were made for associated expenses and benefits were discounted to reflect full use for 40 years with a decline to zero by the 50th year. The pools are expected to be open for public use on a fee-charge basis or with the landowner's permission.

The incidental irrigation benefits will result from increased net income of owners and operators who plan to irrigate from the sediment poola. Benefits were based on supplemental irrigation of 260 acres of forage crops annually during project life, after allowances for associated costs, time lag in accrual, and declining sediment pool capacities.

Local secondary benefits amounting to $7,826 annually will accrue to workers, processors, handlers, and suppliers of additional goods and services that will be needed as a result of the project. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluations.

Other benefits, not evaluated in monetary terms, are increased sense of security of farmers and improved wildlife habitat.

Benefits to landowners and operators from the planned land treatment measures were not evaluated in monetary terms since experience has shown that conservation practices produce benefits in excess of their costs.

Comanche County has not been designated as an area eligible for assistance under the Redevelopment Act. Consequently, no redevelopment benefits were considered.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation cost, including operation and maintenance) is estimated to be $71,646. These measures are expected to produce average annual primary benefits of $84,643 or about $1.20 for each dollar of cost.

The total average annual benefits, including secondary benefits, that will result from the installation of structural measures is estimated to be $92,469, giving a benefit-cost ratio of 1.3 to 1 (table 6).

PROJECT INSTALLATION

Planned land treatment (table 1) will be established by farmers and ranchers during a five-year period in cooperation with the Upper Leon and Brown-Mills Soil Conservation Districts. Approximately 50 percent of needed land treatment has been applied. The goal is to treat adequately at least 80 percent of the land during the installation period. In reaching this goal, it is expected that accomplishments will progress as follows:

Land Use	Fiscal Year					Total
	1st	2nd	3rd	4th	5th	
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	3,299	3,299	2,583	2,582	2,582	14,345
Pasture	4,085	4,085	3,197	3,197	3,196	17,760
Rangeland	7,538	7,538	5,900	5,900	5,899	32,775
Total	14,922	14,922	11,680	11,679	11,677	64,880

Technical assistance in planning and application of land treatment is provided under the going programs of the districts. A standard soil survey is in progress and has been completed on 81,054 acres. The remaining soil survey of 95,712 acres is expected to be completed in five years.

The governing bodies of the Upper Leon and Brown-Mills Soil Conservation Districts will assume aggressive leadership in getting an accelerated land treatment program underway. 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 in accordance with existing agreements for equipment usage in the district. The Soil Conservation Service will provide additional technical assistance to the soil conservation districts in accelerating the planning and application of soil, plant, and water conservation measures. Additional technical assistance will be provided to accelerate completion of the standard soil survey.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings; operating radio, television, and press releases; and using other methods of getting information to landowners and operators in the watershed.

The Commissioners Court of Comanche County has the right of eminent domain by virtue of applicable State law and has the financial resources to fulfill its responsibilities.

The Commissioners Court of Comanche County will:

1. Obtain the necessary land, easements, rights-of-way, and permits for the structural measures to be dedicated to Comanche County and the Upper Leon Soil Conservation District;

2. Determine the legal adequacy of the easements and permits for construction of the structural measures;

3. Provide for the relocation or modification of utility lines and systems, roads, and privately owned improvements necessary for the installation of the structural messures and provide for the necessary improvement of low water crossings on public roads to make them passable during prolonged release flows from the structures or obtain permission to inundate such roads where equal alternate routes are designated for use during periods of inundation; and

4. Provide the necessary legal, administrative, and clerical personnel, facilities, supplies, and equipment to advertise, award, and administer contracts and be the contracting agency to let and service contracts for the structural measures.

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

The structural measures will be constructed during a five-year installation period in the general sequence as follows:

First Year - Floodwater Retarding Structures Nos. 1 and 8 and Multiple-Purpose Structure No. 9

Second Year - Floodwater Retarding Structures Nos. 10, 11 and 13

Third Year - Floodwater Retarding Structures Nos. 2 and 3

Fourth Year - Floodwater Retarding Structures Nos. 5, 12 and 14

Fifth Year - Floodwater Retarding Structures Nos. 4, 6, 7, and Stream Channel Improvement.

FINANCING PROJECT INSTALLATION

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

Funds for the local share of the cost of this project, including land, easements, rights-of-way, and administration of contracts, are available in the general fund of Comanche County and are supported by revenue from existing taxes.

The local share of construction cost of multiple-purpose structure No. 9 allocated to agricultural water management will be provided by the group of landowners and operators involved through the Commissioners Court of Comanche County.

It is anticipated that approximately 95 percent of the easements will be donated. The out-of-pocket cost of easements, local share of construction and installation services, relocation of utilities, roads and improvements, legal services, and administration of contracts is estimated to be $24,880.

The sponsoring local organizations do not plan to use the loan provisions of the Act.

The soil and water conservation loan program of the Farmers Home Administration is available to all eligible farmers in the area. Educational meetings will be held in cooperation with other agencies to outline the services available and eligibility requirements. Present FHA clients will be encouraged to cooperate in the program.

The County Agricultural Stabilization and Conservation committees will continue to provide financial assistance for selected conservation practices.

Structural measures will be constructed during a five-year installation period pursuant to the following conditions:

1. The requirements for land treatment in drainage areas above the floodwater retarding structures and the multiple-purpose structure have been satisfied.

2. All lands, easements, rights-of-way, and permits have been obtained for all structural measures or a written statement is furnished by the Commissioners Court of Comanche County that its right of eminent domain will be used, if needed, to secure any remaining land, easements, or rights-of-way within the project installation period and that sufficient funds are available for purchasing those easements and rights-of-way.

3. Water rights for storage of irrigation water have been obtained for the multiple-purpoae structure.

4. Court orders have been obtained from the Commissioners Court of Comanche County showing that:

   a. County roads affected by detention pools of floodwater retarding structures Nos. 5, 10 and 12 and multiple-purpose structure No. 9 will either be raised two feet above emergency spillway crest elevation at no expense to the Federal Government, closed, or permission granted to temporarily inundate the road provided alternate routes are available.

   b. The county road affected by the sediment and detention pools of floodwater retarding structure No. 6 will either be closed or relocated at no expense to the Federal Government.

5. Provisions have been made for improving low water crossings or bridges and/or culverts on public roads or court orders or necessary permits obtained granting permission to temporarily inundate the crossings, providing equal alternate routes are available for use by all people concerned, during periods when these crossings are impassable due to prolonged flow from the principal spillways of the floodwater retarding structures. If equal alternate routes are not available, provisions will be made at no cost to the Federal Government, to make the crossings passable during prolonged periods of release flows from the structure.

6. Utilities, such as power lines, telephone lines, and pipelines, have been relocated or permission has been obtained to inundate the properties involved.

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

8. The project agreements have been executed.

9. Operation and maintenance agreements have been executed.

10. Public Law 566 funds are available.

The various features of cooperation between the cooperating parties have been covered in appropriate memorandums of understanding and working agreements.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by landowners and operators of the farms and ranches on which the measures are applied under agreement with the Upper Leon and the Brown-Mills Soil Conservation Districts. Representatives of the soil conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform maintenance. They will make district-owned equipment available for this purpose in accordance with existing working agreements.

Structural Measures

The structural measures will be operated and maintained by the Upper Leon Soil Conservation District and the Commissioners Court of Comanche County. Specific operation and maintenance agreements will be executed prior to the issuance of invitation to bid on construction of any of the structural works of improvement included in the work plan.

The multiple-purpose reservoir (No. 9) will be operated in accordance with agreements between the Upper Leon Soil Conservation District, a project sponsor, and the landowners involved. Removal of irrigation water will be accomplished by each holder of State water rights permit according to provisions of his permit.

The estimated annual operation and maintenance cost is $2,800 for the structural measures.

Each year the Commissioners Court of Comanche County will budget sufficient funds for operation and maintenance of the structural works of improvement.

Maintenance will be accomplished through the use of contributed labor and equipment, by contract, by force account, or by a combination of these methods. Monies for maintenance will come from the General Fund of Comanche County. This fund is supported by tax revenue from existing county taxes.

The structural measures will be inspected jointly by representatives of the Upper Leon Soil Conservation District and Commissioners Court of Comanche County after each heavy streamflow. A Soil Conservation Service representative will participate in these inspections annually for a period of three years following construction. For the floodwater retarding structures and the multiple-purpose structure items of inspection will include, but will not be limited to, the condition of the principal spillway, the earth fill, the emergency spillway, the vegetative cover, and the fences and gates installed as a part of the structure. For the release flow channel, items of inspection will include, but will not be limited to, the degree of scour, sediment deposition, bank erosion, obstructions to flow caused by debris accumulation, and excessive brush and tree growth within the channel. The items of inspection listed are those most likely to require maintenance.

The Soil Conservation Service, through the Upper Leon Soil Conservation District and the Commissioners Court of Comanche County will participate in operation and maintenance only to the extent of furnishing technical assistance to aid in inspections and technical guidance necessary.

Provisions will be made for free access of representatives of sponsoring local organizations and Federal Government representatives to inspect and provide maintenance for all structural measures at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Rush Creek Watershed, Texas

Installation Cost Items	Unit	No. to be Applied Non-Federal Land 2/	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other Funds	Total
LAND TREATMENT					
Cropland	Acre	14,345	-	637,997	637,997
Pasture	Acre	17,760	-	250,622	250,622
Rangeland	Acre	32,775	-	617,340	617,340
Technical Assistance			47,095	74,850	121,945
TOTAL LAND TREATMENT			47,095	1,580,809	1,627,904
STRUCTURAL MEASURES					
Floodwater Retarding Structures	No.	13	1,477,023	-	1,477,023
Multiple-Purpose Structure	No.	1	88,210	6,198	94,408
Stream Channel Improvement	Feet	3,570	9,421	-	9,421
Subtotal - Construction			1,574,654	6,198	1,580,852
Installation Services					
Engineering Services			203,440	-	203,440
Other			135,964	-	135,964
Subtotal - Installation Services			339,404		339,404
Other Costs					
Land, Easements, and Rights-of-Way				173,655	173,655
Administration of Contracts				7,000	7,000
Water Rights				600	600
Subtotal - Other				181,255	181,255
TOTAL STRUCTURAL MEASURES			1,914,058	187,453	2,101,511
TOTAL PROJECT			1,961,153	1,768,262	3,729,415

1/ Price Base: 1965

2/ For Land Treatment: Acres to be treated during project installation period

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Rush Creek Watershed, Texas

Measures	Unit	Number Applied To Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Conservation Cropping System	Acre	33,017	0
Cover and Green Manure Crop	Acre	30,712	128,996
Crop Residue Use	Acre	44,286	124,000
Grassed Waterway or Outlet	Acre	214	12,840
Terrace	Feet	3,014,880	150,744
Diversion	Feet	185,998	18,600
Pasture Proper Use	Acre	8,368	0
Pasture and Hayland Planting	Acre	13,407	268,140
Range Proper Use	Acre	30,902	0
Range Rotation - Deferred Grazing	Acre	19,945	69,805
Range Seeding	Acre	3,551	49,714
Brush and Week Control	Acre	11,316	113,160
Farm Pond	No.	660	330,000
TOTAL			1,265,999

1/ Price Base: 1965

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TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Rush Creek Watershed, Texas

(Dollars) 1/

Structure Site Number or Name	Installation Cost-Public Law 566 Funds				Installation Cost - Other Funds					Total Installation Cost
		Installation Services		Total Public Law 566		Adm. of Contracts	Land, Easements, and R/W 2/	Water Rights	Total Other	
	Construction	Engineering	Other		Construction					
Floodwater Retarding Structures										
1	232,187	23,219	19,462	274,868	-	500	18,675	-	19,175	294,043
2	189,632	20,860	16,040	226,532	-	500	15,750	-	16,250	242,782
3	104,502	13,585	8,998	127,085	-	500	8,925	-	9,425	136,510
4	71,185	10,678	6,238	88,101	-	500	5,963	-	6,463	94,564
5	65,621	9,843	5,750	81,214	-	500	7,800	-	8,300	89,514
6	111,136	14,448	9,569	135,153	-	400	15,325	-	15,725	150,878
7	111,719	14,523	9,619	135,861	-	400	10,313	-	10,713	146,574
8	94,852	14,228	8,312	117,392	-	500	13,988	-	14,488	131,880
10	152,171	16,739	12,871	181,781	-	500	23,675	-	24,175	205,956
11	101,917	13,249	8,776	123,942	-	500	7,738	-	8,238	132,180
12	126,306	16,420	10,876	153,602	-	500	16,763	-	17,263	170,865
13	86,866	13,030	7,612	107,508	-	500	6,313	-	6,813	114,321
14	28,929	7,232	2,756	38,917	-	500	3,826	-	4,326	43,243
Subtotal	1,477,023	188,054	126,879	1,791,956	-	6,300	155,054	-	161,354	1,953,310
Multiple-Purpose Structure										
9 Stream Channel Improvement South Copperas Creek	88,210	14,161	8,273	110,644	6,198	500	17,801	600	25,099	135,743
	9,421	1,285	812	11,458	-	200	800	-	1,000	12,458
GRAND TOTAL	1,574,654	203,440	135,964	1,914,058	6,198	7,000	173,655	600	187,453	2,101,511

1/ Price Base: 1965

2/ Includes Legal Fees

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Rush Creek Watershed, Texas

(Dollars) 1/

Item	Purpose: Prevention	Purpose: Agricultural Water Management	Total
COST ALLOCATION			
Floodwater Retarding Structures	1,953,310	-	1,953,310
Multiple-Purpose Structure	116,700	19,043	135,743
Stream Channel Improvement	12,458	-	12,458
TOTAL	2,082,468	19,043	2,101,511
COST SHARING			
Public Law 566			
Construction	1,568,456	6,198	1,574,654
Installation Services	336,458	2,946	339,404
Total - Public Law 566	1,904,914	9,144	1,914,058
Other Funds			
Construction	-	6,198	6,198
Land, Easements, and Rights-of-Way	168,165	2,965	171,130
Administration of Contracts, Water Rights, and Legal Fees	9,389	736	10,125
Total - Other Funds	177,554	9,899	187,453
TOTAL	2,082,468	19,043	2,101,511

1/ Price Base: 1965

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Rush Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8
Drainage Area	Sq.Mi.	23.29	17.88 1/	12.56	5.74	5.63	6.67	4.67	5.73
Storage Capacity									
Sediment Pool (200 ac. ft. limit)	Ac.Ft.	199	200	-	-	-	-	-	-
Sediment Pool (50-yr. and Top of Riser)	Ac.Ft.	223	181	194	89	120	181	125	180
Sediment Reserve (100-yr.)	Ac.Ft.	559	506	255	116	159	221	155	242
Irrigation	Ac.Ft.	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	311	286	140	64	87	125	85	134
Floodwater Detention	Ac.Ft.	4,646	4,997	2,351	1,148	1,198	1,412	1,007	1,186
Total	Ac.Ft.	5,938	6,170	2,940	1,417	1,564	1,939	1,372	1,742
Surface Area									
Sediment Pool (200 ac. ft. limit)	Acre	30	35	-	-	-	-	-	-
Sediment Pool (50-yr. and Top of Riser)	Acre	52	45	29	15	30	26	28	39
Sediment Reserve (100-yr.)	Acre	90	97	46	24	44	55	49	76
Irrigation	Acre	-	-	-	-	-	-	-	-
Floodwater Detention Pool	Acre	310	337	180	120	126	184	129	198
Volume of Fill	Cu.Yd.	585,580	274,410	204,510	121,760	135,020	206,210	213,533	163,200
Elevation Top of Dam	Foot	1535.2	1465.2	1464.0	1373.9	1336.9	1558.6	1576.3	1449.9
Maximum Height of Dam	Foot 7/	68	67	64	50	42	44	43	35
Emergency Spillway									
Crest Elevation	Foot	1529.0	1457.7	1457.0	1369.2	1331.6	1554.7	1571.7	1495.7
Bottom Width	Foot	Natural	400	200	220	150	400	150	200
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		4.0	2.0	4.0	4.0	4.0	3.8	3.8	4.0
Average Curve No. - Condition II		81	80	79	79	82	81	81	81
Emergency Spillway Hydrograph									
Storm Rainfall (6-hour) 3/	Inch	6.16	5.74	6.54	6.60	6.60	6.60	6.60	6.60
Storm Runoff	Inch	4.02	3.56	4.17	4.22	4.54	4.43	4.43	4.43
Velocity of Flow (V_c) 5/	Ft./Sec.	0.9	0	4.5	5.0	3.6	2.6	0	2.9
Discharge Rate 5/	C.F.S.	300	0	554	863	214	233	0	150
Maximum Water Surface Elevation 5/	Foot	1530.1	-	1458.4	1370.9	1332.6	1555.3	-	1496.4
Freeboard Hydrograph									
Storm Rainfall (6-hour) 4/	Inch	12.52	11.66	13.28	13.40	13.40	13.40	13.40	13.40
Storm Runoff	Inch	10.07	9.12	10.55	10.67	11.08	10.93	10.93	10.93
Velocity of Flow (V_c) 5/	Ft./Sec.	7.6	12.4	11.7	9.2	9.8	8.2	9.1	8.6
Discharge Rate 5/	C.F.S.	20,700	23,588	10,020	5,463	4,654	7,183	3,553	4,190
Maximum Water Surface Elevation 5/	Foot	1535.2	1465.2	1464.0	1373.9	1336.9	1558.6	1576.3	1499.9
Principal Spillway									
Capacity - Low Stage	C.F.S.	233	412	126	57	56	67	47	57
Capacity Equivalents									
Sediment Volume	Inch	1.04	1.23	0.88	0.88	1.22	1.48	1.46	1.82
Irrigation	Inch	-	-	-	-	-	-	-	-
Detention Volume	Inch	3.74	5.24	3.51	3.75	3.99	3.97	4.04	3.88
Spillway Storage	Inch	1.85	3.13	2.11	1.98	2.61	2.16	2.76	3.20
Class of Structure		A	A	A	A	A	A	A	A

(Footnotes on last page of Table 3)

Item	Unit	STRUCTURE NUMBER 9	10	11	12	13	14	TOTAL
Drainage Area	Sq. Mi.	12.86	16.08	5.75	8.03	4.30	1.24	130.43
Storage Capacity								
Sediment Pool (200 ac. ft. limit)	Ac. Ft.	-	197	199	197	-	-	992
Sediment Pool (50-yr. and Top of Riser)	Ac. Ft.	185 6/	283	16	103	119	35	2,034
Sediment Reserve (100-yr.)	Ac. Ft.	254	549	248	291	135	45	3,735
Irrigation	Ac. Ft.	453	-	-	-	-	-	453
Sediment in Detention Pool	Ac. Ft.	157	300	58	107	78	25	1,957
Floodwater Detention	Ac. Ft.	2,400	3,456	1,193	2,050	837	252	28,133
Total	Ac. Ft.	3,449	4,785	1,714	2,748	1,169	357	37,304
Surface Area								
Sediment Pool (200 ac. ft. limit)	Acre	-	42	33	31	-	-	171
Sediment Pool (50-yr. and Top of Riser)	Acre	32 6/	72	35	41	20	12	476
Sediment Reserve (100-yr.)	Acre	52	112	55	68	38	21	827
Irrigation	Acre	97	-	-	-	-	-	97
Floodwater Detention Pool	Acre	280	342	132	252	115	58	2,763
Volume of Fill	Cu. Yd.	179,770	350,410	183,100	270,400	169,010	45,650	3,102,563
Elevation Top of Dam	Foot	1319.1	1515.1	1567.4	1473.1	1331.2	1349.2	
Maximum Height of Dam	Foot	54	60	52	50	47	18	
Emergency Spillway								
Crest Elevation	Foot	1313.7	1508.3	1562.1	1468.0	1326.9	1346.2	
Bottom Widch	Foot	300	200	200	200	200	80	
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	
Percent Chance of Use 2/		4.0	3.2	4.0	2.3	4.0	4.0	
Average Curve No. - Condition II		79	80	81	79	79	79	
Emergency Spillway Hydrograph								
Storm Rainfall (6-hour) 3/	Inch	6.49	6.39	6.60	6.60	6.60	6.60	
Storm Runoff	Inch	4.12	4.13	4.43	4.22	4.22	4.22	
Velocity of Flow (V_c) 5/	Ft./Sec.	3.0	0	3.3	0	2.2	2.4	
Discharge Rate 5/	C.F.S.	291	0	232	0	57	36	
Maximum Water Surface Elevation 5/	Foot	1314.6	-	1563.0	-	1327.5	1346.6	
Freeboard Hydrograph								
Storm Rainfall (6-hour) 4/	Inch	13.17	12.97	13.40	13.40	13.40	13.40	
Storm Runoff	Inch	10.40	10.40	I0.93	11.64	10.67	10.67	
Velocity of Flow (V_c) 5/	Ft./Sec.	9.9	11.2	9.8	9.7	8.9	7.3	
Discharge Rate 5/	C.F.S.	9,221	8,739	6,092	5,770	4,487	987	
Maximum Water Surface Elevation 5/	Foot	I319.I	1515.1	1567.4	1473.1	1331.2	1349.2	
Principal Spillway								
Capacity - Low Stage	C.F.S.	129	161	58	80	43	12	
Capacity Equivalents								
Sediment Volume	Inch	0.87	1.55	1.70	1.63	1.45	1.59	
Irrigation	Inch	0.66	-	-	-	-	-	
Detention Volume	Inch	3.50	4.03	3.89	4.79	3.65	3.81	
Spillwsy Storage	Inch	2.60	3.10	2.51	3.48	2.32	3.45	
Class of Structure		A	A	A	A	A	A	

1/ Exclusive of area controlled by other structures. The entire erea cnnsidered in the principal spillway design.
2/ Based on regional analysis of gaged runoff.
3/ Taken from Plate 2-a1, Spillway Design Storm-Class "A" Structures.
4/ Taken from Plate 2-a2, Freeboard Storm-Class "A" Structures.
5/ Maximum during passage of hydrograph.
6/ Top of riser is at top of irrigation pool.
7/ Measured from stream channel.

TABLE 3A - STRUCTURE DATA

STREAM CHANNEL IMPROVEMENT

Rush Creek Watershed, Texas

Channel Designation	Station Numbering for Reach: Station (100 ft.)	Station Numbering for Reach: Station (100 ft.)	Required Channel Capacity (c.f.s.)	Planned Channel Capacity (c.f.s.)	Average Bottom Width (ft.)	Average Side Slope	Average Depth (ft.)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1000 cu. yd.)
South Copperas Creek										
Channel Improvement	31+00	47+90	118	137	16	4:1	2.8	.34	1.8	11.17
	47+90	66+70	118	124	7	4:I	5.0	.05	0.92	11.37
									GRAND TOTAL	22.54

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TABLE 4 - ANNUAL COST

Rush Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures Nos. 1 through 8 and 10 through 14, Multiple-Purpose Structure No. 9, and 3,570 feet of Stream Channel Improvement	68,846	2,800	71,646
TOTAL	68,846	2,800	71,646

1/ Price Base: 1965 prices 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

Rush Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damages		Damage Reduction Benefits
	Without Project	With Project	
Floodwater			
Crop and Pasture	50,276	16,600	33,676
Other Agricultural	28,737	8,918	19,819
Nonagricultural (Road and Bridge)	10,214	2,356	7,858
Subtotal	89,227	27,874	61,353
Sediment			
Overbank Deposition	5,566	939	4,627
Erosion			
Flood Plain Scour	4,766	1,202	3,564
Indirect	9,957	3,003	6,954
TOTAL	109,516	33,018	76,498

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

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Rush Creek Watershed, Texas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/							Average Annual Cost 3/	Benefit Cost Ratio
	Flood Prevention				Agricultural Water Management (Irrigation)	Secondary	Total		
	Damage Reduction	More Intensive Land Use	Incidental 2/	Proctor Reservoir					
Floodwater Retarding Structures Nos. 1 through 8 and 10 through 14, Multiple-Purpose Structure No. 9, and 3,570 feet of Stream Channel Improvement	70,246	5,118	5,082	1,976	2,221	7,826	92,469	71,646	1.3:1
GRAND TOTAL 4/	70,246	5,118	5,082	1,976	2,221	7,826	92,469	71,646	1.3:1

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

2/ Includes 2,234 from recreation and 2,848 from irrigation

3/ From Table 4

4/ In addition, it is estimated that land treatment measures will provide 6,252 damage reduction benefits in the flood plain and 543 sediment damage reduction benefits to Proctor Reservoir

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INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by the Upper Leon and Brown-Mills Soil Conservation Districts assisted by personnel from the Soil Conservation Service at Comanche, Rising Star, and DeLeon. Conservation needs data were compiled from existing conservation plans within the watershed and expanded to represent the conservation needs of the entire watershed. The quantity of each land treatment practice, or combination of practices, necessary for essential conservation treatment was estimated for each land use by capability class. Acres, by land use, to be treated during the five-year installation period were estimated (table 1). The hydraulic, hydrologic, sedimentation, and economic investigationa provided data as to the effects of land treatment measures in terms of the reduction of flood damage. Although measurable benefits would result from application of the planned land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by the local people.

Present hydrologic cover conditions were determined by detailed mapping of selected sample areas representative of each of the three land resource areas. The sample areas amount to 15 percent of the watershed.

Present hydrologic cover conditions for pasture and rangeland were determined on the basis of vegetative ground cover. Present hydrologic cover conditions on cropland were determined after consultation with local Soil Conservation Service personnel concerning crops grown and rotations followed.

Future hydrologic cover conditions were estimated on the basis of the expected percentage of needed land treatment to be applied during the installation period and the probable effectiveness of this application.

Engineering Investigations

A study was made of the watershed to determine where structural measures could be used and, if by including them in the plan, the project objectives for flood prevention and water storage for irrigation could be attained. The procedure used in making that determination was as follows:

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

2. A study of aerial photographs supplemented by field examination indicated the limits of flood plain subject to flood damage. All probable sites for floodwater retarding structures were located on a map of the watershed. By making a stereoscopic study of aerial photographs, supplemented by field examination, it was possible to eliminate those sites which did not have sufficient available storage capacity.

3. The watershed map, showing all possible site locations which might be used to develop a system of structural measures that would meet project objectives, was submitted to the sponsoring local organizations. The sponsors provided data on ownership of land apparently involved in each site and cost estimates on necessary easements.

4. Based on apparent physical, economic, and easement feasibility, the sponsoring local organizations and the Soil Conservation Service agreed that 26 possible site locations for floodwater retarding structures would be investigated. Two of these sites were to be considered for extra storage, one for municipal water for the city of Rising Star and one for water for irrigation. In addition to the 26 possible site locations for floodwater retarding structures, it was agreed that one critical sediment source area would be considered for treatment. It was also agreed that several miles of channel would be investigated for possible improvement.

   It was necessary to plan site No. 1 in series with site No. 2. It is more feasible to get the required storage for floodwater detention with two sites than with one.

5. Each site location was classified for limiting design criteria according to the damage that would result from a sudden major breach of the embankment.

   All of the structures are classified as "a". Site No. 1 and site No. 2 are designed to have storage approaching that required for a class "b" structure because they are in series. Site No. 12 is also designed to have more detention storage than is required for a class "a" structure. The storage was increased to that required for "b" classification because of Farm-to-Market Road Number 1689 immediately downstream.

6. A topographic map of each site was developed to cover the pools, dam, and emergency spillway areas. These maps and related surveys provided necessary information to determine if the required irrigation, sediment, and floodwater detention storage capacity could be obtained, the limit of the pool areas, estimated installation costs, and the most economical design for each structure.

7. The sediment and floodwater storage, structure classification, and principal and emergency spillway layout and design meet or exceed criteria outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

   Multiple routings of freeboard hydrographs were made for all sites to determine the spillway proportion and height of dam which would result in the most economical and feasible design of the structures. Plans of a floodwater retarding structure, typical of these planned for this watershed, are illustrated

by figures 3 and 3A.

8. A detailed investigation was made of State, county, and farm roads having low water crossings on streams below the floodwater retarding structures. Where there are no equal alternate routes, the improvements required to provide passage during periods of prolonged floodwater release from the structures were determined.

   A detailed investigation was also made to see what effect floodwater retarding structures would have on roads, highways, and utility lines above the sites.

9. Structure data tables were developed to show for each structure the drainage area; the capacity needed for floodwater detention and sediment storage in acre-feet and in inches of runoff from the drainage area; the release rate of the principal spillway; acres inundated by the sediment, sediment reserve, and detention pools; the volume of fill in the dam; the estimated costs of the structure; and other pertinent data (tables 2 and 3). In addition, requirements were determined for municipal water storage in sites Nos. 1 and 3 and irrigation water storage in site No. 9.

When the structural measures for flood prevention and agricultural water management development had been determined, a table was developed to show the cost of the measures (table 2). The summation of the total costs for all works of improvement represented the estimated cost of the planned watershed protection and flood prevention project (table 1).

A second cost table was developed to show separately the annual installation cost, annual maintenance cost, and the total annual cost of the structural measures (table 4).

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau Climatological Bulletins, U. S. Geological Survey Water Supply Papers, and local records. These data were analyzed to determine average precipitation depth-duration relationship, seasonal distribution of precipitation, the historical flood series to be used in the evaluation of the project, and frequency of occurrence of meteorological events.

2. The before-project hydrologic conditions of the watershed were determined on the basis of cover conditions, land use and treatment, soil groups, and crop distribution. The condition II curve number of 80 for the hydrologic soil-cover complex

was determined from a 15 percent sample of the watershed.

The after-project conditions were determined by analyzing the results of the land treatment that would be applied during the installation period. This study revealed that a condition II curve number of 79 is applicable.

3. Engineering surveys were made of valley crosa-sections, high water marks, bridges, and other features pertinent in determining the extent of flooding. The cross-sections were selected to represent the stream hydraulics and flood plain area. Evaluation reaches were delineated after joint study with the economiat and geologist.

   Partial valley cross-sections for planning channel improvement were surveyed at approximately 500-foot intervals on South Copperas Creek in the segment where channel enlargement was studied.

4. Cross-section rating curves for Rush Creek and its tributaries were developed from field survey data collected in 3, above, by Manning's formula.

5. Stage-area inundated curves were developed from field survey data for each portion of the valley represented by a cross-section. Area inundated data by incremental depths of flooding were developed for each evaluation reach, using the runoff-peak discharge relationship for selected storms in the evaluation series.

6. The present and project conditions runoff-peak discharge relationshipa were determined by flood routing the runoff from 1-, 10-, and 25-year frequency, 24-hour rainfall, as selected from Technical Paper No. 40, U. S. Weather Bureau. The routings and hydrograph development were made by the use of the IBM 7090 computer, as described in Technical Release No. 20, Project Formulation.

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

   a. The without-project condition.

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

   c. The installation of land treatment measures and structural measures.

8. From a tabulation of cumulative departure from normal precipitation, the period 1936 through 1960 was determined to be representative of the normal precipitation on the watershed, and is the period from which the historical evaluation series was developed. The largest storm in the series approached the 25-year frequency storm for the watershed.

9. The maximum release rates for the principal spillways of the floodwater retarding structures were determined by detailed study of the stream channel and the effects of release rates on design of structures and emergency spillways. The maximum release rate for each floodwater retarding structure will be 10 csm.

10. The channel improvement along South Copperas Creek is designed to prevent damage to areas due to duration of principal spillway release rates. The method of design was such that the channel would carry the release rates at a stable condition.

11. The appropriate emergency spillway and freeboard design storm was selected in accordance with criteria contained in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

12. Investigations for inclusion of additional water storage were requested by the sponsoring local organizations for municipal purposes in sites Nos. 1 and 3 for the city of Rising Star and for irrigation in site No. 9.

    Reservoir operations studies of the sites were made according to procedures outlined in Chapter 2, Texas Engineering Handbook, Section 4, Hydrology. Monthly reservoir evaporation rates and consumptive use of water for crops were made from the Texas Board of Water Engineers Bulletins Numbers 6006 and 6019, respectively. Municipal demands for the city of Rising Star were furnished by the Texas Water Commission.

    The study indicates the storage of water for irrigation in site No. 9 is reliable and water quality will be suitable for production of forage crops.

    After consideration of the total cost for storage, pipeline transportation, and purification of municipal water in sites Nos. 1 and 3, the officials of Rising Star decided not to include municipal storage in these sites.

Sedimentation Investigations

edimentation investigations were made in accordance with procedures as utlined in Watersheds Memorandum WS TX-25, Sedimentation Investigations in ork Plan Development, August 1959, Fort Worth, Texas; Technical Release No. 7, Geologic Investigations for Watershed Planning, March 1961; and Technical Release No. 12, Procedures for Computing Sediment Requirements for

Retarding Reservoirs, September 1959.

Sediment Source Studies

Sediment source studies to determine the 100-year sediment storage requirements were made in the drsinage areas of the 13 planned floodwater retarding structures and one multiple-purpose structure. Detailed studies were made in sample areas selected to be representative of each of the three land resource areas involved. These areas studied in detail amount to a 34 percent sample of the total drainage areas of all planned structures.

The detailed investigations and computations included:

1. Mapping soils by units, percent slope, length of slope, land use, cover condition classes on rangeland, land treatment on cultivated land, and land capability classes within sample areas.

2. Measuring lengths, widths, and depths, and studying old aerial photographs to estimate rates of annual lateral erosion of all gullies and stream channels affected by erosion.

3. Measuring widths and depths and studying old aerial photographs to determine the average annual hesdward erosion of all headcuts and overfalls.

4. Computing average annual erosion rates by sources (sheet, gully, and streambsnk) for esch land use in each land resource area. The soil loss equation by Musgrave was used in sheet erosion computation.

5. Mapping land use and land resource areas of the entire drainage area of each structure site.

6. Computing total average annual erosion within the drainage area of each structure by using the computed erosion rates for each land use within each land resource area.

Estimates of annual gross erosion reflect the effect of expected land treatment on drainage areas of planned structures. A gradual improvement of watershed conditions is expected as a result of the installation of planned land treatment measures.

Sediment storsge requirements for planned structures were determined by adjusting totsl average annual erosion for expected sediment delivery ratios and trap efficiency of structures. The ratio of sediment volume submerged in pools to soil in plsce wss based on volume weights of 62 to 84 pounds per cubic foot for submerged sediment snd 85 to 97 for soil in place.

The allocation of sediment to the pools of single-purpose floodwater retsrding structures was based on a range of 30 to 35 percent deposition in the sediment pools below the riser, 45 to 48 percent in the sediment reserve pools above the riser, and 17 to 25 percent in the detention pools. For

multiple-purpose structure No. 9, the allocation is 70 percent below the riser in the irrigation and sediment pools and 30 percent in the detention pool.

Flood Plain Sediment and Scour Damages

The following sediment and scour damage investigations were made to determine the nature and extent of physical damage to flood plain lands:

1. Field examinations were made within repreaentative sample areas. Factors such as depth and texture of sediment deposits, depth and width of scour channels, nature of undamaged flood plain soils, channel degradation or aggradation, and channel bank erosion were recorded. Areas of damage were mapped.

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

3. A damage table was developed to show percent damage by texture and depth increment for sediment and by depth and width for scour. Due consideration was given to the agronomic and land treatment practices, soils, crop yields, and land capabilities in assigning damages.

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

5. Damages measured within sample areas were expanded, by evaluation reaches, to represent the entire flood plain.

6. Estimates of recoverability of productive capacity were developed from field studies and interviews with farmers.

7. The average annual sediment yield from each source (sheet erosion, gully erosion, streambank erosion, streambed erosion, and flood plain scour) was estimated from detailed sediment source studies and scour damage investigations. Sediment yields to evaluation reaches were computed for without-project conditions, with land treatment measurea applied, and with the combined program of land treatment and structural measures installed.

   The reduction in sediment yield was 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 the reduction of area inundated by floodwater and reduction in damaging sediment yield.

8. Estimates of the reduction of scour damage due to the installation of the project were based on reduction of depth and area inundated by floodwater.

Reservoir Sedimentation

The following procedure was used to estimate the average annual sediment yield from Rush Creek watershed to Proctor Reservoir for present conditions, with land treatment applied, and with the combined program of land treatment and structural measures installed:

1. Studies of sediment sources in drainage areas of planned structures and flood plain scour, streambank erosion, and bedload transport studies were used to estimate the average annual rates of erosion by sources.

2. Sediment delivery ratios were estimated by sources, making allowances for such factors as size, shape, and topography of the watershed; density, drainage pattern, gradient, and capacity of channels; and texture of sediment.

The results of computations indicate an average annual yield to Proctor Reservoir from Rush Creek watershed of 154 acre-feet under present conditions, 140 acre-feet with land treatment applied, and 89 acre-feet with the combined program of land treatment and structural measures installed. The present average annual rate of sediment production is 0.53 acre-feet per square mile. This compares favorably with the rate used by the Corps of Engineers in providing sediment storage in Proctor Reservoir.

Channel Stability Studies

Channel stability studies were made for Rush Creek and its tributaries. Hand auger borings were made at selected locations to study the nature of bedload and underlying materials.

The bedload is primarily fine to medium grained sands classified as SP in accordance with the Unified Soil Classification System. This SP is underlain by sandy clays, shales, sandstones, and limestones at depths ranging from one to four feet. Based on the median grain size of non-cohesive bedload materials, the application of critical tractive force values indicated bedload movement in most stream reaches. Bedload movement would also occur under project conditions.

The Schoklitsch bedload transport equation was used to estimate the rate of bedload movement within each reach. Comparison of estimates of bedload movement under present conditions with that under project conditions indicated that there would be slightly less volume of bedload movement after installation of the project. After comparing estimated incoming bedload with bedload transport capacity with the project installed, it was indicated that there would be slight degradation, temporarily, due to a decrease of incoming sediment. This slight degradation will cease as the clays, shales, sandstones and limestones underlying the bedload are exposed.

Critical Sediment Source Studies

Field examinations of gullies were made to determine conditions at headcuts, overfalls, and banks. Special note was taken of active headcutting and lateral erosion, the type of land being eroded, the nature of sediment movement and deposition downstream, and the degree of natural stabilization caused by re-vegetation. Comparisons of older and new aerial photographs were made to estimate rates of gully and stream channel enlargement.

Most of the gullies show evidence of natural stabilization, caused by changed land use and proper management, and are not considered critical sediment source areas.

There is, however, an area adjacent to the Sweetwater Creek flood plain, 7 miles north of Comanche, where critical gullying has been temporarily delayed by a small dam. Cracks are developing in this dam, and the danger of failure is increasing. This area was selected as a critical sediment source area for study of feasibility of treatment to prevent rejuvenation of land voiding and downstream sediment damages. Past sediment deposition, readily distinguished as being from this source, was traced for a distance of nearly one mile downstream, covering 46 acres. Farther downstream, sediment deposition from this source cannot be distinguished from sediment of other origin.

Geologic Investigations

Preliminary geologic investigations were made at each of the floodwater retarding structure sites to obtain information on the nature and extent of embankment and foundation materials, emergency spillway excavation, emergency spillway stability, and possible problems that might be encountered during construction. These investigations included surface observations of valley slopes, alluvium, channel banks, exposed geologic formations, hand auger borings, and tests with portable seismic equipment. The findings of these investigations were used in making cost estimates of structures and to assure that the sites selected are feasible for construction.

Description of Problems

Formations of the Pennsylvanian and Cretaceous systems are exposed at dam sites. The Pennsylvanian system is represented by shales interbedded with limestones, sandstones, and conglomerates of the Canyon and Strawn groups. The shales are moderately well indurated except for the weathered surface which is 5 to 10 feet thick. The limestones, sandstones, and conglomerates are thin bedded to massive and generally hard to very hard.

Cretaceous strata lie unconformably on the eroded surface of Pennsylvanian beds. The Cretaceous system is represented at structure sites by basal Trinity clays, shales, and poorly cemented sandstones and conglomerates. There is a limited amount of limestones and shales of the Glen Rose formation at high elevations at some structure sites.

Sites Nos. 1, 2, 3, 4, 5, 9, and 13 are located on Pennsylvanian strata. Streams are entrenched and the topography is characterized by strong to moderate relief. The abutments are composed of alternating beds of shale, limestone, and sandstone. In general, the depth to unweathered, non-yielding strata is relatively shallow.

Sites Nos. 6, 7, 8, 10, 11, 12, and 14 are located on Cretaceous strata. The topography is generally more subdued and parent materials more deeply weathered than that of the Pennsylvanian outcrop.

Flood plain alluvium consists mostly of sandy clays, clayey sands, and silty sands. There are some thin lenses of clayey, silty gravel. Some deposits of poorly graded sand and gravel are found on flood plain surfaces and in stream channels. These soils, as classified in accordance with the Unified Soil Classification System, are CL, SC, SM, GC, SP, and GP.

Alluvial material for embankment at site No. 1 is scarce and is underlain by thick bedded limestone. Sufficient volume of material can be obtained, however, by utilizing weathered shale which occurs above the sediment pool elevation. Ample suitable materials for embankments are available within sediment pool areas at all other structure sites.

The foundations of all structure sites located on Cretaceous strata are underlain by poorly cemented sandstones and conglomerates. This condition will necessitate the use of foundation drains and relief wells to intercept water seeping through the permeable foundations and to prevent saturation of the downstream area and portions of embankments. It is estimated that maximum cutoff depths will range from 8 to 15 feet.

Rock excavation is expected in the removal of limestones and sandstones from emergency spillway areas at four structure sites, all of which occur in the Pennsylvanian strata. These sites and the estimated percent of rock in emergency spillway excavation are:

Site No.	Percent Rock
2	30
3	6
4	10
13	20

At some sites, sand beds, which are highly susceptible to erosion will be exposed in emergency spillways. These cuts will be vegetated as soon as possible after construction.

Further Investigations

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

made to determine the suitability and methods of handling foundation and embankment materials.

Economic Investigations

Selection of Evaluation Reaches

In order to evaluate the effects that various combinations of structural measures would have on the reduction of damages and because of the difference of damageable values, frequency of flooding and flood plain characteristics, the flood plain was divided into seven evaluation reaches (figure 1).

Determination of Damages

Damage schedules were obtained within each reach of the flood plain from landowners and operators and covered approximately 60 percent of the flood plain land. Information collected was used to determine land use and crop distribution, yield data, expected changes in land use, characteristics of flooding, damage to crops, pastures, other agricultural damage, and historical information on flooding. Information from these schedules supplemented with information from local agricultural workers familiar with the area served as a basis for making estimates used in the economic evaluations.

Flood plain land use was mapped in the field and recorded on overlay sheets. A separate damageable value was determined for each evaluation reach. Average flood-free yields were based on information obtained from landowners and operators and supplemented with information obtained from local agricultural leaders with allowances made for expected yield increases from improved technology during the life of the project. Flood damages to crops, pastures, other agricultural and non-agricultural properties were determined for a 25-year period from 1936 through 1960 by using a historical storm series. Damages were related to area inundated and depth of inundation. Crop and pasture damage rates, using factors from data compiled in Economics Memorandum TX-11, were related to season of occurrence. Allowances were made for recurrent flooding.

Damages to agricultural property such as fences, farm roads, creek crossings, and cost of removal of debris from fields and livestock losses were estimated from information collected in the field. Road and bridge damages were based on information obtained from county and state records and from landowners having knowledge of these damages. The damage estimates were related to size and frequency of floods as reflected by high water elevations.

The monetary value of the physical damage to flood plain land from deposition of sediment and from scour was based on the value of production lost. Allowances were made for the time lag necessary for recovery and for the non-recoverable loss in production. Flood plain scour damage was related to depth of flooding with weight given to increased velocity from the deeper flows. The monetary value of sediment damage to Lake Proctor was based on the installation cost of the dam. The "straight-line" method was used to

calculate, in monetary terms, the sediment damage per acre-foot. Reduction in monetary damages for sediment deposition was based on the effectiveness of land treatment, trap efficiency of planned floodwater retarding structures and the reductions in flooding.

Indirect damages involve such items as interruption of travel, re-routing and delays of school buses and mail deliveries, and losses in business sustained by business establishments in the area. Inconvenience and delays in caring for livestock at times when creeks are flooding is considered an indirect damage. It was determined that 10 percent of the direct damages would be an equitable estimate for indirect damages.

Benefits from Reduction of Damages

Floodwater, sediment, scour and indirect damages were calculated under the following conditions: Without project, with land treatment, with land treatment and structural measures. The difference between the average annual damages for each progressive increment of protection constitutes the benefits assigned to that increment.

Evaluation of Alternatives

The benefits, costs, and effects of various combinations of structural measures were determined in order to select the most feasible project that would provide adequate and desired levels of flood protection. Evaluations were made of projects consisting of interrelated groups of 10, 12, 13, 14, 15, and 16 floodwater retarding structures. It was determined that a group of 14 structures (13 floodwater retarding structures and 1 multiple-purpose structure) would be the most feasible alternative. An evaluation also was made of a proposed floodwater retarding structure in reach 6, Duncan Creek, and a grade stabilization structure in the critical sediment source area (figure 1). It was determined these two structures are not economically feasible.

Incidental Benefits from Water Management

Incidental water management benefits will result from the installation of the floodwater retarding structures. Flood prevention was the only purpose considered in the location of these structures and no additional Public Law 566 costs are involved in obtaining incidental benefits. When the structures are installed, it is estimated the sediment pools will have initial water storage capacity of 2,289 acre-feet and 422 surface acres. With the expected sediment deposition in the pools, the water storage will eventually decline to zero.

Investigations were made to determine the beneficial uses that would be made of the water in these pools.

Incidental recreation benefits such as fishing, swimming, hunting, boating, camping, and picnicking will become available and convenient to a great many

people.

All of the sites are expected to be open to the public, but some will be open on a fee-charge basis or by free admission with the landowner's permission.

Recreation benefits were estimated in monetary terms for each of the proposed floodwater retarding structures. Factors considered in making the estimates were population within a 40-mile radius, size of the sediment pools in acre-feet and surface area and accessibility of the site. The expected recreational use of the 14 sites was estimated to be 10,950 visitors annually having a value of 50 cents per visitor-day. An allowance was made to cover operation and maintenance costs associated with the recreation activities. The benefits were discounted to show full use for 40 years with a decline to zero by the 50th year because of the expected decreasing capacity of the pools due to sediment inflow.

Investigations revealed that incidental water management benefits from irrigation will accrue to some sites in the proposed plan. The benefits will result from the planned use of some of the water in the sediment pools and will be derived from the increased net income from the land to be irrigated. Irrigation is expected to be confined to forage crops and will be on land adjacent to the site locations. In calculating the increase in net income, allowances were made for associated costs, 5-year lag in accrual of benefits, and a decline to zero between the 40th and 50th year.

Water yield studies indicate an adequate water supply will be available for the activities which produce the incidental benefits. Necessary water rights are to be obtained by the landowners and operators.

Irrigation

Multiple-purpose structure No. 9 will include 453 acre-feet of storage for agricultural water management. Benefits will result from the increase in net income from about 160 acres of forage crops to be irrigated on five farms adjacent to the site. Sprinkler irrigation systems will be used. In calculating the benefits, allowances were made for associated costs and time lag in accrual. Water yield studies indicate an adequate water supply will be available. The water users will be responsible for obtaining the necessary permits for storage and use of the water.

Benefits from Restoration and More Intensive Use of Flood Plain Land

During field investigations, farmers were asked what changes had been made in the use of flood plain land as a result of past flooding. Farmers were also asked what changes they would make in the use of land if flooding were reduced by 50 percent or more.

It was found that as a result of past flooding, some cropland has been planted to pasture. Also some cropland has been abandoned and allowed to be invaded by mesquites and low quality range grasses.

Farmers indicated that when flooding is reduced some of the timber land would be cleared and some fields would be established in improved pasture. Some of the grazing crops would be replaced with hay crops because of the reduced flood threat. Better fencing arrangements will result in increased proper use of pastures which in turn will increase the efficiency of livestock production.

Farmers' statements were considered along with the land capabilities and the general agricultural economic conditions and trends in making the estimates of benefits from restoration and intensification of flood plain land. Consideration was given for the added damage from the remaining flooding to the higher damageable values. Additional costs of production, harvesting, and associated costs were deducted from the expected increased value of the production. Prices were based on long-term levels. The benefits were discounted to allow for a five-year lag in accrual. The restoration benefits have been included as crop and pasture benefits in table 5.

Appraisal of Land and Easement Values

Areas that will be used for project construction and areas to be inundated by pools of reservoirs were determined. Net income from production to be lost in these areas after installation of the project was compared with the appraised value of the land amortized over the period of project life. It was considered there would be no production in the sediment pools and that all land covered by the detention pools would be grassland. The value of land and easements for the structures were determined by appraisal in cooperation with representatives of the sponsoring local organizations. The structure site costs were based on the value of the easements.

The annual net loss in production and associated secondary losses, based on long-term prices, on land to be utilized by the structures were calculated and compared with the amortized cost of the structure sites. The annual structure site cost exceeds the value of the annual loss in production and associated secondary losses; therefore, the structure site costs were used in economic evaluations.

Secondary Benefits

Values of local secondary benefits and local secondary losses were calculated in accordance with the interim procedures outlined in Watersheds Memorandum SCS-57, dated October 3, 1962.

Benefits of a local nature stemming from the project were considered to be 10.0 percent of the direct primary benefits accruing to structural measures.

Secondary losses resulting from installation of structural works were calculated and used in determining "negative project benefits".

Fish and Wildlife Investigations

The Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, United States Department of the Interior, in cooperation with the Texas Parks and Wildlife Department, completed a reconnaissance study of the Rush Creek watershed. A report, dated February 23, 1965, was prepared in accordance with Section 12 of the Watershed Protection and Flood Prevention Act (68 Stat. 666) as amended.

The following is quoted from this report:

> "The streams of the watershed are intermittent and fishing is of no significance. Without the project, these conditions could be expected to remain unchanged.
>
> "With the watershed project, the rate of sedimentation in Proctor Reservoir will be reduced, thereby improving fish habitat in that reservoir. The floodwater retarding reservoirs will create fish habitat in an area where there is good-quality fishing. The proposed reservoirs will provide good fishing if properly managed.
>
> "Wildlife species present in the watershed are white-tailed deer, fox squirrel, turkey, bobwhite, mourning dove, and waterfowl.
>
> "Small populations of deer exist in a few sections of the watershed. Their populations are held to a minimum by present land uses and lack of adequate forage and cover. Hunting for deer is insignificant in the project area.
>
> "Small populations of fox squirrels are present along the streams and in the bottomlands in the project area and hunting for them is light. Most landowners permit the hunting of squirrels.
>
> "Turkeys nest in the watershed and winter in the river bottoms. A few turkeys are taken incidental to other kinds of hunting.
>
> "Bobwhite populations are held at a low level by lack of ground cover, a result of overgrazing and peanut farming. They are hunted occasionally by landowners and their friends.
>
> "The scarcity of food limits the dove population to a few nesting birds. There is little hunting for them.
>
> "Several species of ducks migrate through the watershed, but there is little or no hunting for ducks in the watershed.
>
> "Little or no change could be expected in the wildlife populations because of the future land-use practices and hunting for all species would be expected to remain unchanged without the project.
>
> "It is doubtful that any of the proposed watershed improvement practices will have much effect on the deer population in the project area. Some fox squirrel habitat will be destroyed by construction

of the floodwater retarding structures.

"Erosion prevention and soil building practices will provide more food and cover for turkeys, bobwhites, and mourning doves. Bobwhite and dove populations will increase, and there will be more hunting for these birds in the watershed. The clearing of brush in the construction of the floodwater retarding structures will destroy wintering habitat for turkeys. The floodwater retarding structures will provide resting areas for waterfowl and will provide increased hunting opportunities.

"Soil types, current and anticipated future land uses, and distribution of vegetation in the Rush Creek watershed severely limit the variety and abundance of wildlife. Floodwater retarding structures and land treatment practices proposed for the watershed will result in improved habitat for wildlife. However, there will be losses of bottomland habitat for fox squirrels and turkeys.

"Losses of squirrel and turkey habitat should be mitigated by retaining as much woody vegetation as possible in the clearing operations and planting of wildlife food and cover plants on all feasible sites where the soil has been disturbed during construction.

"Enhancement of wildlife could be achieved by incorporating into the work plan such additional conservation practices as wildlife planting on idle lands, odd areas, damaged streambanks, and steep slopes; wildlife field border plantings, and hedgerow plantings. These enhancement practices are suggested as means of increasing the number and variety of game species and songbirds.

"It is recommended:

1. That as much woody vegetation be retained as possible in the process of clearing for flood-control structures.

2. That plants of value to wildlife for food and cover be planted on all feasible sites around the flood-control structures.

3. That idle lands, odd areas, damaged streambanks, and slopes too steep for cultivation or pasture be planted to beneficial wildlife food and cover plants.

4. That such conservation practices as hedgerow planting and field border planting be incorporated into the watershed work plan as measures which would increase the variety and abundance of wildlife species.

5. That sponsors and landowners in the watershed obtain professional assistance from the Texas Parks and Wildlife Department in choosing appropriate plants for wildlife food and cover plantings, and in the management

of the reservoirs so that good-quality fishing will be maintained."

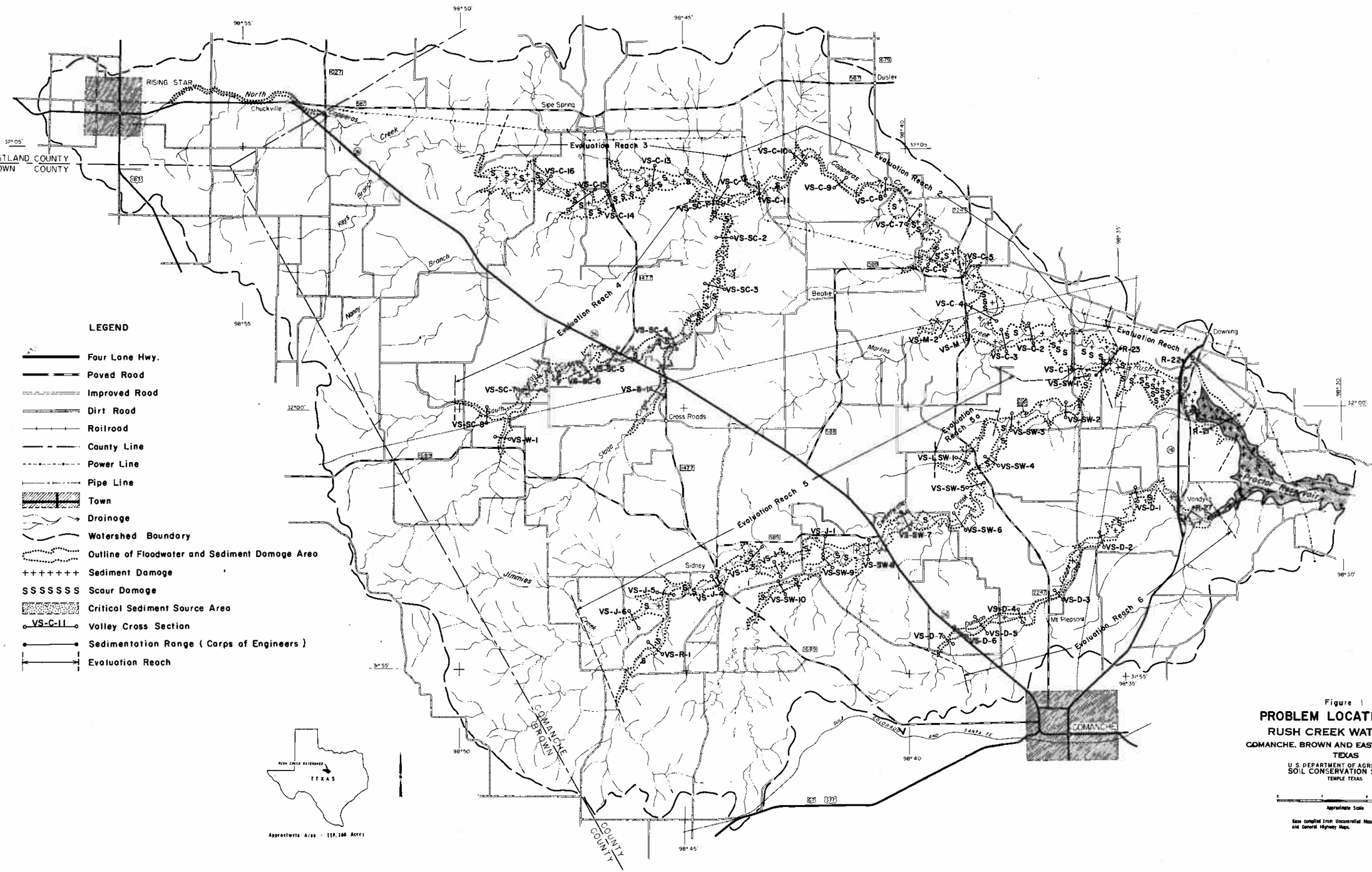


Figure 1

PROBLEM LOCATION MAP

RUSH CREEK WATERSHED

COMANCHE, BROWN AND EASTLAND COUNTIES

TEXAS

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

Base compiled from Uncontrolled Mosaic 4-R-19037 and General Highway Maps.

4-R-20,599

May 22, 1964 Rev. 9-65 4-R-19038

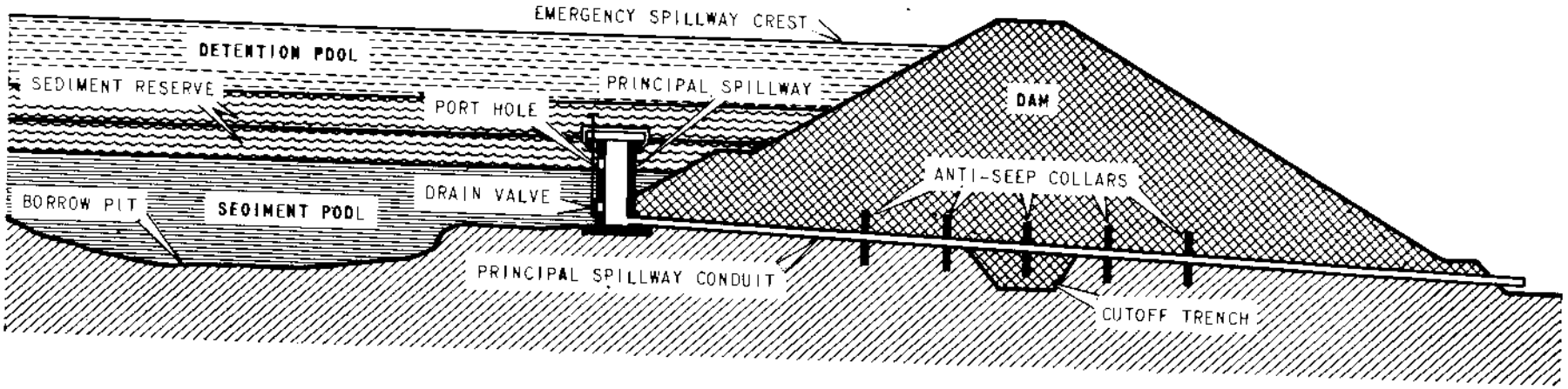


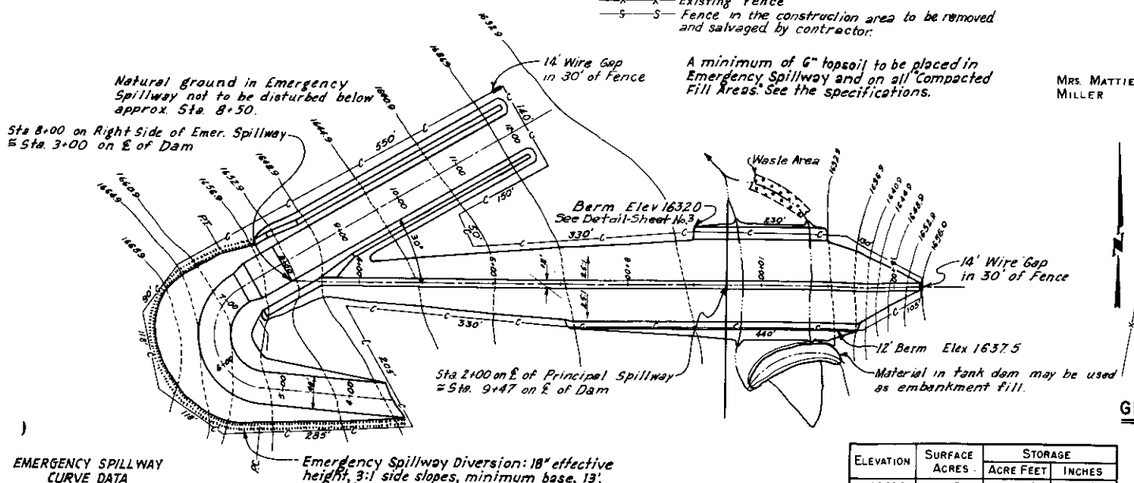
Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Rev. 3-65 A-L-10,071

FENCE LEGEND
—C—C— Fence to be constructed under contract
—X—X— Existing fence
—S—S— Fence in the construction area to be removed and salvaged by contractor.



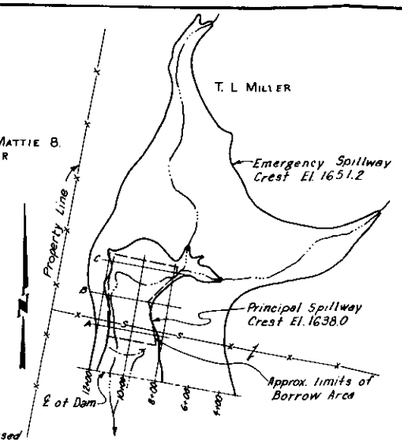
EMERGENCY SPILLWAY CURVE DATA
Δ = 144°00'
D = 71°37'
R = 80.35'
L = 201.0'
P.C. = Sta. 5+29
P.T. = Sta. 7+30

PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

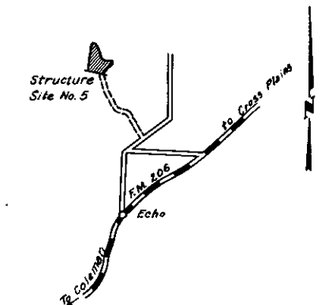
Elevation	Surface Acres	Storage	
		Acre Feet	Inches
1632.9	2	4	0.05
1636.9	6	20	0.27
1638.0	8	28	0.37
1640.9	14	60	0.80
1644.9	20	128	1.70
1648.9	29	226	3.00
1651.2	36.4	301	3.99
1652.9	42	368	4.88
1656.9	53	558	7.40
1660.9	64	792	10.51

Top of Dam (Effective) Elev.	1656.5
Emergency Spillway Crest Elev.	1651.2
Principal Spillway Crest Elev.	1638.0
Sediment Pool Elev.	1638.0
Drainage Area, Acres	904
Sediment Storage, Acre Feet	32
Floodwater Storage, Acre Feet	269
Max. Emergency Spillway Cap., c.f.s.	1830



GENERAL PLAN OF RESERVOIR

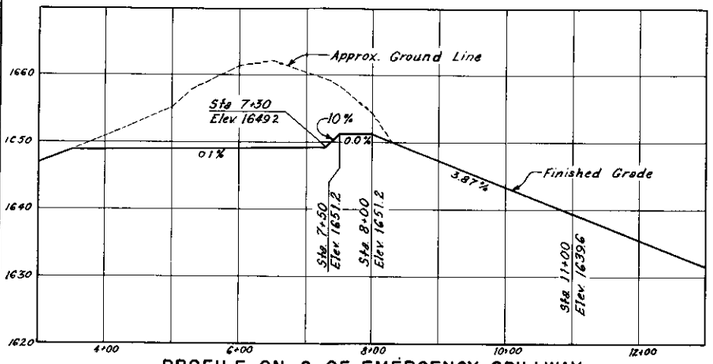
0 400 800 1200 1600
SCALE IN FEET



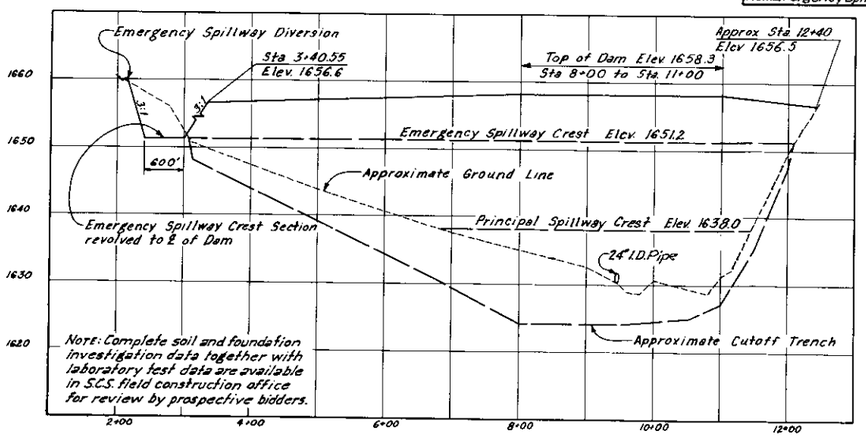
Structure located approximately 12 miles northeast of Coleman, Coleman County, Texas.

VICINITY MAP

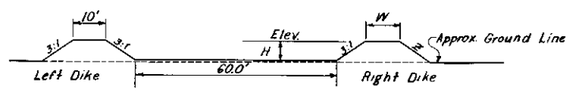
0 1 2 3 4
SCALE IN MILES



PROFILE ON ℄ OF EMERGENCY SPILLWAY



PROFILE ON ℄ OF DAM



Left Dike:
Approx. Sta. 7+75 to Sta. 8+00 Elev 1656.6 From Sta. 8+00 to Sta. 8+50, grade uniformly to H=3.0'. From Sta. 8+50 to 12+00, H=3.0'.

Right Dike:
Approx. Sta 7+40 to Embankment Elev 1656.6, W=14.0', Z=2.5:1. From Embankment to Sta. 9+00 Transition Section. Sta 9+00 to Sta. 12+00 H=3.0', W=10.0', Z=3:1.

Note:
Material forming both dikes to be placed and paid for as "Compacted Fill."
Natural ground in Emergency Spillway not to be disturbed below approx. Sta 8+50

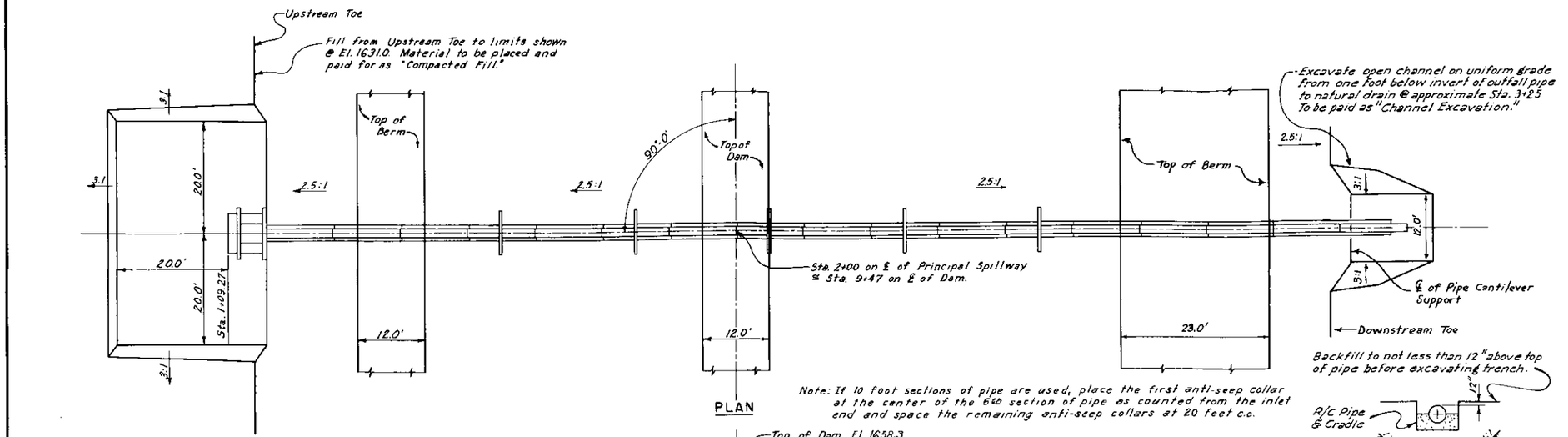
TYPICAL SECTION — EMERGENCY SPILLWAY

Figure 3
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed W.E.C.	Date 3-61	Approved by	
Drawn W.E.C. & H.R.T.	3-61		
Traced H.R.T.	3-61		
Checked W.E.C. & G.W.T.	4-61	Sheet No. 2 of 8	Drawing No. 4-E-15,357

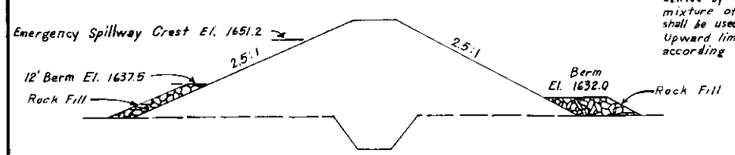
USDA-SCS-FORT WORTH, TEX. 1868



SECTION

PRINCIPAL SPILLWAY

Note: The detail above is planned for 12 foot sections of pipe. Section lengths of 10 feet may be used with invert of joints set on grade line as established above, utilizing 200 feet of pipe, ending at station 3+16. Section lengths in excess of 12 feet will not be permitted.



TYPICAL SECTION

Notes: No Formal Embankment Zoning is required. Selection of materials represented by Laboratory Curve No. 1, 3, and 4 shall be used in Cutoff Trench and center section of Embankment. The material represented by Laboratory Curve No. 2 shall be used in the outer shell. The mixture of rock and earth excavation from the emergency spillway shall be used in the upstream and downstream Berms. Upward limits of moisture will be determined by the Project Engineer according to the workability aspects of materials during construction.

MATERIALS					
LAB TEST		COMPACTION REQUIREMENTS			Lab Curve
Modified		Min. Dry Density	Moisture Range		
Max Dry Den.	Opt'm Moist	Lbs Per Cu Ft.	Percent From	To	No
119.5	12.5	107.2	13.0	UP	1
116.0	6.1	195.7	6.1	UP	2
126.1	10.9	113.9	10.9	UP	3
124.5	11.5	112.0	12.0	UP	4

If the material being placed in the fill contains ¼ inch or larger material in amounts differing from the percentages found in the laboratory sample, the minimum dry density and moisture requirement will be corrected for this variation.

EMBANKMENT DATA

Figure 3A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	W.E.C.	3-61	Approved by: HEAD ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS / STATE CONSERVATION ENGINEER, T. C. S.
Drawn	W.E.C. & H.R.T.	3-61	
Traced	H.R.T.	3-61	TEMPLE, TEXAS
Checked	W.E.C. & G.W.T.	4-61	Sheet No 3 of 8 — Drawing No 4-E-15,357

USDA-SCS-FORT WOATH, TEX. 1955

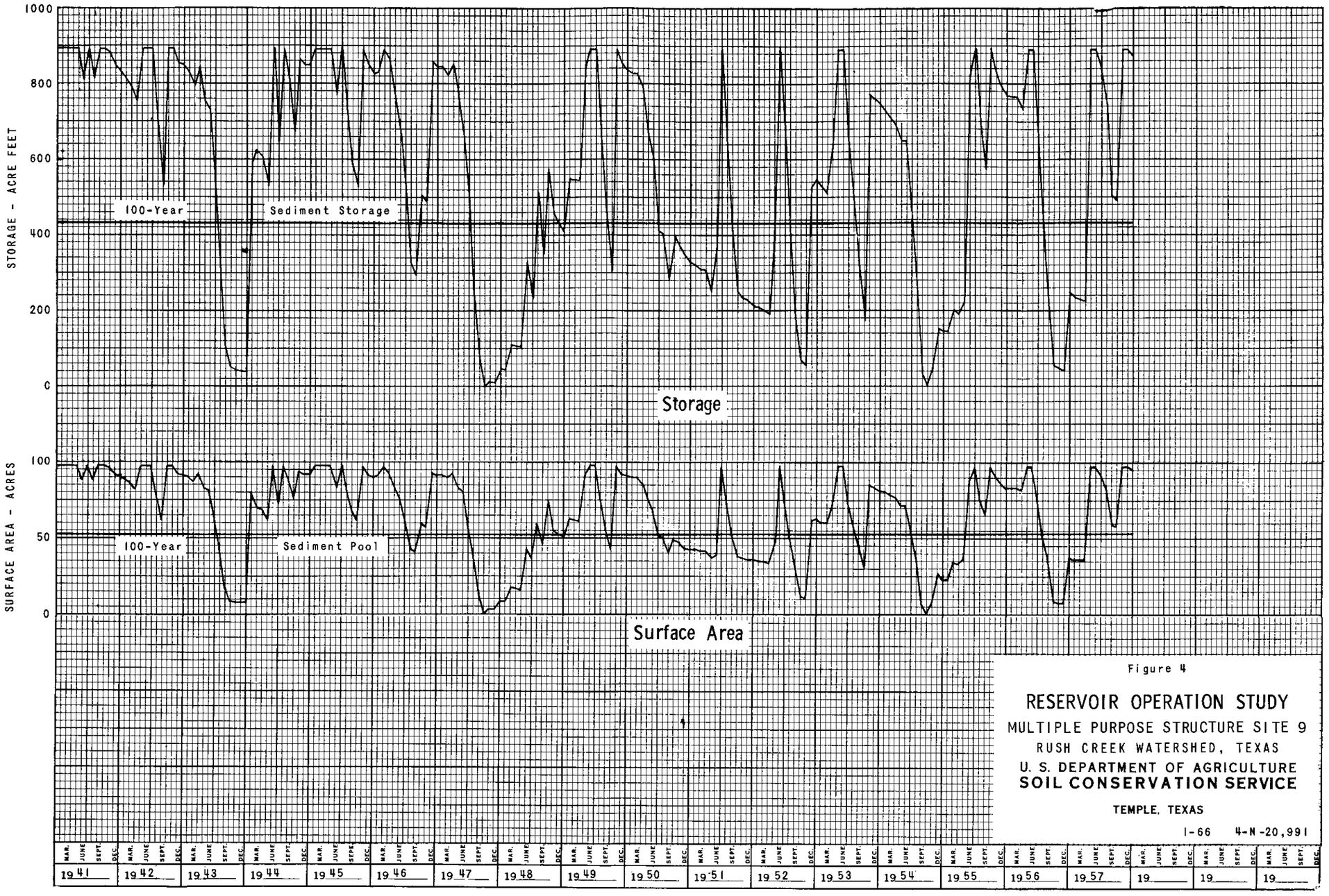


Figure 4

RESERVOIR OPERATION STUDY

MULTIPLE PURPOSE STRUCTURE SITE 9

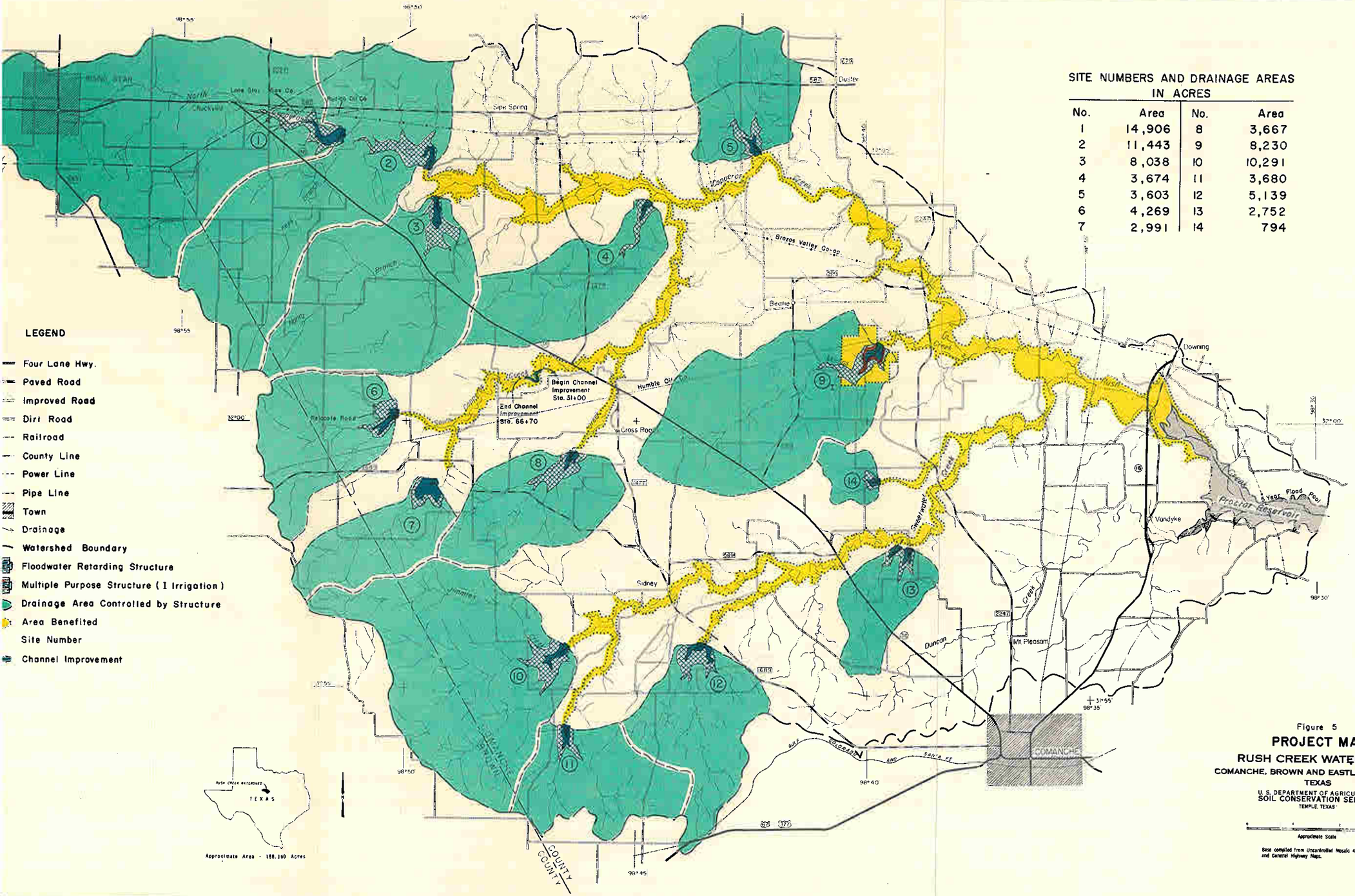
RUSH CREEK WATERSHED, TEXAS

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

I-66 4-N-20,991



SITE NUMBERS AND DRAINAGE AREAS IN ACRES

No.	Area	No.	Area
1	14,906	8	3,667
2	11,443	9	8,230
3	8,038	10	10,291
4	3,674	11	3,680
5	3,603	12	5,139
6	4,269	13	2,752
7	2,991	14	794

Figure 5

PROJECT MAP

RUSH CREEK WATERSHED

COMANCHE, BROWN AND EASTLAND COUNTIES

TEXAS

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

Approximate Scale

Base compiled from Uncontrolled Mosaic 4-R-19037 and General Highway Maps.

Rev. 2-66 4-R-20,600

May 22, 1964 Rev. 9-65 4-R-19038