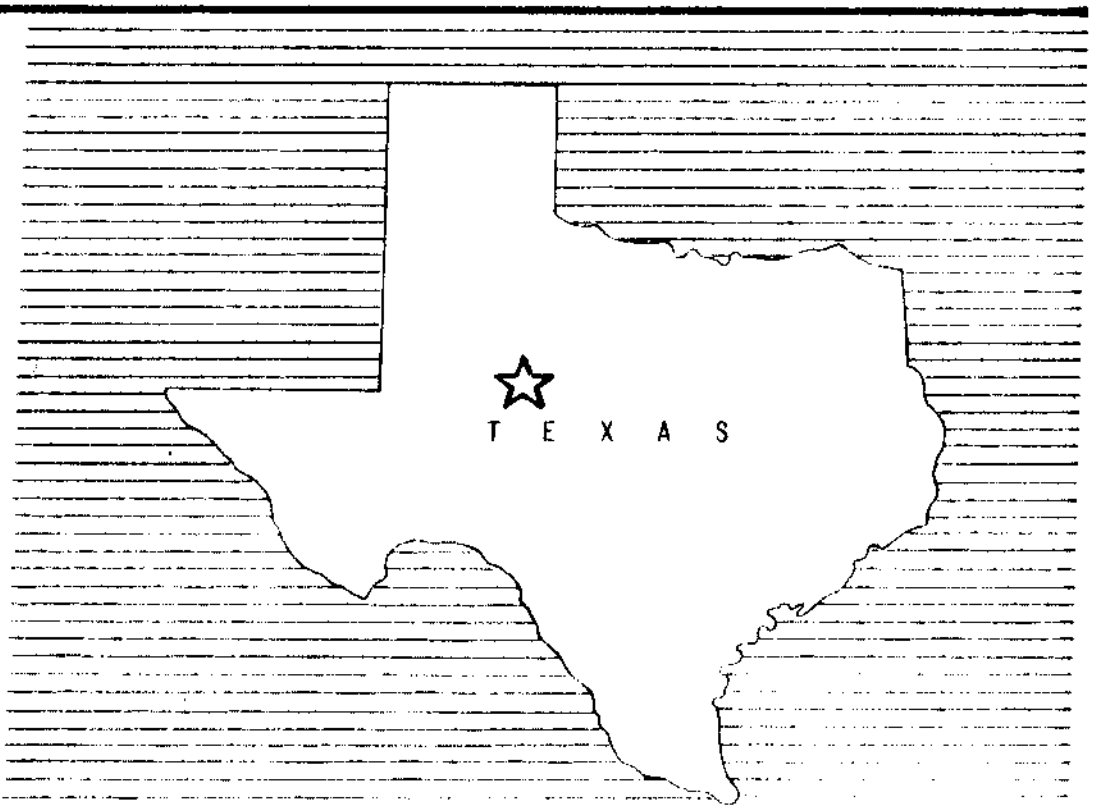
WORK PLAN

FOR WATERSHED PROTECTION
AND FLOOD PREVENTION

KICKAPOO CREEK WATERSHED

COKE COUNTY, TEXAS



March 1960

WATERSHED WORK PLAN AGREEMENT

between the

Coke Soil Conservation District
Local Organization

Coke County Kickapoo Water Control and Improvement District No. 1
Local Organization

City of Bronte
Local Organization

Coke County Commissioners Court

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

and the

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

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the **Kickapoo Creek** Watershed, State of **Texas** under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088); and

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

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

USDA-SCS-Ft.Worth,Tex.-1958
1-14486 4-60

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan will be installed, within 5 years, and operated and maintained substantially in accordance with the terms, conditions, and stipulations provided for therein.

It is mutually agreed that in installing and operating and maintaining the works of improvement described in the watershed work plan:

1. The Sponsoring Local Organization will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement. (Estimated cost $ 20,700 .)

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

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
6 Floodwater Retarding Structures	0	100	606.407

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

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost $ 156,380 .)

   The Service will bear - percent of the cost of installation services applicable to works of improvement for agricultural water management and the Sponsoring Local Organization will bear - percent of the cost of such services. (Estimated cost $ - .)

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

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 3,000 .)

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

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

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

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

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

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

Where there is a Federal contribution to the construction cos 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 th issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

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

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

Coke Soil Conservation District
Local Organization

By _____

Title Chairman

Date May 19, 1960

The signing of this agreement was authorized by a resolution of the gov ing body of the **Coke Soil Conservation District**
Local Organization

adopted at a meeting held on March 1, 1960

_____
(Secretary, Local Organization)

Date May 19, 1960

4-14496 4-60

Coke County Kickapoo Water Control and Improvement District
Local Organization

By T. S. Higginbotham

Title President

Date May 19, 1960

The signing of this agreement was authorized by a resolution of the governing body of the **Coke County Kickapoo Water Control and Improvement Dis**
Local Organization **No.**

adopted at a meeting held on May 19, 1960.

J. D. Criswell
(Secretary, Local Organization)

Date May 19, 1960

City of Bronte
Local Organization

By J. A. Stephenson

Title Mayor

Date May 19, 1960

The signing of this agreement was authorized by a resolution of the governing body of the **City of Bronte**
Local Organization

adopted at a meeting held on March 4, 1960

Helen Kirkland
(Secretary, Local Organization)

Date May 19, 1960

A-14498 4-60

Coke County Commissioners Court
Local Organization

By W W Whitford

Title County Judge

Date May 19, 1960

The signing of this agreement was authorized by a resolution of the gov
ing body of the Coke County Commissioners Court
Local Organization

adopted at a meeting held on March 1, 1960

Howard Brock
(Secretary, Local Organization)
Commissioner

Date May 19, 1960

Local Organization

By _____

Title _____

Date _____

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

adopted at a meeting held on _____

(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agricultu

By _____
Administrator

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

KICKAPOO CREEK WATERSHED
Coke County, Texas

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

Prepared By: Coke Soil Conservation District
(Cosponsor)

Coke County Kickapoo Water Control and Improvement District No. 1
(Cosponsor)

City of Bronte
(Cosponsor)

Coke County Commissioners Court
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
March 1960

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SECTION 1

WATERSHED WORK PLAN

KICKAPOO CREEK WATERSHED
Coke County, Texas
March 1960

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention for the Kickap Creek watershed was prepared by the Coke Soil Conservation District, the C County Kickapoo Water Control and Improvement District No. 1, the City of Bronte, and the Coke County Commissioners Court as cosponsoring local orga zations. Technical assistance was provided by the Soil Conservation Servi of the United States Department of Agriculture.

The watershed is in Coke County, Texas and covers an area of 63.64 square miles or 40,732 acres. Approximately 67 percent is rangeland, 27.5 percen is cropland and 5.5 percent is in miscellaneous uses, such as town, roads, railroads, and stream channels.

There are no Federal lands in the watershed.

The work plan proposes installing, in a 5-year period, a project for the protection and development of the watershed at an estimated total installation cost of $1,060,027. The share of this cost to be borne by Public Law 566 funds is $762,787. The share to be borne by other than Public Law 566 funds is $297,240. In addition, the local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

The cost for land treatment measures is estimated to be $273,540, all of which is to be borne by other than Public Law 566 funds including expected reimbursements from ACPS and $9,440 to be spent by the Soil Conservation Service for technical assistance under its going program during the project installation period. The land treatment included in the work plan is only that which will be installed during the 5-year project period (table 1).

Structural Measures

The structural measures included in the plan consist of 6 floodwater retard ing structures having a total sediment storage and floodwater detention capacity of 8,727 acre-feet. The total cost of structural measures is $786,487, of which the local share is $23,700 and the Public Law 566 share is $762,787. The local share of the cost of structural measures includes

land, easements, and rights-of-way, 87 percent and administering contracts 13 percent. The 6 floodwater retarding structures will be installed durin a 3-year period.

Damages and Benefits

The estimated average annual floodwater, sediment, flood plain erosion, an indirect damage without the project is $37,794 at long-term price levels. The estimated average annual floodwater, sediment, flood plain erosion, an indirect damage with the project installed, including land treatment and structural measures is $3,837, a reduction of approximately 90 percent.

The average annual primary benefits accruing to structural measures are $31,432, which are distributed as follows:

Floodwater damage reduction	$24,200
Sediment damage reduction	2,064
Flood plain erosion damage reduction	644
Indirect damage reduction	4,524

The ratio of the average annual benefits ($31,432) to the average annual cost of structural measures ($28,720) is 1.1:1.

The total benefits of land treatment measures were not evaluated in monetary terms since experience has shown that these soil and water conservation measures produce benefits in excess of their costs.

Provisions for Financing Construction

The Coke County Kickapoo Water Control and Improvement District No. 1 has powers of taxation and eminent domain under applicable State laws. A special district tax for the purpose of flood control has been voted and revenue from this tax will be adequate and available for financing the local share of the structural costs.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by the landowners or operators of the farms and ranches on which the measures will be installed under agreements with the Coke Soil Conservation District.

The Coke County Kickapoo Water Control and Improvement District No. 1 will be responsible for the operation and maintenance of the 6 floodwater retard ing structures. Revenue from the special district tax will be available and adequate for this purpose. The estimated average annual cost of operation and maintenance of all structural measures is $990.

DESCRIPTION OF WATERSHED

Physical Data

The drainage pattern of Kickapoo Creek Watershed is comprised of three tributaries to Kickapoo Creek. Middle Kickapoo Creek originates approximately 3 miles northwest of Fort Chadbourne, Texas and flows in a southerly direction through the eastern edge of the City of Bronte, Texas, where it joins East Kickapoo Creek. East Kickapoo heads approximately 2 miles southeast of Fort Chadbourne and flows in a southwesterly direction. West Kickapoo Creek heads approximately six miles west of Fort Chadbourne and flows toward the southeast through the western edge of Bronte to its confluence with Kickapoo Creek, approximately 1.5 miles southeast of this city. Kickapoo Creek enters the Colorado River approximately 3 miles sout of Bronte.

The topography ranges from nearly mountainous in the northern portion to nearly level along the alluvial valley. Elevations range from more than 2,500 feet to 1,700 feet above mean sea level.

All of the watershed except the extreme northwestern portion lies within the Rolling Plains Land Resource Area and is underlain by strata of the Permian system, which have a gentle regional dip toward the west. Chert conglomerate, sandstones, and shales constitute the San Angelo formation of the Double Mountain group which is underlain by red shales, sandy shales thin dolomites, and soft siltstones and sandstones of the Clear Fork group (undivided). In the northwest portion of the watershed Cretaceous strata (Comanche series) cap the Permian. This portion is within the Edwards Plateau Land Resource Area and consists of massive limestones, calcareous clays and marly clays of the Edwards, Comanche Peak and Walnut formations of the Fredericksburg group and sands, clays, and thin sandy limestones of the Trinity group.

The major soil series found in the watershed are Wichita, Miles, Travesilla Norwood, and Spur.

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

Land Use	Acres	Percent
Cropland	11,200	27.5
Rangeland	27,292	67.0
Miscellaneous 1/	2,240	5.5
Total	40,732	100.0

1/ Includes roads, highways, railroad rights-of-way, urban areas, etc.

The flood plain, as described herein, is the area inundated by the 100-year frequency storm runoff. Approximately 5,204 acres of the watershed, excludi

stream channels, is flood plain. Land use in the flood plain is 41 percer cropland, 50 percent pasture and rangeland, and 9 percent miscellaneous.

The average annual rainfall is 18.64 inches as recorded at U. S. Weather Bureau gage at San Angelo, Texas. The monthly normal precipitation ranges from 0.95 inch in March to 2.96 inches in May. Normal temperatures range from 82.7 degrees Fahrenheit in summer to 47.3 degrees in winter. The nor frost-free period of 233 days extends from March 23 through November 11.

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

Economic Data

The economy of the watershed depends largely upon agricultural production aided by a significant amount of income from petroleum products. During the past decade the size of farm units has increased slightly and at prese the average size is approximately 400 acres, which is sufficient for an economic unit. A majority of the farms sre owner-operated and the average value of land and buildings per farm is $15,600 (1954 agricultural census)

Cash cropping, in the form of cotton, wheat, oats and grain sorghum and livestock production, including cattle, sheep, and goats, are the most important agricultural enterprises in this area.

Bronte, with a population of 1,020, is the only town in the watershed and provides adequate marketing, ginning, educational and medical facilities for the area.

Most of the livestock is marketed in San Angelo, 35 miles south of Bronte.

The watershed is adequately served by approximately 44 miles of Federal, State and County roads, of which 17 miles are hard surfaced. Adequate rail service is provided by the Panhandle and Santa Fe Railroad with good loading and shipping facilities at Bronte.

WATERSHED PROBLEMS

Floodwater Damage

Flooding occurs frequently in the watershed and causes severe damage. Smal floods are an annual occurrence and large floods, which inundate at least half of the agricultural land in the flood plain, (figure 1) occur on an average of once every five years. The town of Bronte has experienced severe damage from floodwater on an average of once every twelve years.

The most damaging flood in recent years occurred August 19, 1953. This floc inundated 4,153 acres of agricultural flood plain and 65 blocks, 205 acres, in the urban area of Bronte causing an estimated $280,720 direct floodwater damage, of which approximately $141,000, 1953 price levels, was to the urban area of Bronte.

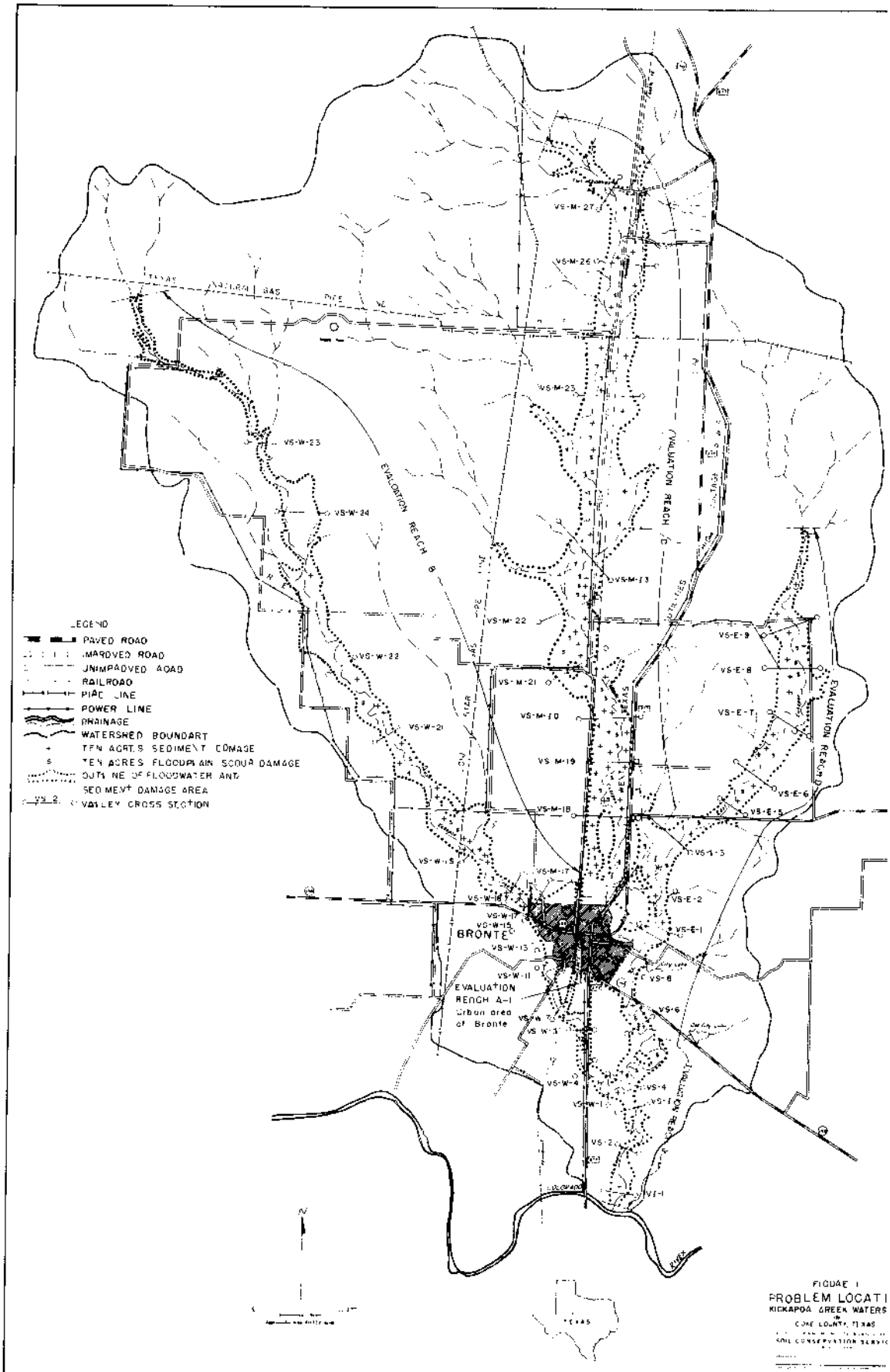


FIGURE 1

PROBLEM LOCATI

KICKAPOO CREEK WATERS

IN

COKE COUNTY, TEXAS

SOIL CONSERVATION SERVIC

White hatching shows urban area of Bronte inundated by flood of August 19, 1953

The same area would he inundated, but to a greater depth, by a 100-year frequency flood.

After installation of planned land treatment measures and floodwater retarding structures, the urban area will be flood-free from floods of 100-year frequency.

Panhandle and Santa Fe Railroad track washed out following the flood of August 18-19, 1953.

Fence and sediment damage following flood of August 18 and 19, 3 miles north of Bronte, Texas.

For the floods expected to occur during the evaluation period, the total direct floodwater damages were estimated to average $28,405 annually, at long-term price levels, of which $4,770 is crop and pasture damage, $3,993 is other agricultural damage, $8,733 is nonagricultural damage to transportation facilities and $10,909 is urban damage.

Indirect damages such as interruption of travel and rail shipments, rerouting of school bus and mail routes, losses sustained by businesses in the area, and similar losses are unusually heavy in this watershed because of the concentration of damageable values in the flood plain and the unusu high incidence of damage to transportation facilities. The average annual value of these indirect damages is estimated to be $5,222.

Sediment Damage

Overbank deposition of sandy loam, which is low in organic matter and fert ity, results mainly from upland erosion. These deposits range in depth fr 2 to 12 inches and have reduced the productive capacity of 1,031 acres of flood plain land (figure 1). It is estimated that 270 acres are damaged 1(percent; 615 acres, 20 percent; and 146 acres, 30 percent. This amounts t an average annual monetary damage of $3,210 at long-term price levels. A summation of the estimated average annual sediment yields above the 6 planned floodwater retarding structures is 36.96 acre-feet.

The estimated average annual rate of sediment accumulation in the floodwate retarding structure pools is 1.4 acre-feet per square mile of watershed area.

Erosion Damage

Sediment source studies indicate that erosion rates are moderate, with no critical sediment source areas existing. There are, however, some areas of very active streambank and gully erosion, the most severe of which is approximately one-half mile on Middle Kickapoo Creek near Fort Chadbourne.

Sheet erosion accounts for approximately 67 percent of the annual gross erosion, gully erosion 8 percent, streambank erosion 5 percent, and flood plain scour 20 percent. The average annual rate of upland gross erosion under present conditions is 2.84 acre-feet per square mile.

Flood plain scour damage is moderate in extent. It is estimated that the productive capacity of 417 acres has been damaged by this process as follow 319 acres, 10 percent; 70 acres, 20 percent; and 28 acres, 30 percent. Thi represents an average annual monetary damage of $957 at long-term price lev

Problems Relating to Water Management

There is no activity relative to drainage or irrigation in the watershed. No individual landowners or group of landowners or municipality has indicated an interest in including measures for agricultural or nonagricultura water management purposes.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

The watershed is served by the Soil Conservation Service Work Unit at Robe Lee, Texas. This work unit has assisted farmers and ranchers in preparing 68 soil and water conservation plans on 26,770 acres (70 percent of the agricultural land) within the watershed and has given technical assistance in establishing and maintaining planned measures. Approximately 58 percer of the planned measures have been applied.

Efforts to control or prevent flooding of agricultural lands in the waters have been minor. Some attempts have been made to enlarge or straighten th stream channels of both West Kickapoo and Middle Kickapoo Creeks in Bronte but these efforts have had little appreciable effect on the reduction of flood damage.

There are no other existing or proposed works of improvement in this wate shed which will affect, or be affected by, the works of improvement includ in the plan.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures for Watershed Protection

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Coke Soil Conservation District is necessary for a sound watershed protection and flood preventio program on the watershed. Basic to reaching this objective is the establi ment and maintenance of all applicable soil and water conservation and pla management practices essential to proper land use. Emphasis will be place on the establishment of land treatment practices which have a measurable effect on the reduction of floodwater, sediment, and erosion damages.

Of the total watershed area of 40,732 acres, 20,832 acres lie above planne floodwater retarding structures. Land treatment is especially important f protection of these watershed lands to support and supplement the structur measures. Land treatment constitutes the only planned measures for the remaining upland area. Land treatment measures on the 4,525 acres of agricultural land within the flood plain are important in reducing floodwater, sediment and erosion damage. This acreage excludes the flood plain area inundated by the pools of the planned floodwater retarding structures and 205 acres of urban area in the City of Bronte.

The amounts and estimated costs of the measures that will be installed by the landowners and operators are shown in table 1. The estimated total cos of planning and installing these measures is $273,540. This cost is to be borne by other than P. L. 566 funds and includes expected reimbursements from ACPS, based on current program criteria, and $9,440 to be spent by the Soil Conservation Service in providing technical assistance under its going program to the district during the project installation period. It is not expected that any additional technical assistance, above the going program,

TABLE I - ESTIMATED PROJECT INSTALLATION COST 1/

Kickapoo Creek Watershed, Texas
Price Base: 1960

Installation Cost Item	Unit	Number to be Applied Non-Federal Land	Estimated Cost Public Law 566 Funds (dollars)	Estimated Cost Other Funds (dollars)	Total (dollars)
LAND TREATMENT FOR					
Watershed Protection					
Soil Conservation Service					
Conservation Cropping System	cre	7,000	-	NC	NC
Contour Farming	Acre	9,000	-	13,500	13,500
Contour Strip Cropping	Acre	500	-	1,000	1,000
Cover Cropping	Acre	7,500	-	60,000	60,000
Crop Residue Use	Acre	7,500	-	15,000	15,000
Rotation, Hay and Pasture	Acre	2,500	-	12,500	12,500
Waterway Development	Acre	30	-	1,200	1,200
Pasture Planting	Acre	250	-	1,500	1,500
Rotation Grazing	Acre	250	-	1,250	1,250
Stubble Mulching	Acre	3,000	-	6,000	6,000
Brush Control	Acre	5,000	-	50,000	50,000
Deferred Grazing	Acre	20,000	-	12,000	12,000
Proper Use	Acre	20,250	-	20,250	20,250
Range Seeding	Acre	4,000	-	32,000	32,000
Diversion Construction	Mile	2	-	1,300	1,300
Farm Ponds	No.	25	-	25,000	25,000
Terraces-Level	Mile	40	-	6,800	6,800
Pitting	Acre	600	-	1,200	1,200
Net Wire Diversions	Mile	4	-	3,600	3,600
Technical Assistance			-	9,440	9,440
SCS Subtotal			-	273,540	273,540
TOTAL LAND TREATMENT				273,540	273,540
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	6	606,407	-	606,407
SCS Subtotal			606,407	-	606,407
Subtotal - Construction			606,407	-	606,407
Installation Services					
Soil Conservation Service					
Engineering Services			109,153	-	109,153
Other			47,227	-	47,227
SCS Subtotal			156,380	-	156,380
Subtotal - Installation Services			156,380	-	156,380
Other Costs					
Land, Easements, and Rights-of-Way			-	20,700	20,700
Administration of Contracts			-	3,000	3,000
Subtotal - Other			-	23,700	23,700
TOTAL STRUCTURAL MEASURES			762,787	23,700	786,487
TOTAL PROJECT			762,787	297,240	1,060,027
SUMMARY					
Subtotal SCS			762,787	297,240	1,060,027
TOTAL PROJECT			762,787	297,240	1,060,027

1/ No Federal land in watershed.

will be necessary to keep land treatment in balance with structural dev ment. Landowners and operators will maintain land treatment measures i accordance with provisions of the farmer-district cooperative agreement with the Coke Soil Conservation District.

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

Range grasses making good recovery following brush control and deferred grazing.

Planting of Weeping Lovegrass, KR Bluestem, Sideoats Grama and Blue G made in spring of 1951. Excellent growth made in spite of extremely weather in 1952 and first 6 months of 1953. Austin Sandusky farm 3 m northwest of Bronte, Texas.

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

Structural Measures for Flood Prevention

A system of 6 floodwater retarding structures will be installed to aff the needed protection to flood plain lands and urban areas which cannc

provided by land treatment measures alone.

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

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

This system of structures will temporarily detain runoff from 51 percent of the entire watershed. The 6 floodwater retarding structures will have a total floodwater detention capacity of 6,616 acre-feet and will tempora: ily detain an average of 3.81 inches of runoff from the watershed area above them. This is the equivalent of 1.95 inches of runoff from the ent: 40,732 acre watershed.

Floodwater retarding structures 1 through 5 will temporarily detain runof: from 65.5 percent of the watershed area which contributes directly to flo damage to the urban areas of Bronte. The floodwater detention capacity, 5,993 acre-feet, of the 5 structures is the equivalent of 2.71 inches of runoff from the area above Bronte.

The system of 6 structures in combination with the existing channel carry· ing capacities will afford the desired protection for the flood plain lan including the urban areas in Bronte.

The total estimated cost of establishing these works of improvement is $786,487 of which $23,700 will be borne by local interests and $762,787 b P. L. 566 funds (table 1). The average annual equivalent cost is estimate to be $27,730 for installation and $990 for operation and maintenance, mal a total annual cost of $28,720.

Sufficient detention storage is available at all structure sites to make possible the use of vegetative spillways, thereby effecting a substantial reduction in cost over concrete or similar types of spillways.

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

BENEFITS FROM WORKS OF IMPROVEMENT

With the installation of the combined program of land treatment and struc- tural measures, the estimated average annual monetary floodwater, sediment flood plain erosion and indirect damages within the watershed will be redu from $37,794 to $3,837, a 90 percent reduction. About 93 percent of the expected reduction will result from the system of floodwater retarding str tures.

Average annual flooding will be reduced from 1,375 acres to 409 acres. Th urban area of Bronte will be flood-free from all storms up to a 100-year frequency event.

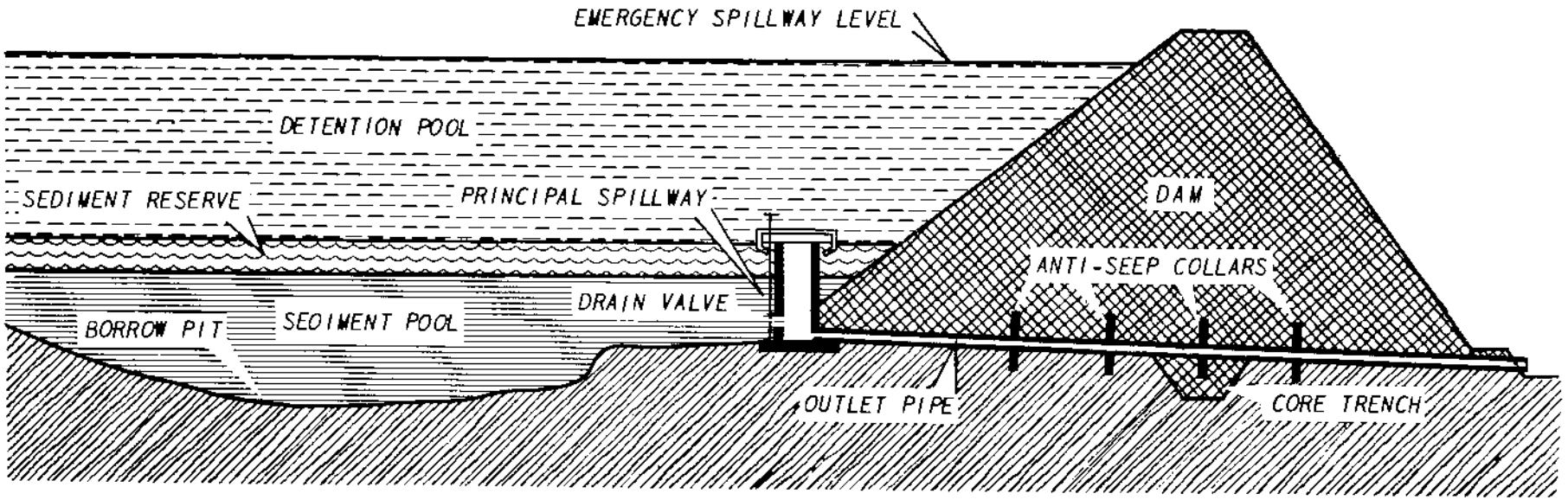


Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Revised 10-24-57 4-L-10,071

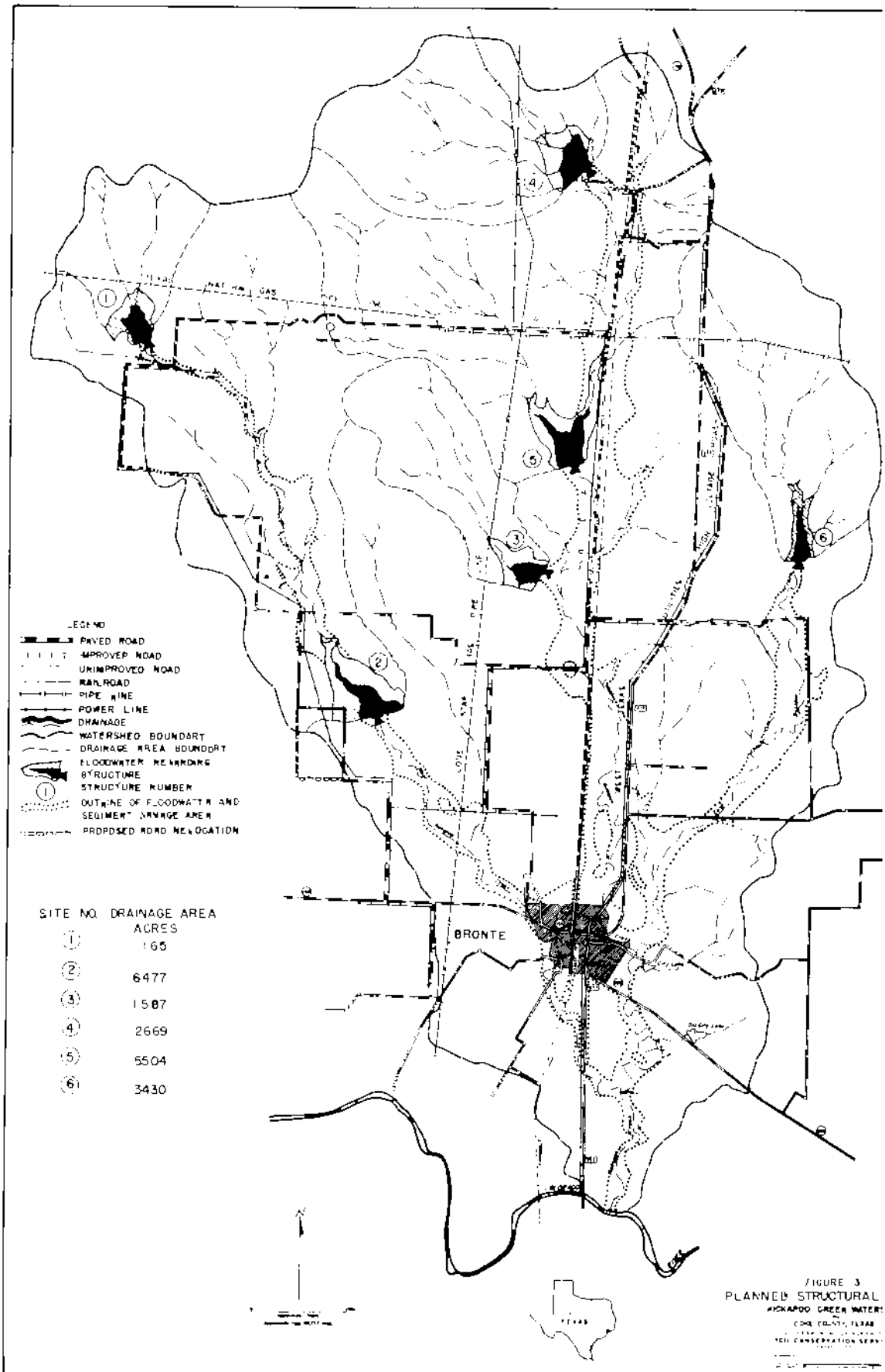


FIGURE 3
PLANNED STRUCTURAL

The area on which sediment damage from overbank deposition will occur annually is expected to be reduced from 1,031 to 220 acres, a reduction of 79 percent. About 18 percent of the expected reduction will result from land treatment and 82 percent from the structural measures.

The area on which flood plain scour damage will occur is expected to be reduced from 417 acres to 112 acres, a reduction of 73 percent.

After construction of Site 4, the approximately one-half mile of severe streambank erosion on Middle Kickapoo Creek near Fort Chadbourne will be materially reduced.

With the planned land treatment measures installed, it is estimated that the annual gross erosion in the watershed will be reduced from 190 to 141 acre-feet per year and the sediment production from upland areas will be reduced approximately 11 percent.

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

Average Annual Area Inundated

Evaluation Reach (figure 1)	Location	Without Project (acres)	With Project (acres)	Reduction (percent)
A	Kickapoo Creek Below Bronte	176	80	55
A-1	Bronte Urban Area	16	0	100
B	West Kickapoo Creek	294	120	59
C	Middle Kickapoo Creek	568	106	81
D	East Kickapoo Creek	321	103	68
	Total	1,375	409	70

Average Annual Damages

Evaluation Reach (figure 1)	Location	Without Project (dollars)	With Project (dollars)	Reduction (percent)
A	Kickapoo Creek Below Bronte	1,036	264	75
A-1	Bronte Urban Area	13,091	0	100
B	West Kickapoo Creek	4,671	1,011	78
C	Middle Kickapoo Creek	14,776	1,350	91
D	East Kickapoo Creek	4,220	1,212	71
	Total	37,794	3,837	90

Area Inundated by 50-Year Frequency Storm 1/

Evaluation Reach (figure 1)	Location	Without Project (acres)	With Project (acres)	Reductio (percent)
A	Kickapoo Creek Below Bronte	462	338	27
A-1	Bronte Urban Area	205	0	100
B	West Kickapoo Creek	939	503	46
C	Middle Kickapoo Creek	1,997	851	57
D	East Kickapoo Creek	755	483	36
	Total	4,358	2,175	50

1/ Approximately same magnitude as storm of August 19, 1953.

Direct Floodwater Damage by 50-Year Frequency Storm 1/

Evaluation Reach (figure 1)	Location	Without Project (dollars)	With Project (dollars)	Reducti (percen
A	Kickapoo Creek Below Bronte	7,472	1,507	80
A-1	Bronte Urban Area	159,087	0	100
B	West Kickapoo Creek	21,345	5,051	76
C	Middle Kickapoo Creek	113,022	6,856	94
D	East Kickapoo Creek	9,044	4,322	52
	Total	309,970	17,736	94

1/ Approximately same magnitude as storm of August 19, 1953.

The total flood prevention benefits as a result of structural measures ar estimated to be $31,432 annually.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (converted from total stallation cost, plus operations and maintenance) is estimated to be $28, The structural measures are expected to produce average annual benefits o $31,432 or $1.09 for each dollar of cost. In addition to the direct mone benefits, there are other substantial values which will accrue from the p ject such as an increased sense of security, better living conditions, an increased opportunity for recreation, and improved wildlife conditions, n of which have been used for project justification.

The benefits of land treatment measures were not evaluated in monetary terms since experience has shown that these soil and water conservation measures produce benefits in excess of their costs.

ACCOMPLISHING THE PLAN

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

The cosponsors will be assisted in fulfilling their responsibilities by the Upper Colorado River Authority, Bronte Lions Club and Bronte Indepen dent School Board.

Land Treatment Measures

The land treatment measures itemized in Table 1 will be established by farmers and ranchers over a 5-year period in cooperation with the Coke Soil Conservation District, which is provided technical assistance by the Soil Conservation Service in the planning and application of these measures under its going program.

The governing body of the Coke Soil Conservation District with the assis ance of the Coke County Kickapoo Water Control and Improvement District No. 1 will assume aggressive leadership in advancing the land treatment program. The landowners within the watershed will be encouraged to adop and carry out soil and water conservation plans on their farms. Distric owned equipment will be made available to the landowners in accordance w existing arrangements for equipment usage in the district.

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

The county ASC Committee will cooperate with the governing body of the s conservation district by selecting and providing financial assistance fo those ACPS practices which will accomplish the conservation objectives i the shortest possible time.

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

Structural Measures for Flood Prevention

The Coke County Kickapoo Water Control and Improvement District No. 1 h the right of eminent domain under applicable State laws and will obtain the necessary land, easements and rights-of-way including the relocatio of utilities, roads, and improvements; will provide necessary legal, adm trative, and clerical personnel, facilities, supplies and equipment to advertise, award, and administer contracts; and will determine the lega adequacy of easements and permits for construction of the floodwater re ing structures. Funds for the local share of the project cost includin land, easements, rights-of-way, and administration of contracts, will be available from the existing special district tax and is adequate for th purposes.

The easements will be dedicated to the Coke County Kickapoo Water Contr and Improvement District No. 1. The Coke County Kickapoo Water Control and Improvement District No. 1 will provide for the necessary improvemer of low water crossings on private and public roads to make them passabl during prolonged release flows from the structures or obtain permission inundate road crossings where equal alternate routes are designated for during periods of inundation and will provide for the relocation of the public road affected by Floodwater Retarding Structure 2.

The 5 floodwater retarding structures on West and Middle Kickapoo Creek (Sites 1 through 5) constitute a single construction unit and all land, easements, and rights-of-way will be obtained before Public Law 566 fun are made available.

The one floodwater retarding structure on East Kickapoo Creek (Site 6) i a single construction unit and all land, easements, and rights-of-way wi be obtained before Public Law 566 funds are made available.

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

Fiscal Year	Measure	P. L. 566 Funds	Other Funds	Total
		(dollars)	(dollars)	(dollars)
1st	Sites 1 and 2	288,617	11,250	299,867
	Land Treatment	0	54,708	54,708
2nd	Sites 3 and 4	190,475	5,640	196,115
	Land Treatment	0	54,708	54,708
3rd	Sites 5 and 6	283,695	6,810	290,505
	Land Treatment	0	54,708	54,708
4th	Land Treatment	0	54,708	54,708
5th	Land Treatment	0	54,708	54,708
	Total	762,787	297,240	1,060,027

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

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

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

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

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

4. Arrangements are completed for relocating County road at Site 2.

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

6. Operation and maintenance agreements have been executed.

7. Project agreements have been executed.

8. Public Law 566 funds are available.

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

The various features of cooperation between the cooperating parties hav been covered in appropriate memoranda of understanding and working agre ments.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by landowners and operators the farms on which the measures are applied, under agreements with the Coke Soil Conservation District. Representatives of the soil conservation district will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform management practices and maintenance. They will make district-owned equipment available for this purpose.

Structural Measures for Flood Prevention

The 6 floodwater retarding structures will be operated and maintained b the Coke County Kickapoo Water Control and Improvement District No. 1. Funds for this purpose will come from the special district tax which is available and adequate for this purpose. The estimated average annual operation and maintenance cost of all structural measures is $990 based on long-term prices. The District will also establish a permanent reserve fund of $6,000 by setting aside a minimum of $200 per year per structure. This reserve fund will be kept available for abnormally costly maintenance activities that may result from excessive storms or other causes. When it becomes necessary to use any of the reserve fund for maintenance, the District will take appropriate action to replenish the fund at the minimum rate of $200 per structure per year.

All structural measures will be inspected at least annually and after each heavy rain by representatives of the Coke County Kickapoo Water Control and Improvement District No. 1 and Coke Soil Conservation Distr A Soil Conservation Service representative will participate in these in spections at least annually. For the floodwater retarding structures, items of inspection will include, but will not be limited to, the conditions of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill, the emergency spillway, and fences and gates installed as part of the flood water retarding structures.

The Soil Conservation Service, through the Coke Soil Conservation Distr will participate in operation and maintenance activities only to the ex tent of furnishing technical assistance.

Provisions will be made for free access of representatives of the co-sponsoring organizations and Federal agencies to inspect and provide ma tenance for all structural measures and their appurtenances at any time.

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

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

The necessary maintenance work will be accomplished either by contract, force account, or equipment available to Coke County Kickapoo Water Cor trol and Improvement District No. 1.

COST SHARING

Land treatment measures will be installed through funds other than Publ Law 566 at an estimated cost of $273,540 (table 1). This cost includes ACPS payments based on present program criteria and technical assistance under the going district program. The required local costs for structural measures consisting of the value of the land, easements, and rigl of-way including the relocation of utilities, roads, and improvements ($20,700), and the cost of administering contracts ($3,000), are estima at $23,700.

The entire construction cost for structural measures, amounting to $60(will be borne by Public Law 566 funds. In addition, the installation services cost of $156,380 will be a Public Law 566 expense. This is a total Public Law 566 cost of $762,787 for the installation of structurs measures.

The total project cost of $1,060,027 will be shared 72.0 percent ($762, by Public Law 566 funds and 28.0 percent ($297,240) by other than Publi Law 566 funds.

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

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

SECTION 2

INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Project Formulation

Project Objectives

Flood problems were discussed with representatives of the Coke Soil Conservation District, the Coke County Kickapoo Water Control and Improvement District No. 1, the City of Bronte, and the Coke County Commissioners Court. The project objectives desired by the local co-sponsoring organizations were to provide flood-free protection to the urban area of Bronte from a storm such as occurred on August 19, 1953, and to provide a degree of flood protection that would result in a reduction of existing damages to other than the urban area, an average of at least 75 percent.

Subsequent hydrologic investigations revealed that the August 19, 1953 storm approximated 50-year frequency occurrence. To meet the criteria as set forth in Section 21, Watershed Protection Handbook, it was determined that the possibility of providing protection to Bronte from a 100-year frequency occurrence would be investigated.

Land Treatment Measures

The status of land treatment measures for the watershed was developed b the Coke Soil Conservation District assisted by personnel from the Soil Conservation Service at Robert Lee. Conservation needs data were compi from existing conservation plans within the watershed and expanded to represent the conservation needs of the entire watershed. The quantity each land treatment practice which contributes directly to flood preven that will be applied during the 5-year installation period was estimate (table 1). The hydraulic, hydrologic, sedimentation, and economic inve gations provided data as to the effects of these measures in terms of t reduction of flood damages resulting from land treatment. Although sig cant benefits would result from application of these needed land treatn measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by the local people.

Structural Measures

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

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, system of roads, and other pertinent information. A stereoscopic study of 4-inch consecutive aerial photographs was used to locate all probable floodwater retarding structure sites, the limits of the flood plain, and the points at which valley cross sections should be surveyed to develop data for the determination of hydraulic characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys. Cross sections of the stream channels and flood plain were surveyed at the selected locations. Data developed from these cross sections permitted the computation of peak discharge-damage relationships for various flood flows. A map was prepared of the flood plain on which land use, cross section locations, and other pertinent information were recorded.

2. A field examination was made of all probable floodwater retarding structure sites previously located stereoscopically. Sites which did not have sufficient storage capacities or economic feasibility were dropped from further consideration. From the remaining sites, a system of floodwater retarding structures was selected for further consideration and detaile survey. Site 1 is in series with Site 2 and Site 4 is in series with Site 5. These series of sites are necessary because of the limited storage at Sites 2 and 5, and alternat sites with adequate storage are not available to provide the needed degree of control to effect the desired level of damag reduction. Plans of a floodwater retarding structure, typica of those planned for the watershed, are illustrated by figure 4 and 4A.

3. A topographic map was made of the pool, dam, and spillway are of each of the proposed sites to determine the storage capaci of the site, the estimated cost of the dam including spillway limits of the pool areas, and the area involved in the dam an spillway. The height of the dams and the size of the pools were determined by the criteria outlined in Washington Engine ing Memorandum, SCS 27 and Texas State Manual Supplement 2441. The limits of the detention and sediment pools of the propose floodwater retarding structures and the flood plain of the st were drawn to scale on a copy of the base map.

   Structure data tables were developed to show for each structu the drainage area, the capacity needed for floodwater detentic and for sediment storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spil way, the acres of flood plain and upland inundated by the sedi ment and detention pools, the volume of fill in the dams, the estimated cost of the structures, and other pertinent data (tables 2, 3, and 5).

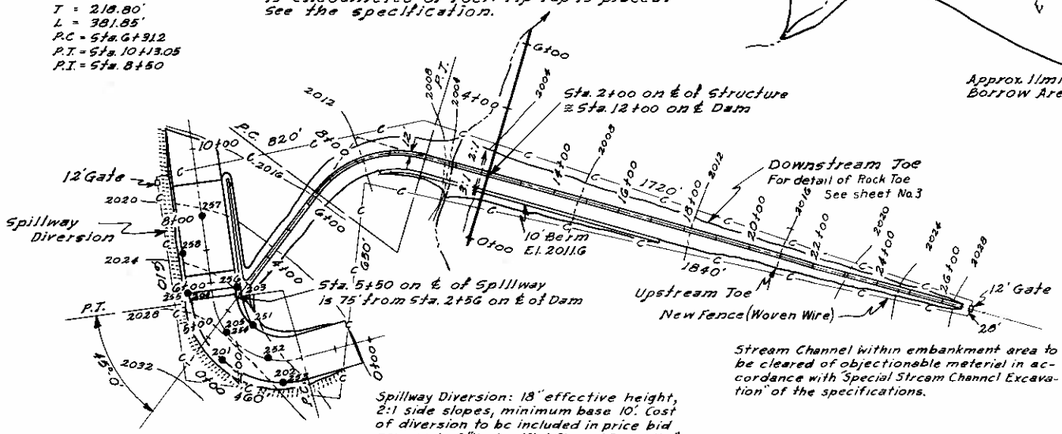
Clay
Silt
Limestone
Flagstone & Cobbles
Lime

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

LEGEND OF BORINGS

EMBANKMENT CURVE DATA
Δ = 69°-0'
D = 18°04.3'
R = 318.3G'
T = 218.80'
L = 381.85'
P.C. = Sta. G+91.2
P.T. = Sta. 10+13.05
P.I. = Sta. 8+60

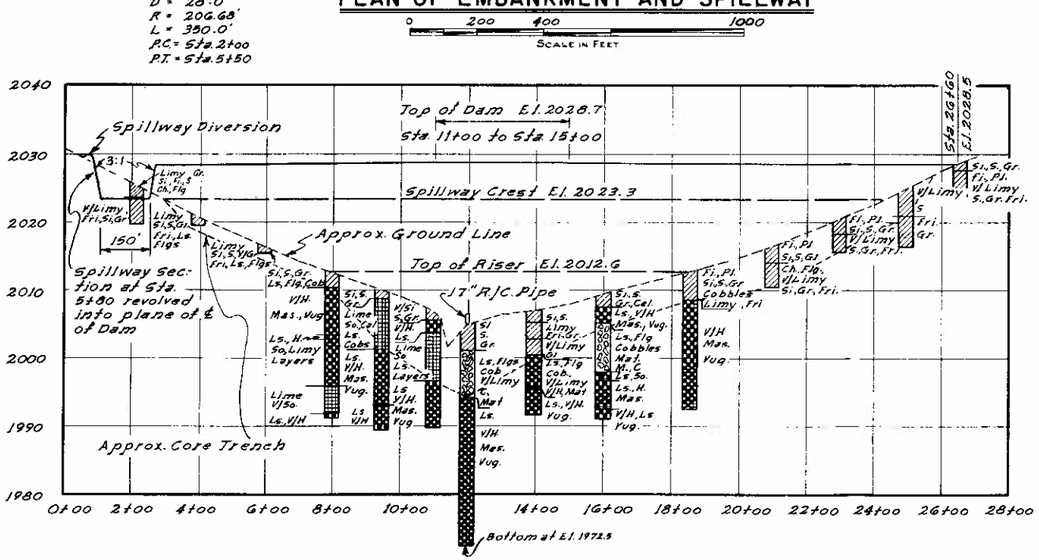
A minimum of G" of topsoil to be placed in spillway and on all embankment, dike, spillway slopes and waste area except where rock is encountered or rock rip rap is placed. See the specification.



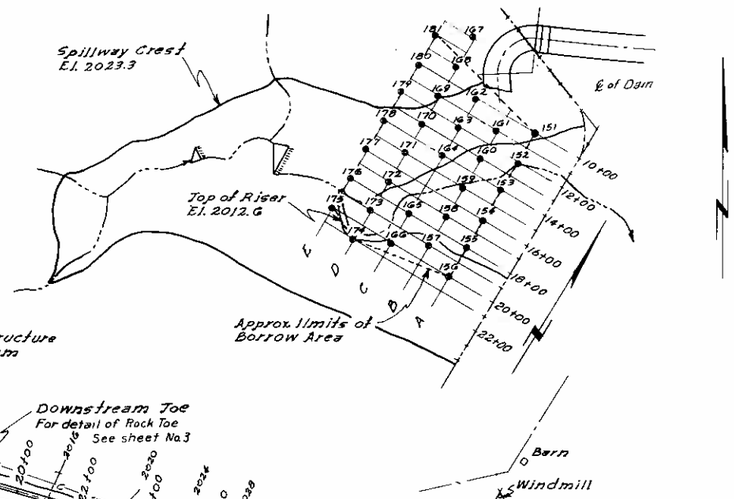
SPILLWAY CURVE DATA
Δ = 98°-0'
D = 28°-0'
R = 20G.GG'
L = 350.0'
P.C. = Sta. 2+00
P.T. = Sta. 5+50

PLAN OF EMBANKMENT AND SPILLWAY

0 200 400 1000
SCALE IN FEET

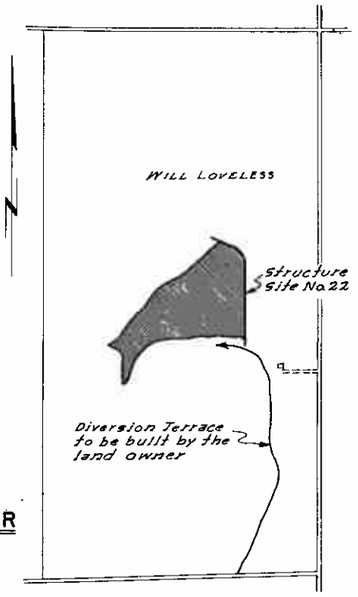


PROFILE ON ℄ OF DAM



GENERAL PLAN OF RESERVOIR

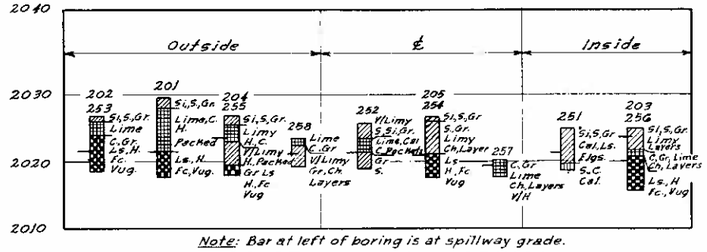
0 400 800 1600
SCALE IN FEET



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

VICINITY MAP

0 ¼ ½ 1
SCALE IN MILES



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

LOG OF SPILLWAY BORINGS

SEE PLAN OF EMBANKMENT AND SPILLWAY

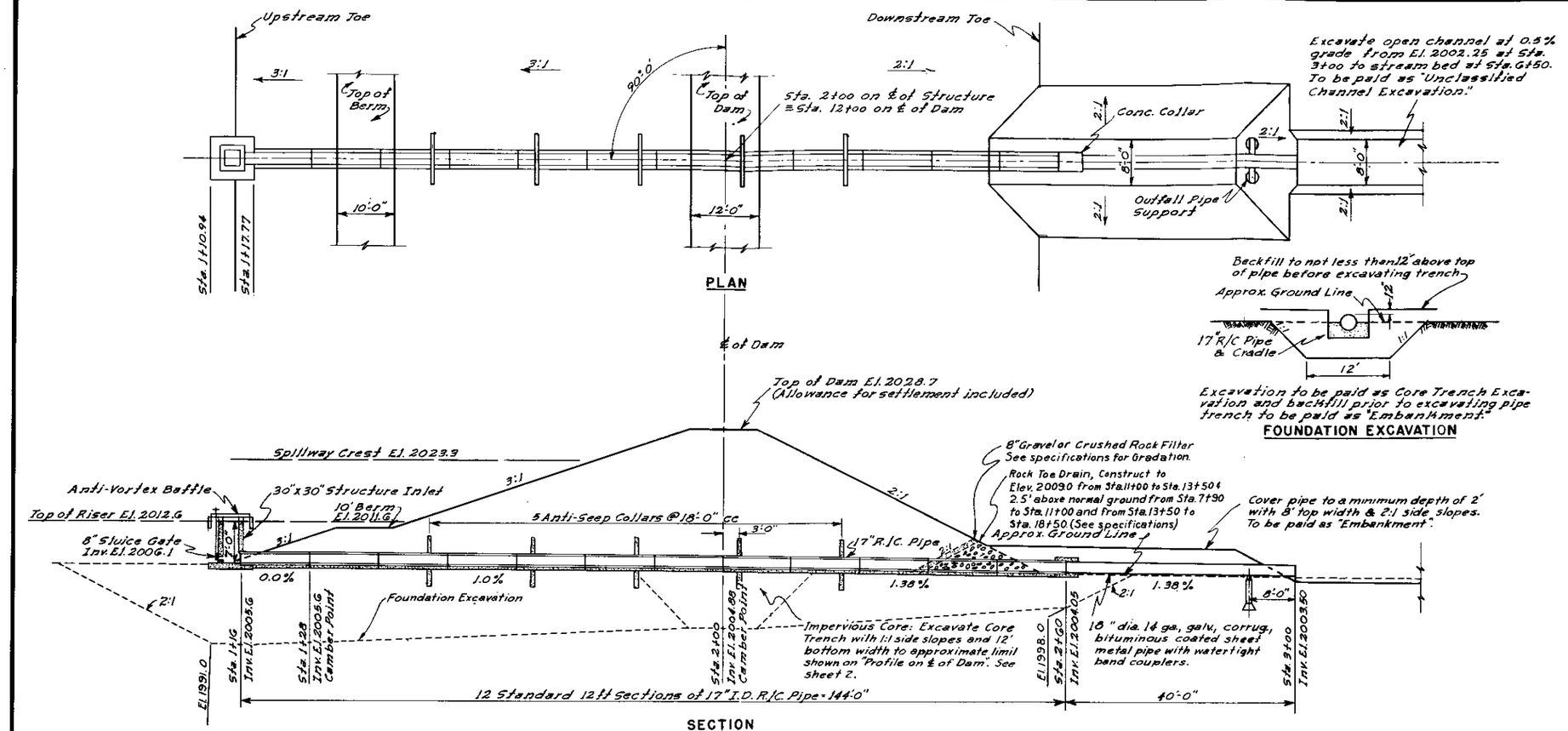
Elevation	Surface Acres	Storage Acre Ft.	Storage Inches
2012.G	16.84	51.70	0.50
2016.0	30.7G	132.GG	1.28
2020.0	54.21	302.GO	2.92
2023.3	74.94	515.G8	5.00
2024.0	79.33	569.G8	5.50
2028.0	108.17	944.G8	9.13

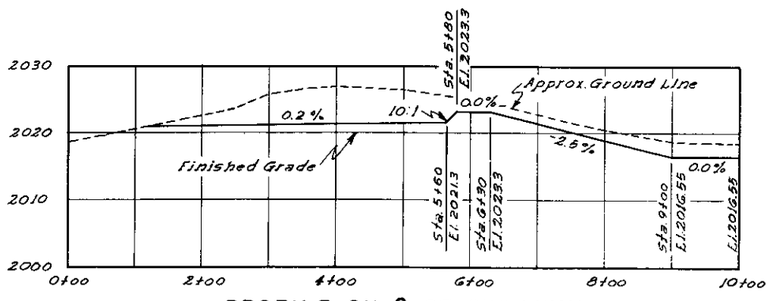
Top of Dam (Effective) Elev.	2028.5
Spillway Crest Elev.	2023.3
Top of Riser Elev.	2012.G
Sediment Pool Elev.	2012.G
Drainage Area, Acres	1242.0
Sediment Storage, Ac. Ft.	51.7
Floodwater Storage, Ac. Ft.	464.0

Figure 4
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND PROFILE

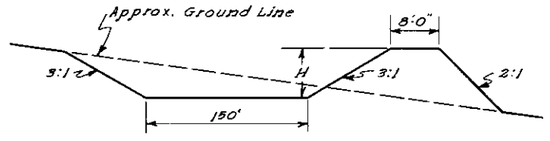
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	H.C.N.	Date 8-56	Approved by: W.M.
Drawn	H.C.N. & G.R.	8-56	FORT WORTH, TEXAS
Traced	G.R.	8-56	STATE CONSERVATION ENGINEER
Checked	H.C.N & H.H.L.	9/56	TEMPLE, TEXAS
		Sheet No 2 of 7	Drawing No 4-E-10,760





PROFILE ON ℄ OF SPILLWAY



Top of Dike, El. 2028.55 from Sta. 5+00 to Sta. 6+30 12 ft. top width with 10:1 end slope. Transition from El. 2028.55 at Sta. 6+30 to 4 ft. height at Sta. 7+00, top width 8 ft. H = 4 ft. from Sta. 7+00 to Sta. 9+00, top width 8 ft. with 10:1 end slope.

TYPICAL SPILLWAY SECTION

Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.C.N.	8-56	Approved by	
Drawn H.C.N. & G.R.	8-56		
Traced G.R.	8-56	Sheet No. 3 of 7 sheets	Drawing No. 4-E-10,760
Checked H.C.N. & H.H.L.	8/56		

4. A detailed investigation was made of county and farm roads having low-water crossings on the 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 structures were determined.

5. Damage resulting from floodwater, sediment, and erosion were determined from damage schedules, surveys of sample areas, and flood routings under present conditions and adjusted in consideration of future economic development without the project. Reductions in these damages resulting from the propose works of improvement were estimated on the basis of reduction in sediment yields and in reduction of peak discharges as determined by flood routings under future conditions for whic it was assumed that the proposed works of improvement had bee installed. Benefits so determined were allocated to individu measures or groups of interrelated measures on the basis of the effects of each on reduction of damages. In this manner it was determined that floodwater retarding structures could be economically justified. By further analysis those individ and interdependent floodwater retarding structures which had favorable benefit to cost ratios were determined. Those whic were unfavorable were dropped from further consideration and alternate sites were investigated until the most economical system of floodwater retarding structures was developed which would provide the degree of protection desired by the sponsor ing local organizations and meet the requirements of Section of the Handbook. This system consisted of five interrelated floodwater retarding structures necessary to provide the desi degree of protection for the urban area of Bronte and one ind pendent floodwater retarding structure necessary to provide protection to the flood plain of East Kickapoo Creek.

When the structural measures for flood prevention had been determined, table was developed to show the cost of each type of measure. The sum tion of the total costs for all works of improvement represented the estimated cost of the planned watershed protection and flood preventio project (table 1). A second cost table was developed to show separate the annual installation cost, annual maintenance cost, and total annua cost of the structural measures (table 6).

Hydraulic and Hydrologic Investigations

The following steps were taken as part of the hydrologic investigation determinations:

1. Basic meterologic and hydrologic data were tabulated from Climatological Bulletins, U. S. Weather Bureau and Water Supply Papers, U. S. Geological Survey. These data were analyzed to determine average precipitation depth-duration relationships, seasonal distribution of precipitation,

rainfall-runoff relationships, runoff-peak discharge relatio ship and the relationship of geology, soils and climate to runoff depth-frequency for single storm events.

2. Engineering surveys were made to collect information on selected stream reaches, including valley cross sections, channel capacities, high water elevations of selected storms, bridge capacities and other hydraulic characteristic and on proposed floodwater retarding structure sites to collect data used in design. The cross sections and evaluation reaches were selected on the ground in conference with the economist and sedimentation specialist.

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

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

5. The period 1923 through 1958 was selected as the most representative of normal precipitation on the watershed, and is the period from which the annual runoff frequency line for evaluation was developed.

6. Reference valley cross sections W-17, West Kickapoo, and M-18 Middle Kickapoo, were used to determine the frequency at which urban flooding of Bronte would begin from these two streams. Urban flooding begins at both reference sections at a runoff frequency of 12 years or an 8.5 percent chance storm For reference section W-17 this is 8,500 cubic feet per secon and for section M-18 this is 9,990 cubic feet per second.

7. It was determined that 0.09 inch of runoff was the minimum volume that would produce flooding to a depth that would caus damage at the smallest channel cross-section. Therefore no runoff of less than 0.09 inches was considered for flood rout ing purposes. This amount of runoff would be produced by 1.9 inches of rainfall under moisture condition I, 0.97 inch unde moisture condition II, and 0.39 inch under moisture condition III. Runoff of 0.09 inch would produce a discharge of 200 cubic feet per second at the minimum valley cross section (E- This would produce a discharge of 495 cubic feet per second a reference valley cross section 2 which is located approximate 0.50 mile north of the confluence of Kickapoo Creek and the Colorado River. The channel capacity at the reference sectio is 4,400 cubic feet per second.

From the runoff frequency data developed, the 100-year frequency runoff of 6.60 inches would inundate, under present conditions, 5,204 acres of flood plain. This is the flood plain area. Of this 5,204 acres, 205 acres is in urban area.

8. Stage-area inundation curves were developed from field survey data for each portion of the valley represented by a cross section in the agricultural evaluation reaches (Reaches A, B, C, and D)) Area inundated, by incremental depth of flooding, was determined for each agricultural evaluation reach by routing volumea of runoff for selected frequencies using the peak discharge-volume relationship and summating the area flooded for each portion of the valley represented by a valley cross section.

9. The area, by depth increments, that would have been inundated by the selected frequency flood events was determined for:

   a. Present condition.

   b. With land treatment measures applied.

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

   d. With alternate system of structures.

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

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

12. Emergency spillway capacities were determined in accordance with Washington Engineering Memorandum SCS 31 (Rev.), Technical Release No. 2 (Tentative), Washington Deaign Section, Dated October 1, 1956; Supplement A to Tentative Technical Release No. 2, dated May 13, 1957; Section 3.21, NEH, Section 4, Supplement A; and Texas State Manual Supplement 2441.

13. Maximum release rates for the principal spillways of the floodwater retarding structures were determined by a detailed study of the stream channel, and the effect of release rates on the design of structures and emergency spillways. The maximum release rates will be 10 csm for all structures.

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

Structure Number	Structure Classification	Minimum Floodwater Detention Required 1/ (inches)	Actual Floodwater Detention Planned (inches)
1	A	2.32	5.11
2	B	3.06	3.99
3	B	3.57	4.89
4	B	3.27	4.53
5	B	3.00	3.68
6	A	1.92	2.18

1/ For Class A Structures; 25-year frequency based on regional analy of gaged runoff.

For Class B Structures; 50-year frequency based on regional analy of gaged runoff.

Detention volumes in excess of the minimum established by the criteri Texas State Manual Supplement 2441 were used for Sites 1, 2, 3, 4, an in order to provide adequate protection for urban areas from a storm 100-year frequency magnitude. The detention storage used in Site 5, addition to affording the necessary urban protection, obtained a more economical structure design. Detention volume in excess of the minim requirement for Site 6 was used in order to obtain a more economical structure design.

Sedimentation Investigations

Sedimentation investigations for the work plan were made in accordanc with procedures as outlined in Watershed Memorandum EWP-7, "Sedimenta Investigations in Work Plan Development", August 21, 1959, Fort Worth Texas.

Sediment Source Studies

Sediment source studies to determine the 50-year sediment storage req ments were made in the drainage areas of the 6 planned floodwater ret ing structures according to the following procedures:

1. Detailed investigations were made in the drainage areas above 4 of the planned floodwater retarding structures. Estimates of sediment rates were made for the remaining 2 planned structures based on similarity of these drainage areas to areas which had been surveyed in detail.

2. Field surveys for detailed investigations included:

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

   b. Determining the lengths, depth, and estimating the annual lateral erosion of all gullies and stream channels affected by erosion.

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

3. Office computations included summarizing erosion by sources (sheet, gully, and streambank) in order to fit these data into formulas for computation of the annual gross erosion in tons. Sediment rates for structures were determined by adjusting annual gross erosion for expected delivery rates and trap efficiency.

4. The sediment rates were adjusted to reflect the effect of expected land treatment on the drainage areas of the planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the installation of the needed land treatment measures expected to be installed during the first 5 years and maintained at 75 percent effectiveness during the next 45 years.

5. The estimated ratio of sediment storage volume in the sediment pools to soil in place ranges from 1.3 to 1.5 for floodwater retarding structures in the watershed.

6. The allocation of sediment to the structure pools was based on 30 percent deposition in the detention pool and 70 percent in the sediment pool.

Flood Plain Sedimentation and Scour Damages

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

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

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

degradation or aggradation, were studied.

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

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

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

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

Geologic Investigations

Preliminary geologic investigations were made at all of the planned 1 water retarding structure sites and included lithologic and stratigraphic studies of the valley slopes, alluvium, channel banks, and ex posed geologic formations. Hand auger borings were made at all sites to obtain preliminary information on the nature and extent of embankm material, emergency spillway excavation, and possible problems that might be encountered in construction.

Description of Problems

All sites except Site 6 are located entirely within the San Angelo fc tion. Site 6 has its abutments in the San Angelo formation and the r mainder of the site underlain by strata of the Clear Fork group (undivided).

The estimated percent of rock excavation in the emergency spillways i as follows: Sites 1, 2, and 3, 0 percent; Site 4, 40 percent; Site 5 50 percent; and Site 6, 25 percent.

The soils for embankment purposes, as classified in accordance with Unified Soil Classification System, are primarily SM, ML, and CL. Small disturbed samples were taken during the preliminary investiga Laboratory analyses of these samples revealed low soluble salt cont and no critical dispersion.

Prior to construction, detailed investigations, including explorati with core drilling equipment, will be made at all floodwater retard structure sites. Laboratory tests will be made to determine the st ity of foundation strata and the suitability and methods of handlin the materials to be used in the embankment.

Economic Investigation

Determination of Annual Benefits from Reduction in Damage

Agricultural damage estimates were based on schedules obtained in th field covering approximately 46 percent of the flood plain of Kickap Creek and its tributaries. These schedules covered land use and crc distribution, yields and historical data on flooding and flood damag Most of the flood damage information obtained was for floods which occurred in 1953 and 1957.

The basic information on urban damages was derived from damage sched covering approximately 76 percent of the business establishments and 26 percent of the residential units in the urban area subject to flo water damage.

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

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

Evaluation Reach A - Agricultural flood plain from bottom of watershed upstream to valley cross sections, W-17, M-17, and E-1.

Evaluation Reach A-1-Urban Area of Bronte.

Evaluation Reach B - Flood Plain of West Kickapoo Creek above valley cross section W-17.

Evaluation Reach C - Flood plain of Middle Kickapoo Creek above valley cross section M-17.

Evaluation Reach D - Flood plain of East Kickapoo Creek above valley cross section E-1.

Farmers and ranchers in the flood plain were asked to state changes made in land use as a result of past flooding. Operators of flood lands also were asked what changes they would make in their use of flood plain if flooding were reduced. Their responses indicated th because of the type of farming enterprises in the area, the relativ infrequency of agricultural flooding, and the potentialities of the flood plain, such changes would be rather small. Therefore no bene fits from restoration or changed use of agricultural land were calc lated.

Areas that will be inundated by the sediment pools and detention po of floodwater retarding structures were excluded from damage calcul An estimate was made however, of the value of production lost in th areas after installation of the project. In this appraisal it was sidered that there would be no production in the sediment pools. Tl land covered by the detention pools was assumed to be converted to land under project conditions. The cost of land, easements, and ri of-way for the six floodwater retarding structures was determined b individual appraisal in cooperation with representatives of the spor ing organizations. Floodwater retarding structure site costs were on appraisals of the value of the easements with consideration of t values that will remain after the land is devoted to project purpose The average annual net loss in production, based on long-term prices within the sites was calculated and this value compared with the amc tized cost of the structure sites. The larger amount was used in th economic evaluation of the project to assure a conservative appraisa

Details of Methodology

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

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Kickapoo Creek Watershed, Texas
Price Base: 1960

Structure Number	Installation Cost - Public Law 566 Funds: Construction: Engineers Estimate	Construction: Contingencies	Instal. Services: Engineering	Instal. Services: Other	Total Public Law 566	Installation Cost-Other Funds: Adm. of Contracts	Easements and Rights-Of Way	Total Other	Total Installation Cost
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	62,164	6,216	12,308	5,325	86,013	500	1,290	1,790	87,803
2	146,425	14,643	28,992	12,544	202,604	500	8,960	9,460	212,064
3	45,246	4,525	8,959	3,876	62,606	500	1,920	2,420	65,026
4	92,413	9,241	18,297	7,918	127,869	500	2,720	3,220	131,089
5	159,210	15,921	31,524	13,639	220,294	500	3,940	4,440	224,734
6	45,821	4,582	9,073	3,925	63,401	500	1,870	2,370	65,771
TOTAL	551,279	55,128	109,153	47,227	762,787	3,000	20,700	23,700	786,487

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Kickapoo Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	Total
Drainage Area	Sq. Mi.	1.82	10.12 1/	2.48	4.17	8.60 1/	5.36	32.55
Storage Capacity								
Sediment Pool	Ac. Ft.	144	200	149	200	200	146	1,039
Sediment Reserve Below Riser	Ac. Ft.	0	118	0	109	346	0	573
Sediment in Detention Pool	Ac. Ft.	40	103	45	100	165	46	499
Floodwater Detention	Ac. Ft.	496	2,154	647	1,008	1,688	623	6,616
Total	Ac. Ft.	680	2,575	841	1,417	2,399	815	8,727
Surface Area								
Sediment Pool (top of riser)	Acre	25	75	38	54	102	38	332
Floodwater Detention Pool	Acre	74	256	124	168	262	99	983
Volume of Fill	Cu. Yd.	142,000	355,700	84,400	202,500	321,820	72,110	1,178,530
Elevation Top of Dam	Foot	2,065.2	1,899.6	1,882.8	2,000.8	1,914.7	1,922.0	xxx
Maximum Height of Dam	Foot	33	33	20	28	31	22	xxx
Emergency Spillway								
Crest Elevation	Foot	2,062.2	1,894.0	1,879.8	1,995.8	1,909.0	1,918.0	xxx
Bottom Width	Foot	140	430	430	230	400	400	xxx
Type	xxx	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 2/	xxx	1.0	1.0	1.0	1.0	1.3	2.8	xxx
Average Curve Number - Cond. II	xxx	80	77	80	79	78	77	xxx
Emergency Spillway Hydrograph								
Storm Rainfall (6 hr.)	Inch	5.87	8.06	8.88	8.51	7.94	5.61	xxx
Storm Runoff	Inch	3.67	5.32	6.45	5.99	5.35	3.14	xxx
Velocity of Flow (Vc) 3/	Ft./Sec.	0	4.6	3.2	3.5	4.6	3.5	xxx
Discharge Rate 3/	C.F.S.	0	1,281	425	315	1,272	546	xxx
Maximum Water Surface Elevation 3/	Foot	xxx	1,895.3	1,880.6	1,996.8	I,910.5	1,919.0	xxx
Freeboard Hydrograph								
Storm Rainfall (6 hr.) 4/	Inch	13.50	17.73	19.54	18.71	17.46	12.89	xxx
Storm Runoff	Inch	10.91	14.58	16.83	15.86	14.49	9.89	xxx
Velocity of Flow (Vc) 3/	Ft/Sec.	7.2	10.4	7.2	9.6	10.1	8.4	xxx
Discharge Rate 3/	C.F.S.	1,632	15,791	4,975	6,438	13,472	7,446	xxx
Maximum Water Surface Elevation 3/	Foot	2,065.2	1,899.6	1,882.8	2,000.8	1,914.7	1,922.0	xxx
Principal Spillway								
Capacity Low Stage	C.F.S.	18	119	25	42	128	54	xxx
Capacity Equivalents								
Sediment Volume	Inch	1.90	0.78	1.47	1.84	1.55	0.67	xxx
Detention Volume	Inch	5.11	3.99	4.89	4.53	3.68	2.18	xxx
Spillway Storage	Inch	2.54	3.03	3.24	4.43	3.77	1.67	xxx
Class of Structure	xxx	A	B	B	B	B	A	xxx

1/ Exclusive of area controlled by other structures. The entire drainage area considered in the emergency spillway design.
2/ Based on regional analysis of gaged runoff.
3/ Maximum during passage of the [illegible]

TABLE 4 - SUMMARY OF PHYSICAL DATA

Kickapoo Creek Watershed, Texas

Item	Unit	Quantity Without Project	Quanti With Proj
Watershed Area	Sq. Mi.	63,64	-
Watershed Area	Acre	40,732	-
Area of Cropland	Acre	11,200	11,058
Area of Rangeland	Acre	27,292	27,102
Area of Miscellaneous Use	Acre	2,240	2,572
Overflow Area Subject to Damage 1/	Acre	4,730 2/	2,567
Overflow Area Damaged by:			
Overbank Deposition	Acre	1,031 3/	220
Flood Plain Scour	Acre	417 3/	112
Annual Rate of Erosion:			
Sheet	Ac. Ft.	127	113
Gully	Ac. Ft.	15	11
Streambank	Ac. Ft.	10	10
Scour	Ac. Ft.	38	7
Average Annual Rainfall	Inch	18.64	-

1/ Area inundated by the runoff from a 1 percent chance storm event.

2/ Excludes 474 acres of flood plain within structure sites.

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

4/ The area on which production loss will occur each year after all recove has taken place and equilibrium has been reached.

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TABLE 5 - SUMMARY OF PLAN

Kickapoo Creek Watershed, Texas

Item	Unit	Quantity
Years To Complete Project	Year	5
Total Installation Cost		
Public Law 566 Funds	Dollar	762,787
Other	Dollar	297,240
Annual O & M Cost		
Public Law 566 Funds	Dollar	0
Other	Dollar	990
Average Annual Monetary Benefits 1/	Dollar	31,432
Agricultural	Percent	30
Nonagricultural	Percent	70
Structural Measures		
Floodwater Retarding Structures	Each	6
Area Inundated by Structures		
Flood Plain		
Sediment Pool	Acre	175
Detention Pool	Acre	299
Upland		
Sediment Pool	Acre	157
Detention Pool	Acre	352
Watershed Area Above Structures	Acre	20,832
Reduction of Floodwater Damage	Dollar	25,879
By Land Treatment Measures		
Watershed Protection	Percent	5.9
By Structural Measures	Percent	85.2
Reduction of Sediment Damage	Dollar	2,526
By Land Treatment Measures		
Watershed Protection	Percent	14.4
By Structural Measures	Percent	64.3
Reduction of Erosion Damage	Dollar	699
By Land Treatment Measures		
Watershed Protection	Percent	5.7
By Structural Measures	Percent	67.3

1/ From Structural Measures

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TABLE 6 - ANNUAL COST

Kickapoo Creek Watershed, Texas

Measures	Amortization of Installation Cost 1/ (dollars)	Operation and Maintenance Costs 2/ Other (dollars)	Operation and Maintenance Costs 2/ Total (dollars)	Total Annual Costs (dolla
Floodwater Retarding Structures				
1 through 5 3/	25,411	855	855	26,26
6	2,319	135	135	2,45
TOTAL	27,730	990	990	28,72

1/ Price Base: 1960 prices amortized for 50 years at 2.5 percent.

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

3/ Interrelated measures.

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TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES

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

Item	Estimated Average Annual Damage			Average Annual Monetar
	Without Project	After Land Treatment for W/S Protection	With Project	Benefit
	(dollars)	(dollars)	(dollars)	(dollar
Floodwater Damage				
Crop and Pasture	4,770	4,463	1,320	3,143
Other Agricultural	3,993	3,721	992	2,729
Nonagricultural				
Transportation	8,733	8,068	214	7,854
Urban	10,909	10,474	0	10,474
Subtotal	28,405	26,726	2,526	24,200
Sediment Damage				
Overbank Deposition	3,210	2,748	684	2,064
Subtotal	3,210	2,748	684	2,064
Erosion Damage				
Flood Plain Scour	957	902	258	644
Subtotal	957	902	258	644
Indirect Damage	5,222	4,893	369	4,524
Total, All Damages	37,794	35,269	3,837	31,432
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	31,432
TOTAL PRIMARY BENEFITS	xxx	xxx	xxx	31,432
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	31,432

1/ As projected by ARS, September 1957.

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TABLE 8 - BENEFIT COST ANALYSIS

Kickapoo Creek Watershed, Texas

Measures	AVERAGE ANNUAL BENEFITS 1/ Flood Prevention					Average Annual Cost 2/	Benefit Cost Ratio
	Floodwater	Sediment	Erosion	Indirect	Total		
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures							
1 through 5 3/	22,461	1,652	212	4,257	28,582	26,266	1.1:1
6	1,739	412	432	267	2,850	2,454	1.2:1
GRAND TOTAL	24,200	2,064	644	4,524	31,432	28,720	1.1:1

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

2/ Derived from installation costs based on 1960 price level and operation and maintenance cost based on long-term price levels, as projected by ARS, September 1957.

3/ Floodwater retarding structures Nos. 1 through 5 are interrelated.

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TABLE 8A - BENEFITS AND COSTS BY CONSTRUCTION UNITS

Kickapoo Creek Watershed, Texas

Construction Unit and Structures	Annual Benefits 1/ (dollars)	Annual Costs (dollars)
CONSTRUCTION UNIT No. 1		
Floodwater Retarding Structures 1 through 5	27,790	26,266
CONSTRUCTION UNIT No. 2		
Floodwater Retarding Structure 6	2,735	2,454

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

2/ Derived from installation costs based on 1960 price levels and operat and maintenance cost based on long-term prices, as projected by ARS, September 1957.

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