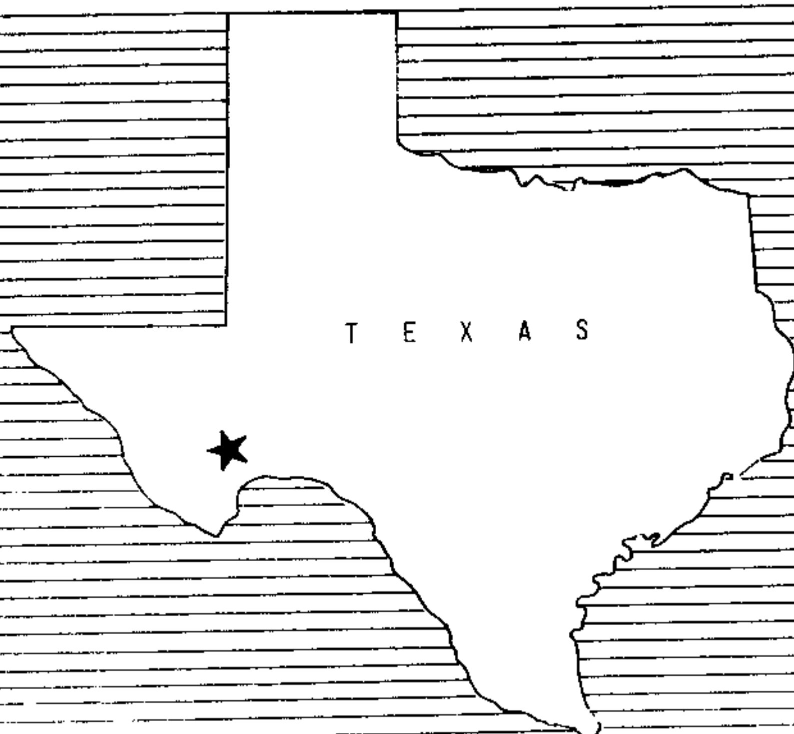
WATERSHED WORK PLAN

FOR WATERSHED PROTECTION,
AND FLOOD PREVENTION

SANDERSON CANYON WATERSHED

TERRELL, PECOS, AND BREWSTER COUNTIES, TEXAS



NOVEMBER 1969

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WATERSHED WORK PLAN AGREEMENT

between the

Rio Grande-Pecos River Soil and Water Conservation District
Local Organization

Big Bend Soil and Water Conservation District
Local Organization

Trans-Pecos Soil and Water Conservation District
Local Organization

Terrell County Commissioners Court
Local Organization

Pecos County Commissioners Court
Local Organization

Brewster County Commissioners Court
Local Organization

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

and the

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

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Sanderson Canyon Watershed, State of Texas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd 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 Sanderson Canyon Watershed, State of Texas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

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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 10 years.

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

1. The Sponsoring Local Organization will acquire without cost to the Federal Government such land rights as will be needed in connection with the works of improvement. (Estimated cost $ 79,455 .)

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

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
11 Floodwater Retarding Structures	-	100	3,550,281
Channel Improvement	-	100	197,036

4. The percentages of the engineering costs to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Engineering Costs (dollars)
11 Floodwater Retarding Structures	-	100	177,514
Channel Improvement	-	100	9,868

5. The Service, as duly requested by the Sponsoring Local Organization, will advertise, award, and administer contracts for structural measures. The Sponsoring Local Organization and the Service will each bear their costs for project administration, estimated to be $6,200 and $545,966 respectively.

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50 percent 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 is not a fund-obligating document. Financial and other assistance to be furnished by the Service in carrying out the watershed work plan are contingent on the appropriation of funds for this purpose.

A separate agreement will be entered into between the Service and the Sponsoring Local Organization before either party initiates work involving funds of the other party. 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.

14. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. 15.1-15.12), which provide that no person in the United States shall on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving Federal financial assistance.

Rio Grande-Pecos River Soil and Water Conservation District
Local Organization

By Will J. Murrah
Will J. Murrah

Title Chairman, Board of Directors

Address Sanderson, Texas 79748
Zip Code

Date March 17, 1970

The signing of this agreement was authorized by a resolution of the governing body of the Rio Grande-Pecos River Soil and Water Conservation District
Local Organization
adopted at a meeting held on March 9, 1970.

Clarence Chandler Sr.
(Secretary, Local Organization)
Clarence Chandler, Sr.

Address Dryden, Texas 78851
Zip Code

Date March 17, 1970.

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Big Bend Soil and Water Conservation District
Local Organization

By [signature]
Rex Ivey, Jr.
Title Chairman, Board of Directors

Address Box 841, Alpine, Texas 79830
Zip code

Date March 17, 1970

The signing of this agreement was authorized by a resolution of the governing body of the Big Bend Soil and Water Conservation District
Local Organization
adopted at a meeting held on March 2, 1970.

[signature]
(Secretary, Local Organization)
George Mills

Address Box 718, Alpine, Texas 79830
Zip Code

Date March 17, 1970

Trans-Pecos Soil and Water Conservation District
Local Organization

By [signature]
Philip Robbins
Title Chairman, Board of Directors

Address Box 1623, Fort Stockton, Texas 79735
Zip Code

Date March 17, 1970.

The signing of this agreement was authorized by a resolution of the governing body of the Trans-Pecos Soil and Water Conservation District
Local Organization
adopted at a meeting held on March 3, 1970.

[signature]
(Secretary, Local Organization)
Vernon E. Danielson

Address Box 1465, Fort Stockton, Texas 79735
Zip Code

Date March 17, 1970

Terrell County Commissioners Court
Local Organization

By [signature]

R. S. Wilkinson
Title County Judge, Terrell County

Address Sanderson, Texas 79748
Zip code

Date March 17, 1970

The signing of this agreement was authorized by a resolution of the governing body of the Terrell County Commissioners Court
Local Organization
adopted at a meeting held on March 9, 1970.

[signature]
(Secretary, Local Organization)
County Clerk Ruel Adams
Address Sanderson, Texas 79748
Zip Code
Date March 17, 1970

Pecos County Commissioners Court
Local Organization
By [signature]
Walter L. Buenger
Title County Judge, Pecos County

Address Fort Stockton, Texas 79735
Zip Code

Date March 17, 1970

The signing of this agreement was authorized by a resolution of the governing body of the Pecos County Commissioners Court
Local Organization
adopted at a meeting held on March 9, 1970.

[signature]
(Secretary, Local Organization)
County Clerk Billy Hodges
Address Fort Stockton, Texas 79735
Zip Code
Date March 17, 1970

Brewster County Commissioners Court
Local Organization

By *Felix P. McGaughy*
Felix P. McGaughy
Title County Judge, Brewster County

Address Alpine, Texas 79830
Zip Code

Date March 17, 1970

The signing of this agreement was authorized by a resolution of the governing body of the Brewster County Commissioners Court
Local Organization
adopted at a meeting held on March 9, 1970.

Sara Pugh
(Secretary, Local Organization)
County Clerk Sara Pugh
Address Alpine, Texas 79830
Zip Code
Date March 17, 1970.

____
Local Organization

By ______________________________

Title ______________________________

Address ______________________________
Zip Code

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)

Address ______________________________
Zip Code
Date ______________________________

Soil Conservation Service
United States Department of Agriculture

By ______________________________

Date ______________________________

WATERSHED WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

SANDERSON CANYON WATERSHED

Terrell, Pecos, and Brewster 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:

Rio Grande-Pecos River Soil and Water Conservation District
(Sponsor)

Big Bend Soil and Water Conservation District
(Sponsor)

Trans-Pecos Soil and Water Conservation District
(Sponsor)

Terrell County Commissioners Court
(Sponsor)

Pecos County Commissioners Court
(Sponsor)

Brewster County Commissioners Court
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
November 1969

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USDA-SCS-FORS WORTH, TEX. 1969

ADDENDUM

SANDERSON CANYON, TEXAS

This Addendum shows the project costs, benefits, and benefit-cost ratio based on a 5-1/8 percent interest rate. Annual project costs, benefits, and benefit-cost ratio are as follows:

1. Project costs are $242,678
2. Project benefits are 389,302
3. The project benefit-cost ratio is 1.6 to 1

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WATERSHED WORK PLAN

SANDERSON CANYON WATERSHED

November 1969

SUMMARY OF PLAN

The work plan for watershed protection and flood prevention for Sanderson Canyon watershed has been prepared by the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts and the Commissioners Courts of Terrell, Pecos, and Brewster Counties as sponsoring local organizations. Technical assistance has been provided by the Soil Conservation Service, United States Department of Agriculture. The Bureau of Sport Fisheries and Wildlife of the United States Department of the Interior, in cooperation with the Texas Parks and Wildlife Department, made a reconnaissance study of the fish and wildlife resources of the watershed.

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

Sanderson Canyon watershed comprises an area of 216 square miles in Terrell, Pecos, and Brewster counties. It is estimated that 97.4 percent of the watershed is rangeland, 1.1 percent is pasture, and 1.5 percent is in miscellaneous uses such as the town of Sanderson, public roads, railroads, ranch headquarters, and stream channels. There is no Federal land in the watershed.

The principal problem within the watershed is one of frequent flooding on portions of the 4,366 acres of flood plain which results in damages to range and pasture grasses, soils, agricultural properties, residential and commercial properties, roads, bridges, and railroad properties. The total floodwater and indirect damages are estimated to average $387,055 annually.

The work plan proposes installing, in a ten-year period, needed land treatment measures, eleven floodwater retarding structures, and approximately 1,800 feet of channel improvement. Land treatment measures included are those which contribute directly to watershed protection and reduction of floodwater damages.

The total project installation cost is estimated to be $4,770,528, including $204,178 for installation of planned land treatment and $4,566,350 for structural measures. The share of total project installation cost from sources other than Public Law 566 funds is estimated to be $289,833, and the Public Law 566 share is estimated to be $4,480,695. The Public Law 566 cost share for structural measures is estimated to be $4,480,695, and the local share is estimaed to be $85,655.

Average annual damages will be reduced from $387,055 to $8,047 by the proposed project. Average annual benefits accruing to structural measures in the watershed will be $389,302, which includes $359,907 damage reduction benefits and $29,395 secondary benefits. The ratio of total average annual

benefits accruing to structural measures ($389,302) to the average annual cost of these measures ($231,627) is 1.7:1.0.

Land treatment measures will be operated and maintained by owners and operators of the land upon which the measures will be applied under agreement with the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts. The Terrell County Commissioners Court will be responsible for operation and maintenance of structural measures. The cost of operation and maintenance for floodwater retarding structures and channel improvement is estimated to be $7,100 annually.

DESCRIPTION OF WATERSHED

Physical Data

Sanderson Canyon watershed lies in southwestern Texas, covering portions of Terrell, Pecos, and Brewster Counties. It comprises an area of 216 square miles (138,240 acres). The town of Sanderson lies along the main stem of Sanderson Canyon at the eastern end of the watershed. Del Rio is 120 miles southeast of Sanderson; El Paso lies about 300 miles to the northwest; and Big Bend National Park is about 75 miles southwest.

All streams in the watershed are ephemeral. Dry and Rattlesnake Creeks are major headwater tributaries of Sanderson Canyon. They originate about 30 miles west of Sanderson and 12 miles east of Marathon, flow toward the east, and join about 16 miles west of Sanderson. From this confluence, Sanderson Canyon continues in a general eastward course and flows through the town of Sanderson. Three Mile Draw is another major tributary which enters Sanderson Canyon from the north immediately upstream from Sanderson.

The lower limit of the watershed, as included in this work plan, is about one mile downstream from Sanderson. Farther downstream, Sanderson Canyon flows for a distance of approximately 40 miles eastward and southward through an extremely rugged area to the Rio Grande.

The watershed lies within a deeply dissected portion of the Edwards Plateau, a subprovince of the Great Plains Physiographic Province. The boundary between the Edwards Plateau and the Basin and Range Province occurs at the western watershed divide. The topography is characterized by very steeply sloping ridges and canyon walls separated by rather broad alluvial valleys. The downstream slope of the main valley is steep, averaging greater than 40 feet per mile. Elevations range from approximately 5,200 feet above mean sea level along the western divide to about 2,700 feet in the valley below Sanderson.

Exposed geologic strata in the watershed consist of limestone and sandstone of the Lower Cretaceous (Comanche) Series and valley alluvium of the Pleistocene and Recent Series. The predominant outcropping rocks are hard, massive limestones of the Fredericksburg and Washita Groups. They are primarily the Edwards and Georgetown Limestone formations which have a combined average thickness greater than 600 feet.

The Edwards Limestone is underlain, in descending order, by the Comanche Peak Limestone formation, Walnut Clay formation, Maxon Sandstone formation, and Glen Rose Limestone formation. The Comanche Peak Limestone and Walnut Clay are either very thin or absent in the vicinity and are of little significance. There are exposures of Maxon Sandstone and Glen Rose Limestone along the valley walls of Dry Creek in the western portion of the watershed. The Maxon Sandstone consists mainly of brown, well indurated, medium-grained sandstone and is the main water-bearing formation in the vicinity. The sandstone dips to the south-southeast at a rate greater than the land surface, and at Sanderson it occurs about 300 feet beneath the surface. The Glen Rose Limestone is comprised of alternating beds of calcareous shale and thin limestone with some sandstone interbedded toward the top.

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Topography, vegetation, and soils typical of Sanderson Canyon Watershed.

Soil profile, typical of the steeper areas of the watershed
(5 inches of stony clay loam over fractured limestone bedrock).

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Deep and extensive Quaternary deposits of gravel, sand, silt, clay, cobbles, and boulders occupy the valleys of Sanderson Canyon and its larger tributaries. These deposits range to greater than 250 feet in thickness.

The watershed lies entirely within the Edwards Plateau Land Resource Area. Very shallow, loamy, stony soil of the Ector series is found in association with the steeper areas which exhibit much bare limestone. Shallow to deep, moderately permeable, gravelly loams of the Sanderson and Upton series occur on alluvial fans and footslopes. Deep, moderately permeable silty clay loam of the Reagan series usually is found on stream terrace deposits and outwash plains. Deep, moderately to rapidly permeable, gravelly loams, primarily of the Dev series, occupy flood plains.

The following tabulation shows land use within the watershed.

Land Use	Acres	Percent
Rangeland	134,635	97.4
Pasture	1,582	1.1
Miscellaneous 1/	2,023	1.5
Total	138,240	100.0

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

The vegetative cover is generally sparse and is comprised of semi-desert type shrubs and grasses. Hydrologic cover conditions range from poor to good, the majority being in poor condition. Lack of dependable rainfall and a high evaporation rate are major deterrents to achieving good hydrologic cover. Range sites commonly found within the watershed include Shallow Divide, Steep Rocky, Low Stony Hills, Gravelly, Deep Soil, and Overflow. In climax condition, the dominant grasses consist of sideoats grama, cane bluestem, blue grama, bush muhly, plains bristlegrass, skeleton-leaf goldeneye, vine mesquite, and green sprangletop. Present upland vegetation consists primarily of red grama, hairy tridens, croton, perennial threeawn, sideoats grama, acacia, juniper, mesquite, tarbush, sacahuista, lechuguilla, sotol, creosote bush, and piñon pine. Common vegetation presently on flood plains includes buffalograss, vine mesquite, green sprangletop, tanglehead, little leaf sumac, Texas black walnut, hackberry, and mesquite.

The climate is semi-arid continental. Summers are warm to hot. Winters are fairly mild, but rapid and wide changes in temperature occur with the passage of cold fronts. Temperature extremes in the watershed vicinity have ranged from 114 degrees to minus 7 degrees Fahrenheit. At Sanderson, the mean minimum January temperature is 36 degrees and the mean maximum July temperature is 96 degrees. The normal growing season is 237 days. Average annual precipitation is about 12 inches, the wettest season occurring from May to October.

Water for the town of Sanderson, rural domestic use, and livestock is obtained primarily from wells. Farm ponds also supply some livestock water.

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Except for periods of drought, these sources have supplied adequate amounts of water to satisfy daily needs.

Economic Data

Ranching is the principal agricultural pursuit in the watershed. The land is used primarily for the grazing of sheep, goats, cattle, and wildlife. The sale of livestock and livestock products accounted for 95 percent of the total ranch income in the watershed. The remaining 5 percent of ranch income is from hunting leases. Other elements of the economy include the Southern Pacific Railroad, which maintains a terminal point at Sanderson; a wool and mohair warehouse; and numerous motels, restaurants, and service stations. Situated at the junction of two Federal highways in a sparsely settled region, Sanderson provides facilities for many tourists and travelers.

Income producing recreation ranks high in the watershed in the form of hunting leases. Terrell County is reported by the Texas Parks and Wildlife Department to have the largest deer population per acre in the Trans-Pecos region.

There are 23 ranches located wholly or partially within the watershed averaging 12,276 acres in size.

Approximately 18 percent of the ranch operators worked off-the-ranch for 100 days or more in 1968.

It is estimated that less than 10 percent of the agricultural land in the benefited area is devoted to ranches using 1-1/2 man-years or more of hired labor.

The average value of land and buildings per ranch in Terrell County, which is typical of the watershed, is estimated at $249,700 (based on 1964 agricultural census data). The estimated current market price of land ranges from $20 to $40 per acre. Approximately 40 percent of the agricultural land is leased.

The town of Sanderson, located in the lower portion of the watershed, has an estimated population of 2,000. It is the county seat of Terrell County and the trade center for the surrounding ranch area, providing marketing and supply services which are important in the local economy. Sanderson is the only town in the watershed. It is unincorporated and governed by the Terrell County Commissioners Court.

The watershed is served adequately by approximately 63 miles of Federal and County roads of which 43 miles are hard surfaced. The Southern Pacific Railroad has loading facilities in Sanderson.

Land Treatment Data

Ranchers, operating about 95 percent of the agricultural land in the watershed, are practicing soil and water conservation in cooperation with the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation

Districts. Soil Conservation Service work units at Sanderson, Alpine, and Fort Stockton are assisting the districts in preparing and applying soil and water conservation plans.

There are no critical sediment source areas and no improper use of watershed land.

There are 23 ranches wholly or partially within the watershed, of which 16 are under district agreement. Conservation plans cover about 95 percent of the agricultural land. Soil and range surveys have been completed on the entire watershed. It is estimated that 50 percent of the needed land treatment practices have been installed and that 90 percent of the waterahed is adequately protected from erosion. Needed land treatment measures have been applied to date at an estimated expenditure of $538,685 by landowners and operators (table 1A).

The level of accomplishment for needed land treatment practices is expected to reach 80 percent in 10 years as a result of the planned land treatment program.

Fish and Wildlife Resource Data

The fish and wildlife aspects of the watershed, as described by the Bureau of Sport Fisheries and Wildlife, are as follows:

> "There is no significant fish habitat in the watershed. Consequently, there is no sport or commercial fishing.
>
> Principal wildlife species in the watershed are mule deer, white-tailed deer, javelina, scaled quail, bobwhite, mourning dove, white-winged dove, cottontail, and jackrabbit. Wildlife of lesser importance because of their low populations are black bear, waterfowl, mountain lion, and porcupine.
>
> Mule deer are more plentiful than white-tailed deer and together they provide good hunting. Javelinas are moderately abundant, but do not sustain much hunting. Bobwhite populations are low.
>
> Scaled quail and mourning doves are common and supply most of the upland-game hunting. There is little hunting for white-winged doves.
>
> The moderately abundant cottontails are prized by landowners, and they do not permit much hunting for them. However, they do permit hunting for jackrabbits which are abundant in the watershed.
>
> There is no significant amount of trapping of fur animals in the project area.
>
> In the future, mule deer, scaled quail, mourning doves, and jackrabbits will continue to supply most of the hunting. Increases in human population would result in an increase in hunting for

these animals. There should be greater demand for javelina hunting. The amount of hunting and trapping for the other species is not expected to change significantly."

WATERSHED PROBLEMS

Floodwater Damage

Areas of sizable proportions need additional land treatment to improve cover for protection from rapid runoff. The potential for improved watershed conditions has been exhibited by conservation minded ranchers, but the improvement comes slowly because of climatic limitations.

An estimated 4,366 acres of the watershed, excluding stream channels, is flood plain. This is the area that would be inundated by a 100-year frequency flood.

Present flood plain land use is as follows: rangeland, 78 percent; pasture, 11 percent; and miscellaneous uses, including roads, railroads, highways, and urban areas, 11 percent. Current trends are toward improvements of native rangeland.

Attempts have been made to enlarge and levee Sanderson Canyon and Three Mile Draw. This has resulted in very little reduction of flood damage. The adverse economic and physical effect of flooding has been felt throughout the entire watershed and will prompt local participation in the alleviation of the flood problem.

High intensity rains, strong topographic relief, and poor cover conditions are major factors contributing to flooding in Sanderson Canyon. Flash flooding results when rapid runoff from steep upland areas travels down short lateral tributaries and reaches the more gently sloping valley of the central and lower parts of the watershed before local runoff has drained off.

Flooding occurs frequently in portions of the watershed causing damages to agricultural and nonagricultural properties. Major floods, inundating more than half the flood plain, occur on the average of once every three to four years. Minor floods, inundating less than half the flood plain, occur on the average of about once a year.

The most diastrous flood in recent years occurred on June 11-12, 1965. The total storm rainfall occurred over a ten-hour period and varied from approximately 9 inches in the upper portion of the watershed, to 5.5 inches in the lower portion. The recurrence interval of the resulting flood peak was estimated to be about 40 years. The resulting flood inundated approximately 4,110 acres of flood plain in the watershed, of which 430 acres are located inside the urban area of Sanderson.

According to local residents, Sanderson Canyon flowed during the night of June 11-12, 1965, and at about 7:00 AM Friday, June 12, was barely going over the bridge at the corner of Oak and Fifth Streets in Sanderson.

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Floodwater damage
to urban property
in Sanderson
from flood of
June 11, 1965.

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PHOTOGRAPHS COURTESY OF TEXAS DEPARTMENT OF PUBLIC SAFETY

Floodwaters destroyed the Sanderson Wool Commission Company warehouse.

Raging waters destroyed this home. Adobe construction is typical of many of the homes in the urban area.

PHOTOGRAPHS COURTESY OF TEXAS DEPARTMENT OF PUBLIC SAFETY

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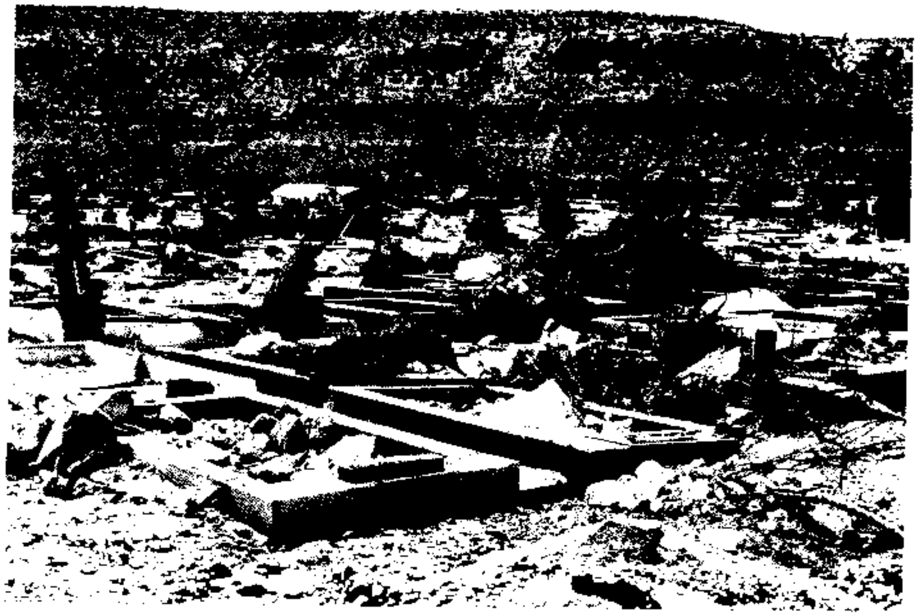
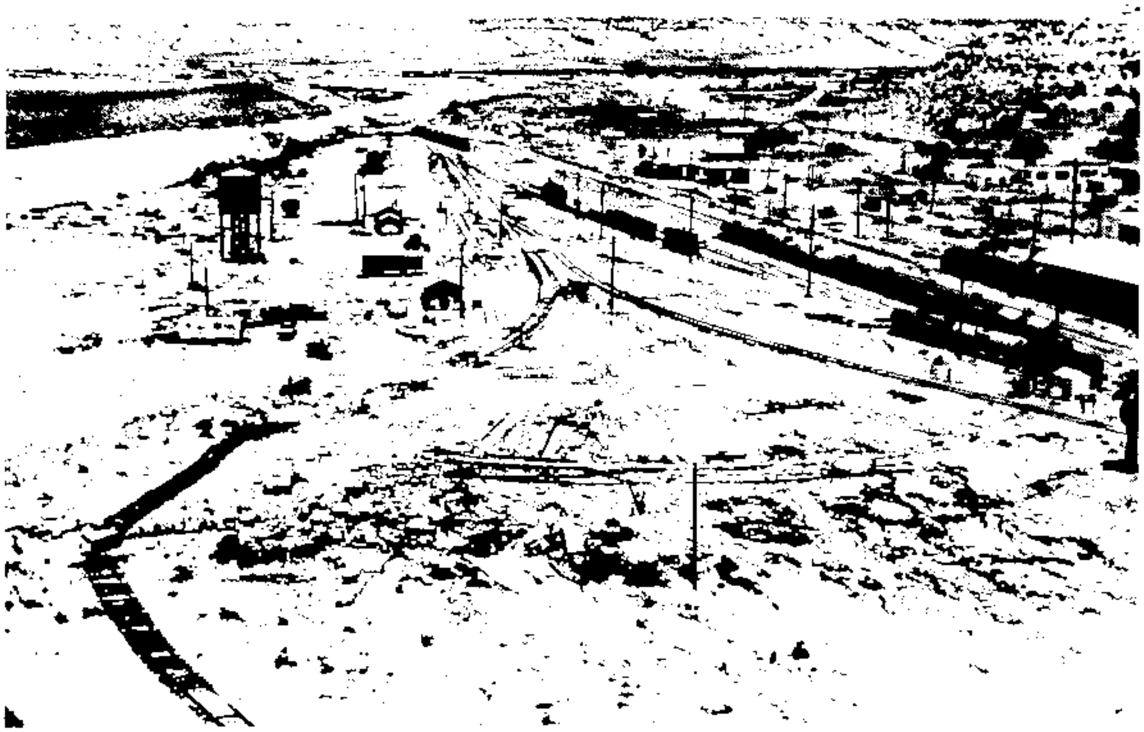


Floodwaters uncovered many graves,
washing bodies and headstones downstream.

Looking west along U. S. Highway 90. Rubble is all that
remained of cafe and service station destroyed by floodwaters.

 PHOTOGRAPHS COURTESY OF TEXAS DEPARTMENT OF PUBLIC SAFETY



Aerial view, looking northwest, showing Southern Pacific railroad yard. Note damage to tracks and bridge approaches. Sanderson Canyon is in the left of the photo.

Aerial view, looking northwest, showing damages to Southern Pacific railroad. Note workmen repairing railroad bridge in left of photo.

PHOTOGRAPHS COURTESY OF TEXAS DEPARTMENT OF PUBLIC SAFETY

Automobile swept downstream against bridge support.

Aerial view of Sanderson. Note that foundations are all that remained of motel units destroyed by floodwaters. Several persons were swept away by the rushing waters.

PHOTOGRAPHS COURTESY OF TEXAS DEPARYMEHT OF PUBLIC SAFETY

Looking northeast at intersection of U. S. Highway 90 and 5th Street. Note Salvation Army mobile canteen in background. Several organizations provided emergency assistance.

Local people were immunized against typhoid fever.

Within minutes a wall of water came down the canyon not allowing time to warn all of the residents in the low-lying areas. The resulting flood took the lives of 26 persons including 16 children. Two bodies were never found.

Many of the flood victims were swept away by the rushing waters as they tried vainly to reach safety. Four children were washed out of a tree, unable to hold on against the raging waters. Three persons were washed off the bridge on Sanderson Canyon at Fifth Street as they attempted to cross the bridge in their automobile.

Flood waters cut a swath through the cemetery, uncovering graves and washing bodies and headstones miles downstream.

The Red Cross established headquarters in Sanderson and provided food, medical care, lodging, and other necessities for victims of the flood. Volunteers from surrounding towns pitched in to help victims clean up and reorganize businesses and homes.

A survey made by the American Red Cross showed 54 homes destroyed and 169 homes damaged. Several businesses were destroyed or damaged extensively. Damages to transportation facilities including the railroad and highway were extensive. The direct monetary floodwater damage in Sanderson from this flood was in excess of $1,580,000.

A flood resulting from a 100-year frequency event would inundate virtually the same area as the flood of 1965. Depths of flooding would be increased about 1.0 foot to 1.8 feet. However, additional damages would be relatively small because most properties suffered almost maximum possible damage from the 1965 flood.

For the floods expected to occur during the evaluation period, which includes floods up to the 100-year frequency, the total direct floodwater damage is estimated to average $316,359 annually at adjusted normalized prices (table 5). Of this amount, $530 is crop and pasture damage, $3,334 is other agricultural damage, $156,225 is transportation damage, and $156,270 is damage to urban and other nonagricultural development.

Indirect damages such as interruption of travel, losses sustained by businesses, evacuation of premises when floods threaten, and similar losses are estimated to average $70,696 annually.

Sediment Damage

Although modern deposits of gravel, cobbles, and boulders may be found on some parts of the flood plain, the over-all damage caused by overbank deposition of sediment on agricultural land is very minor. This is attributed mainly to the low sediment production rate and the predominance of native range as flood plain land use.

Stream bedload consists of coarse sand, gravel, cobbles, and boulders. The median grain size ranges from approximately 0.2 to 0.8 inches. The stream bed is in a stable condition. This is caused primarily by the development of protective armoring consisting of coursa gravel and cobbles. The armoring resulted because the finer fraction of bedload is more easily transported downstream leaving behind the coarser material which forms armor plating on the stream bottom. Major flood flows, however, result in transportation of coarse material from gravel bars and channel banks. Deposition of bedload is most evident at restrictions such as railroad and highway bridges where cleanout is necessary. The monetary value of this type of damage is included with floodwater damage.

The estimated average annual sediment production rate is 0.34 acre-feet per squsre mile. This amounts to an average annual sediment yield of 73 acre feet at the lower limit of the watershed. Of this, it is estimated that 28 scre feet per year will reach the recently completed Amistad Reservoir on the Rio Grande. Because of the low frequency of large flows capable of transporting significant volumes of the coarse bedload, sediment delivered from Sanderson Canyon watershed to Amistad Reservoir should be mainly fine-textured sediment transported in suspension. In addition to causing loss of storage capacity, sediment derived from Sanderson Canyon watershed is a source of pollution in the Rio Grande lowering the quality of water for irrigation, recreation, power generation, fish habitat, and other possible future uses.

Erosion Damage

The low inherent erodability of most of the Edwards Plateau soils and the low frequency of high intensity rainfall are primarily responsible for a relatively low gross erosion rate. The average annual rate of gross erosion is estimated to be 3.78 tons per acre. Sheet erosion accounts for 89 percent, gully erosion 7 percent, streambank erosion 3 percent, and flood plain scour 1 percent of total erosion. Stream beds are armor-plated.

Flood plain scour in the agricultural area has removed soils from an estimated 145 acres ranging up to two feet in depth. However, because the damaged areas are rangeland with semi-desert vegetation, scour damage is not monetarily significant.

Problems Relating to Water Management

There is no activity relative to drainage or irrigation in the watershed. There is no local interest in providing additional storage in any planned floodwater retarding structure for agricultural or nonagricultural water management purposes.

Sanderson obtains its water supply from wells extending into the Maxon Sandstone. Water quality is good, but yields are quite small because of the fine texture of the sandstone. The water supply is presently adequate, but obtaining an ample supply for an increase in population in Sanderson would be difficult. The water level is about 350 feet beneath the land surface, and about 250 feet of the sandstone is saturated. The underlying Glen Rose Formation is not known to yield large supplies of water. In general, it is a poor water-bearing formation. Deeper test drilling is not advisable because of the likelihood that any aquifers occurring deeper than the Glen Rose Formation would be highly mineralized. Storage of surface water is not feasible because of the combination of low yield, high evaporation rate, and high seepage loss potential at possible reservoir sites in the Sanderson vicinity.

PROJECTS OF OTHER AGENCIES

There are no existing or proposed wster resource development projects of any other agency within the watershed.

The works of improvement included in this plan will have no known detrimental effects on any existing or proposed downstream works of improvement of other agencies; conversely, they will complement the works of improvement of the International Boundary and Water Commission by reducing sediment delivery into Amistad Reservoir.

PROJECT FORMULATION

Residents in the Sanderson Canyon watershed are vitally interested in seeking ways to reduce flood damages.

Following the disastrous flood of 1965, representatives of the Commissioners Courts of Terrell, Pecos, and Brewster Counties; the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts; and the Soil Conservation Service made studies and held meetings to identify existing flood problems and reach agreement on water and land resource development needs. Desires of sponsoring locsl organizations were discussed and project objectives were formulated. Watershed protection and flood prevention were the primary objectives expressed by the sponsors.

Agreement was reached on the following specific objectives.

1. Reduce erosion and increase rainfall infiltration by establishing land treatment measures which would contribute directly to watershed protection and flood prevention. The goal is to establish 80 percent of the needed land treatment measures during the 10-year installation period. At least 75 percent of the land above floodwater retarding structures would be adequately protected from erosion before construction would begin on any structural measure.

2. Attain a reduction of 70 to 75 percent in average annual damages in the agricultural reaches in the watershed.

3. Attain a reduction of 90 to 95 percent in average annual damages in Sanderson with consideration given to the 100-year frequency storm.

Possible sites for thirteen floodwater retarding structures and one segment of channel improvement were investigated in order to select the least costly system needed to provide the agreed upon level of protection. In selecting sites for structural measures, consideration was given to locations which would provide maximum protection to areas most subject to damage. Topographic, geologic, and hydrologic conditions had considerable influence upon the size, number, design, and cost of structures included in the plan.

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Two floodwater retarding structure sites were investigated but not included in the final project. One was located on the main stem of Dry Creek about seven miles upstream from Site No. 2 (figure 4). The other was on a tributary which joins Dry Creek from the north about three miles upstream from Site No. 2. Damages on the intervening flood plain between these sites and Site No. 2 are very minor, and the entire drainage area of Site No. 2 can be controlled more economically by one structure. For these reasons, the two upstream sites were not included in the planned project.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Ranchers, controlling about 95 percent of the agricultural land in the watershed, are applying and maintaining soil and water conservation plans on their land with assistance from the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts. These plans, which are essential to a sound program for watershed protection and flood prevention, are based on the use of each acre within its capabilities and its treatment in accordance with its needs. Needed land treatment measures have been applied to date at an estimated expenditure of $538,685 by landowners and operators (table 1A).

Increased application and maintenance of land treatment measures is particularly important for protection of the 149.79 square miles which comprise the drainage areas of the eleven planned floodwater retarding structures. This treatment will reduce the capacities required for sediment accumulation and will retard runoff into the structures.

There are 66.21 square miles downstream from floodwater retarding structures that will continue to contribute sediment and runoff to flood plain areas. Land treatment on these lands will further reduce floodwater and sediment damages.

The acreage in each major land use, on which land treatment measures will be established during the ten-year project installation period, is included in table 1. These measures will be established and maintained by landowners and operators in cooperation with the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts.

It is expected that about 415 acres of rangeland will be converted to pasture during the project installation period.

Proper grazing use, range seeding, and deferred grazing will be practiced to improve the quality of vegetation and maintain adequate cover for soil protection. Rangeland with infestations of woody plants will be either bulldozed, root plowed, chained, or sprayed to control brush. Destruction of cover caused by overuse around present watering places will be reduced by establishing ponds, wells, pipelines, and troughs or tanks.

A good base cover of desirable forage plants will be attained by pasture planting and pasture management.

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Rangeland in excellent condition as result of conservation treatment.

Good stand of sorghum alum following brush control and pasture planting and management.

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Damage to land caused by rapid runoff from steeper areas will be reduced by construction of diversions.

Local people will continue to install and maintain measures needed in the watershed following the project installation period.

The application of land treatment planned for the installation period will reduce average annual erosion by about 5 percent and increase infiltration of rainfall as a result of increased grass vigor.

Structural Measures

A system of 11 floodwater retarding structures and approximately 1,800 feet of channel improvement will be constructed in the Sanderson Canyon watershed. Figure 1 shows a section of a typical floodwater retarding structure. Figure 1A shows a typical cross section of channel improvement. Figures 2 and 2A include a general plan and profile, plan of reservoir, and cross section of a zoned embankment typical of the type of floodwater retarding structure included in this work plan.

The locations of structural measures to be installed are shown on the Project Map (figure 4).

Major factors which will affect construction of floodwater retarding structures will be rock excavation in emergency spillways, permeable gravel deposits within foundations, zoning of available borrow material within embankments, and lack of adequate on-site supply of water for construction purposes.

All emergency spillways will have erosion resistant rock crests and forebays. Exit channels will consist primarily of CL and GC soils, classified in accordance with the Unified Soil Classification System.

Structural details will be treated in the final design phase. Preliminary and present indicators are that the principal spillways will be on compressible foundations and will have monolithic rectangular reinforced concrete inlets. Floodwater retarding structures Nos. 2 and 11 lend themselves to monolithic rectangular reinforced concrete barrels, and structures Nos. 1, 3, 4, 5, 6, 7, 8, 9, and 10 to prestressed concrete-lined, steel cylinder pipe outlet barrels. Rock-lined plunge pools for all floodwater retarding structures except Nos. 2 and 11, and reinforced concrete deenergizing basins for these two are included in the preliminary details.

Principal spillway capacities and floodwater detention storage in all planned floodwater retarding structures will provide a one percent chance of emergency spillway use.

There are sufficient volumes of silty clay, sandy clay, and gravelly clay for construction of very slowly permeable central embankment sections. The remainder of embankments will be comprised primarily of clayey sand, silty gravel, sandy gravel, and limestone. The gravel content of the coarser textured soils is sufficient for natural development of protective desert pavement. This is particularly important at sites where emergency spillway excavation will not yield sufficient volumes of limestone for complete rock outer embankment sections.

Foundations are characterized by the presence of flood plain and stream terrace deposits of clay, silt, sand, and gravel with highly permeable horizons. These materials have good bearing and shear strength, but foundation and embankment drainage features will be needed at all sites.

All structures are designed with sufficient capacities to provide 100-year project life. Because of the expected high rate of seepage losses in pools of floodwater retarding structures, no portion of sediment pools is expected to store water. All planned structure pools are considered dry.

The eleven planned floodwater retarding structures will detain an average of 1.99 inches of runoff from 149.79 square miles of drainage area. The eleven structures will control runoff from approximately 69 percent of the total watershed.

Tables 1, 2, and 3 show details on quantities, cost, and design for each structure.

Installation of floodwater retarding structures will require relocation or modification of known existing improvements as follows: livestock water pipelines at Sites Nos. 1, 8, 10, and 11; water well and storage reservoir at Site No. 11; utility lines at Sites Nos. 3, 5, 10, and 11; private roads at Sites Nos. 1, 2, 5, 6, 7, 8, and 9; county road at Site No. 3; fences at Sites Nos. 1, 2, 3, 4, 5, 6, 7, and 11; buildings at Sites Nos. 2 and 11; and pens or corrals at Sites Nos. 2 and 11.

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

The planned channel improvement will not significantly change the regimen of Sanderson Canyon. Channel improvement will consist of a trainer dike, excavation, and modification of exit and approach sections to Southern Pacific Company railroad bridge number 516.23 (figure 3). An appurtenance to channel improvement will be a 90-foot prestressed concrete bridge extension.

Alteration of the exit and approach reaches to the railroad bridge will extend approximately 1,000 feet upstream and 800 feet downstream from the bridge. The depth of excavation will range from 0.5 to 3.0 feet. The material through which the channel will be excavated consists of moderately well graded gravel containing scattered cobbles and boulders. The present channel contains extensive gravel bars and the lowest portion is armorplated. The planned channel improvement will have a 200-foot bottom, 3:1 side slopes, and a slightly depressed center to prevent low flows from meandering (figure 1A).

The dike will be set on the edge of the channel excavation and have side slopes of 3:1 with a 12-foot top. Material to be excavated from the channel is suitable for use as a mass fill for the dike. Sufficient quantities of coarse-grained material are available to interface rock riprap.

Rock riprap is planned for the inside and outside curves of channel improvement upstream from the railroad bridge. Riprap for the inside curve is planned to extend approximately 70 feet upstream from the bridge. The outside curve will have riprap for approximately 370 feet upstream from the bridge.

The planned dike will be built to prevent floodwaters from leaving the improved channel and flowing eastward along Downie Street in Sanderson (figure 3). The dike will be constructed approximately three feet above the natural ground and will extend about 600 feet upstream from the bridge on the east side of the improved channel (figure 3).

The 90-foot bridge extension to be added to the present twelve 10x9-foot box culverts will be three 30-foot spans of prestressed concrete.

Two side inlets enter the segment of planned channel improvement above the planned dike. Inlet structures will be reinforced concrete drops or chutes.

Excavation of channel material not used in construction of the trainer dike will be disposed of by placement or spoiling within the rights-of-way.

The present railroad bridge and the planned 90-foot extension have a skewness of 17 degrees (figure 3). This small angle of skewness will create some turbulence in the upstream entrance in the upstream entrance to the bridge. The planned rock riprap and armor-plated channel bottom will tolerate this tubulence. However, the sponsors have been made aware of the possible maintenance problem in this portion of channel improvement.

The 100-year frequency flood will be contained within the section of channel improvement.

The planned design 100-year frequency discharge of 17,200 cfs was selected from flood routings made for without and with project conditions.

Relocation of the telephone line along the north side of the railroad tracks within the area of channel improvement will be necessary. This cost will be borne by the sponsoring local organizations.

EXPLANATION OF INSTALLATION COST

Land treatment measures listed in table 1 will be applied by local interests at an estimated cost of $204,178. This includes $15,658 of Public Law 46 funds to be provided by the Soil Conservation Service under the going program for technical assistance during the ten year installation period and cost-sharing in the establishment of approved conservation measures under the Great Plains Conservation Program of the Soil Conservation Service and the Agricultural Conservation Program as administered by the Agricultural Stabilization and Conservation Service.

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The costs of application of the various measures are based on present prices being paid by landowners and operators in the area.

The total installation cost of the structural measures is estimated to be $4,566,350, of which $4,480,695 will be borne by Public Law 566 funds and $85,655 by local interests.

The Public Law 566 costs for installation of structural measures are $3,747,317 for construction, $187,382 for engineering services, and $545,996 for project administration.

The local costs for installation of structural measures include $37,900 for the value of land; $26,655 for relocation or modification of water wells and reservoirs, power lines, private and county roads, telephone lines, livestock water, pipelines, fences, buildings, and corrals; $10,000 for modification of the Southern Pacific railroad bridge; $4,900 for legal fees, and $6,200 for project administration.

Construction costs include the engineer's estimate and contingencies. Included is an estimated $145,606 to extend Southern Pacific railroad bridge number 516.23 crossing the improved channel of Sanderson Canyon. This cost will be borne by Public Law 566 funds. It is not anticipated that any costs not associated with structural stability will be incurred. Any costs necessary for ballast, rails, ties, telegraph lines, power lines, signal systems, temporary rerouting of traffic, providing flagmen, or other features not directly associated with structural stability of the bridge and approaches will be borne by the sponsors. The engineer's estimates were based on unit costs of structural measures in similar areas modified by special conditions inherent to each individual site location. Included are such items as permeable foundations, special placement of embankment materials, rock excavation in emergency spillways, and scarcity of on-site water supplies for construction purposes. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs.

Engineering services and project administration costs were based on an analysis of previous work in similar areas. Engineering services costs consist of, but are not limited to detailed surveys, geologic investigations, laboratory analysis, reports, designs, and cartographic services.

Public Law 566 project administration costs consist of construction inspection and supervision, contract administration, maintenance of Soil Conservation Service State Office records and accounts, and Washington Office and E&WP Unit costs.

The local costs for project administration includes sponsors' costs related to contract administration, overhead and organizational administrative costs, and whatever construction inspection they desire to make at their own expense.

The cost of land rights was determined by appraisal in cooperation with representatives of the local sponsoring organizations.

The following is the estimated schedule of obligations for the ten-year installation period.

Schedule of Obligations

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
First	Land Treatment	-	14,721	14,721
	Channel Improvement	237,624	19,750	257,374
Second	Land Treatment	-	15,721	15,721
	Structures Nos. 7 and 8	542,202	6,400	548,602
Third	Land Treatment	-	19,722	19,722
	Structures Nos. 9 and 10	521,891	7,740	529,631
Fourth	Land Treatment	-	16,722	16,722
	Structure No. 11	697,582	12,985	710,567
Fifth	Land Treatment	-	16,722	16,722
	Structure No. 2	777,415	10,560	787,975
Sixth	Land Treatment	-	20,179	20,179
	Structure No. 1	428,785	10,820	439,605
Seventh	Land Treatment	-	22,813	22,813
	Structure No. 6	404,500	4,630	409,130
Eighth	Land Treatment	-	24,813	24,813
	Structures Nos. 4 and 5	595,319	6,840	602,159
Ninth	Land Treatment	-	27,813	27,813
	Structure No. 3	275,377	5,930	281,307
Tenth	Land Treatment	-	24,952	24,952
	Total	4,480,695	289,833	4,770,528

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

EFFECTS OF WORKS OF IMPROVEMENT

This project will benefit directly the owners and operators of approximately 13 ranches in the agricultural land of the flood plain and the owners and occupants of about 240 residential and business units in Sanderson through reduction of floodwater damage.

After installation of the combined program of land treatment and structural measures, average annual flooding will be reduced from 1,534 acres to 515 acres, a reduction of 66 percent.

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Sediment deposition in Amistad Reservoir originating in the watershed will be reduced by 17 acre feet annually.

Reduction in area inundated varies with respect to location within the watershed. The general locations of the areas to be benefited as a result of reduced flooding, caused by the combined program of land treatment and structural measures are presented in the following tabulations:

Average Annual Area Inundated

Evaluation: Reach (figure 4)	Location	Without Project (acres)	With Project (acres)	Reduction (percent)
1	Urban Area-Town of Sanderson	122	6	95
2	Sanderson Canyon	1,300	473	64
3	Three Mile Draw	112	36	68
	Total	1,534	515	66

Area Inundated

Evaluation: Reach (figure 4)	Average Recurrence Interval							
	2-Year		5-Year		25-Year		100-Year	
	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)
1	0	0	308	0	425	0	435	106
2	1,132	0	2,427	1,153	3,183	2,212	3,510	2,509
3	0	0	314	0	360	282	421	308
Total	1,132	0	3,049	1,153	3,968	2,494	4,366	2,923

Figure 3 shows the urban area of Sanderson inundated by the flood of June 11-12, 1965, and the area that will be inundated by a 100-year frequency flood without and with project conditions. The proposed project will provide flood-free protection to all existing urban properties except a portion of the railroad yards, one house, and a few vacant lots and yards of houses located along the channel of Sanderson Canyon. The depth in the areas subject to continued flooding from the 100-year frequency flood is a maximum of 2.0 feet at the lowest part of the railroad yards. Average depth of remaining flooding is about 1.0 foot. With the project installed, damages to urban properties will be reduced from $1,736,132 to $56,514. About $46,000 of the remaining damage will be to equipment and facilities in the railroad yards. The actions of people during times of floods, whether major or minor, cannot be predicted. However, with any reasonable precautions, the hazard to life from floodwaters will be eliminated.

Additional structural works of improvement were considered but were of minor significance in providing increased protection to the properties still subject to flooding. It is not economically feasible to provide flood free protection from the 100-year event for these areas.

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The sponsors are aware that the project will not provide complete flood free protection to all urban properties. The Terrell County Commissioners Court will notify property owners in Sanderson of the flood hazards that still will remain after project installation and will discourage further construction of improvements within the areas still subject to flooding.

The direct monetary floodwater damage, resulting from a recurrence of a flood similar to the one that occurred in 1965 will be reduced about 97 percent with installation of the planned program of land treatment and structural measures.

Application of the planned land treatment program is expected to reduce annual upland erosion from about 523,000 tons to 496,000 tons, a reduction of 5 percent. The average annual sediment yield from the watershed will be reduced from an estimated 73 acre-feet to 25 acre-feet as a result of the combined program of land treatment and floodwater retarding structures.

The combined program is also expected to reduce sediment deposition in Amistad Reservoir by 17 acre-feet per year.

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

> "With the project, the installation of land treatment measures, except brush control, and the construction of floodwater retarding structures should improve wildlife habitat. The harmful effects of brush control would be offset by the planting of Johnson graas on the cleared areas."

Analysis of information collected indicated that no significant changes would be made in the use of agricultural land within the flood plain, either in the form of restoration of former productivity or in more intensive use. Conditions other than frequency of flooding are responsible for the rather low intensity of agricultural use on most of the flood plain.

A total of 697 acres of land in sediment pools, dams, and emergency spillways will be retired from agricultural production. All of this is grassland.

Indirect damages, which are extremely high in the watershed because of the catastrophic nature of large floods, will be virtually eliminated. Cost of relief, precautionary health measures, and housing during the period of restoration of homes will be minimized.

Secondary benefits, including improved economic conditions in the area, will result from the installation of the complete project for flood prevention. A continuation of the great monetary losses being suffered by the railroad could result in the removal of the railroad terminal point from Sanderson. This would result in a great loss of employment and affect adversely the entire economy of the area. With the project installed, this hazard will be reduced greatly. 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, better living conditions, and improved wildlife habitat.

PROJECT BENEFITS

The estimated average annual monetary floodwater and indirect damages (table 5) within the watershed will be reduced from $387,055 to $8,047 by the proposed project. This is a reduction of 98 percent.

The benefit from reduction of sediment deposition in Amistad Reservoir is estimated to average $250 annually.

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.

Reductions in monetary flood damages vary with respect to locations within the watershed. The following tabulations show the general locations of damage reduction benefits attributed to the combined program of land treatment and structural measures.

Average Annual Damage

Evaluation Reach (figure 4)	Location	Without Project	With Project	Reduction
		(dollars)	(dollars)	(percent)
1	Urban Area-Town of Sanderson	359,586	2,163	99
2	Sanderson Canyon	27,289	5,855	79
3	Three Mile Draw	180	29	84
Total		387,055	8,047	98

Direct Monetary Floodwater Damage

Evaluation Reach (figure 4)	Average Recurrence Interval: 2-Year Without Project	2-Year With Project	5-Year Without Project	5-Year With Project	25-Year Without Project	25-Year With Project	100-Year Without Project	100-Year With Project
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	1,500	0	402,041	0	1,367,275	750	1,736,132	56,514
2	3,329	0	8,893	3,167	16,122	7,663	20,297	10,438
3	0	0	267	0	790	188	1,136	464
Total	4,829	0	411,201	3,167	1,384,187	8,601	1,757,565	67,416

It is estimated that the project will produce local secondary benefits, which exclude indirect benefits in any form, averaging $29,395 annually. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

Terrell, Pecos, and Brewster Counties have not been designated as areas eligible for assistance under the Economic Development Act. Consequently, no redevelopment benefits were considered.

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COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation and project administration cost, plus operation and maintenance) is $231,627. These measures are expected to produce average annual benefits, excluding secondary benefits, of $359,907 resulting in a benefit-cost ratio of 1.6:1.0.

The ratio of total average annual project benefits, accruing to structural measures ($389,302) to the average annual cost of structural measures ($231,627) is 1.7:1.0 (table 6).

PROJECT INSTALLATION

Landowners and operators will establish planned land treatment (table 1) in cooperation with the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts during a ten-year period. Technical assistance in planning and application of land treatment is provided under the going program of the districts. Soil and range surveys have been completed on the entire watershed.

An estimated 50 percent of needed soil and water conservation practices have been applied. About 90 percent of the agricultural land is adequately protected from erosion. The goal is to increase the level of land adequately treated to at least 80 percent during the installation period.

In reaching this goal, it is expected that accomplishments of additional adequate treatment will progress as shown in the following tabulation:

Land Use	Fiscal Year					
	1st	2nd	3rd	4th	5th	6th
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Pasture	0	0	0	0	0	150
Rangeland	8,350	8,350	8,350	8,350	8,350	8,350
Total	8,350	8,350	8,350	8,350	8,350	8,500

Land Use	Fiscal Year - Continued				
	7th	8th	9th	10th	Total
	(acres)	(acres)	(acres)	(acres)	(acres)
Pasture	150	150	150	150	750
Rangeland	8,350	8,350	8,350	8,350	83,500
Total	8,500	8,500	8,500	8,500	84,250

The governing bodies of the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts will assume agressive leadership in getting an accelerated land treatment program underway. Landowners and operators will be encouraged to apply and maintain soil and water

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conservation measures on their ranches. In addition, landowners and operators of ranches where floodwater retarding structures will be located will be encouraged to apply and maintain measures for the enhancement of wildlife. The Soil Conservation Service will provide technical assistance in the planning and application of soil, plant, and water conservation measures.

Special emphasis will first be placed on getting a higher degree of land treatment in the drainage areas of floodwater retarding structures. Then the emphasis will be on land outside drainage areas of structures.

The Extension Service will assist with the educational phase of the program by providing information to landowners and operators in the watershed.

The Terrell, Pecos, and Brewster County Commissioners Courts have rights of eminent domain under applicable State law and have the financial resources to fulfill their responsibilities.

The Soil Conservation Service, in compliance with a request from the sponsors, will provide the necessary administrative and clerical personnel; facilities, supplies, and equipment to advertise, award, and administer contracts; and will be the contracting agency to let and service contracts. The Terrell County Commissioners Court will represent sponsoring local organizations in coordination with the Soil Conservation Service on matters concerning construction.

The Terrell County Commissioners Court will have the following responsibilities pertaining to eleven planned floodwater retarding structures and approximately 1,800 feet of channel improvement:

1. Obtain the necessary land rights for all works of improvement;

2. Provide for ballast, rails, ties, telegraph lines, power lines, signal systems, temporary rerouting of traffic, flagmen, and/or other features of modifying railroad bridge number 516.23 (Southern Pacific Company) not directly associated with structural stability of the bridge and approaches;

3. Provide for the relocation or modification of utility lines and systems, roads, and privately owned improvements necessary for installation of structural measures;

4. Provide for the necessary improvements to low water crossings on public and private roads to make them passable during prolonged release flows from floodwater retarding structures or obtain permission to inundate such roads where equal alternate routes are designated for use during periods of inundation;

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

6. Obtain a court order from Pecos County Commissioners Court providing that the county road affected by the embankment

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and detention pool of floodwater retarding structure No. 3 will be relocated at no expense to the Federal Government.

The Terrell County Commissioners Court will enter into a construction agreement with the Southern Pacific Company on railroad bridge modification after concurrence of the Soil Conservation Service. The Southern Pacific Company, the Sponsoring Local Organizations, and the Soil Conservation Service will review final construction plans.

Construction of the channel, training dike, and appurtenances will be the responsibility of the Soil Conservation Service. The Southern Pacific Company will make the necessary modification of railroad bridge number 516.23 and it's appurtenances in accordance with terms of the construction agreement to be entered into.

Technical assistance will be provided by the Soil Conservation Service in preparation of plans and specifications, construction inspection, preparation of contract payment estimates, final inspection, execution of certificate of completion, and related tasks necessary to install planned structural measures not including the railroad bridge.

The structural measures will be constructed during the first nine years of a ten-year project installation period in the general sequence as follows:

First Year	-	Channel Improvement
Second Year	-	Floodwater Retarding Structures Nos. 7 and 8
Third Year	-	Floodwater Retarding Structures Nos. 9 and 10
Fourth Year	-	Floodwater Retarding Structure No. 11
Fifth Year	-	Floodwater Retarding Structure No. 2
Sixth Year	-	Floodwater Retarding Structure No. 1
Seventh Year	-	Floodwater Retarding Structure No. 6
Eighth Year	-	Floodwater Retarding Structures Nos. 4 and 5
Ninth Year	-	Floodwater Retarding Structure No. 3

In order for construction to proceed according to schedule, all land rights for floodwater retarding structures and channel improvement are scheduled by the Terrell County Commissioners Court to be secured by the end of the time periods as shown in the following tabulation. The schedule will be effective not later than the date the work plan is approved for operations.

Time Period	Works of Improvement
First six months	Channel Improvement and Floodwater Retarding Structures Nos. 3, 4, 5, 7, and 8
Second six months	Floodwater Retarding Structures Nos. 9, 10, and 11
Third six months	Floodwater Retarding Structure No. 1
Fourth six months	Floodwater Retarding Structures Nos. 2 and 6

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out works of improvement described in this work plan will be provided under authority of the Watershed Protection and

Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

The cost of applying land treatment measures will be borne by landowners and operators.

Funds for the local share of the cost of this project relative to structural measures will be provided by Terrell County. The Commissioners Court of Terrell County will set aside revenue funds to finance the local share of installation cost of the planned eleven floodwater retarding structures and approximately 1,800 feet of channel improvement.

The sponsors will carry out all phases of project installation, operation and maintenance and have the financial ability to make adequate arrangements for carrying out their responsibilities.

It is anticipated that approximately 50 percent of the easements for structural measures will be donated. Out-of-pocket costs for land rights, legal expenses, and project administration are estimated to be $66,700.

Structural measures will be constructed during the first nine years of the ten-year project installation period pursuant to the following conditions:

1. Requirements for land treatment in drainage areas of floodwater retarding structures have been satisfied.

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

3. 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 principal spillways of 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 flow from structures.

4. A court order has been obtained from the Pecos County Commissioners Court showing that the county road affected by the embankment and detention pool of floodwater retarding structure No. 3 will be relocated at no expense to the Federal Government.

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

6. Project agreements have been executed.

7. Operation and maintenance agreements have been executed.

8. Public Law 566 funds are available.

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

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

The County Agricultural Stabilization and Conservation committee will cooperate with the governing bodies of the soil and water conservation districts by continuing to provide financial assistance for selected conservation practices.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Planned land treatment measures will be maintained by landowners and operators of ranches on which measures are applied under agreement with the Rio Grande-Pecos, Big Bend, and Trans-Pecos Soil and Water Conservation Districts. Representatives of the districts will make periodic inspections of land treatment measures to determine maintenance needs and encourage landowners and operators to perform maintenance.

Structural Measures

The Commissioners Court of Terrell County will be responsible for operation and maintenance of the eleven floodwater retarding structures and approximately 1,800 feet of channel improvement. This includes Site No. 1 in Brewster County and Sites Nos. 2 and 3 in Pecos County.

Railroad bridge number 516.23 will be maintained by the Southern Pacific Company.

The estimated annual operation and maintenance cost for floodwater retarding structures and channel improvement is $7,100. Monies for operation and maintenance will be supplied from the General Fund of Terrell County. This fund is supported by revenue from existing taxes. Each year the Terrell County Commissioners Court will budget sufficient funds for operation and maintenance.

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A specific operation and maintenance agreement will be executed prior to the issuance of invitation to bid on construction of any of the eleven floodwater retarding structures and channel improvement.

Floodwater retarding structures and channel improvement will be inspected at least annually and after each heavy rain by representatives of the Terrell County Commissioners Court and the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts. A Soil Conservation Service representative will participate in these inspections for a period of at least three years following construction. The Soil Conservation Service will participate in inspections as often as it elects to do so after the third year. Items of inspection will include, but will not be limited to, conditions of principal spillways and their appurtenances, emergency spillways, and earth fills for floodwater retarding structures and degradation, aggradation, bank erosion, the condition of rock riprap, obstruction of flow caused by debris and/or sediment lodged against the railroad bridge, growth of brush and trees, and the condition of side inlets and drains for channel improvement. The need for frequent cleanout of gravel deposits beneath the railroad bridge is anticipated.

Upon acceptance of the completed works of improvements from the contractors, the Terrell County Commissioners Court will be totally responsible for all maintenance. Maintenance will be performed promptly as the need arises.

The Soil Conservation Service will assist in operation and maintenance only to the extent of furnishing technical guidance.

Provisions will be made for unrestricted access by representatives of sponsoring local organizations and the Federal Government to inspect all structural measures and their appurtenances at any time and for sponsoring local organizations to operate and maintain them.

The Terrell County Commissioners Court will maintain a record of all maintenance inspections made and maintenance performed and have it available for inspection by Soil Conservation Service personnel.

The necessary maintenance work will be accomplished either by contract, force account, or equipment owned by sponsoring local organizations.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Sanderson Canyon Watershed, Texas

Installation Cost Item	Unit	Number Non-Federal Land	Estimated Cost (Dollars) 1/ Public Law 566 Funds Non-Federal Land	Other Non-Federal Land	Total
LAND TREATMENT					
Soil Conservation Service					
Rangeland	Acre	83,500	-	160,756	160,756
Pasture	Acre	750	-	27,764	27,764
Technical Assistance			-	15,658	15,658
TOTAL LAND TREATMENT				204,178	204,178
STRUCTURAL MEASURES					
Construction					
Soil Conservation Service					
Floodwater Retarding Structures	No.	11	3,550,281	-	3,550,281
Channel Improvement	Foot	1,800	197,036	-	197,036
Subtotal - Construction			3,747,317	-	3,747,317
Engineering Services					
Soil Conservation Service					
Floodwater Retarding Structures	No.	11	177,514	-	177,514
Channel Improvement	Foot	1,800	9,868	-	9,868
Subtotal - Engineering Services			187,382	-	187,382
Project Administration					
Soil Conservation Service					
Construction Inspection			226,809	-	226,809
Other			319,187	6,200	325,387
Subtotal - Administration			545,996	6,200	552,196
Other Costs					
Land Rights			-	79,455	79,455
Subtotal - Other			-	79,455	79,455
TOTAL STRUCTURAL MEASURES			4,480,695	85,655	4,566,350
TOTAL PROJECT			4,480,695	289,833	4,770,528

1/ Price Base: 1969

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

Sanderson Canyon Watershed, Texas

Measures	Unit	Number Applied To Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Proper Grazing Use	acre	73,777	86,444
Range Deferred Grazing	acre	23,492	17,619
Brush Control	acre	5,637	73,281
Pasture and Hayland Management	acre	1,000	2,000
Pasture and Hayland Planting	acre	1,583	15,830
Diversion	feet	10,251	6,151
Well	no.	36	108,000
Trough or Tank	no.	55	55,000
Pond	no.	12	12,000
Pipeline	feet	324,720	162,360
TOTAL LAND TREATMENT			538,685

1/ Price Base: 1968

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Sanderson Canyon Watershed
(Dollars) 1/

Item	Installation Cost P. L. 566 Funds: Construction	Installation Cost P. L. 566 Funds: Engineering	Installation Cost P. L. 566 Funds: Total P. L. 566	Installation Cost Other Funds: Land Rights	Installation Cost Other Funds: Total Other	Total Installation Cost
Floodwater Retarding Structures						
1	358,775	17,939	376,714	10,220	10,220	386,934
2	650,482	32,524	683,006	9,810	9,810	692,816
3	230,414	11,521	241,935	5,380	5,380	247,315
4	248,273	12,414	260,687	2,820	2,820	263,507
5	249,845	12,492	262,337	3,120	3,120	265,457
6	338,455	16,923	355,378	4,080	4,080	359,458
7	301,309	15,065	316,374	3,330	3,330	319,704
8	152,366	7,618	159,984	2,120	2,120	162,104
9	215,012	10,751	225,763	1,820	1,820	227,583
10	221,666	11,083	232,749	5,120	5,120	237,869
11	583,684	29,184	612,868	12,385	12,385	625,253
Subtotal	3,550,281	177,514	3,727,795	60,205	60,205	3,788,000
Channel Improvement 2/	197,036	9,868	206,904	19,250	19,250	226,154
Subtotal	197,036	9,868	206,904	19,250	19,250	226,154
Subtotal - Waterahed	3,747,317	187,382	3,934,699	79,455	79,455	4,014,154
Project Administration			545,996		6,200	552,196
GRAND TOTAL	3,747,317	187,382	4,480,695	79,455 3/	85,655	4,566,350

1/ Price Base: 1969
2/ Includes modification of Southern Pacific Company Railroad Bridge Number 516.23 and approximately 1,800 feet of channel improvement.
3/ Includes $4,900 for legal fees; $10,000 for modification of railroad bridge; and $26,655 for relocation or modification of other fixed improvements and utilities.

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Sanderson Canyon Watershed, Texas

Item	Unit	Structure Number 1	2	3	4	5	6	7	8	9	10	11	Total
Class of Structnre		B	B	B	C	C	C	C	C	C	C	C	xxx
Drainage Area	Sq.Mi.	19.58	53.23	7.95	10.42	8.88	15.96	7.84	3.35	4.20	4.52	13.86	149.79
Controlled	Sq.Mi.	-	-	-	-	-	-	-	-	-	-	19.91	xxx
Curvo No. (1-day)(AMC II)		82	82	82	82	82	82	82	82	82	82	82	xxx
T_c	Hrs.	1.92	3.01	0.87	1.34	1.32	1.55	0.86	0.58	0.78	0.59	1.55	xxx
Elevation Top of Dam	Ft.	3672.9	3523.2	3361.0	3234.4	3184.0	3085.1	3228.1	3116.1	2951.8	3008.1	2874.2	xxx
Elevation Crest Emergency Spillway	Ft.	3659.6	3510.8	3350.5	3222.1	3173.4	3070.2	3215.0	3104.6	2939.8	2995.2	2855.8	xxx
Elevation Crost Principal Spillway	Ft.	3639.0	3489.4	3334.0	3203.3	3152.9	3046.9	3197.0	3085.8	2921.1	2975.5	2837.5	xxx
Elevation Crest Lowest Ungated Outlet	Ft.	3636.0	3482.0	3334.0	3202.2	3152.9	3043.0	3197.0	3085.8	2921.1	2975.5	2835.2	xxx
Maximum Height of Dam	Ft.	49	55	39	51	55	64	49	48	50	56	57	xxx
Volume of Fill	Cu.Yd.	574,200	1,092,400	287,800	357,200	445,850	530,300	324,600	220,850	337,500	284,500	837,200	5,292,400
Total Capacity	Ac.Ft.	2,757	5,990	1,429	1,906	1,681	2,562	1,480	740	907	976	1,782	22,210
Sediment Pool(Lowest Ungated Outlet) 1/	Ac.Ft.	198	200	148	200	199	196	155	79	96	113	199	1,783
Sediment Aerated 1st 50 years	Ac.Ft.	354	852	148	239	199	324	155	79	96	113	288	2,847
Sediment Aerated 2nd 50 years	Ac.Ft.	366	852	148	239	208	323	155	80	97	111	296	2,875
Sediment in Detention Pool-Aerated	Ac.Ft.	73	170	30	50	43	60	29	16	20	24	59	574
Retarding Pool	Ac.Ft.	1,964	4,116	1,103	1,378	1,231	1,855	1,141	565	694	728	1,139	15,914
Surface Area													
Sediment Pool(Lowest Ungated Outlet)	Acres	41	51	32	35	27	28	27	13	19	17	35	325
Sediment Pool-Principal Spillway Crest	Acres	54	124	32	39	27	40	27	13	19	17	44	436
Retarding Pool	Acres	192	363	128	139	127	156	127	62	73	79	117	1,563
Principal Spillway													
Rainfall Volume (areal)(1-day)	In.	6.31	6.25	6.60	6.70	6.70	6.54	6.80	6.80	6.80	6.80	6.51	xxx
Rainfall Volume (areal)(10-day)	In.	10.65	10.61	10.90	11.00	11.10	10.89	11.10	11.10	11.10	11.10	10.87	xxx
Runoff Volume (10-day)	In.	3.40	2.80	4.33	4.12	4.30	3.71	4.44	5.34	5.07	5.00	3.16	xxx
Capacity (Maximum)	cfs	255	573	112	125	128	210	119	123	123	126	1,055	xxx
Frequency Operation-Emergency Spillway	% chance	1	1	1	1	1	1	1	1	1	1	1	xxx
Size of Conduit	In.	42	54x54	30	30	30	36	30	30	30	30	72x72	xxx
Emergency Spillway													
Rainfal2 Volume (ESH)(areal)	2n.	6.93	5.29	7.70	11.18	11.20	10.36	11.20	11.20	11.20	11.20	10.62	xxx
Runoff Volume (ESH)	In.	4.85	3.34	5.57	8.92	8.94	8.13	8.94	8.94	8.94	8.94	8.38	xxx
Type		Rock	Rock	Rock	Rock	Rock	Rock	Rock	Rock	Rack	Rock	Rock	xxx
Botton Width	Ft.	200	400	150	400	450	400	300	200	200	200	400	xxx
Velocity of Flow (V_e)	Ft./Sec.	11.7	11.2	9.6	11.5	10.4	12.7	11.0	9.5	10.3	10.5	13.0	xxx
Slope of Exit Channel	Ft./Ft.	0.046	0.020	0.220	0.022	0.130	0.150	0.120	0.086	0.090	0.130	0.038	xxx
Maximum Water Surface Elevation	Ft.	3665.4	3515.8	3354.6	3227.4	3177.9	3076.9	3220.2	3108.7	2944.2	3000.0	2862.1	xxx
Freeboard													
Rainfall Volume (FH)(areal)	In.	14.67	11.40	16.60	28.14	28.40	26.36	28.50	28.50	28.50	28.50	22.29	xxx
Runoff Volume (FH)	In.	12.32	9.14	14.22	25.67	25.93	23.90	26.03	26.03	26.03	26.03	19.86	xxx
Maximum Water Surface Elevation	Ft.	3672.9	3523.2	3361.0	3234.4	3184.0	3085.1	3228.1	3116.1	2951.8	3008.1	2874.2	xxx
Capacity Equivalents													
Sediment Volume	In.	0.76	0.66	0.77	0.95	0.95	0.83	0.81	0.98	0.95	1.03	0.87	xxx
Retarding Volume	In.	1.88	1.45	2.60	2.48	2.60	2.18	2.73	3.16	3.10	3.02	1.54	xxx

1/ Valume included in sediment aeroted 1st 50 years.

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TABLE A - ANNUAL COST

Sanderson Canyon Watershed, Texas

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
Floodwater Retarding Structures Numbers 1 through 11 and Channel Improvement	197,680	7,100	204,780
Project Administration	26,847		26,847
GRAND TOTAL	224,527	7,100	231,627

1/ Price Base: Installation - 1969, O&M - Adjusted normalized prices.

2/ 100-years at 4.825 percent interest.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Sanderson Canyon Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	Estimated Average Annual Damage: With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	530	189	341
Other Agricultural	3,334	996	2,338
Nonagricultural			
Transportation	156,225	5,165	151,060
Urban	156,270	240	156,030
Subtotal	316,359	6,590	309,769
Indirect	70,696	1,457	69,239
TOTAL	387,055	8,047	379,008

1/ Price Base: Adjusted normalized prices, April 1966.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Sanderson Canyon Watershed, Texas
(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/			Average Annual Cost 2/	Benefit Cost Ratio
	Damage Reduction	Secondary	Total		
Floodwater Retarding Structures Numbers 1 through 11 and Channel Improvement	359,907 3/	29,395	389,302	204,780	1.9:1.0
Project Administration				26,847	
GRAND TOTAL 4/	359,907	29,395	389,302	231,627	1.7:1.0

1/ Price Base: Adjusted normalized prices, April 1966.
2/ From Table 4.
3/ Includes $250 sediment damage reduction benefits - Amistad Reservoir.
4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $19,351 annually.

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INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by the Rio Grande-Pecos River, Big Bend, and Trans-Pecos Soil and Water Conservation Districts assisted by personnel from the Soil Conservation Service work units at Sanderson, Alpine, and Fort Stockton, Texas. Conservation needs data were compiled from existing conservation plans within the watershed and expanded to represent 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. The estimated number of acres, by land use, to be treated during the project installation period ia shown on table 1. Hydraulic, hydrologic, sedimentation, and economic investigations provided data as to the effects of land treatment measures in terms of reduction of flood damage. Although measurable benefits would result from application of 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 local people.

Hydrologic soil and cover conditions were determined by detailed mapping of a 38 percent sample of the watershed.

Present hydrologic cover conditions were determined on the basis of the percentage of vegetative ground cover and litter. 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 the application.

Hydraulics and Hydrology

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau climatological bulletins for the rainfall gage at Sanderson, Texas. These data were analyzed to determine seasonal distribution of precipitation, rainfall-runoff relationships, and monthly runoff volumes.

2. Present hydrologic conditions of the watershed were determined on the basis of cover conditions, land use and treatment, and soil groups. An average condition II curve number of 83 for the hydrologic soil-cover complex was based on a 38 percent sample of the watershed.

   Analysis of land treatment to be applied during the installation period revealed that an average condition II curve number of 82 is applicable for project conditions.

3. Engineering surveys were made of valley cross sections, channel cross sections, high water marks, bridges, and

other features pertinent in determining the extent of flooding. The cross sections were selected to represent stream hydraulics and flood plain area. Final locations were made after joint study with the economist and geologist.

4. Cross section rating curves for the urban area of Sanderson, Texas, were developed by water surface profiles using the computer facilities at the South Regional Technical Service Center, Fort Worth, Texas. Rating curves for agricultural valley cross sections were developed by Mannings' formula.

5. Stage-area inundated curves were developed for each valley cross section. The area inundated by incremental depths of flooding was determined for each evaluation reach, using runoff-peak discharge relationship for selected storms in the frequency series.

6. Present and project condition runoff-discharge relationships were determined by flood routing the 100-year frequency storm. Present and project condition peak discharges were then determined for selected storms in the frequency series.

   Routings were made for present and project conditions of the 100-year frequency storm by use of the convex routing method.

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. Without project

   b. Installation of land treatment measures for watershed protection

   c. Installation of land treatment and structural measures (including several alternative systems of structural measures)

8. The maximum release rates for the principal spillways of floodwater retarding structures were designed to drawdown the detention pool volume in 10 days or less after inflow ceases.

9. The appropriate principal spillway, emergency spillway design, and freeboard storms were selected in accordance with criteria contained in NEH, Chapter 21, Section 4, Hydrology, Part I-Watershed Planning.

Engineering

Studies were made on both the agricultural flood plain and the urban flood plain in Sanderson to locate those areas subject to flood damage. High

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water marks of the June 1965 flood were in evidence. The areas subject to flood damage were separated into evaluation reaches in order to formulate the most feasible system of structural measures necessary to meet project objectives.

No sites were given consideration as possible multiple-purpose structures because of the poor water holding potential of soils in Sanderson Canyon watershed.

Comprehensive surveys and investigations were made at thirteen possible floodwater retarding structure sites and on approximately four miles of Sanderson Canyon through the urban area of Sanderson.

Eleven floodwater retarding structures, approximately 1,800 feet of channel improvement, and modification of Southern Pacific Company's railroad bridge number 516.23 were selected for inclusion in the final work plan. Structure locations are shown on figures 3 and 4.

Two floodwater retarding structure sites upstream from Site No. 2 were investigated and analyzed but not selected for inclusion in the final project. One site was on Dry Creek approximately 7 miles west of Site No. 2. The long, high embankment necessary to obtain satisfactory storage would have resulted in an excessive construction cost. The other site considered was on a tributary which joins Dry Creek approximately 3 miles upstream from Site No. 2. The drainage area of this possible site is small and can be controlled by a structure at Site No. 2 at less construction cost.

Sediment and floodwater storage, structure classification, 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 both principal and emergency spillways were made to determine principal spillway sizings, detention storage requirements, and to analyze the affects of release flows on downstream improvements such as highway and railroad bridges and low water crossings. Least cost studies were made on the planned floodwater retarding structure sites because of extensive rock excavation and the large embankment quantities required. Because the rock will be thick to massively bedded, hard limestone with only slight dip, vertical slopes in the rock portions of emergency excavation will be stable.

A detailed investigation was made of State, county, and ranch roads having crossings on streams below floodwater retarding structures.

Structure data tables were developed to show the total cost of each structure (table 2). Table 3 provides specific site information. Table 4 was developed to show separately the annual installation cost, annual maintenance cost, and total annual cost of structural measures.

The slope area measurement computations indicate that an average velocity of 11 feet per second occurred during the 1965 flood through the area of planned channel improvement. The water surface profile computation indicates the highest average velocity in the improved channel also will be 11 feet per second with the total project installed.

Water surface profile computations indicate that, under project conditions, the 100-year frequency storm will pass through the proposed modified railroad bridge without overtopping or endangering the safety of the railroad.

Geology

Soils and Foundations

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, types of material in emergency spillway excavation, emergency spillway stability, and other problems that might be encountered during construction. These investigations included surface observations of valley slopes, alluvium, channel banks, and exposed geologic formations; hand auger borings; and hand portable seismograph tests. Geologic maps, reports, and well logs pertaining to the watershed vicinity were studied.

Findings of these investigations were used to aid in estimating structure costs and to assure that sites selected are feasible for construction.

The entire watershed lies within a deeply dissected area of the Edwards Plateau, a subprovince of the Great Plains Physiographic Province. All planned floodwater retarding structures will be located on the outcrops of the Edwards Limestone and alluvium, colluvium, and terrace deposits of the Pleistocene and Recent Series.

The Edwards Limestone consists mainly of massive beds of subcrystalline, dense, fine grained, brittle limestone containing thin beds and nodules of flint. There are also occasional layers of shale or thin bedded limestone. Solution of the Edwards Limestone is indicated by minute cavities and small caves, but there is no evidence of any large interconnected cavern system in the watershed vicinity.

Sanderson Canyon was once much deeper than it is today. Thick Quaternary deposits of interbedded silty gravel, clayey sand, sandy clay, and silty clay occupy the valleys of Sanderson Canyon and its tributaries. A study of well logs indicates that the alluvium ranges to greater than 250 feet in thickness.

The structure of the rocks exposed within the watershed is rather simple. The regional dip is about one degree south-southeast. Minor faulting was seen north of Sanderson in the form of northwest trending shear zones and normal faults of little displacement. A very gentle anticline occurs in the western part of the watershed and is incised by the valley of Dry Creek.

Foundations of floodwater retarding structures will be predominantly thick Quaternary Alluvium, which includes very highly permeable horizons. The need for foundation and embankment drainage features is anticipated. On site materials should be suitable for use as filter material at most sites. Foundations are expected to have good bearing and shear strength.

The higher portions of abutments and emergency spillway areas are generally characterized by a thin soil mantle, nonexistant in some places, underlain by the Edwards Limestone. The surface slope of the limestone on abutments and in the subsurface is believed to be gentle enough to preclude serious differential settlement problems in foundations.

The following tabulation shows preliminary estimates of rock excavation volumes in emergency spillways.

Site Number	Cubic Yards
1	72,935
2	98,300
3	70,480
4	58,200
5	18,870
6	72,330
7	15,470
8	31,110
9	42,220
10	65,120
11	102,650

The rock through which emergency spillways will be excavated consists of slightly dipping, highly durable, thick-bedded to massive limestone. Vertical cuts in the rock portions of emergency spillway excavation will be stable.

Ample soils, suitable for embankment use, are available within sediment pool areas. Fine-textured soils are rather scarce at some sites. It is estimated, however, that sufficient volumes of silty clay, sandy clay, and gravelly clay are available at all sites for construction of minimum central sections of very slowly permeable material. The remainder of embankments will be comprised primarily of clayey sand, silty gravel, and sandy gravel from sediment pool areas and limestone from emergency spillway excavation. The gravel content of the coarser-textured soils is sufficient for natural development of protective desert pavement. This is particularly important at sites where emergency spillway excavation will not yield sufficient volumes of limestone for complete rock outer embankment sections.

Sufficient volumes of surface water for construction purposes are not available in the watershed vicinity. It will be necessary to use ground water. Some water probably will be pumped from on-site wells, but low yields could make necessary the piping of water from more reliable sources in the near vicinity. The Maxon Sandstone is the main water-bearing formation in the watershed area. The overlying Edwards Limestone and Quaternary Alluvium contain very little water. Apparently there are no extensive impervious layers to prevent water from seeping downward through the Edwards Limestone and into the Maxon Sandstone. Based on well data in the Sanderson vicinity, it is estimated that the water depth will average about 400 feet at floodwater retarding structure sites and that the yields will range from 10 to 30 gallons per minute.

Detailed investigations, including exploration with core drilling equipment, will be made at all sites prior to final design. Laboratory analysis will be made to determine suitability and methods of handling foundation and embankment materials.

Ground Water

A limited investigation was made to determine the probable effect the project would have on ground water resources of the area.

Pertinent information was gathered from United States Geological Survey publications concerning ground water in the vicinity of Sanderson. Field studies included mapping of surface geologic strata. The Maxon Sandstone (Trinity Group) is the main aquifer underlying the watershed. It is exposed in the western portion of the watershed, but it dips beneath the surface toward the east and occurs at a depth of about 300 feet at Sanderson. Throughout most of the watershed, the Maxon Sandstone is overlain by formations of the Fredericksburg Group, constituted mostly by the Edwards Limestone. Thick deposits of permeable Quaternary Alluvium overlie the Fredericksburg Group in the valley of Sanderson Canyon.

The strata overlying the Maxon Sandstone contain very little water. Apparently there are no impervious beds extensive enough to prevent water from seeping downward and into the sandstone. Shale and limestone beds within the Glen Rose Formation make up the lower confining layer for water in the Maxon Sandstone.

Installation of floodwater retarding structures will cause some increased ground water recharge which will benefit both rural and urban residents in the Sanderson vicinity. Investigations to determine adequate estimates of average annual volumes of ground water recharge under present and project conditions would require excessive time and funds in relation to expected benefits. For this reason, no detailed studies or monetary evaluation of ground water recharge were made.

Sedimentation

Sediment Storage

Determinations of 100-year sediment storage requirements for the planned floodwater retarding structures were made according to the following procedure:

> Detailed studies of soils, slopes, and cover were made within sample areas covering 38 percent of the watershed. The sample areas were selected to be representative of the watershed in respect to sediment producing characteristics. Average annual sheet erosion rates, for both present and future conditions, were computed. The soil loss equation by Musgrave was used. Estimates of average annual sheet erosion within drainage

areas of structure sites were based on the computed erosion rates.

Computations of gully and streambank erosion were based on estimated lateral bank erosion rates, bank heights, and channel lengths affected by erosion.

Sediment delivery ratios and trap efficiency adjustments were applied to computed average annual erosion to arrive at estimates of sediment volumes to be deposited in reservoirs.

Because of the expected high rate of seepage losses in pools of floodwater retarding structures, all sediment was computed as aerated. Therefore, no allowance was made for differences in density between soil in place and sediment.

Allocation of sediment to the pools of floodwater retarding structures was based on sediment texture and reservoir topography. The allocation was approximately 90 percent in sediment and sediment reserve pools and 10 percent in detention pools.

Flood Plain Land Damages

Investigations were made to determine the nature and extent of physical damage to flood plain lands. The cross section method was used in accordance with prescribed procedures.

Reductions of damages caused by flood plain scour and overbank deposition of sediment were not calculated because such damages were found not to be monetarily significant.

Reservoir Sedimentation

Studies of sediment sources in Sanderson Canyon watershed were used as a basis for estimating the effects of the planned project on sediment deposition in Amistad Reservoir. Sediment delivery ratios were estimated, by sources, for non-project and project conditions, making allowances for such factors as size, shape, topography, and relief-length ratio of the sediment contributing area; density, drainage pattern, gradient, and capacities of channels; and texture of sediment.

The estimated average annual sediment yield to Amistad Reservoir from Sanderson Canyon watershed is 28 acre-feet. An average annual reduction of 17 acre-feet of sediment deposition in Amistad Reservior is expected as a result of the installation of land treatment and floodwater retarding structures on Sanderson Canyon watershed.

Channel Stability

Both aggradation and degradation are occurring in the streams of Sanderson Canyon watershed, but when considered as a whole, the stream-system is in regimen. This is true in that streambed adjustments to changes in characteristics of flow and sediment load are gradual. Field studies and mechanical analyses of bedload indicate that moderately well graded gravel, which extends to great depth, constitutes the material through which channel improvement will be installed. The D_{75} grain size is about one inch. More than 90 percent of the bedload volume ranges between 0.15 millimeters and 12 inches. Medium boulders are found scattered throughout the bedload. The fine grained fraction is insignificant. Degradation is prevented by armor plating in the thalweg, which is incised about one foot beneath the bar surface. During the flood of 1965, the peak velocity of flow within the channel banks reached approximately 20 feet per second. The channel bed and banks remained stable above and below the railroad bridge, and gravel deposits filled the major portion of bridge openings.

Because of the stability of the present channel during major flows; the supply of bedload sufficient to fully charge major flows; the extensiveness of coarse gravel, cobbles, and boulders immediately available for armor plating; and decreases in discharges and velocities after total project installation, degradation is not expected to be a problem in the segment of channel to be improved. Instead, some aggradation is expected beneath the railroad bridge. It is anticipated that frequent cleanout of gravel deposits will be necessary.

Economics

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

Because of the diversity of damageable values and flood plain characteristics, the flood plain was divided into three evaluation reaches (figure 4). Of these, one was in the urban area of Sanderson.

Determination of Nonagricultural Damages

Because the major floodwater damages in this watershed are to nonagricultural property, the synthetic frequency method of analysis was used. Information was collected in the field on damages experienced from the flood of June 1965 and from several minor floods. At the same time an evaluation was made of the damages that would occur from a flood which could be expected to occur on an average of once in 100 years. Under without project conditions, a flood of this magnitude would resnlt in high water elevations in Sanderson of from approximately 1.0 foot to 1.8 feet higher than the high water elevations experienced in 1965. High water marks from the experienced floods were used to determine peak stages which in turn were related to stages calculated for the synthetic series. Stage damage curves were developed to cover the range of damage producing floods. Average annual damages under the present state of development were calculated.

Because a high percent of the damage by the larger floods is to businesses, indirect damages associated with urban flooding will bear a higher than normal relationship to the direct damage. Expenses associated with dislocation of residents and rehabilitation of businesses will be extremely high. For this reason, it is estimated that indirect damages to urban property would approximate 20 percent of the direct damage.

Estimates of damages to railroads, roads, highways, and bridges in the flood plain were obtained from railroad officials, county officials, state highway officials, and supplemented by information from local residents. It was estimated that indirect damage to transportation facilities would approximate 25 percent of the direct damage.

Determination of Agricultural Damages

Agricultural damage calculations were based on information obtained in interviews with owners and operators of approximately 50 percent of the acreage of the flood plain. Schedules covered flooding and flood damage; past, present, and intended future use; and yield data. Verification of information gained by interviews in the field was obtained from local agricultural technicians.

The synthetic frequency method of analysis of damages was used, and the occurrence of more than one flood in a growing season was considered in determining crop and pasture damage. The computed damages were discounted for the recurrence with allowance for partial recovery between floods.

Other agricultural damages to fences and farm roads and livestock losses were estimated from information collected in the field and correlated with area and depth of flooding.

Indirect damages involve such items as additional travel time for ranchers in transporting products and farm equipment, cost of extra feed for live-stock, loss of benefits from grazing, and other related items. It was estimated that indirect damage to agricultural property would approximate 10 percent of the direct damage.

Negative Project Benefits

Areas that will be used for project construction and areas to be inundated by pools of reservoirs were excluded from damage calculations. 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. No production in sediment pools was considered, and the land covered by detention pools was assumed to be rangeland under project conditions. The annual value from the loss of net income from these areas was less than the amortized value of the land; therefore, the easement value was used in economic justification.

Secondary Benefits

The value of local secondary benefits stemming from the project were estimated to be equal to 10 percent of direct benefits. This excludes all indirect benefits from the computation of secondary benefits.

Fish and Wildlife

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Texas Parks and Wildlife Department, has completed a reconnaissance study of Sanderson Canyon watershed. This report was valuable in work plan development pertaining to fish and wildlife. In addition to data presented in other parts of the work plan, the following recommendations are reproduced from the Bureau of Sport Fisheries and Wildlife reconnaissance survey report:

"It is recommended that:

1. Serious consideration be given by the project sponsors to include additional storage for fishing and hunting and other forms of recreation in any of the reservoirs that will maintain a permanent pool of sufficient depth to sustain fishlife year around.

2. Contingent upon the development of additional storage, as advocated in Recommendation No. 1, preparation of the basin and stocking of the reservoir should be done under the advice of the Texas Parks and Wildlife Department.

3. As much brush and timber as possible be retained in the project area for wildlife.

4. When brush control results in the loss of wildlife cover and food plants, Johnson grass or other plants useful to wildlife and adaptable to the area should be planted on cleared areas, or on areas where soils are suitable for their growth.

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

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

4-27999 10-69

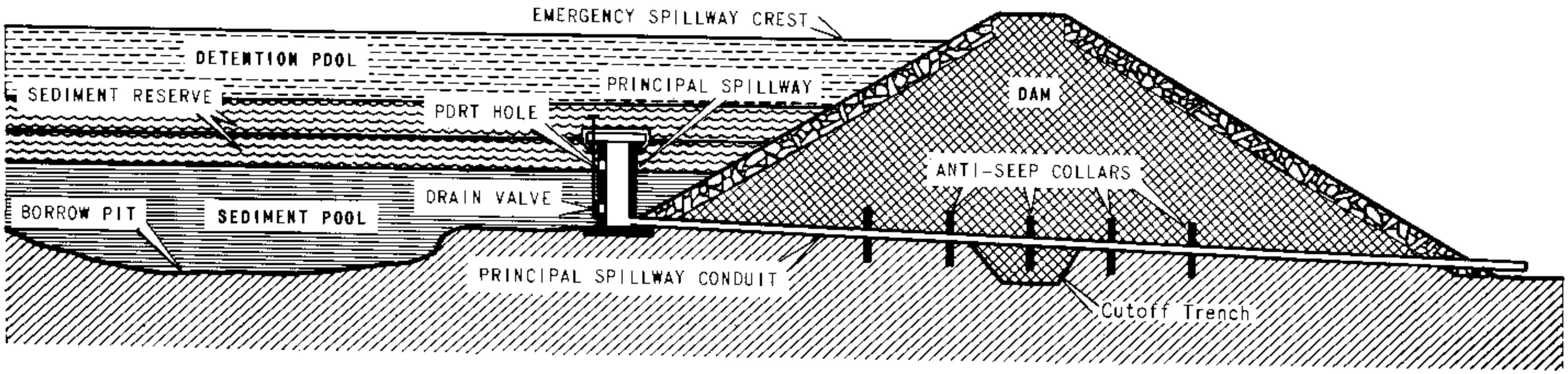


Figure I

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

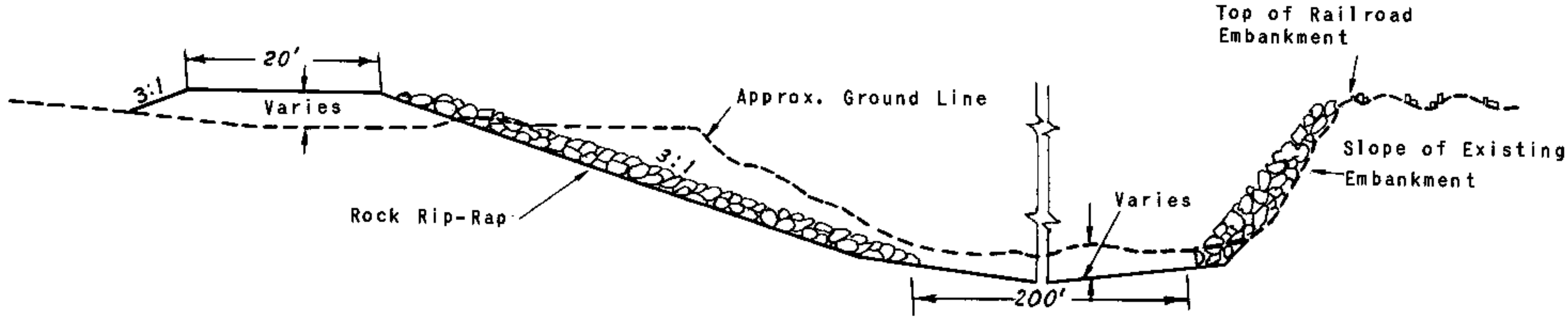
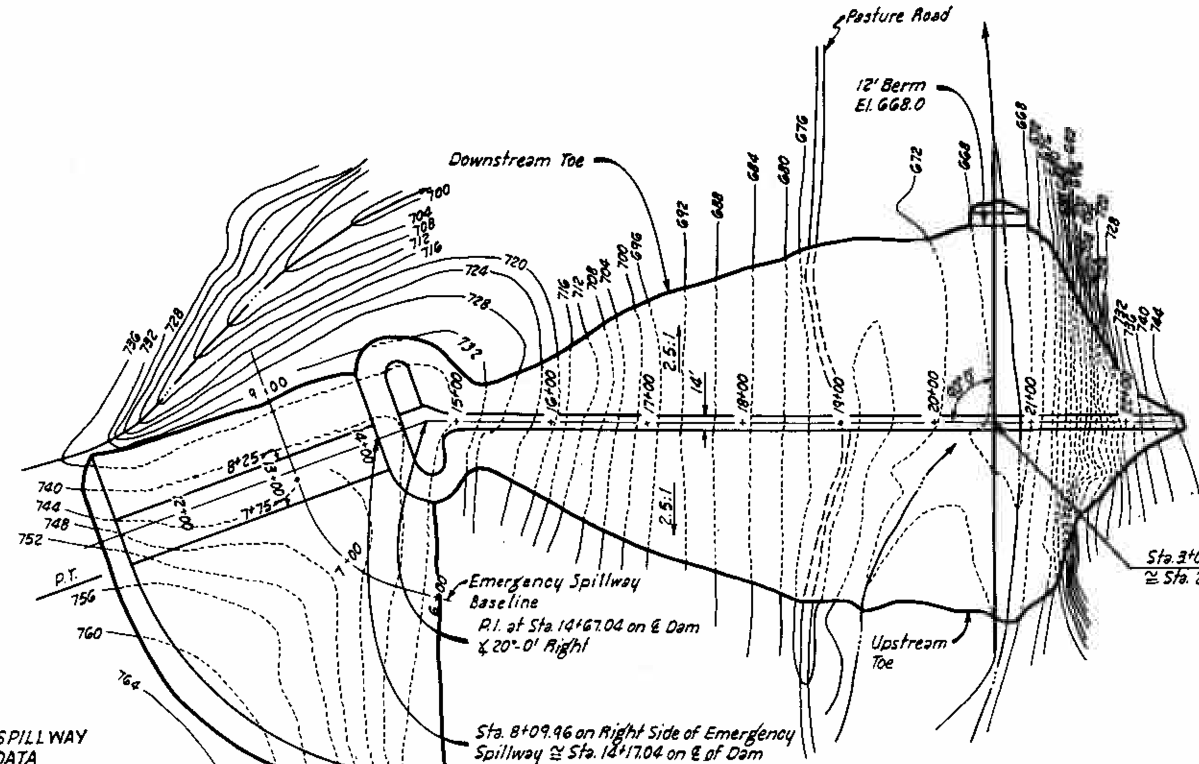


Figure I-A

TYPICAL CROSS SECTION OF CHANNEL IMPROVEMENT

Immediately Above Railroad Bridge No. 516.23

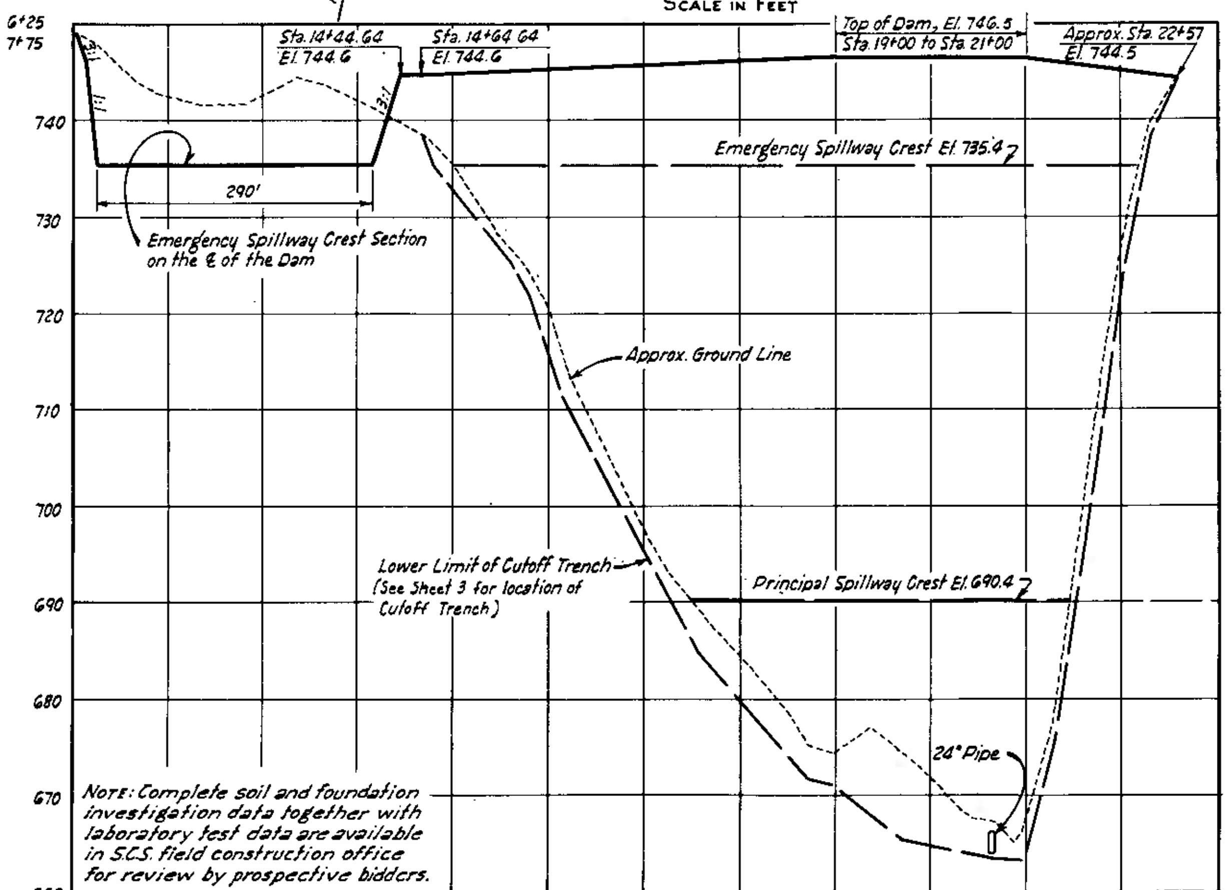
10-69 4-L-28579



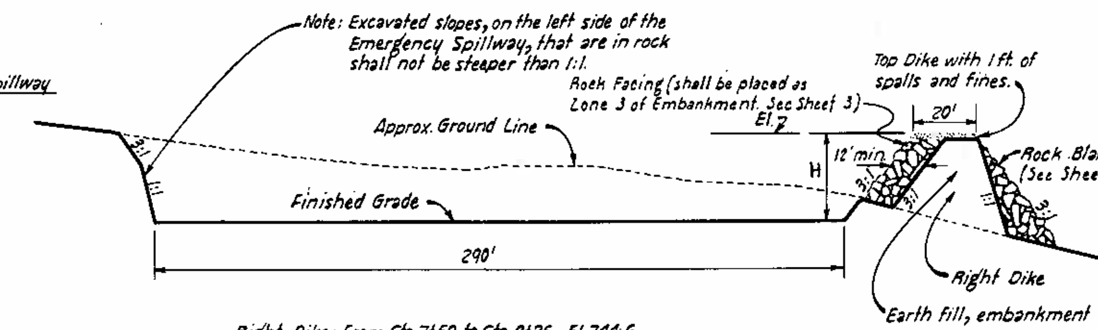
PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

EMERGENCY SPILLWAY CURVE DATA
Δ = 57°-0'
D = 38°-0'
R = 150.78'
L = 150'
P.C. = Sta. 6+25
P.T. = Sta. 7+75

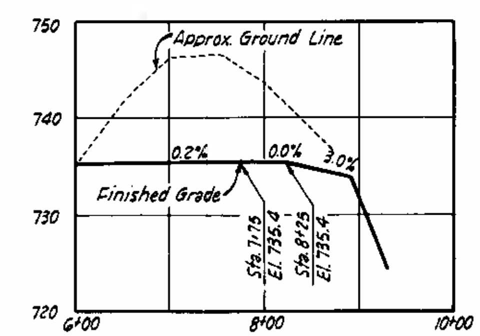


PROFILE ON ℄ OF DAM



Right Dike: From Sta. 7+50 to Sta. 8+25, El. 744.6
From Sta. 8+25 to Sta. 8+75, H = 9.2 ft.
Note: Materials used in forming dike shall be placed and paid as "Earthfill, Embankment".
(See Sheet 3 for placement of rock materials)

TYPICAL SECTION – EMERGENCY SPILLWAY

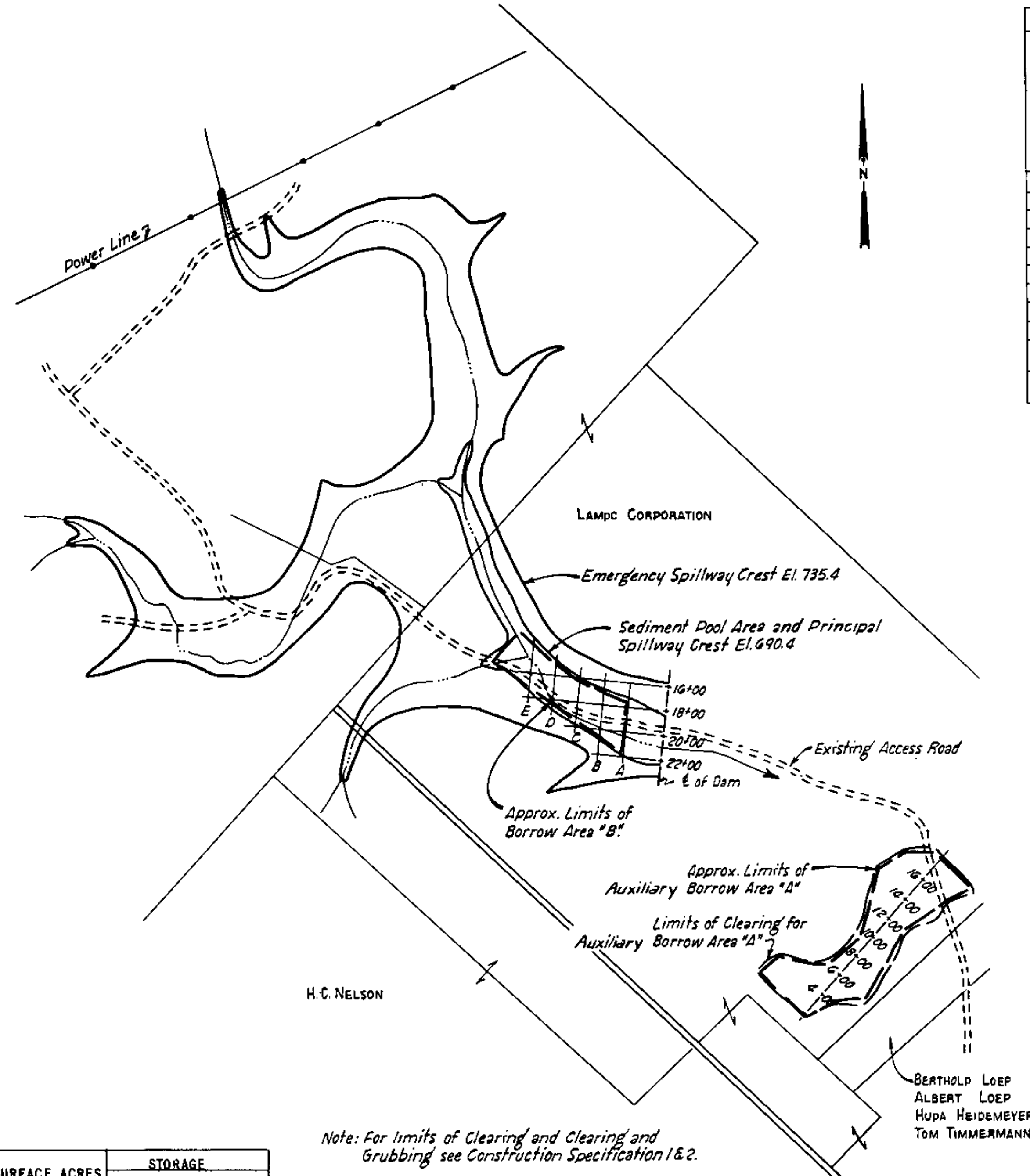


PROFILE ON BASELINE OF EMERGENCY SPILLWAY

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
EMBANKMENT AND EMERGENCY SPILLWAY
PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed M.D.K.	2-66	Approved by
Drawn M.D.K.	2-66	
Traced R.C.G.	2-66	Sheet 2 of 12
Checked M.D.K. & G.W.T.	3-66	Drawing No. 4-E-21,155



Note: For limits of Clearing and Clearing and Grubbing see Construction Specification 1 & 2.

GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET

ELEVATION	SURFACE ACRES	STORAGE Acre Feet	STORAGE Inches
688	16	94	0.14
690.4	18.5	135	0.20
692	20	166	0.24
696	26	258	0.37
700	32	374	0.54
704	39	516	0.75
708	49	692	1.00
712	59	908	1.32
716	70	1166	1.69
720	82	1470	2.13
724	95	1824	2.64
728	110	2234	3.24
732	128	2710	3.93
735.4	147.5	3178	4.61
736	151	3268	4.74
740	171	3912	5.67
Top of Dam (effective) Elev.			744.5
Emergency Spillway Crest Elev.			735.4
Principal Spillway Crest Elev.			690.4
Sediment Pool Elev.			690.4
Drainage Area, Acres			8,272
Sediment Storage, Ac. Ft.			138
Floodwater Storage, Ac. Ft.			3,040
Max. Emergency Spillway Cap., cfs			20,115

MATERIAL PLACEMENT DATA

Embankment Zone No. /1	Source of Fill Materials: Material Location /2	Average Depth, feet: From	Average Depth, feet: To	Type or Unified Classification	Field Control Test: ASTM Test Number	Field Control Test: ASTM Test Method	Max. Allowable Particle Size	Max. Uncompacted Layer Thickness	Specified Compaction Class	Min. Dry Density, Percent of Field Test Max. Dry Density	Moisture Limits, Relative to Field Test Optimum: From	Moisture Limits: To	Laboratory Test Data: ASTM Test Number	ASTM Test Method	Curve No.	Max. Dry Density, p.c.f.	Optimum Moisture, %
1	Borrow A-1	0	2	MH	D-1557	A	6"	9"	A	90	Opt.	+4%	D-1557	A	1	101.0	20.5
1	Borrow A-1	2	4	CH	D-1557	D	6"	9"	A	90	-1%	+5%	D-1557	C	1-X	114.0	14.0
1	Borrow A-1	5	10	CH	D-1557	A	6"	9"	A	90	Opt.	+5%	D-1557	A	4	109.0	17.0
1	Borrow A-1	10	14	CL	D-1557	D	6"	9"	A	90	-1%	+4%	D-1557	C	2-X	119.0	14.0
1	Borrow A-3	0	9	CH	D-1557	D	6"	9"	A	90	-1%	+4%	D-1557	C	4-X	110.0	18.0
1	Borrow A-3	9	18	CL	D-1557	A	6"	9"	A	90	-1%	+4%	D-1557	A	8	116.5	14.5
2	Borrow A-1	3	6	GC	D-1557	A	6"	9"	A	90	-2%	+3%	D-1557	A	3	113.5	14.5
2	Borrow A-1	11	16	GC	D-1557	D	6"	9"	A	90	-1%	+4%	D-1557	C	3-X	127.0	10.5
2	Borrow A-3	0	11	GC	D-1557	C	6"	9"	A	90	-1%	+4%	D-1557	C	5-X	126.0	10.0
3	/3			Limestone Rock	-	-	24"	24"	/4								
4	/3			Limestone Rock	-	-	24"	24"	/5								

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

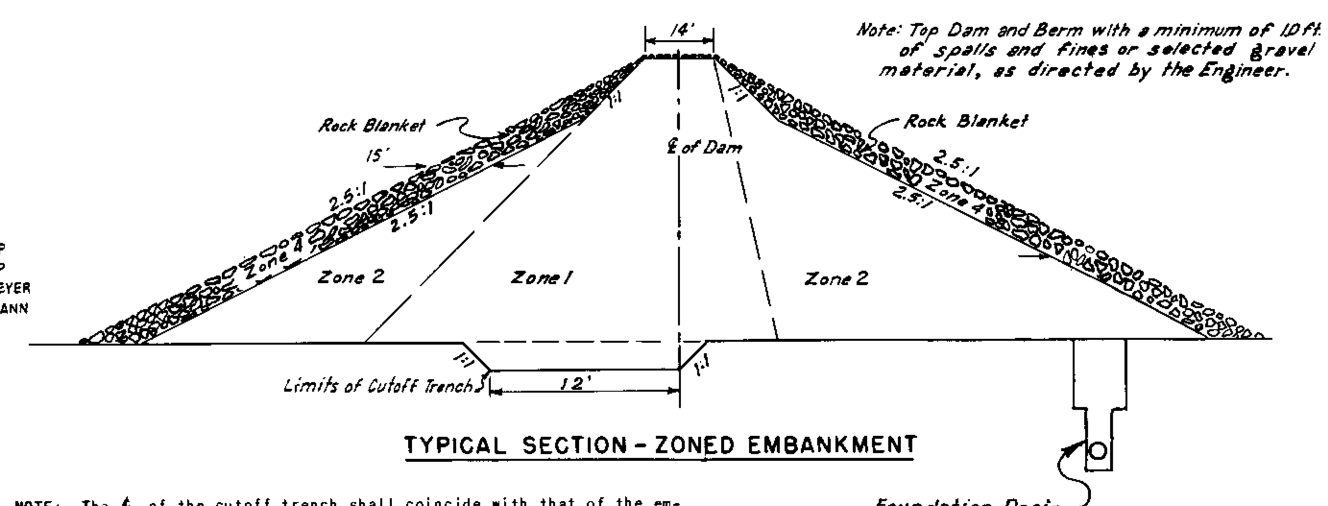
/2 Materials from the required excavations that are not tabulated in the table above and that are suitable and acceptable for earth fill shall have the same placement and control requirements as that specified for like materials covered under Materials Placement Data.

/3 Rock materials for construction of Zones 3 and 4, rock facing for the emergency spillway dike, and the rock lining of the plunge basin shown on Sheet 5 shall be obtained from the required rock excavation in the emergency spillway and foundation excavation and from the over-sized rock material from the borrow and other required excavations. The Contractor shall be required to excavate approximately 26,000 cu. yds. from Borrow Area "B" to fulfill the requirements for rock materials shown in the typical section.

/4 No specified compaction or moisture control will be required. The rock placed in Zone 3 and in the rock lining for the plunge basin shall be dumped and spread into place in approximately horizontal layers not more than 2 ft. in thickness and shall be placed in such a manner as to produce a reasonably homogeneous, stable fill that contains no segregated pockets of large or small fragments or large unfilled spaces caused by bridging of the larger fragments.

Where a bedding layer beneath the rock is specified, the bedding materials shall be spread uniformly on the prepared subgrade surfaces to the depths indicated. Compaction of the bedding layers will not be required, but the surfaces of such layers shall be finished free from mounds, dips, or windrows.

/5 No specified compaction or moisture control will be required. The rock placed in Zone 4 shall be dumped and spread into place in approximately horizontal layers not more than 2 feet in thickness. The rock shall be placed and manipulated so that the completed fill shall be graded with the smaller rock fragments placed toward the inner portion of the fill and the larger rock fragments placed on the outer slopes and shall be placed in such a manner as to produce a stable fill that contains no large unfilled spaces caused by bridging of the larger fraction. Inclusion of spalls, gravel, and other fine materials in an amount not in excess of that required to fill the voids in the coarser material will be permissible. Placement and manipulation of the rock material may be accomplished by initially depositing the rock material in a sequence of workable piles or layers near the outer edge of the concurrent lifts of Zone 2, in order to provide suitable room for a raking or combing operation to move the rock material into Zone 4 and accomplish the specified placement.



TYPICAL SECTION - ZONED EMBANKMENT

NOTE: The ℄ of the cutoff trench shall coincide with that of the embankment from Sta. 14+64 to Sta. 16+00 and from Sta. 22+00 to Sta. 22+57. From Sta. 16+50 to Sta. 21+50, the ℄ of the cutoff trench shall be located 20 ft. upstream from the ℄ of the embankment. Transition sections between Sta. 16+00 and Sta. 16+50 and between Sta. 21+50 and Sta. 22+00 shall be as staked by the Engineer.

ZONED EMBANKMENT DATA

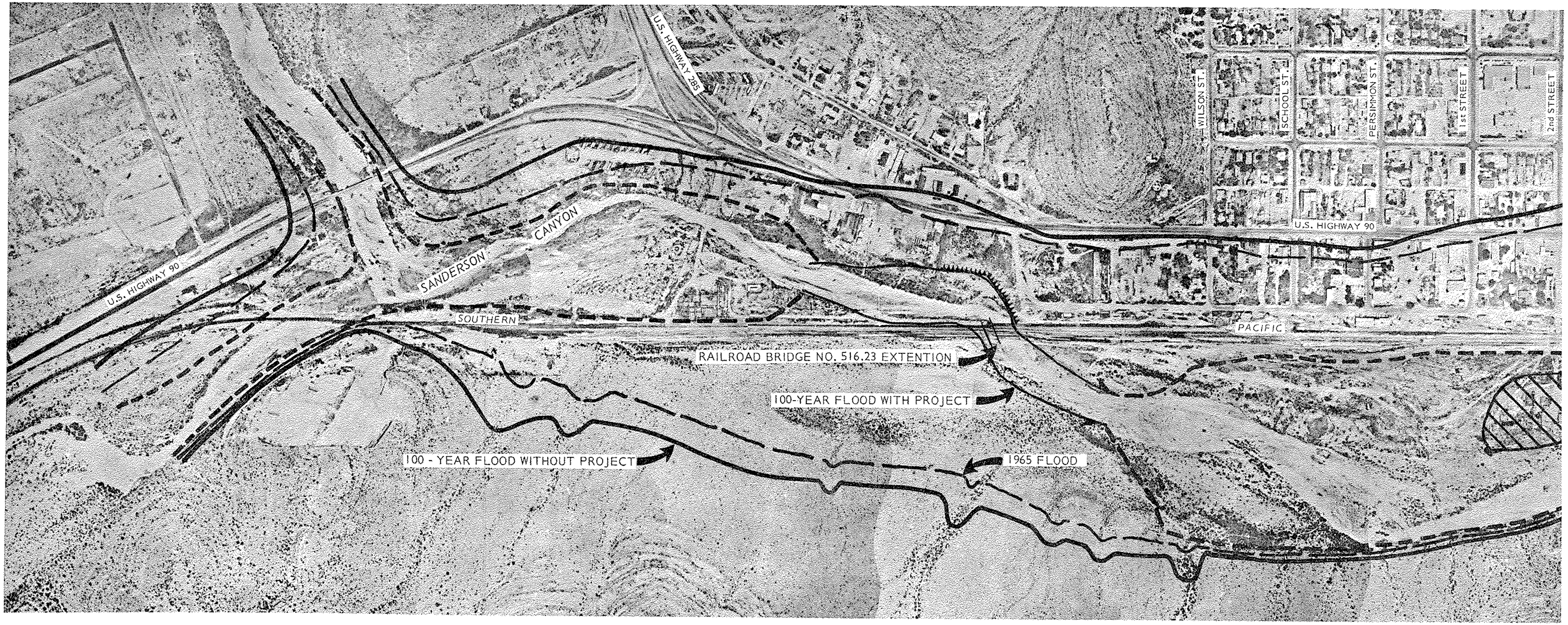
REV. 10-69

Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN OF RESERVOIR & SECTION-ZONED EMBANKMENT

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed M.D.K.	2-66	Approved by [signature] Head Engineering & Watershed Planning Unit, Fort Worth, Texas
Drawn M.D.K.	2-66	[signature] State Conservation Engineer, S.C.S., Temple, Texas
Traced R.C.G.	2-66	Sheet No. 5 of 12
Checked M.D.K. & G.W.T.	3-66	Drawing No. 4-E-21,155

USDA-SCS-FORT WORTH, TEX. 1969



USDA-SCS-FORT WORTH, TEX. 1969

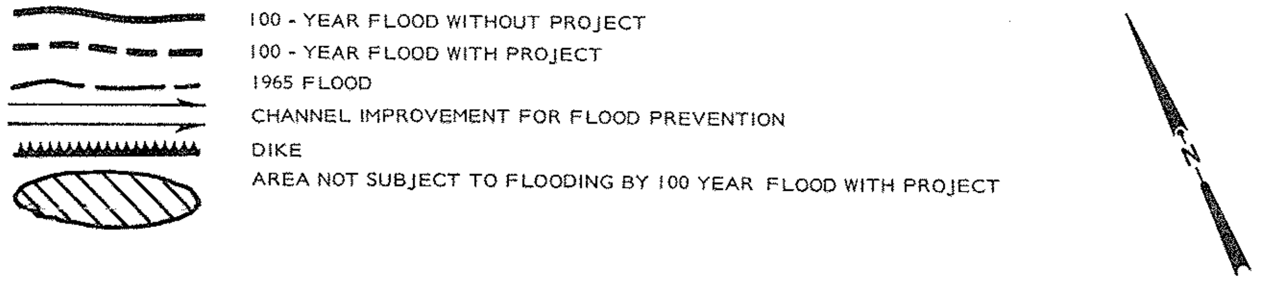


Figure 3

URBAN FLOOD PLAIN

SANDERSON, TEXAS

SANDERSON CANYON WATERSHED

BREWSTER, PECOS AND TERRELL COUNTIES, TEXAS

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

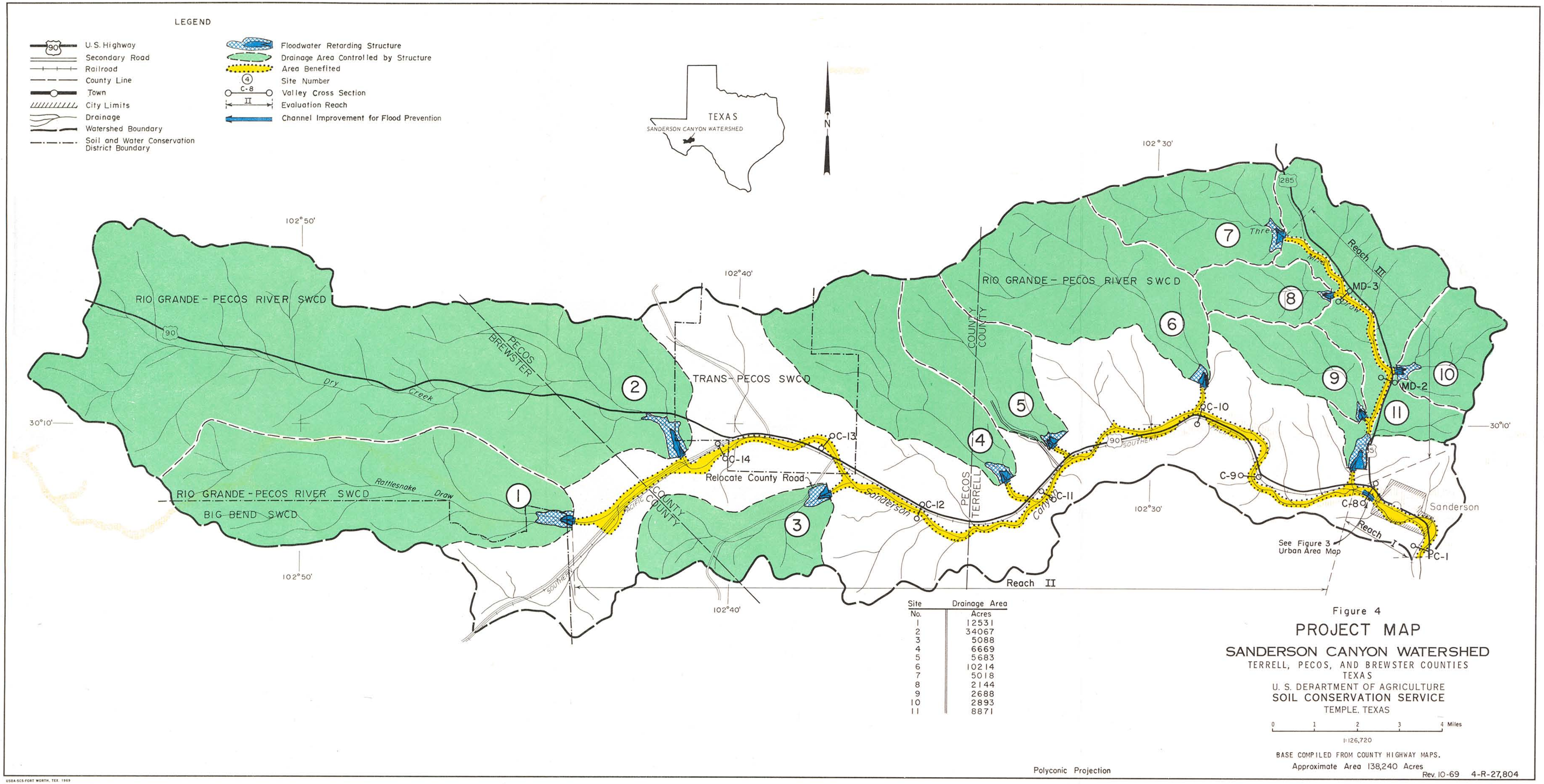
500 0 500 1000 1500

APPROXIMATE SCALE IN FEET

1 INCH = 500 FEET or 1:6000

Rev. 10-69

4-R-27776



Site No.	Drainage Area Acres
1	12531
2	34067
3	5088
4	6669
5	5683
6	10214
7	5018
8	2144
9	2688
10	2893
11	8871

Figure 4

PROJECT MAP

SANDERSON CANYON WATERSHED

TERRELL, PECOS, AND BREWSTER COUNTIES
TEXAS

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

BASE COMPILED FROM COUNTY HIGHWAY MAPS.
Approximate Area 138,240 Acres
Rev. 10-69 4-R-27,804