PRELIMINARY
Flood Control Work Plan
BITTER CREEK WATERSHED
A Subwatershed of the Washita River
OK-SCD-22 Wa. No. 37
April 5, 1951

DESCRIPTION OF THE WATERSHED

Bitter Creek rises in the northeastern part of Grady County and flows in a southerly direction for approximately 20 miles, entering the Washita River about seven miles east of Chickasha in Grady County, Oklahoma. West Bitter and Brushy Creeks comprise the western portion of the watershed area. The eastern portion is drained by East Bitter and Spring Creeks. East Bitter and West Bitter Creeks join about one mile south of U. S. Highways 277 and 62 to form the main stem of Bitter Creek. Friend Creek, a small direct tributary of the Washita River, is also included in the watershed plan.

Amber, located on the northwestern boundary of the area, is the only town in the watershed. There are 156 miles of roads, of which 26 miles are hard-surfaced.

The watershed has an area of 73,243 acres (114.4 sq. mi.), of which 69,889 acres are in farms and ranches. The remaining area is composed of 1,504 acres in stream channels, urban areas, roads, railroad and miscellaneous uses, and 1,850 acres which lie within the confines of the Corps of Engineers' proposed flood control and water supply reservoir. The bottomland area, 14,086 acres, is divided as follows: 12,052 acres in Bitter Creek; 206 acres in Friend Creek; and 1,828 acres of Washita River bottomland not subject to flooding by Bitter Creek or its tributaries. These figures include 628 acres of stream channels in Bitter Creek, 1,500 acres of bottomland in the Corps of Engineers' reservoir site on West Bitter Creek, and 20 acres of stream channels in Friend Creek.

Soils and Land Use

The entire watershed is in the Reddish Prairies Problem Area in Soil Conservation. It is divided into five sub-problem areas on the basis of differences in soils, topography, land use, land treatment, and contribution to modern sedimentation rates.

The soils of Area A are dominantly dark grayish brown to dark reddish brown, deep to shallow, and medium-textured. A large percentage of the soils have very slowly permeable (claypan) subsoils, and "slick spots" are numerous. The soils are productive, and 74 percent of the area (3,885 acres) is used for the production of cultivated crops. Of the remaining, 20 percent (1,054 acres) is in pasture or range land, 1 percent (44 acres) is in miscellaneous uses, and 5 percent (262 acres) is

abandoned cropland. Area A is located on the divides in the western part of the drainage area and occupies 5,245 acres, or 7.1 percent, of the watershed.

The soils in Area B are reddish in color and moderately productive. They are classified as follows: deep, medium-textured soils, 50 percent; shallow and very shallow, medium-textured, 42 percent; and rough broken land, 8 percent. Nineteen percent of the area (10,393 acres) is cultivated; 45 percent (24,260 acres) is in pasture; 1 percent (500 acres) is in miscellaneous uses; and 35 percent (18,409 acres) is abandoned cropland. This area contains 53,562 acres of rolling or hilly land and occupies 73.0 percent of the watershed.

Area C consists primarily of deep, medium-textured bottomland soils which are reddish brown to dark brown in color. Only 5 percent of the soils are fine-textured. Generally, these soils are very productive, 89 percent of the area (9,574 acres) being in cultivation. Of the remainder, 5 percent (486 acres) is in woods pasture and 6 percent (698 acres) is in miscellaneous uses. Some of the bottomland on Bitter Creek is on a low terrace which has not flooded in modern times. Area C occupies 10,758 acres, or 14.8 percent, of the watershed.

Area D is Washita River bottomland and terrace soils which are not subject to overflow from streams in the Bitter Creek watershed. The soils are reddish brown to dark brown in color. Approximately 50 percent are deep, fine-textured, and 50 percent are deep, medium-textured soils. These soils are very productive. Seventy percent of the area (1,276 acres) is in cultivation, 23 percent (420 acres) is in woods pasture, and 7 percent (132 acres) is in miscellaneous uses. Nearly all of the area in woods pasture is subject to frequent flooding by the Washita River. This area occupies 1,828 acres, or 2.5 percent, of the watershed.

Area E is composed of 1,850 acres which lie within the confines of the Corps of Engineers' proposed flood control and water supply reservoir. This reservoir occupies 2.5 percent of the watershed area.

Total land use in the watershed is as follows:

Land Use	Acres	Percent of Watershed Area
Cultivated Land	25,128	34.3
Pasture	25,314	34.6
Woody Pasture	906	1.2
Idle	18,671	25.5
Miscellaneous	1,374	1.9
Corps of Engineers' Reservoir Site	1,850	2.5
Total	73,243	100.0

Geology and Topography

The drainage area consists of gently rolling to hilly topography in the Redbed Plains section of the Central Lowland province. It is well drained by a system of V-shaped valleys trending in a southerly direction. The main alluvial valley bottom is approximately 10,000 feet wide at a point immediately below the junction of East and West Bitter Creeks. The valley narrows down to 2,000 feet in width at hydrologic section 1B, approximately two miles below the junction. Near the headwaters of the creek the bottomland narrows to 200 feet or less.

The Chickasha formation and Duncan sandstone are the exposed geological units through which the stream flows. Both formations are of Permian age. The upper part of the Chickasha formation consists of a series of deep red to purple mudstone conglomerate lenses, separated by very fine-grained, pink uncemented sand. The middle portion is a stratum of pink, unconsolidated fine-grained sand in which no massive lenses occur. The lower part of the Chickasha formation consists of a series of massive, dark red mudstone lenses separated by red shales and an occasional sandy shale. In the northern part of the watershed the lenses in the Upper Chickasha are less massive, and the formation occurs mainly as banded gypsiferous shale.

The Duncan sandstone consists chiefly of a well-cemented sandstone 10 to 50 feet thick, which varies in color from buff to light red. Below this sandstone are alternate beds of very soft green and red shales and thin sandstones.

Climate

The climate is usually mild with extreme variations. The average maximum temperature for August is 95.8 degrees Fahrenheit, and the average minimum for January is 26.8 degrees. However, extremes of 11 degrees below and 116 degrees above zero have been recorded.

The growing season has varied from 189 days in 1932 to 268 days in 1927. The average frost-free period of 217 days extends from March 29 to November 1. The area is characterized by high-intensity rains in the spring, summer, and fall months. Storms over the area are of two types: those of long duration (1 to 5 days), and the high-intensity storms which usually last but a few hours. Storms of either type have produced damaging floods in the Bitter Creek watershed.

The average annual rainfall is 30.86 inches. Records show that about 77 percent of this rainfall comes during the growing period of April through October.

Water Resources

Potable water, although usually high in mineral content, is obtainable from wells in most parts of the watershed. One hundred and fourteen farm

and ranch ponds have been constructed on Soil Conservation District cooperators' farms. In the immediate future, 140 additional stockwater ponds are needed for better distribution of grazing in the area. The Corps of Engineers' proposed reservoir, when constructed, will provide a new or additional source of water for the City of Chickasha. This reservoir site is shown on the work plan map.

ECONOMY OF THE WATERSHED

Agricultural Economy

The Bitter Creek watershed is an agricultural area. Livestock production and dairying are important enterprises on the farm and ranch units which range in size from 80 to 1,950 acres. Forage and grain crops are produced on 88 percent of the cultivated land. These crops are fed to dairy cattle, beef cattle, hogs, and sheep; and a surplus is marketed.

Crops grown on the bottomland include alfalfa, small grains, corn, and broomcorn. Upland areas in cultivation are used to produce small grains, grain sorghums, and cotton. Idle land is being seeded to native grasses for pasture.

The Bitter Creek watershed is served by one Soil Conservation Service work unit which is assisting the Grady County Soil Conservation District. This work unit has assisted farmers and ranchers in preparing 197 conservation plans on 49,892 acres within the watershed boundaries. Where land treatment measures have been applied and maintained for as long as two or three years, crop yields have increased 9 to 34 percent.

Urban and Other Influences

Urban influences upon the economy of Bitter Creek watershed area are important. This area is in Oklahoma City's milkshed. Because of this market for whole milk, 50 percent of the cattle are dairy animals. The importance of dairying is further indicated by the more than 50 grade-A units which are in production. The Oklahoma City stock yards handle most of the livestock marketing for farmers and ranchers in the area.

Chickasha has market facilities for all types of agricultural production from the watershed. Storage, warehousing, and processing establishments are available to producers of grains, broomcorn, cotton, and certified field crop seeds. Chickasha is the seat of county government. It is the home of Oklahoma College for Women and the Cotton Research Station of Oklahoma A&M College. Merchandising facilities of Chickasha adequately meet the needs of the area.

Residents of both Chickasha and Oklahoma City have purchased farms and ranches in the Bitter Creek watershed. This urban demand for ownership has created higher land prices.

U. S., State, and County roads accommodate travel by cars and trucks to all points of the area. Railroad service is available at Chickasha and Amber.

Although there is no oil development in the watershed, there has been extensive leasing activity. Sales of royalty and lease payments have been an important economic influence.

FLOOD PROBLEMS AND DAMAGES

Bitter Creek has flooded frequently and caused high annual damage. During the 20-year period from 1923 to 1942 inclusive, there were 11 floods which covered more than one-half of the flood plain, and 71 smaller floods. Eighty percent of the larger floods occurred during the spring and summer months, causing great damage to growing crops. The flood plain, exclusive of channel area, is 94.4 percent cultivated. Damage rates are high due to the intensive cropping system.

FLOOD CONTROL ACTIVITIES

Farmers and ranchers have spent much time and money during the past few years on ditches and levees and in straightening creek channels. Usually this work has been done on an individual basis without regard to the over-all flood problem. For this reason these efforts are effective only during small floods and are of minor importance in eliminating damages from large storms.

LAND TREATMENT ACTIVITIES

During the past three years, landowners and operators in 22 small neighbor groups, with membership wholly or partly within the Bitter Creek watershed, have been cooperating with their soil conservation district in the application and maintenance of land treatment practices on their lands.

HYDRAULIC AND HYDROLOGIC INVESTIGATIONS

The rainfall series for the period 1923 through 1942 was selected as most representative for the watershed. All damage-producing storms for this period were routed under the following conditions: (1) Present conditions, (2) with land treatment practices and measures applied, and (3) with land treatment measures applied and the system of floodwater detention structures in operation.

The storm used for detention structure design would produce 4.2 inches of runoff under present conditions. Runoff of this magnitude is not expected to occur more frequently than once in 25 years, and this value was used in determining minimum floodwater detention storage requirements. From a study of rainfall-runoff and channel-size relationships for this watershed, it was found that a rain of 1.27 inches was the minimum which would cause flooding at the smallest channel section under present conditions. This section, 2-DB, is located on the east fork of Bitter Creek

one-half mile above U. S. Highways 277 and 62 and has a channel capacity of 550 cubic feet per second. With land treatment practices and measures applied to the watershed, 1.50 inches of rainfall would be required to produce flooding at this section. With land treatment practices and the proposed system of floodwater detention structures in operation, 1.91 inches of rainfall would be required to flood section 2-EB.

The largest rain which occurred during the 20-year period was one of 6.12 inches, which produced 2.98 inches of runoff. Under present conditions, 5,693 acres of the flood plain would be inundated by the runoff from this storm. If such a rain were to occur after land treatment practices and measures have been applied, it is estimated that the area inundated would be reduced to 5,248 acres. These figures are based on the entire flood plain area, assuming the Corps of Engineers' reservoir in place. With land treatment measures applied and the detention structures in operation, only 2,125 acres would be flooded as a result of such a storm. However, an additional 380 acres of flood plain would lie within the permanent pools of proposed detention structures and 308 acres within the detention pools.

The channel capacity of Bitter Creek at valley section 1 is 4,250 cubic feet per second. This section is located approximately one-half mile above the mouth of Bitter Creek. The peak discharge at this point for a 6.12-inch rain under present conditions was 19,200 cubic feet per second. The discharge would be reduced to 6,600 cubic feet per second by land treatment and the proposed system of floodwater detention structures. Both of these figures are based upon the assumption that the Corps of Engineers' reservoir is in place.

SEDIMENTATION CONDITIONS

Channel enlargement in the main valleys and entrenched gullies in the headwaters of the drainage area are the chief sediment sources. Bank erosion is occurring in all major branches of the watershed. It is estimated that 3.77 acres are lost annually by bank erosion in the alluvial bottoms. The channel banks average 16 feet high; therefore, approximately 60 acre-feet of sediment is produced annually from this source alone. A few deep, entrenched gullies occur in the watershed. They average 50 feet wide at the top and 20 feet in depth, and erosion is occurring on 50 to 100 percent of the length of the gully sides.

Sheet and gully erosion are severe on abandoned cultivated land in the watershed. This change in land use has reduced the amount of sheet erosion, but numerous small gullies still produce large amounts of sediment. These gullies are V-shaped, averaging 2 to 6 feet in depth and 10 to 20 feet wide at the top. In some areas the gullies are less than 100 feet apart. Section-line roads are producing appreciable amounts of sediment to proposed detention structure sites. It is estimated that 40 acre-feet of sediment is being produced annually from these areas.

Accelerated Overbank Deposition

Examinations were made along all hydrologic cross-sections in the Bitter Creek watershed to determine the area affected and extent of damage by overbank deposits. Damaging modern deposits were found on 2,976 acres, or 24.2 percent, of the bottomland area. The textures of the modern deposits are dominantly fine and very fine sands with low percentages of silt and clay in the mixture. The highest percent of damage occurs in the narrow first bottoms in East and West Bitter Creeks. In these areas the trees have modern sediment accumulated around their trunks to a depth of from 4 to 7 feet. In the lower part of the valley the first bottom has been completely filled with sediment, and its elevation is now higher than the low terrace. This is causing increased flood and sediment damage to the widest portions of the bottomland area.

The old soil beneath the modern deposits is dark brown to black in color and moderately fertile. Analysis of this old soil at cross-section 3-Br. shows it to be high in potassium, neutral in reaction, and medium in organic matter and phosphorous content. Analysis of modern sediment near the channel at cross-section 2-WB shows the potassium content to be doubtful and the organic matter content to be very low. Application of commercial fertilizer (4-16-0) at the rate of 300 pounds per acre is recommended for alfalfa production by the Soils Operation Laboratory at Stillwater, Oklahoma.

Modern sediments range in color from brown to yellowish red. Assessed damages were estimated to range from 10 to 80 percent, depending on the texture, color, and depth of the recent deposit.

The Corps of Engineers' flood control reservoir will cover a portion of the flood plain of West Bitter Creek and Brushy Creek. This portion of the damageable flood plain is, therefore, subtracted from the bottomland total for damage calculations.

The extent of damage by modern overbank deposits was estimated to be a total of 353 acres damaged 10 percent; 1,064 acres damaged 20 percent; 431 acres damaged 40 percent; 390 acres damaged 60 percent; and 139 acres damaged 80 percent. The period of accelerated erosion is estimated to be 50 years.

Alluvial Fans

Damaging alluvial fans are numerous in the watershed. Severe sheet and gully erosion on adjacent hill areas have deposited sediment on the bottomland to depths of from 6 inches to 3 feet. These areas are above ordinary overflow from the main channels. The degree of damage varies locally with the color, depth, and texture of deposit. It is estimated that 886 acres, or 7.6 percent, of the bottomland area have been damaged by alluvial fans.

The extent of damage by alluvial fans was estimated to be 34 acres damaged 10 percent, 799 acres damaged 20 percent, and 135 acres damaged 40 percent. The period in which this damage has occurred is estimated to be 50 years.

Channel Filling

Channel filling is a major source of damage. The main upstream channels have enlarged during the past 40 years and have caused gully entrenchment in the headwater areas. Erosion from the entrenched areas, along with rapid channel enlargement in the upper part of the bottomland, is rapidly filling the channels near the mouth of the creek. At the bridge where U. S. Highway 62 crosses West Bitter Creek the channel has filled 3 feet in the past 15 years, according to highway engineering records. The channel has a sandy bedload, and filling occurs either over the entire bottom of the channel or in the form of bars 50 to 200 feet long. Increased flooding due to reduced channel capacities is causing the farmers to straighten channels and build levees. An increase in the annual cost of controlling floodwater and sediment by these methods is expected in the future.

Reservoir Damage

The proposed Corps of Engineers' reservoir has a net drainage area of 55 square miles. The annual rate of sediment contribution is estimated to be 1.8 acre-feet per square mile of drainage area under present conditions of land treatment. It is expected that the application of land treatment measures would bring about a 40 percent reduction in the sedimentation rate, leaving an estimated annual deposition of 1.08 acre-feet per square mile of drainage area.

A further reduction in the rate of sediment deposition in the Corps of Engineers' proposed reservoir would result from the construction of the planned floodwater detention structures. An estimated 90 percent of the sediment reaching the detention structures would be retained in the permanent pools. Therefore, the annual sediment contribution to the proposed reservoir would be reduced to 0.108 acre-foot per square mile of drainage area for the 32 square miles controlled by the system of detention structures. The total sediment contribution to the reservoir under present conditions is 99.0 acre-feet annually. The sediment contribution would be reduced to 28.3 acre-feet per year by land treatment and the proposed system of floodwater detention structures.

Sediment Output Rates

Sediment output rates are high in the watershed. The sediment is coming from active sheet and gully erosion and enlargement of the stream channels. Predictions of sediment output rates are based on a close study of recent aerial photographs of the watershed and a reconnaissance of the watershed area.

Estimated sediment deposit rates to downstream detention structures are 0.5 to 1.0 acre-foot per square mile in sub-problem area A and 1.0 to 2.5 acre-feet in sub-problem area B.

Reduction of sediment output rates in the future is expected to result from further adjustments in land use and intensified land treatment.

FLOOD PLAIN SCOUR AND CHANNEL ENLARGEMENT

Flood Plain Scour

It is estimated that 239 acres, or 2.4 percent, of the bottomland area have been damaged by flood plain scour. Damages were estimated to range from 10 to 90 percent. The percent of damage is based on loss of topsoil and changes in topography causing increased farming hazards.

The extent and percentages of damage by flood plain scour were estimated to be a total of 22 acres damaged 10 percent, 94 acres damaged 25 percent, 91 acres damaged 50 percent, 24 acres damaged 75 percent, and 8 acres damaged 90 percent. These damages are based on a 10-year scour cycle. These are net damages and do not include the area inundated by the proposed Corps of Engineers' reservoir.

Channel Enlargement

Channel enlargement is causing a substantial loss of good bottomland in the Bitter Creek watershed. Bank erosion was observed at nearly all hydrologic cross-sections. Annual lateral cutting of the banks was estimated to range from 6 to 36 inches. In some areas as little as 10 percent of the bank areas are eroding, but in the most severe areas the banks are eroding on 100 percent of both sides. The worst areas are located at hydrologic cross-sections 3-WB, 4-WB, 6-WB, 7-WB, 4-Br., 2-EB, 5a-EB and 3b-Sp.

The annual loss of land by channel enlargement in the Bitter Creek watershed is estimated to be 3.77 acres. This is the net acreage loss, assuming the proposed Corps of Engineers' reservoir is in place.

FLOOD DAMAGES

Flood damage information for approximately three-fourths of the flood plain area of Bitter Creek and its tributaries was obtained from landowners or operators. Most of the specific information as to amounts and extent of damage related to the May, 1949 flood and the flood of July, 1950. Other information obtained included flood plain land use, yields of major crops, property damages which would result from a major flood, and general flood problems. The percentage of damage to flood plain lands by sedimentation and scour was determined on the basis of reduced productivity and increased cost of production.

Information concerning flood damages to roads and bridges was obtained from Grady County road officials.

Damage rates to crops and pastures were determined for both season and depth of flooding. Monetary evaluation was based on present prices and costs. After estimating the amount of crop damage which would have resulted from a single flood during the 20-year rainfall series, this figure was adjusted for recurrence of flooding. Flood plain areas lying within the pool limits of proposed detention structures and the Corps of Engineers' reservoir were excluded from all damage calculations.

The total direct floodwater and sedimentation damages are estimated to average $124,256 annually under present conditions, of which $84,188 (68 percent) is crop and pasture damage. These figures are based on the entire flood plain area, exclusive of that covered by the Corps' reservoir. After excluding the areas of flood plain inundated by the proposed floodwater detention structures, the average annual direct damage would be $111,924, of which $74,044 is crop and pasture damage. In addition, there are numerous indirect damages such as the interruption of travel, losses sustained by dealers and industries dependent upon agricultural products from or sales to residents of the flooded areas, depreciation in property values in the flooded areas, and similar items. Ten percent of the total annual value of the direct damages, or $11,192, was taken as a conservative evaluation of the annual indirect flood damages. The average annual monetary flood damages are summarized in Table 1.

THE REMEDIAL PROGRAM AND ITS EVALUATION

Land Treatment Measures Needed

The major land treatment measure needed is the seeding of 19,400 acres (27 percent of the area) of the following two types of areas: (1) Idle land, and (2) areas now in cultivation on which a permanent grass cover needs to be established.

Approximately 460 miles of terraces are needed to assist in the control of erosion on 7,000 acres of cultivated land. About 160 acres of vegetated waterways are needed to carry the runoff from these systems of terraces, and 20 drop-inlet structures are needed for the protection of the vegetated waterways.

Other land treatment measures needed include 77 miles of farm diversions; 254 farm ponds; 180 miles of fencing to enclose newly retired and reseeded areas; improved crop rotations on 24,998 acres of cropland; and 26,220 acres of improved range and pasture management.

The estimated total cost of installing these measures is $771,015, and the annual cost, including installation and maintenance, is $40,782.

Flood Control Structures and Measures

The flood control structures and measures needed to provide adequate flood protection for the flood plain lands and highways are shown in Table 2, items 1 through 5.

A system of 11 detention structures is needed to protect the flood plain lands along Bitter Creek and its tributaries. The proposed detention structures and their drainage areas are shown on the Work Plan Map. Descriptive information concerning the detention structures is summarized in Table 5.

The system of detention structures and the Corps of Engineers' reservoir will detain the runoff from 75 percent of the portion of Bitter Creek lying above cross-section 1. If the Corps of Engineers' reservoir is eliminated, 50 percent of the area lying above this cross-section will be controlled by the proposed system of detention structures.

As indicated, it will be necessary to relocate portions of several county roads. A transmission line and a pipe line must also be moved where they cross the pool areas of proposed detention structures.

The estimated total cost of applying these structures and measures is $571,846, and the annual cost, including installation and maintenance, is $17,617.

Effect of These Measures on Damages and Benefits

The combined program of land treatment and flood control measures described above would prevent damage from 25 of the 71 minor floods and 11 major floods such as occurred in the 20-year period 1923 to 1942 inclusive. The remaining floods would be reduced to minor floods covering an average of 850 acres annually and causing an estimated average annual damage of $21,190.

The annual benefit from reduction of sediment in the Corps of Engineers' reservoir is estimated to be $3,564 from land treatment measures and $2,799 from the proposed floodwater detention structures.

Most of the expected reduction in annual flood damages would be effected by land treatment measures. The annual value of the reduction in flood damages attributable to the detention structures is estimated to be $45,917 out of the total of $101,926 from all measures as shown in Table 1.

Owners and operators of flood plain lands say that if flood protection is provided they will intensify their use of these lands by growing higher value crops such as alfalfa, cotton, and broomcorn on areas now used for grain sorghums and small grains. They also expect to clear the timber from woods pasture areas and place them under cultivation after flooding has been reduced. It is estimated that this more intensive use would increase the net income to the land, after all expenses are deducted, by $13,680 annually. The total flood control benefits are estimated to be $115,606 annually. In addition, it is estimated that the benefits to landowners and operators in upland areas of the watershed from the application of land treatment measures would be $256,525 annually. The total expected benefit from the combined program would amount to $372,131 annually.

The expected land treatment benefits were determined by estimating the increased net income to the land which would result from the application of the needed land treatment practices and measures. It was assumed that the proportion of cropland used for each crop would not change, although the total area used for cropland would be decreased by the retirement of idle cropland and steep and severely eroded areas to native grasses. Likewise, it was assumed that there would be no change in the percentages of cattle used for dairying and beef production, although the total number of cattle would increase materially because of the increased acreages of pasture and the greater per-acre pasture carrying capacity to be expected from the application of land treatment measures.

The estimated increase in annual net income is $52,599 from crops and $203,926 from pasture, or a total of $256,525 annually.

Comparison of Costs and Benefits

The ratio of the average annual benefit from detention structures, $59,597, to the average annual cost of the detention structures and appurtenant structures, $17,617, is 3.38:1.

The ratio of the average annual benefit, $312,534, from the land treatment measures and practices to their average annual cost, $40,782, is 7.66:1.

The ratio of total average annual benefits, $372,131, to total average annual costs, $58,399, is 6.37:1. See Table 4.

ANNUAL MAINTENANCE

Estimated annual maintenance costs after the land treatment measures and flood control structures have been installed are shown in Table 3.

It is expected that the flood control structures will be maintained by the benefited farmers under an agreement with the soil conservation district which carries the responsibility for maintenance. Group organizations of farmers will be developed for this purpose. The land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed.

Table 1
Summary of Average Annual Monetary Floodwater and Sediment Damage
and Flood Control Benefit from the Recommended Program
BITTER CREEK WATERSHED
(1950 Prices)

Damages	Average Annual Damage			Average Annual Benefit		
	Under Present Conditions	With Land Treatment Only	With Land Treatment and Detention Storage	From Land Treatment Only	From Detention Storage Only	Total Flood Control Benefits
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage						
Crop and Pasture	74,044	40,687	12,767	33,357	27,920	61,277
Other Agricultural	2,355	1,230	0	1,125	1,230	2,355
Roads and Bridges	13,000	5,850	0	7,150	5,850	13,000
Levees	2,300	1,035	207	1,265	828	2,093
Scour	2,332	1,469	617	863	852	1,715
Sub-Total	94,031	50,271	13,591	43,760	36,680	80,440
Sediment Damage						
Overbank Deposition	8,983	5,390	3,126	3,593	2,264	5,857
Reservoir (C. of E. Res.)	8,910	5,346	2,547	3,564	2,799	6,363
Sub-Total	17,893	10,736	5,673	7,157	5,063	12,220
Indirect Damage	11,192	6,100	1,926	5,092	4,174	9,266
Total Damage	123,116	67,107	21,190	xxx	xxx	xxx
Benefit from Reduction of Damage	xxx	xxx	xxx	56,009	45,917	101,926
Benefit from More Intensive Use of Flood Plain	xxx	xxx	xxx	xxx	13,680	13,680
Total Flood Control Benefits	xxx	xxx	xxx	56,009	59,597	115,606

Table 2
Cost Estimate Table
BITTER CREEK WATERSHED

Structure or Measure	Unit	No.	Cost			
			To Farmer	To Federal Funds	To State, County or Other	Total
Detention Structures	Each	11	$	$443,170	$51,500	$ 494,670
Site Acquisition	Total			64,880		64,880
Culverts	Each	4			8,411	8,411
Relocating Roads	Mile	2.1			2,580	2,580
Floodwater Diversions	Mile	3.0		1,305		1,305
Seeding Retired Areas	Acre	19,400	197,880	131,920		329,800
Farm Waterways	Acre	160	12,000	4,000		16,000
Terracing	Mile	460	57,500			57,500
Farm Diversions	Mile	77	11,550			11,550
Drop Inlets, Inc. Fills	Each	20		60,000		60,000
Farm Ponds	Each	254	114,300			114,300
Farm Fencing	Mile	180	72,000			72,000
Farm and Ranch Planning and Application	Acre	73,243		109,865		109,865
Total			$465,230	$815,140	$62,491	$1,342,861
Estimated Amount to be Expended During 1952 Fiscal Year			$ 54,000	$122,500		$ 176,500

Table 3
Annual Costs
BITTER CREEK WATERSHED

Structure or Measure	Unit	No.	Annual Cost		
			Installation	Maintenance	Total
Detention Structures	Each	11	$14,427	$ 1,100	$15,527
Site Acquisition	Total		1,622		1,622
Culverts	Each	4	210	40	250
Relocating Roads	Mile	2.1	65		65
Floodwater Diversions	Mile	3	33	120	153
Seeding Retired Areas	Acre	19,400	11,213		11,213
Farm Waterways	Acre	160	580	640	1,220
Terracing	Mile	460	2,300	4,600	6,900
Farm Diversions	Mile	77	462	616	1,078
Drop Inlets, Inc. Fills	Each	20	1,500	500	2,000
Farm Ponds	Each	254	4,572	4,572	9,144
Farm Fencing	Mile	180	2,880	3,600	6,480
Farm and Ranch Planning and Application	Acre	73,243	2,747		2,747
Total			$42,611	$15,788	$58,399

Flood Control Structures and Measures		$17,617
Land Treatment Practices and Measures		40,782
Annual Maintenance - Farmer	$15,748	
Annual Maintenance - State, County or Other	40	

Table 4
Comparison of Average Annual Benefit and Cost of the Recommended Program
BITTER CREEK WATERSHED
(1950 Prices)

Source of Benefit	Annual Cost	Annual Benefit	Benefit per Dollar of Cost
	(dollars)	(dollars)	(dollars)
Detention Storage	17,617	59,597	3.38
Land Treatment			
Flood Control	xxx	56,009	xxx
Land Treatment	xxx	256,525	xxx
Total	40,782	312,534	7.66
All Sources	58,399	372,131	6.37

Table 5
Detention Structure Data
BITTER CREEK WATERSHED

Site No.	Drainage Area Sq. Mile	Storage Capacity Acre Feet Perm. Pool	Storage Capacity Acre Feet Det. Pool	Storage Capacity Acre Feet Total	Inches of Runoff Perm. Pool	Inches of Runoff Det. Pool	Inches of Runoff Total	Surface Area Acres Top of Perm. Pool	Surface Area Acres Top of Det. Pool	Max. Ht. of Dam Ft.	Flood Plain Inundated Perm. Pool Ac.	Flood Plain Inundated Det. Pool Ac.	Flood Plain Inundated Total Acres	Volume of Fill Cu. Yds.	Draw-down Rate cfs	Type of Spill way	Estimated Total Cost
1	2.54	225	530	755	1.66	3.93	5.59	38	84	34	18	10	28	53,090	13	Veg.	$ 21,236
2	2.93	228	687	915	1.46	4.40	5.86	46	86	42	39	15	54	72,215	15	"	28,886
3	2.08	167	477	644	1.50	4.30	5.80	27	63	41	13	5	18	49,660	10	"	19,864
4	10.44	900	4150	5050	1.62	7.48	9.10	135	349	54	82	84	166	145,595	52	"	58,238
5	5.59	475	1278	1753	1.62	4.34	5.96	64	165	46	27	39	66	119,115	28	"	47,646
6	1.06	88	239	327	1.55	4.22	5.77	17	37	48	0	0	0	32,265	5	"	12,906
7	7.30	555	1871	2426	1.43	4.80	6.23	75	212	52	37	70	107	176,740	37	"	70,696
8	12.54	1000	4846	5846	1.50	7.27	8.77	182	420	64	129	79	208	264,600	63	"	105,840
9	4.56	373	1081	1454	1.53	4.43	5.96	49	123	50	24	3	27	116,475	23	"	46,590
10	1.31	74	213	287	1.05	3.05	4.10	12	32	45	0	0	0	33,830	7	"	13,532
11	1.38	105	341	446	1.42	4.64	6.06	24	51	36	11	3	14	44,340	7	"	17,736
Total	51.73	4190	15713	19903				669	1622		380	308	688	1,107,925			$443,170 1/

1/ Construction Cost - $385,365
Technical Services - 57,805

APPENDIX

Table 1

Increase in Income Through More Intensive Use of Flood Plain Lands

BITTER CREEK WATERSHED

(1950 Prices)

Land Use	Acres	Yield	Production	Gross Income	Cost	Net Income
Present Conditions						
Alfalfa	1,302	4.25 Ton	5,533	$112,559	$ 43,957	$ 68,602
Corn	733	40 Bu.	29,320	38,409	16,954	21,455
Broomcorn	648	.25 Ton	162	56,700	28,998	27,702
Oats	641	50 Bu.	32,050	26,922	8,948	17,974
Wheat	518	25 Bu.	12,950	26,029	7,274	18,755
Cotton	667	400 Lb.	266,800	99,250	50,065	49,185
Grain Sorghum	196	2000 Lb.	392,000	7,566	3,125	4,441
Woods Pasture	250	1.00 Ac.		250	125	125
Miscellaneous	50					
Total	5,005			$367,685	$159,446	$208,239
After Land Treatment and Detention Storage						
Alfalfa	1,549	4.25 Ton	6,583	$133,437	$ 52,497	$ 80,940
Corn	633	40 Bu.	25,320	33,169	14,641	18,528
Broomcorn	771	.25 Ton	192.8	67,480	34,604	32,876
Oats	541	50 Bu.	27,050	22,722	7,553	15,169
Wheat	518	25 Bu.	12,950	26,029	7,274	18,755
Cotton	793	400 Lb.	317,200	117,998	59,627	58,371
Woods Pasture	150	1.00 Ac.		150	75	75
Miscellaneous	50					
Total	5,005			$400,985	$176,271	$224,714

Net Increase	$ 16,475
Less Overhead	1,648
Less Added Damage	1,147
Net Benefit	$ 13,680

APPENDIX
Table 2

SEDIMENT DAMAGE TO CORPS OF ENGINEERS' RESERVOIR
AND BENEFITS TO THE PROPOSED RESERVOIR
THAT CAN BE EXPECTED BY INSTALLATION
OF UPSTREAM FLOOD CONTROL MEASURES

Basic Data

Stream - West Bitter Creek

Location - 7 miles by valley above junction with Washita River

Drainage Area - 57 square miles

Storage Capacity

Sediment Storage	6,700 acre-feet
Water Supply	11,600 acre-feet
Flood Control	14,000 acre-feet
Total	32,300 acre-feet

The annual rate of sediment contribution to the proposed Corps of Engineers' Reservoir on West Bitter Creek is estimated to be 1.8 acre-feet per square mile of drainage area. Cost per acre-foot of storage, Corps of Engineers' Reservoir = $90.00.

It is believed that the land treatment program will reduce the sediment output rate by 40 percent when these practices are established.

Surface area of water supply and sediment storage for Corps of Engineers' Reservoir is approximately 2 square miles.

Then 57 - 2 = 55 square miles net drainage area applicable to the land treatment measures.

Then 1.8 x 55 x .40 = 39.6 acre-feet of sediment prevented by the land treatment practices.

The annual benefit from land treatment will be $90.00 x 39.6 = $3,564.00.

The drainage area above the reservoir protected by floodwater retarding structures is approximately 32 square miles.

Since low release rates are planned for these structures, it is estimated that they will retain at least 90 percent of the sediment transported from the drainage area to them.

APPENDIX
Table 2 (Cont'd.)

Then 1.8 x .40 = 0.72 acre-foot of sediment per square mile of drainage that is stopped by the land treatment measures, and 1.8 minus 0.72 equals 1.08 acre-feet per square mile that will reach the detention structures. The sediment retained by these structures will be 1.08 x .90 x 32.0 or 31.1 acre-feet annually.

The annual benefit from reduction of sediment to the Corps of Engineers' Reservoir by the proposed floodwater retarding structures will be $90.00 x 31.1 or $2,799.00.

Summary

Annual damages = (55 x 1.8 x 90) = $8,910.00 present conditions

Annual damages = $8,910 - $3,564 = $5,346.00 with land treatment only

Annual damages = $8,910 - $6,363 = $2,547.00 with detention storage and land treatment

Annual benefit = $3,564.00 from land treatment measures

Annual benefit = $2,799.00 from detention storage

Annual benefit = $6,363.00 from detention storage and land treatment measures.

R-6-W

R-5-W

T-9-N

T-8-N

T-7-N

T-6-N

APPROX. AREA 73,243 ACRES

0 1/2 1 2 Miles

AMBER

Middleberg

C of E Reservoir

DA 1625

DA 165

DA 875

DA 1380

DA 3580

DA 667

DA 420

DA 680

DA 4670

DA 8025

DA 3920

DA 180

DA 840

DA 880

FRISCO R.R.

O.N.G.

WASHITA RIVER

Bitter Creek

West Fork Bitter Creek

East Fork Bitter Creek

Spring Creek

Friend Creek

LEGEND

- Watershed Boundary
- Paved Road
- Dirt Road
- Railroad
- Property Line and Land Hook
- Section Line
- Township Line
- Drainage
- Town
- Cemetery
- School
- River
- Pipe Line
- Private Road
- Detention Structure
- Culvert
- Floodwater Diversion
- Drainage Area Boundary
- DA Acres Drainage Area
- Floodwater & Sediment Damage Area
- Site Number

PRELIMINARY
FLOOD CONTROL WORK PLAN
BITTER CREEK WATERSHED
SUB-WATERSHED NO.37 OF THE WASHITA RIVER
OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H H. BENNETT - CHIEF
REGION 4 DIRECTOR — LOUIS P. MERRILL

REFERENCE

CARTOGRAPHIC APPROVAL — TECHNICAL APPROVAL

COMPILED — TRACED — CHECKED — DATE

JBL GB 6-L-51 4-R-8153

Revised 5-28-51 5-12-49 JB Base 4-R-7304

LEGEND

A Deep and shallow medium textured Rolling Red Plains soils.

B Deep, shallow, very shallow and rough broken Rolling Red Plains soils.

C Fine and medium textured bottomland soils.

D Washita River bottomland and terrace soils.

—— Hydrologic Cross Sections

TOTAL ACRES IN BITTER CREEK WATERSHED = 73,243 ACRES

APPROX. AREA 73,243 ACRES

0 1/2 1 2 Miles

R-6-W R-5-W T-9-N T-8-N T-7-N T-6-N

AMBER

Middleberg

FRISCO R.R.

O.N.G.

WASHITA RIVER

Bitter Cr.

West Fork Bitter Cr.

East Fork Bitter Cr.

Sugg Cr.

LEGEND

Watershed Boundary
Paved Road
Dirt Road
Railroad
Property Line and Land Hook
Section Line
Township Line
Drainage
Town
Cemetery
School
River
Pipe Line

PROBLEM AREA IN SOIL CONSERVATION AND BOTTOMLAND MAP

BITTER CREEK WATERSHED

SUB-WATERSHED NO. 37 OF THE WASHITA RIVER
OKLAHOMA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT - CHIEF
REGION 4 DIRECTOR — LOUIS P. MERRILL

REFERENCE

CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL

COMPILED	TRACED	CHECKED	DATE	
	J.B.L.	G. B.	5-14-51	4-R-8122

5-12-49 J.B. Base 4-R-7304