WATERSHED WORK PLAN

SOUTH HARPETH RIVER WATERSHED

CHEATHAM, DAVIDSON, AND WILLIAMSON COUNTIES

TENNESSEE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MAY 1964

WATERSHED WORK PLAN

SOUTH HARPETH RIVER WATERSHED

Williamson, Davidson and Cheatham Counties, Tennessee

Prepared under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by: South Harpeth River Watershed District

Williamson County Soil Conservation District

Davidson County Soil Conservation District

Cheatham County Soil Conservation District

With assistance by:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service

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SUMMARY OF PLAN

This document is a plan for watershed protection and flood prevention in the 52,120 acre (81.44 sq. mi.) South Harpeth River Watershed located in Williamson, Davidson and Cheatham Counties, Tennessee. The plan was developed by the South Harpeth River Watershed District and the Williamson, Davidson and Cheatham County Soil Conservation Districts. The United States Department of Agriculture, Soil Conservation Service, and Forest Service, provided assistance under the provisions of Public Law 566.

The primary problem of the watershed is flood damage to crops and pasture, fences, roads, bridges, rural property, and other fixed improvements, and flood plain scour. Some portions of the main flood plain begin flooding following rainfall of about 1.7 inches within a 24-hour period. The largest storm in the 20-year evaluation period caused flooding on 2,681 acres of land.

The objectives of the sponsors are: (1) a significant improvement of soil and water conservation measures, (2) a reduction in flooding to the extent that cultivated row crops, hay and pasture, can be managed for optimum production, and (3) flood damage to roads, bridges, rural property and other fixed improvements be reduced to a minimum.

The planned works of improvement to be installed during a five-year period are; (1) the application of needed soil and water conservation measures on 14,411 acres of land for watershed protection, (2) the installation of three floodwater retarding structures and 140,375 feet of stream channel improvement for flood prevention, and (3) the installation of mitigating measures (cool water inlet) that temper or reduce damages to fish habitat.

The total estimated installation cost of the project is $1,806,518, of which $1,356,336, or 75 percent, will be P. L. 566 funds and $450,182, or 25 percent, will be Other funds.

The total estimated installation cost of all land treatment measures is $326,010; $26,850 from P. L. 566 funds for technical assistance and $299,160, Other funds. All land treatment measures will be planned and applied farm by farm by the landowners and operators at their own expense in cooperation with the Williamson, Davidson and Cheatham County Soil Conservation Districts. The Soil Conservation Service and the Tennessee Division of Forestry, in cooperation with the U. S. Forest Service, will furnish the technical assistance needed for installing the forestry measures.

The three floodwater retarding structures will be installed by contract during the third and fourth project years. The total estimated installation cost of the three floodwater retarding structures and mitigating measures is $1,353,123, of which $1,217,981 is P. L. 566 funds and $135,142 is Other funds. The stream channel improvement will be installed by contract during the fifth project year. The total estimated installation cost of all stream channel improvement is $127,385, of which $111,505 is P. L. 566 funds and $15,880 is Other funds.

The total cost of $2,200 for installing the mitigating measures will be borne by P. L. 566 funds for construction, engineering services, and other (administrative, etc.).

The South Harpeth River Watershed District will assume the responsibility for installing, operating and maintaining all structural measures for flood prevention and will further be responsible for all costs in acquiring the needed land, easements, and rights-of-way for the installation of structural measures. The District will administer all contracts, and will also be responsible for all other costs, such as, additional organizational costs, assessor fees, legal fees, and other administrative costs.

The South Harpeth River Watershed District has initiated negotiations with the Farmers Home Administration to finance its share of the project installation costs by utilizing the loan provisions of Section 8, P. L. 566, as amended. The loan will be repaid by the District through an annual assessment which is in accordance with the provisions of the Tennessee Watershed District Act of 1955, as amended.

It is estimated that 2,127 acres of flood plain land will be directly benefited by the proposed structural program. No monetary benefits are claimed on 64 acres of the above flood plain in the backwater area of Harpeth River. It is also estimated that the flood plain on Harpeth River below its confluence with South Harpeth River will receive some benefits. The average annual benefits used in project justification are estimated to be $68,175. The three floodwater retarding structures and 140,375 feet of stream channel improvement for flood prevention will be installed, operated and maintained at a total annual cost estimated to be $52,182, which includes $5,323 for operation and maintenance. The benefit-cost ratio is 1.3:1.0.

DESCRIPTION OF WATERSHED

The South Harpeth River Watershed has a drainage area of about 52,120 acres (81.44 sq. mi.), of which 40,040 acres (62.56 sq. mi.) are in Williamson County, 9,170 acres (14.33 sq. mi.) are in Davidson County, and 2,910 acres (4.55 sq. mi.) are in Cheatham County, Tennessee. The watershed is long and relatively narrow with a maximum length of about 16 miles in a north-south direction and a maximum width of about six miles. The South Harpeth River is a northerly flowing stream and is a tributary of the Harpeth River. The confluence of the Harpeth and Cumberland Rivers is about four miles above Cheatham Dam and the confluence of the Harpeth and South Harpeth Rivers is about 37 miles above the Cumberland River. The basically agricultural economy is founded on the soils which are derived from the limestone bedrock of the Highland Rim and the Nashville Basin.

Physical Data

The rainfall distribution during the growing season is generally adequate for crop production. The mean annual precipitation is about 47 inches, with 27 inches occurring in the months of April through November. The wettest month is January with a mean of 5.72 inches and the driest month is October with a mean of 2.15 inches. The mean annual temperature is 59.2 degrees with the monthly averages of 37.2 degrees in January and 78.5 degrees in July. The average length of the growing season is 192 days, with the first and last killing frosts occurring in the months of November and April respectively.

The watershed is located intermediate to two physiographic provinces. The headwaters of the South Harpeth River and its major tributaries are on the Highland Rim. The lower reaches are on the Nashville Basin. The uplands are highly dissected and are characterized by narrow, winding ridges and "V"-shaped valleys. The difference in elevation between ridgetops and adjacent flood plains is about 200 feet and the maximum relief is about 500 feet which is the difference in elevation between the highest points on the southern divide and the confluence of South Harpeth and Harpeth Rivers.

The geologic formations exposed in the watershed are limestone, siltstone, and shale of Mississippian, Devonian, Silurian, and Ordovician age. The Mississippian, St. Louis and Warsaw formations underlie the uplands and are predominantly limestone and cherty limestone that weather to red or yellow cherty clay residuum. The Devonian Chattanooga shale underlies the Warsaw formation and outcrops in the valley walls. The Silurian age Brassfield limestone and Wayne group and Ordovician age Richmond group and Leipers formation are predominantly limestone with some interbedded shales. They outcrop below the Chattanooga shale in the valley walls and underlie the alluvial flood plain soils.

The soils developed in this watershed are divided into three general soil groups. They are the Huntington-Lindside-Armour-Captina soils, Bodine-Mountview-Sulphura-Greendale soils, and Baxter-Mountview-Bodine-Dickson soils.

The Huntington-Lindside-Armour-Captina soils occupy about 12 percent of the watershed and are found in the flood plain and terraces of the main stream and its tributaries. These soils are generally deep to very deep, moderately well-drained to well-drained and moderately productive to highly productive. The Bodine-Mountview-Sulphura-Greendale soils occupy about 65 percent of the watershed and are found in the uplands except on the western side of the watershed. The Bodine and Sulphura soils occupy the steep slopes and are shallow, well-drained to excessively-drained, and low in fertility. The Mountview soils are found on the ridgetops and are deep, well-drained, moderately productive, and the Greendale soils are found in the bottomlands of the Highland Rim and are deep, well-drained, moderately productive soils. The Baxter-Mountview-Bodine-Dickson soils occupy about 23 percent of the watershed and are found in the uplands in the western part of the watershed. The Baxter soils are deep, well-drained, and moderate in productivity, and the Dickson soils are moderately well-drained, deep, and productive.

The Two Jays Bird Sanctuary is located on the left bank of South Harpeth River near the lower end of the watershed. This property is owned and actively managed by the Nashville Chapter of the Tennessee Ornithological Society. The 61-acre area is maintained for its dense cover for birds on the slopes and on the narrow flood plain adjoining the left side of the stream. The area is used both as a wildflower preserve, and a sanctuary for migratory and native birds.

Forest Land

The forested area is moderately rolling to steep. Soils are 88 percent moderately deep and moderately permeable; the balance is shallower and less permeable. Five percent of the woodland soils are in very poor hydrologic condition and 62 percent is in poor hydrologic condition because of past fires and grazing and present widespread overcutting. Thirty-three percent of woodland soils are in fair hydrologic condition.

Fire protection for the past five years is adequate for watershed management, but earlier fires have left 10 percent of the upland forest with moderate damage to soil hydrologic conditions and 45 percent with light damage. Grazing has damaged soil hydrologic conditions to a moderate degree on eight percent of the upland forest and lightly on another 35 percent. Light damage to soil hydrologic conditions from overcutting is evident on 89 percent of the upland forest; another three percent shows moderate damage due to heavy overcutting and unwise logging methods on steep terrain. The survey for watershed planning showed 19 percent of the wooded area with moderate to severe soil erosion.

Fish and Wildlife

Quail, squirrel, and rabbit are the outstanding wildlife species in this watershed. Good populations of these species are attributable to, (1) large areas of idle land in the upper end of the watershed, (2) stands of mass-producing timber on slopes and along water courses, and (3) small broken fields with brushy fence rows.

South Harpeth River is a typical smallmouth and rock bass stream. The pools generally are short and relatively deep with fair cover. This combination is conducive to a good game fish population. The water is cool with temperatures that normally do not exceed 80 degrees Fahrenheit. This cool temperature is maintained by springfed flows from the tributaries and shade from the tree-lined banks. Total fishing pressure for all species is approximately 9,500 visitor-days per year.

Economic Data

The agricultural economy of the watershed is largely dependent upon the raising of livestock, growing of cultivated crops and harvesting forestry products. Transportation and marketing facilities are adequate, with the area being served by a network of State and County roads.

The present land distribution is 9,184 acres in cropland, 3,925 acres in grassland, 34,528 acres in woodland, and 4,483 acres in miscellaneous use or is idle. About 56 percent of the cropland is in or adjacent to the flood plain. The flood plain, which is all open land, is the most fertile and productive to be found within the watershed, and is highly important to the overall agricultural economy. The average net income per farm is low because of the low natural fertility and physical characteristics of the uplands and low intensity use of the flood plain due to flood damage.

According to the latest available County Agricultural census (1959), the average value of farm products sold per farm in Williamson, Davidson and Cheatham Counties is about $3,500. The average value of farm products sold per farm in the South Harpeth River Watershed is estimated to be $2,100. The 10-year average (1954-63) value of farm products sold per farm in Tennessee is about $3,300.

The number and quality of livestock on nearly every farm has increased greatly in recent years. The chief source of gross income from marketing farm products is livestock, with beef cattle, hogs, dairy products, and sheep, ranking in that order. The principal crops grown are tobacco, corn, silage, barley, hay and pasture. The principal row crop grown in terms of acreage is corn. The leading source of cash receipts from marketing crops is tobacco. Grain and forage crops are used primarily as feed in the livestock program. At present, grains are not produced in sufficient quantities to supply the needs of the individual farmers.

There are no public or large industrial holdings of forest land on the watershed. Most woodland is held in small, farm-type ownerships.

The watershed lies in a region of hardwood timber types. Seventeen percent of the stands sampled were good hardwoods and 83 percent were fair hardwoods. High-grading and overcutting has downgraded species composition in the dominant stand on the more productive site.

Ninety percent of the upland forest has medium to better merchantable stocking. Merchantable stock is of seedling and sapling size on 70

percent of the area and only eight percent bears a merchantable stand of sawlog material.

There are about 275 families, or 1,200 people, living on 250 farms. Seventy percent of these are owner-operated. These farms range from 45 acres to 1,250 acres. It is estimated that the average size of the 100 farms containing flood plain is 300 acres and the value, including fixed improvements, is $35,000. The average size of the 150 upland farms is 140 acres and the value, including fixed improvements, is $10,000.

About 200 families, or 1,000 people, reside on tracts of five acres or less. The incorporated town of Fairview lies on the western divide and 800 of its 1,100 population live in the watershed.

There are about 500,000 people within 25 miles of the watershed. The cities of Nashville and Franklin are the chief trade centers and work areas for off-farm employment, with Nashville the leading market for farm products. It is estimated that 40-50 percent of the farm families supplement their farm income by off-farm employment.

The watershed is serviced by a network of State and County roads. The southern section is served by State Highway 96 which crosses the flood plain at Fernvale. State Highway 100 crosses the flood plain at Linton and serves the middle portion of the watershed. A rural development paved road parallels the flood plain over most of its length. In addition to the above, there are a number of gravel roads that provide an easy access to nearby markets and business areas.

The entire watershed is under the Soil Conservation District Programs of the Williamson, Davidson and Cheatham County Districts, organized in 1951, 1946, and 1944, respectively. There are 30 farms, containing 7,483 acres, which have basic soil and water conservation plans and 63 other farms which have received assistance from the Districts. These farms represent about 43 percent of the watershed area. In the ten-year period from 1954-1963, conservation measures were applied in the watershed with District assistance at a total estimated cost of $293,108. (See Table 1A, page 23. There has been some improvement work of a minor nature done on South Harpeth River and its tributaries, but since widespread coordination of effort was lacking, it has not had a lasting effect on relieving the overall problem.

WATERSHED PROBLEMS

The primary problem of the watershed is flood damage to crops and pasture, fences, roads, bridges, rural property, and other minor fixed improvements, and flood plain scour. The total average annual flood damage under present conditions is estimated to be $33,916. The average annual flood damage to crop and pasture values is $7,155; roads and bridges, $11,400; rural property, $3,140; minor fixed improvements, $2,007; flood plain scour, $5,575; and indirect, $4,639. The present value of land with a flooding problem, as quoted by farmers, ranges from $200 to $300 per acre.

Flood Damage

The largest storm in the evaluation period occurred June 16-17, 1960, and produced 4.88 inches of rain in 10 hours. This storm had an estimated 2.33 inches of runoff which inundated 2,681 acres of land. Some portions of the main flood plain begin flooding following rainfall of about 1.7 inches within a 24-hour period.

Eighty-three damaging flood events were evaluated during the 20-year period from January 1943, through December 1962. Damaging floods to crops and pastures occurred in every month of the cropping period of April through November. The largest number of flood events during this period came in the months of April, July and August. The larger floods, which occur about once in three years, cause almost complete crop loss.

Frequent spring floods during April and May delay land preparation and planting on flood plain lands. Floods that occur after normal planting time make it necessary to prepare a new seedbed before replanting. This often results in broken, uneven stands, increased cost of production, and greatly reduced yields. About 45 percent of the floods during the cropping season occur during the critical months of April, May and June. Farmers report having to replant as many as two to three times a season due to flooding. This necessitates having to use a short-season variety crop that normally produces lower yields.

The flood plain was used for the production of high-value cultivated crops and rotational hay or pasture until recent years. The present high risk of flooding, plus the increased cost of production, has forced flood plain farmers to shift acreages of high-value crops, especially silage and tobacco, to adjacent uplands. The flood hazard has caused some areas of upland unsuited for row crops to be retained in cultivation.

The larger floods occur during the winter months of December through March. The largest number of floods in this season occurred during the months of January and February, with an average of about two floods per year. These floods do the major damage to roads, bridges, minor fixed improvements and rural property with resultant costly repair and replacement work.

The flood damage to scattered rural property occurs about once every four to six years. The largest storm in the evaluation series caused damage to a church camp with six buildings, a general store, four rural homes, six barns and other buildings. The contamination of home water supplies by floodwater is a health hazard of great concern to many rural inhabitants. The losses to rural property consist of floodwater and sediment damage to buildings, their contents, outside improvements, and complete destruction of small buildings.

Damage to roads within the flood plain consists of scouring of the shoulders, silting of road drainage ditches, washing away of segments of earth fill, washing off surface gravel, the breaking of asphalt

paving and the erosion of portions of the roadbed and fill beneath the pavement. The damage to bridges and box culverts ranged from damage to abutments and approaches to the complete loss of the bridge.

During periods of overflow, all fence within the flooded area is either completely washed away, knocked down, or damaged by accumulations of debris. The cost of repairing this damage is often as expensive as that of constructing a new fence.

Sediment Damage

Sediment production is moderate in this watershed. The erosion of the stream banks and sediment delivered from the uplands has resulted in the deposition of some sediment in the stream channels or waterways, and has built up levees along their banks. The deposition of sediment on the fertile flood plain from overbank flow has not resulted in any direct damage to crops and pasture. There are no critical sediment producing areas in the watershed.

Erosion Damage

The continued cultivation of row crops on rolling and steep upland soils and the lack of adequate cover have contributed to the loss of top soil. The effect from the loss of top soil has reduced yields per acre and soil deterioration is occurring. Much of this open land has been subjected to moderate sheet erosion.

The damage in the flood plain is caused by scouring or erosion during periods of overbank flow. The width and depth of the scour channels and the severity of the damage is related to the depth, velocity, duration, and type and amount of ground cover at the time of flood flow. The effect of these scour channels has reduced the productive capacity of 169 acres of flood plain.

Indirect Damage

Indirect damages in the watershed are associated with the agricultural and non-agricultural damages. The losses are less obvious, but are just as real and their effects are felt long after the flood has subsided. The indirect damages that accrue are a result of the disruption of traffic, mail delivery, and school bus service; delay and inconvenience to the traveling public; and the interruption of the management, feeding, disease control program, and marketing of livestock and livestock products.

Problems Relating to Water Management

Farm Drainage

Overbank deposition resulting from overflows has built up natural levees along the banks of the streams. These levees impede the return of surface waters into the natural channels. While the main stream channels do not have adequate capacities for floodwater, their capacities are more than adequate to meet drainage needs.

PROJECTS OF OTHER AGENCIES

There are no soon to be constructed works of improvement (County, State or Federal) for water resource development which will affect or be affected by the works of improvement included in this plan.

The Tennessee Division of Forestry, in cooperation with the U. S. Forest Service, operates a fire prevention and suppression organization in Williamson, Davidson and Cheatham Counties and a forest management assistance program on the watershed area. The State furnishes these services through Section 2 of the Clarke-McNary Act and the Cooperative Forest Management Act. There are no national forest lands in the watershed.

The South Harpeth River Watershed is located in the Harpeth River Basin. This watershed comes under the purview of the Corps of Engineers, Nashville District. This agency has been informed of the plans and progress made in the work plan development.

The Corps of Engineers' proposed Three Island Power and Flood Control Project on the Harpeth River 37.1 miles below the confluence of South Harpeth and Harpeth Rivers was approved for study in 1938, and is in a "deferred for re-study" status. The maximum flood pool of the proposed Three Island Dam will not affect the South Harpeth River Watershed Project.

It is believed that the proposed works of improvement in the South Harpeth River Watershed constitutes needed and harmonious elements in a comprehensive development of the Harpeth River Basin. Any reduction in the rate of sedimentation due to the installation of the project would result in less maintenance downstream.

BASIS FOR PROJECT FORMULATION

In formulating this program for flood prevention, the major consideration was the cause, amount and location of flood damage in the flood plain. The nature of these damages was discussed with the local sponsoring organization so there would be a common understanding of the type and degree of protection that might be expected from any control program installed in the watershed.

Project formulation was based on the objectives agreed upon with the sponsoring local organizations. These objectives are three-fold in purpose: (1) a significant improvement in establishing soil and water conservation measures; (2) a reduction in flooding to the extent that cultivated row crops, hay or pasture, in rotation, can be managed for optimum production; and (3) flood damage to roads, bridges, rural property and other fixed improvements be reduced to a minimum.

Land treatment measures are considered one of the basic elements in formulating a watershed project and are essential if it is to function successfully. Land treatment measures included in this plan were selected on the basis that they will: (1) be effective in reducing erosion damage on existing crop land; (2) reduce runoff and sediment production that would adversely affect operation, maintenance, and the

useful life of the proposed works of improvement; (3) be necessary to assure the realization of benefits used in justification of structural measures for flood prevention; and (4) increase the efficiency of land use on existing farms.

The selection of the structural works of improvement was guided by the objectives of the Sponsoring Local Organization, physical characteristics of the watershed, and appropriate engineering criteria. The presence of limestone bedrock and gravel deposits limits the stream channel improvement that can be accomplished economically and places the burden of meeting the desired level of protection on floodwater retardation.

During the preliminary investigation, seven physically adapted sites for floodwater retarding structures were selected for evaluation. These sites were located on Hunting Camp Creek, Caney Fork Creek, Inman Branch, Bedford Creek, Big East Fork Creek, Linton Branch, and Upper South Harpeth River near its confluence with Arkansas Creek. The presence of limestone indicated costly foundation treatment and increased costs for other appurtenances associated with the floodwater retarding structures, such as, emergency spillways. It soon became apparent that all seven floodwater retarding structures, with their high construction costs, would not be economically feasible. Alternate combinations of these floodwater retarding structures, in conjunction with channel improvement, were analyzed to determine a system that would provide a degree of protection compatible with the sponsors' objectives. The three floodwater retarding structures proposed in the plan provide the maximum protection at the least cost. Channel improvement (clearing and snagging) will supplement the land treatment and structural program in providing protection to the extent needed to meet project objectives.

In determining the overall structural program, consideration was given to incremental benefits, costs, and degree of protection. The structural program presented in this plan is the best of several proposals which were considered.

A preliminary design with cost estimates for a recreational development with minimum basic facilities was made at Structure No. 6. The sponsoring local organization did not feel that they could undertake the financial obligations of installing, operating and maintaining a recreational development.

An estimate of fishery resources in this stream was based on a fish population and creel census study made by the Tennessee Game and Fish Commission on this and other similar smallmouth and rock bass streams in Middle Tennessee, and through interviews with fishermen using the stream. Conditions for populations of smallmouth and rock bass appear to be good with the exception of the fact that periodic sharp flooding tends to keep the stream bottom unstable in some areas. Permanent storage of water within the sediment pools of the three floodwater retarding structures will cause the water to stratify, with a resultant increase in temperature of the upper layers. Release of this warmer water into the stream will increase the downstream water temperatures to the point that it cannot support the present smallmouth and rock bass populations.

WORKS OF IMPROVEMENT TO BE INSTALLED

The planned works of improvement to be installed are; (1) the application of needed conservation measures on 14,411 acres of land for watershed protection; (2) the installation of three floodwater retarding structures and the improvement of 140,375 feet of stream channel for flood prevention; and (3) the installation of mitigating measures (cool water inlet) that temper or reduce damages to fish habitat.

Land Treatment Measures

The land treatment measures to be installed on 14,411 acres for watershed protection will have a measurable physical effect on the watershed and were acceptable to the local sponsoring organization. These measures will improve the hydrologic condition, decrease runoff, erosion and the sediment production, and assure the realization of benefits used in project justification.

The application of conservation measures on 2,755 acres of cropland will consist of conservation cropping systems, contour stripcropping, gradient or parallel terraces, grassed waterways, cover and green manure crops, and drainage field ditches. The treatment of 3,317 acres of new grassland will consist of the establishment of grassed waterways and permanent hayland and pasture planting. The improvement of 8,200 acres of woodland will consist of tree planting and hydrologic stand improvement. Hydrologic stand improvement includes conversion to suitable species, interplanting, improvement harvesting, release of desired production, and woodland management. The construction of farm ponds and stream channel improvement will be on 139 acres of miscellaneous land. The land treatment measures for watershed protection will be installed at an estimated total cost of $326,010.

The practice of general farming prevails and the trend is increased rotation of crops in order to maintain fertility and produce an ample supply of forage and grain for livestock feed. The basic concept in the rotation is a cultivated crop, followed by small grain and then grasses or legume-grass mixture. The land treatment measures to be installed will vary with the land use, economic conditions, acreage controls, customs, trends, conservation needs, and flood reduction.

Cooperators will plant trees on 665 acres of depleted, poorly protected open land. For best results in watershed management, landowners should plant good hardwood sites to suitable hardwood species. Adapted pine species are recommended as adequate for the drier, more exposed sites. To insure successful treatment, the cooperators should fence the planted areas out of grazing lands.

Stand improvement for watershed protection is needed on 67 percent of the upland forest. During the installation period, measures to correct deficiencies in forest cover and to accelerate improvement in soil hydrologic condition will be applied to a net area of 2,190 acres.

In release operations, forest technicians should give preference to growing stock and seed trees (where needed) of yellow poplar, ash, walnut, hard maple, and red maple, American elm, black cherry, and hickory. These species are high in the ability to build rich organic soil. For additional

benefit, woodsworkers should leave vigorous dogwood and mulberry in all stands. To develop the highest overall value, forest managers should give preference to good stock of white oak, northern red oak, bur oak, and cherry bark red oak, over other individuals of inferior quality (though of preferred species).

If necessary to prevent use by grazing animals, cooperators should fence out areas treated for hydrologic stand improvement.

All species recommended for retention in the stand produce food and shelter for wildlife. Well-developed forest soils encourage the production of game food and promote orderly stream flow.

The conservation measures to be installed will be within land capabilities, and treatment will be in accordance with needs for sustained agricultural production. Alternative measures and land use will be in keeping with standard criteria established and used in soil and water conservation. Alternative measures that are necessary and justifiable for the conservation, development, protection and improvement of the individual farms may be installed.

Structural Measures

Floodwater retarding structures for the control of damaging water flow and sediment are planned for three locations as shown on the Watershed Project Map, page 37. Each structure includes an earth dam with a fixed drawdown tube of concrete pipe and an emergency spillway excavated in rock. A reinforced concrete riser will establish the elevation of the sediment pool. A metal slide headgate, located near the bottom of the riser, will permit drainage of the sediment pool. It will also permit the necessary fluctuation of the water level for the control of obnoxious vegetation and mosquitoes. All embankments, borrow areas, and other areas disturbed in construction will be stabilized with suitable vegetation.

Two of the floodwater retarding structures will be designed using a single-stage inlet. This is a concrete riser with an opening at the top that will be set at the elevation of the normal pool. One of the three will be designed using two-stage inlets. The operation of this structure will be essentially the same as that of a single-stage inlet. The primary difference will be that the crest of the riser will be extended above the normal pool to a depth at which the flood storage involved will provide the protection necessary to realize the project objectives. The low-stage flood storage will be released through a small opening in the side of the riser and at a low release rate. As the water continues to rise above the upper stage or crest of the riser, the release rate will be greatly increased. The high release rate of the upper stage will reduce the amount of flood storage required by the structure, and as a result, will minimize the amount of easement area required by the construction of the dam. A section of a typical floodwater retarding structure with a two-stage inlet is shown on page 36.

Design data for these structures is shown in Table 3, page 25. The three floodwater retarding structures provide 8,506 acre-feet of floodwater detention and control about 38.5 percent of the watershed area.

This floodwater detention capacity is the equivalent of 5.08 inches of runoff from the area above structures and 1.96 inches from the total watershed area. The total estimated cost of installing the floodwater retarding structures, including mitigating measures, is $1,353,123, Table 2, page 24,and the annual cost, including operation and maintenance of $2,664, ($50 mitigating measures) is $45,491.

Channel improvement will be installed on approximately 140,375 feet of stream channels. This improvement will consist of 74,200 feet on South Harpeth River, 10,700 feet on Little East Fork Creek, 9,100 feet on Linton Branch, 4,000 feet on Bedford Branch, 5,000 feet on Poplar Branch, 3,200 feet on Inman Branch, 7,300 feet on East Fork Creek, and 26,875 feet on 17 minor tributaries. The improvement of the 17 minor tributaries will provide an outlet for floodwater from adjacent hill land across the flood plain into South Harpeth River.

All channel improvement will be clearing and snagging and will include spreading or removal of gravel and sand bars, removal of drifts, brush, and trees within the wetted perimeter. The larger trees located along the top of the channels will not be disturbed. This growth should add to the stability of the channel banks and the resulting shade can reduce channel maintenance by retarding small vegetative growth. The larger trees will also provide shade and cover for wildlife and help maintain the water temperature.

A section of South Harpeth River, beginning at Valley Section 13 and extending downstream to Fernvale, will need the gravel bars removed rather than spread. Removal of these gravel bars will bring the planned channel capacity of this reach in line with that of the rest of the channel.

The location of the planned channel improvement will generally be limited to that as shown on the Project Map. Existing bridges and culverts are adequate to provide the planned capacities.

Total estimated installation cost for all channel improvement is $127,385, Table 2, and the annual cost, including operation and maintenance of $2,659, is $6,691.

Kinds of measures, quantities and distribution of installation costs between P. L. 566 funds and Other funds for the total project are shown on Table 1, page 22.

Mitigating Measures

The principal spillway of each floodwater retarding structure will be modified to include a cool water inlet. This inlet will be an appurtenance to the principal spillway and consist of a vented tube that extends from slightly above the surface of the sediment pool to a predetermined depth. This modification will remove the normal base stream flow from below the surface of the permanent pool, to avoid increasing the downstream water temperatures. For the cool water inlet to be effective, the bottom of the inlet will be located one to two feet

above the normal valley floor. One foot should be used when the present ditch or stream bottom is more than three feet below the valley floor and two feet when the stream is less than three feet below the valley floor.

Where consistent with sound engineering practice in design and construction, trees, stumps, gravel bars and rocks, presently providing cover and shade for the protection and propagation of fish will be retained during the clearing and snagging operations for stream channel improvement.

The total estimated cost of all mitigating measures is $2,200.

EXPLANATION OF INSTALLATION COSTS

The total estimated installation cost of the project is $1,806,518, of which $1,356,336, or 75 percent, will be P. L. 566 funds and $450,182, or 25 percent, will be Other funds. The schedule for estimated installation costs by project years is shown on page 15.

The total estimated installation cost for all land treatment measures is $326,010; $26,850 from P. L. 566 funds and $299,160 from Other funds. These estimated installation costs include labor, materials, machinery, and all direct and indirect costs related to these measures.

The total estimated installation cost of land treatment, except forestry measures, is $270,310; $252,310 will be Other funds and $18,000 will be P. L. 566 funds for accelerated technical assistance. The funds for technical assistance will be $14,565 from P. L. 566 and $11,380 from the going conservation program for the preparation and application of basic farm conservation plans, and $3,435 from P. L. 566 funds and $620 from the going conservation program for soil surveys.

Forest land treatment measures cost $55,700. Of this amount, $8,850 is P. L. 566 funds and $46,850 is Other funds. The Tennessee Division of Forestry will furnish $8,850 of State funds as part of these Other funds. The landowners and operators will bear the $37,600 cost of installing the forestry measures. The State money will be used to match P. L. 566 funds in providing technical assistance to install land treatment measures on private land. The going Cooperative Forest Management Program will furnish an estimated $400 of these Other funds for technical assistance. The $8,850 of P. L. 566 funds with matching State funds ($8,850) will provide accelerated technical forestry assistance on private lands.

The total estimated installation cost of the three floodwater retarding structures and mitigating measures is $1,353,123. The cost to be borne by P. L. 566 funds for construction, engineering services, and other (administrative, etc.) is $1,217,981. The estimated construction cost is $994,560, which includes $168,500 for foundation treatment and $106,560 for contingencies. The estimated cost of installation services needed to install the structures is $223,421. The total installation cost to be borne by Other funds is estimated to be $135,142. The estimated cost of land rights--land, easements, and rights-of-way--is $131,050, administering contracts, $450; and other costs, $3,642. Also included in the estimated land rights costs is an allowance of $32,000 for relocating

roads and $8,000 for relocating service powerlines. The other costs are for additional organization costs, assessor fees, legal fees, or general administrative costs which are incurred in connection with obtaining the above land rights, or costs incurred as an obligation of the South Harpeth River Watershed District.

The total cost of $2,200 for installing the mitigating measures will be borne by P. L. 566 funds for construction, engineering services and other (administrative, etc.).

The total estimated installation cost of the 140,375 feet of stream channel improvement is $127,385. The costs to be borne by P. L. 566 funds for construction, engineering services, and other (administrative, etc.) is $111,505. The estimated construction cost is $97,490, which includes $10,445 for contingencies. The estimated installation services needed to install the stream channel improvement is $14,015. The total estimated installation cost to be borne by Other funds for the stream channel improvement is $15,880. The cost of land, easements and rights-of-way is $15,125, administering contracts, $150, and other costs, $605.

SCHEDULE OF ESTIMATED INSTALLATION COSTS

Project Year	Estimated Cost (Dollars)		
	Non-Federal Land	Non-Federal Land	Total
	P. L. 566	Other funds	
(1)	(2)	(3)	(4)
First	3,195	42,747	45,942
Second	76,355	107,611	183,966
Third	701,018	143,353	844,371
Fourth	467,638	84,759	552,397
Fifth	108,130	71,712	179,842
TOTAL	1,356,336	450,182	1,806,518

EFFECTS OF WORKS OF IMPROVEMENT

It is estimated that 2,127 acres of flood plain land on about 90 farms will be directly benefited by the proposed structural program. No monetary benefits are claimed on 64 acres of the above flood plain which is in the backwater area of Harpeth River. The current average market value of this flood plain land is estimated to be increased $200 to $300 per acre. The net returns per acre on the benefited area will be increased and the overall economy of the entire community will be enhanced.

Flooding during the cropping season of April through November will be less frequent than once in five years on 84 percent of the 2,063 acres of flood plain land on which benefits are claimed. The area inundated by the maximum storm in the evaluation period will be reduced by 22 percent, and flooding during the entire year will be less frequent than once in three years on 78 percent of the flood plain benefited by structural measures.

It is estimated that crop and pasture damage will be reduced by 90 percent; road and bridge, 76 percent; minor fixed improvements, 86 percent; rural property, 93 percent; flood plain scour, 81 percent; indirect, 82 percent; and the sediment yield, 33 percent.

The drainage area of South Harpeth River Watershed consists of about 16 percent of the drainage area of Harpeth River at the confluence of Harpeth River and South Harpeth River. The 33 percent reduction in gross erosion will reduce the sediment available for delivery to Harpeth River. It is estimated that the flood plain on Harpeth River below its confluence with South Harpeth River will receive some benefits.

The objectives of the individual farmer are to develop a long-range plan which will give the highest net income, based on appraisal of production alternatives that will provide the most productive use of his resources of land, labor, capital, and management. The application of conservation measures will provide more adequate cover, improve infiltration and physical conditions of the soil, contribute to the control of excessive runoff, reduce sheet erosion, increase yields per acre, and aid in maintaining the effectiveness of group facilities for watershed protection and flood prevention.

It is estimated that 233 acres can be restored to former productive use and 997 acres of flood plain can be used more intensively for the production of corn, silage, barley, hay and pasture, in rotation. The farmers indicate their need for the higher quality forage and grain crops for livestock which is the chief source of farm income. Increased yields can be expected due to better management practices and improved technology made possible with the project installed.

The establishment of full tree cover on depleted, poorly protected open lands will largely eliminate soil decline on those areas and the damaging surface runoff and sediment loads which result from storm rainfall. Installation of the hydrologic stand improvement measures prescribed in the work plan and protection of the treated areas will decrease damaging storm runoff from forest areas. Under management which maintains a good inventory of preferred growing stock in sawtimber trees and poles, as well as the younger stock, the forest lands of the watershed will produce an average merchantable volume four to five times greater than at present. The total forest land area of 34,526 acres will increase to 34,944 acres under the watershed program.

The frequency, duration and magnitude of flood damage has resulted in some areas of uplands that are more suited to permanent grass to be used for the production of cultivated crops. With the project installed, the benefited lands can be more intensively used for the production of cultivated row crops and higher quality forage crops which will permit needed land use adjustments to be made on the uplands. The future land use in the watershed is anticipated to be 7,302 acres cropland, 34,944 acres woodland, 7,077 acres grassland, and 2,797 acres miscellaneous use. Estimates indicate that there will be no increase in the total acreage of allotted crops within the watershed.

The local secondary benefits stemming from or induced by this project are considered pertinent to the economic evaluation. These secondary

benefits will accrue as a result of increases in the sale of agricultural products and increased income to local processors, business establishments, and other individuals not directly benefited. These local secondary benefits are also considered to include the transporting, processing and marketing of those goods and services that produce the primary benefits and the supply of additional materials and services required to make possible the increased net returns which stem from the installation of the project.

The reservoirs created by the sediment pools in the three floodwater retarding structures will provide incidental water related recreation by organized groups or the general public. The stilling basins located at the outlet of the principal spillway of each floodwater retarding structure will also provide excellent pools for fishing. These facilities will be available to the 3,000 watershed residents as well as 500,000 additional residents within a 25-mile radius. It is estimated that incidental recreation will amount to 14,550 user-days annually. The South Harpeth River Watershed District will provide access to the partially developed recreational facilities. The inclusion of a special provision in the easements granted or purchased will define and assure this access.

The value of farm products sold per farm is below the State and County averages. Redevelopment benefits will accrue from the installation of the proposed project and will provide employment for unemployed or underemployed local labor. Accelerated technical and financial assistance provided as a result of the installation of this project will improve the individual farmer's standard of living in this low income area, and enhance the overall economy of the entire community.

Mitigating Measures

The inclusion of a cool water inlet, as an integral part of the principal spillway, will help maintain the present cool, downstream water temperatures and the present population of smallmouth and rock bass. The retention of a portion of the wet cover and pools during channel improvement will provide some cover and shade for the protection and propagation of fish.

Waterflow control measures (floodwater retarding structures and channel improvement) will reduce the present periodic sharp floods which keep the stream channel bottom unstable. These waterflow control measures will be beneficial to fish habitat.

PROJECT BENEFITS

The average annual benefits used in justification of the floodwater retarding structures and stream channel improvement are estimated to be $68,175, Table 6, page 29.

The average annual flood damage without the project is estimated to be $33,916, and the estimated benefits from flood damage reduction are $28,049, Table 5, page 28. These benefits consist of reduction in crop and pasture damage amounting to $6,426, which includes $3,485 from

restoration to former productivity; other agricultural, $1,726; road and bridge, $8,640; rural property, $2,920; flood plain scour, $4,525; and indirect, $3,812. The remaining damages of $5,867 with the project installed are not expected to limit the agricultural use of the land or adversely affect this project. The average annual benefits of $462, accruing as a result of the application of land treatment measures, were not used in project justification.

The estimated more intensive land use benefits of $26,284 will accrue as a result of flood prevention. These benefits are estimated on the basis of the difference in net returns with and without the project, and consideration was given to farmer participation, the capability of the soils and their potential productivity.

The value of local secondary benefits amounts to $7,079; those stemming from the project are estimated to be $5,052, and those induced by the project are estimated to be $2,027. The value of secondary benefits from a national viewpoint were not considered pertinent in the economic evaluation or justification of this project. Incidental recreation benefits are estimated at $7,225. The economic impact of project installation is considered pertinent but redevelopment benefits were not evaluated or used in project justification.

COMPARISON OF BENEFITS AND COSTS

The installation of three floodwater retarding structures and 140,375 feet of stream channel improvement for flood prevention will be installed, operated and maintained at a total average annual cost estimated to be $52,182. The average annual benefits used in project justification are estimated to be $68,175, which include local secondary benefits of $7,079 accruing within the zone of influence of the project. The benefit-cost ratio accruing as a result of project installation from both primary and secondary monetary benefits is 1.3 to 1.0, and from primary benefits is 1.2 to 1.0.

PROJECT INSTALLATION

The sponsors of the South Harpeth River Watershed District desire that the land treatment and structural measures be installed during a five-year period.

The land treatment measures for watershed protection will be planned and applied, farm by farm, in cooperation with the going and accelerated program of the Williamson, Davidson and Cheatham County Soil Conservation Districts.

The Soil Conservation Service will accelerate their technical assistance to the going District conservation program from P. L. 566 funds. The Tennessee Division of Forestry, in cooperation with the U. S. Forest Service, will assign foresters trained in watershed management to help install the forestry measures prescribed by the watershed work plan. The plan provides for 21 man-months of additional forester time for technical assistance to private landowners. This total 21 man-months includes technical assistance for all forest land management planning incidental

to and necessary for accomplishing the measures prescribed in the plan. Public Law 566 and the Tennessee Division of Forestry will share the costs of accelerated technical assistance for forest land treatment measures during the installation period. If the State cannot finance its share during the first year of installation, the total cost of forestry technical assistance for this period may be financed from P. L. 566 funds. After the first year of installation, the cost-sharing for forestry technical assistance will be in accordance with that under going cooperative forestry programs.

The South Harpeth River Watershed District has sufficient legal authority--including raising of funds through taxation or assessments and the power of eminent domain--to acquire all land, easements and rights-of-way needed for the project. This authority will be used as needed for the orderly progress in installing the planned works of improvement. The South Harpeth River Watershed District will be responsible for all costs in acquiring the needed land, easements and rights-of-way, administering contracts, and other costs, such as, additional organizational, assessor, legal, court hearing and other administrative.

The Williamson County Soil Conservation District will obtain agreements from farm owners and operators to carry out recommended soil and water conservation measures on not less than 50 percent of the land situated in the drainage area above each floodwater retarding structure. These agreements will be obtained prior to any P. L. 566 funds being provided for the construction of each individual structure.

Prior to providing financial assistance for the construction of any Planned structural measure, at least 75 percent of the effective land treatment measures must be installed, or their installation commenced, on those sediment source areas which, if uncontrolled, would require a material increase in the cost of construction, operation, and maintenance of the structural works of improvement.

The three floodwater retarding structures are contingent upon each other and will be built as a unit during the third and fourth project years. The stream channel improvement is contingent upon the three floodwater retarding structures and is scheduled to be done the fifth project year. The stream channel improvement is scheduled to begin at the lowest point needed downstream and move upstream.

The roads within the pool areas of floodwater retarding structures Number 3 and 6 will be moved, raised or abandoned as agreed upon by the sponsoring local organization, the local branch of government responsible for the roads and the Soil Conservation Service. In all cases, the sponsoring local organization will be responsible for obtaining the necessary land rights. The service powerlines within the pool areas of each of the floodwater retarding structures will be relocated as agreed upon by the sponsoring local organization and the Soil Conservation Service. In all cases, the sponsoring local organization will be responsible for the disposition of these roads and powerlines.

FINANCING PROJECT INSTALLATION

The South Harpeth River Watershed District was authorized by referendum on June 9, 1960, and was formed in accordance with the provisions of the

Tennessee Watershed District Act of 1955, as amended. The South Harpeth River Watershed District has completed its formal organization and has actively participated in the development of this proposed watershed work plan. The major costs of organizing have already been incurred and were locally financed. The District will also bear all costs of court hearings, assessor fees, and other related administrative costs. This will permit operation under the Tennessee Watershed District Act of 1955, as amended.

The land treatment measures for watershed protection will be installed by the landowners and operators at their own expense. Such cost-sharing assistance as available under the Agricultural Conservation Program or other going program will be utilized in applying these measures.

The South Harpeth River Watershed District has initiated negotiations with the Farmers Home Administration by filing a letter of intent to finance its share of the project installation costs by utilizing the loan provisions of Section 8, P. L. 566, as amended. The loan will be repaid by the District through an annual assessment. The amount of the assessment will be determined so as to meet both the loan repayment needs of the District and the annual operating expenses. In addition, a maintenance assessment will provide the funds needed to adequately maintain the works of improvement.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

The land treatment measures for watershed protection will be operated and maintained by landowners and operators at their own expense in cooperation with the Williamson, Davidson and Cheatham County Soil Conservation Districts.

Forest land treatment measures will be installed on private land under agreement with the sponsoring Soil Conservation Districts. The landowners and operators concerned will be responsible for the operation and maintenance of these measures. Soil Conservation District representatives, with the cooperation of the Tennessee Division of Forestry, will make periodic inspections of these forest land treatment measures to determine maintenance needs and to encourage maintenance.

The South Harpeth River Watershed District will be responsible for adequately protecting, operating and maintaining the three floodwater retarding structures and 140,375 feet of stream channel improvement, estimated to cost $5,323 annually. The District will arrange with the landowners and operators for minor maintenance jobs to be done as a part of their regular farm operations, estimated to be $2,397 annually. The major maintenance jobs, estimated to cost $2,926 annually, will be accomplished by the District. The Watershed District will provide by annual assessment, under authority of the Tennessee Watershed District Act of 1955, as amended, whatever amount is needed for adequate maintenance.

The maintenance of the improved stream channel will include the removal of drifts and silt bars and the controlling of obnoxious vegetative growth. The maintenance of floodwater retarding structures will include removal of debris from principal spillway, keeping adequate vegetation on dam and emergency spillway, and the repair of any damage resulting from flood events. All floodwater retarding structures will be maintained in accordance with regulations of the Tennessee State Department of Public Health.

The South Harpeth River Watershed District will make periodic inspections as needed and at least annually to determine the condition and any remedial treatment needed. A record of the inspections and maintenance operations will be kept on file and will be available for use by representatives of the Soil Conservation Service. The Soil Conservation Service will participate in inspections at least once annually and will furnish only technical guidance or other information necessary for operation and maintenance.

The South Harpeth River Watershed District will execute specific maintenance agreements prior to the issuance of invitations to bid on construction of any structural measure.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
South Harpeth River Watershed, Tennessee

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) 1/		
		Non-Fed Land	P. L. 566 Funds	Other Funds	Total
			Non-Fed Land	Non-Fed Land	
(1)	(2)	(3)	(4)	(5)	(6)
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	2,755	0	75,690	75,690
Grassland	Acre	3,317	0	147,190	147,190
Miscellaneous Land	Acre	139	0	17,430	17,430
Technical Assistance	xxxx		18,000	12,000	30,000
SCS - Subtotal			18,000	252,310	270,310
Forest Service					
Woodland	Acre	8,200	0	37,600	37,600
Technical Assistance	xxxx		8,850	9,250	18,100
FS - Subtotal			8,850	46,850	55,700
TOTAL - LAND TREATMENT			26,850	299,160	326,010
STRUCTURAL MEASURES					
Soil Conservation Service					
Construction					
Floodwater Retarding Structures	No.	3	994,560	0	994,560
Stream Channel Improvement	Feet	140,375	97,490	0	97,490
SCS - Subtotal			1,092,050	0	1,092,050
Subtotal - Construction			1,092,050	0	1,092,050
Installation Services					
Soil Conservation Service					
Engineering Services	xxxx		141,905	0	141,905
Adm. & Misc.	xxxx		95,531	0	95,531
SCS - Subtotal			237,436	0	237,436
Subtotal - Installation Services			237,436	0	237,436
Other Costs					
Land, Easements & R/W	xxxx		0	146,175	146,175
Admin: Contracts & Other	xxxx		0	4,847	4,847
Subtotal - Other Costs			0	151,022	151,022
TOTAL - STRUCTURAL MEASURES			1,329,486	151,022	1,480,508
TOTAL PROJECT			1,356,336	450,182	1,806,518
SUMMARY					
Total - SCS			1,347,486	403,332	1,750,818
Total - FS			8,850	46,850	55,700
TOTAL PROJECT			1,356,336	450,182	1,806,518

1/ Price base - 1963.

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
South Harpeth River Watershed, Tennessee

Measures (1)	Unit (2)	Units Applied To Date (3)	Total Estimated Cost (Dollars) 1/ (4)
LAND TREATMENT			
Conservation Cropping System	Acre	1,175	14,100
Cover & Green Manure Crops	Acre	3,250	81,250
Diversions	Feet	19,500	3,120
Grassed Waterways	Acre	20	1,500
Hayland Planting	Acre	410	13,220
Pasture Planting	Acre	3,515	158,175
Terraces, Gradient	Feet	6,500	260
Wildlife Habitat Development	Acre	3	60
Farm Ponds	No.	36	7,920
Tree Planting	Acre	421	7,578
Hydrologic Stand Improvement	Acre	395	5,925
TOTAL - LAND TREATMENT MEASURES	xxxx	xxxx	293,108

1/ Price base - 1963.

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

South Harpeth River Watershed, Tennessee
(Dollars) 1/

Structure Site No. or Name	INSTALLATION COST - P. L. 566 FUNDS				INSTALLATION COST - OTHER FUNDS			TOTAL INSTAL. COST
	Construction	Instal. Services		Total P. L. 566 Funds	Admin: Contracts & Other 2/	Land, Easements & R/W	Total Other Funds	
		Engineering	Adm. & Misc.					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Floodwater Retarding Structures - 1	243,040	32,550	22,047	297,637	738	14,700	15,438	313,075
3	409,920	54,900	37,186	502,006	2,276	76,150 3/	78,426	580,432
6	341,600	45,750	30,988	418,338	1,078	40,200 4/	41,278	459,616
Subtotal - Structures	994,560	133,200	90,221	1,217,981 5/	4,092	131,050	135,142	1,353,123
Stream Channel Improvement Clearing & Snagging	97,490	8,705	5,310	111,505	755	15,125	15,880	127,385
GRAND TOTAL	1,092,050	141,905	95,531	1,329,486	4,847	146,175	151,022	1,480,508

1/ Price base - 1963.
2/ Includes an allowance of $4,247 for court hearing costs, assessor fees, and related general administrative costs of the watershed district and $600 for administering contracts.
3/ Includes $20,000 for road relocation and $3,000 for relocating a service powerline.
4/ Includes $12,000 for road relocation and $5,000 for relocating a service powerline.
5/ Includes $2,200 for the installation of mitigating measures.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
South Harpeth River Watershed, Tennessee

Item (1)	Unit (2)	Structure Numbers 1 (3)	3 (4)	6 (5)	Total (6)
Drainage Area	Sq.mi.	5.05	18.14	8.20	31.39
Storage Capacity					
Sediment					
Submerged	Ac.ft.	76	186	139	401
Aerated	Ac.ft.	72	187	136	395
Floodwater	Ac.ft.	1,204	4,887	2,415	8,506
Total	Ac.ft.	1,352	5,260	2,690	9,302
Between High & Low Stages	Ac.ft.	698	-	-	698
Surface Area					
Sediment Pool	Ac.	13	41	31	85
Floodwater Detention Pool	Ac.	61	266	170	497
Volume of Fill	Cu.yds.	278,993	367,636	350,977	997,606
Elevation - Top of Dam	Ft/MSL	667.0	683.0	631.0	-
Maximum Height of Dam	Ft.	60.5	59.0	53.0	-
Emergency Spillway					
Crest Elevation	Ft/MSL	659.0	671.0	622.0	-
Bottom Width	Ft.	95	70	66	-
Type	-	Rock	Rock	Rock	-
Percent Chance of Use	-	3	2	3	-
Average Curve No. - Cond. II	-	73	76	77	-
Emergency Spillway Hydrograph					
Storm Rainfall (6-hr)	In.	7.85	7.54	7.85	-
Storm Runoff	In.	4.68	4.75	5.13	-
Velocity of Flow (Vc) 1/	Ft/Sec.	-	-	-	-
Discharge Rate 1/	c.f.s.	-	-	-	-
Max. W.S. Elevation 1/	Ft.	-	-	-	-
Freeboard Hydrograph					
Storm Rainfall (6-hr)	In.	14.55	13.97	14.55	-
Storm Runoff	In.	10.90	10.79	11.49	-
Velocity of Flow (Vc) 1/	Ft/Sec.	13.4	16.0	14.3	-
Discharge Rate 1/	c.f.s.	7,143	8,900	5,400	-
Max. W.S. Elevation 1/	Ft/MSL	667.0	683.0	631.0	-
Principal Spillway					
Capacity - Low Stage	c.f.s.	50.5 2/	190 3/	88 3/	-
Capacity - High Stage	c.f.s.	117 3/	-	-	-
Capacity Equivalents					
Sediment Volume	In.	0.55	0.39	0.63	-
Detention Volume	In.	4.47	5.05	5.52	-
Spillway Storage	In.	2.00	3.78	4.02	-
Class of Structure	-	"a"	"b"	"a"	-

1/ Maximum during passage of hydrograph.
2/ Maximum discharge.
3/ Average discharge.

TABLE 3A - STRUCTURE DATA - CHANNELS
South Harpeth River Watershed, Tennessee

Channel Designation (1)	Station Numbers For Reaches Station (2)	Station (3)	Total Watershed Area (4)	Uncontrolled Watershed Area (5)	Required Channel Capacity (6)	Average Release Rate of Structures (7)	Design "n" Value (8)	Clear & Snag (9)
South Harpeth River			(sq.mi)	(sq.mi)	(c.f.s)	(c.f.s)		(mi)
Valley Section - 13	100+00	222+00	29.59	7.45	681	181	0.045	2.31
Valley Section - 14	222+00	282+00	35.05	11.86	950	232	0.045	1.14
Valley Section - 15	282+00	322+00	35.93	12.74	1104	232	0.045	0.76
Valley Section - 16	322+00	373+00	40.66	17.47	1428	232	0.045	0.97
Valley Section - 17	373+00	413+00	44.89	21.70	1682	232	0.045	0.76
Valley Section - 18	413+00	463+00	46.14	22.95	1750	232	0.045	0.95
Valley Section - 19	463+00	522+00	60.46	29.07	1800	314	0.045	1.12
Valley Section - 20	522+00	612+00	67.83	36.44	1991	314	0.045	1.70
Valley Section - 21	612+00	676+00	71.07	39.68	2100	314	0.045	1.21
Valley Section - 22	676+00	751+00	76.69	45.30	2037	314	0.045	1.42
Valley Section - 23	751+00	822+00	78.73	47.44	2023	314	0.045	1.34
Valley Section - 24	822+00	842+00	80.36 (Outlet)	48.97	2019	314	0.045	0.38
Major Tributaries								
Little East Fork Creek								
Valley Section - 11	288+00	395+00	4.44	4.44	480	-	0.045	2.03
Linton Branch								
Valley Section - 11	399+00	490+00	3.95	3.95	420	-	0.045	1.72
Bedford Branch								
Valley Section - 11	252+00	292+00	3.80	3.80	430	-	0.045	0.76
Poplar Branch								
Valley Section - 11	569+00	619+00	2.90	2.90	360	-	0.045	0.95
Inman Branch								
Valley Section - 11	145+00	177+00	1.58	1.58	235	-	0.045	0.61
East Fork Creek								
Valley Section - 12	350+00	423+00	8.42	0.45	130	80	0.045	1.38
Minor Tributaries							0.045	5.09

TABLE 4 - ANNUAL COST
South Harpeth River Watershed, Tennessee
(Dollars)

Evaluation Unit (1)	Amortization of Installation Cost 1/ (2)	Operation and Maintenance Cost 2/ (3)	Total Annual Cost (4)
Floodwater retarding structures in conjunction with related stream channel improvement	46,859	5,323	52,182
GRAND TOTAL - ANNUAL COST	46,859	5,323	52,182

1/ The floodwater retarding structures and stream channel improvement are amortized for 100 years at three percent interest (0.03165), using a 1963 price base.
2/ Price base - long-term projected prices.

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
South Harpeth River Watershed, Tennessee
(Dollars) 1/

Item (1)	ESTIMATED AVERAGE ANNUAL BENEFITS		Damage Reduction Benefits (4)
	Without Project (2)	With Project (3)	
FLOODWATER			
Crops and Pasture 2/	7,155	729	6,426
Other Agricultural 3/	2,007	281	1,726
Non-Agricultural			
Road and Bridge	11,400	2,760	8,640
Rural Property	3,140	220	2,920
Subtotal - Floodwater	23,702	3,990	19,712
EROSION			
Flood Plain Scour	5,575	1,050	4,525
INDIRECT	4,639	827	3,812
GRAND TOTAL - FLOOD DAMAGE	33,916	5,867	28,049

1/ Price base - long-term projected prices.
2/ Includes $3,485 benefits from restoration to former productivity on 233 acres of flood plain land.
3/ Includes fences, farm bridges, and water gates.

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
South Harpeth River Watershed, Tennessee
(Dollars)

Evaluation Unit	ESTIMATED AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost	Benefit Cost Ratio
	FLOOD PREVENTION						
	Flood Damage Reduction 2/	More Intensive Land Use	Incidental Recreation	Local Secondary Benefits 3/	Total		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Floodwater retarding structures in conjunction with related stream channel improvement	27,587	26,284	7,225	7,079	68,175	52,182	1.3:1.0
GRAND TOTAL	27,587	26,284	7,225	7,079	68,175	52,182	1.3:1.0

1/ Price base - Long-term projected prices for benefits. See Table 4 for costs.
2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $462 annually.
3/ Local secondary benefits stemming from primary benefits are $5,052 and induced by project installation, are $2,027.

INVESTIGATIONS AND ANALYSES

Engineering Surveys

The engineering field surveys on the South Harpeth River Watershed consisted of establishing 25 miles of vertical control, surveying 24 valley cross-sections, and 100 channel cross-sections. Mean sea level was used as the datum for elevations. All vertical control was established with an elevation tolerance of 0.07 times the square root of the length of circuit (m) in miles.

The valley and channel cross-sections were chained and elevations recorded to the nearest 0.1 foot. These sections were located on aerial photographs and distances between sections were scaled from these photographs. Elevations of bridges, road crossings, culverts and other control points were established.

Topographic maps of the floodwater retarding structures were prepared on photographic prints as base maps. Contours were run at four-foot intervals by level and were located on the base map using a telescopic alidade and plane table.

The field survey data, profiles and cross-sections were plotted showing the present ditches and average ground elevations to give an adequate picture of valley shape for flood-routing and design computations. The topographic maps of the floodwater retarding structure sites were used to develop stage-storage and stage-area curves for design.

Design

The structure classification assigned to Structures Number 1 and 6 was "a" class. Any damage that would result from a failure would be primarily to agricultural lands. However, since these structures have a contract cost exceeding $75,000, criteria approaching that of class "b" was used. Structure Number 3 was assigned a structure classification approaching that of the "b" classification. A structure failure could result in damage to a few isolated homes, a store, and to State Highway 96, but the possibility of loss of life would be remote.

Provisions are made for storing the expected 100-year sediment accumulation in each structure. Eighty percent of the first 50-year sediment accumulation is stored in the sediment pool; the remaining 20 percent of the first 50-year and the second 50-year sediment accumulation is stored in an aerated sediment pool and does not detract from the flood pool.

Preliminary designs of the floodwater retarding structures were based on the design criteria as established in Engineering Memo SCS-27 and Engineering Memo TN-11. The cost of foundation treatment was estimated from the information furnished in the geologic report. The emergency spillway design was based on "b" class criteria, short-cut flood-routing procedure outlined in TR-2, and design criteria as established in Engineering Memo SCS-27 and Engineering Memo SCS-31 (Revised, dated April 2, 1959). All detention volume requirements were determined by short-cut methods described in Engineering Memo TN-11 (dated January 17, 1964).

Structure Number 1 will have a two-stage principal spillway. Structures Number 3 and 6 will have single-stage principal spillways. Design for the two-stage principal spillway outlet was based on criteria established by Watersheds Memo EWP-5.

The required peak discharges for channel design were determined by a partial duration series developed from the historical series. The annual storm runoff was obtained from a logarithmic plotting of runoff versus frequency in years. The runoff for the annual storm was comparable with the runoff that could be expected to occur from the one-year frequency, 24-hour storm, assuming an average antecedent moisture condition. The main channels were designed to accommodate the peak flow for the annual storm that occurs during the months of April through November. Supplement "B" of Section 5, National Engineering Handbook, was used as a guide in determining the values of "n" in Manning's Formula.

The channel designs revealed that no channel enlargement is necessary on South Harpeth River; however, clearing and snagging will need to be performed on all channels.

Hydrologic

Precipitation data were obtained from the U. S. Weather Bureau publication, "Climatological Data and Hourly Precipitation Data". The historical series was developed from 20 years of records for the non-recording gage at Franklin, Tennessee. The hourly storm distribution was obtained from the U. S. Weather Bureau recording precipitation gage at Nashville, Tennessee. The maximum storm of the evaluation series began around 7:00 p.m., June 16, 1960, and continued for approximately 10 hours. There was a total of 4.88 inches of rainfall which produced an estimated 2.33 inches of runoff.

Using data from field surveys, stage-discharge relationships at 19 valley cross-sections were calculated using Manning's Formula. The determination of "n" values and the storage indication method of flood-routing were used as outlined in Sections 4 and 5 of the National Engineering Handbook. In developing the maximum flood plain inundated, base hydrographs were flood-routed through four hydraulic reaches and flood-routed peaks were compared with known flood marks. Stage-area inundation tables were developed for six evaluation reaches by one-foot increments based on flood-routed hydrographs. The tables ranged from zero flooding to maximum flood plain inundated in the evaluation series. Peak rates of discharge at intermediate cross-sections were obtained from a logarithmic plotting of routed peaks versus drainage area.

Geologic and Sedimentation

All available geologic maps and reports were reviewed for the purpose of noting geologic relationships. The composition of sedimentary layers, their lateral variations, and any other geologic condition which may affect the structural works were considered.

Preliminary investigations at the proposed floodwater retarding structure sites were made with a refraction seismograph, hand auger, and inspection of outcrops and road cuts in the area.

These seismic investigations have indicated areas of questionable rock in the foundation of Structures 3 and 6. The bedrock in Structure No. 1 appears to be sound but a deep, alluvial fill over bedrock is present. From surface indications in the watershed and surrounding area, caverns and solution channels in the limestone bedrock do not appear to be prevalent. Extensive caverns in the foundation are not expected; however, cavernous conditions beneath solid rock cannot be located by use of the refraction seismograph and if any are present, they will be delineated in the detailed site investigation.

Form SCS-375, Preliminary Geologic Investigation of Dam Sites, was compiled for each of the proposed structures. On these forms, and in a narrative geologic report of South Harpeth River Watershed, the geologic conditions peculiar to the area were discussed and geologic conditions that should be given special consideration during detailed site investigations were outlined.

The calculations of gross erosion were made by use of Musgrave's Equation, land use and cover, percent slope, length of slope, and maximum two-year, 30-minute rainfall are factors used in these calculations to determine gross erosion under present conditions, and future conditions with the project installed.

Detailed land use measurements were made of the area above each proposed floodwater retarding structure. This data was used in the procedure as outlined in Technical Release No. 12, Soil Conservation Service, Engineering Division, September 1959, to determine the required volume of sediment pools.

The area of the flood plain lands affected by scour damage were determined by mapping of the flood plain. Data gathered were processed and expanded for the reaches involved and summaries were prepared showing location and extent of these damages. These form the basis for calculations by the Party Economist.

Land Use and Treatment

Soil surveys of the South Harpeth River Watershed were made from 1944 to the present by Soil Scientists of the Soil Conservation Service. This mapping showed soil type, slope, and degree of erosion. Soil surveys of Williamson County have been completed by Soil Scientists of the Soil Conservation Service, in cooperation with the Tennessee Agricultural Experiment Station, and a report is being prepared for publication.

Present open land use of the uplands was determined by use of aerial photographs and by consultation with the local Work Unit Conservationists. Present land use of the flood plain was determined by field mapping on aerial photographs.

The amount of land treatment now on the ground was determined from farm plans, plus field checks. The land treatment measures to be installed during the five-year period were determined from the total needs of the watershed.

Forestry

A systematic field survey by the U. S. Forest Service showed ground cover, forest and soil hydrologic conditions, and treatment needs. This survey, supporting data, and information from other agencies and forestry officials determined the amount of remedial measures. The measures recommended contribute directly to flood reduction and soil stabilization. The installation period limits the amount of work in the recommended program.

Fish and Wildlife

A fish population analysis was made of South Harpeth River in 1953 by the Tennessee Game and Fish Commission. Estimates of visitor-days were based on studies and observations on this and other similar smallmouth and rock bass streams in Middle Tennessee. This study indicates that the fishing pressure on the 13.8 stream miles in this watershed is approximately 3,420 visitor-days per year for smallmouth and rock bass.

A study and analysis was made by biologists of the Tennessee Game and Fish Commission, U. S. Fish and Wildlife Service and Soil Conservation Service, of the fish and wildlife resources. This study included physical characteristics of the stream and watershed, fish and wildlife species, population, hunting and fishing pressure, and success. A formal report by the U. S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, in cooperation with the Tennessee Game and Fish Commission, will be made of their studies and investigations of this watershed.

Economic

The methods used in making economic investigations and analyses followed those approved by the Soil Conservation Service in benefit-cost evaluations on land and water resource projects. The methods followed are in accordance with instructions in the Economic Guide for Watershed Protection and Flood Prevention, and Economics in Watershed Planning for the Southeast. Basic data were obtained from local farmers, agricultural workers, State and County Highway officials, experiment stations, and agricultural publications.

Basic information was obtained by interviews with 32 landowners and operators having about 50 percent of the benefited land and consisted of the following: present land use and yields; normal flood-free land use and yields; anticipated land use and yields with various degrees of flood protection; information concerning the normal sequence of the various farming operations; estimates of the percent damage to the various crops and pasture by depths of inundation by months or specific flood events; and damage to rural property and minor fixed improvements by depths of inundation or by specific storm events.

Long-term projected prices were used as a basis for benefit computations, cost of production and cost of operation and maintenance. These projected prices were developed from data furnished by the Agricultural Research Service and Agricultural Marketing Service, dated September, 1957. A 1963 price base was used as the basis for installation costs. The costs of land, easements and rights-of-way were developed in meetings with the

Watershed District sponsors. The unit costs of roads and bridges were developed in meetings with State and County Highway officials.

Damageable values were calculated from appropriate summaries and from cost and price information. They were estimated on the basis of present land use and cropping practices and normal flood-free yields. The percent damage factors applied to this base gave damages by depth of inundation by seasons. Damageable values, stage-area, stage-damage relationships, flood series and information concerning erosion damage were used in determining average annual damage without and with the project.

Restoration to former productive use and more intensive land use benefits were estimated on the basis of the difference in net returns to crop and pasture with and without the project. These estimates were based on the information furnished by landowners and operators as to their intentions in regard to use of the affected lands with the project installed. However, in order to keep scheduled information within the land use capabilities of the soils, consideration was given to their potential productivity. A summary of the estimated restoration to former productive use and more intensive land use benefits is shown in the table on page 35.

The value of local secondary benefits stemming from or induced by the project were evaluated and used in project justification. Secondary benefits from a national viewpoint were not considered pertinent in the evaluation or justification of this proposed work plan. The total estimated local secondary benefits and the values used in the evaluation are shown in the following table:

ESTIMATE OF LOCAL SECONDARY BENEFITS

Items (1)	Total Amounts (Dollars) (2)	Percent of Total (3)	Local Secondary Benefits (4)
Direct Primary Benefits	50,521	10	5,052
Added Crop and Pasture Production Costs	20,271	10	2,027
GRAND TOTAL	70,792	10	7,079

Benefits claimed from recreational use by organized groups or the general public for fishing, hunting, boating, swimming, camping, picnicking, hiking, and similar forms of water-related recreation were evaluated as an incidental effect of the proposed works of improvement and used in the economic justification of this work plan. Benefits are based on the number of visitor-days of use per year at a value of $0.50 per visitor-day where little, if any, basic facilities are provided for recreational purposes.

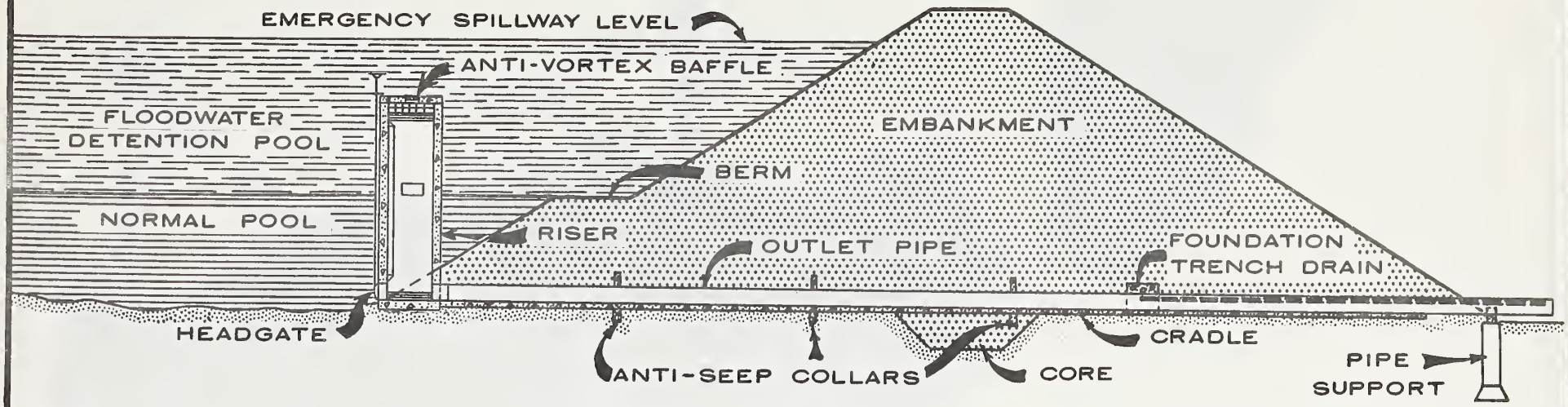
SUMMARY OF BENEFITS FROM RESTORATION TO FORMER PRODUCTIVE USE
AND MORE INTENSIVE USE OF LAND
South Harpeth River Watershed, Tennessee
(Dollars) 1/

Land Use	Present Conditions			Project Conditions		
	Acres	Average Flood-Free Yield	Net Returns	Acres	Average Yield	Net Returns
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Corn	90	60 bu.	3,398	432	73 bu.	24,001
Silage	-	-	-	116	16 tons	9,884
Hay	99	1.8 tons	1,732	153	2 tons	3,450
Pasture	808	4.8 AUM's	8,686	529	6 AUM's	9,222
Barley	(28)	25 bu.	336	(82)	30 bu.	1,604
Idle	233			0		
Total	1,230		14,152	1,230		48,161
	Difference in Net Returns with and without project					34,009
	Discounted difference in Net Returns					30,642
	Less added flood damage to higher damageable values					873
	Average annual benefits					29,769 2/

1/ Price base - long-term projected prices.
2/ Benefits from restoration to former productivity are $3,485, and more intensive use of land, $26,284.

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

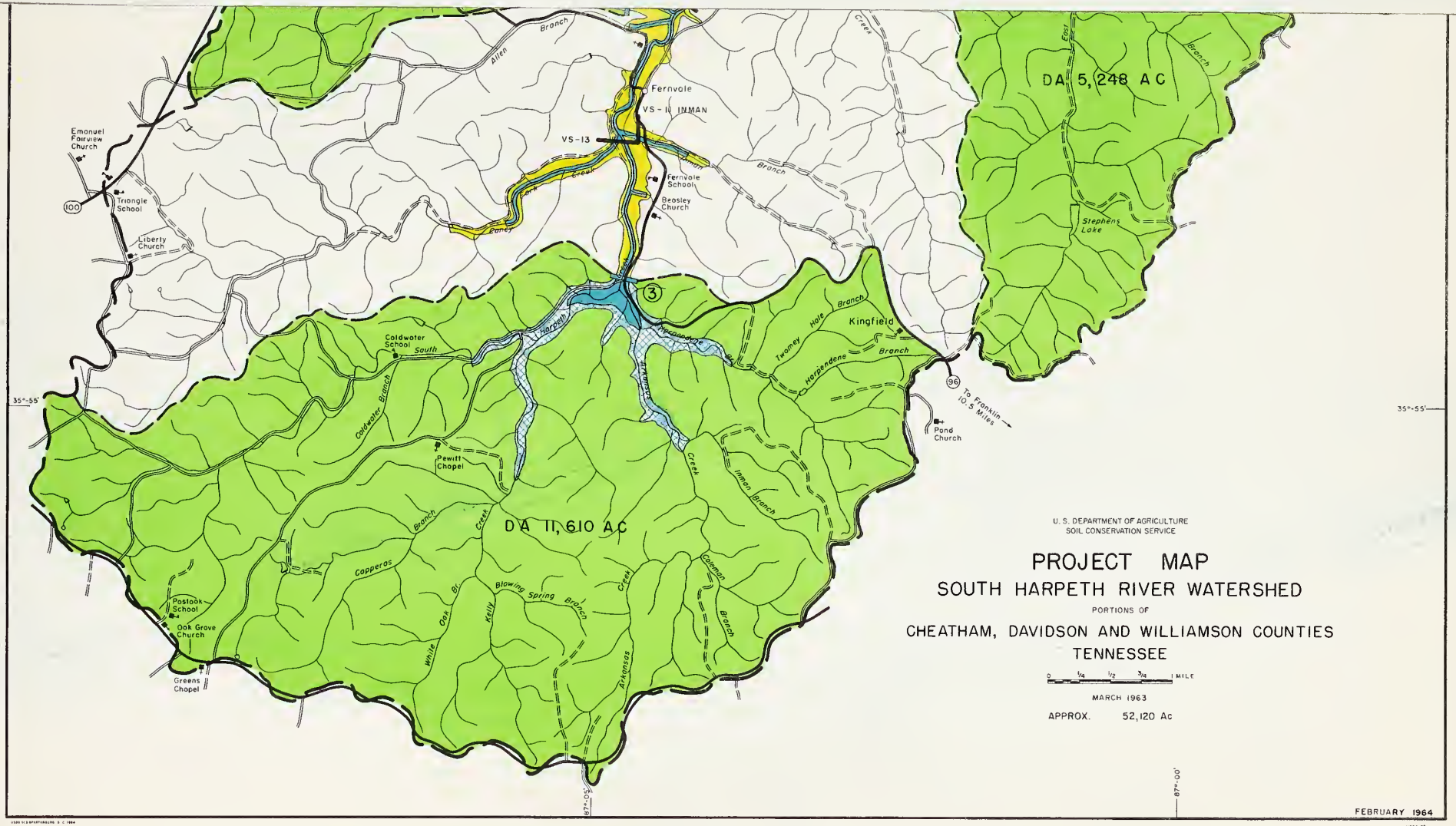


SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

(TWO STAGE DROP INLET)

USDA SCS-SPARTANBURG, S. C. 1962

MR62-49



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PROJECT MAP

SOUTH HARPETH RIVER WATERSHED

PORTIONS OF

CHEATHAM, DAVIDSON AND WILLIAMSON COUNTIES

TENNESSEE

0 1/4 1/2 3/4 1 MILE

MARCH 1963

APPROX. 52,120 Ac

FEBRUARY 1964

LOCATION MAP

CHEATHAM
DAVIDSON
WILLIAMSON

LEGEND

- PAVED ROADS
- IMPROVED ROADS
- UNIMPROVED ROADS
- (96) STATE HIGHWAY NUMBERS
- DRAINAGE
- WATERSHED BOUNDARY
- DRAINAGE AREA CONTROLLED BY STRUCTURE
- AREA BENEFITED

PROJECT MEASURES

- FLOODWATER RETARDING STRUCTURE
- CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
- VS-20 VALLEY SECTION AND NUMBER

HARPETH RIVER

CHEATHAM CO
DAVIDSON CO

CHEATHAM CO
WILLIAMSON CO

DAVIDSON CO
WILLIAMSON CO

POWER LINE

VS-24
VS-25
VS-22
VS-21
VS-20
VS-19
VS-18
VS-17
VS-16
VS-15
VS-14
VS-13

VS-11 POPLAR
VS-11 LINTON
VS-11 LITTLE EAST FORK
VS-12 EAST FORK
VS-11 BEDFORD
VS-11 INMAN

Fairview
Linton
Harpeth School
Fairvale School
Bradley Church
Triangle School
Liberty Church
Emanuel Fourview Church
Caldwater School South
Pond Church
Oak Grove Church
Gibson Chapel
Little East Fork School
Little Zion Church
Fosque School

To Nashville 11 Miles
To Franklin 10.5 Miles

DA 3,232 AC

DA 11,610 AC

DA 5,248 AC

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PROJECT MAP
SOUTH HARPETH RIVER WATERSHED
PORTIONS OF
CHEATHAM, DAVIDSON AND WILLIAMSON COUNTIES
TENNESSEE

MARCH 1963

APPROX 52,120 Ac

FEBRUARY 1964