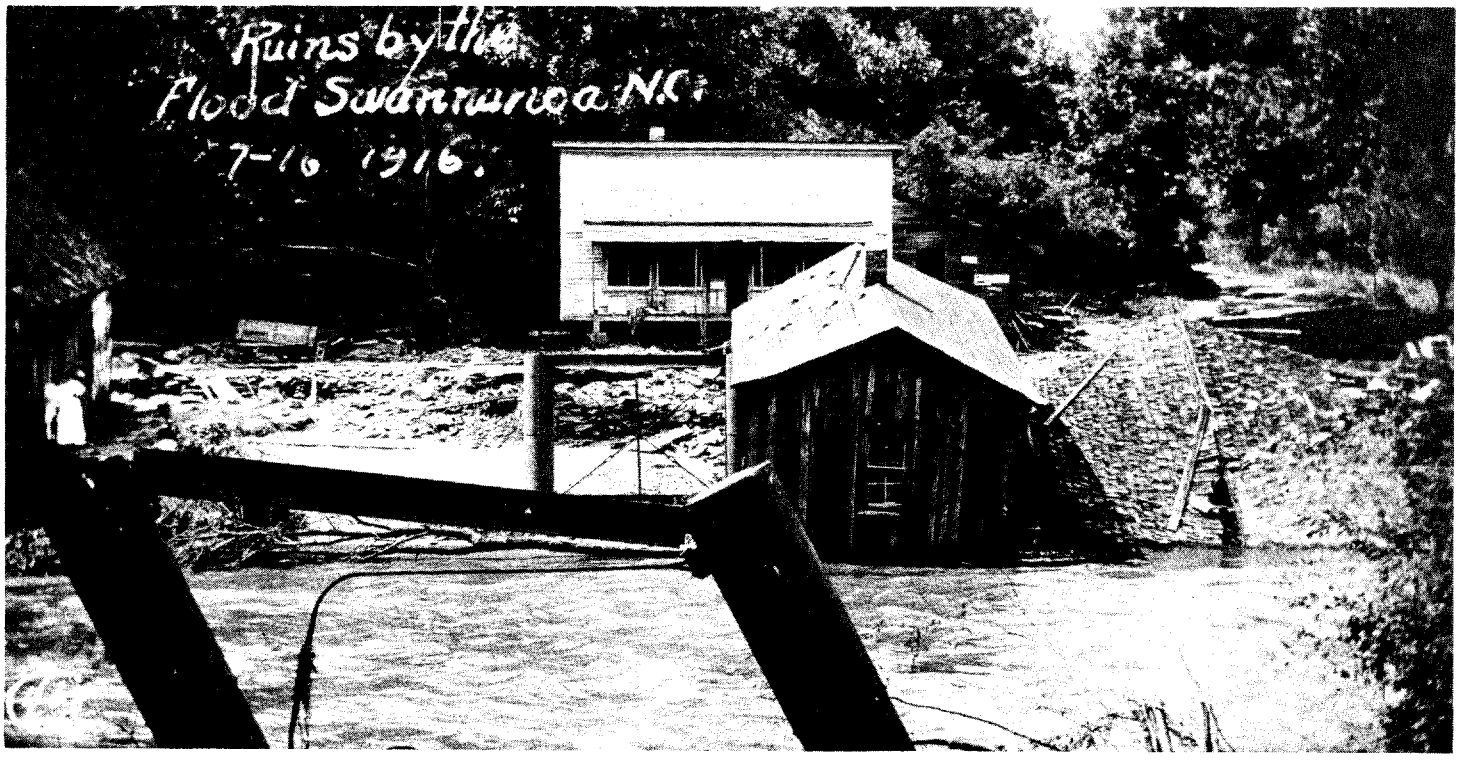
FLOODS ON SWANNANOA RIVER AND BEETREE CREEK IN VICINITY OF SWANNANOA NORTH CAROLINA



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

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FLOODS
ON
SWANNANOA RIVER
AND
BEETREE CREEK
IN VICINITY OF
SWANNANOA, NORTH CAROLINA

REPORT NO. 0-6198

KNOXVILLE, TENNESSEE
MAY 1963

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The bridge piers are at the location now occupied by the Whitson Avenue concrete bridge over the Swannanoa River at Swannanoa, Mile 15.4. The store in center of picture is still in existence. The view is taken from left bank. Another view of the wreckage from right bank is shown in Figure 7.

(Photo by Gragg Studio, Black Mountain, N. C.)

FOREWORD

Tennessee Valley Authority
Division of Water Control Planning

FOREWORD

This report relates to the flood situation along Swannanoa River and Beetree Creek in the vicinity of Swannanoa, North Carolina. It has been prepared at the request of the Buncombe County Board of Commissioners through the North Carolina Department of Water Resources to aid (1) in the solution of local flood problems and (2) in the best utilization of lands subject to overflow. The report is based upon work that TVA has been carrying on since its beginning in connection with its water resource operations throughout the Tennessee Valley. TVA has assembled information on rainfall, runoff, historical and current flood heights, and other technical data bearing upon the occurrence and magnitude of floods in localities throughout the region which provide the basis for preparation of this report.

The report does not include plans for the solution of flood problems. Rather, it is intended to provide the basis for further study and planning on the part of the town of Swannanoa in arriving at solutions to minimize vulnerability to flood damages. This might involve (1) the construction of flood protection works, (2) local planning programs to guide developments by controlling the type of use made of the flood plain through zoning and subdivision regulations, or (3) a combination of the two approaches.

The report covers three significant phases of the Swannanoa flood problem. The first brings together a record of the largest known floods of the past on Swannanoa River and Beetree Creek. The second treats of Regional Floods. These are derived from consideration of the largest floods known to have occurred on streams of similar physical characteristics in the same general geographical region as that of Swannanoa River and Beetree Creek and generally within 50 miles of Swannanoa. The third develops the Maximum Probable Floods for Swannanoa River and Beetree Creek. Floods of this magnitude on most streams are considerably larger than any that have occurred in the past. They are the floods of infrequent occurrence that are considered in planning protective works, the failure of which might be disastrous. Such floods

are used by TVA in the design of the physical features of reservoirs, dams, powerhouses, and local flood protection works.

In problems concerned with the control of developments in the flood plains of Swannanoa River and Beetree Creek, and in reaching decisions on the magnitude of floods to consider for this purpose, appropriate consideration should be given to the possible future occurrence of floods of the magnitude of (1) those that have occurred in the past, (2) the Regional Floods, and (3) the Maximum Probable Floods.

The report contains maps, profiles, and cross sections which indicate the extent of flooding that has been experienced and that might occur in the future in the vicinity of Swannanoa. This report should be useful in planning new developments in the flood plains. From the maps, profiles, and cross sections the depth of probable flooding by either recurrence of the largest known floods or by occurrence of the Regional or Maximum Probable Floods at any location may be ascertained. By having this information, floor levels for buildings may be planned either high enough to avoid flood damage or at lower elevations with recognition of the chance and hazards of flooding that are being taken.

I.

RESUME

OF

FLOOD SITUATION

I.

RESUME OF FLOOD SITUATION

Swannanoa, North Carolina, is located on the Swannanoa River 15 miles above the confluence of Swannanoa River and the French Broad River at Asheville. Beetree Creek, a tributary with a drainage area of 14.1 square miles, flows southward and joins Swannanoa River 2 miles downstream from the community of Swannanoa. This investigation covers Swannanoa River from Mile 7.58 to Mile 17.36[1] and the lower 2 miles of Beetree Creek. The total area of the Swannanoa River watershed above the lower limit of the reach studied is 95.4 square miles.

Residential areas are on both banks of the river at Swannanoa. Business developments are mostly on the left bank, the newer developments being along U. S. Highway 70 which follows the stream. A portion of the business and residential development at Swannanoa is on land which has been inundated by floods of the past. A substantially larger area is within reach of the overflow from the greater floods of the future.

Plants of the Beacon Manufacturing Company, blanket manufacturers, and the Draper Corporation, makers of wood products for the textile industry, are at the edge of the Swannanoa River flood plain at Swannanoa. A plant of Amcel Propulsions, Incorporated, manufacturers of solid explosives and propellant charges, is on the Beetree Creek flood plain.

Records of river stages and discharges are available for only a relatively short period for the Swannanoa River at Swannanoa, but records were maintained from 1920 to 1926 and from 1934 to date on the Swannanoa River just above the mouth at Biltmore. Records are available for Beetree Creek at a

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1. Previous reports of the flood situation on Swannanoa River above and below Swannanoa were issued as follows:

> Floods on French Broad and Swannanoa Rivers in Vicinity of Asheville, North Carolina, issued December 1960.
>
> Floods on Swannanoa River and Flat Creek in Vicinity of Black Mountain and Montreat, North Carolina, issued April 1962.

The three reports together cover the Swannanoa River from the mouth to Mile 22.3.

stream gage above Beetree Reservoir since 1926. Floods on Beetree Creek are slightly affected by storage and diversion at Beetree Dam, a City of Asheville water-supply dam completed in 1926. Burnett Dam, another part of the Asheville water-supply system completed in 1954 on North Fork Swannanoa River, affects flows on that stream which joins Swannanoa River 2 miles above Swannanoa.

In compiling a record of early floods on the two streams, it has been necessary to interview residents along the streams who have knowledge of past floods and to conduct research in newspaper files and historical documents. From these investigations and from studies of possible future floods on Swannanoa River and Beetree Creek in the vicinity of Swannanoa, the flood situation, both past and future, has been developed. The following paragraphs summarize the significant findings with regard to the flood situation which are discussed in more detail in succeeding sections of this report.

THE GREATEST FLOOD known to have occurred on the Swannanoa River and Beetree Creek of which there is definite record occurred on July 16, 1916. There was broad overflow along the Swannanoa River through Swannanoa and along Beetree Creek, but there was little development along the streams at that time.

* * *

A GREAT FLOOD occurred on the Swannanoa River in 1791, soon after settlement of the region began. The available evidence indicates that this flood exceeded the flood of 1916 by 5 feet or more. It is probable that the flood exceeded the 1916 flood by a sizable amount on Beetree Creek also.

* * *

OTHER LARGE FLOODS on the Swannanoa River occurred on August 16, 1928, August 13, 1940, and June 16, 1949. The flood of August 13, 1940, was the highest of these, reaching within 2 feet of the flood of July 1916 in the Swannanoa vicinity. The August 13, 1940, flood was also important on Beetree Creek.

* * *

RESERVOIRS in the Swannanoa River basin have an effect upon the height of floods on Swannanoa River and Beetree Creek in the Swannanoa vicinity. Beetree Reservoir on Beetree Creek and Burnett Reservoir on North Fork Swannanoa River are water-supply projects. They are not designed or operated for flood control and any flood control storage that occurs is incidental to the project operation.

* * *

REGIONAL FLOODS on Swannanoa River and Beetree Creek in the vicinity of Swannanoa are based upon floods experienced on streams within 50 miles of the community, a number of which are larger than any known floods on the two streams. This indicates that greater floods than those experienced so far may reasonably be expected in the future. Based upon the magnitude of floods that have occurred on neighboring streams, a Regional Flood may occur on Swannanoa River that would be about 8 feet higher than the July 1916 flood crest. A Regional Flood on Beetree Creek would reach stages averaging 3.5 feet higher than the July 1916 flood crest.

* * *

MAXIMUM PROBABLE FLOOD determinations indicate that floods could occur on Swannanoa River about 12 feet higher than the 1916 flood crest. A Maximum Probable Flood on Beetree Creek would be about 5 feet higher than the 1916 flood.

* * *

FLOOD DAMAGES that would result from a recurrence of a flood as large as that of July 1916 on Swannanoa River and Beetree Creek would be considerably greater than at the time of the actual flood because of the development now on the flood plains and the higher stages caused by the obstructions on the flood plains of the two streams. The Regional and Maximum Probable Floods, with their greater depths and velocities, would cause extensive damages.

* * *

MOST FREQUENT FLOOD OCCURRENCES on Swannanoa River and Beetree Creek in the vicinity of Swannanoa have been in the spring and summer, especially in the month of August. Most of the higher floods have been summer floods resulting from very heavy hurricane rainfall or intense thunderstorms. However, floods have occurred in the fall and winter months, and large floods may occur at any time.

* * *

VELOCITIES OF WATER during the July 1916 flood ranged up to 10 feet per second in the channel of Swannanoa River at Swannanoa and up to 5 feet per second on the flood plain. Along Beetree Creek, velocities were up to 14 feet per second in the channel and 6 feet per second on the flood plain. During a Maximum Probable Flood, velocities in the channel of Swannanoa River would range up to 25 feet per second, and on lower Beetree Creek up to 19 feet per second. On the flood plain the corresponding figures would be 14 and 9 feet per second.

* * *

DURATION OF FLOODS is short on both Swannanoa River and Beetree Creek. During the August 13, 1940, flood the Swannanoa River at Biltmore was above bankfull stage for 14 hours and had a maximum rate of rise of 2.4 feet per hour. During a Maximum Probable Flood on Swannanoa River, the stream would rise 18 feet in 8 hours with a maximum rate of rise of 5 feet per hour, remaining out of banks for about 12 hours. On Beetree Creek the Maximum Probable Flood would rise 11 feet in 3 hours with a maximum rate of rise of 4 feet in one-half hour, remaining out of banks for 11 hours.

* * *

HAZARDOUS CONDITIONS would occur during very large future floods as a result of the rapidly rising streams, high velocities, and deep flows. Many buildings and bridges would be swept away and the lives of those occupying homes and other structures would be endangered.

* * *

FUTURE FLOOD HEIGHTS that would be reached if floods of the magnitude of the Regional and Maximum Probable occurred in the vicinity of Swannanoa are shown in Table 1. The table compares these flood crests with the crest of the July 1916 flood on Swannanoa River and Beetree Creek.

TABLE 1

RELATIVE FLOOD HEIGHTS

VICINITY OF SWANNANOA

Flood	Location	Mile	Estimated Peak Discharge cfs	Above 1916 Flood feet
	Swannanoa River			
July 16, 1916	Whitson Ave., Swannanoa	15.43	24,000	0
Regional (regulated)			40,000[1]	9.3
Maximum Probable (regulated)			57,000[2]	11.8
	Beetree Creek			
July 16, 1916	Farm School Road	0.18	6,000	0
Regional			19,000	3.7
Maximum Probable			27,000	4.4

(1) Natural flow without Burnett Dam would be 43,000 cfs.

(2) Natural flow without Burnett Dam would be 60,000 cfs.

II.

PAST FLOODS

II.

PAST FLOODS[1]

This section of the report is a history of floods which have occurred on the Swannanoa River and its tributary, Beetree Creek, in the vicinity of Swannanoa, in Buncombe County, North Carolina. The portion of Swannanoa River considered extends from the U. S. Highway 70 bridge at Azalea, Mile 7.58, to the mouth of North Fork Swannanoa River, Mile 17.36, a distance of 9.78 river miles. A previous report entitled "Floods on French Broad and Swannanoa Rivers in Vicinity of Asheville, North Carolina" covers the Swannanoa River from the mouth upstream to the U. S. Highway 70 bridge at Azalea, and another report entitled "Floods on Swannanoa River and Flat Creek in Vicinity of Black Mountain and Montreat, North Carolina" covers the Swannanoa River from the mouth of North Fork Swannanoa River upstream to Mile 22.3 above Black Mountain. The investigation on Beetree Creek covers the lower two miles of that stream. Beetree Creek joins Swannanoa River at Mile 13.52, two miles downstream from Swannanoa.

The Swannanoa River flows generally westward from the mouth of North Fork Swannanoa River through Swannanoa and for some $5\frac{1}{2}$ miles downstream, where it turns southward to Azalea. Beetree Creek follows a gently curving course which changes from westward to southward in the reach considered. Wide bottom lands are found at Swannanoa and along the Swannanoa River for three miles of its course below the town, but the lower four miles of the reach follow a winding course through a narrow, almost gorge-like valley. Bottom lands along Beetree Creek change from a few hundred feet in width at the upper end of the reach to a width of 1800 feet near the mouth.

Beetree Dam, on Beetree Creek four miles above the mouth, and Burnett Dam, on North Fork Swannanoa River five miles above its confluence with Swannanoa River, are part of the Asheville municipal water-supply system. A sizable part of the normal flow of these streams is diverted into pipe lines at these sites. Storage in Burnett Reservoir affects major flood flows, but storage in Beetree Reservoir is not significantly effective.

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1. Prepared by Hydraulic Data Branch.

Business and residential developments are found along both banks of the river at Swannanoa. The newer commercial developments are along three-lane U. S. Highway 70, which follows the left bank through the town. The older business center is also south of the river, but near the Southern Railway and the plant buildings of the Beacon Manufacturing Company. The plant of the Draper Corporation is on the left-bank flood plain just west of Swannanoa.

Records of river stages and discharges are available for only two short periods on the Swannanoa River at Swannanoa, May 1907 to June 1909 and January 1926 to December 1931. Streamflow records were maintained from 1920 to 1926 and have been continuous since 1934 at a gaging station on the Swannanoa River at Biltmore, 14 miles downstream from Swannanoa. Records are complete since 1926 for Beetree Creek at a gaging station above Beetree Reservoir, and are available for the period 1926 to 1958 for a stream gage on North Fork Swannanoa River.

Flood history investigations made by TVA engineers in 1941 developed information on Swannanoa River floods prior to the beginning of streamflow records. Local residents have been interviewed and research has been carried on in newspaper files and historical documents. From these sources it has been possible to develop a history of known floods covering the past 172 years on Swannanoa River and the past 60 years or so on Beetree Creek.

This section of the report discusses separately the flood history of the two streams.

1. SWANNANOA RIVER VALLEY

Settlement

Buncombe County was formed in 1792 from a part of Burke and Rutherford Counties and at first contained all the land in North Carolina lying west of the Blue Ridge. This had been Cherokee Indian land until the North Carolina General Assembly declared it open to the white man in 1783.

The route crossing the Blue Ridge at Swannanoa Gap and following the Swannanoa River was an important artery of travel from the earliest days. Most of the settlers of the Swannanoa and upper French Broad River valleys

came by this route. The first railroad to be built into this part of North Carolina, the Western North Carolina Railroad, crossed the Blue Ridge at Swannanoa Gap, and was completed through Swannanoa to Biltmore, near the mouth of Swannanoa River, on October 3, 1880. The line has since been made part of the Southern Railway system.

The name Swannanoa comes from "Shawano", one of the common early spellings of "Shawnee", the tribe of Indians who were once residents of the valley. The first recorded settler of the Swannanoa River valley was Samuel Davidson, who built a home on the bank of Christian Creek before 1790. Major William Davidson, another early settler, lived near the mouth of Beetree Creek. Piney Grove Presbyterian Church, located between Swannanoa and Beetree Creek, was established in 1794.

Swannanoa dates much of its growth and prosperity from the establishment of the Beacon Manufacturing Company plant at the site in 1925. In 1933 the firm closed down its Rhode Island operations and since that date has had its entire blanket production operation at Swannanoa. Employment at the plant was about 1200 persons at the start of operations and varies now between 1500 and 2500 persons. Homes which were built near the plant by the company have now been sold into private ownership.

The Draper Corporation has occupied its present quarters just west of Swannanoa since 1955. The plant produces items for use by the textile trade, principally shuttle blocks made of dogwood lumber, and employs between 50 and 100 persons.

Warren Wilson College, located on the right bank 3 miles downstream from Swannanoa, was established in 1894 by the Board of National Missions of the Presbyterian Church in the USA. It was originally called Asheville Farm School for Boys and taught secondary school as well as junior college subjects. In 1942 it was consolidated with Dorland-Bell School for Girls, which the church had been operating at Hot Springs, North Carolina, and given the present name. The secondary school program was discontinued in 1957. The school now operates as an accredited coeducational junior college with a student body of about 280, including about 50 who are from foreign countries. The college operates on a self-help plan in which all students work part-time at the college or on the college farm. Additional facilities are being added at the college to

meet the increasing demand for admissions, and a change to a four-year college curriculum is under consideration.

The 1960 census gives the population of Swannanoa, which is not incorporated, as 2185 persons. For Swannanoa Township, which is essentially that area contributing to the reach of Swannanoa River included in this investigation, the 1960 population was 8611 persons.

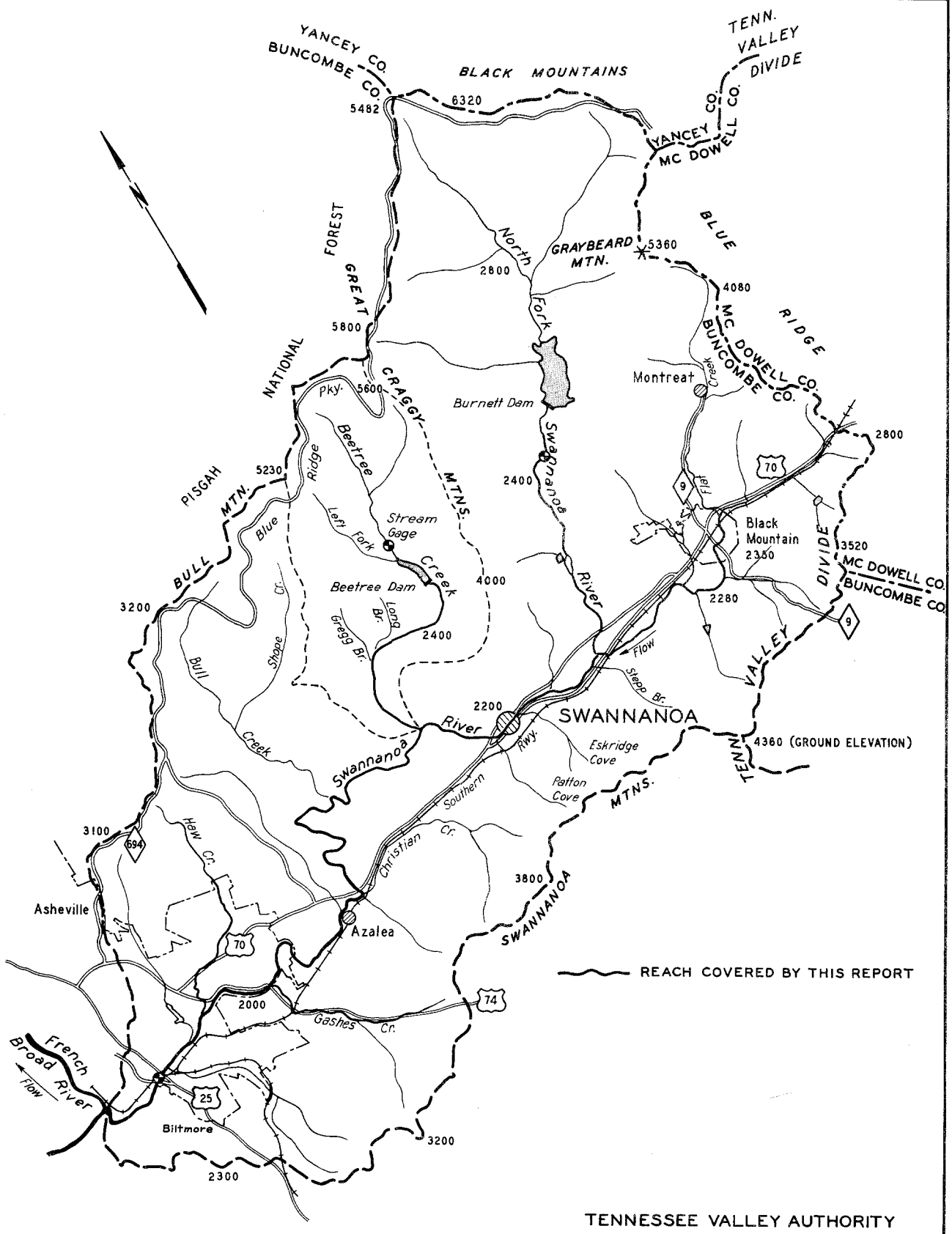
The Stream and Its Valley

As shown on Plate 1, the Swannanoa River drains a rugged mountain area of 133 square miles, lying to the east of Asheville and wholly within Buncombe County, North Carolina. The watershed is roughly rectangular in shape, about 17 miles long and 7 to 10 miles wide. The stream rises at the Blue Ridge, flows generally westward through Black Mountain and Swannanoa, and joins the French Broad River at Asheville, 15 miles downstream from Swannanoa. Elevations along the Blue Ridge at the east of the basin and the Swannanoa Mountains at the south range generally from 3000 to 4000 feet, but in the Craggy Mountains and the Black Mountains along the north and northeast sides of the basin, where the principal tributaries of Swannanoa River rise, elevations range from 5000 to more than 6000 feet. Streams drop steeply from the ridges to the valley floor, where the elevations range from 2350 feet at Black Mountain to 2200 feet at Swannanoa, and 2000 feet at Biltmore and Asheville.

North Fork Swannanoa River, the largest tributary of Swannanoa River, drains 31.8 square miles and joins the stream at Grovestone, Mile 17.36, at the upper end of the reach covered by this study. It heads in the high mountains at the northeast corner of the basin. The area above Burnett Dam, 21.9 square miles, is in heavy forest cover and is owned and managed by the City of Asheville as a protected water-supply source.

Beetree Creek, which is the next largest tributary and lies just west of the North Fork Swannanoa River drainage area, will be discussed later in the report. Bull Creek, which lies next west of Beetree Creek, drains 10.6 square miles and enters Swannanoa River at Mile 11.02, four miles below Swannanoa.

Tributaries which enter on the left bank of Swannanoa River are all small and have relatively little effect upon flood heights on the main stream. Stepp Branch drains Lytle Cove south of Grovestone. A branch which drains



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

SWANNANOA RIVER WATERSHED

SCALE 0 1 2 3 MILES

MAY 1963

HD-1311

Eskridge Cove flows through the property of the Beacon Manufacturing Company in Swannanoa and enters the river just above the Whitson Avenue bridge. Two branches from Patton Cove join the river opposite Swannanoa School.

Pertinent drainage areas of Swannanoa River and its tributaries are given in Table 2.

In the reach covered by this investigation the channel of Swannanoa River falls from elevation 2225 feet to elevation 2043 feet, an average of 18.6 feet per mile. The slope changes through the reach from about 25 feet per mile at and above Swannanoa to 20 feet per mile near the mouth of Beetree Creek and 13 feet per mile near Azalea.

The bottom lands along Swannanoa River for the most part consist of a relatively thin topsoil underlain by heavy gravel and boulders. These gravel deposits have been for many years a prime source of concrete aggregate for roads and the building industry of the Asheville area. The agricultural lands are mostly in pasture.

Flood-plain widths vary from about 300 to nearly 3000 feet within the limits of this study. The narrowest reaches are found between Mile 11.8 and Azalea, where the stream flows between close-set rolling hills. Between Grovestone and Swannanoa the flood plain is 1000 to 2000 feet wide. Through the principal development at Swannanoa the flood plain is 700 to 1000 feet wide, then widens to 2000 feet near Swannanoa School and old U. S. Highway 70 bridge. From old U. S. Highway 70 to Mile 13, below Beetree Creek, the range is from 700 to 1800 feet. At Mile 12.5 the flood plain reaches its widest point, 3000 feet, then narrows to about 1500 feet at Mile 12 and to about 300 feet at Mile 11.2.

Developments in the Flood Plain

Plates 7 and 8 show the flood plain of Swannanoa River. Except for the immediate area at Swannanoa, the use of land in the flood plain is idle or limited generally to agriculture. At the present time no sand and gravel deposits are being worked within the limits of this study. A number of sizable developments are near the edge of the flood plain, but out of reach of foreseeable floods.

The Salisbury line of the Southern Railway follows the edge of the south, or left-bank, flood plain from Grovestone through Swannanoa, then continues westward into the drainage of Christian Creek to rejoin the Swannanoa

TABLE 2

DRAINAGE AREAS IN WATERSHED OF SWANNANOA RIVER

Stream	Location	Mile Above Mouth	Drainage Area sq. mi.
Swannanoa River	Mouth	0	133
	USGS Stream Gage at Biltmore	1.56	130
	Lower limit of study (U. S. Hwy. 70 bridge at Azalea)	7.58	95.4
	Above Beetree Creek	13.52	64.8
	Whitson Avenue, Swannanoa	15.43	60.4
	Upper limit of study (Above N. Fk. Swannanoa River)	17.36	22.2
Bull Creek	Mouth	0	10.6
Beetree Creek	Mouth	0	14.1
North Fork Swannanoa River	Mouth	0	31.8
	Burnett Dam	4.9	21.9

River at Azalea. U. S. Highway 70, a three-lane concrete highway, parallels the railroad and carries heavy east-west traffic between Asheville and the Piedmont and Coastal sections of North Carolina. At Swannanoa the highway swings away from the railroad to parallel closely the left bank of the river through the town. A construction project recently announced will add a fourth traffic lane to U. S. Highway 70 to meet the increasing traffic load. Planning studies are also being made to determine the location for Interstate Highway 40 in the Asheville-Swannanoa-Black Mountain vicinity. It is anticipated that the highway will follow a route south of the railroad in the Swannanoa-to-Grovestone reach and that the projected four-lane U. S. Highway 70 will still be needed for local traffic. These highway changes can be expected to have an effect upon developments in the flood plain of Swannanoa River.

The old location of U. S. Highway 70 passes through Swannanoa on the right-bank flood plain and crosses the river below the town, at Mile 14.80, where it joins the present Highway 70 location on the left bank. A paved secondary

road, Farm School Road, crosses the river and flood plain at Mile 12.21, where it turns upstream to follow on or near the right-bank flood plain to Swannanoa. Riceville Road follows the right bank from Farm School Road to Mile 10. An unpaved road follows the left bank from Azalea upstream to Mile 10.5.

The main plant buildings of the Beacon Manufacturing Company are located along the Southern Railway just upstream from Whitson Avenue in Swannanoa. The floor at the upstream end of the plant is at elevation 2209.2 feet, 16 feet above the height reached by the flood of July 1916, and respectively $8\frac{1}{2}$ and $5\frac{1}{2}$ feet higher than the regulated Regional and Maximum Probable Floods.[1] The floor elevation at the downstream end of the plant is at elevation 2213.2 feet, about 24 feet higher than the July 1916 flood, and respectively 15 and 12 feet higher than the Regional and Maximum Probable Floods.

The plant of the Draper Corporation is also near the railway, opposite Mile 14.9. Its floor elevation is 2193.9 feet, about 15 feet higher than the 1916 flood, 13 feet above the Regional Flood, and 12 feet above the Maximum Probable Flood.

The older established businesses of Swannanoa are located near the Beacon Manufacturing Company plant, along Railroad Avenue, South Avenue, Alexander Place, and Whitson Avenue, and are above the elevation of the highest known flood. A Maximum Probable Flood would just reach a few buildings along Whitson Avenue. The more recent developments have been along U. S. Highway 70, near the left bank of the river downstream from Whitson Avenue. These include seven service stations, a bulk oil storage, a used car lot, a garage, a tire sales shop, a radio and television repair shop, two food stores, a self-service laundry, a barbershop, and a cafe. These business places, as well as the highway, are on ground which has been filled some 6 to 8 feet above the original ground level. The floor levels of these buildings are, in general, about the elevation which was reached by the flood of July 1916. The Regional and Maximum Probable Floods would flood these businesses to depths of 3 and 7 feet, respectively.

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1. Burnett Reservoir on the North Fork Swannanoa River provides some storage for flood flows, and as a result all future floods will be regulated to some extent. In this report, the terms "Regional Flood" and "Maximum Probable Flood", when applied to the Swannanoa River, refer to those floods as regulated by Burnett Reservoir. Hereinafter in the text the term, regulated, has been omitted for the sake of brevity.

A trailer park, a church, and several houses, located along North Avenue, Harrison Avenue, Park Street, Asheville Road, and Welch Road, are within the area which was overflowed in the flood of July 1916. A Maximum Probable Flood would affect approximately 40 houses in this area. At the trailer park the 1916 flood was about 4 feet deep. A Regional Flood would be 5 feet deep and a Maximum Probable Flood would be 6 feet deep at that location.

About twenty houses are located on the right-bank flood plain near Swannanoa School in the area which was overflowed in the 1916 flood.

Regional and Maximum Probable Floods would be respectively about 2 and 4 feet higher than 1916 flood at this location.

At Swannanoa School, the lowest classroom floors are at elevation 2181.4 feet, which is $4\frac{1}{2}$ feet above the 1916 crest height at this point. Other classrooms at the school are at elevations 2191.4 and 2192.7 feet and the lunchroom is at elevation 2188.5 feet. The school is above the elevation of the Maximum Probable Flood.

On the right bank at Swannanoa a garage and two service stations are along old U. S. Highway 70, and six houses are on low ground between the road and the river upstream from the Whitson Avenue bridge. Constrictions in the channel in this area will increase the height of future floods, and the Regional and Maximum Probable Floods would be respectively 9 and 11 feet higher than the 1916 flood. On the left bank upstream from Whitson Avenue in the vicinity of Edwards Avenue, there are 46 houses that would be flooded to depths up to 8 feet by a Regional Flood and 11 feet by a Maximum Probable Flood.

Buildings at Warren Wilson College are all on high ground overlooking the river, but much of their farm land is subject to overflow and scour in time of flood. Farm buildings at the college, and generally throughout the reach studied, are above known flood heights.

In the reach under investigation on the Swannanoa River the Maximum Probable Flood would affect about 130 buildings.

Gravel removal operations have altered conditions in the Swannanoa River flood plain. This is true to a marked degree above Swannanoa, where operations by the B. V. Hedrick Gravel and Sand Company have ranged over the entire flood plain of North Fork Swannanoa River from Burnett Dam to the

mouth and along Swannanoa River from the mouth of North Fork down to Mile 15.8, a short distance above the Whitson Avenue bridge. Gravel has also been excavated from the property of Warren Wilson College, along the right bank from Mile 13.0 to Mile 12.3.

There are other developments which are outside the Swannanoa River flood area but which would be affected when roads in the vicinity are overtopped by floodwater. In the Grovestone section are an electronics component plant, a precision tool manufacturing plant, and two wood processing firms. Along old U. S. Highway 70 west of Grovestone are the Owen Consolidated High School, the Presbyterian Home for Children, and The Juvenile Evaluation Center of the North Carolina Board of Correction and Training, the latter in buildings erected as an Army Medical Center during World War II.

Warren Wilson College and the homes and industries at Swannanoa all get their water from the Asheville water-supply system. These developments are also served by the sewerage system of the Swannanoa Sanitary District, connecting to an outfall sewer which follows the Swannanoa River and now discharges into the French Broad River at Asheville. This system is being incorporated into a Metropolitan Sanitary District, which will provide waste treatment facilities to serve the Asheville area, plus several sanitary districts which together serve a large part of rural Buncombe County.

Bridges across the Stream

Five highway bridges and one private bridge cross Swannanoa River in the reach covered by this investigation. Table 3 lists pertinent elevations for these bridges and shows their relation to the crest of the flood of July 1916. Plate 9 shows the relation of the floor and underclearance at the bridges to the flood profiles for the reach. Figures 1 and 2 are photographs of the bridges.

The U. S. Highway 70 bridge at Azalea, Mile 7.58, built in 1936 and known locally as Gudger Bridge, is a concrete structure of three spans. Approach fills block the narrow flood plain at the bridge site and heading up occurs during large floods. An iron bridge at the same location in 1916 was washed out by the flood that year.

TABLE 3

BRIDGES ACROSS SWANNANOA RIVER

Mile above Mouth	Identification	Water Elev. feet	Floor Elev. feet	Regional Flood Crest Elev. feet	July 1916 Flood Crest Elev. feet	Underclearance Elev. feet	Above 1916 Flood feet	Below 1916 Flood feet
7.58	U. S. Highway 70	2043.2	2070.2	2081.5	2064.0	2066.4	2.4	
8.97	Private	2059.4	2075.3	2096.7	2080.7	2071.5		9.2
12.21	Farm School Road	2110.8	2123.7	2134.4	2126.8	2120.5		6.3
13.92	Secondary road	2145.6	2157.0	2162.0	2157.6	2155.2		2.4
14.80	Old U. S. Highway 70	2161.5	2178.1	2178.3	2175.0	2174.2		0.8
15.43	Whitson Avenue	2170.5	2190.0	2198.1	2188.8	2186.1		2.7

A private bridge at Mile 8.97 provides access to a house on the right bank of Swannanoa River. This is a one-span bridge, consisting of log girders set on timber crib abutments. Steel cables are strung beneath the bridge to give added support to the bridge span. Fill at the abutments restricts the already narrow flood plain. The bridge would be overtopped and probably washed out in any flood which approached the magnitude of the flood of August 13, 1940.

The bridge at Mile 12.21, known as the Farm School Road bridge, is a single-span, steel truss bridge, put at this site after a smaller bridge was washed out in the flood of August 13, 1940. Low approach fills cross the wide left- and right-bank flood plains. Access to the bridge is affected when water overflows the left-bank approach fill at elevation 2122.4 feet.

A light-weight steel truss bridge carries secondary road traffic across the river at Mile 13.92. A bridge at this site was washed out during the June 16, 1949, flood. Access to the bridge is affected at elevation 2150.4 feet, when overflow begins on the road crossing the right-bank flood plain.

The old U. S. Highway 70 bridge, Mile 14.80, just below Swannanoa School, is a three-span concrete bridge built in 1920. Flood flow at the site is restricted by a solid bridge rail, by an approach fill 6 to 8 feet high on the narrow left-bank flood plain, and by the road fill which follows the right bank upstream from the bridge. During the August 13, 1940, flood there was a drop of 3.4 feet through this bridge.

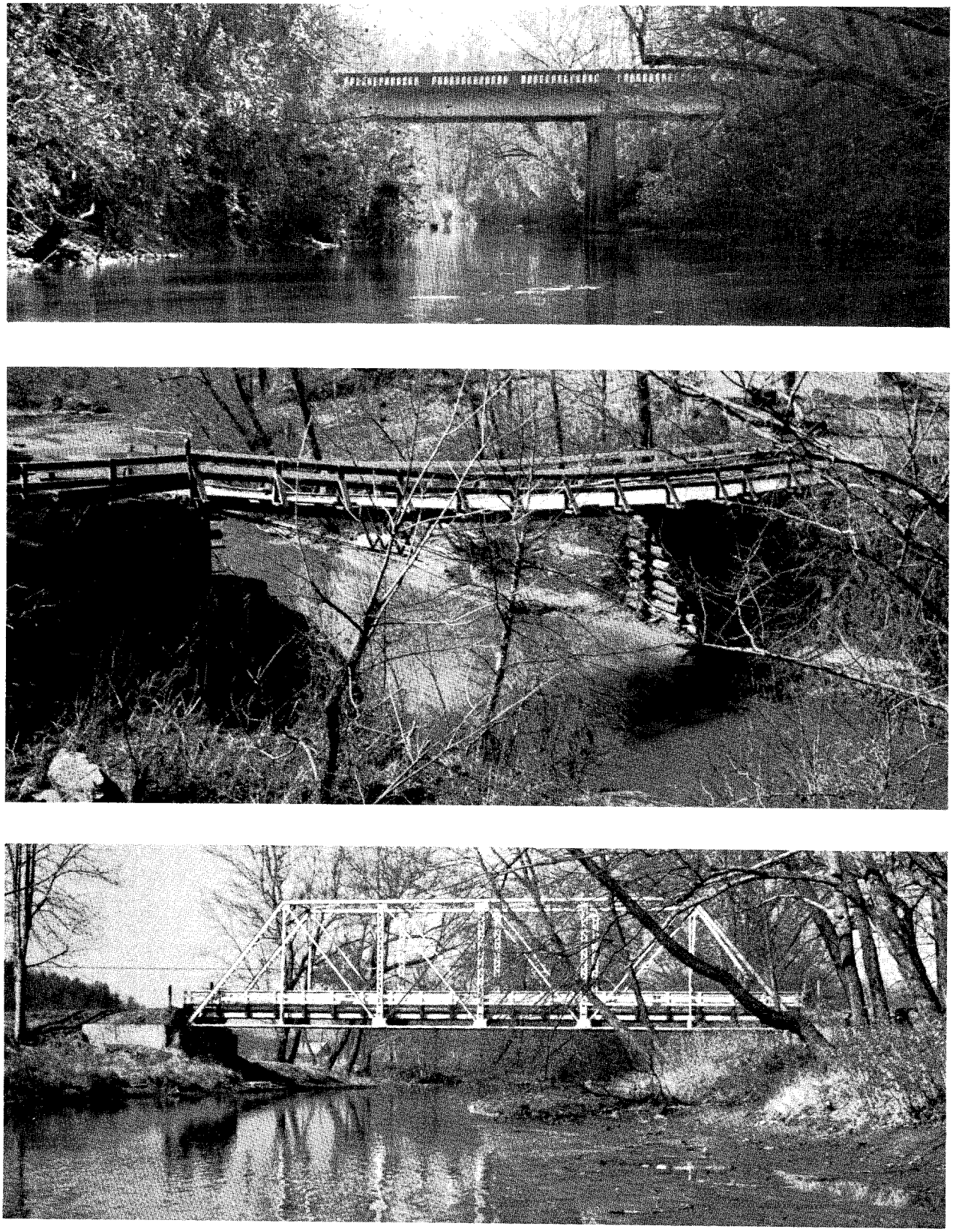


Figure 1. --SWANNANOA RIVER BRIDGES, AZALEA TO ASHEVILLE FARM SCHOOL

Top view shows the U. S. Highway 70 bridge, upstream side, at Mile 7.58. Middle view shows the upstream side of a private bridge at Mile 8.97. The bridge on Farm School Road at Mile 12.21 is shown in bottom picture, looking downstream.

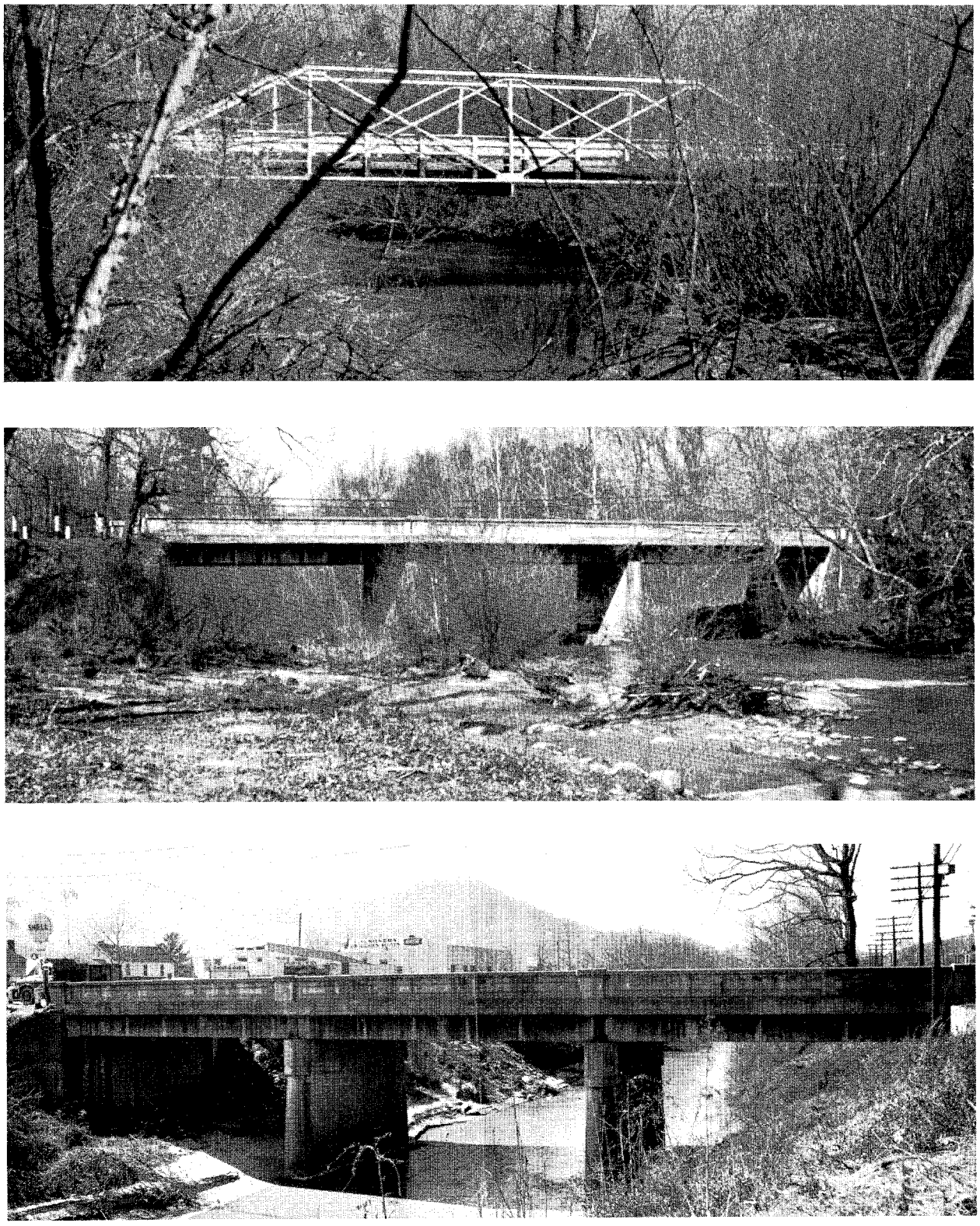


Figure 2. --SWANNANOA RIVER BRIDGES, PINEY GROVE TO SWANNANOA

Top view is upstream side of bridge on a secondary road at Piney Grove, Mile 13.92. Middle view is the old U. S. Highway 70 bridge at Mile 14.80, upstream side. This bridge was built in 1920. Bottom view shows the Whitson Avenue bridge in Swannanoa at Mile 15.43, upstream side. The bridge was built in 1928 and raised about $3\frac{1}{2}$ feet in 1947.

The bridge at Whitson Avenue in Swannanoa, Mile 15.43, is a three-span concrete bridge, built in 1928. The bridge was raised 3.6 feet in 1947 to bring the floor to the level of the new U. S. Highway 70 location on the left-bank flood plain. Because of the restrictive effect of the bridge and the fill which has been placed on the banks in this area, the 1916 and 1940 floods would be higher if they were to recur today. A light steel truss bridge was washed away at this site in the 1916 flood, as shown in the cover photograph.

Obstructions to Flood Flow

The effect of the obstructions due to the bridges and their approach fills has been described in the previous section. The extensive changes to the flood plain through Swannanoa, due to the placing of fill for U. S. Highway 70 and for the developments which have been built along the highway, can be expected to cause future flood heights to be appreciably higher through the town.

On the other hand, the removal of huge quantities of gravel from the flood-plain area upstream from Swannanoa and on the Warren Wilson College property has increased the flow capacity of the channel and overbank areas, so that flood heights will now be somewhat lower through these reaches should floods such as those of 1916 or 1940 recur.

Burnett Dam

Burnett Dam, completed in 1954 on North Fork Swannanoa River 4.9 miles above the mouth, adds some 5-3/4 billion gallons or about 17,650 acre-feet of useful storage to the Asheville water supply. The dam is earth fill, 140 feet high and 1500 feet long. An earth saddle dam is 700 feet long. A concrete spillway and discharge channel are at the left abutment. Three 18-foot by 18-foot tainter gates control the reservoir level and spillway discharge. The spillway crest is at elevation 2583.5 feet, the top of gates at 2601.5 feet, and the top of dam at 2612.5 feet. Normal full-pool elevation is 2600.0 feet. A concrete intake tower connects to a valve house and chlorinator building below the dam. A 36-inch pipeline, completed in 1962, provides an added 25 million gallons per day in capacity by gravity feed to the Asheville distribution system. Two other pipelines, each 16-inch, lead from the original water-supply intakes above the reservoir.

This reservoir, and Beetree Reservoir on Beetree Creek, are normally full so that the only storage available for flood flows is in the uncontrolled surcharge above the normal operating level. Beetree Reservoir is so small that its effect upon flood flows is negligible; however, Burnett Reservoir does have an effect upon flood flows. The design of the spillway is such that outflows from the reservoir are limited. This causes storage of inflows in excess of the spillway capacity, thus reducing the peak flows on the North Fork Swannanoa River and thereby reducing to a smaller extent flood flows on the Swannanoa River downstream from the mouth of North Fork Swannanoa River. A recurrence of the July 1916 flood would be lowered less than one foot at Swannanoa. On rare occasions a flood might occur following a prolonged dry period when the reservoir was drawn down below full-pool level. Should this occur, the available storage would tend to reduce peak flows downstream to a greater extent.

Ok to here 6-20-65

FLOOD SITUATION

Flood Records

Records of river stage and discharge are relatively sparse for the Swannanoa River in the immediate vicinity of Swannanoa. A staff gage was installed by the U. S. Geological Survey at a site near the present Whitson Avenue bridge on May 28, 1907. Records were maintained at this gage until June 30, 1909. From January 6, 1926, to December 31, 1931, observations were made at a staff gage located 1000 feet upstream from the bridge.

More complete records of flow are available for a gaging station on the Swannanoa River at Biltmore, 14 miles downstream from Swannanoa. A staff gage was observed at the Biltmore Avenue bridge, Mile 1.58, from December 1, 1920, to September 30, 1926. Since May 8, 1934, continuous records of streamflow are available from a recording stream gage 100 feet downstream from the bridge. The Geological Survey also made observations of streamflow at Azalea, 8 miles downstream from Swannanoa, from August 1946 through September 1947. The longer record at Biltmore is useful as an index to the frequency of occurrence of flooding on the river.

Records of streamflow are available for North Fork Swannanoa River from January 1926 to May 1958 from a recording stream gage maintained at a site 4.1 miles above the mouth.

To supplement the record obtained at these gaging stations, local residents were interviewed for dates and heights of floods. Files of the Asheville newspapers were searched, as were historical records and documents. Reports of field investigations made by TVA engineers have yielded valuable data. High water marks were located in the field to develop in detail the flood-crest profiles of July 1916, and the mid- and late August 1940 floods.

Flood Stages and Discharges

Table 4 lists peak stages and discharges for known floods exceeding bankfull stage of 12 feet at the Geological Survey gage on the Swannanoa River at Biltmore. Table 5 lists the highest eight floods in the order of magnitude. For floods in the period 1920-1926 and from 1934 to date the flood crest stages are those observed at the gage. Stages for floods occurring prior to these records are from high water marks or are estimated from newspaper and historical accounts or from interviews with local residents.

Flood Occurrences

Plate 2 shows crest stages and months of occurrence of known floods which have exceeded the bankfull stage of 12 feet on the Swannanoa River at Biltmore. Table 6 shows the monthly distribution of 18 of the 19 known floods occurring in the period since 1791. No month of occurrence is available for the flood in 1810.

The most frequent occurrence of large floods has been in the spring and summer months. August is the month with the largest number of floods. A longer period of record would probably show floods occurring in every month of the year.

Duration and Rate of Rise

Plate 3 shows the stage hydrograph at the Biltmore gaging station for the flood of mid-August 1940. Also shown is the crest stage of the July 1916 flood and the estimated crest stage of the April 1791 flood. During the mid-August 1940 flood the Swannanoa River rose from a stage of 4.0 feet on August 12 to the crest of 19.00 feet on August 13 in 24 hours, at an average rate of rise of 0.6 foot per hour. The maximum rate of rise in an hour was 2.4 feet between 5 and

TABLE 4

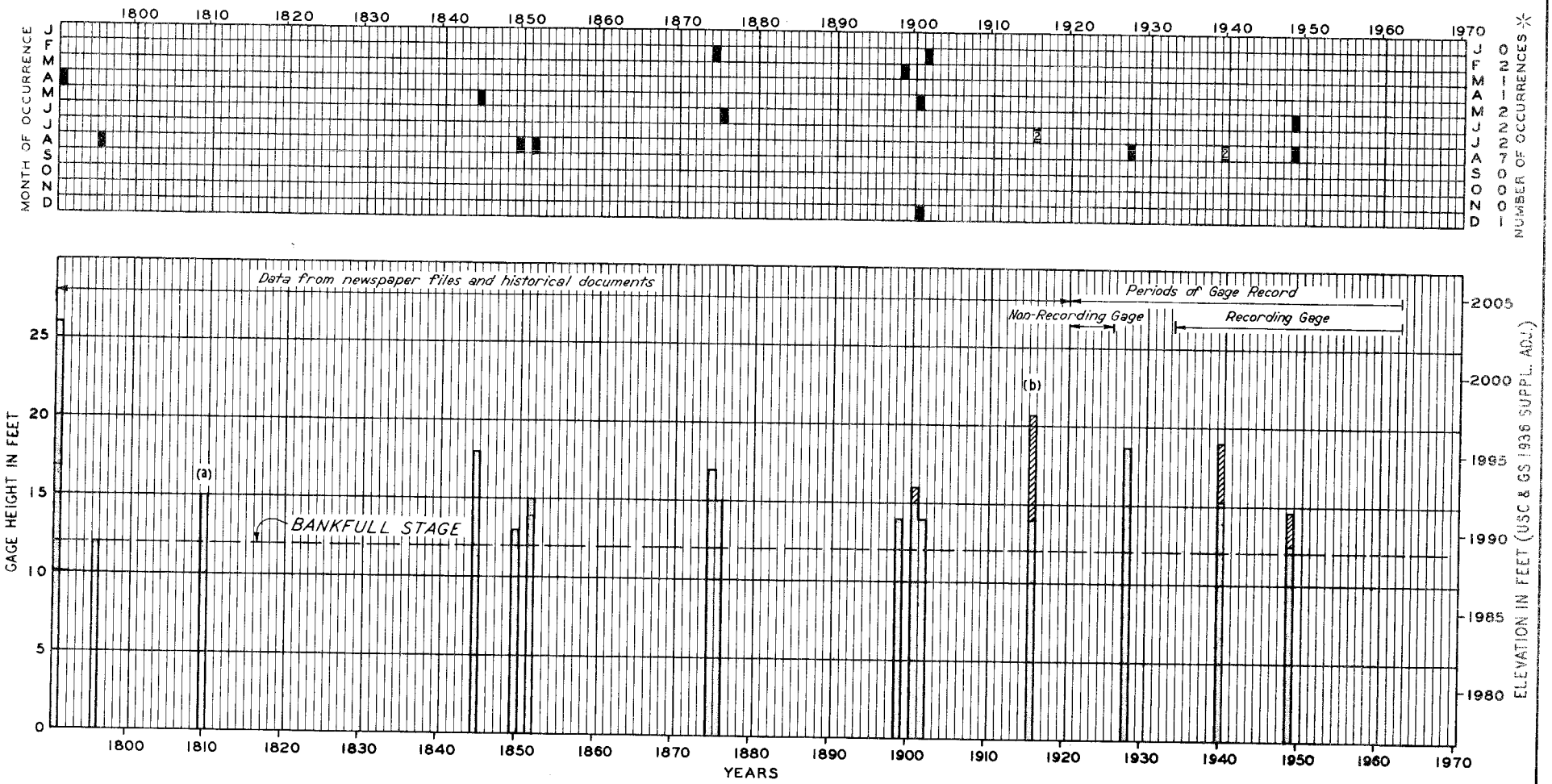
SWANNANOA RIVER AT BILTMORE, NORTH CAROLINA

FLOOD CREST ELEVATIONS AND DISCHARGES ABOVE BANKFULL STAGE

1791-1963

This table includes all known floods above bankfull stage of 12 feet at the U. S. Geological Survey gaging station, River Mile 1.56, just downstream from the Biltmore Avenue bridge. Drainage area is 130 square miles.

Date of Crest	Gage Heights		Peak Discharge	
	Stage feet	Elevation feet	Amount cfs	Per Sq. Mile cfs
April 1791	26	2003	40,000	308
August 1796	15	1992	10,600	82
1810	15	1992	10,600	82
May 1845	18	1995	16,400	126
August 1850	13	1990	7,300	56
August 1852	15	1992	10,600	82
February 1875	17	1994	14,400	111
June 17, 1876	15	1992	10,600	82
March 19, 1899	14	1991	8,800	68
May 21, 1901	16	1993	12,400	96
December 30, 1901	15	1992	10,600	82
February 28, 1902	14	1991	8,800	68
July 10, 1916	14	1991	8,800	68
July 16, 1916	20.7	1997.3	23,000	177
August 16, 1928	18.7	1995.3	17,800	137
August 13, 1940	19.00	1995.58	18,400	142
August 30, 1940	15.34	1991.88	11,200	86
June 16, 1949	14.65	1991.23	9,930	76
August 28, 1949	12.56	1989.14	6,760	52



(a) Month unknown.

(b) Stage based on high water marks.
All stages referred to
U.S. Geological Survey gage
at River Mile 1.56

✳ Number of occurrences during 172 years,
1791 to April 1963, excluding 1810 Flood.

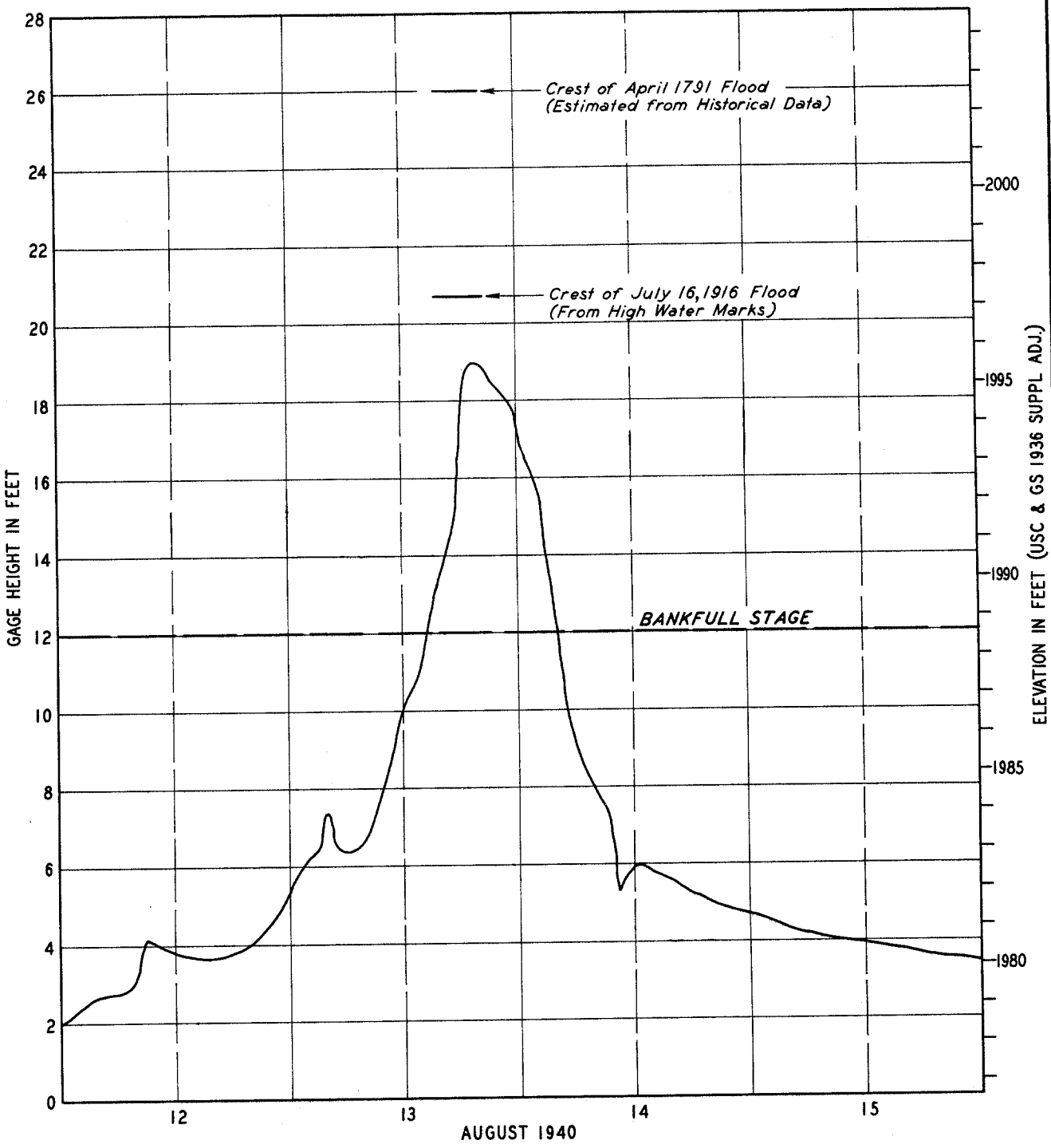
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

FLOODS ABOVE BANKFULL STAGE SWANNANOA RIVER AT BILTMORE, NORTH CAROLINA

MAY 1963

PLATE 2

PLATE 3



Gage at Mile 1.56

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

STAGE HYDROGRAPHS

FLOOD OF MID-AUGUST 1940
SWANNANOA RIVER
AT BILTMORE, NORTH CAROLINA
MAY 1963

TABLE 5

HIGHEST KNOWN FLOODS IN ORDER OF MAGNITUDE

SWANNANOA RIVER AT BILTMORE

Order No.	Date of Crest	Gage Height	
		Stage feet	Elevation feet
1	April 1791	26	2003
2	July 16, 1916	20.7	1997.3
3	August 13, 1940	19	1995.6
4	August 16, 1928	18.7	1995.3
5	May 1845	18	1995
6	February 1875	17	1994
7	May 21, 1901	16	1993
8*	August 30, 1940	15.34	1991.9

*Five other floods in the period prior to gage records are estimated to have been of about the magnitude of that of August 30, 1940.

TABLE 6

MONTHLY FLOOD DISTRIBUTION

SWANNANOA RIVER AT BILTMORE, NORTH CAROLINA

1791-1963

Month	Number of Occurrences	Month	Number of Occurrences
January	0	July	2
February	2	August	7
March	1	September	0
April	1	October	0
May	2	November	0
June	2	December	1
			18

6 p.m. on August 13, just 1½ hours before the crest occurring at 7:30 p.m. The river was above bankfull stage at Biltmore for 14 hours.

Velocities

Velocities in the channel of Swannanoa River at Swannanoa during large floods such as those of 1916 and mid-August 1940 ranged up to 10 feet per second. In the flood plain, velocities ranged up to 5 feet per second. During large floods, velocities in both channel and overbank areas would be even greater. The results of high velocities of flow are shown in Figure 3, photographs taken after the 1916 flood.

Flooded Areas, Flood Profiles, and Cross Sections

Plates 7 and 8 show the approximate areas along the Swannanoa River in the vicinity of Swannanoa that were inundated by the flood of July 1916 and that would be inundated by the Maximum Probable Flood. The actual limits of these overflow areas on the ground may vary somewhat from those shown on the map because the contour interval of the map does not permit precise plotting of the flooded area boundaries. The contour interval on Plate 7 is 40 feet, with 20-foot intervals at some places in the flood plain.

Plate 9 shows high water profiles on the Swannanoa River for the floods of July 1916 and mid-August 1940. Also shown are the profiles for the Regional and Maximum Probable Floods which are discussed in Sections III and IV, respectively.

Plate 11 shows typical cross sections of the Swannanoa River in the reach investigated. The locations of the sections are shown on the map, Plate 7, and the profile, Plate 9. Each cross section shows the elevation and extent of overflow of the July 1916 flood and the Regional and Maximum Probable Floods.

FLOOD DESCRIPTIONS

Following are descriptions of known large floods that have occurred in the general vicinity of Swannanoa. These are based upon newspaper accounts, historical records, and investigations by TVA engineers.

Figure 3. --EFFECTS OF FLOOD VELOCITIES, JULY 1916

These photographs bear witness to the force of the Swannanoa River floodwaters. Upper view shows trees bent over by the flow, and the lower view is upstream toward a farm field which was lost to the flood. The original channel is at the extreme right of picture.

(Photos by Gragg Studio, Black Mountain, N. C.)

Information is meager on floods prior to 1916 on Beetree Creek and the upper Swannanoa River. A search of early Asheville newspapers gives hints of floods in the headwater region but no clue from which flood heights can be estimated. On the other hand, there are numerous references to floods and flood damage on the lower river in the immediate vicinity of Asheville. Experience in more recent floods indicates that damaging or near-damaging floods probably occurred on the headwater streams whenever there were overflows on the lower Swannanoa River but that the effects close to Asheville crowded out the news from the headwater areas.

April 1791

Flood history research shows that many large floods occurred in the early years of settlement in the vicinity of Asheville. The earliest known of these floods occurred in April 1791. Since the country was only sparsely settled at the time, information on the flood is naturally scarce but is still sufficient to establish quite definitely that it was the greatest flood on Swannanoa River of which there is any knowledge.

In an article printed in the Asheville "Citizen" on July 27, 1916, information on the flood is credited to Mr. W. J. Alexander, a member of one of the first families to settle in the Swannanoa River valley. Mr. Alexander, who was born in 1830, was told by his grandfather of a flood in April 1791 on Swannanoa River which apparently was fully as large as the great flood of 1916, if not larger. The grandfather lived at that time on Beetree Creek, near Swannanoa. Mr. W. O. Riddick, at Azalea, 8 miles downstream from Swannanoa, stated that at the time of the 1916 flood a number of the older residents of the valley talked to him about another flood 125 years before, which they described as being at least as high as the 1916 flood and several thought it was four to six feet higher.

The weight of evidence indicates that there was such a great flood in 1791 and that it probably exceeded the 1916 flood on Swannanoa River and most of its tributaries by a substantial amount.

1796 and 1810

Historical reference is found to a flood on both the French Broad and Swannanoa Rivers in August 1796. Another flood in 1810 was said to have been particularly high on the Swannanoa River.

May 1845

The Asheville "Citizen" article of July 27, 1916, previously mentioned, quotes Mr. W. J. Alexander as saying that the first notable flood in his lifetime occurred in May 1845, when he was 15 years old. Mr. Joe Cheeseborough, who was born in 1873 and who lived nearly all his life on Swannanoa River just above Biltmore, recalled that an old Negro slave who was born in 1798 told him about this flood as "spreading from hill to hill" on the Swannanoa River. Mr. Cheeseborough believed that the 1845 flood was about like the 1916 flood at his home.

1850-1915

Floods occurred in August 1850 and August 1852. The Asheville "News" of September 2, 1852, stated that the French Broad was higher than two years before and "Even the sweet Swannanoa got high and played some wild pranks, among other things, carrying off the bridge at Mr. Patton's, two miles from here."

Intense rainfall caused a flood late in February 1875. The "Citizen" for March 4, 1875, reported that "the Swannanoa and French Broad Rivers rose so rapidly that persons residing along their banks had to abandon their houses and effects and flee for safety. In many domiciles the water was 3 or 4 feet deep."

A flood on June 17, 1876, was one of the great floods on the upper French Broad River, but the flood was not so severe on the Swannanoa River. The Signal Service weather observer, in his report on the flood at Asheville, stated: "The Swannanoa did not reach the height attained in the spring of 1875." On the lower reach of the Swannanoa River the crest height for this flood has been established as about equal to that of the August 30, 1940, flood.

Three floods occurred in a period of ten months shortly after the turn of the century. On May 21, 1901, homes and stores were flooded in Biltmore, and Asheville's water supply, obtained then from a pumping plant on Swannanoa River, was disrupted for several days when the plant was flooded and water lines were washed out. On December 30, 1901, the Swannanoa River was very nearly as high as in the May flood and water was again in homes and stores in the Biltmore area. There was another flood on February 28, 1902, but this one was not so high as either the May or December floods on Swannanoa River.

The January 26, 1906, issue, referring to a storm a few days earlier, states that "The damage near Asheville is confined chiefly to the destruction of the dam at Montreat whence considerable property was swept off and to the vicinity of Bee Tree where the roads are likewise practically too serious for travel." The paper on the previous day stated: "Great damage is reported from the Bee Tree section as the result of Monday's rain.

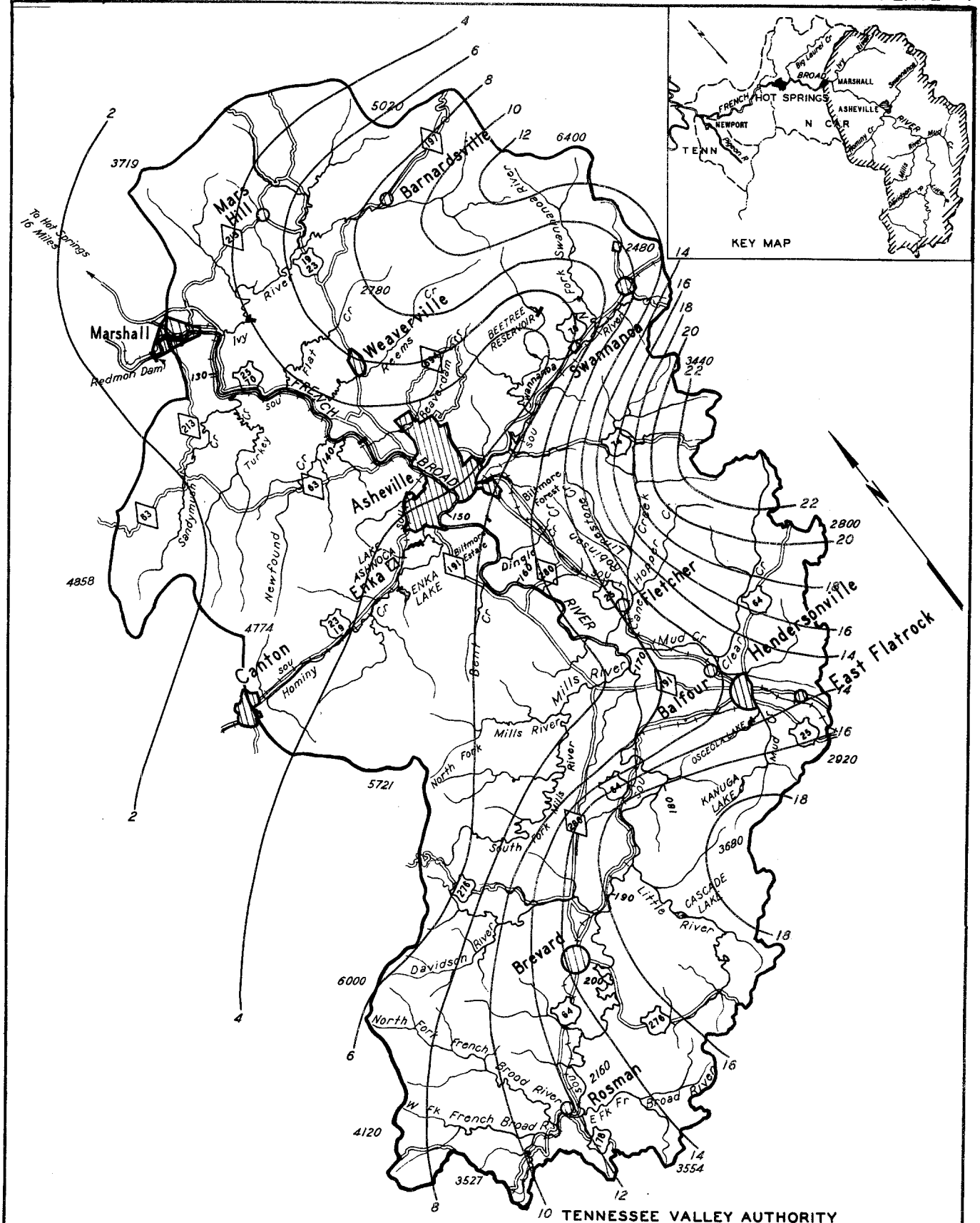
"The rain appears to have been heavier there than elsewhere and the high mountain walls which rise from the valley made a situation which gave full effect to the destructive power of the downpour. . . . The continued downpour made the stream a river which swept with it fallen trees, rocks and debris, and destroyed the wagon road along the creek in many places.

"Allen Coggins, who came in yesterday from Bee Tree, said that it was impossible to use the road which was literally washed away and that he came on foot along the side of the mountain. The rain, he said, was the heaviest one there in 20 years."

July 16, 1916

This is the greatest flood of which there is definite record on the Swannanoa River. It resulted from a tropical hurricane storm that passed inland over Charleston, South Carolina, on July 14 and advanced northwestward across South Carolina. As it moved overland the storm lost much of its surface intensity but maintained its intensity and high moisture content in the upper levels. The presence of a high-pressure area over the northeastern states caused the storm to be directed against the highest portion of the Blue Ridge, which it was unable to cross because of insufficient energy.

The heaviest rainfall during the storm occurred along the Blue Ridge, including the eastern boundary of the Swannanoa River basin. Plate 4 shows the estimated rainfall distribution over the French Broad River watershed above Marshall, North Carolina. Altapass, North Carolina, on the Blue Ridge 29 miles northeast of Swannanoa, recorded 23.7 inches for the storm, 22.2 inches of this falling in 24 hours. As the map shows, rainfall amounts decreased rapidly to the north and west of the Blue Ridge. Asheville received only 2.85 inches for the storm. General rains which had fallen over the area a week earlier had put most streams out of their banks and the streams had been receding for only a few days when the great storm of July 15-16 hit.


KEY MAP
BROAD
MARSHALL
FRENCH
HOT SPRINGS
ASHEVILLE
NEWPORT
N CAR
TENN
Big Laurel Cr
Ivy
Spring Cr
Hominy Cr
River
Mud Cr
Pigeon R
Davidson R
Mills R
Marshall
Mars Hill
Barnardsville
Weaverville
Swannanoa
Asheville
Canton
Enka
Fletcher
Hendersonville
East Flatrock
Balfour
Brevard
Rosman
Marshall
To Hot Springs 16 Miles
Redmon Dam
Ivy
Flat
Reems
Beetree Reservoir
Swannanoa River
Sandymush Cr
Turkey Cr
New Found
Lake Aspheola
Enka Lake
Biltmore Estate
Biltmore Forest
Dingle Creek
Hoopers Creek
Cane
Mud Cr
Clear Cr
Berry Cr
Mills River
North Fork Mills River
South Fork Mills River
Oscola Lake
Kanuga Lake
Cascade Lake
Little River
Davidson River
North Fork French Broad River
W Fk French Broad R
Broad River
E Fk Fr Broad River
Scale 0 5 10 Miles
~10~ INCHES RAINFALL
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH
UPPER FRENCH BROAD AREA
SHOWING
JULY 1916 ESTIMATED STORM RAINFALL
DECEMBER 1960

ASF-1311

Figure 4. --WRECKAGE OF LUMBER PLANT, JULY 1916

The view is downstream toward the McEwen Lumber Company at Azalea. The buildings were repaired and most of them are still in use. Much stacked lumber was lost here in the flood.

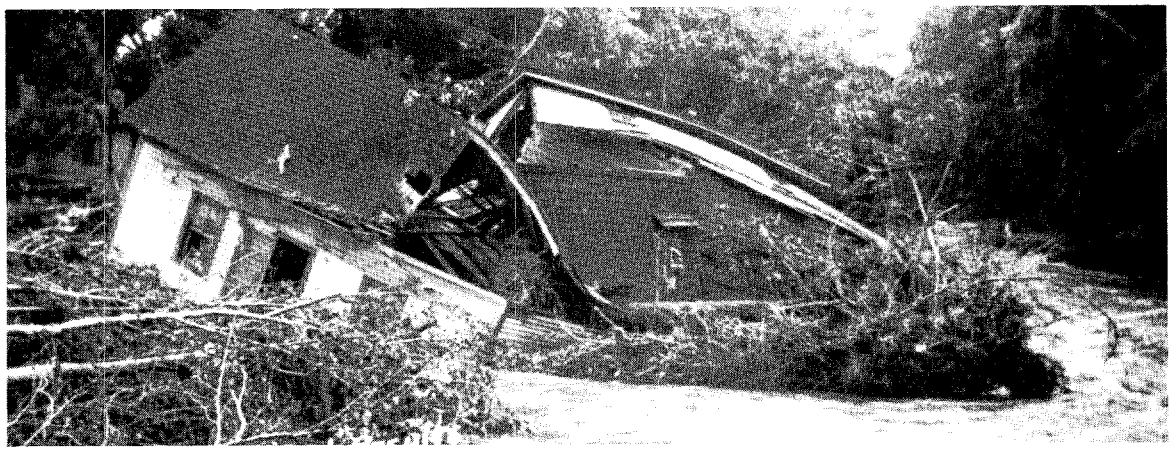


Figure 5. --WRECKED HOUSES AT AZALEA, JULY 1916

These views are on left bank of the Swannanoa River a short distance above the McEwen Lumber Company.

(Photos on this page by Gragg Studio, Black Mountain, N. C.)

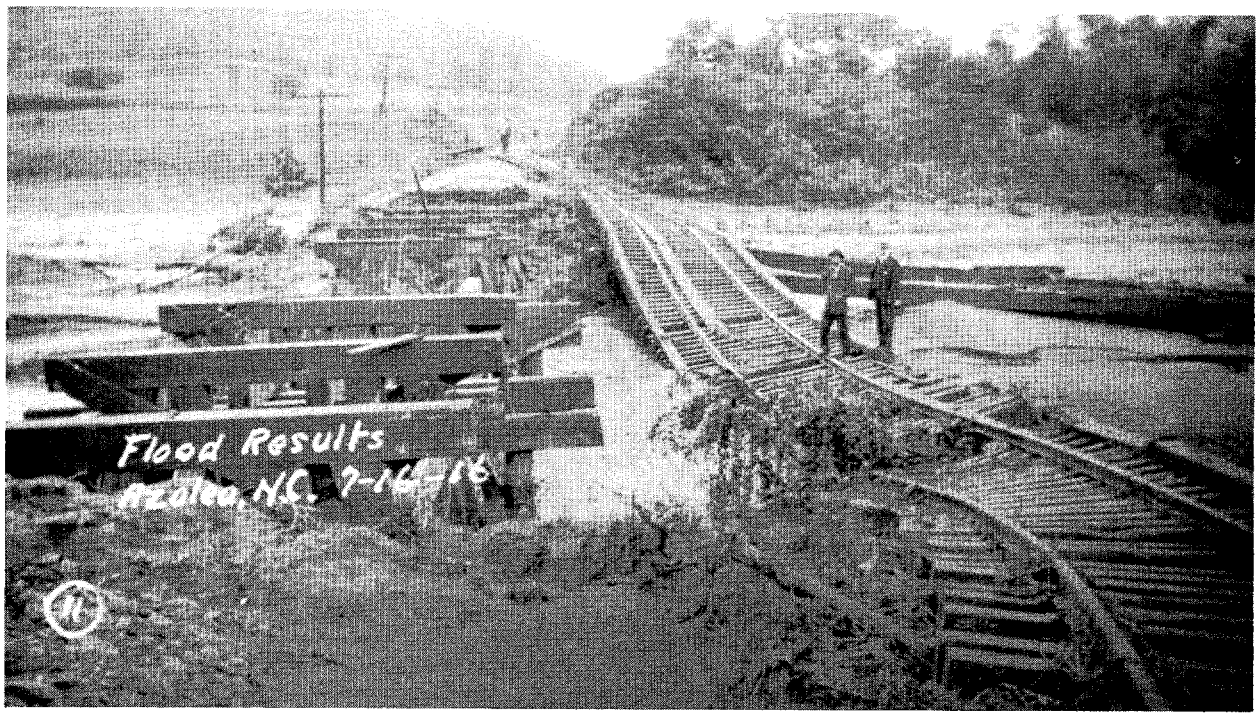


Figure 6. --RAILWAY DAMAGE IN JULY 1916

The view is east across Christian Creek, which flows toward left, but the Swannanoa River, out of picture at left, carried the track off the trestle to the right.

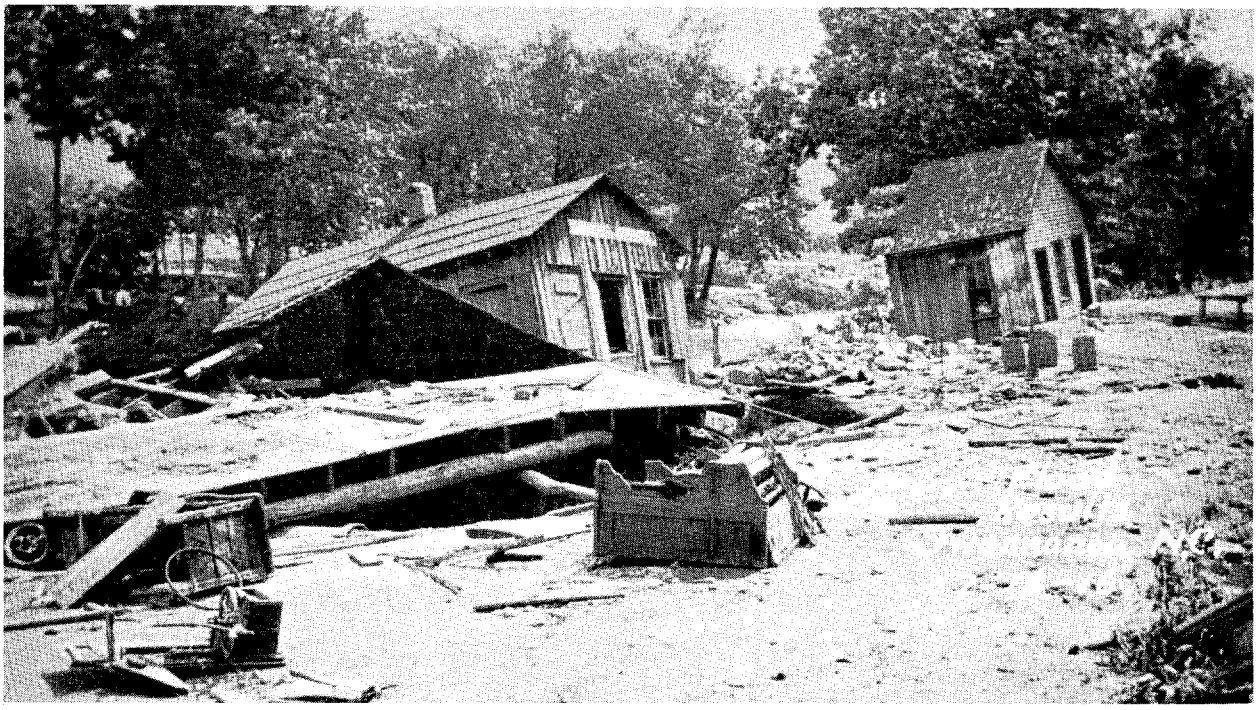


Figure 7. --BUILDINGS DEMOLISHED AT SWANNANOA, JULY 1916

View downstream from right bank showing the same two buildings as in the cover photo. Building in center is lodged against the bridge pier.

(Photos on this page by Gragg Studio, Black Mountain, N. C.)

Over the length of the Swannanoa River the flood exacted a heavy toll in land and property. Figures 4 through 7 are photographs of damage in the Swannanoa-to-Azalea reach of the river. These are part of a group of photographs located in the course of flood history investigations which were made in the Black Mountain vicinity in 1962. One of the photographs shows conditions in the vicinity of the bridge at Swannanoa, at the site of the present Whitson Avenue bridge. Others show the severe damage inflicted to private property and the railroad in this reach of the river.

George Coggins, Asheville realtor, was able to describe the flood in considerable detail both on the Swannanoa River and on Beetree Creek. At the time of the flood he was living at a house near the mouth of Beetree Creek, on what is now the property of Amcel Propulsions, Incorporated. His father, H. Allen Coggins, operated the Swannanoa Roller Mills, a large water-powered flour mill, established at this site about 1890, and also had extensive property holdings in the Beetree Creek and Swannanoa areas.

All the bridges in this reach of Swannanoa River were carried away. This included the steel bridge at Swannanoa, another at Azalea, and a swinging footbridge below Swannanoa, at Mile 13.92. In Swannanoa, a store, a blacksmith shop, and three houses were lost. The Whitson Mill and Cannery, located on the left bank in Swannanoa, had heavy damage. The several stores, which then made up the main business section of Swannanoa and were located near the Southern Railway, were not affected.

Damage was heavy along Beetree Creek. The Craggy Lumber Company, later called the Beetree Lumber Company, had a sawmill at Beetree Post Office, near the mouth of Spruce Fork, Mile 3.4. A logging railroad extended upstream through the area now occupied by Beetree Reservoir into the head of the watershed, and downstream along the creek and across Swannanoa River to a connection with the Southern Railway just west of Swannanoa. There was severe damage to the sawmill and the buildings nearby, including a commissary, a mess hall, and several dwellings. Trestle work and the tracks of the railroad were almost a total loss. Water surrounded a house and washed out a grist mill at Mile 3. A school at the present site of Beetree Christian Church, Mile 2.7, had water over the floor. Bridges were washed out, including one at the mouth of Gregg Branch and one near the present Farm School Road bridge. Farm land was affected by heavy scour and deposits of gravel.

August 16, 1928

Although not so high or nearly so damaging as the flood of July 1916, this was a large flood on Swannanoa River and Beetree Creek. At Swannanoa, high water marks located for the flood put it within about 2 feet of the 1916 flood and only 2 to 3 inches lower than the crest of the August 13, 1940, flood.

On Beetree Creek concern developed that Beetree Dam, completed two years earlier, was in danger and several families were evacuated below the dam. The following account from the Asheville "Citizen" of August 17, 1928, describes the situation and gives a report to the public by the Asheville City Engineer.

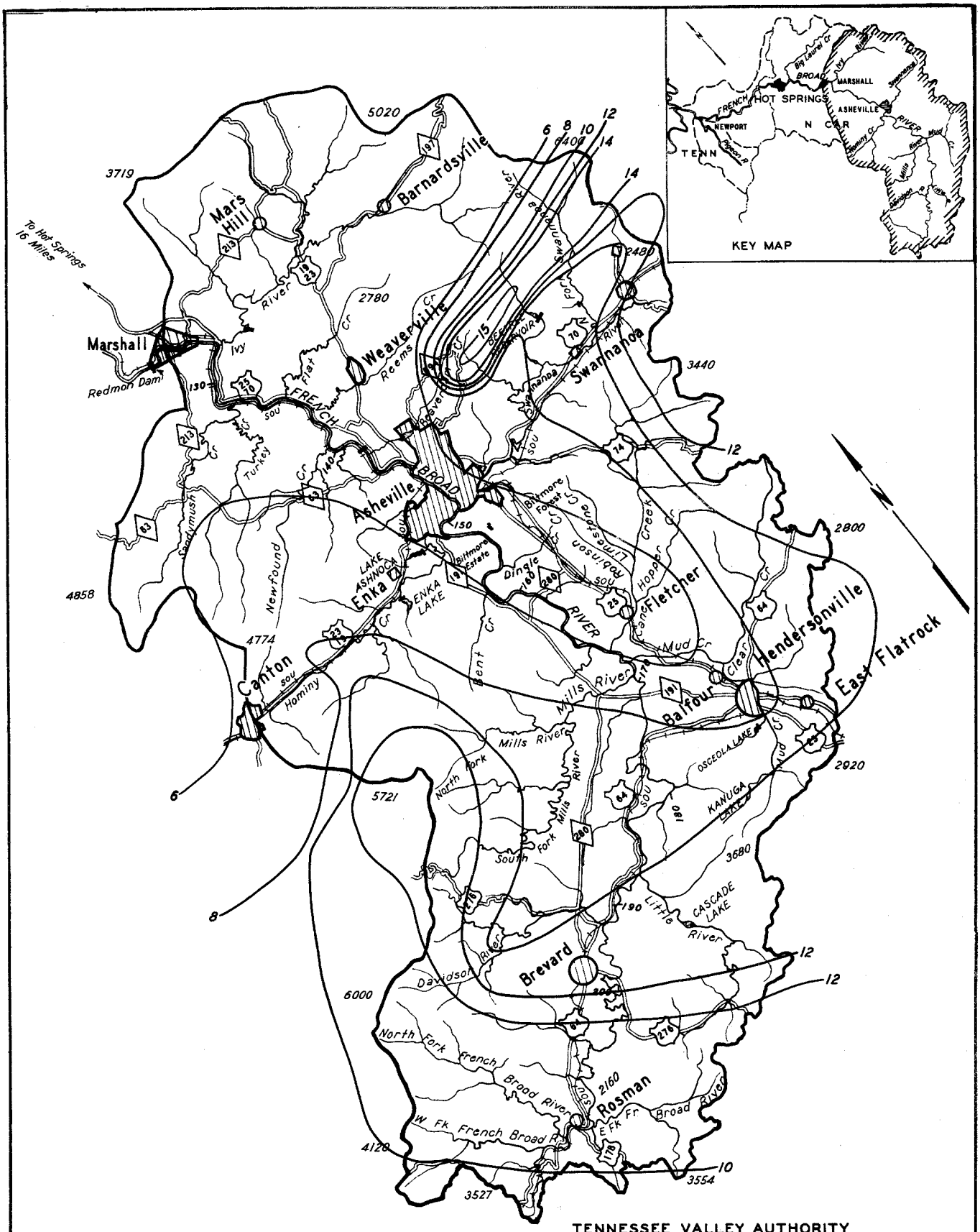
BEETREE DAM HOLDS

> Many rumors that floated about to the effect that Beetree Dam had been seriously damaged and was about to go out were set at ease late yesterday afternoon when Stanley H. Wright, City Engineer, returned from the impounding reservoir . . . . "You may quote me to the effect," Mr. Wright said, "that Beetree Dam was not even scratched by the flood. The flood gates and the spillway cared for the entire volume of flood water in nice style and a close inspection reveals that they were just as intact as they were the day the dam was built. My judgment is that Beetree Dam would withstand a flood twice the volume of yesterday's without injury. It was well built and designed to care for just such an emergency." . . . .

August 13, 1940

Two large floods affected the mountain headwaters of the Tennessee Valley in August 1940; but the first of these, on August 13, was the only one of consequence in the upper Swannanoa River valley. This flood resulted from a tropical storm whose center moved inland at Savannah, Georgia, on August 11, then described a great circle to the west and north, bringing heavy rains to much of the southeast. In the Swannanoa basin rainfall amounts ranged from 5 inches at Asheville to 15 inches on North Fork Swannanoa River watershed and 16 inches on upper Bull Creek. Plate 5 shows the distribution of rainfall during this storm, with 10 to 12 inches generally indicated for the Swannanoa River basin included in this study.

The flood ranks next to that of 1916 in severity in the vicinity of Swannanoa. At the upper limits of the study 700 feet of U. S. Highway 70 was washed out by overflow depths up to two feet, and 1000 feet of Southern Railway



TENNESSEE VALLEY AUTHORITY
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HYDRAULIC DATA BRANCH

UPPER FRENCH BROAD AREA SHOWING MID-AUGUST 1940 STORM RAINFALL

DECEMBER 1960

ASF-1311

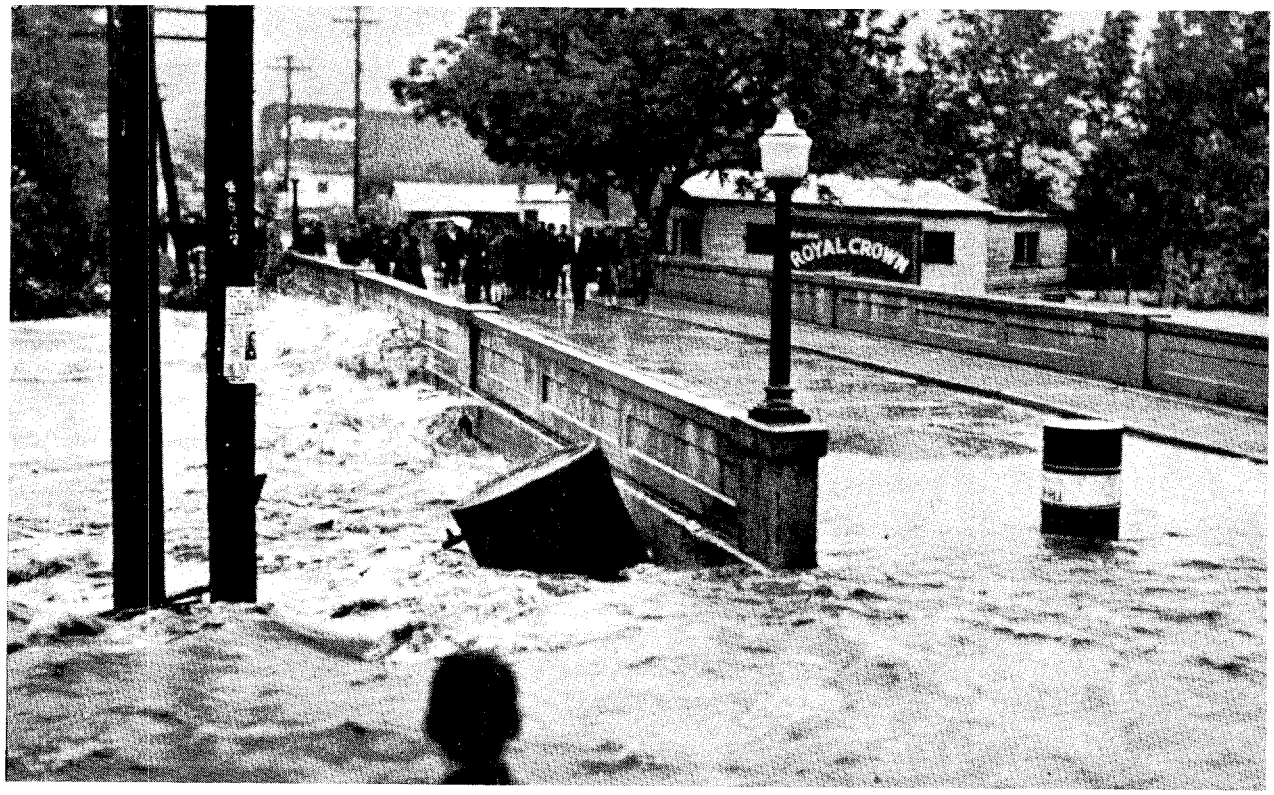

Figure 8. --FLOOD OF AUGUST 13, 1940, AT SWANNANOA

Upper view is from right bank across Whitson Avenue bridge. Lower view is east along U. S. Highway 70 from approximately the same point, and was taken about 3 p. m.

(Upper photo by Asheville Citizen-Times)

tracks were washed out. A steel bridge at the Asheville Farm School at Mile 12.21 washed out during the flood. At Swannanoa two service stations and two houses were washed away, two houses were severely damaged, and three others were flooded. At the Beacon Manufacturing Company the river did not reach the plant, but overflow from Eskridge Creek flooded the basement, damaging finished blankets and stocks of cotton and paper.

Beetree Reservoir was full at the beginning of the rise and the entire flow passed over the spillway and through the bypass valve. At the peak of the flood 1060 cubic feet per second went over the spillway and 300 cubic feet per second through the valve. Below the dam several footbridges washed out, stream banks were scoured, and 100 feet of the 24-inch pipe line from the reservoir to the Asheville water system washed out. On North Fork Swannanoa River the two 16-inch lines were washed out. The Beetree line was repaired in 36 hours and no water shortage developed at Asheville.

Photographs of the mid-August 1940 flood in the vicinity of Swannanoa are shown in Figure 8.

August 30, 1940

In the vicinity of Swannanoa this flood was two feet lower than the mid-August flood and there was little additional damage.

June 16, 1949

Intense rains in the headwaters of the Swannanoa River basin in the 3-day period June 14-16, 1949, produced a flood on Beetree Creek and Swannanoa River which was the highest since August 1940. This was part of a widespread disturbance that produced floods of considerable magnitude throughout much of the southeastern part of the Tennessee Valley. The storm in the Swannanoa River watershed started with a moderately heavy shower in the morning of June 14. A steady rain began in the afternoon and continued until noon of the 15th. The final and most intense precipitation began around 8 p.m. on June 15 and lasted until the evening of the 16th. A recording rain gage at North Fork registered 8.50 inches in 21 hours during this period, and the total for the storm period varied from 2.26 inches at Asheville to 10.15 inches at North Fork. At Swannanoa 4.81 inches of rain fell.

The heavy rainfall in the headwaters of North Fork Swannanoa River resulted in a flood on that stream that was estimated to be one foot higher than the August 13, 1940, flood, but lower than the 1916 flood. As the flood crest moved downstream its height in relation to the 1940 flood decreased. At Swannanoa it was 13 inches lower than the mid-August 1940 flood and 10 inches lower than the 1928 flood. At the old U. S. Highway 70 bridge at Mile 14.80 this flood was 2.2 feet lower than the mid-August 1940 flood. Near the lower limits of the study, it was 3.7 feet lower than the mid-August 1940 flood and at the Biltmore gage it was 4.35 feet lower.

In the vicinity of Swannanoa 4 houses and a garage were flooded and four other houses were surrounded by water but not flooded. Some scouring occurred in farm lands downstream from Swannanoa, and the bridge at Mile 13.92 was washed out.

Rainfall over the Beetree Creek watershed was lighter than over the North Fork Swannanoa River watershed, and the flood on this creek was lower than the 1928 flood and the two August 1940 floods. There was some damage to roads along the creek.

August 28, 1949

Within the limits of this study this flood was about three feet lower than the June 1949 flood, and although overflow occurred in the vicinity of Swannanoa, damage was small. Three houses were flooded to shallow depths.

March 12, 1963

Minor flooding occurred at several low-lying areas on the Swannanoa River in the reach covered by this report. The stage at Biltmore, however, was 0.8 foot under bankfull level. On Beetree Creek water was out of banks at several locations, but only minor flooding occurred. Damage was light, being limited to bank scour, silting of a few fields, and a culvert washing out at Mile 1.95.

2. BEETREE CREEK VALLEY

The Stream and Its Valley

Beetree Creek drains a steep mountain area of 14.1 square miles lying north of Swannanoa. The watershed, shown on Plate 1, is 6 miles long by 3 miles wide. The basin is bounded on the east by the Great Craggy Mountains and on the north by Bull Mountain. Elevations around the upper basin rim range from 4000 to more than 5000 feet, with high points at Lane Pinnacle, 5230 feet, and Craggy Knob, 5600 feet. The Blue Ridge Parkway, the scenic route connecting Shenandoah National Park in Virginia with the Great Smoky Mountains National Park on the North Carolina-Tennessee state line, crosses the watershed just under the upper valley rim, at elevations ranging from 4300 to 5300 feet. Craggy Gardens, at the northeast corner of the watershed, with its natural display of mountain rhododendron, is one of the top attractions on the parkway.

Beetree Dam, located about the midpoint of the watershed, impounds water for the Asheville water-supply system. The 7.6-square-mile of watershed above Beetree Dam is in heavy forest cover and is wholly owned and managed by the City of Asheville as a protected water-supply source. The only cultivated land in the watershed is in the valley bottoms downstream from Beetree Dam and in the small coves which are tributary to this reach.

The streams in the upper watershed of Beetree Creek drop steeply from the basin rim to be joined by Left Fork at the head of Beetree Reservoir, at elevation 2668 feet. Beetree Creek flows generally southward to Beetree Dam, turns westward for $1\frac{1}{2}$ miles, then turns southward again to the confluence with Swannanoa River at Mile 13.52, two miles downstream from Swannanoa.

In the reach covered by this investigation the channel of Beetree Creek falls from elevation 2293 feet to elevation 2135 feet, an average of 79 feet per mile. Long Branch and Gregg Branch join the stream on the right bank, but both drain small areas and would not affect flood flows to any sizable degree.

The flood plain is 400 to 800 feet wide from Mile 2 downstream to Mile 1.0, then widens gradually to 1800 feet near the junction with Swannanoa River. The bottom land is underlain by heavy gravel and boulders, and much

TABLE 7

DRAINAGE AREAS IN WATERSHED OF BEETREE CREEK

Stream	Location	Mile above Mouth	Drainage Area sq. mi.
Beetree Creek	Mouth	0	14.1
	Farm School Road	0.18	14.1
	Upper limit of study	2.0	10.1
	Beetree Dam	3.93	7.57
	USGS stream gage	4.82	5.46

of the reach has been used as a source of aggregate for roads and for the construction industry. Land which is used for agriculture is mostly in pasture.

Pertinent drainage areas of Beetree Creek are given in Table 7.

Developments on the Flood Plain

Plates 7 and 8 show the flood plain of Beetree Creek. The larger part of the land in the flood plain is idle or in use for agricultural purposes.

The property on the right bank of Beetree Creek from the mouth upstream to Mile 1.64 is now in the ownership of Amcel Propulsions, Incorporated, a subsidiary of Celanese Corporation of America. Principal buildings are at the edge of the right-bank flood plain, Mile 0.6 to Mile 0.8, and in the small coves near Mile 1.0 and Mile 1.5. The site was originally purchased and developed in 1951-1952 by the Oerlikon Tool and Arms Corporation, a Swiss firm, for the development and manufacture of rockets and rocket components. U. S. Defense Department contracts were not forthcoming, however, and the development never reached the magnitude which was projected at the onset of the project. The present operation at the plant consists of the manufacture and loading of solid explosives and propellants. The two principal buildings, with floor elevations at 2211.8 and 2213.3 feet, are above the height of the Maximum Probable Flood on Beetree Creek. A smaller building at Mile 1.5 has a floor elevation of 2261.8 feet, about one foot above the July 1916 flood, but it would

be flooded by the Regional and Maximum Probable Floods to depths of about $3\frac{1}{2}$ and $5\frac{1}{2}$ feet, respectively.

Farm School Road crosses the creek and flood plain at Mile 0.18. Beetree Road follows the left-bank flood plain through the study reach. A road follows the edge of the right-bank flood plain from Farm School Road, through the property of Amcel Propulsions, to the bridge at Mile 1.64.

Two houses are on low ground near Mile 1.7. Other houses are near the edge of the flood plain and above the height of known floods. Beetree Heights, a residential development located along Beetree Road near the Farm School Road intersection, contains a number of houses which would be affected by a Maximum Probable Flood. In the reach covered by this study about 10 houses would be reached by a Maximum Probable Flood.

Excavation of gravel deposits has altered conditions along lower Beetree Creek to an important degree. Such changes are evident on the Amcel property from Farm School Road upstream to Mile 0.9 and, from more recent operations, between Miles 1.8 and 2.2. Stripping of the gravel from these areas has caused changes in the channel location and has affected flood heights.

A 24-inch pipeline, carrying water from Beetree Reservoir, crosses Beetree Creek at Mile 2.15 and follows Beetree Road to a junction with three pipelines from Burnett Reservoir on North Fork Swannanoa River just upstream from Farm School Road. From this junction three pipelines cross the flood plain and creek at Mile 0.3, to supply the Asheville distribution system. One of these lines is 16-inch diameter, one 24-inch, and the most recent addition is a 36-inch line installed in 1962.

Bridges across the Stream

Two bridges and a culvert cross Beetree Creek in the reach investigated. Table 8 lists pertinent elevations for the bridges and shows their relation to the crest of the flood of July 1916. Plate 10 shows the relation of the floor and underclearance at the bridges to the flood profiles on Beetree Creek. Figure 9 shows photographs of the bridges.

All of the bridges have underclearances which are lower than some of the large floods of the past. Most would be carried away by any flood that approached the magnitude of the flood of July 1916.

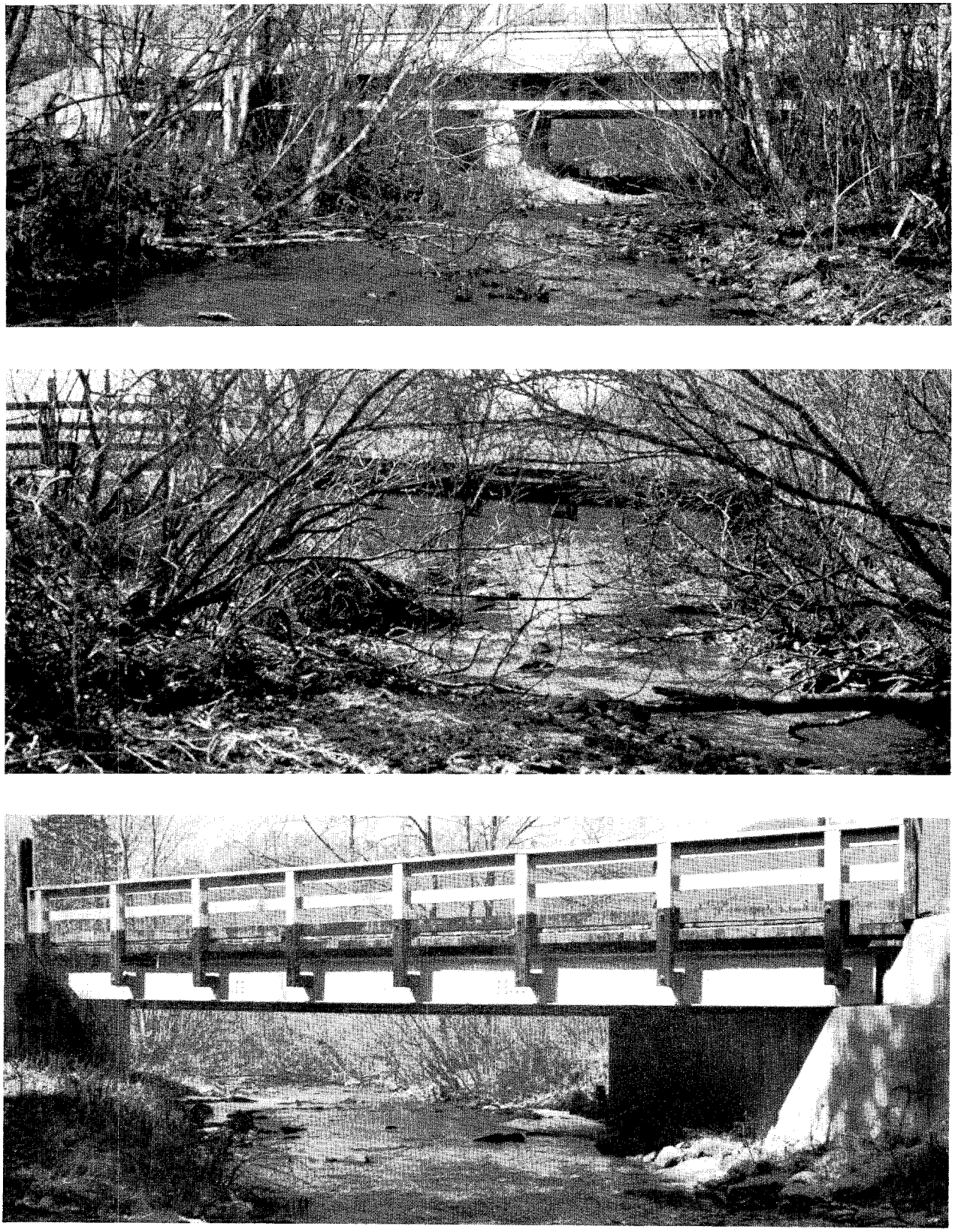

Figure 9. --BRIDGES OVER BEETREE CREEK

Top view is upstream side of Farm School Road bridge at Mile 0. 18. Middle view is upstream side of Gregg Branch Road bridge at Mile 1. 64, about 1/3 mile above Gregg Branch. Bottom view is upstream side of Long Branch Road bridge, Mile 2. 22.

TABLE 8

BRIDGES ACROSS BEETREE CREEK

Mile above Mouth	Identification	Low Water Elev. feet	Floor Elev. feet	Regional Flood Crest Elev. feet	July 1916 Flood Crest Elev. feet	Underclearance Elev. feet	Above 1916 Flood feet	Below 1916 Flood feet
0.18	Farm School Road	2149.0	2161.6	2161.8	2158.1	2157.3		0.8
1.64	Gregg Branch Road	2264.5	2271.1	2279.0	2275.8	2269.2		6.6
1.95	Private road[a] (42" culvert)	2289.6	2293.7	2300.5	2297.6	2291.7		5.9
2.22	Long Branch Road[b]	2316.2	2325.1	2331.9	2329.1	2322.8		6.3

(a) Washed out in March 1963.
(b) Above upper limit of study.

The bridge at Farm School Road, Mile 0.18, is a two-span concrete structure with a solid guard rail. The approach road on the left bank is at flood-plain elevation over a large part of its length and is overflowed beginning at elevation 2155 feet.

The bridge at Mile 1.64, upstream from Gregg Branch, is of one-span, steel girder, wood floor construction, with a short approach fill at each bank.

The culvert at Mile 1.95 is on a private road which crosses the flood plain at a gravel borrow area, providing access to a house and farm on the right bank. The flood on March 12, 1963, washed out the 42-inch diameter culvert and a section of the road.

The bridge at Long Branch Road, Mile 2.22, is a single-span structure with steel girders and wood floor, set at an angle to the stream. There are fills at both abutments.

Each of the four bridges with its approach fills tends to constrict the channel so that heading up would occur during major floods.

Obstructions to Flood Flow

There are no appreciable obstructions to flood flow along Beetree Creek except at the bridges and their approaches, which have been described previously. In the areas where gravel has been excavated in large quantities, flood heights will be lower now than under the original channel and overbank conditions.

Beetree Dam

Completed in 1926, Beetree Dam provides 500 million gallons or about 160 acre-feet of storage for the Asheville water supply. The dam is earth fill, 85 feet high and 900 feet long. A concrete spillway at the right end of the dam provides for flood discharge. A concrete discharge channel leads from the spillway to the base of the dam. A concrete intake tower and low-level outlet near the left end of the dam connects to a 24-inch pipeline and has a discharge valve by which the reservoir may be lowered or emptied. A water-treatment plant below the dam contains equipment for chlorination and ammoniation of the water.

FLOOD SITUATION

Flood Records

The U. S. Geological Survey established a recording stream gage on Beetree Creek above Beetree Reservoir on February 6, 1926, and records of stream stage and discharge have been maintained continuously since that date. Flood discharges below Beetree Dam have been slightly affected by the storage effects of the reservoir and diversions of flow into the water-supply pipeline at the dam.

To supplement the records available at the gaging station, local residents have been interviewed for dates and heights of floods, and newspaper files and historical records have been searched. Following the minor flood of March 12, 1963, TVA engineers established a flood profile from the mouth upstream to the bridge at Mile 2.22.

Flood Occurrences

Flood records indicate that major floods on Beetree Creek occur at about the same frequency as those on the Swannanoa River.

Duration and Rate of Rise

Small, mountainous watersheds such as that of Beetree Creek produce floods which are characterized by very rapid rates of rise and short duration. A flood as great as that in 1916 would rise several feet in less than one hour and remain out of banks for less than 12 hours.

Velocities

Along lower Beetree Creek velocities in the channel during floods such as that of 1916 would range up to 14 feet per second, and in the overbank areas velocities would be as high as 6 feet per second.

Flooded Areas, Flood Profiles, and Cross Sections

Plates 7 and 8 show the approximate areas along Beetree Creek that were inundated by the flood of July 1916 and that would be inundated by the Maximum Probable Flood. The actual limits of these overflow areas on the ground may vary somewhat from those shown on the map because the contour interval of the map does not permit precise plotting of the flooded area boundaries. The contour interval on Plate 7 is 40 feet.

Plate 10 shows high water profiles on Beetree Creek for the floods of July 1916 and March 12, 1963. Also shown are the profiles for the Regional and Maximum Probable Floods, which are discussed in Sections III and IV of this report.

Plate 11 shows typical cross sections of Beetree Creek in the reach investigated. The locations of the sections are shown on the map, Plate 7, and the profile, Plate 10. Each cross section shows the elevation and extent of overflow of the July 1916 flood and the Regional and Maximum Probable Floods.

FLOOD DESCRIPTIONS

Descriptions of the large floods on Beetree Creek are included with the discussion of past floods on Swannanoa River.

III.

REGIONAL FLOODS

III.

REGIONAL FLOODS[1]

This section of the report relates particularly to floods on streams whose watersheds are comparable with those of Swannanoa River and Beetree Creek.

Large floods have been experienced in the past on streams in the general geographical and physiographical region of Swannanoa, North Carolina. Heavy storms similar to those that caused these floods could occur over the watersheds of the Swannanoa River and its tributaries. In this event, floods would result on these streams comparable in magnitude with those that were experienced on neighboring streams. Floods of this size are designated as Regional Floods. It is therefore desirable, in connection with any determination of future floods that may occur on Swannanoa River and Beetree Creek, to consider floods that have occurred in the region on watersheds whose topography, watershed cover, and physical characteristics are similar to those of these two streams.

Maximum Known Floods in the Region

Storm rainfall over the watersheds in the southern Appalachian Mountains, including the Swannanoa River watershed, is influenced considerably by the topography of the region. This is true of the occasional tropical summer hurricanes as well as the large cyclonic storms more typical of the winter months. Moist air moving northward and westward from the Gulf and Atlantic Coasts is forced upward by the gradually sloping ground rising to the crest of the Tennessee Valley Divide. As a result, the easterly slopes of the Divide and the area immediately beyond the crest within the Valley are subject to heavy orographic rainfall. The distribution of this rainfall, however, is different over the watersheds to the east and south of the Tennessee Valley Divide than over the watersheds within the Valley. On the coastward slopes the heavy precipitation that results when the moist air is lifted by the mountains is generally widespread, covering entire river basins. Within the Tennessee Valley the heavy precipitation is confined largely to a narrow band along the top and immediately beyond the Divide. Characteristically, the rainfall diminishes on the downstream slopes

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1. Prepared by Hydraulic Data Branch.

within the Valley, although occasionally tongues or cells of heavy rainfall have been experienced for considerable distances within the Valley.

Table 9 lists the maximum known floods experienced on watersheds comparable with those of Swannanoa River and Beetree Creek and within about 50 miles of Swannanoa. Because of the distribution of rainfall during heavy storms, the floods that occurred on watersheds that lie to the south and east outside the Tennessee Valley have not been considered in the determination of Regional Floods on the Swannanoa River watershed.

Many very severe storms have been experienced over watersheds in the Swannanoa region. The storm of May 18-21, 1901, caused particularly large floods in the Watauga and Nolichucky River Basins when an estimated eight inches of rain fell in a 24-hour period on ground saturated from previous rain. The numerous "waterspouts" and landslides that were reported in the news accounts attest to the intensity of the rainfall. In the Cane Creek watershed near Burnsville, North Carolina, as many as 17 landslides were counted on the side of a single hill and the resulting flood on that creek was in the order of a Maximum Probable Flood. This flood on the Nolichucky River became known as the "May Tide."

The storm of July 15-16, 1916, was the second of two tropical hurricanes which moved inland over the southeastern United States in July 1916. The first hurricane dissipated over southern Alabama but brought sufficient rainfall to western North Carolina on July 8-10 to saturate the ground. The second hurricane brought heavy rainfall along the Blue Ridge Mountain Divide between the Atlantic and Tennessee River Basins. At Altapass, North Carolina, the storm rainfall totaled 23.7 inches, 22.2 inches of this falling in 24 hours. Record floods were experienced on the Upper French Broad River and its tributaries when an estimated maximum of 16 to 18 inches of precipitation fell on these watersheds during the two-day period. The resulting flood was the highest of record on the upper Swannanoa River in the vicinity of Swannanoa, North Carolina.

The storm of mid-August 1940, like that of July 1916, originated as a tropical hurricane. The path of the storm center approximated a large "U" with the base along the Blue Ridge Mountains, one arm extending to Savannah, Georgia, and the other along the Virginia-North Carolina state line to the coast. Heavy rainfall was experienced along the eastern Tennessee Valley Divide from

TABLE 9

MAXIMUM KNOWN FLOOD DISCHARGES

ON STREAMS IN REGION OF SWANNANOA, NORTH CAROLINA

Map Reference No.	Stream	Location	Drainage Area sq. mi.	Date	Peak Discharge Amount cfs	Peak Discharge Per Sq. Mi. cfs
1	Mud Creek	at Naples, N. C.	109	July 1916	40,000	367
2	N. Toe River	at Altapass, N. C.	104	July 1916	30,800	296
3	Watauga River	nr Sugar Grove, N. C.	90.8	Aug. 13, 1940	50,800	559
4	E. Fk. Tuckasegee River	nr Tuckasegee, N. C.	80.3	Aug. 30, 1940	30,000	374
5	S. Toe River	at Newdale, N. C.	60.8	Jan. 1927	33,000	543
6	Watauga River	nr Sugar Grove, N. C.	55.1	Aug. 13, 1940	41,000	744
7	Elk River	nr Elk Park, N. C.	42.0	Aug. 13, 1940	27,500	655
8	Cane River	nr Burnsville, N. C.	36.6	Aug. 13, 1940	18,000	492
9	Watauga River	nr Valle Crucis, N. C.	33.1	Aug. 13, 1940	38,000	1150
10	Hominy Creek	ab Candler, N. C.	28.9	Aug. 30, 1940	12,400	429
11	N. Fk. Swannanoa River	nr Black Mountain, N. C.	23.8	June 16, 1949	16,500	693
12	Cane Creek	ab Bakersville, N. C.	22.0	May 19-20, 1901	30,500	1390
13	Elk River	bel Banner Elk, N. C.	20.1	Aug. 13, 1940	16,500	822
14	Elk River	nr Banner Elk, N. C.	17.8	Aug. 13, 1940	22,000	1240
15	Wolf Creek	nr Tuckasegee, N. C.	14.1	Aug. 30, 1940	14,500	1030
16	W. Fk. Pigeon River	at Spruce nr Waynesville, N. C.	12.2	Aug. 30, 1940	16,500	1350
17	Swannanoa River	at Black Mountain, N. C.	11.2	July 16, 1916	17,000	1520
18	Dutch Creek	at Valle Crucis, N. C.	10.6	Aug. 13, 1940	16,000	1510
19	Devils Fork	nr Hendersonville, N. C.	9.3	July 16, 1916	7,500	806
20	Flat Creek	ab Weaverville, N. C.	6.4	July 16, 1941	3,000	467
21	Rt. Fk. Swannanoa River	nr Black Mountain, N. C.	5.1	June 16, 1949	4,500	882
22	Crab Orchard Creek	nr Boone, N. C.	2.1	Aug. 13, 1940	6,000	2860

the Hiwassee River Basin northeast to the Watauga headwaters. The highest flood of record was experienced on many streams in the region as a result of rainfall which totaled up to 15 inches in some areas in the upper Watauga and Swannanoa River Basins.

Much of the same area was again deluged by heavy rains which occurred about two weeks later on August 29-30. Unlike the first storm, the second one lasted only approximately one day and resulted from thunderstorm activity rather than a hurricane. The heaviest rainfall of the storm occurred over the headwaters of the Tuckasegee River and averaged over 10 inches on some of the tributaries.

The June 14-16, 1949, storm was part of a widespread disturbance that produced floods of considerable magnitude throughout much of the southeastern part of the Tennessee Valley. The highest flood of record was experienced on the North Fork Swannanoa River at Black Mountain, North Carolina, where 8.50 inches of rainfall was recorded in 21 hours. Approximately 2.5 inches of rain had fallen during the two days prior to this intense burst of rainfall.

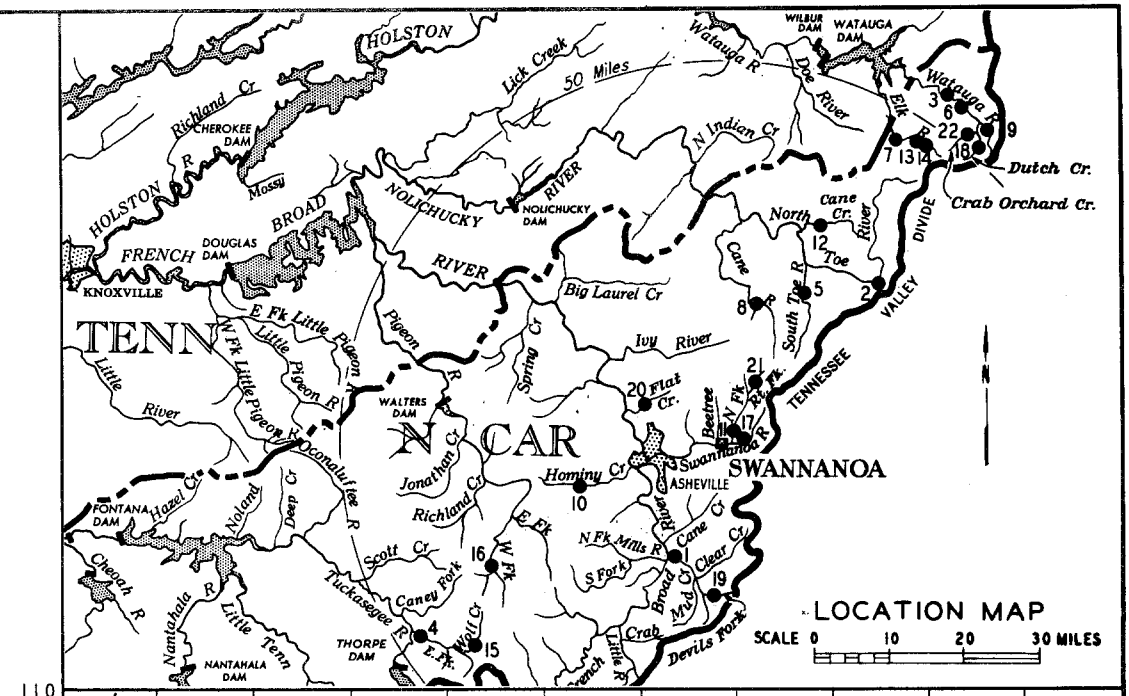
All of the floods listed in Table 9 have occurred on watersheds in the region of Swannanoa that are similar in physical characteristics. This indicates that floods of like magnitude, modified to take into account differences in drainage area characteristics, could occur in the future on Swannanoa River and Beetree Creek.

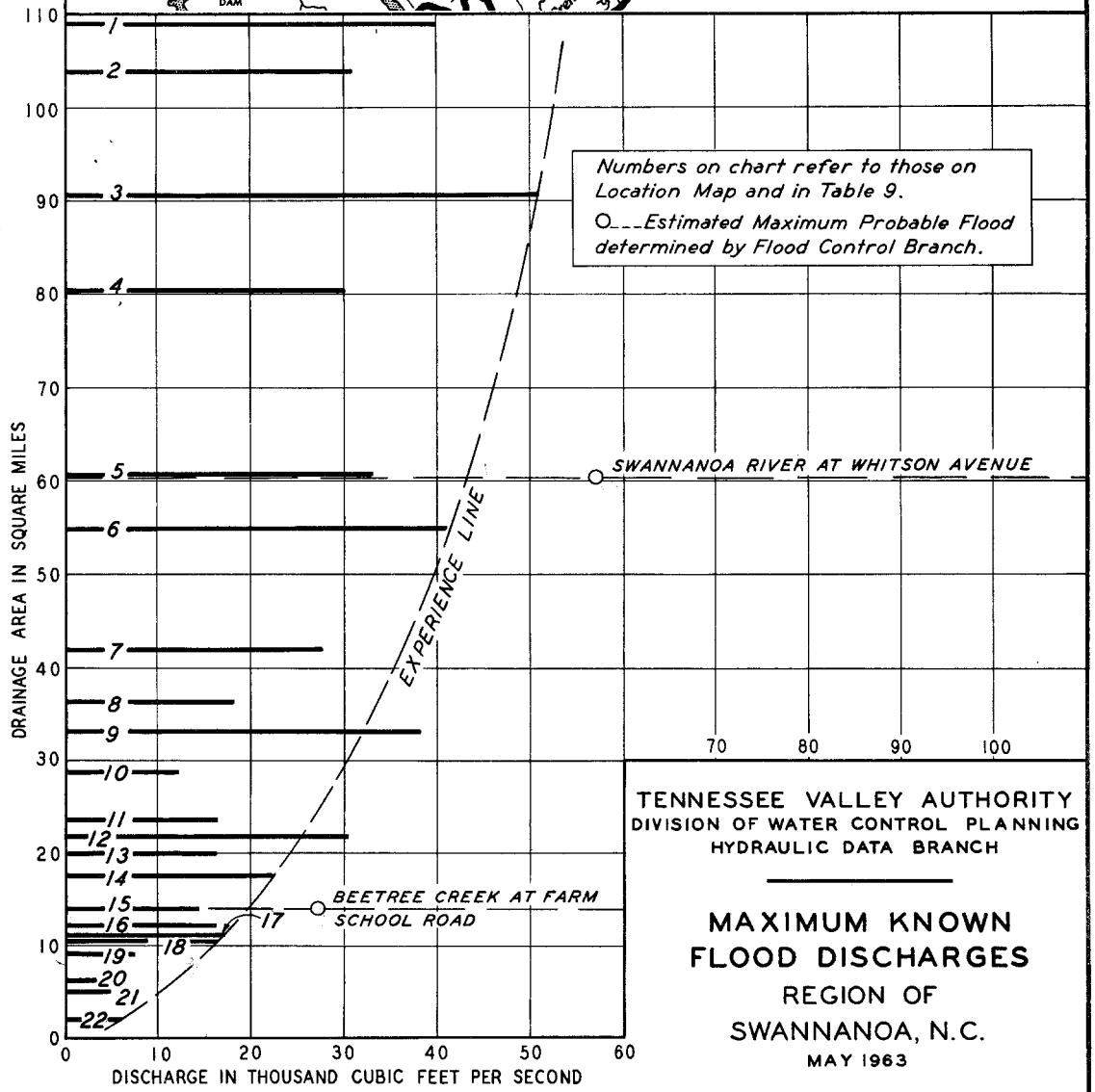
Determination of Regional Floods

Plate 6 is a diagram of the discharges tabulated in Table 9, together with a map showing the locations of the discharge measurements. The largest floods have occurred on those watersheds with headwaters on the Tennessee Valley Divide that lie in the narrow band or spillover area that is subject to heavy orographic precipitation. Above Swannanoa, the Swannanoa River Basin lies in this area and would be as susceptible to heavy rainfall as any of the watersheds in this region.

Most of the floods listed in Table 9 were caused from the tropical hurricanes of either July 1916 or mid-August 1940. However, record floods can result from other storms. Examples of these were the storm of May 1901 which was general over the eastern Tennessee Valley and the late August 1940 storm of intense rainfall over a localized area.

PLATE 6





TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

MAXIMUM KNOWN FLOOD DISCHARGES
REGION OF
SWANNANOA, N.C.
MAY 1963

HD-1311

All of the floods listed in Table 9 are comparatively recent, having occurred in this century. This emphasizes that floods of these magnitudes cannot be considered as rare events in this region and, therefore, it must be anticipated that such floods will occur again in the future.

Plate 6 shows that two flood discharges have exceeded the experience line that is used to determine the Regional Flood at Swannanoa. These are the mid-August 1940 flood on the Watauga River near Valle Crucis, North Carolina, and the May 1901 flood on Cane Creek, above Bakersville, North Carolina. Both of these floods were produced by particularly intense rainfall over a relatively small area and were more in the order of a Maximum Probable Flood. Therefore, even though these discharges were experienced in the region they were not considered in estimating the Regional Flood.

When estimating the Regional Flood on the Swannanoa River and Beetree Creek, the effect of reservoir storage in upstream dams must be considered. Although Burnett Reservoir on the North Fork Swannanoa River is designed for water supply, it does provide some flood storage. Studies show that at Swannanoa the reduction in discharge of a flood of the magnitude of a Regional Flood would be in the order of 3000 cubic feet per second. The Beetree Reservoir, being smaller, would not significantly reduce the peak discharge of a flood of the magnitude of the Regional Flood on Beetree Creek.

Based upon the maximum flood discharges experienced in the region, it is reasonable to expect future flood discharges on Swannanoa River and Beetree Creek to be in the order of those given in Table 10. For the purposes of this report, floods of this magnitude are designated as Regional Floods.

A Regional Flood may occur on Swannanoa River in the reach investigated that would be from about 1 to 17 feet higher than the 1916 flood, but about 8 feet higher throughout most of the reach. At Swannanoa, a Regional Flood would be from about 4 to 9 feet higher than the 1916 flood above Whitson Avenue bridge and 1 to 3 feet higher below that bridge. On Beetree Creek, a Regional Flood may occur about 2 to 5 feet higher than the 1916 flood.

The profile of the Regional Flood on Swannanoa River is shown on Plate 9. Plate 10 shows the Regional Flood profile on Beetree Creek. Figures 10 to 13 show the height that would be reached by the Regional Flood at several locations in the vicinity of Swannanoa.

TABLE 10

REGIONAL FLOOD PEAK DISCHARGES

Stream	Location	River Mile	Drainage Area sq. mi.	Discharge cfs
Swannanoa River	Whitson Avenue, Swannanoa	15.43	60.4	40,000(*)
Beetree Creek	Farm School Road	0.18	14.1	19,000

(*) Natural flow without Burnett Dam would be 43,000 cfs.

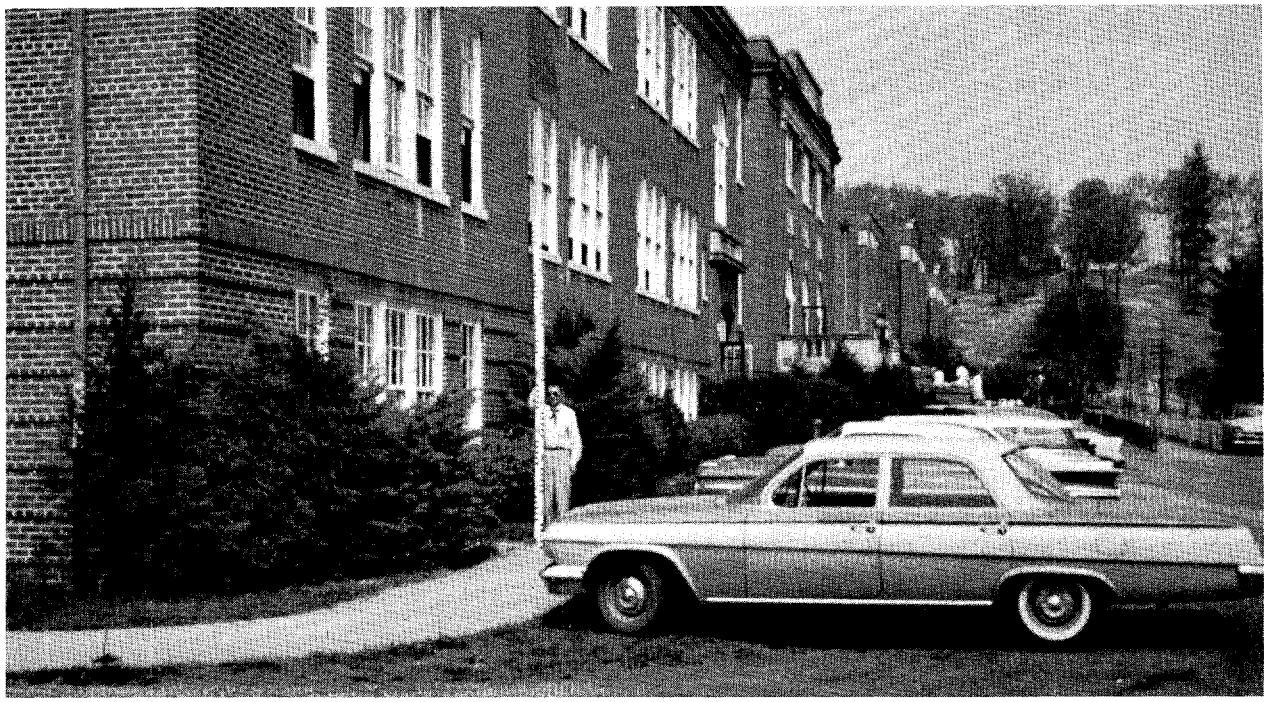


Figure 10. --FLOOD HEIGHTS AT SWANNANOA SCHOOL

The rod is held at the downstream or southwest corner of the school, located on the north side of old Highway 70 below town. The regulated Maximum Probable Flood level would be about two feet below the base of the rod.

Figure 11. --FLOOD HEIGHTS AT SWANNANOA TRAILER PARK

The park is at Welch Road at Mile 15. 13 of the Swannanoa River, on south side of U. S. Highway 70. Arrows show heights of the maximum known (July 1916) flood and the regulated Regional and Maximum Probable Floods.

Figure 12. --FLOOD HEIGHTS ON NORTH AVENUE

These houses are on North Avenue downstream from Whitson Avenue, at Mile 15.40. The view is westerly toward Park Street. Arrows show heights of the maximum known (July 1916) flood and the regulated Regional and Maximum Probable Floods.

Figure 13. --FLOOD HEIGHTS AT WHITSON AVENUE

This service station is on U. S. Highway 70 on the southwest corner of the Whitson Avenue intersection, Mile 15.43. The 1916 flood was one foot lower than the base of the rod in the photograph. Arrows show the regulated Regional and Maximum Probable Flood heights.

IV.

MAXIMUM PROBABLE FLOODS

IV.

MAXIMUM PROBABLE FLOODS[1]

This section discusses the Maximum Probable Floods on the Swannanoa River and Beetree Creek in the vicinity of Swannanoa, North Carolina, and some of the hazards of great floods. Floods of the magnitude of the Maximum Probable Floods are the kind considered in planning construction and operation of protective works, the failure of which might be disastrous. They represent reasonable upper limits of expected flooding.

Drainage areas at the upper and lower limits, respectively, of the study are 22.2 and 95.4 square miles on the Swannanoa River and 10.1 and 14.1 square miles on Beetree Creek.

Extreme floods on these streams are most likely to result from either of two types of storms--intense periods of rainfall during winter storms of fairly long duration, or short-duration storms of the cloudburst or hurricane type usually occurring during summer. Infiltration and other losses are generally low in winter and generally high in summer.

DETERMINATION OF MAXIMUM PROBABLE FLOODS

In determining the Maximum Probable Floods on the Swannanoa River and Beetree Creek in the vicinity of Swannanoa, consideration was given to great storms and floods that have already occurred on these watersheds and to those which have occurred elsewhere but could have occurred in this area. This procedure provides information about possible floods and storms additional to that which can be gained from the short-term local hydrologic records alone.

Reductions in flood flows resulting from spillway storage at Burnett Dam completed in 1954 on the North Fork Swannanoa River were taken into consideration when determining Maximum Probable Flood flows along the Swannanoa River downstream from the confluence with the North Fork. Beetree Dam on Beetree Creek produces no significant reduction in downstream flood flows.

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1. Prepared by Flood Control Branch.

The maximum known flood on the Swannanoa River in the vicinity of Swannanoa occurred in July 1916. The peak discharge at the Whitson Avenue bridge, Mile 15.43, is estimated to have been 24,000 cubic feet per second. On Beetree Creek the maximum known flood also occurred in July 1916. The peak discharge at the Farm School Road bridge, Mile 0.18, is estimated to have been 6,000 cubic feet per second. Even with upstream regulation it is reasonable to expect that greater floods will occur on these streams.

Observed Storms

Observed storms are meteorologically transposable to the Swannanoa area from within a broad region extending generally from the Atlantic Ocean to the Appalachian Divide and from Florida through Pennsylvania. The moisture source for storms in this region is the warm, moist air flowing northward from the tropical Atlantic Ocean. In general, the moisture potential for a given region decreases with its increased distance from the moisture source. Transposition of storms from within the broad region includes adjustments for the particular meteorological conditions to be expected at Swannanoa.

Table 11 lists known rainfall depths for several large storms transposable to this area.

TABLE 11

SELECTED MAXIMUM OBSERVED STORMS TRANSPOSABLE TO THE REGION OF SWANNANOA, NORTH CAROLINA

Date	Location	Area	Rainfall	
			Duration	Depth
		sq. mi.	hours	inches
July 1916	North Carolina	20	6	7.7
		95	6	7.3
August 1939	New Jersey	20	6	9.7
		95	6	9.1
September 1940	New Jersey	20	6	19.6
		95	6	17.3
October 1941	Florida	20	6	12.3
		95	6	10.5
July 1960	Georgia	Point	3	12.5
June 1961	North Carolina	3.49	2.5	8.5

Upon the basis of these and other data, as adjusted for conditions at Swannanoa, the following rainstorms were adopted for computing the Maximum Probable Floods.

Location	Drainage Area	Rainfall	
		Duration hours	Depth inches
Swannanoa River			
Lower Limit	95.4	4	13.5
Upper Limit	22.2	4	16.4
Beetree Creek			
Lower Limit	14.1	2	12.2
Upper Limit	10.1	2	12.6

From a meteorological standpoint, storms as much as 40 percent greater than these can occur.

Observed Floods

Factors such as the meteorology of the region and flood-producing characteristics of the watershed were given consideration in determining whether peak discharges on other streams are applicable. Tables 9 and 12 list peak discharges for observed floods on several streams of approximately the size of those discussed in this report. For comparison, the discharge of the maximum known flood on each stream included in this study is listed in Table 12.

Maximum Probable Flood Discharges

From consideration of the flood discharges in Table 12 and of the transposition to the Swannanoa area of outstanding storms, the peak discharges of the Swannanoa River--taking into account the effect of dependable storage in Burnett Dam Reservoir--and Beetree Creek Maximum Probable Floods were determined to be as follows:

Stream	Location	Drainage Area sq. mi.	Peak Discharge cfs
Swannanoa River	Lower limit of study	95.4	81,000
	Whitson Avenue, Swannanoa	60.4	57,000 (*)
	Upper limit of study	22.2	28,000
Beetree Creek	Lower limit of study	14.1	27,000
	Farm School Road	14.1	27,000
	Upper limit of study	10.1	23,000

(*) Natural flow without Burnett Dam would be 60,000 cfs.

TABLE 12

SELECTED MAXIMUM OBSERVED FLOODS

Stream	Location	Drainage Area sq. mi.	Date	Peak Discharge Amount cfs	Peak Discharge Per Sq. Mi. cfs
Pigeon River	Spruce, N. C.	8.4	1940	16,400	1,950
Steels Creek	Tablerock, N. C.	16	1940	24,000	1,500
Stony Fork	Hendrix, N. C.	27.1	1940	37,000	1,365
Elk Creek	Elkville, N. C.	50.0	1940	70,000	1,400
Linville River	Branch, N. C.	65.0	1940	39,500	608
Wilson Creek	Adako, N. C.	66.0	1940	99,000	1,500
Catawba River	Marion, N. C.	170	1940	71,000	418
Swannanoa River	Whitson Ave., Swannanoa	60.4	1916	24,000	399
Beetree Creek	Farm School Road	14.1	1916	6,000	426

Frequency

It is not possible to assign a probability of occurrence or frequency to the Maximum Probable Flood. The occurrence of such a flood would be a rare event; however, it could occur in any year.

Possible Larger Floods

Floods larger than the Maximum Probable are hydrologically possible; however, the combination of factors that would be necessary to produce such floods would seldom occur. The consideration of floods of this magnitude is of greater importance in some problems than in others but should not be overlooked in the study of any problem.

HAZARDS OF GREAT FLOODS

The amount and extent of damage caused by any flood depend in general upon how much area is flooded, the height of flooding, the velocity of flow, the rate of rise, and the duration of flooding.

Areas and Heights of Flooding

The areas flooded by the Maximum Probable and maximum known floods are shown on Plates 7 and 8. Depths of flow can be estimated from the crest profiles which are shown on Plates 9 and 10.

Profiles were computed by using stream characteristics for selected reaches as determined from observed flood profiles, topographic maps, and cross sections which were surveyed in 1963. The elevations shown on Plates 9 and 10 and the overflow areas shown on Plates 7 and 8 have been determined with an accuracy consistent with the purposes of this study and the accuracy of the basic data. More precision would require costly surveys not warranted by this study.

The profiles of the Maximum Probable Floods depend in part upon the degree of destruction or clogging of various bridges during the floods. Because it is impossible to forecast these events, it was assumed that all structures would stand and that no clogging would occur.

The Maximum Probable Flood profile on the Swannanoa River is from 2 to 25 feet higher than elevations experienced in the July 1916 flood, and about 12 feet higher over most of the reach. The maximum difference occurs in the gorge section of the stream approximately at Mile 9. On Beetree Creek the Maximum Probable Flood profile is from 3 to 10 feet higher than elevations experienced in the July 1916 flood and about 5 feet higher over most of the reach.

Figures 10 to 13 on pages 51 and 52 show the height that would be reached by the Maximum Probable Flood at several locations in the vicinity of Swannanoa.

Velocities, Rates of Rise, and Duration

Water velocities during the Maximum Probable Flood depend largely upon the size and shape of the cross section, the condition of the stream, and the bed slope, all of which vary on different streams and at different locations on the same stream.

During the Maximum Probable Flood, velocities in the main channel of the Swannanoa River in the gorge section from about Mile 8 to about Mile 12.8 would, in general, be about 19 feet per second with a maximum of about 25 feet per second. In the remaining portion of the stream which this study covers, channel velocities would range from about 3 to 15 feet per second. In the overflow area, velocities would range from less than 1 to about 7 feet per second with a maximum of about 14 feet per second in the right-bank overflow plain below the Swannanoa School.

The Maximum Probable Flood on the Swannanoa River one-half mile upstream from the Whitson Avenue bridge would rise about 18 feet above low water to its crest stage in 8 hours with a maximum rate of rise of 5 feet in one hour. Bankfull stage in the vicinity of the old U. S. Highway 70 bridge, Mile 14.8, would be exceeded for approximately 12 hours.

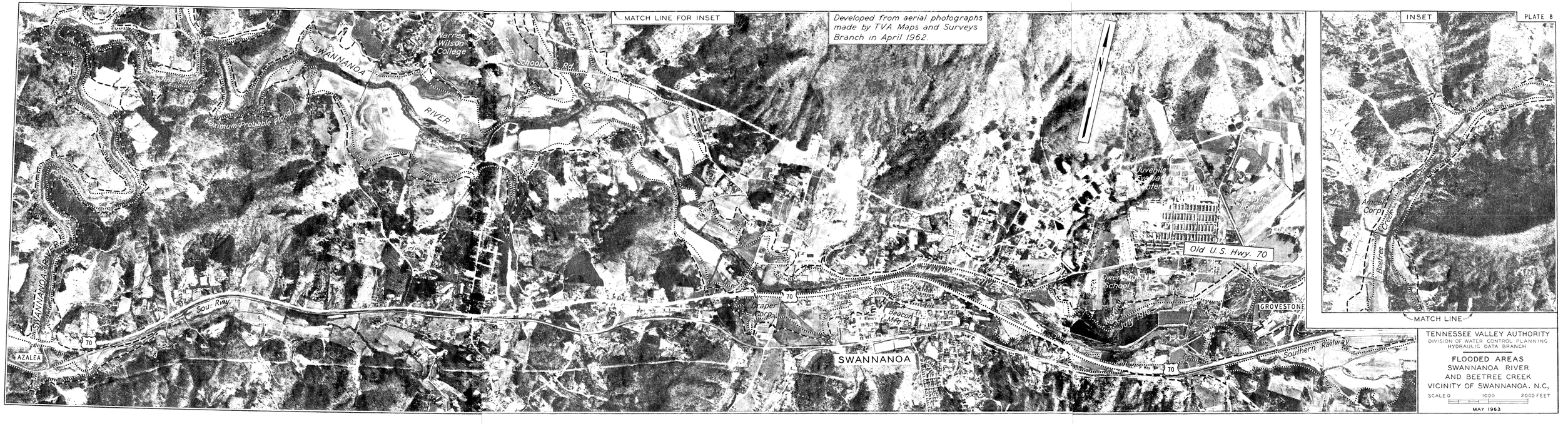
During the Maximum Probable Flood, velocities in the main channel of Beetree Creek would in general range from about 5 to about 19 feet per second with a maximum velocity of about 25 feet per second in the vicinity of Beetree Church, Mile 2.0. Velocities in the overflow area of Beetree Creek would range from about 1 to about 9 feet per second.

The Maximum Probable Flood on Beetree Creek at Mile 0.30 would rise about 11 feet above low water to its crest stage in 3 hours with a maximum rate of rise of about 4 feet in one-half hour. At this location the Maximum Probable Flood would exceed bankfull stage for approximately 11 hours.

These rapid rates of rise and high stream velocities in combination with deep flooding would create a hazardous situation in developed areas.

HD-1311


TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH
FLOODED AREAS
SWANNANOA RIVER
AND BEETREE CREEK
VICINITY OF SWANNANOA, N. C.
SCALE 0 1000 2000 FEET
MAY 1963
PLATE 7
LEGEND:
Overflow Limits
July 1916
Maximum Probable Flood *
M-11 Miles above Mouth
12 Cross Section
1 Section from previous report
2172.4 Ground Elevation in feet (1936 Suppl Adj)
Contour interval 40 feet
* Regulated on Swannanoa River
Overflow areas developed by Hydraulic Data Branch.
Elevations for Maximum Probable Floods computed by Flood Control Branch.
Base map is a portion of USGS-TVA topographic maps 201 SW, 201 SE, dated 1943 and 201 NW, dated 1947.
MATCH LINE FOR INSET
INSET
MATCH LINE
SWANNANOA
RIVER
Jones Mtn
Warren Wilson College
New Salem Ch
Wilson
Lower Swannanoa Sch
Piney Grove Ch
Swannanoa Sch
PATTON CEM
Grovemont
RADIO TOWER (WANJ)
Old U.S. Hwy. 70
NORTH FK
GROVESTONE
SWANNANOA
Beacon Mfg Co
Zion Ch
SOUTHERN RWY
Christian Creek
AZALEA
Beetree Cr
Beetree Rd
School Rd.
LAKE EDEN
Gregg Br
Flow


MATCH LINE FOR INSET
Developed from aerial photographs made by TVA Maps and Surveys Branch in April 1962.
Warren Wilson College
SWANNANOA
RIVER
Maximum Probable Flood
School Rd.
Beetree Cr.
SWANNANOA RIVER
Sou. Rwy.
AZALEA
70
Draper Corp.
Beacon Mfg Co.
SWANNANOA
Juvenile Diagnostic Center
Old U.S. Hwy. 70
Owen High School
Kenilworth Inn
GROVESTONE
Southern Railway
July 1916
INSET
PLATE 8
Amcell Corp.
Beetree Creek
MATCH LINE
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH
FLOODED AREAS
SWANNANOA RIVER
AND BEETREE CREEK
VICINITY OF SWANNANOA, N.C.
SCALE 0 1000 2000 FEET
MAY 1963

Azalea

Swannanoa

Grovestone

Historic flood profiles and magnitude of Regional Flood determined by Hydraulic Data Branch.

Profiles of Maximum Probable and Regional Floods (Regulated) computed by Flood Control Branch.

Gorge

Maximum Probable Flood (Regulated)

Regional Flood (Regulated)

July 1916

August 13, 1940

Water Surface-Jan. 1963 Stream Bed

Aug. 30, 1940

Top of Bank

Floor

Clearance

Butt Creek

Private Road

Farm School Road

Beetree Creek

Secondary Road

Maximum Probable Flood (Regulated)

Regional Flood (Regulated)

Aug. 13, 1940

Aug. 30, 1940

1928

Floor

Clearance

July 1916

Top of Bank

Water Surface-Jan. 1963 Stream Bed

Old U.S. Hwy. 70

Whitson Ave.

Eskridge Creek

Sleepy Branch

U.S. Hwy. 70

Southern Ry.

North Fork Swannanoa River

Section from Black Mtn. Montreat Report

Section

Section

U.S. Hwy. 70

Section from Asheville Report

Section

ELEVATION IN FEET (USC & GS 1936 SUPPL. ADJ.)

2160 2140 2120 2100 2080 2060 2040

2240 2220 2200 2180 2160 2140 2120 2100 2080 2060 2040

MILES ABOVE MOUTH

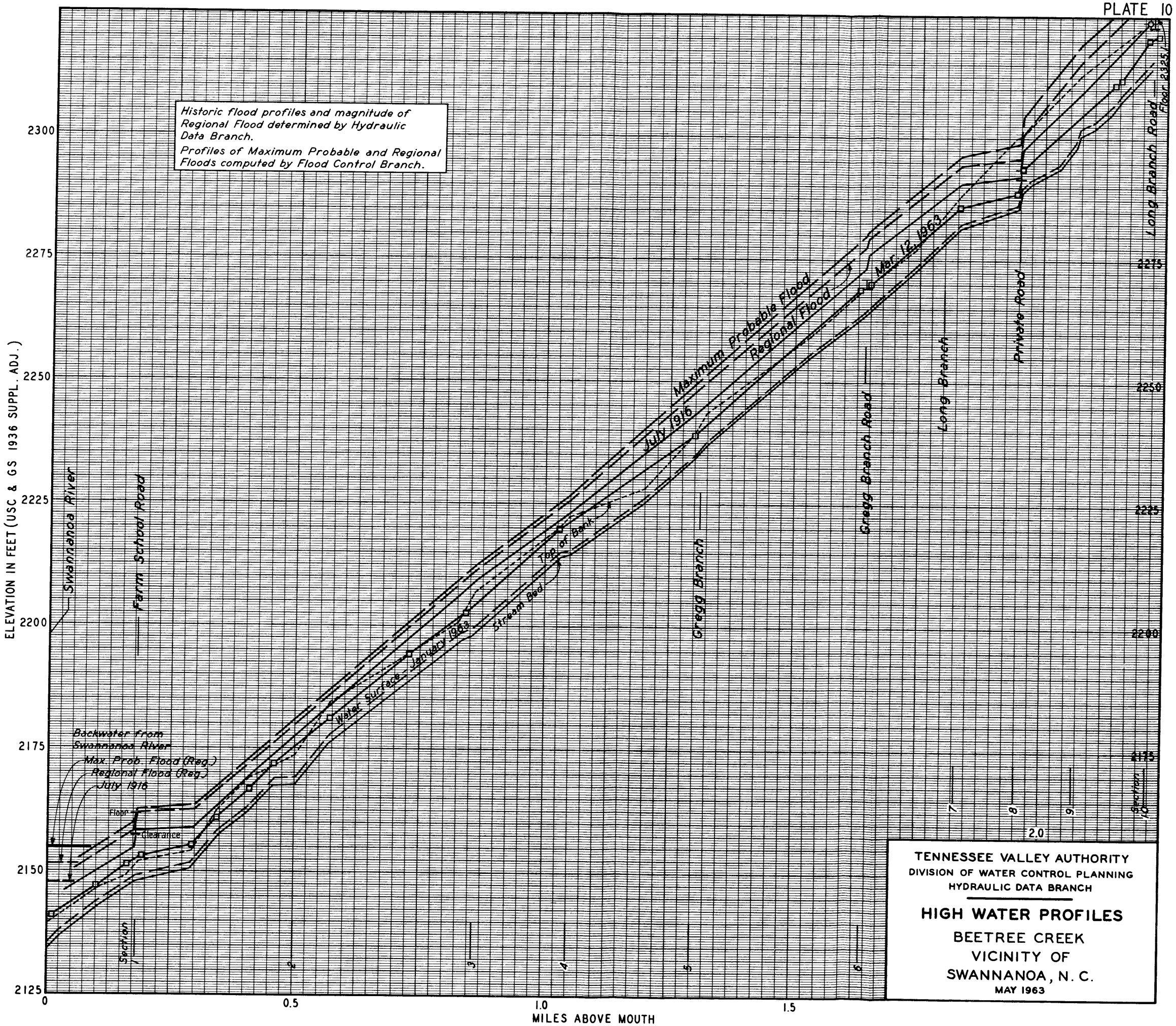
7 8 9 10 11 12 13 14 15

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

HIGH WATER PROFILES
SWANNANOA RIVER
VICINITY OF
SWANNANOA, N. C.
MAY 1963

PLATE 10

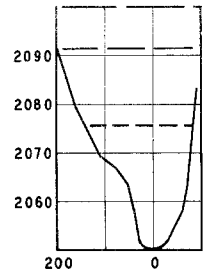


HD-1311

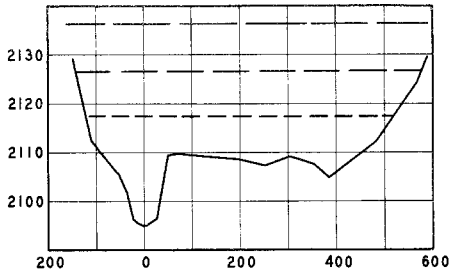
Sections taken looking downstream.

Elevations of Maximum Probable and Regional Floods computed by Flood Control Branch.

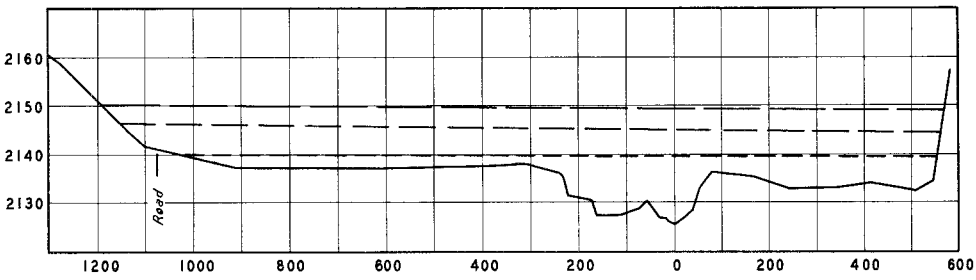
Maximum Probable and Regional Floods are regulated on Swannanoa River.



SECTION 2-MILE 8.56

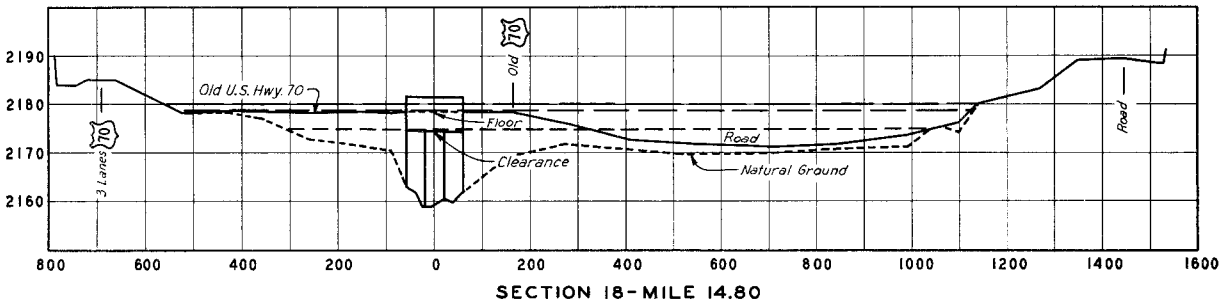


SECTION 9-MILE 11.40



SECTION 14-MILE 13.16

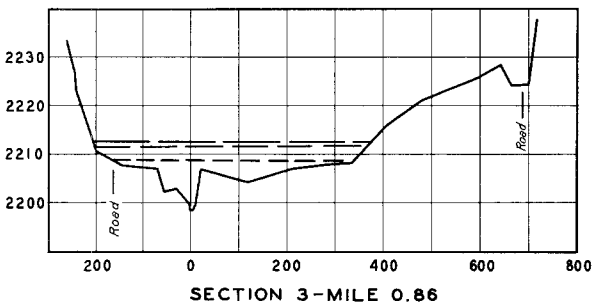
ELEVATION IN FEET (USC & GS 1936 SUPPL. ADJ.)



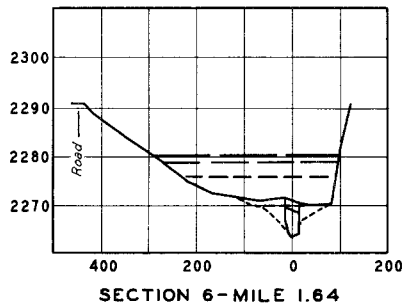
SECTION 18-MILE 14.80

18 sections not shown

SWANNANOA RIVER



SECTION 3-MILE 0.86



SECTION 6-MILE 1.64

8 sections not shown

LEGEND:

——— ——— Maximum Probable Flood

— — — Regional Flood

— — — — — July 1916

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

CROSS SECTIONS

SWANNANOA RIVER AND BEETREE CREEK VICINITY OF SWANNANOA, N.C.

MAY 1963

HORIZONTAL DISTANCE IN FEET

BEETREE CREEK

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