

FLOODS ON SWANNANOA RIVER AND FLAT CREEK

Vicinity of BLACK MOUNTAIN & MONTREAT NORTH CAROLINA



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE

May 24, 1962

Colonel Harry E. Brown, Director
State of North Carolina Department of
Water Resources
Post Office Box 9392
Raleigh, North Carolina

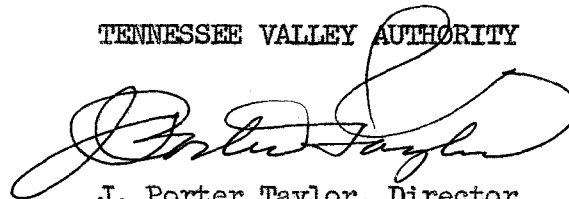
Dear Colonel Brown:

In response to the request of the Black Mountain Town Council and the Vice President of the Mountain Retreat Association, the governing body for Montreat, through the North Carolina Department of Water Resources, TVA has prepared the report, Floods on Swannanoa River and Flat Creek, Vicinity of Black Mountain and Montreat, North Carolina. The purpose of this report is to provide basic information on floods that have occurred or may occur which would be helpful in the state and local programs of city planning and development at Black Mountain and Montreat. We are furnishing you copies of the report for distribution to the appropriate state and city agencies and individuals.

Also, copies of the report are being furnished interested Federal agencies for their information and use.

Very truly yours,

TENNESSEE VALLEY AUTHORITY



J. Porter Taylor, Director
Division of Navigation and
Local Flood Relations

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

FLOODS
ON
SWANNANOA RIVER
AND
FLAT CREEK
IN VICINITY OF
BLACK MOUNTAIN
AND
MONTREAT
NORTH CAROLINA

REPORT NO. 0-6172

KNOXVILLE, TENNESSEE
APRIL 1962

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COVER PHOTO

Flood of July 1916 destroys Southern Railway bridge at Mile 21.33 on Swannanoa River in Black Mountain, North Carolina. Photograph furnished by Gragg Studio, Black Mountain, North Carolina.

FOREWORD

Tennessee Valley Authority
Division of Water Control Planning

FOREWORD

This report relates to the flood situation along the Swannanoa River and Flat Creek in the vicinity of Black Mountain and Montreat, North Carolina. It has been prepared at the request of the Black Mountain Town Council and the Vice President of the Mountain Retreat Association, the governing body for Montreat, 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 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 Black Mountain and the Mountain Retreat Association 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 Black Mountain and Montreat flood problem. The first brings together a record of the largest known floods of the past on the Swannanoa River and Flat 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 the Swannanoa River and Flat Creek and generally within 50 miles of Black Mountain and Montreat. The third develops the Maximum Probable Floods for the Swannanoa River and Flat 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 physical features of reservoirs, dams, powerhouses, and local flood protection works.

The report contains maps, profiles, and valley cross sections which indicate the extent of flooding that has been experienced and that might occur in the future in the Black Mountain and Montreat vicinity.

In problems concerned with the control of developments in the flood plains of the Swannanoa River and Flat 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 derived from a study of those that have occurred on streams of similar physical characteristics in the region of Black Mountain and Montreat, and (3) the Maximum Probable Floods that it is estimated might occur.

This report should be useful in planning new developments in the flood plain. From the maps, profiles, and cross sections, the depth of probable flooding by either recurrence of the largest known flood 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

Black Mountain, North Carolina, is located on the Swannanoa River 21 miles above the confluence of Swannanoa River and the French Broad River at Asheville. Flat Creek, a tributary with a drainage area of 6.05 square miles, joins Swannanoa River at Black Mountain. Montreat is a development owned by the Mountain Retreat Association, under the control of the Presbyterian Church in the United States, and having the powers and responsibilities of a municipality under the laws of the State of North Carolina. The headwaters and all but the lower 1.5 miles of the channel of Flat Creek are within the property of the Mountain Retreat Association. The corporate limits of Black Mountain extend for 0.3 mile along Flat Creek and for 1.0 mile along the Swannanoa River. This investigation covers the Swannanoa River from Mile 17.36 to Mile 22.3 and Flat Creek from the mouth to Mile 2.6. The total area of the Swannanoa River watershed above the lower limit of the reach studied in this report is 22.2 square miles.

In recent years there has been increased development of the flood plains of the upper Swannanoa River and Flat Creek. Many commercial establishments and residences are subject to flooding. Black Mountain has experienced overflows a number of times since it was incorporated 69 years ago, the largest of these being in July 1916. The most recent serious flooding occurred in June 1949.

There are no records of river stage or discharge on the Swannanoa River at Black Mountain or on Flat Creek at Montreat. Records of river stage and discharge were maintained from 1920 to 1926 and from 1934 to date on the Swannanoa River just above the mouth at Biltmore. 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 the Swannanoa River and Flat Creek in the vicinity of Black Mountain and Montreat, 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 KNOWN FLOOD on the upper Swannanoa River and Flat Creek of which there is definite knowledge occurred on July 16, 1916. Two high water marks are known for this flood in the Black Mountain area, but there is not sufficient data to develop high water profiles. Overflow was "hill to hill" on Flat Creek below the Montreat property and on the Swannanoa River through Black Mountain, but there was little development along the streams at that time.

* * *

A GREAT FLOOD occurred on the Swannanoa River in April 1791, soon after settlement of the region began. The available evidence indicates that this flood exceeded the flood in 1916 by five feet or more on the lower Swannanoa River. It is probable that the flood was greater than the 1916 flood on the upper Swannanoa River and on Flat Creek also.

* * *

OTHER BIG FLOODS on the Swannanoa River, for which data were obtained, occurred on August 16, 1928; August 13 and 30, 1940; and on June 16, 1949. The flood of August 13, 1940, was the highest of these, reaching within about 1 to 3 feet of the flood of July 1916 in the Black Mountain vicinity. The August 13, 1940, and June 1949 floods were also important on Flat Creek. The 1940 flood was slightly higher than the 1949 flood and had about the same relation to the 1916 flood as on Swannanoa River.

* * *

REGIONAL FLOODS on the Swannanoa River and Flat Creek in the vicinity of Black Mountain and Montreat are based upon floods experienced on streams within 50 miles of the two communities, a number of which are larger than any known floods on the two streams. This indicates that greater floods than those of which there is definite knowledge so far may reasonably be expected in the future. Based upon the magnitude of floods that have occurred on the neighboring streams, a Regional Flood may occur on the Swannanoa River at Black Mountain that would be generally 1 to almost 14 feet higher than the August 13, 1940, flood crest. This flood would not be much greater than the 1791 flood under present channel and flood plain conditions and would be only a few feet higher than the 1916 flood. A Regional Flood on Flat Creek in the vicinity of Black Mountain and Montreat would reach stages generally 2 to 13 feet higher than the June 1949 flood crest.

* * *

MAXIMUM PROBABLE FLOOD determinations indicate that floods could occur on the Swannanoa River in the Black Mountain vicinity up to about 14 feet higher than the 1940 flood crest. Here again, this flood would not be appreciably greater than the 1791 flood under present conditions. A Maximum Probable Flood on Flat Creek would be 3 to 15 feet higher than the 1949 flood.

* * *

FLOOD DAMAGES that would result from a recurrence of floods as large as those of July 1916 on the Swannanoa River and Flat Creek would be considerably greater than in the actual flood because of the development now in 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 even heavier damages.

* * *

MOST FREQUENT FLOOD OCCURRENCES on the Swannanoa River and Flat Creek have been in the late spring and summer and especially in August. Most of the higher floods have been summer floods resulting from very heavy hurricane rainfall or intense thunderstorms. However, floods occur also in the fall and winter months, and on small drainage areas such as that above Black Mountain and Montreat large floods may come at any time.

* * *

VELOCITIES OF WATER during the July 1916 flood ranged up to 13 feet per second in the channel of the Swannanoa River in the Black Mountain vicinity and up to 8 feet per second on the flood plain. Along the lower reaches of Flat Creek, velocities in the channel and flood plain were probably comparable with those on the Swannanoa River. Farther upstream near Montreat the velocities were as much as 19 feet per second in the channel and up to 6 feet per second in the overbank areas. During a Maximum Probable Flood, velocities on the Swannanoa River and on lower Flat Creek would range up to 15 feet per second in the channel and up to 9 feet per second on the flood plain. For Flat Creek at Montreat the corresponding figures would be 19 and 6 feet per second.

* * *

DURATION OF FLOODS is short on both the Swannanoa River and Flat Creek. In the flood of June 1949 both streams were above bankfull stage in the Black Mountain vicinity for about 12 hours. On the lower river at Biltmore, where this flood was less severe, the river was above bankfull stage 6 hours. In the flood of August 13, 1940, the period above bankfull stage at Biltmore was 14 hours; the average rate of rise was 0.6 foot per hour and the maximum rate was about 2.4 feet per hour. It is probable that at Black Mountain and Montreat the rates of rise exceeded these figures. During the Maximum Probable Flood the rise on Swannanoa River at Black Mountain would be about 10 feet in 3 hours, with a maximum rate of about 4.5 feet per hour. On Flat Creek at Montreat, the rate of rise would be 14 feet in $1\frac{1}{2}$ hours and the maximum rate about 10 feet in one-half hour.

* * *

HAZARDOUS CONDITIONS would occur during very large future floods as a result of the rapidly rising streams, the high velocities, and the 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 on the Swannanoa River and Flat Creek are shown in Table 1. The table compares these future flood crests under present conditions with the crest of the August 13, 1940, flood on Swannanoa River and June 16, 1949, flood on Flat Creek.

TABLE 1
RELATIVE FLOOD HEIGHTS
IN VICINITY OF BLACK MOUNTAIN AND MONTREAT

<u>Flood</u>	<u>Location</u>	<u>Mile</u>	<u>Estimated Peak Discharge cfs</u>	<u>Above 1940 Flood feet</u>	<u>Above 1949 Flood feet</u>
<u>Swannanoa River</u>					
Aug. 13, 1940	Southern Railway	17.58	10,000	0	
Regional			24,500	8.6	
Maximum Probable			28,000	8.9	
Aug. 13, 1940	at Lakey Street	20.96	7,000	0	
Regional			18,500	5.7	
Maximum Probable			21,200	6.0	
<u>Flat Creek</u>					
June 16, 1949	at Montreat Dam	2.49	1,600		0
Regional			7,000		4.0
Maximum Probable			10,000		4.6

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, Flat Creek, in the vicinity of Black Mountain and Montreat, Buncombe County, North Carolina. The portion of Swannanoa River considered extends from Mile 17.36, at the mouth of North Fork Swannanoa River and 3.6 miles downstream from Black Mountain, to Mile 22.3, 0.8 mile above the upper corporate limit of Black Mountain. The investigations on Flat Creek cover the 2.6 miles of the stream from the mouth to the head of Lake Susan in Montreat. Flat Creek joins the Swannanoa River at Mile 21.45, in Black Mountain. One mile of the Swannanoa River and 0.3 mile of Flat Creek are within the corporate limits of Black Mountain. Flat Creek above Mile 1.5 is within the property owned by the Mountain Retreat Association, a corporation under the direction of the Presbyterian Church in the United States.

The Swannanoa River flows generally westward in the reach investigated. Flat Creek flows generally southward through Montreat to its confluence with Swannanoa River. In the center of the Presbyterian Church assembly development is Montreat Dam, 23 feet high, forming Lake Susan with a surface area of about $1\frac{1}{2}$ acres. The region is heavily forested and steeply mountainous except for the relatively wide bottom land along the lower portion of Flat Creek and along Swannanoa River. The larger part of the developed area at Black Mountain, including the main business district, lies on high ground but some commercial and industrial development and a number of residences are on the flood plain. Below the Montreat boundary the land along Flat Creek has been largely developed to commercial and residential use. Within the assembly grounds there is little or no bottom land along the stream and developments are generally above flood height.

No records of river stages or discharges have been maintained on the Swannanoa River at Black Mountain or Flat Creek at Montreat. Streamflow records have been kept intermittently since 1920 on the Swannanoa River at Biltmore, 20 miles downstream from Black Mountain.

(1) Prepared by Hydraulic Data Branch.

Flood history investigations made by TVA Hydraulic Data Branch engineers in 1941 developed information on floods on the Swannanoa River downstream from the mouth of North Fork Swannanoa River. In 1950 investigations were made to extend the information on floods on the Swannanoa River upstream through Black Mountain and on Flat Creek from the mouth through Montreat. 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 on Swannanoa River and Flat Creek at Black Mountain and Montreat covering the past 60 years or more.

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 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 to Biltmore, near the mouth of Swannanoa River, on October 3, 1880. This line is now a 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 settlement which developed at the site of Black Mountain was first known as Gray Eagle. It was renamed Black Mountain for the nearby range of mountains of that name in 1870. Black Mountain was incorporated on March 4, 1893. The 1960 Census Report gives the population of Black Mountain as 1313 persons. However, a large portion of the community lies outside the present corporation limits. Property to the north and west of the original limits has been annexed in recent years and other additions are being contemplated.

The town of Black Mountain has for some time been one of the more important resort centers in the Asheville area. A number of private summer camps surround it and five religious assembly grounds are located nearby. The largest assembly area is owned by the Presbyterian Church at Montreat, in the Flat Creek valley upstream from Black Mountain. The tract contains some 3000 acres of land, mostly in forest, and includes essentially all of the watershed of Flat Creek above Mile 1.5.

The name Montreat comes from "Mountain Retreat Association," the corporation which was chartered by the State of North Carolina to operate the facility March 2, 1897. The charter created the town of Montreat at the same time and gave to the corporation the powers and functions of a municipality. First operated as an interdenominational religious assembly area, Montreat was purchased by the Presbyterian Church in the United States in 1906, to be used for summer conferences and as a site for summer homes for church people.

Montreat College was established on the church ground in 1916. Operated for some time as a four-year girls' school, it now has a two-year coeducational program and operates under the name of Montreat-Anderson College. The present enrollment is about 250.

Some 400 homes are on the Montreat grounds. Only about 50 of these are occupied the year around so that only a few hundred persons are there during the winter months. In the summer the homes are fully occupied and with the attendance at the various camps and conferences there may be 2500 persons in residence at any one time. Planning studies are currently being made which envision doubling the capacity of the college, making extensive improvements to the buildings now in use, and adding new facilities.

The Stream and Its Valley

The Swannanoa River drains a rugged mountain area of 133 square miles, lying wholly within Buncombe County, North Carolina. The river basin is about 17 miles long and 7 to 10 miles wide. The stream flows generally westward and joins the French Broad River at Asheville, 21 miles downstream from Black Mountain.

In the vicinity of the towns of Black Mountain and Montreat the principal streams are the upper reach of the Swannanoa River and Flat Creek. This

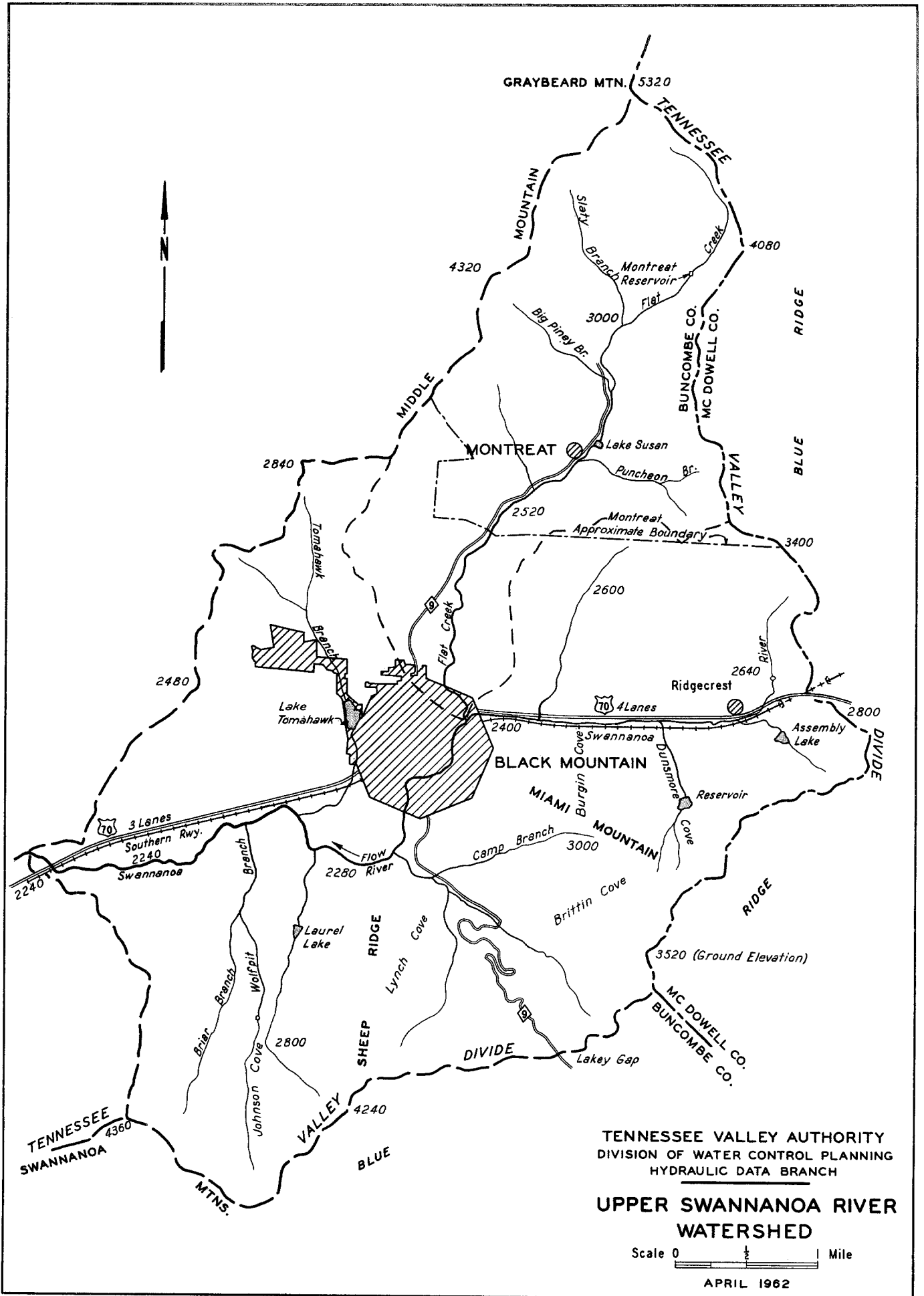
part of the watershed, shown on Plate 1, is about 8 miles long and $2\frac{1}{2}$ to $4\frac{1}{2}$ miles wide. The total drainage area at the lower limit of the reach studied in this report is 22.2 square miles. Flat Creek flows through Montreat and joins the Swannanoa River within the corporate limits of Black Mountain. Both Flat Creek and Swannanoa River have their origin on the western slopes of the Blue Ridge, which separates the Tennessee Valley drainage from the Atlantic Coast drainage to the east. The watershed above Black Mountain is mountainous and heavily forested except for some reaches along the streams. Elevations range from 2340 feet at the town of Black Mountain to as high as 5360 feet at Graybeard Mountain, 4.5 miles north.

The Swannanoa River is formed at Ridgecrest, where a number of small streams converge from the steep coves and ridges. The stream flows westward to Black Mountain, makes a semicircle to the south of the main business district, then continues westward to the confluence with North Fork Swannanoa River at Grovestone.

The principal tributary to upper Swannanoa River is Flat Creek, which will be discussed later. Tomahawk Branch, which heads up on the slopes of Middle Mountain, flows through the western part of Black Mountain and enters Swannanoa River at Mile 19.39. Two streams drain the steep slopes of the Blue Ridge and the Swannanoa Mountains which lie south and southwest of Black Mountain. Camp Branch collects the flow from Brittin Cove and Lynch Cove and flows into Swannanoa River at Mile 20.27. Wolfpit Branch enters the stream at Mile 18.97. Pertinent drainage areas in the upper Swannanoa River basin are shown in Table 2.

Channel slopes are steep on the upper Swannanoa River, averaging 36 feet per mile for the reach covered by this investigation. The rate of fall changes gradually from about 60 feet per mile above Black Mountain to about 25 feet per mile near Grovestone. The bottom lands are relatively broad and consist of a thin topsoil underlain by heavy gravel and boulders, evidently deposited by floods of the past. These bottoms are cut up by numerous flood channels and show progressive meandering of the stream channel in the erodible material. The agricultural lands are mostly in pasture.

Flood-plain widths vary from between 300 and 600 feet above the mouth of Flat Creek up to as much as 1600 feet downstream from Black Mountain. Within the corporate limits of the town the flood plain is generally 800 to 1000 feet in width. The widest section is about Mile 18.6 near radio station WFGW. Elsewhere



TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

**UPPER SWANNANOA RIVER
 WATERSHED**

Scale 0 $\frac{1}{4}$ 1 Mile

APRIL 1962

TABLE 2

DRAINAGE AREAS OF STREAMS IN SWANNANOA RIVER WATERSHED

<u>Stream</u>	<u>Location</u>	<u>Mile above Mouth</u>	<u>Drainage Area</u> sq. mi.
Swannanoa River	Upper end of reach	22.30	3.35
	Below Flat Creek	21.40	10.9
	Lakey Street	20.96	11.2
	Southern Railway	17.58	22.1
	Lower end of reach	17.36	22.2
	Biltmore (stream gage)	1.56	130
	Mouth	0	133
Flat Creek	Upper end of reach	2.59	2.76
	Montreat Dam	2.49	2.80
	Montreat boundary	1.51	4.65
	U. S. Highway 70	0.10	6.02
	Mouth	0	6.05
Camp Branch	Mouth	0	2.93
Tomahawk Branch	Mouth	0	1.94
Wolfpit Branch	Mouth	0	1.75

downstream from Black Mountain, the flood-plain width varies between 1000 and 1500 feet except near Mile 19.0 where it narrows to about 600 feet.

The corporate limits of Black Mountain include a one-mile length of the Swannanoa River between Miles 20.56 and 21.55.

Developments in the Flood Plain

Plates 8, 9, and 10 show the flood plain of the Swannanoa River. Except for the immediate area at Black Mountain and along the lower end of the study reach, near Grovestone, the use of the flood-plain lands is limited generally to agriculture.

The Salisbury Line of the Southern Railway crosses the Swannanoa River at Mile 17.58, near Grovestone, and follows the right bank of the river to Black Mountain. It crosses to the left bank at Mile 21.33, in Black Mountain, then

follows that bank to Ridgecrest, where it leaves the basin through a tunnel at Swannanoa Gap. A spur track at Grovestone serves the industries which are in that vicinity. Except at the bridge crossings the track is generally above the elevation of the highest known floods on Swannanoa River.

U. S. Highway 70 carries heavy east-west traffic between Asheville and the Piedmont and Coastal sections of North Carolina. West of Black Mountain, U. S. Highway 70 is a three-lane concrete highway. From Black Mountain east it is a four-lane divided highway which also carries the designation of Temporary Interstate Highway 40. The highway crosses Swannanoa River at Mile 17.56, just downstream from the Southern Railway bridge at Grovestone. Its location lies north of and closely parallel to that of the railway through the basin. Numerous developments of a service nature are along the highway but these are generally above any flood danger.

Planning studies are currently being made to determine the location for Interstate Highway 40 in the vicinity of Black Mountain. It is anticipated that the highway will pass through the Swannanoa River basin between Ridgecrest and Asheville. However, planning studies have not progressed to a point to foretell what effect the highway might have upon developments in the flood plain and upon future floods.

The principal business development of Black Mountain is north of the river along State Street, the main east-west artery of the town, and on Broadway and Cherry Street between State Street and the railway. All the developments in this section are at elevations well above that of the highest known floods on the Swannanoa River. Some of the developments south of the railway are subject to flooding. These include a bulk oil plant on Lakey Street, and a grocery and a riding stable on Black Mountain Avenue. A trailer court is on the left bank, on Sycamore Street between Lakey Street and Black Mountain Avenue. A building supply warehouse and a hosiery mill near the intersection of Lakey and Vance Streets are above the highest floods of the past but are within range of the Maximum Probable Flood. Two churches and about 25 houses are within the area which would be overflowed in a recurrence of the July 1916 flood on the Swannanoa River. A Maximum Probable Flood would affect about 75 houses and a number of the businesses in the vicinity of Sutton Avenue and West Midland Avenue.

Begley's Lake is a private fishing lake development on the left-bank flood plain below the Southern Railway, Mile 21. 1 to 21. 2. Included is a lake of about three acres, an eating place, and a number of trailer parking sites. Nearly all this area is within the range of any large flood.

The land on the right-bank flood plain, Mile 18. 1 to 18. 7, was used for a number of years for a private flying field. In more recent years the site has been used by a firm manufacturing a special low-altitude parachute. Former hangar buildings were converted for use in the assembly of the parachutes and the testing was done from two steel towers erected near the riverbank. This firm is presently in the process of moving its operations to a site outside the Swannanoa River basin and a radio broadcasting station is being built on the land. Three transmitting towers on the right-bank flood plain have bases which range in elevation from 2259. 4 to 2265. 8 feet. Offices, studios, and transmitting equipment will be in a building near the railway, with its principal floor at elevation 2279. 1 feet. A recurrence of the flood of August 13, 1940, would put water over one or more of the tower bases. A Maximum Probable Flood would cover all tower bases and reach an elevation of 2275 feet near the main building, and the Regional Flood would reach an elevation of 2274 feet.

A plant of the Kearfott Division of General Precision, Incorporated, is located on the right bank of Swannanoa River just below U. S. Highway 70. The plant manufactures small electrical components. The buildings are on graded land raised some 18 feet above the original flood-plain elevation. The principal floors are at elevation 2254. 4 feet, about 14 feet above the elevation reached by the flood of August 13, 1940, at the location, and about 7 or 6 feet above the height expected at the site in a Regional or Maximum Probable Flood, respectively.

A number of other industries are in the Grovestone vicinity. Two wood products firms are northeast of the Kearfott plant. A manufacturer of precision tools and components is located south of U. S. Highway 70 at Stepp Branch and 2000 feet southwest of the Kearfott plant. All three of these plants are outside of the Swannanoa River flood plain.

Black Mountain obtains its principal water supply from an intake and reservoir located in Dunsmore Cove, $1\frac{1}{2}$ miles east of the town. An intake on a branch north of Burgin Cove, the original supply for the town, is not used at present. A reservoir located on Miami Mountain, at the east corporate limit, supplies

pressure to the town distribution system. An interconnection at the Montreat property line ties the system to that of the Mountain Retreat Association. Montreat supplies water to Black Mountain at this point as it is available in exchange for fire fighting services. Interconnection to the Asheville water supply is made at a 6-inch line in the northwest section of Black Mountain. Water is available to the system at this point, but the other sources are normally ample for the town's needs.

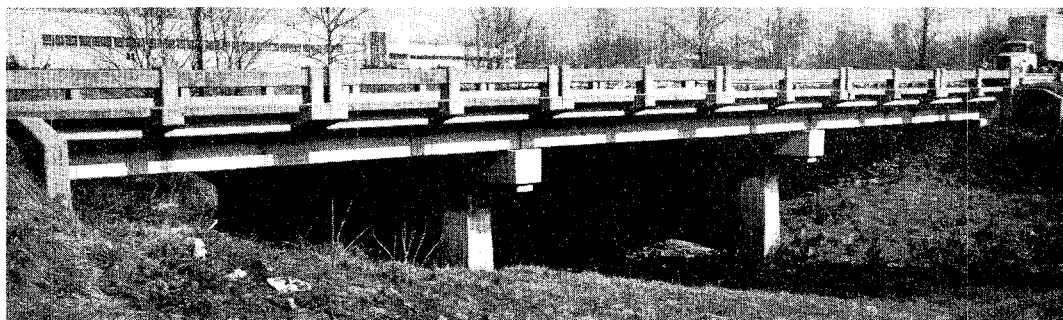
Black Mountain and vicinity are served by the sewerage system of the Swannanoa Sanitary District. An outfall sewer follows the Swannanoa River from Ridgecrest through Black Mountain to Asheville, where it discharges into the French Broad River. The sewer line, constructed in 1929, is now in poor condition. Floods have damaged the line, and settling and shifting have caused numerous leaks and blockages. The system is to be incorporated into a newly organized Metropolitan Sanitary District. This district will include Asheville and the larger part of Buncombe County. A treatment plant to be built near Asheville will treat the sanitary waste from the whole area. It is anticipated that the project will include extensive renovations of the existing collecting system in the Black Mountain vicinity.

Bridges across the Stream

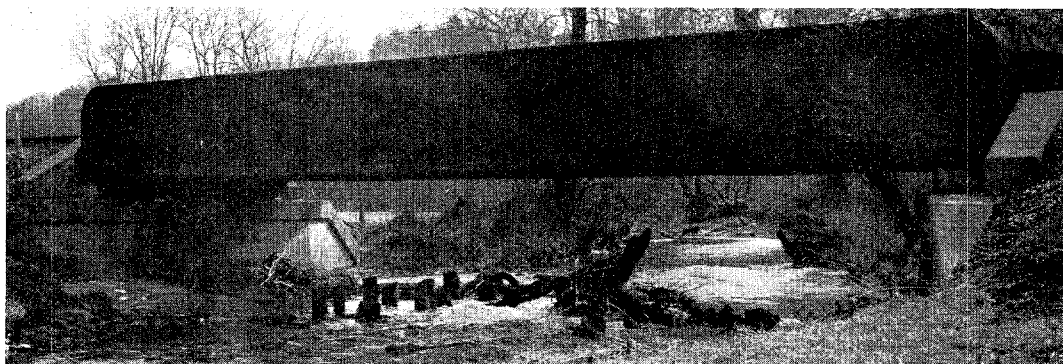
Two railway bridges, six highway bridges, and two private bridges cross the Swannanoa River in the reach included in this investigation. Table 3 lists pertinent elevations for these bridges and shows the relation to the crest of the flood of August 13, 1940, on the river. Plate 11 shows the relation of the floor and underclearance at the bridges to the flood profiles for the reach. Figures 1 and 2 are photographs of all but the two private bridges.

Only one of the bridges, the Southern Railway bridge at Black Mountain, has an underclearance which is above the crest height determined for the flood of July 1916. It is probable, however, that the bridge would be overtopped if a flood of this magnitude were to occur under the present conditions at the site. All the other bridges have floors or approaches which would be affected by floods considerably less severe than the 1916.

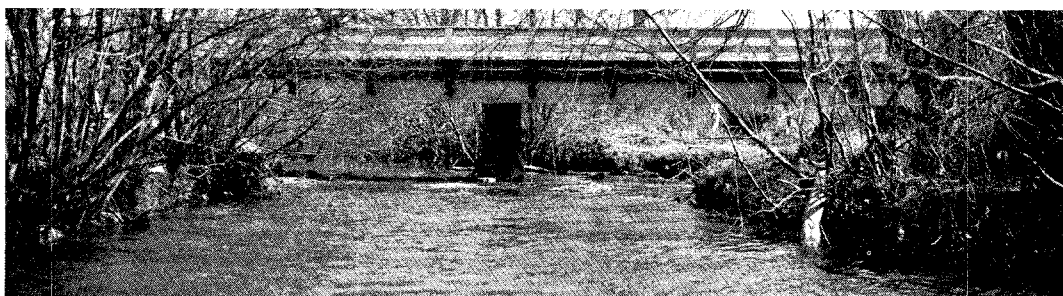
Heavy east-west truck and auto traffic is carried by the three-lane U. S. Highway 70 bridge which is at Mile 17.56. This is a three-span steel and



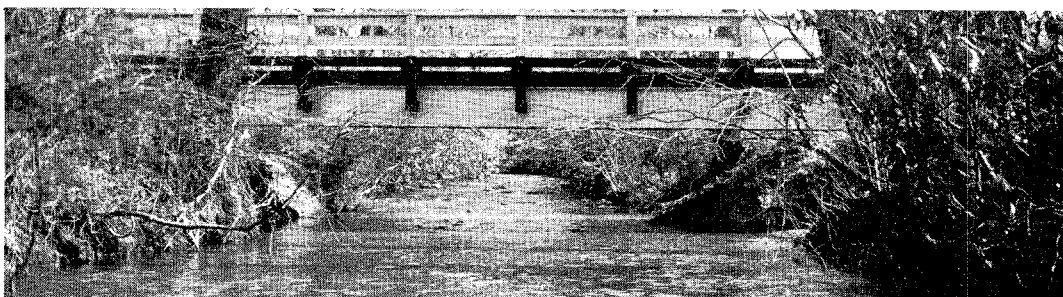
U. S. Highway 70 bridge at Mile 17.56, upstream side,
from railway embankment near bridge shown below.



Downstream side of Southern Railway bridge, Mile 17.58,
from a point beneath the highway bridge shown above.

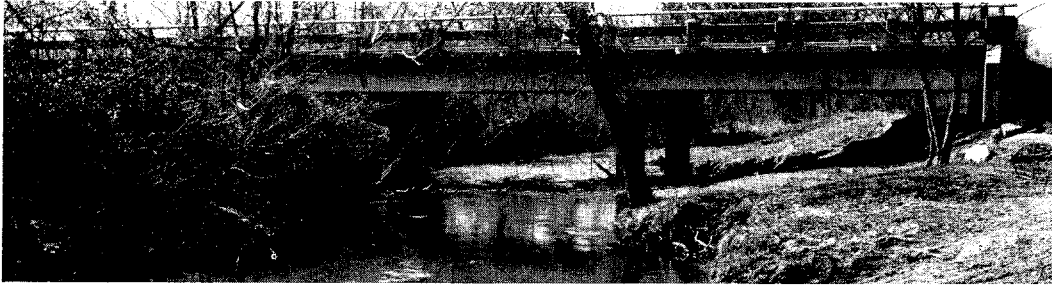


Blue Ridge Road bridge at Mile 19.07, downstream side.

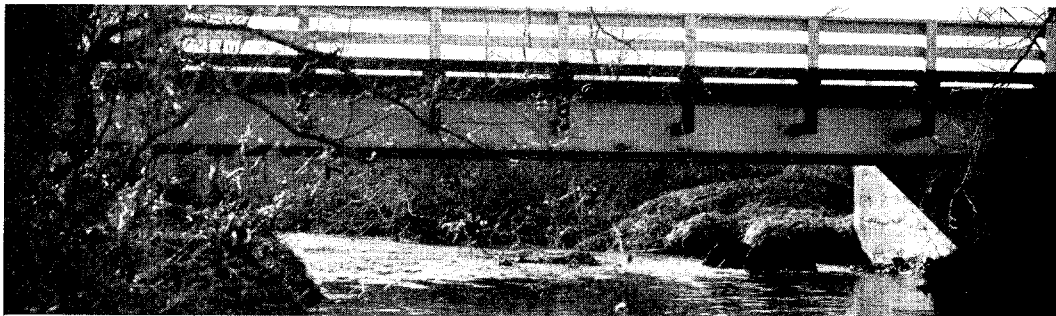


Blue Ridge Road bridge at Mile 20.01, downstream side.

Figure 1. --SWANNANOVA RIVER BRIDGES NEAR GROVESTONE



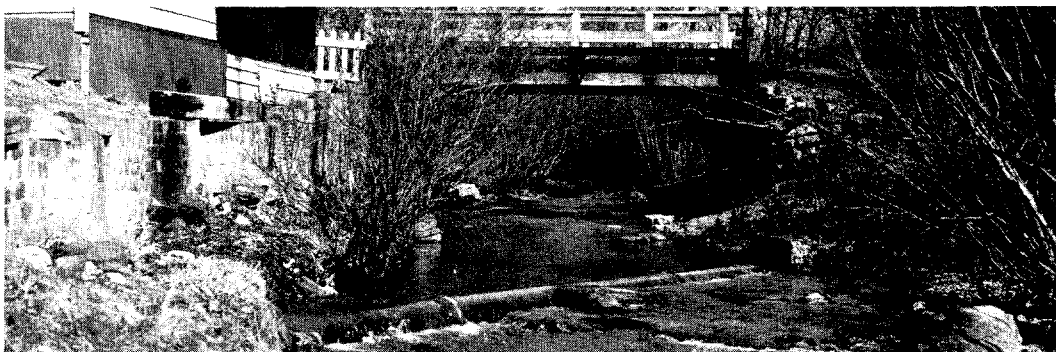
State Highway 9 bridge at Mile 20.89, upstream side.



Lakey Street bridge at Mile 20.96, upstream side.



Southern Railway bridge at Mile 21.33, upstream side.



Bridge at Mile 22.30, downstream side. Note sewer line crossing the stream.

Figure 2. --SWANNANOVA RIVER BRIDGES AT BLACK MOUNTAIN

TABLE 3
BRIDGES ACROSS SWANNANOA RIVER IN VICINITY OF
BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

<u>Mile above Mouth</u>	<u>Identification</u>	<u>Stream Bed Elev. feet</u>	<u>Floor Elev. feet</u>	<u>Aug. 13, 1940, Flood Crest Elevation feet</u>	<u>Underclearance</u>		
					<u>Elev. feet</u>	<u>Above Flood Crest feet</u>	<u>Below Flood Crest feet</u>
17.56	U. S. Hwy. 70	2231.0	2246.0	2241.0	2243.3	2.3	
17.58	Southern Rwy.	2231.3	2244.3 ^(a)	2241.8	2240.8		1.0
19.07	Blue Ridge Rd.	2267.1	2276.9	2277.7	2274.3		3.4
20.01	Blue Ridge Rd.	2293.2	2302.4	2303.4	2299.4		4.0
20.89	N. C. Hwy. 9	2330.0	2341.5	2337.9	2338.9	1.0	
20.96	Lakey Street	2332.4	2341.6	2340.1	2338.6		1.5
21.33	Southern Rwy.	2343.0	2365.2 ^(a)	2353.6	2358.1	4.5	
21.61	Private road	2357.8	2367.1	2366.0	2364.6		1.4
22.11	Private road	2391.2	2399.1	2396.7	2397.4	0.7	
22.30	Road	2404.1	2415.2	2410.0	2413.5	3.5	

(a) Top of rail.

concrete bridge built in 1947. Approach fills block the full 1500-foot width of the flood plain to a height of 5 to 9 feet. The underclearance at the bridge is at elevation 2243.3 feet, 2.3 feet above the crest height for the flood of August 13, 1940. A Maximum Probable Flood would overtop the bridge and road by about five feet.

Blue Ridge Road is a loop highway which serves local traffic south of the river as well as the Blue Ridge Assembly area in Johnson Cove. The road crosses Swannanoa River at two points, Miles 19.07 and 20.01. The lower bridge is a two-span steel girder, timber deck bridge with an approach fill on the left bank which averages about 5 feet in height. The upper bridge is of similar construction with one span. Approach fills there average about 5 feet high on the right bank and 3 feet high on the left bank. Bridges at both of these sites were washed out in 1940. They were replaced and were overtopped again during the flood of June 1949.

Two highway bridges cross Swannanoa River within the corporate limits of Black Mountain. State Highway 9, which carries traffic from Montreat and Black Mountain south to the Lakey Gap area and Bat Cave, crosses at Black Mountain Avenue, Mile 20.89. This three-span steel and concrete bridge was built in 1950 to replace a smaller bridge which had been overtopped by the floods of 1916, 1940, and 1949. The underclearance at the present bridge is above the crest height reached by all except the 1916 flood, but raising of the approach fills for the new bridge at least partially overcame the advantage of the increased opening under the bridge. The floor of the bridge is at elevation 2341.5 feet, but overflow of the left approach will start at 2339 feet, when water will overtop Sycamore Street which parallels the river on that bank. A Maximum Probable Flood would overtop the bridge by about $2\frac{1}{2}$ feet.

Just upstream from Highway 9, at Mile 20.96, is the Lakey Street bridge. This is a one-span steel girder, wood floor bridge which replaces a lighter steel girder bridge that was at the site in 1949. The underclearance at the present bridge is about equal to the 1949 flood crest height but lower than the 1940 flood crest. The floor of the bridge is lower than the 1916 flood crest height. A low approach fill crosses the right-bank flood plain. Access to the bridge is affected when overflow of this approach begins at elevation 2339.8 feet. The flood of July 1916 reached an elevation of 2343.1 feet at this point. A Maximum Probable Flood would reach an elevation of 2346.1 feet.

Three small bridges upstream from the mouth of Flat Creek serve residences south of the railway. All are low structures within range of any large flood. At Mile 21.61 is a single-span steel girder bridge built in 1958 by a private real estate developer to provide access to the Burgin Cove section. A private bridge at Mile 22.11 is of light log and plank construction. The highway bridge at Mile 22.30 is a steel girder wood floor bridge.

The Southern Railway bridge at Mile 17.58, 100 feet upstream from the U. S. Highway 70 bridge, consists of a heavy steel girder span with an underclearance elevation of 2240.8 feet. This is 2.5 feet lower than the underclearance elevation at the highway bridge. The net opening under the bridge is also less than at the highway bridge. The approach fills parallel those of the highway and are slightly lower. The top of the tracks at the bridge is at elevation 2244.3 feet and overflow begins at this elevation. A Maximum Probable Flood at this point is expected to have a crest elevation of 2250.8 feet.

The railway bridge which crosses Swannanoa River in Black Mountain at Mile 21.33, just below the mouth of Flat Creek, has a fill which blocks the flood plain to a height of 13 to 18 feet. The bridge was installed in 1917 to replace one washed out in the 1916 flood. The present opening is wider than at the old bridge but the girders are heavier and deeper, so that the net increase in opening is small. A recurrence of the 1916 flood under present conditions would probably overtop the bridge and fill.

Obstructions to Flood Flow

The numerous bridge approaches on the flood plain of Swannanoa River present substantial obstruction to flood flows. These have been discussed previously. Grading for the Kearfott plant at Grovestone has blocked the right-bank flood plain at that point. Other developments which are on the flood plain do not present any significant obstruction to flood flows.

FLOOD SITUATION

Flood Records

There are no records of river stages or discharges available for the Swannanoa River in the immediate Black Mountain vicinity. Records have been maintained for 33 of the last 41 years at a gaging station on the Swannanoa River at Biltmore, North Carolina, near the mouth of the stream and 20 miles downstream from Black Mountain. The U. S. Geological Survey made observations on a staff gage at the Biltmore Avenue bridge, at River 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 made observations of streamflow on the Swannanoa River at Swannanoa, 5 miles downstream from Black Mountain, from May 1907 to June 1909 and from January 1926 to December 1931, and at Azalea, 13 miles below Black Mountain, from August 1946 through September 1947.

To supplement the record obtained at these gaging stations, local residents were interviewed for information on dates and heights of floods. Files of the Asheville newspapers were searched, as were historical records and documents. Following the flood of June 16, 1949, field investigations were made in

TABLE 4
SWANNANOA RIVER AT BILTMORE, NORTH CAROLINA
FLOOD CREST ELEVATIONS AND DISCHARGES ABOVE BANKFULL STAGE
1791-1962

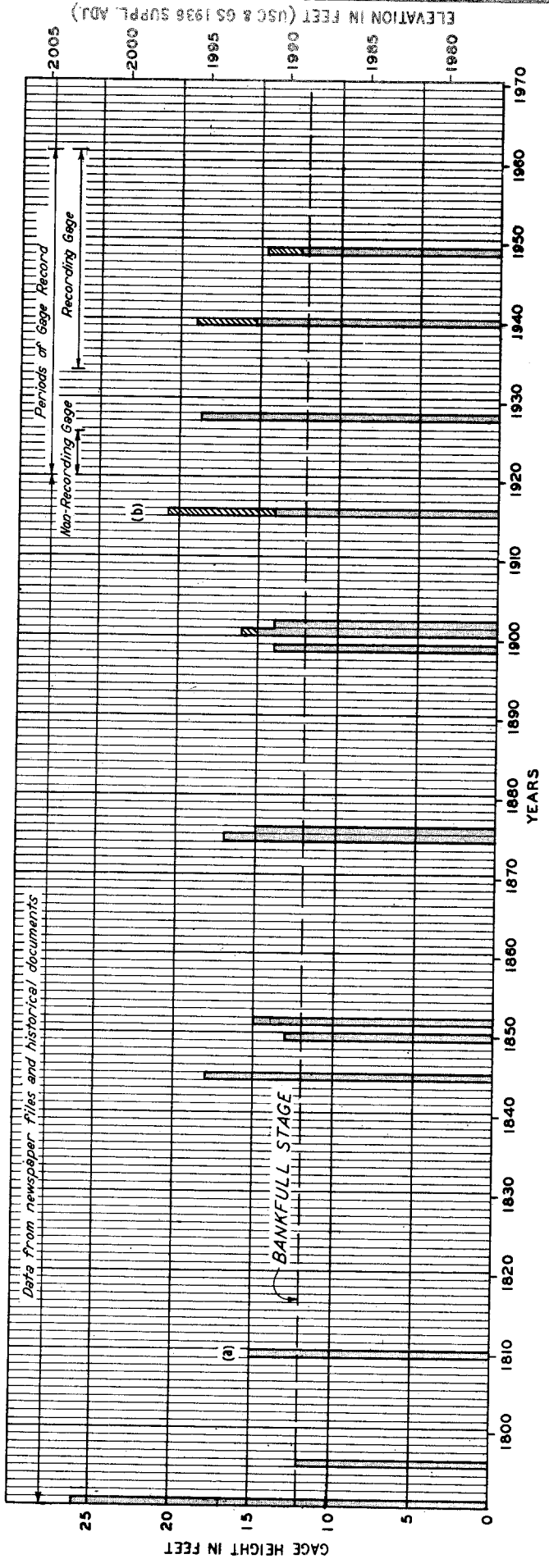
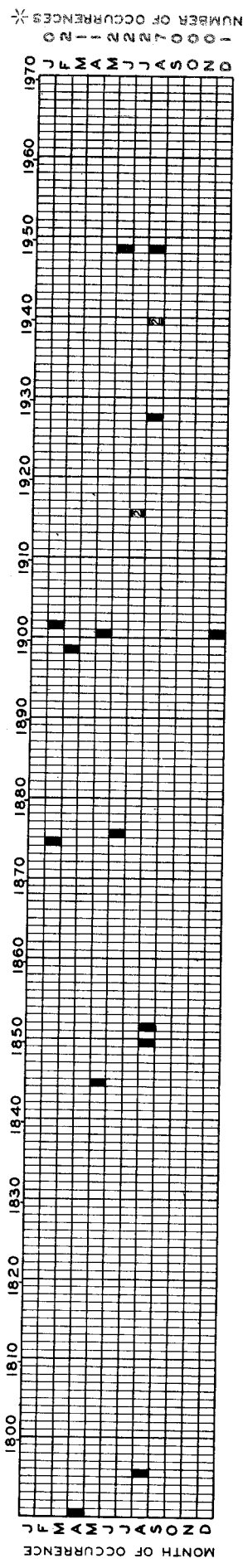
This table includes all known floods above bankfull stage of 12 feet at the U. S. Geological Survey gaging station, River Mile 1.56, just downstream from the Biltmore Avenue bridge. Drainage area is 130 square miles.

<u>Date of Crest</u>	<u>Gage Heights</u>		<u>Peak Discharge</u>	
	<u>Stage</u> feet	<u>Elevation</u> feet	<u>Amount</u> cfs	<u>Per Sq. Mile</u> cfs
April 1791	26	2003	40,000	308
August 1796	15	1992	10,600	82
	1810	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

the Black Mountain-Montreat area and the reports on these have supplied valuable information.

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 8 floods in 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.

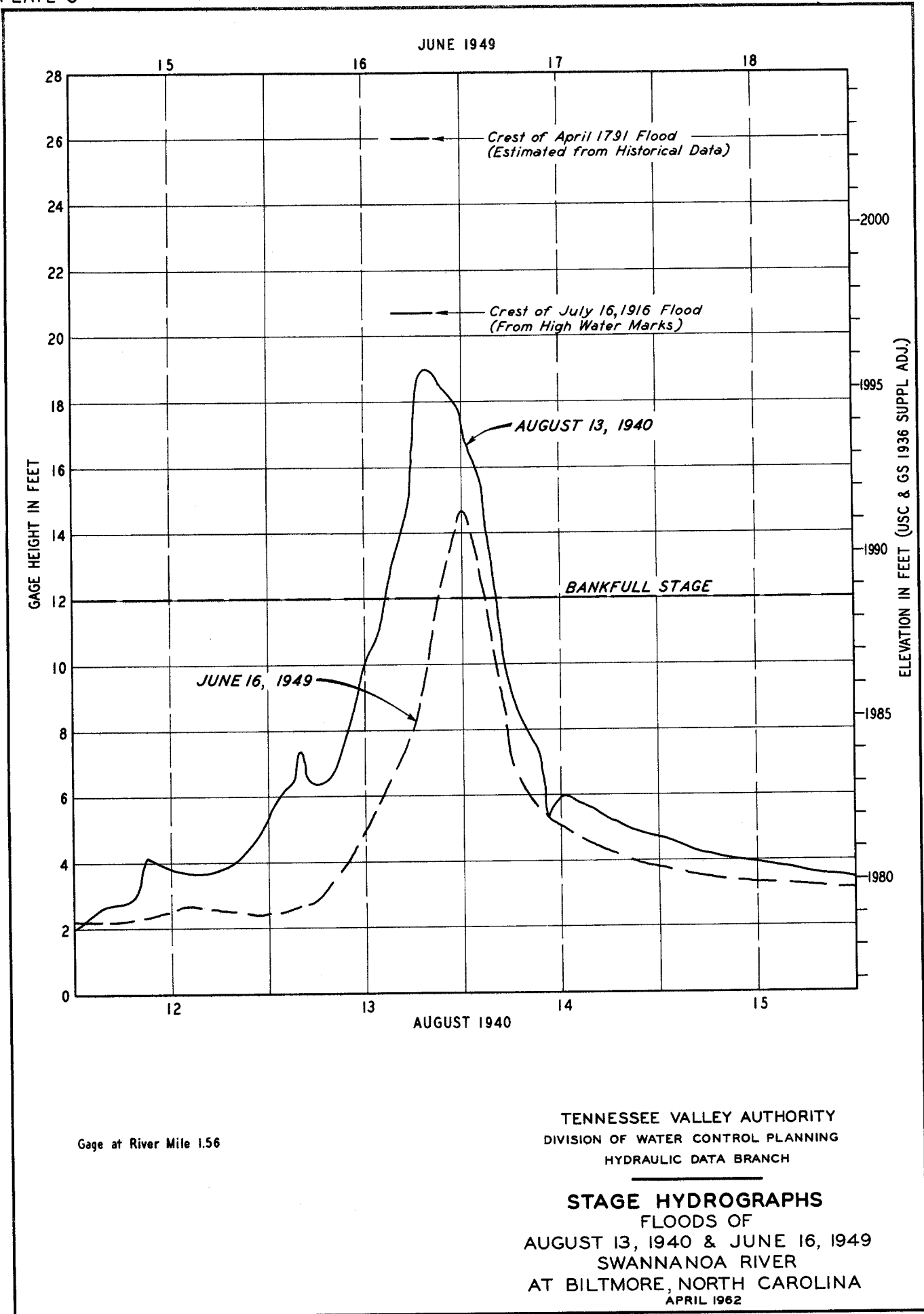


(a) Month unknown.
 (b) Stage based on high water marks.
 All stages referred to
 U.S. Geological Survey gage
 at River Mile 1.56
 * Number of occurrences during 171 years,
 1791-1962, excluding 1810 flood.

TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH
**FLOODS ABOVE
 BANKFULL STAGE**
 SWANNANOVA RIVER
 AT BILTMORE, NORTH CAROLINA
 APRIL 1962

* NUMBER OF OCCURRENCES

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



Gage at River Mile 1.56

TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

STAGE HYDROGRAPHS
 FLOODS OF
 AUGUST 13, 1940 & JUNE 16, 1949
 SWANNANOA RIVER
 AT BILTMORE, NORTH CAROLINA
 APRIL 1962

TABLE 5
HIGHEST KNOWN FLOODS IN ORDER OF MAGNITUDE
SWANNANOA RIVER AT BILTMORE

<u>Order No.</u>	<u>Date of Crest</u>		<u>Gage Height</u>	
			<u>Stage feet</u>	<u>Elevation feet</u>
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
1791-1962

<u>Month</u>	<u>Number of Occurrences</u>	<u>Month</u>	<u>Number of Occurrences</u>
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

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.

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

Rate of Rise and Velocities during Floods

Plate 3 shows stage hydrographs at the Biltmore gaging station for the floods of August 13, 1940, and June 16, 1949. Also shown is the crest stage of the July 1916 flood and the estimated crest stage of the April 1791 flood. During the August 13, 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 6 p. m. on August 13, just $1\frac{1}{2}$ hours before the crest occurring at 7:30 p. m. The period above bankfull stage at Biltmore was 14 hours. In the flood of June 1949, the Swannanoa River was about bankfull stage in the Black Mountain vicinity for about 12 hours and at Biltmore for about 6 hours.

Average velocities in the channel of Swannanoa River at Black Mountain during large floods such as those of 1916, 1940, and 1949, were in the order of 3 to 13 feet per second. In the flood plain, velocities ranged up to 8 feet per second. During the 1791 and larger floods, velocities in both channel and overbank areas might be even greater. The results of high velocity of flow are shown in Figure 3, taken after the 1916 flood, which shows typical damage to the roads then in use by wagons and an occasional automobile.

Flooded Area, Flood Profiles, and Cross Sections

Plate 8 shows the approximate area along the Swannanoa River that was inundated by the flood of August 13, 1940, the highest known flood for which there are sufficient data to develop the overflow limits. Plates 9 and 10 show at an enlarged scale the 1940 overflow for a part of the reach. The actual limits of these overflow areas on the ground may vary somewhat from those shown on the maps because the contour interval of the maps does not permit precise plotting of the flooded area boundaries. The contour interval on Plate 8 is 40 feet. Plates 9 and 10 are based upon maps prepared by the North Carolina State Highway Department which have a contour interval of 5 feet. The latter maps were used wherever available in defining the flooded area.

Plate 11 shows high water profiles on the Swannanoa River for the floods of August 13, 1940, and June 16, 1949, and a high water mark for the July 16, 1916, flood. Also shown are profiles for the Regional and Maximum Probable Floods which are discussed in Sections III and IV, respectively.

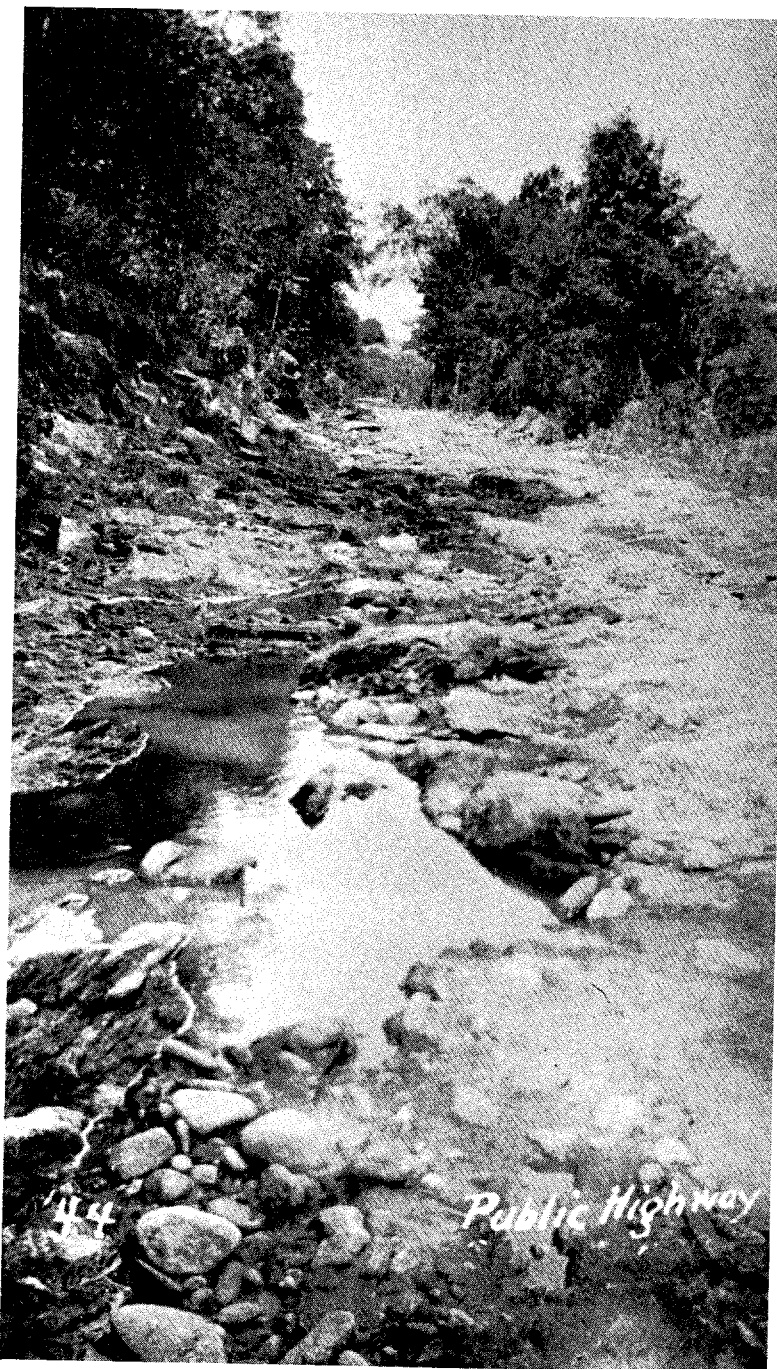


Figure 3. --TYPICAL HIGHWAY DAMAGE IN JULY 1916

The location of this scene is not known, but it is typical of the scour damage sustained by the roads of that day as a result of the flood.

(Photo by Gragg Studio)

Plate 14 shows typical cross sections of the Swannanoa River valley in the reach investigated. The location of the cross sections is shown on the map, Plate 8, and the profile, Plate 11. Each cross section shows the elevation and extent of overflow of the August 13, 1940, the Regional, and the Maximum Probable Floods. A number of cross sections, the locations of which are shown on the afore-mentioned map and profile, are not reproduced but are available from the Hydraulic Data Branch of TVA.

FLOOD DESCRIPTIONS

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

Information is meager on floods prior to 1916 on Flat 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 and $7\frac{1}{2}$ miles downstream from Black Mountain. Mr. W. O. Riddick, at Azalea, 13 miles below Black Mountain, 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.

An item in the August 13, 1897, issue of the "Citizen" notes that on August 6 a bridge was washed away on Flat Creek.

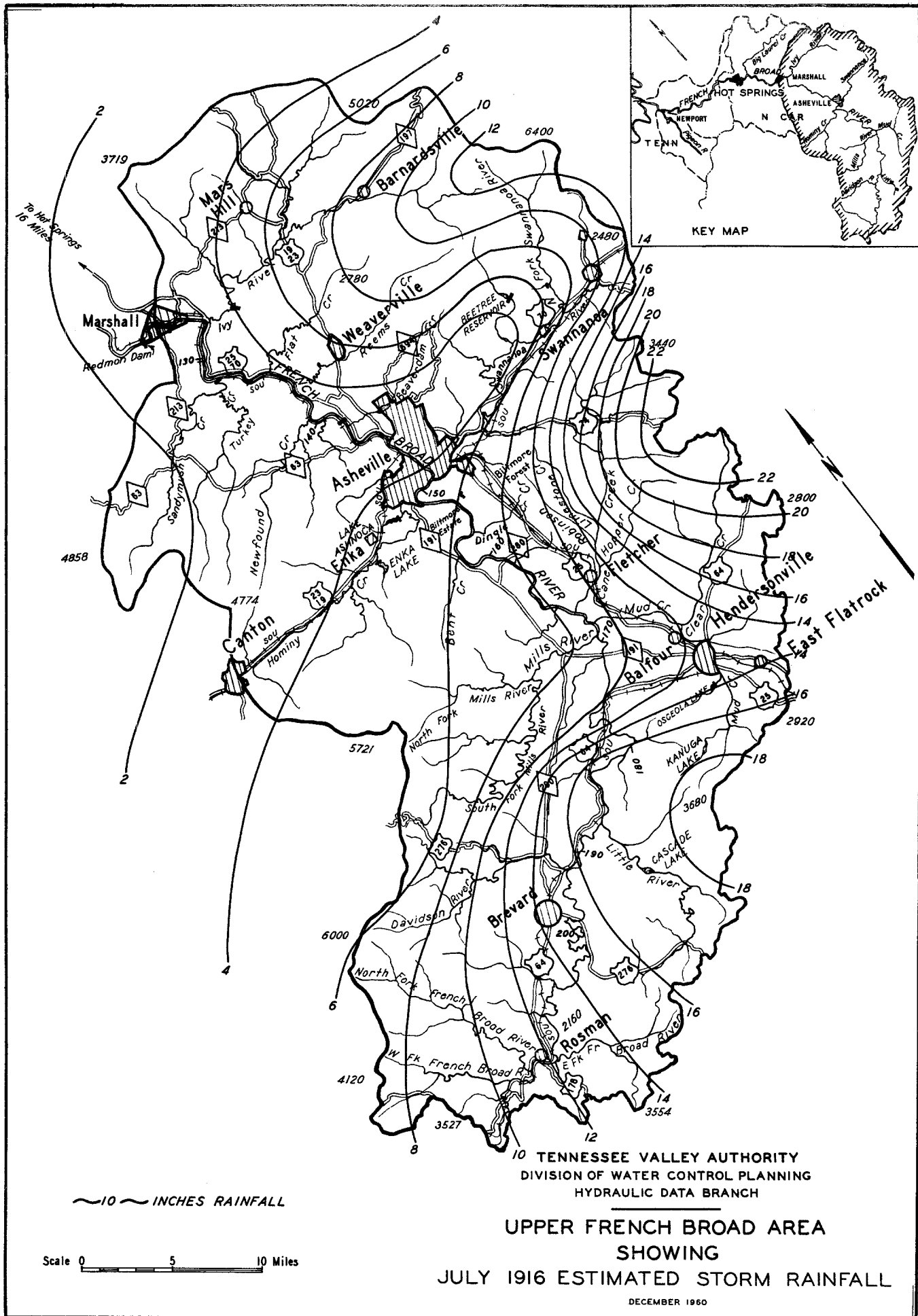
Three floods occurred in a period of ten months shortly after the turn of the century. On May 21, 1901, homes and stores were flooded in Biltmore, and Asheville's water supply, obtained then from a pumping plant on Swannanoa River, was disrupted for several days when the plant was flooded and water lines 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 that the rain in the Beetree section was the heaviest there in 20 years.

July 16, 1916

This is the greatest flood of which there is definite record on the Swannanoa River and Flat Creek. It resulted from a tropical hurricane storm that passed inland over Charleston, South Carolina, on July 14 and advanced northward 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



~ 10 ~ INCHES RAINFALL

Scale 0 5 10 Miles

10 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

estimated rainfall distribution over the French Broad watershed above Marshall, North Carolina. Altapass, North Carolina, on the Blue Ridge 26 miles northeast of Black Mountain, 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.

In the vicinity of Black Mountain and Montreat the July 1916 flood is well established as the highest of which there is definite knowledge. All the older residents interviewed had much to say about the flood but most had very hazy recollections about the actual crest elevation at any point. During the investigation for this report, a photo studio was found which had in its possession several pictures of the 1916 flood. Six of these views are shown in Figures 4 through 7.

At Montreat it was the height of the summer assembly period and the hotels and cottages were full. Workmen watched at the timber crib dam through the day and night of July 15 to keep the spillway clear. Sandbags were piled on top of the earth section on the left bank, but this was overtopped and a large section was washed out near daylight on July 16. Bridges above and below the lake were swept away and a garage building below the dam was flooded.

Mrs. Ruby Hardwick, whose husband operated the Montreat Store at Mile 2.2 for many years, recalls that water broke over the bank at the rear of the store and flooded a stable there. It was necessary to tear boards from the side of the stable to get a horse out. The June 1949 flood did not break over this bank by about two feet, which would indicate that the 1916 flood was higher by three feet or more here. However, such comparisons cannot be taken as definite on steep narrow channels such as Flat Creek has in this reach.

Below the Montreat gate Flat Creek overflowed "hill to hill," but the extent of the overflow was apparently not much greater than in the later floods of 1940 and 1949. Mr. Gus Jackson lived at Mile 1.05 in 1949 but lived 500 feet upstream in 1916. He stated that his house was not flooded in 1916 and that there were "islands" of dry ground at the crest of the flood, very much as he observed during the 1949 flood. There were only one or two houses then in the vicinity of Mile 1, where there were 16 houses in the flood plain in 1949. Mr. Jackson recalls that some houses may have been flooded in 1916 but stated that none was washed away.



Figure 4. --OVERFLOW AT BLACK MOUNTAIN, JULY 16, 1916

The view is south near the site of the present State Highway 9 bridge. The main channel is to the right of the view, and the current from left to right is flowing across the road.

(Photo by Gragg Studio)

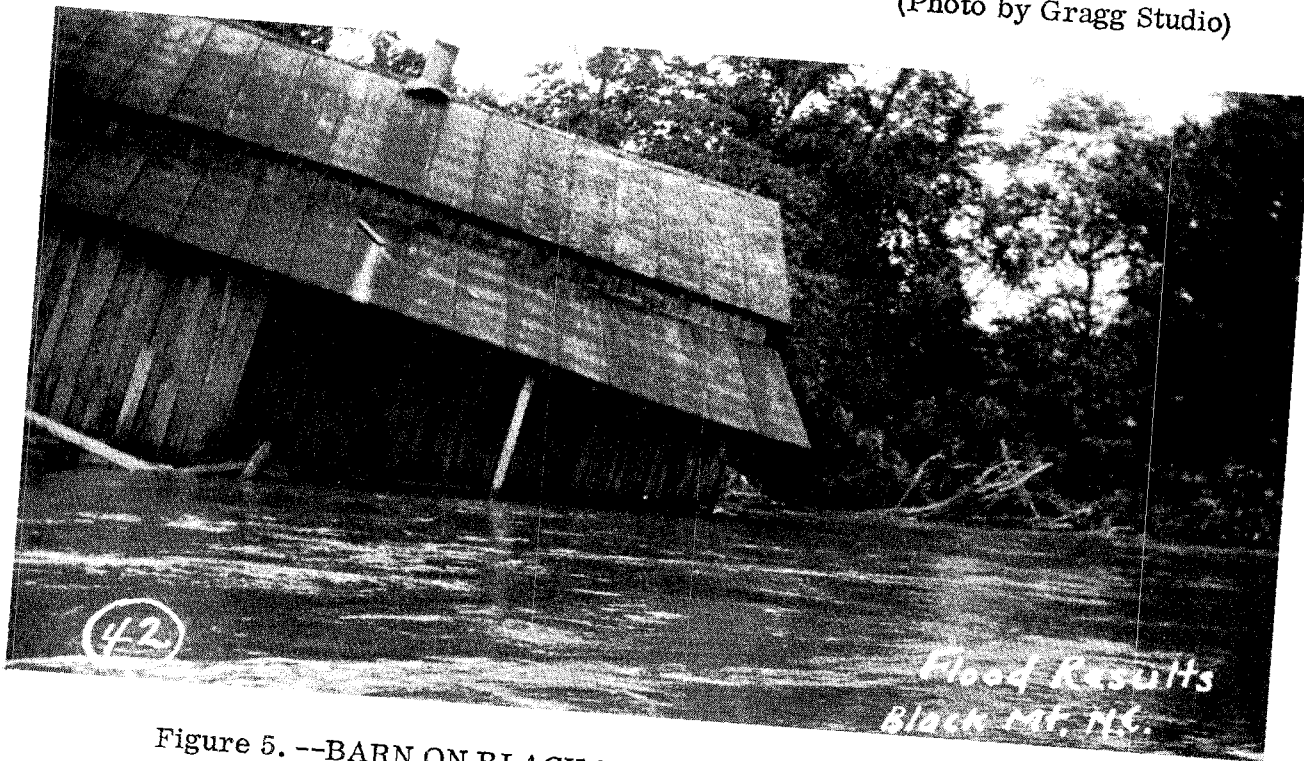


Figure 5. --BARN ON BLACK MOUNTAIN AVENUE IN JULY 1916

This view is across the Swannanoa River at Mile 20.89 from left bank at upstream side of Black Mountain Avenue, the present State Highway 9.

(Photo by Gragg Studio)

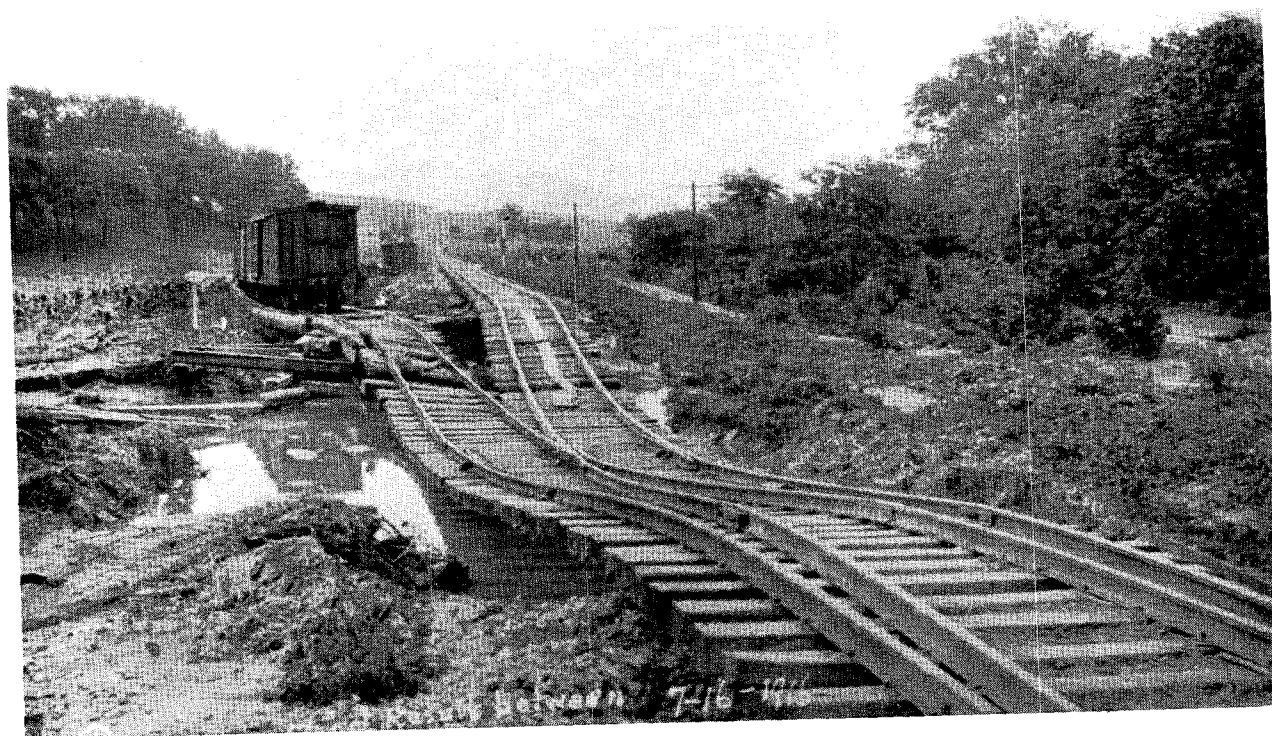


Figure 6. --RAILWAY DAMAGE ON SWANNANOA RIVER, JULY 1916

Upper view shows Southern Railway bridge at Mile 21.33 after loss of the right abutment and a section of the fill. The lower view is believed to be in the vicinity of Stepp Branch near the present site of Ex-Cell-O plant, at Mile 17.2 near Grovestone.

(Photos by Gragg Studio)



Figure 7. --FLOOD EFFECTS ON FLAT CREEK, JULY 1916

Upper view is toward right bank of Flat Creek from Cotton Avenue, Mile 0.73. The location of the lower view cannot be determined definitely but it is believed to have been taken along Flat Creek near the crest of the flood on July 16.

(Photos by Gragg Studio)

Mr. H. A. Kerlee, former Black Mountain postmaster, was able to point out an apple tree which the 1916 flood reached at the Kerlee home, near the old Black Mountain High School and just upstream from present U. S. Highway 70. He stated that in 1916 the creek channel followed the present Flat Creek Road between Miles 0.7 and 0.5. His high water mark shows the 1916 flood to have been 2.5 feet higher than the June 1949 flood at that point. The school building and the homes in the vicinity of Mile 0.4 have been built since 1916. He described overflow on the left bank as extending beyond the Flat Creek Road and on the right bank as extending through the playground of the Black Mountain Grammar School. Overflow covered all the bottom land below U. S. Highway 70.

Mr. Garland Stepp witnessed the 1916 flood on Swannanoa River in the vicinity of Lakey Street and Black Mountain Avenue. His testimony shows that the Lakey Street bridge and street grade was the same from 1916 through 1949. Water was 2 feet over the bridge floor in the 1916 flood and the street was overtopped for a total length of about 600 feet. Mr. Stepp's description of the flood puts it 4 feet above the crest reached in June 1949.

There were no houses in the Swannanoa River flood plain at Black Mountain at the time of the 1916 flood. A small machine shop on the right bank just above Black Mountain Avenue was the only point of commercial damage.

The Southern Railway suffered severe damage in the 1916 flood, with some of the heaviest on the Asheville-Salisbury Line east of Ridgecrest. At the Swannanoa River bridge in Black Mountain, Mile 21.33, one of the abutments failed and a 60-foot length of fill was washed out.

August 16, 1928

Swannanoa River near the mouth at Biltmore was within about two feet of the 1916 flood at this time, but farther upstream in the Black Mountain vicinity the flood was far less severe. Where people were found who could recall the 1928 flood, their testimony was in agreement that it was far under the floods of 1940 and 1949. On Flat Creek it could be established only that this flood was considerably less severe than the flood of June 1949 and that overflow was not very extensive.

August 13, 1940

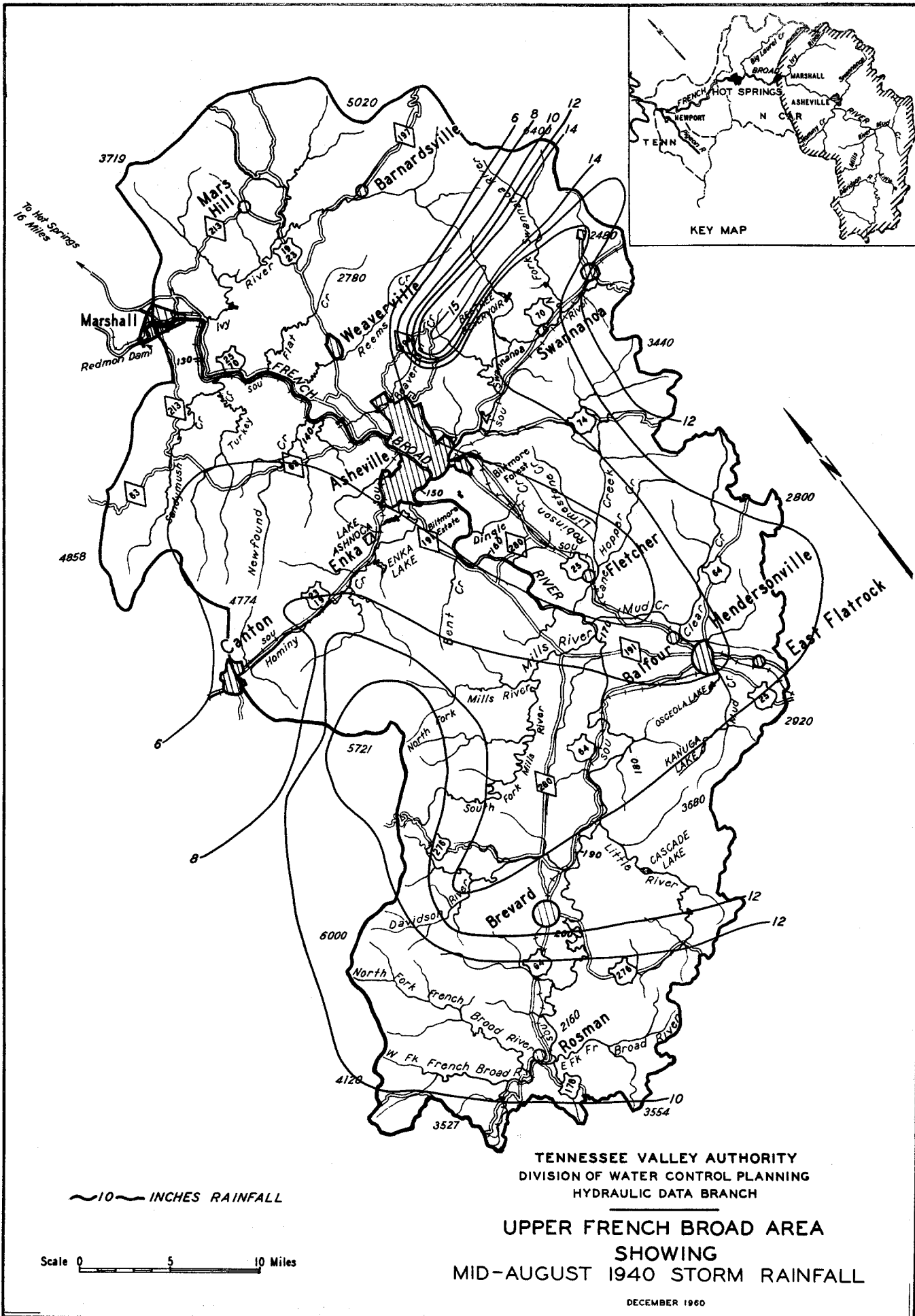
Two large floods affected the mountain headwaters of the Tennessee Valley in August 1940, but the first of these, on August 13, was the only one of consequence in the upper Swannanoa River valley. This flood resulted from a tropical storm whose center moved inland at Savannah, Georgia, on August 11, 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 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 above the mouth of North Fork Swannanoa River.

The flood ranks next to the 1916 in severity in the vicinity of Black Mountain and Montreat. In Montreat there was some testimony that the flood of June 1949 was as great or greater, but below Mile 1.5, where broad overflow begins, the 1940 flood is definitely established as the larger. Mrs. Lois Lytle lived on the left bank of Flat Creek at Mile 1.1 during both the 1940 and 1949 floods. In 1940 water was 7 inches deep in her house, the only house on Flat Creek to be flooded. The 1949 flood was 1.5 feet lower at this point.

Along the Swannanoa River much the same relation was found between the 1940 and 1949 flood crest elevations. At the Gulf Oil Company bulk plant just above Lakey Street, water was 6 inches deep in the warehouse in 1940, 1.6 feet higher than the 1949 flood at this point. High water marks located at Mile 18.7, opposite the east end of the old Nichols Airport, showed the 1940 flood to have been 1.3 feet higher than the 1949 flood. Bridges over Swannanoa River at both Blue Ridge Road crossings, Miles 19.07 and 20.01, were washed out.

June 16, 1949

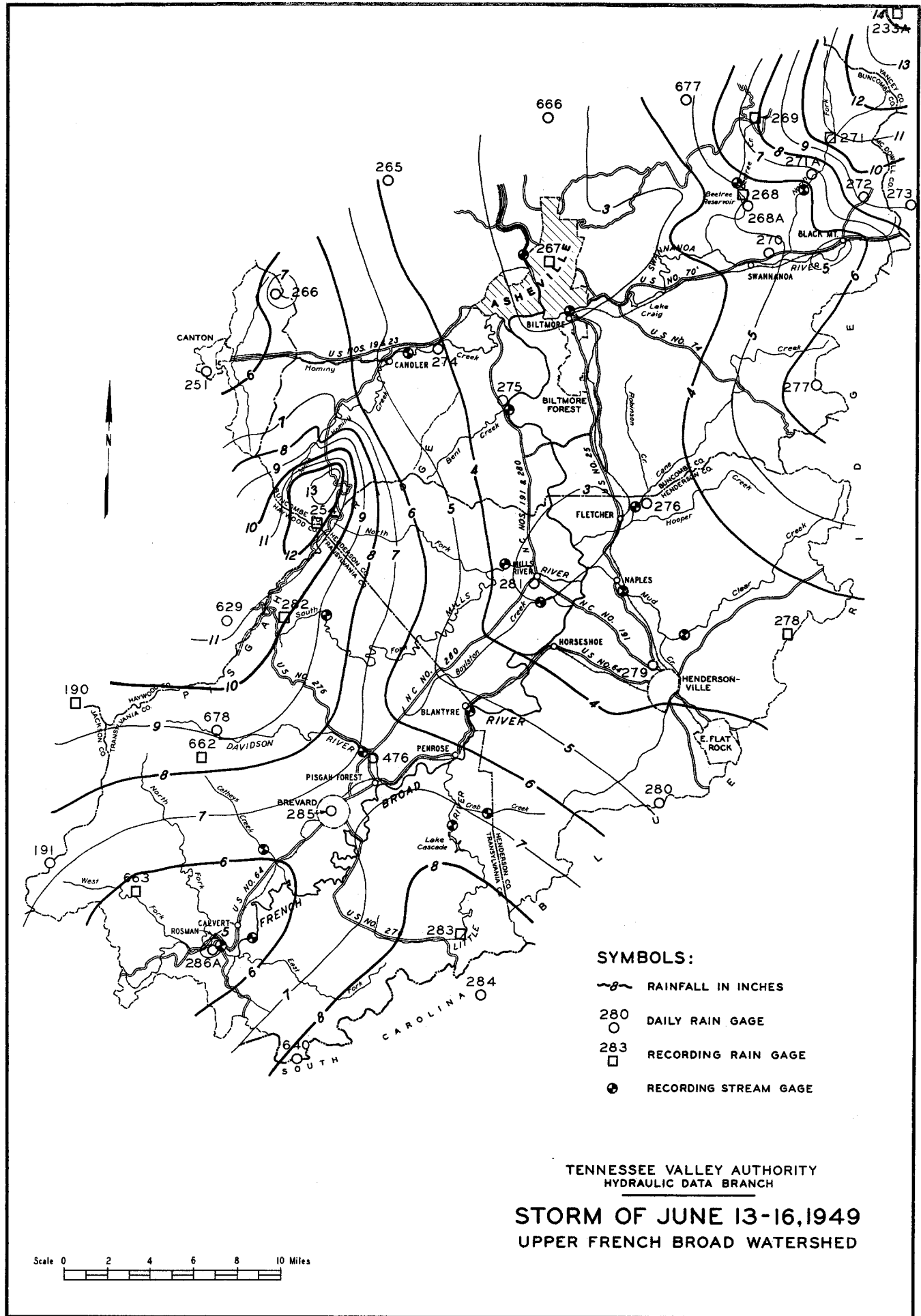
Intense rains in the headwaters of the Swannanoa River basin in the 3-day period June 14-16, 1949, produced a flood on Flat Creek and the Swannanoa River which was the highest since August 1940. This was part of a widespread disturbance that produced floods of considerable magnitude throughout much of 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



TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH
 UPPER FRENCH BROAD AREA
 SHOWING
 MID-AUGUST 1940 STORM RAINFALL

DECEMBER 1960

ASF-1311



and most intense precipitation began around 8 p. m. on June 15 and lasted until late in the evening of the 16th. A recording rain gage at North Fork registered 8.50 inches in 21 hours during this period; and farther up the slope of the Black Mountains and outside the basin of the Swannanoa River, a gage on Mt. Mitchell recorded 9.93 inches in 22 hours. The total for the storm period varied from 2.26 inches at Asheville to 10.15 inches at North Fork. At Montreat 9.30 inches of rain fell. Plate 6 shows the distribution of rainfall over the French Broad River basin above Asheville.

As the waters rose on June 16, workers patrolled the walkway at Montreat Dam to prevent drift from clogging the spillway openings. Fence wire was removed from the guardrail over the concrete section of the dam to prevent collection of debris there, if the lake should continue to rise. The two 12-inch drain lines in the base of the dam were opened to help carry the flood discharge.

The concrete bridges in the Montreat development withstood the flood but lightly constructed bridges at Mile 2.33 and Mile 2.19, Texas Road, were carried away.

Just below the Montreat gate, water overtopped and washed out the Flat Creek Road bridge, Mile 1.39. Heavy overflow spilled into Flat Creek Road at this point. It followed the road, causing heavy washing as far as Padgett Town Road and lighter damage over much of the road from that point downstream to U. S. Highway 70. The low-lying bridge at Padgett Town Road was washed out.

U. S. Highway 70 was overflowed by Flat Creek for a length of about 250 feet along the right-bank approach. Water on the highway reached a depth of 2 feet, sufficient to stop through traffic for a short time near the crest of the flood at 3 p. m. Water was off the road by 5 p. m. and had drained off the bottoms along Flat Creek shortly thereafter. One house and an eating place were flooded. Thirteen other houses were surrounded by the water.

Water from Swannanoa River overflowed the yard of the bulk oil distributing plant just above Lakey Street and carried away 85 barrels of oil products from a storage platform. The crest was 1 foot below the warehouse floor.

At Lakey Street water did not reach the bridge girders, but a 200-foot length of the street at the right of the bridge was overflowed to a shallow depth.

At North Carolina Highway 9, Black Mountain Avenue, approach conditions at the bridge had been altered only a few months before the flood when the

fill across the bottom was raised by amounts up to 3 feet and the street was paved. The highway was overflowed to a shallow depth for a length of 150 feet.

In the Lakey Street-Sycamore Street-Black Mountain Avenue vicinity, two houses and a church were flooded. One house and another church were surrounded by the flood waters.

Shallow overflow of bridge and approaches occurred at both Blue Ridge Road crossings below Black Mountain, Miles 19.07 and 20.01. Bottom lands were overflowed the full reach from Black Mountain to Grovestone, to widths ranging from 200 to 800 feet.

August 28, 1949

The overflow from this flood was of little consequence and road damage was negligible. The crest was in banks or at top of banks through lower Flat Creek and the Swannanoa River at Black Mountain. At the Biltmore gage, this flood exceeded bankfull stage by only a half foot.

2. FLAT CREEK VALLEY

The Stream and Its Valley

Flat Creek drains a steep, heavily wooded mountain area of 6.05 square miles, lying to the north of Black Mountain. The watershed, shown on Plate 1, is 4.5 miles long by just over 2 miles at its widest point. Two steep ridges bound the upper part of the watershed; the Blue Ridge on the east and another ridge, named Middle Mountain, on the west. Elevations along the basin rim vary from about 3600 feet up to 5360 feet at Graybeard Mountain at the upper tip of the watershed, where the two ridges intersect.

Montreat is about the midpoint of the watershed and at a mean elevation of about 2700 feet. Three streams, Flat Creek, Slaty Branch, and Big Piney Branch, drop from the high slopes to converge just above Montreat. From Lake Susan at the center of the Montreat development, Flat Creek flows southwestward through a narrow valley for one mile to the Montreat property boundary, then southward through a gradually widening flood plain to the Black Mountain corporate limit and the confluence with Swannanoa River 0.3 mile beyond.

The flattest mile on the part of Flat Creek covered by this investigation has a fall of 70 feet, indicating that the name was not intended to be descriptive, except possibly in a relative sense. The bottom lands along Flat Creek are too rocky for good farm land. A large number of low- to medium-priced homes have been built along the lower reach of the creek. Many of these have gardens and there is also some corn raised on the bottom lands. The flood plain varies in width from 200 feet above the Montreat property boundary at Mile 1.5 to 1000 feet at the Black Mountain corporate limit just above U. S. Highway 70. The tributary streams in the reach are small and have little or no effect upon flood heights on the main stream.

Developments on the Flood Plain

Plates 8 and 12 show the flood plain of Flat Creek. Residences and a few commercial developments take up a large part of the available flood plain land, the remainder being in use for agricultural purposes. Land devoted to agriculture is generally in small tracts, operated as part-time farms by persons who obtain their principal income from employment elsewhere.

Within the Montreat property boundary the little flood-plain land available is occupied by assembly and college buildings or by privately owned residences or cottages. Above Lake Susan, buildings crowd closely against the stream banks. A two-story gymnasium building on the left bank and the Lakeside Building on the right bank adjoin the heavy masonry pedestrian bridge which is at the upstream side of the lake. Upstream from the Lakeside Building is the Boys' Club Building. A frame building, now on the left bank upstream from the gymnasium, is to be replaced by a new recreation building, according to the expansion plans proposed for the Montreat development.

The left-bank side of Lake Susan is developed for swimming and bathing and is equipped with slides and floats. Immediately below the dam is a play and picnic area. A small parking area is on the left bank, just downstream from Lookout Drive, at Anderson Auditorium. On the left bank at Mile 2.32 there is a garage and workshop building and just below this building is a paved tennis court area. On the right bank just below Texas Road, Mile 2.19, is an area graded for recreation uses. Just upstream from Texas Road is a group of store buildings, facing on Assembly Drive, which are above flood height. These include

the Montreat Post Office, a drug store, and a general store. On the left-bank flood plain below Texas Road there are five houses of recent construction. A house on the right bank at Mile 1.72 is within range of the largest floods.

Between the Montreat property line and Cotton Avenue there are numerous houses in the flood plain, found principally along Flat Creek Road, Padgett Town Road, and Cotton Avenue itself. Near Mile 1.2 is the Pine Lodge development of some 12 cottages, 7 of which are close to the creek bank and subject to flooding. At the intersection of Flat Creek Road and Padgett Town Road there is a grocery store and a tavern. Between Padgett Town Road and Cotton Avenue and between Cotton Avenue and the Black Mountain corporate limit there is some open land used for pasture and gardens. A church is on Flat Creek Road 0.2 mile above U. S. Highway 70, and seven houses in a group are on the flood plain nearby.

The former Black Mountain High School buildings, on the left bank just above U. S. Highway 70 and just outside the town's corporate limit, are now used for the elementary grades. The lower grammar grades use the buildings on the right bank facing on State Street. The ground and lower floor at the former high school buildings is at elevation 2373.9 feet. The ground at the school buildings on the right bank is at elevation 2380.2 feet. The flood of June 1949 reached an elevation of about 2367 feet at this point. A Maximum Probable Flood would be at about 2376 feet elevation.

Radio station WBMT began operating in 1960 from studios and transmitter constructed on low flood-plain land at Mile 0.25, opposite the Black Mountain grammar school buildings. Ground in the vicinity is at elevation 2369, the building floor is at elevation 2372.0, and the base of the transmitting tower is at elevation 2371.5 feet. Flood heights at the site are comparable with those given for the school buildings.

A small amusement area development, on the right bank immediately above the U. S. Highway 70 bridge, consists of a miniature golf course, shuffle-board courts, trampolines, and a drive-in eating place. At the downstream side of U. S. Highway 70 is located a service station and an oil products distributor. Between U. S. Highway 70 and the Southern Railway, about 15 houses and a number of businesses would be affected by large floods on Flat Creek and on the Swannanoa River.

Bridges across the Stream

Ten highway bridges and eight footbridges cross Flat Creek in the 2.6 miles of the stream included in this investigation. Five of the vehicular bridges and six of the footbridges are within the property boundary of the Mountain Retreat Association. Table 7 lists pertinent elevations for these bridges and shows the relation to the crest of the flood of June 16, 1949. Plate 13 shows the relation of the floor and underclearance at the bridges to the flood profiles for the reach. Figures 8 and 9 are photographs of the bridges.

The bridge across Flat Creek at U. S. Highway 70 is the only one which is within the corporate limit of Black Mountain. The other bridges carry local traffic only. All except the bridge at Mile 2.1 have underclearances which are lower than some of the large floods of the past. Some of them are overtopped in any serious flood.

The bridge at U. S. Highway 70, Mile 0.10, was built to accommodate the wider pavement when the road was made four lanes from Black Mountain east to Ridgecrest and Old Fort in 1954. It replaced a two-span concrete girder bridge which had an underclearance only 5 feet above the normal water surface. In June 1949 the flood crest was 0.8 foot below the bridge floor. The present stream crossing is a three-opening box culvert with an underclearance elevation which is 1.8 feet higher than the old bridge floor and about equal to the elevation reached at this point by the flood of July 1916. However, the bridge approaches now considerably restrict the floodway and the crest would be higher if a flood of that magnitude were to occur under the present conditions. Also, a bridge opening of this type is subject to stoppage by drift accumulations during floods. The bridge underclearance and also the low point of the right-bank approach are at elevation 2366.8 feet.

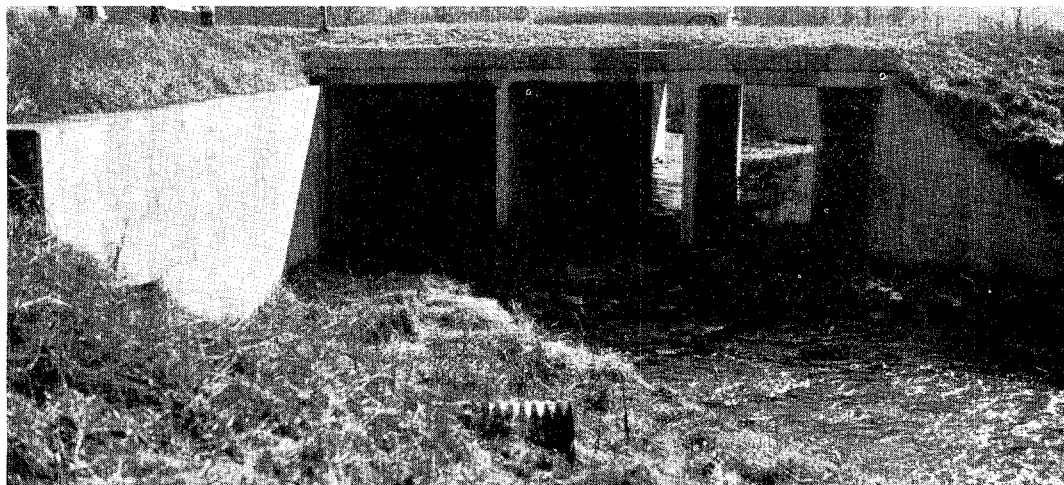
Four state-maintained bridges are in the reach of Flat Creek between the Black Mountain corporate limits and the Montreat property boundary. The bridge at Cotton Avenue, Mile 0.73, is a one-span, wood floor, steel girder structure which replaces a bridge at the same site washed out in the June 1949 flood. The underclearance is at elevation 2404.3 feet, but heavy overflow on the left bank, along Flat Creek Road, begins well before flood waters reach this elevation. The 1949 flood overflowed this area and reached about the elevation of the underclearance at the present bridge.

TABLE 7
BRIDGES ACROSS FLAT CREEK IN VICINITY OF
BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

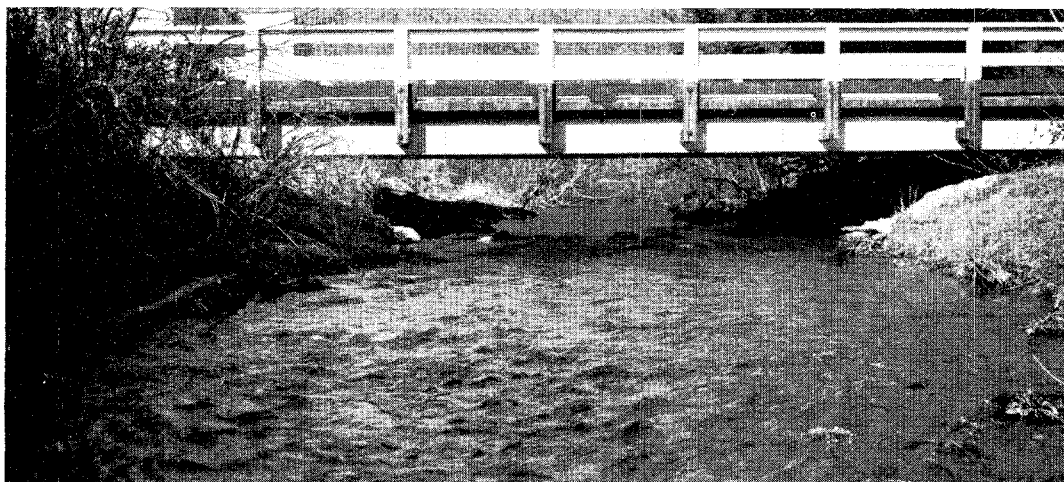
Mile above Mouth	Identification	Stream Bed Elev. feet	Floor Elev. feet	June 1949	Underclearance		
				Flood Crest Elev. feet	Above Flood Crest feet	Below Flood Crest feet	
0.10	U. S. Hwy. 70	2355.8	2370.3	2364.0	2366.8	2.8	
0.23	Footbridge	2362.3	2365.8	2368.4	2365.3		3.1
0.73	Cotton Ave.	2398.4	2406.8	2403.4	2404.3	0.9	
0.98	Padgett Town Rd.	2418.1	2424.5	2423.9	2422.5		1.4
1.17	Footbridge	2438.8	2445.0	2441.0	2444.3	3.3	
1.38	Flat Creek Rd.	2461.0	2468.1	2466.3	2465.6		0.7
1.48	Road	2471.1	2480.0	2479.4	2477.5		1.9
2.10	Road	2567.7	2581.9	2572.7	2580.7	8.0	
2.12	Footbridge	2570.7	2580.2	2575.6	2579.3	3.7	
2.19	Texas Road	2582.7	2590.5	2587.8	2588.8	1.0	
2.30	Footbridge	2606.5	2613.4	2611.8	2612.6	0.8	
2.40	Road	2622.5	2633.1	2628.2	2630.5	2.3	
2.43	Footbridge	2629.5	2636.5	2633.0	2635.6	2.6	
2.44	Lookout Rd.	2630.1	2640.1	2634.2	2637.3	3.1	
2.49	Footbridge (Montreat Dam)	2649.5	2668.0	2667.4	2667.4	0	0
2.55	Footbridge	2661.5	2670.5	2669.0	2668.8		0.2
2.57	Footbridge	2666.1	2673.8	2670.8	2673.0	2.2	
2.60	Kentucky Road	2672.8	2683.8	2619.0	2680.7	1.7	

The bridge at Padgett Town Road, Mile 0.98, is a one-span steel girder bridge set at the level of the stream banks. Any flood which is out of banks in this reach flows over the bridge floor. The bridge was washed out in June 1949.

Flat Creek Road follows the left bank of the creek from U. S. Highway 70 to Mile 1.38, where it crosses to join Montreat Road on the right bank. The bridge is a one-span steel girder, set at some angle to the stream. The bridge floor is at top-of-bank elevation and will be overtopped during any overbank flow. A similar structure was washed out here in 1949.



U. S. Highway 70 bridge at Mile 0.10, upstream side.

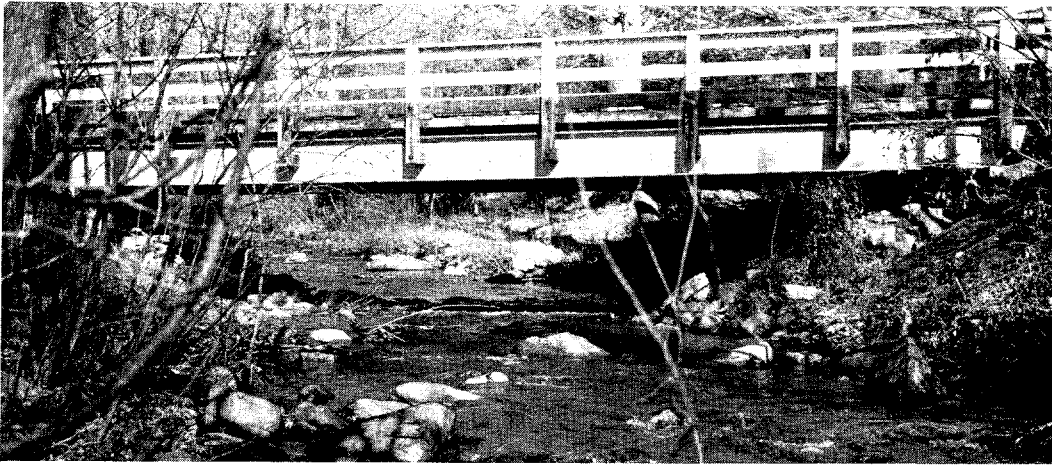


Padgett Town Road bridge at Mile 0.98, downstream side.

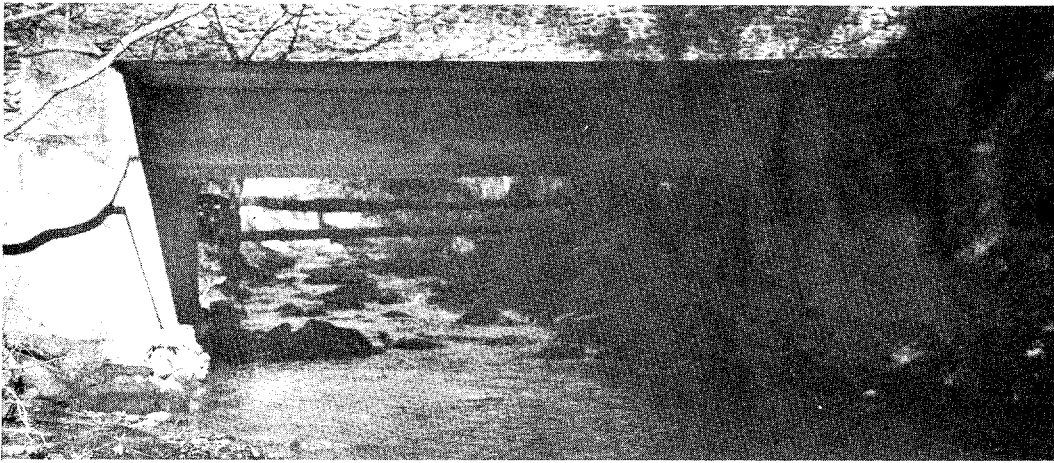


Flat Creek Road bridge at Mile 1.38, upstream side.

Figure 8. --FLAT CREEK BRIDGES IN BLACK MOUNTAIN AND VICINITY



Bridge at Mile 1.48, downstream side.



Bridge at Montreat, Mile 2.40, downstream side. Note sewer lines crossing the creek several feet above low water.



Footbridge and Lookout Road bridge, Miles 2.43 and 2.44, downstream side. Part of the Montreat Dam appears in top center of picture.

Figure 9. --FLAT CREEK BRIDGES IN VICINITY OF MONTREAT

The bridge at Mile 1.48 has been built since the 1949 flood to serve a group of houses on the left bank. This is a single-span steel girder bridge, set at top-of-bank elevation, similar to the bridge just downstream and subject to comparable flood effects.

Roads and bridges which are within the Montreat boundary are built and maintained by the Mountain Retreat Association or by private property owners. Although Montreat has the general power of a municipality it does not share in allocated state highway funds, as do towns like Black Mountain.

Three bridges at Montreat are of one-span reinforced concrete construction, built about 1922. These are located at Miles 2.40, 2.44, and 2.60; together they serve the main assembly and college buildings which are grouped around Lake Susan. At each bridge heavy concrete and masonry guard rails extend above the roadway and, with the floor structure, provide sizable obstructions to flood flows. Approach fills cause additional interference to flood waters. The underclearances at the bridges are above the height of the highest recent flood, that of June 1949, by amounts ranging from 1.7 to 3.1 feet. The larger floods which are possible of occurrence, such as the Regional and the Maximum Probable Floods, would overtop the floor at the bridges by 6 feet or more.

Two vehicular bridges on the Montreat property are lightly built log and plank structures. A bridge at Mile 2.10, built since 1949, serves a group of five houses on the left bank. The Texas Road bridge at Mile 2.19 gives access from Assembly Drive to homes along Texas Road and the roads which adjoin it on the left-bank side. Approach fills provide some obstruction at both bridges. The bridge at Texas Road was washed out in 1949.

Three lightly built footbridges cross Flat Creek between the Montreat property line and Lake Susan. One at Mile 2.12 serves the houses on the left bank near that point. A footbridge at Mile 2.30 provides access to tennis courts and a garage building. A bridge at Mile 2.43, just below Lookout Road, is for the pedestrian traffic in that vicinity. These bridges have only 5 to 8 feet of clearance above the normal water-surface elevation and are subject to loss or damage in any serious flood.

The walkway which crosses the spillway at Montreat Dam has a clearance of 3.4 feet over the spillway crest and provides a net width of opening of 56 feet. In the flood of June 1949 water at the upstream side of the dam was at the

underclearance elevation at the walkway, 2667.4 feet. At elevation 2668.0 feet, water will flow over the concrete portion of the dam and begin to spill into Assembly Drive at the right end of the dam. In a Regional Flood and Maximum Probable Flood it is estimated the crests at the dam would be 3.4 feet and 4.0 feet, respectively, above the walkway. Both of these floods would overflow the bridge and most of the earth-fill section to the left, with the almost certain loss of the larger part of this fill.

A heavy concrete and masonry footbridge, shown in the bottom picture in Figure 10, crosses Flat Creek at the head of Lake Susan, at Mile 2.55. A solid guard rail above the three arch type openings, together with buildings which are close to either end of the bridge, provides an appreciable obstruction to flood flows at this point. Some water can pass around the right end of the bridge in high flows, at either side of the Boys' Club Building, but the left bank is blocked to all flows by the gymnasium building. The top of the arch openings is at elevation 2668.8 feet, 0.2 foot below the 1949 flood elevation.

A lightly constructed footbridge crosses the creek at Mile 2.57, just above the Boys' Club Building.

There are two footbridges over Flat Creek below the Montreat development. One is at Mile 1.17, at the Pine Lodge cottages. The other, at Mile 0.23 just above U. S. Highway 70, provides access to the studios and transmitter for radio station WBMT. Both of these bridges are built close to the water surface and are likely to be lost in any sizable flood.

Obstructions to Flood Flow

The effect of the bridges and bridge approaches upon flood flows along Flat Creek has been discussed previously. The effect of encroachment on the flood plain by the buildings at the head of Lake Susan has also been mentioned. Earth grading and building construction has reduced the floodway at a number of other points in the Montreat development, as well. Below the Montreat boundary the extensive development of houses on the flood plain obstructs flood flows to a substantial degree. Conditions have been altered to some extent also by the construction of retaining walls and by earth grading along the creek.

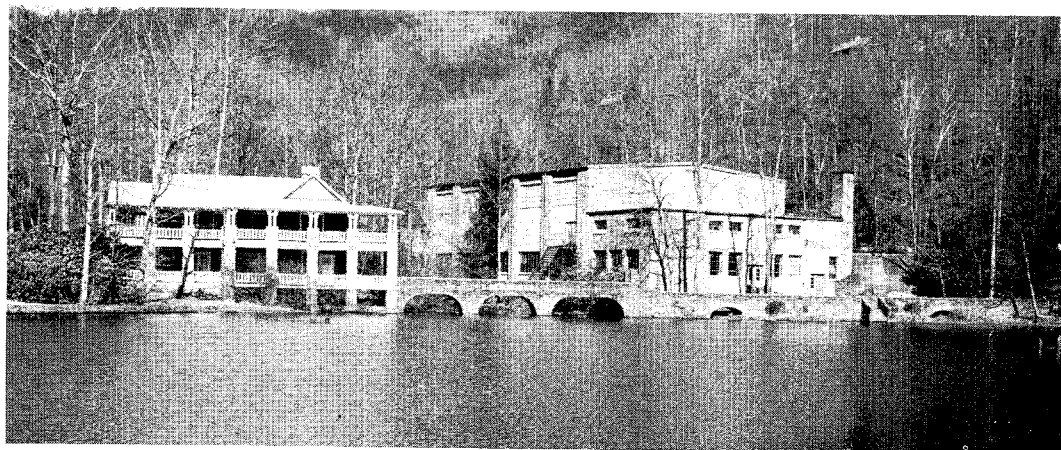
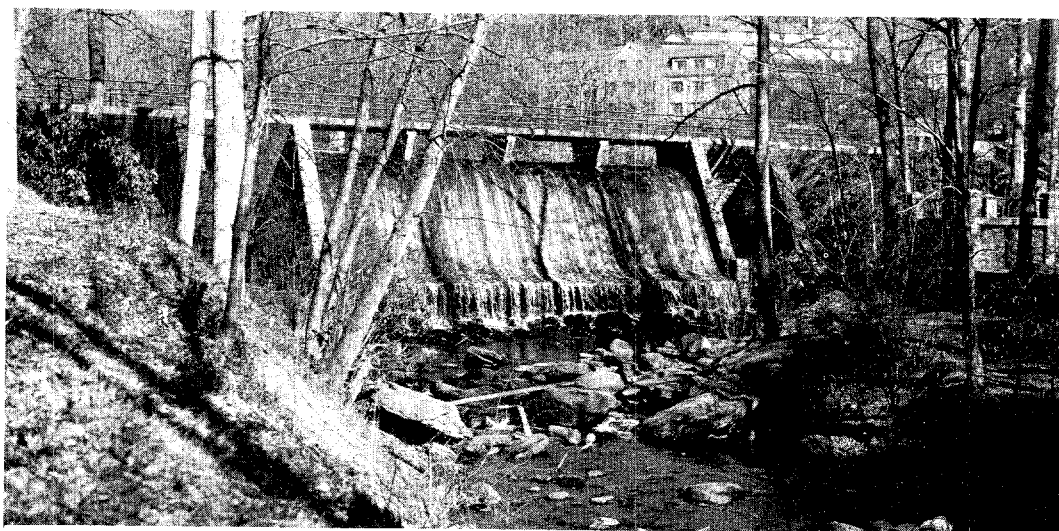
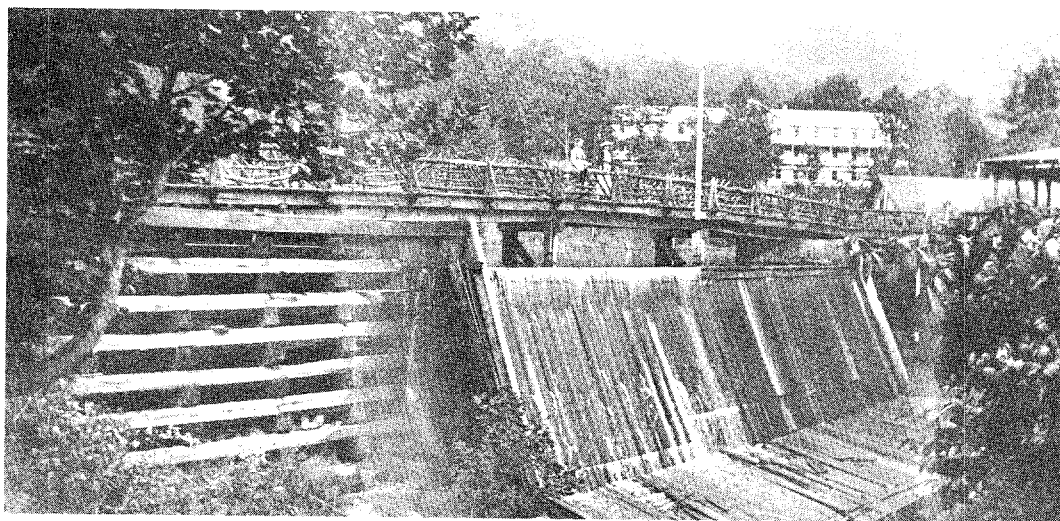


Figure 10. --LAKE SUSAN DEVELOPMENT AT MONTREAT

Top view shows the dam on Flat Creek which impounds Lake Susan as it appeared in 1916. Middle view is the concrete dam that replaced the old timber crib structure, and the bottom picture shows the upstream end of the lake as viewed from the dam.

(Top photo by Gragg Studio)

Montreat Dam

The present dam at Mile 2.49 was built with funds provided in 1924. The earliest plans for the development at Montreat envisioned a dam and lake at this site, and the first dam was probably built soon after the turn of the century. Asheville newspapers reported the destruction of this dam by a flood in January 1906. Photographs taken about 1910 show a timber crib dam at the site. This structure was damaged in the flood of July 1916. The upper two views in Figure 10 show the dam as it appeared in 1916 and as it now exists.

The dam is 23 feet high. It has a concrete spillway 56 feet wide. Concrete buttress sections at either side of the spillway make the total length of the concrete section 145 feet. An earth fill extends for about 250 feet to the left of the concrete. The $1\frac{1}{2}$ -acre lake was named Lake Susan when the present dam was built. The dam is known both as Montreat Dam and Lake Susan Dam, the former name having more common usage.

FLOOD SITUATION

Flood Records

No records of river stages or discharges are available for Flat Creek. Following the flood of June 16, 1949, field investigations were made along Flat Creek in the vicinity of Black Mountain and Montreat and reports on these have yielded valuable information. Local residents were interviewed for information on dates and heights of floods. Files of the Asheville newspapers have been searched for flood references. Church and historical records and documents have been reviewed.

Rate of Rise and Velocities during Floods

Small, steeply mountainous watersheds, such as that of Flat Creek, produce floods which are characterized by very rapid rates of rise and high velocities. In the vicinity of Montreat, velocities in the channel of Flat Creek during floods, such as those in 1916 or 1949, are estimated to have ranged up to 19 feet per second and in the overbank areas up to 6 feet per second. During the June 1949 flood, Flat Creek was above bankfull stage in the Black Mountain vicinity for about 12 hours.

Flooded Area, Flood Profiles, and Cross Sections

Plates 8 and 12 show the approximate area along Flat Creek that was inundated by the June 1949 flood, the highest known flood for which there are sufficient data to develop the overflow limit. The actual limits of the overflow area 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 both plates is 40 feet.

Plate 13 shows high water profiles on Flat Creek for the flood of June 1949 and also for the Regional and Maximum Probable Floods. The latter are discussed in Sections III and IV, respectively.

Plate 14 shows typical cross sections of the Flat Creek valley in the reach studied. The location of the cross sections is shown on the map and profile, Plates 12 and 13. Each cross section shows the elevation and extent of overflow of the June 1949 flood and the Regional and Maximum Probable Floods. A number of cross sections, the locations of which are shown on the afore-mentioned map and profile, are not reproduced but are available from Hydraulic Data Branch of TVA.

FLOOD DESCRIPTIONS

Descriptions of the large floods on Flat Creek are included with the discussion of past floods on the 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 the upper Swannanoa River and Flat Creek.

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

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 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

(1) Prepared by Hydraulic Data Branch.

band along the top and immediately beyond the divide. Characteristically, the rainfall diminishes on the downstream slopes within the Valley, although occasionally tongues or cells of heavy rainfall have been experienced for considerable distances within the Valley.

Table 8 lists the maximum known floods experienced on watersheds comparable with those of upper Swannanoa and Flat Creek and within about 50 miles of Black Mountain and Montreat, North Carolina. Because of the distribution of rainfall during heavy storms, the floods that occurred on watersheds that lie to the south and east, outside of the Tennessee Valley, have not been considered in the determination of Regional Floods on the Swannanoa River watershed.

Many very severe large storms have been experienced over the watersheds along the eastern Tennessee Valley Divide. The storms of May 1901, July 1916, August 1940, and June 1949 are among the largest and most damaging since the turn of the century. The storm of May 18-21, 1901, caused particularly severe floods on the Watauga and Nolichucky Rivers. An estimated 8 inches of rain fell in a 24-hour period on ground saturated from previous rain. The numerous "water-spouts" and landslides that were reported in news accounts attest to the intensity of the rainfall. The resulting 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 that moved inland over the southeastern part of the country during July 1916. The first hurricane brought sufficient rainfall to western North Carolina on July 8-10 to saturate the ground. The second hurricane brought extremely heavy rainfall along the Blue Ridge mountain divide between the Atlantic and Tennessee River drainage. Rainfall totaling 22.2 inches was recorded in a 24-hour period at Altapass, about 26 miles northeast of Black Mountain. The resulting flood was the highest of record on the upper Swannanoa River near 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 the Hiwassee River basin northeast to the Watauga headwaters. The highest flood of record

TABLE 8

MAXIMUM KNOWN FLOOD DISCHARGES

ON STREAMS IN REGION OF BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

Map Ref. No.	Stream	Location	Drainage Area sq. mi.	Date	Peak Discharge	
					Amount cfs	Per Sq. Mi. cfs
1	Cane River	nr Burnsville, N. C.	36.6	August 13, 1940	18,000	492
2	Watauga River	nr Valle Crucis, N. C.	33.1	August 13, 1940	38,000	1,150
3	S. Fk. Toe River	nr Busick, N. C.	32.8	August 13, 1940	18,000	550
4	Hominy Creek	abv Candler, N. C.	28.9	August 30, 1940	12,400	429
5	N. Fk. Swannanoa River	nr Black Mountain, N. C.	23.8	June 16, 1949	16,500	693
6	Cane Creek	abv Bakersville, N. C.	22.0	May 19-20, 1901	30,500	1,390
7	Elk River	bel Banner Elk, N. C.	20.1	August 13, 1940	16,500	822
8	Cane River	nr Pensacola, N. C.	18.1	August 13, 1940	15,000	830
9	Elk River	nr Banner Elk, N. C.	17.8	August 13, 1940	22,000	1,240
10	Bat Fork	at mouth nr Hendersonville, N. C.	14.9	July 16, 1916	12,000	805
11	W. Fork Pigeon River	at Spruce nr Waynesville, N. C.	12.2	August 30, 1940	16,500	1,350
12	Swannanoa River	at Black Mountain, N. C.	11.2	July 16, 1916	17,000	1,520
13	Dutch Creek	at Valle Crucis, N. C.	10.6	August 13, 1940	16,000	1,510
14	Devils Fork	nr Hendersonville, N. C.	9.3	July 16, 1916	7,500	806
15	Flat Creek	abv Weaverville, N. C.	6.4	July 16, 1941	3,000	467
16	Rt. Fk. Swannanoa River	nr Black Mountain, N. C.	5.1	June 16, 1949	4,500	882
17	Flat Creek	at Montreat Dam, N. C.	2.8	July 16, 1916	4,000	1,430
18	Crab Orchard Creek	nr Boone, N. C.	2.1	August 13, 1940	6,000	2,860

was experienced on many streams in the region as a result of this rainfall, which totaled up to 15 inches in some areas in the upper Watauga and Swannanoa River basins.

The June 14-16, 1949, rainfall 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 near 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.

Storms similar to those that caused these large floods in the region could occur over the Swannanoa River watershed. In that event, floods comparable in magnitude with those experienced on the neighboring streams whose watersheds are similar to that of Swannanoa River could also occur on the Swannanoa River.

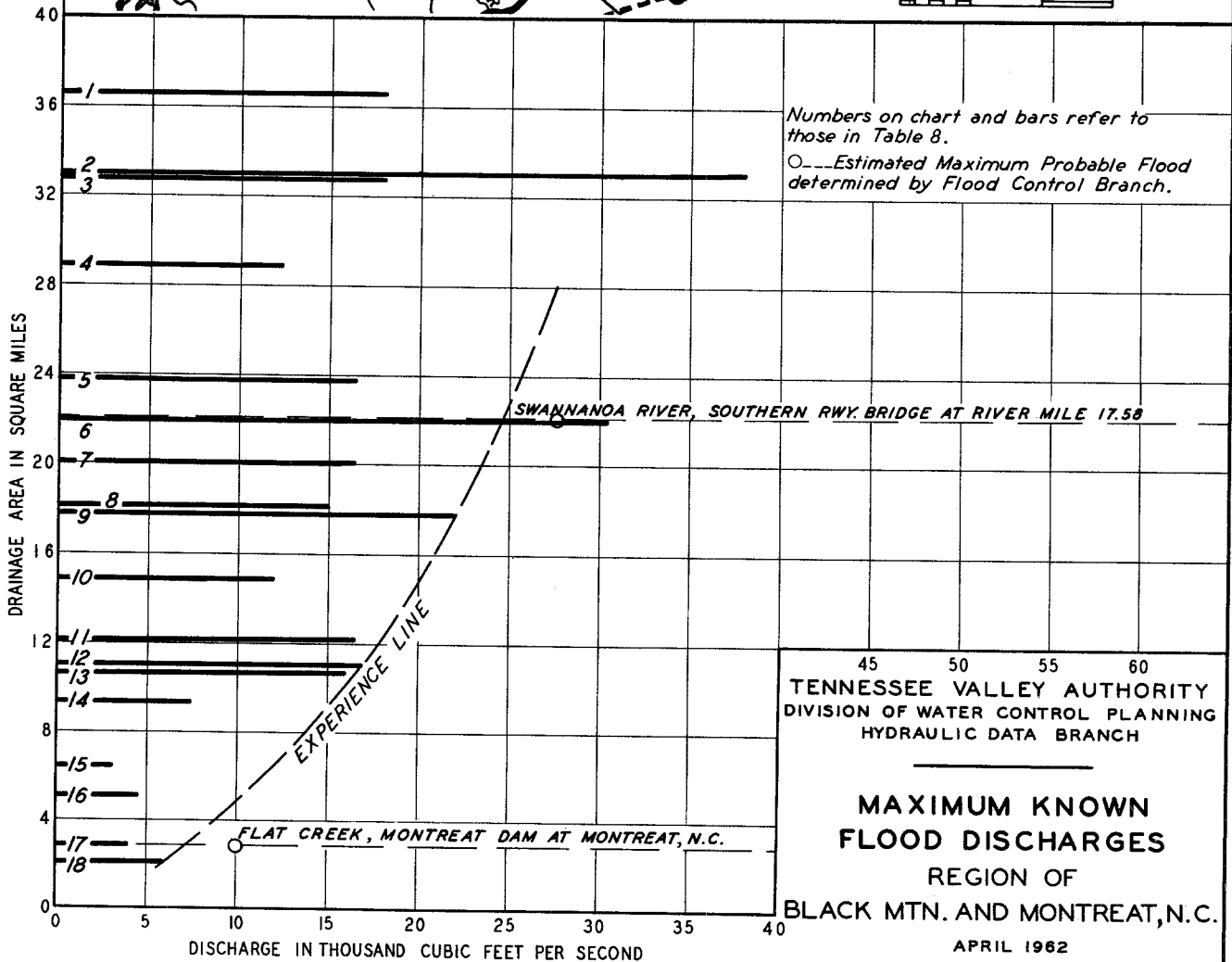
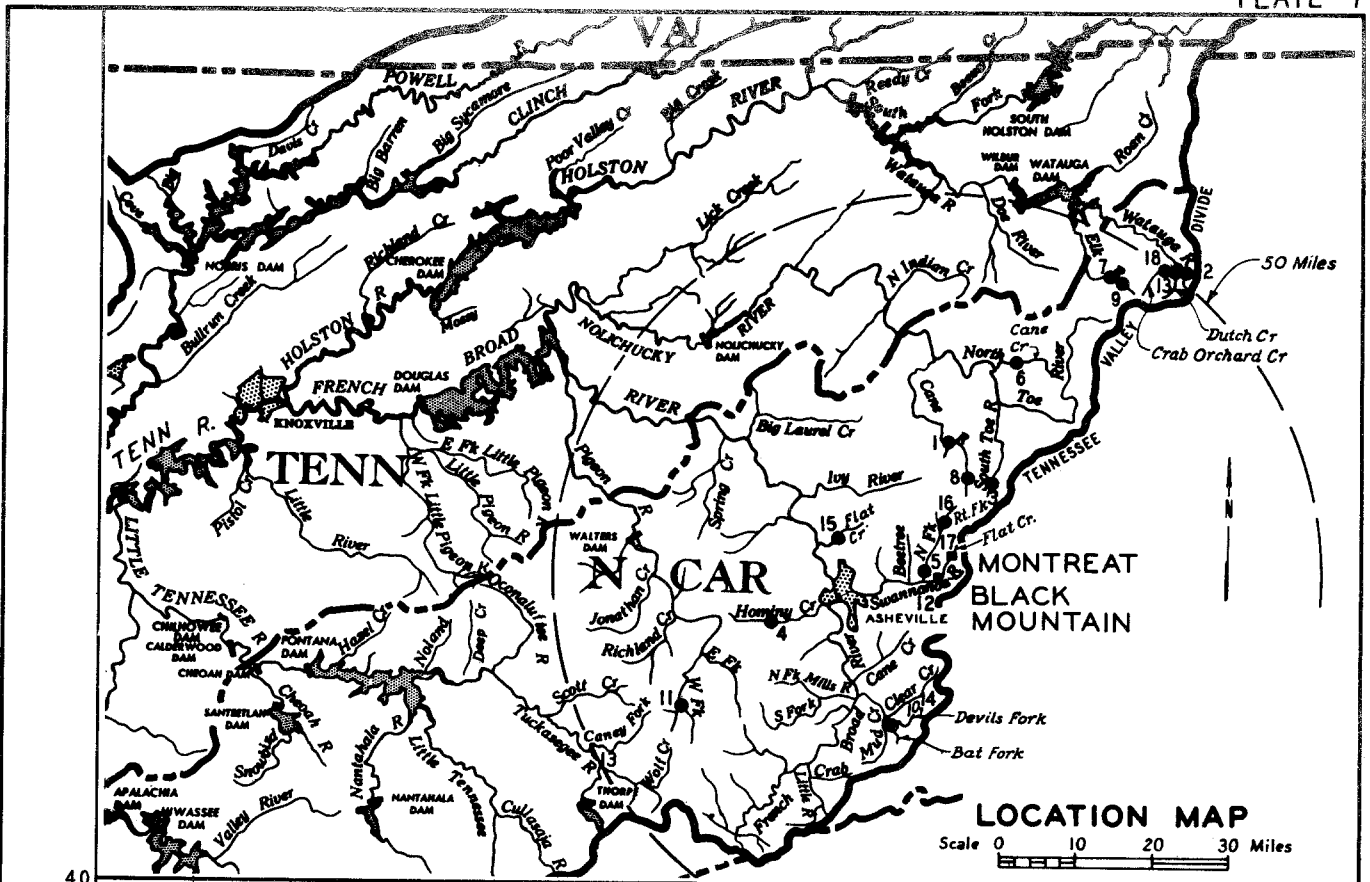
Based upon the magnitude of storms that have occurred on neighboring streams, a Regional Flood may occur in the vicinity of Black Mountain and Montreat about 1 to almost 14 feet higher than the mid-August 1940 flood on the upper Swannanoa River and 2 to 13 feet higher than the June 1949 flood on Flat Creek.

Upper Swannanoa River and Flat Creek vs. Regional Flood Discharges

Plate 7 is a diagram of the discharges tabulated in Table 8, together with a map showing the locations of the discharge measurements.

The upper Swannanoa River watershed, with its headwaters on the Tennessee Valley Divide, lies in the narrow band or spillover area that is subject to heavy, widespread, orographic precipitation. This watershed, therefore, is as susceptible to heavy rainfall as any of the watersheds in this region.

The largest five floods observed in this region have occurred on watersheds which lie in this spillover area. All of these floods resulted from either the tropical hurricanes of July 1916 and August 1940, or the storm of May 1901 which was general over the eastern Tennessee Valley. The fact that these three floods occurred within a 40-year period emphasizes the fact 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.



TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

**MAXIMUM KNOWN
 FLOOD DISCHARGES**
 REGION OF
 BLACK MTN. AND MONTREAT, N.C.

APRIL 1962

The experience line on Plate 7 that is used to determine the Regional Flood includes the largest known flood on the Swannanoa River at Black Mountain, that of July 16, 1916. Plate 7 shows that two flood discharges, that of May 1901 on Cane Creek above Bakersfield, North Carolina, and that of August 1940 on the Watauga River near Valle Crucis, North Carolina, exceed this experience line. Particularly heavy rainfall over these two watersheds resulted in discharges that are in the order of a Maximum Probable Flood. For this reason, these two discharges, even though they have been experienced in the region, have not been considered in estimating the Regional Flood.

Table 9 lists the estimated Regional Flood discharges for the Swannanoa River and Flat Creek.

TABLE 9
REGIONAL FLOOD PEAK DISCHARGES

<u>Stream</u>	<u>Location</u>	<u>River Mile</u>	<u>Drainage Area sq. mi.</u>	<u>Discharge cfs</u>
Swannanoa River	Southern Railway at Lakey Street	17.58	22.1	24,500
		20.96	11.2	18,500
Flat Creek	at Montreat Dam	2.49	2.80	7,000

The profiles of the Regional Floods on the Swannanoa River and Flat Creek are shown on Plates 11 and 13.

The heights of the Regional Flood, and of the Maximum Probable Flood discussed in Section IV, at several locations along the Swannanoa River and Flat Creek are shown in Figures 11 through 17, which present the pictures in upstream order.



Figure 11. --GENERAL PRECISION, INC., PLANT AT GROVESTONE

The Kearfott Division of this corporation is located just below the U. S. Highway 70 bridge over the Swannanoa River. The factory is above all floods considered in this report, but the parking lot would be inundated by the Regional and Maximum Probable Floods to the extent shown. The June 1949 flood elevation was 3.9 feet lower than the base of rod.

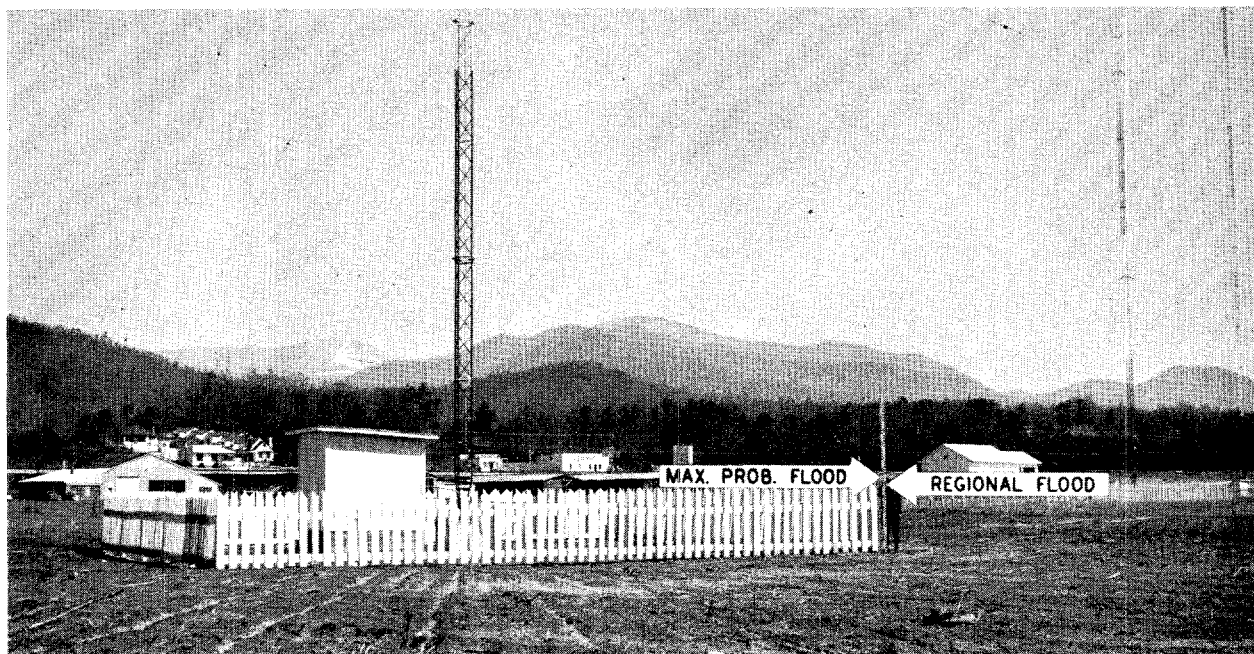


Figure 12. --RADIO STATION WFGW AT OLD NICHOLS AIRPORT

The building at right, under construction for the studio and transmitter, is 4 feet above the Maximum Probable Flood, but the tower in the foreground is in the flood plain as shown by the arrows on the rod. The view is northeast at Mile 18.36.

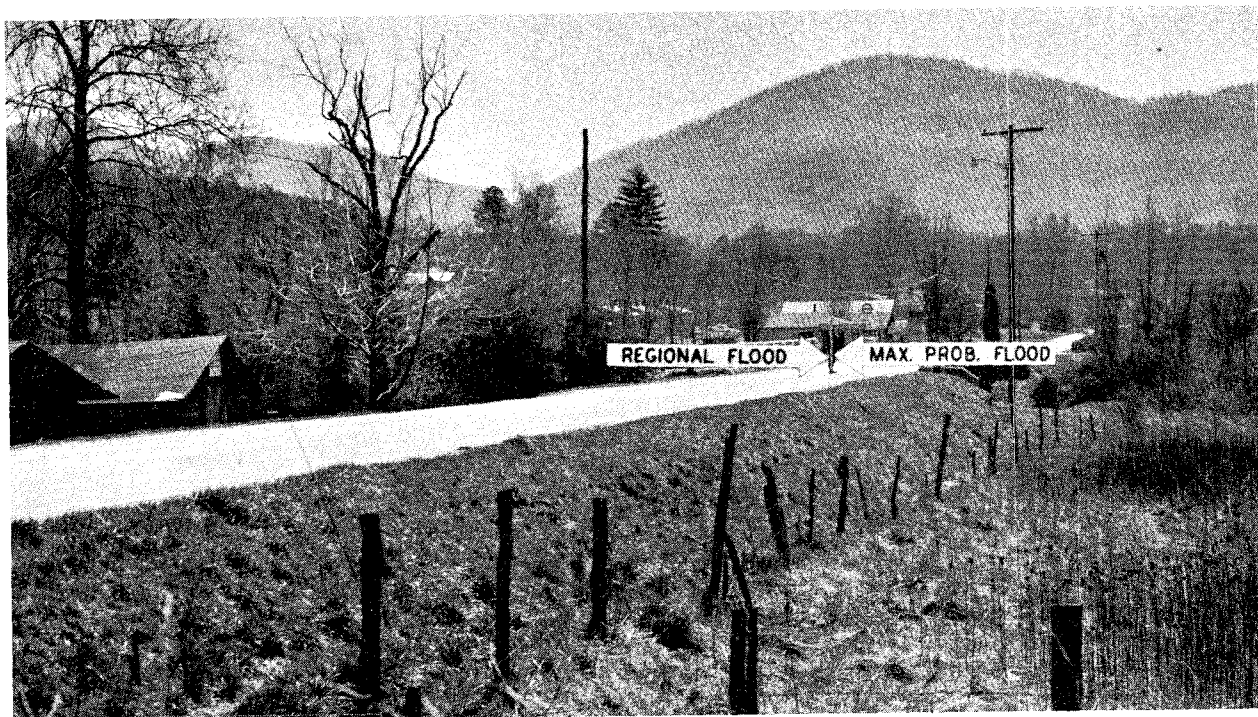


Figure 13. --FLOOD HEIGHTS ALONG BLACK MOUNTAIN AVENUE

Upper view is south along the avenue, which is State Highway 9 and crosses the Swannanoa River at Mile 20.9. The barn at left is at the site of a barn damaged in the 1916 flood and shown in Figure 5. The bridge and fill were built in 1950. Lower view shows Huggins Chapel, which lies in the left-bank flood plain on the east side of the avenue. The floor was flooded 1 foot deep August 13, 1940, and 0.4 foot in June 1949. Arrows show the Maximum Probable and Regional Flood heights in both views. The drop through the bridge in these floods would be 3.9 feet; the arrows refer to the height on the upstream side.

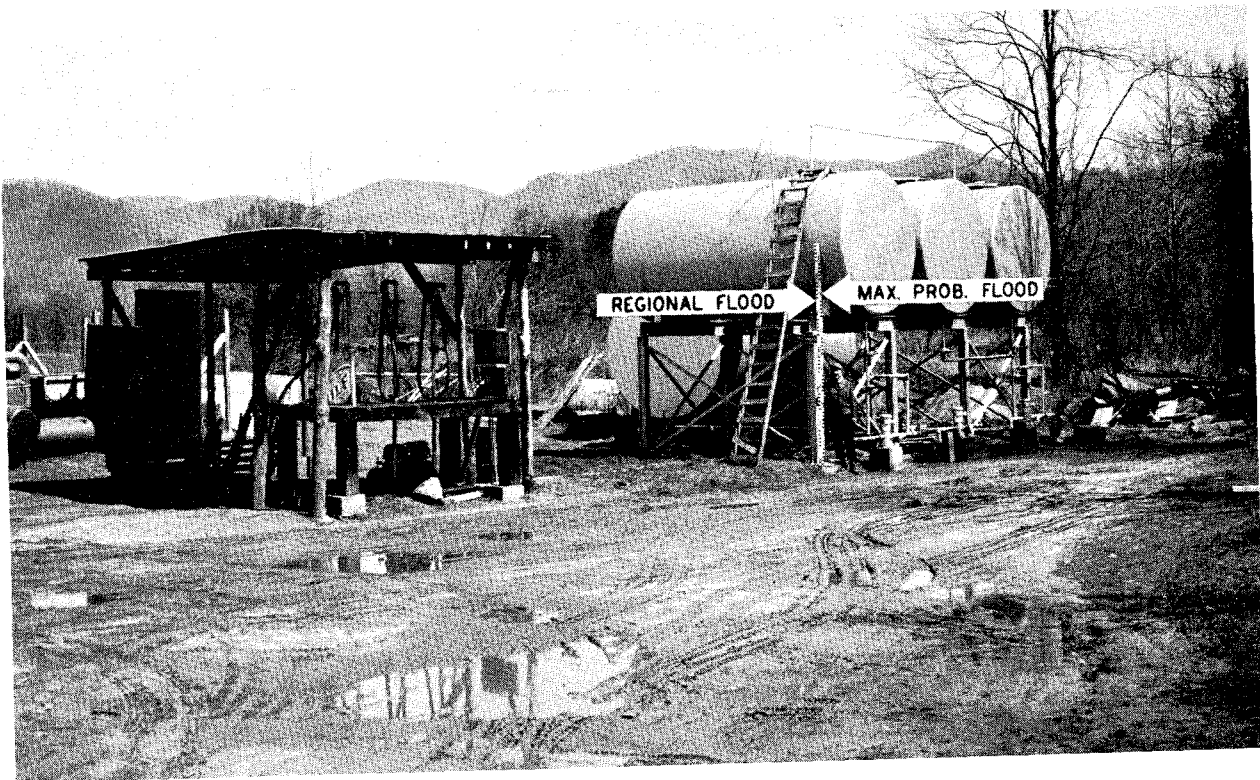


Figure 14. --FLOOD HEIGHTS IN VICINITY OF LAKEY STREET BRIDGE

Upper view is the Church of God on Lakey Street, which was surrounded by flood water in June 1949. In 1916 the flood height was about 2 feet above the floor level (base of rod). Lower view shows the plant area of the Gulf oil distributor between the church and the river, at Mile 21.0. The Regional and Maximum Probable Flood heights are shown by arrows; note that the difference between them is only 0.4 foot.



Figure 15. --FLOOD HEIGHTS NEAR MOUTH OF FLAT CREEK, BLACK MOUNTAIN
 Top view is west along U. S. Highway 70, State Street. The road is over the Flat
 Creek culvert. Middle view shows the Black Mountain Elementary School, formerly
 the high school, on Flat Creek Road on left bank, near Mile 0. 2. Bottom view shows
 the studio and transmitter building of Station WBMT on left bank at Mile 0. 24. Ar-
 rows show heights of the Maximum Probable and Regional Floods on Flat Creek,
 which differ from each other in each case by 0. 7 foot.



Figure 16. --FLOOD HEIGHTS AT PADGETT TOWN ROAD

The Fred Miller Grocery is at the southwest corner of Padgett Town and Flat Creek Roads, at Mile 0.98 on left bank. The June 1949 flood was 0.8 foot lower than the floor level. Arrows show heights of the Regional and Maximum Probable Floods.

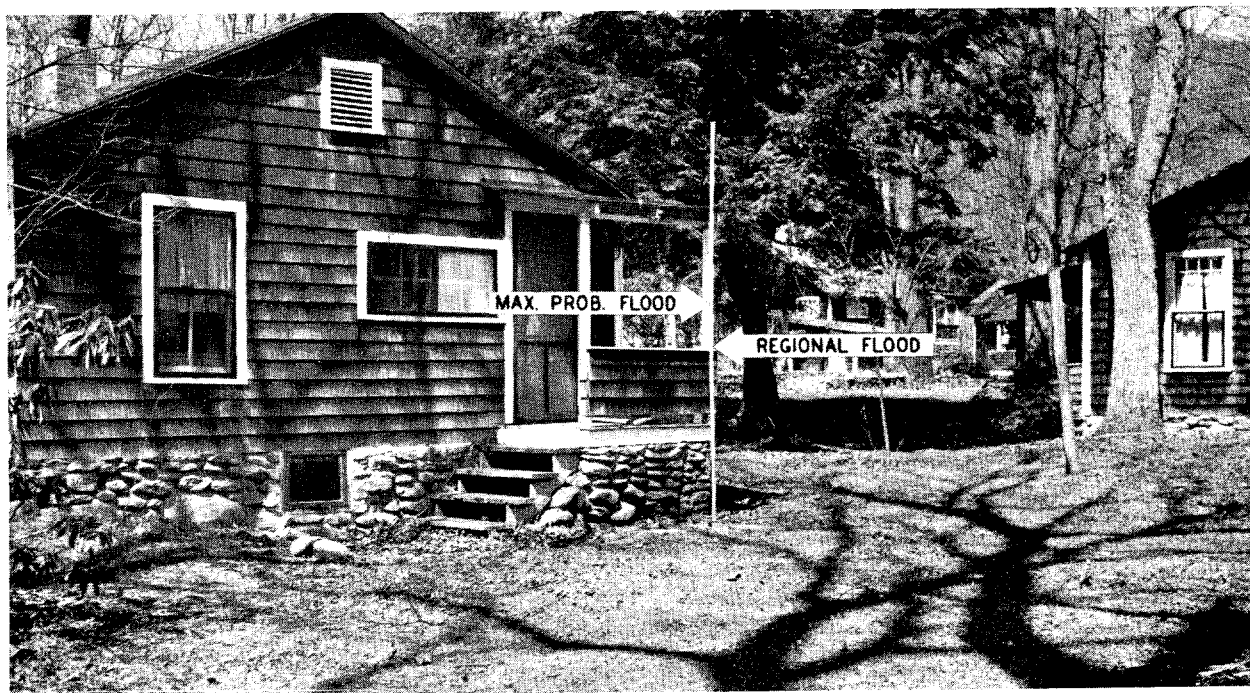


Figure 17. --FLOOD HEIGHTS AT PINE LODGE COTTAGES

This development is on the right bank of Flat Creek at Mile 1.18. The June 1949 flood height was 0.9 foot lower than the base of the rod that stands at the porch corner. Arrows show heights of the Regional and Maximum Probable Floods.

IV.

MAXIMUM PROBABLE FLOODS

IV.

MAXIMUM PROBABLE FLOODS⁽¹⁾

This section discusses the Maximum Probable Floods on the upper Swannanoa River and Flat Creek and some of the hazards of great floods. Floods of the magnitude of the Maximum Probable 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.

The two streams involved in this study--upper Swannanoa River and Flat Creek--have drainage areas of 22.2 and 6.05 square miles respectively at the downstream limits of the study. At the upstream limits the corresponding drainage areas are 3.3 and 2.7 square miles.

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 FLOOD DISCHARGES

To determine the Maximum Probable Floods on the upper Swannanoa River and Flat Creek in the vicinity of Black Mountain and Montreat, consideration was given to great storms and floods that have already occurred on this watershed and to those which have occurred elsewhere but could have occurred on these areas. This procedure provides information about possible floods and storms additional to that which can be gained from the short-term local hydrologic records alone.

The maximum known flood on the Swannanoa River in the vicinity of Black Mountain occurred in July 1916. The peak discharge at the Lakey Street bridge, Mile 20.96, is estimated to have been 17,000 cubic feet per second. On Flat Creek the maximum known flood also occurred in July 1916. The peak dis-

(1) Prepared by Flood Control Branch.

charge at Montreat Dam is estimated to have been 4,000 cubic feet per second. It is reasonable to expect that greater floods will occur on these streams.

Observed Storms

Observed storms are meteorologically transposable to the Black Mountain and Montreat 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. When transferring storms within the broad region to the Black Mountain and Montreat area, appropriate adjustments were made for differences in this moisture potential.

Table 10 lists known rainfall depths for several large storms transposable to these watersheds.

TABLE 10

SELECTED MAXIMUM OBSERVED STORMS TRANSPOSABLE

TO THE REGION OF BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

<u>Date</u>	<u>Location</u>	<u>Duration</u> hours	<u>Area</u> sq. mi.	<u>Rainfall</u> <u>Depth</u> inches
June 1937	Ivy, N. C.	1.5	4.0	6.25
July 1938	Hayesville, N. C.	1	4.0	6.0
July 1916	North Carolina	6	54	7.8
September 1940	New Jersey	6	54	18.4
October 1941	Florida	6	54	11.2
September 1957	Barnardsville, N. C.	2	3.56	5.5
July 1960	Grizzle Creek, Ga.	3	Point	12.5
June 1961	Mitchell County, N. C.	2.5	3.49	8.5

Upon the basis of these and other data, as adjusted for conditions in the watersheds, a rainstorm of 16.4 inches in 4 hours was adopted for computing the Swannanoa River Maximum Probable Flood at the lower limit of the study and

16.6 inches in 3 hours for the Flat Creek Maximum Probable Flood at the lower limit of the study.

Storms greater than these can occur. From a meteorological standpoint, storms as much as 40 percent greater than those adopted to compute the Maximum Probable Floods are possible.

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 8 and 11 list peak discharges for observed floods on several streams of approximately the size of the Swannanoa River and Flat Creek. For comparison, the discharges of the maximum known floods on these streams are listed.

TABLE 11
SELECTED MAXIMUM OBSERVED FLOODS
IN VICINITY OF BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

<u>Stream</u>	<u>Location</u>	<u>Drainage Area</u> sq. mi.	<u>Date</u>	<u>Peak Discharge</u>	
				<u>Amount</u> cfs	<u>Per Sq. Mi.</u> cfs
Big Creek	Sunburst, N. C.	1.32	1940	12,900	9,800
Big Creek	Sunburst, N. C.	1.69	1940	12,400	7,340
Dutch Creek	Valle Crucis, N. C.	2.42	1940	9,200	3,800
N. Fk. Catawba R.	Asheford, N. C.	5.20	1940	15,000	2,900
Pigeon River	Spruce, N. C.	8.4	1940	16,400	1,950
N. Fk. Catawba R.	Woodlawn, N. C.	41.8	1940	55,000	1,320
Elk Creek	Elkville, N. C.	50.0	1940	70,000	1,400
Watauga River	Sugar Grove, N. C.	55.1	1940	41,000	745
Linville River	Branch, N. C.	65.0	1940	39,500	608
Wilson Creek	Adako, N. C.	66.0	1940	99,000	1,500
Swannanoa River	Black Mountain	11.2	1916	17,000	1,520
Flat Creek	Montreat Dam	2.80	1916	4,000	1,430

Maximum Probable Flood Discharges

From consideration of the flood discharges in Table 11 and of the transposition to the Black Mountain and Montreat area of outstanding storms, the peak

discharge of the Swannanoa River Maximum Probable Flood at the Southern Railway bridge near the lower limit of the study was determined to be 28,000 cubic feet per second and at Lakey Street, 21,200 cubic feet per second. The Flat Creek Maximum Probable Flood was determined to be 13,000 cubic feet per second at the mouth and 10,000 cubic feet per second at Montreat Dam.

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, and the rate of rise.

Areas Flooded and Heights of Flooding

The areas flooded by the Maximum Probable Floods and maximum known floods are shown on Plates 8, 9, 10, and 12. Depths of flow can be estimated from the crest profiles which are shown on Plates 11 and 13.

The Maximum Probable Flood profile on the Swannanoa River is from 2 to 14 feet higher than elevations experienced in the August 13, 1940, flood. The maximum difference occurs just upstream from the Southern Railway bridge at Mile 21.33 and is the result of heading-up due to the small opening through the large railroad fill. On Flat Creek the Maximum Probable Flood profile is 3 to

15 feet higher than elevations experienced in the June 16, 1949, flood. The maximum difference occurs at the road bridge at Mile 2. 10.

The elevations shown on Plates 11 and 13 and the overflow areas shown on Plates 8, 9, 10, and 12 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.

Figures 11 to 17 on pages 52 to 56 show the height that would be reached by the Maximum Probable Flood at several locations in the vicinity of Black Mountain and Montreat.

Velocities and Rates of Rise

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 the different streams and at different locations on the same stream.

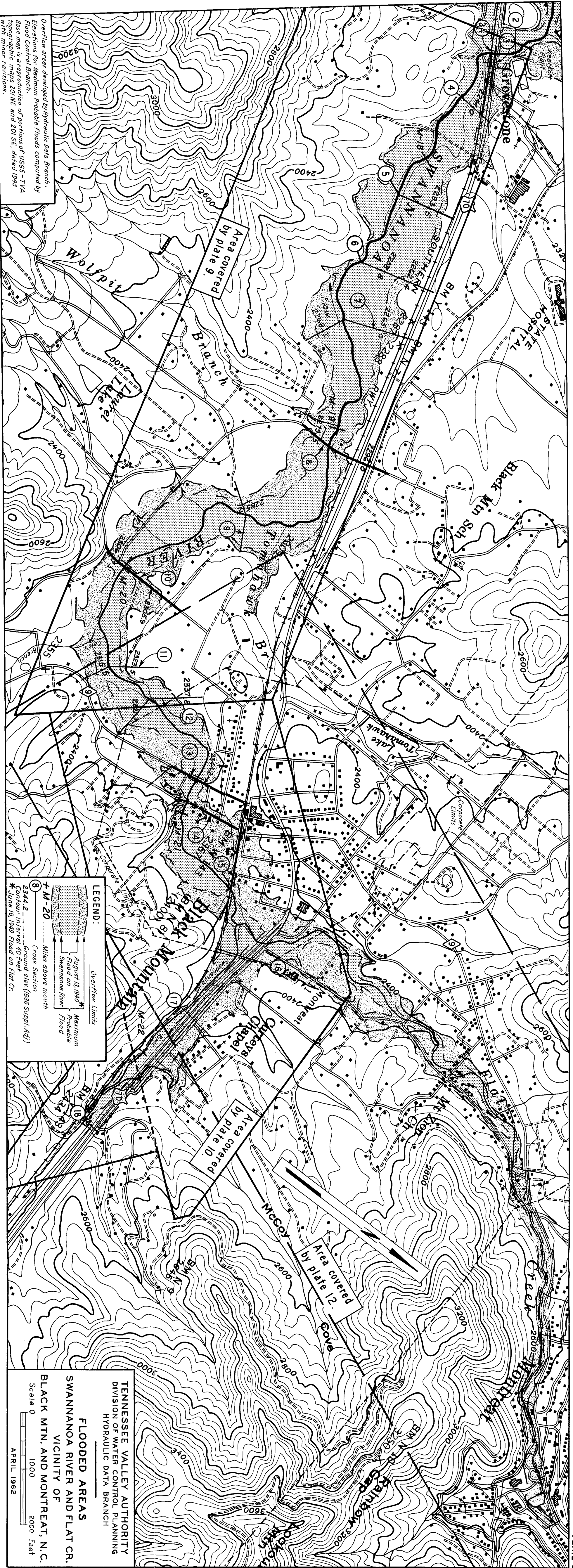
During the Maximum Probable Flood, velocities in the main channel of the Swannanoa River in the vicinity of Black Mountain and Montreat would range from more than 4 to 15 feet per second. In the overflow area, velocities would be about 1 to 9 feet per second.

The Maximum Probable Flood on the Swannanoa River at Mile 21. 14, between Lakey Street and the Southern Railway bridge, would rise about 10 feet above low water to its crest stage in about 3 hours with a maximum rate of rise of about 4. 5 feet in 1 hour.

On Flat Creek during the Maximum Probable Flood, velocities in the main channel would range from about 3 to 19 feet per second. In the overflow area, velocities would range from about 1 to 6 feet per second.

The Maximum Probable Flood on Flat Creek near the mouth below U. S. Highway 70 bridge would rise about 15 feet above low water to its crest stage in about $3\frac{1}{2}$ hours with a maximum rate of rise of 5 feet in one-half hour. Immediately above the bridge at Mile 2. 40, Flat Creek would rise about 14 feet above low water to its crest stage in about $1\frac{1}{2}$ hours with a maximum rate of rise of 10 feet in one-half hour.

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



Overflow areas developed by Hydraulic Data Branch.
 Elevations for Maximum Probable Floods computed by
 Flood Control Branch.
 Base map is a reproduction of portions of USGS - TVA
 topographic maps 201 NE and 201 SE, dated 1943
 with minor revisions.

Area covered
 by plate 9.

Area covered
 by plate 10.

Area covered
 by plate 12.

LEGEND:

Overflow Limits

Maximum Probable Flood

August 13, 1940
 Flood on Swannanoa River

Ground elev. (1936 Suppl. Ad.)
 Contour 2, In Interval 40 Feet
 * June 16, 1949 Flood on Flat Cr.

Miles above mouth

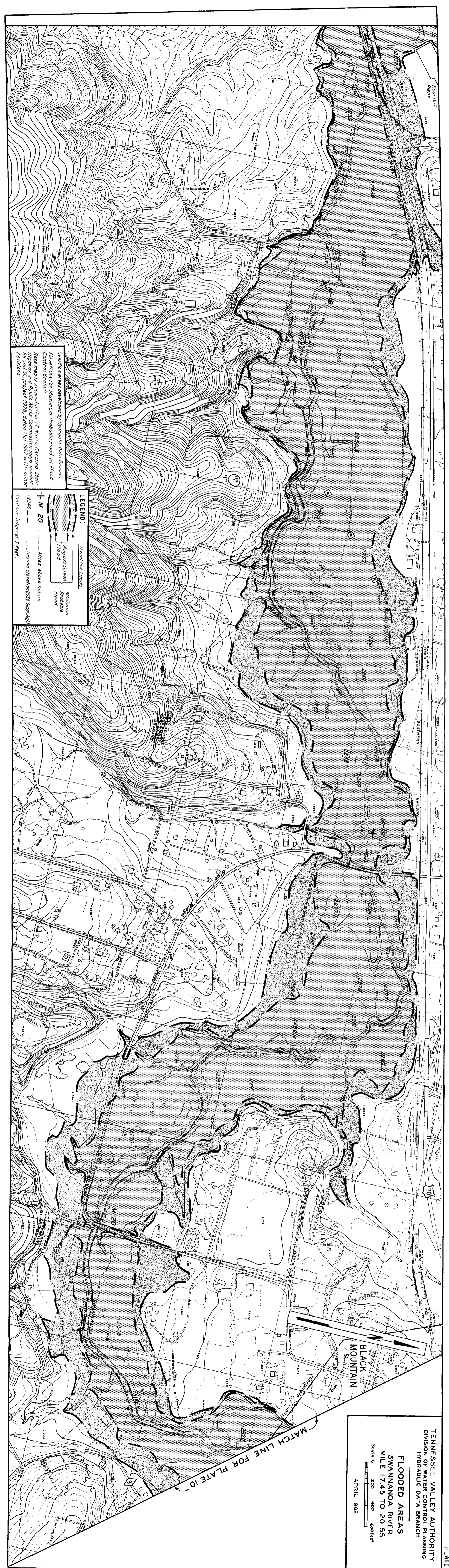
Cross Section

FLOODED AREAS
SWANNAOA RIVER AND FLAT CR.
VICINITY OF
BLACK MTN. AND MONTREAT, N.C.

TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

Scale 0 1000 2000 Feet

APRIL 1962



TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH
FLOODED AREAS
SWANNANOA RIVER
MILE 17.45 TO 20.55
 Scale 0 200 400 600 Feet
 APRIL 1962

MATCH LINE FOR PLATE 9



Overflow areas developed by Hydraulic Data Branch.
Elevations for Maximum Probable Flood by Flood Control Branch.
Base map is a reproduction of North Carolina State Highway and Public Works Commission maps number 57 and 58, project 9998, dated Oct. 1957 with minor revisions.

LEGEND:

Overflow Limits

August 8, 1940 Flood

Maximum Probable Flood

+ M - 22 Miles above mouth

+ 2348 Ground elevation (1938 Suppl. Ad)

Contour interval 5 Feet.

INSET A

MATCH LINE

PLATE 10

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

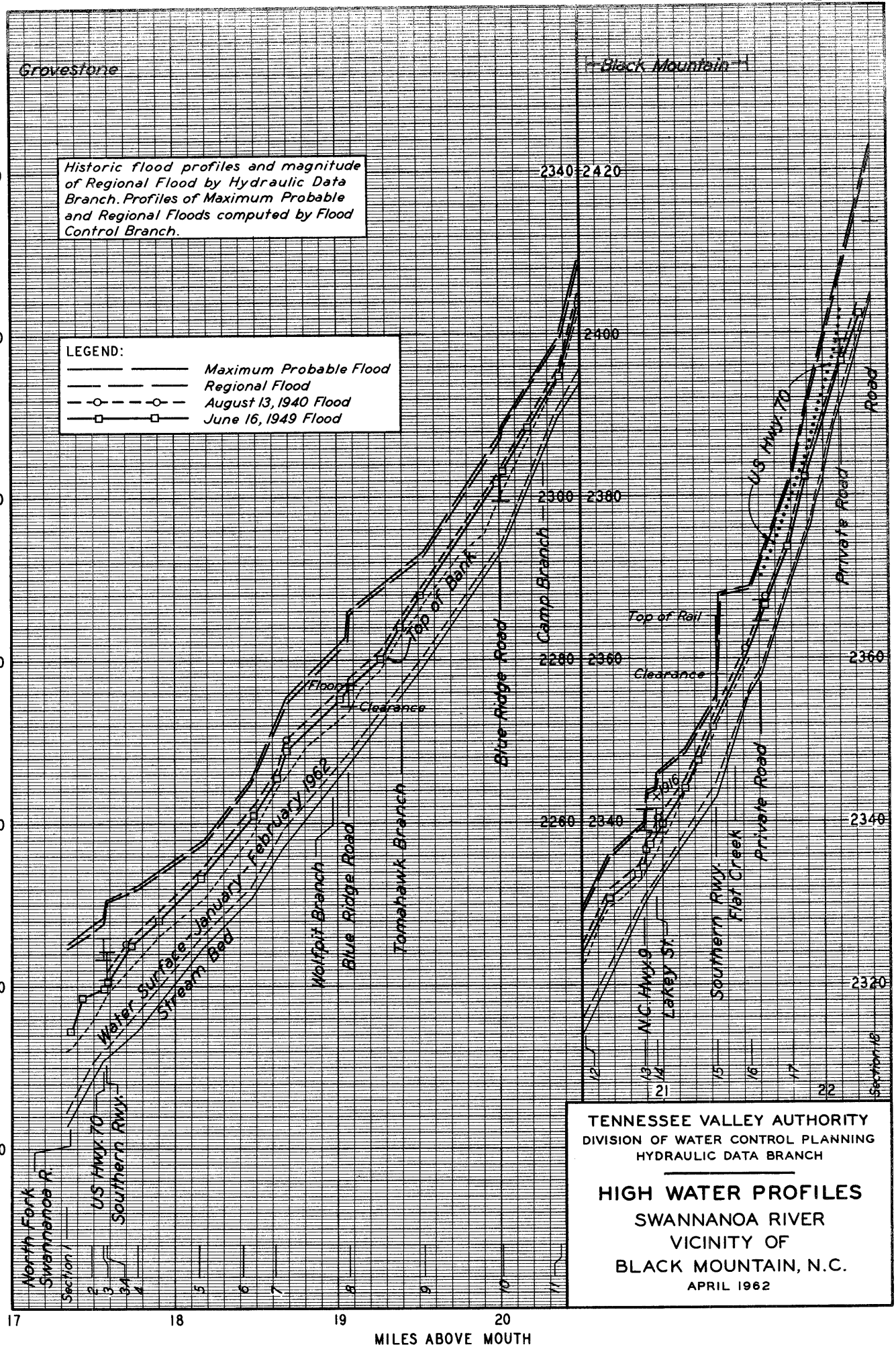
FLOODED AREAS
SWANNAOA RIVER
MILE 20.55 TO 22.30

Scale 0 200 400 600 feet

APRIL 1962

MATCH LINE FOR INSET A

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



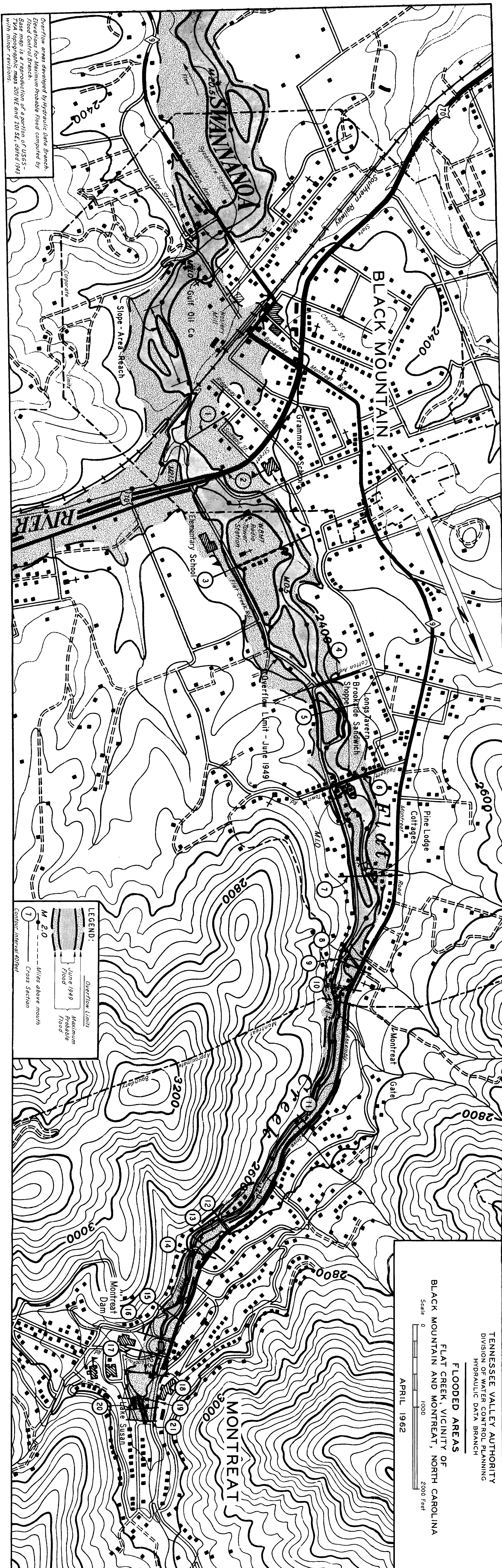
Historic flood profiles and magnitude of Regional Flood by Hydraulic Data Branch. Profiles of Maximum Probable and Regional Floods computed by Flood Control Branch.

LEGEND:
 ———— Maximum Probable Flood
 - - - - - Regional Flood
 ······ August 13, 1940 Flood
 - · - · - June 16, 1949 Flood

TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

HIGH WATER PROFILES
 SWANNANOA RIVER
 VICINITY OF
 BLACK MOUNTAIN, N.C.
 APRIL 1962

17 18 19 20 21 22
 MILES ABOVE MOUTH



Overflow areas developed by Hydraulic Data Branch, Elevations for Maximum Probable Flood computed by Flood Control Branch. Base map is a reproduction of a portion of USGS-7VA topographic maps 201 NE and 201 SE, dated 1943 with minor revisions.

LEGEND:

- Overflow Limits
- June 1949 Flood
- Maximum Probable Flood
- Miles above mouth
- Cross Section
- Contour interval 40 feet

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

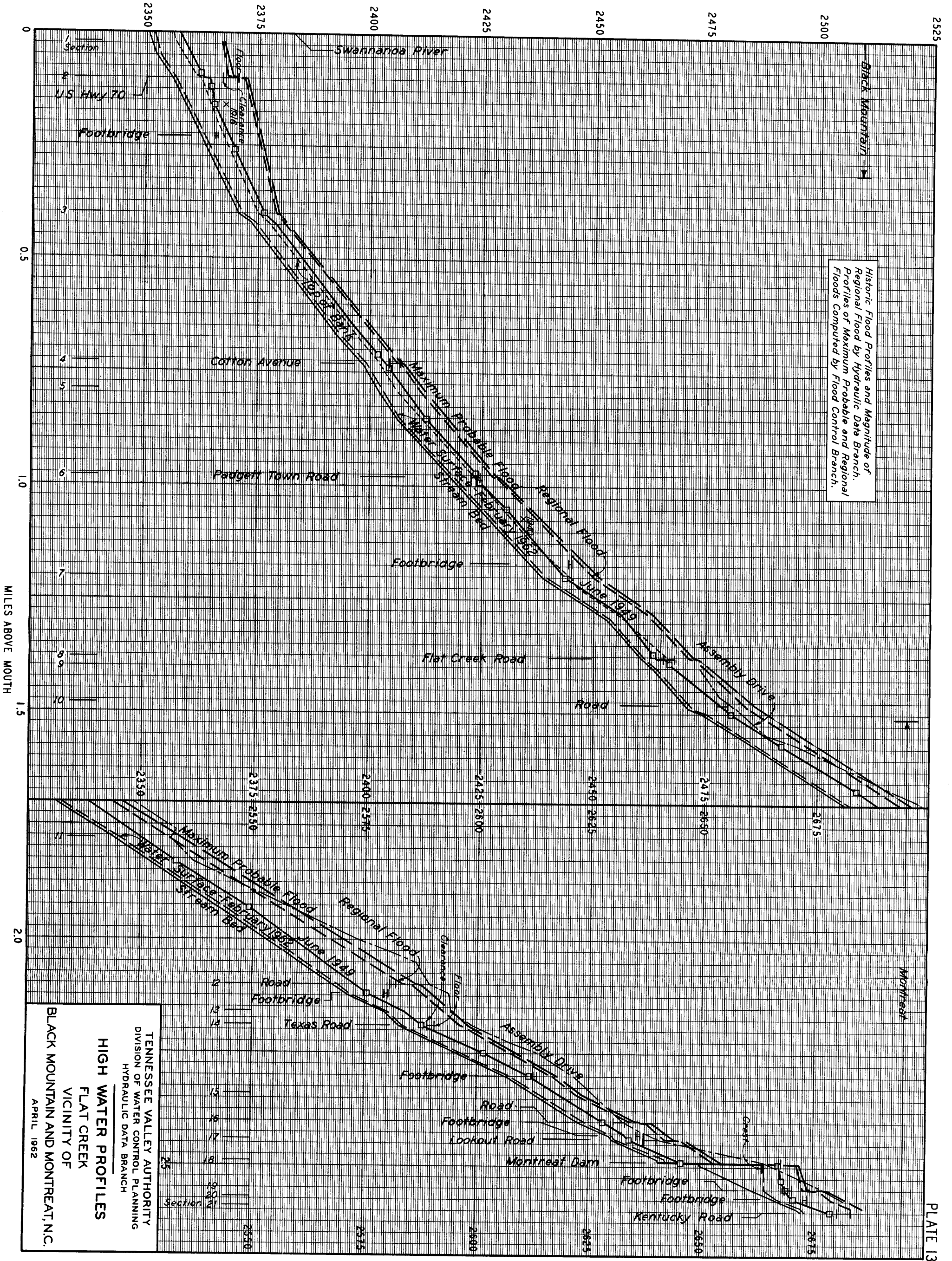
FLOODED AREAS
FLAT CREEK, VICINITY OF
BLACK MOUNTAIN AND MONTREAT, NORTH CAROLINA

APRIL 1962

Scale

2000 Feet

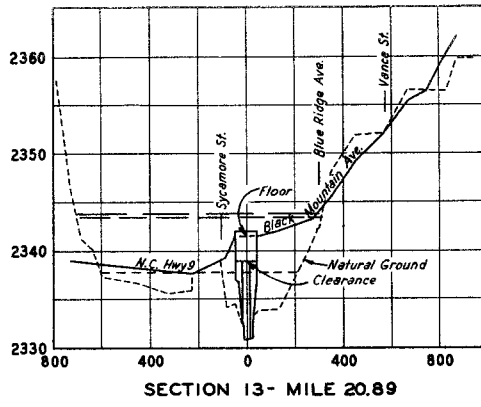
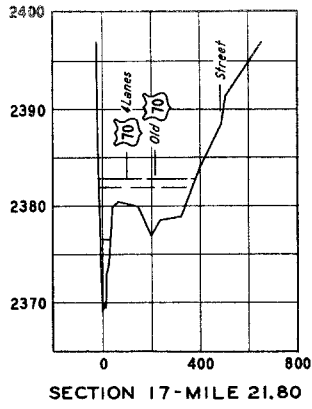
ELEVATION IN FEET (USC & GS 1936 SUPPL. ADJ.)



Historic Flood Profiles and Magnitude of Regional Flood by Hydraulic Data Branch. Profiles of Maximum Probable and Regional Floods Computed by Flood Control Branch.

MILES ABOVE MOUTH

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH
HIGH WATER PROFILES
FLAT CREEK
VICINITY OF
BLACK MOUNTAIN AND MONTREAT, N.C.
APRIL 1962



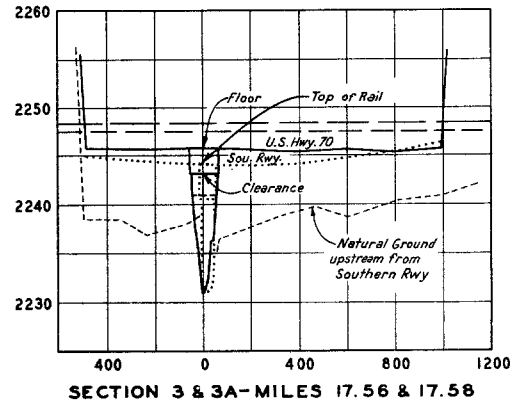
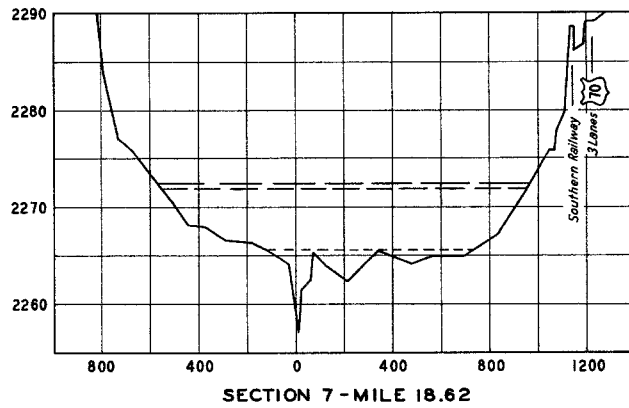
LEGEND:

- Maximum Probable Flood
- - - Regional Flood

August 13, 1940 flood on Swannanoa River.
June 16, 1949 flood on Flat Creek.

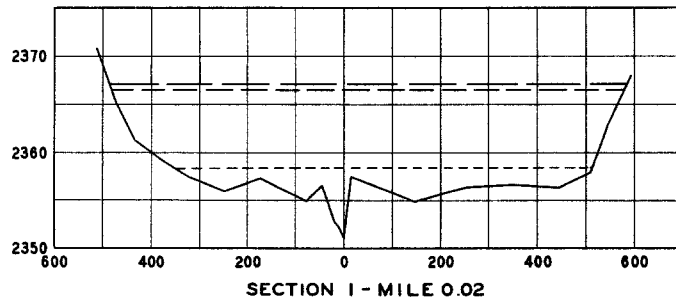
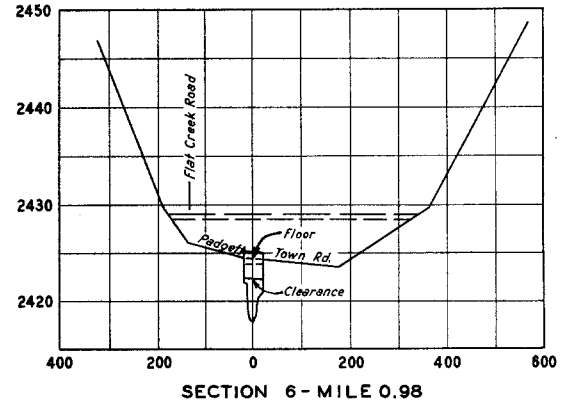
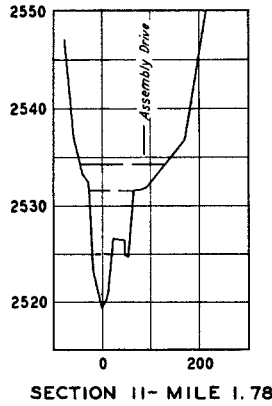
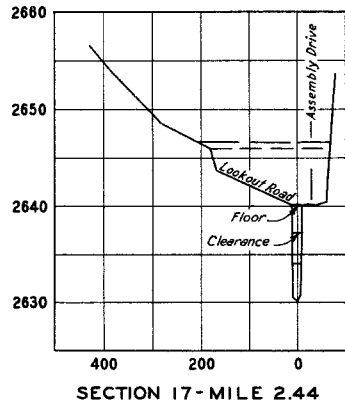
Sections taken looking downstream.
15 sections on Swannanoa River not shown.
17 sections on Flat Creek not shown.

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



SWANNANOA RIVER

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



TENNESSEE VALLEY AUTHORITY
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HYDRAULIC DATA BRANCH

CROSS SECTIONS
SWANNANOA RIVER AND
FLAT CREEK
VICINITY OF
BLACK MOUNTAIN AND MONTREAT, N.C.
APRIL 1962

HORIZONTAL DISTANCE IN FEET **FLAT CREEK**