Roanoke Valley Regional Stormwater Management Plan

Volume 1: Report

Sponsored by:

- Fifth Planning District Commission, and

- City of Roanoke
- City of Salem
- County of Roanoke
- Town of Vinton

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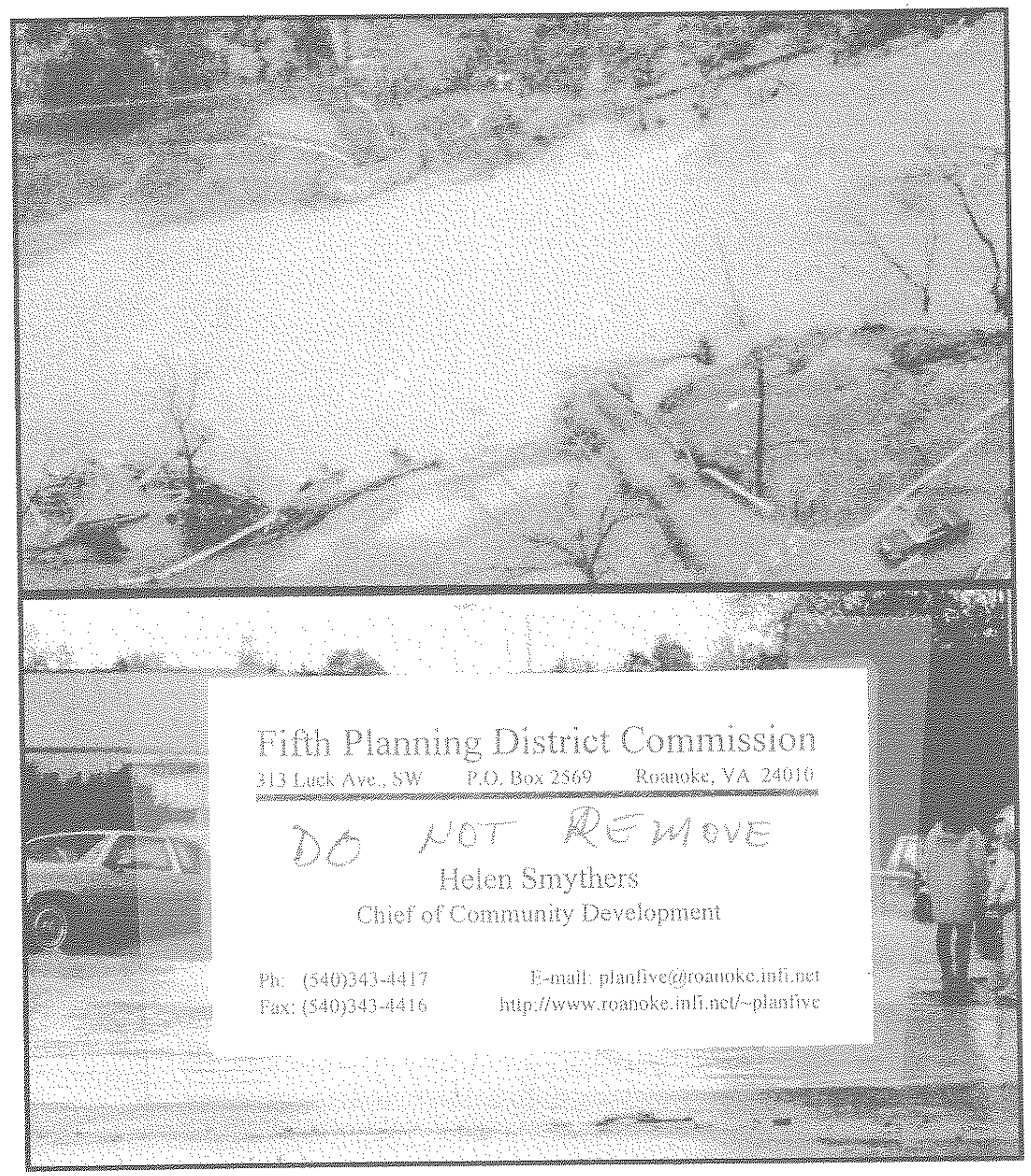

Working Together to Address the Roanoke Valley Flooding Problems!

Covering:

- Back Creek Watershed
- Barnhardt Creek Watershed
- Butt Hollow Creek Watershed
- Carvin Creek Watershed
- Cole Hollow Branch Watershed
- Dry Branch Watershed
- Gish Branch Watershed
- Glade Creek Watershed
- Lick Run Watershed
- Mason Creek Watershed
- Mudlick Creek Watershed
- Murray Run Watershed
- Ore Branch Watershed
- Peters Creek Watershed
- Tinker Creek Watershed
- Wolf Creek Watershed

Prepared by Dewberry&Davis in cooperation with:

- CH2M Hill
- T.P. Parker&Son
- Barton Aerial Technologies

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1.0 INTRODUCTION

Authority and Acknowledgments

This report was prepared by Dewberry & Davis under contract to the Fifth Planning District Commission (5th PDC) of the Commonwealth of Virginia. The 5th PDC covers the Counties of Alleghany, Botetourt, Craig and Roanoke; the cities of Clifton Forge, Covington, Roanoke, and Salem; and the Towns of Iron Gate, Fincastle, Troutville, Buchanan, New Castle, and Vinton. Localities participating in this study include only the Cities of Roanoke and Salem, the County of Roanoke and the Town of Vinton.

The following key individuals supplied information, or actively participated in the preparation of this report:

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Their assistance and participation has been invaluable in the compilation of information and in the preparation of this report. Without their support of this report, its completion would have been difficult, if not impossible.

This report was completed in December of 1996.

Purpose of Study

The Roanoke Valley Regional Stormwater Management Plan is a multi-jurisdictional effort coordinated by the 5th PDC. The project is funded by the City of Roanoke, the City of Salem, the County of Roanoke, the Town of Vinton, and a stormwater mitigation grant from the Federal Emergency Management Agency (FEMA).

The overall focus of the report is the implementation of policies and procedures for mitigation of floods in the Roanoke Valley. Moreover, to accomplish this, other components included in this study will assist the jurisdictions' decision making process in the immediate- and near-future as demographics and land uses change. Some of these components that will serve as a base for the stormwater management guidelines include:

Enhancement of the 1993 FEMA Flood Insurance Study

- improve accuracy of topography used in the FIS
- add detail to 112 miles of FIS HEC-2 modeling including cross sections and recalibration to make it a component of a long range planning tool
- develop rainfall runoff models that can be calibrated to the Interactive Flood Observation and Warning System (IFLOWS) and are capable of projecting year 2020 land use conditions
- provide training on hydrologic/hydraulic model uses as well as supplement and enhance existing data in digital file format such as ARC/INFO GIS for future use and enhancement by the local governments or Regional Authority

Development of master plans for individual watersheds

- delineate 100 yr. floodplain limits based on ultimate land uses
- compare impacts of existing and developed land use patterns
- provide recommendations to minimize or eliminate flooding problems

Development of specific multi-jurisdictional projects and policies

- provide cost beneficial and permitable solutions which will reduce existing flooding problems
- minimize future damages due to planned development

Development of implementation practices including policies, ordinances and guidelines for funding methods to construct the identified projects

- develop a stormwater quality management plan
- prepare maintenance guidelines and model maintenance agreement
- develop an implementation program

Preparation of watershed plans for selected areas

- provide plan of action
- develop a priority list

Study Limits

The study area consists of the development of watershed plans for sixteen priority watersheds that are tributaries to the Roanoke River and drain a combined area of 248 square miles. The overall watershed area is shown on the Vicinity Map (Figure 1). The study also includes detailed hydraulic modeling of 30 streams in the 16 priority watersheds covering a length of 112 miles. The watersheds studied in this report are listed in Table 1.1. The hydraulic study reaches are listed in Table 1.2. A summary of how each watershed and stream length is distributed among the four jurisdictions is presented in Table 1.3.

Table 1.1 Studied Watersheds

Watershed	Drainage Area (mi^2)	Watershed	Drainage Area (mi^2)
Back Creek	58.7	Lick Run	7.8
Barnhardt Creek	4.2	Mason Creek	27.6
Butt Hollow	2.7	Mudlick Creek	9.6
Carvin Creek	28.0	Murray Run	2.9
Cole Hollow	5.9	Ore Branch	4.1
Dry Branch	4.5	Peters Creek	9.0
Gish Branch	2.0	Tinker Creek	42.8
Glade Creek	33.0	Wolf Creek	4.9

Table 1.2 Studied Hydraulic Reaches

Stream	Study Length (Ft.)	Downstream Limits	Upstream Limits
Back Creek (& 4 Tribs.)	131,700 (36,700)	Confluence with Roanoke River	~ 800' upstream of Apple Grove Lane
Barnhardt Creek	24,000	Confluence with Roanoke River	~ 4800' upstream of Grandin Rd.. Ext.
Butt Hollow Creek	4,900	Confluence with Roanoke River	Interstate 81
Carvin Creek	28,300	Confluence with Tinker Creek	Interstate 81
Cole Hollow Branch	7,200	Norfolk & Western Railroad	Brogan Circle
Cook Creek	4,800	Confluence with Glade Creek	~ 600' upstream of Crumpacker Drive
Deer Branch	7,000	Confluence with W. Fork Carvin	~ 2200' upstream of Peters Creek Rd..
Dry Branch	15,800	Confluence with Roanoke River	~ 500' upstream of Frosty Lane
Gish Branch	9,700	Confluence with Mason Creek	Interstate 81
Glade Creek	29,000	Confluence with Tinker Creek	Roanoke/Botetourt County Line
Glade Creek-Trib. A	6,800	Confluence with Glade Creek	Downstream of U.S. Route 221/460
Glade Creek-Trib. B	4,650	Confluence with Glade Creek	~ 500' upstream of Ruritan Road
Jumping Run Creek	9,300	Confluence with Mason Creek	~ 3700' upstream of Carvin Cove Rd.
Lick Run	35,000	Confluence with Tinker Creek .	~ 500' upstream of Sioux Ridge Road
Mason Creek	53,300	Confluence with Roanoke River	Plunkett Road
Mudlick Creek	31,000	Confluence with Roanoke River	~ 3700' upstream of Canter Drive
Murray Run	19,000	Confluence with Roanoke River	~ 1200' upstream of Crawford Road
Ore Branch (& Trib.)	11,300 (4,600)	Confluence with Roanoke River	Confluence of Tributaries
Peters Creek	27,500	Confluence with Roanoke River	Confluence of Tributaries A&B
Peters Creek-Trib. A	5,300	Confluence with Peters Creek	~ 100' upstream of Timberview Road
Peters Creek-Trib. B	2,100	Confluence with Peters Creek	~ 2000' upstream of Green Ridge Rd..
Peters Creek-Trib. C	5,800	Confluence with Peters Creek	Upstream of Embassy Drive
Tinker Creek	50,500	Confluence with Roanoke River	Roanoke/Botetourt County Line
Trout Run	2,900	2000' u/s of conf. with Lick Run	~ 100' upstream of 7th Street
West Fork Carvin Creek	17,500	Confluence with Carvin Creek	Interstate 81/581 Interchange
Wolf Creek	19,400	Confluence with Roanoke River	Blue Ridge Parkway

Table 1.3 Distribution of stream lengths and watershed areas

	JURISDICTION									
	Roanoke City		*Roanoke Co.*		*Vinton*		*Salem*		TOTAL	
	Stream Length (ft)	Drainage Area (mi²)	Stream Length (ft)	Drainage Area (mi²)	Stream Length (ft)	Drainage Area (mi²)	Stream Length (ft)	Drainage Area (mi²)	Stream Length (ft)	Drainage Area (mi²)
Back Creek			131,700	58.7					131,700	58.7
Barnhardt	10,000	0.9	13,900	2.7			1700	0.6	25,600	4.2
Butt Hollow			600	2.5			4,300	0.2	4,900	2.7
Cole Branch				3.2			8,200	2.7	8,200	5.9
Dry Branch			5,700	3.7			10,100	0.8	15,800	4.5
Mason		0.1	18,900	24.2			23,500	3.3	42,400	27.6
Gish Branch				1.1			10,000	0.9	10,000	2.0
Mudlick	13,000	1.4	18,100	8.2					31,100	9.6
Murray Run	14,800	1.5	4,400	1.4					19,200	2.9
Ore Branch	11,300	2.6		1.5					11,300	4.1
Peters Creek	22,300	4.5	5,100	4.5					27,400	9.0
Tinker	20,100	7.9	22,100	4.4	8,000	0.6			50,200	42.8
Glade	6,300	2.6	15,600	5.2	6,000	1.4			27,900	33.0
Carvin	3,800	0.2	24,500	15.9					28,300	28.0
Lick Run	35,200	7.8							35,200	7.8
Wolf Creek			7,000	3.9	12,400	1.0			19,400	4.9
TOTAL	136,800	29.5	267,600	141.1	26,400	3	57,800	8.5	488,600	247.7

* Drainage area within the County of Botetourt is included in the total column. Because the County of Botetourt elected not to participate in the study, no stream reaches were studied in the County of Botetourt.

1.1 STUDY AREA DESCRIPTION

General

The study area is located in the southwestern portion of Virginia along the western slopes of the Blue Ridge Mountains. The study area covers most of the Town of Vinton (3 square miles) , the Cities of Salem (10.5 square miles) and Roanoke (30.7 square miles) and Roanoke County (141.1 square miles).

Of the 251 square miles of watershed study area, approximately 56% of the area is within Roanoke County, approximately 12% is within the City of Roanoke, approximatley 4% is within the City of Salem and approximately 1% is within the Town of Vinton. The remaining 27% of the watershed study area is located in the southern part of Botetourt County. This area is the headwaters for the streams that flow in a southerly direction toward the Roanoke River. The Roanoke River flows in an easterly direction through the central part of Roanoke County and approximately through the central part of the watershed study area. It is the principal link for all of the streams studied in this report

Climatic and Physiographic Characteristics

The climate in this area of Virginia is mild, exemplified by warm summers and moderately cool winters. Average monthly temperatures range from a low of 36°F in January to a high of 73°F in July. The average annual temperature is 54°F. Annual precipitation is 43 inches and proportionate throughout the year. The highest monthly rainfalls occur between May and September. Snowfall depths average about 20 inches per year. Snowfall depths are greater in the higher elevations.

The area is characterized by mountainous and hilly terrain interspersed with large valleys. Elevations range from over 3600 ft. in the western mountainous regions to 900 ft. along the Roanoke River at the southeastern edge of the study area.

Most of the watershed study area lies within the Ridge and Valley physiographic province which is characterized by long parallel ridge lines and intervening valleys. Most of the ridges in the highland areas are comprised of erosive resistant sedimentary rock. Parallel to the ridges are the lowland and valley areas. These lowland areas are formed from the weathering and rapidly erodible limestone, dolomite and shale rocks exposed during the formation of the

Appalachian mountains.

There is a wide range of soil classification within the watershed study area. Many of the soils within the watershed study area are strongly acidic, typical of the mountains in the region. The National Resource Conservation Service (NRCS), formerly Soil Conservation Service (SCS), categorizes the 30,000 soil series into 4 hydrologic groups, A, B, C, and D. Soils in the A hydrologic soil group have the highest infiltration capacity; D soils have the lowest infiltration capacity (i.e., higher runoff volumes are characteristic of the C and D soils). The soils in the study consist of approximately 40% B, 30% C and 30% D, and in general terms are moderately to poorly drained.

Existing Land Use

Existing land uses were determined primarily from 8,000:1 and 16,000:1 aerial photography taken in March 1995 of the County of Roanoke, the Cities of Roanoke and Salem, and the Town of Vinton. For areas in the County of Botetourt, existing land use categories were determined from 24,000:1 aerial photography taken in the 1970's, supplemented with County of Bortetourt existing land use data presented in comprehensive plans and determined from field investigations. The 1995 aerial photographs allowed seventeen different existing land uses to be identified. These land use categories are shown below.

Existing Land Use Categories

Open space (lawn, parks etc.)
Open water (Lakes, ponds, etc.)
Paved parking lots, roofs, driveways, etc.
Commercial & business districts (average 85% impervious surfaces)
Industrial districts (average 72% impervious surfaces)
Residential districts, ⅛ acre average lot size (town houses) (average 65% impervious surfaces)
Residential districts, ¼ acre average lot size (average 38% impervious surfaces)
Residential districts, ⅓ acre average lot size (average 30% impervious surfaces)
Residential districts, ½ acre average lot size (average 25% impervious surfaces)
Residential districts, 1 acre average lot size (average 25% impervious surfaces)
Residential districts, 2 acre average lot size (average 12% impervious surfaces)
Agricultural, cultivated land
Pasture, grassland, or range land
Brush, weed, and grass mix
Woods
Railroad
Non-contributing areas

Developed Land Use

Future development often results in increased runoff rates and volume, which produce higher flood elevations and adversely affect downstream areas. Therefore, it is important to assess the effect of developed conditions (Year 2020) on peak runoff rates and volumes. Using zoning maps, comprehensive plans, and maps of all communities in the study area, developed land use projections to the Year 2020 were developed. Note that these projections were developed only to estimate the impact of future development on flooding and are not an official community endorsed planning projection. The Year 2020 developed conditions land use projections are based on the following information provided by the communities and developed conditions (Year 2020) discharges may be reduced by future revisions to these community projections that include more cluster development or a reduction in high-intensity land uses.

The developed land use plan for Salem is presented in the *Future Land Use* map dated *May 1993*. Because very little developable land exists within the City, land uses are projected to change very little. Therefore, Year 2020 land use for the City of Salem, representing approximately 100% build-out , is consistent with the current City of Salem comprehensive plan.

The Town of Vinton Comprehensive Plan adopted in December 1994 states that only 11.8% of the usable Town area remains vacant. Therefore, Year 2020 land use for the Town of Vinton, representing approximately 100% build-out, is consistent with the current Town of Vinton comprehensive plan.

The City of Roanoke developed land use projections are presented in the *Roanoke Vision*, the comprehensive development plan for Roanoke from 1985 to 2005. The City is approximately 95% developed, with the most significant change being the conversion of most of the remaining agricultural land uses to residential land uses. No projection adjustments were made for Year 2020 land use.

The County of Roanoke projects extensive development within certain areas of the county. These development corridors include development along Routes 221, 220, 419, 311, 117, a small segment of I-81, and development south and east of the Town of Vinton. These development corridors were adjusted, based on the projected growth rates, to project 2020 land use.

The County of Botetourt projects sizable development in the area adjoining the County of Roanoke, particularly in the areas tributary to Tinker and Glade Creek. This development includes a 1,100 acre industrial park and significant increases in residential land uses. These development corridors were adjusted, based on the projected growth rates, to project 2020 land use.

All the communities, except the County of Roanoke, use a function-based land use designation. That is, land uses were designated by the intended uses such as residential, industrial, commercial, etc. However, in the County of Roanoke, land use planning is based on the planned "character" of an area, such as a rural village, village center, rural preserve, etc. These "character-based" designations consist of several function-based land use designations such as residential land uses mixed with commercial land use. However, the proposed areas of each function-based land use is not specified within the character-based designation.

Given the different conventions, and the different resolutions of planning land use data provided by each community, the land use categories presented for existing land uses were supplemented with the following land use categories for developed conditions (Year 2020).

Supplemental Developed Land Use Category	Comments
Low Density Residential	Function-based land use designation, 1- to 2- acre average lot size.
Medium Density Residential	Function-based land use designation, ⅓- to ½-acre average lot size
High Density Residential	Function-based land use designation, ⅛- to ¼-acre average lot size.
Rural Village Center	Character-based land use designation
Rural Village	Character-based land use designation
Rural Preserve	Character-based land use designation

1.2 Flood History

The history of flooding in the Roanoke Valley has been well documented since records were kept. The area was first settled in the late 1600's however, development did not occur in earnest until the railroad arrived in 1880. According to newspaper accounts, the history of flooding from the Roanoke River is much more documented than along the tributaries. Since 1877 over 17 large floods have occurred in the Roanoke Valley with 4 of the largest in the past 20 years. Dates of significant flooding include the following:

1877	August, 1928	July, 1947	November, 1985
August, 1892	October, 1932	August, 1961	April, 1992
October, 1893	January, 1935	July, 1962	June, 1995
October, 1906	August, 1939	June, 1972	
Spring, 1913	August, 1940	April, 1978	

In the past 20 years four of the largest floods on record have occurred including June, 1972, April, 1978, November, 1985, and April, 1992. Based on the rainfall amounts and durations which resulted in these flood events, the June, 1972, April, 1978, and November, 1985 flood events have recurrence intervals, respectively, of approximately 50-, 130-, and 10-year.

In this period of active flood activity, flooding damages have been estimated exceeding $200 million with over 12,000 impacted residential structures and over 1,000 businesses.

The flood of November, 1985, being the flood of record, provides the most documented peak discharges and high water marks. Records from 1985 show that debris blockage of stream crossings is a significant factor in the extent of flooding which cannot be ignored. Based on available post disaster photographs and records maintained by local governments and VDOT, several stream crossings experienced severe debris blockage. The impact of debris blockage on flood elevations is presented in Chapter 2.

The amount and extent of damage caused by any flood depends in general upon the topography of the flooded area, developments in the floodplain, depth and duration of flooding, the velocity of flow and the rate of rise of the floodwater. Southwest Virginia is a very vulnerable area for flood and debris damage, in part, due to the ridge-valley composition of the terrain, the many streams and tributaries that drain the region, and the climatic effects of the mountain ridges throughout the region. This region is susceptible to both localized flooding and regional flooding. Bursts of high intensity rainfall (e.g., thunderstorms) can result in flooding along some tributaries while other immediate areas may not be affected at all. Heavy rains from tropical storms from the south and southeast can cause wide range damage throughout the area. The mountain ranges act as barriers and guide tropical storms in a northeasterly direction.

The most severe flooding on the Roanoke River is usually the result of heavy rains associated with tropical storms, while tributary stream flooding is usually the result of local thunderstorms or frontal systems. Flooding along tributaries is compounded when the streams in the lower elevations create back-ups in the feeder streams.

Major floods in the area have occurred in 1940 and 1972 with discharges of 24,400 and 28,800 cfs, respectively, as measured at the U.S. Geological Survey gage on the Roanoke River at Niagra, Virginia (near where the Blue Ridge Parkway crosses the Roanoke River). On Tinker Creek at Dale Avenue (0.7 miles upstream from the confluence with Roanoke River) the August 1940 storm produced a discharge of 9000 cfs. The flood damage from the August 1940 storm was extensive and resulted in major damage to buildings, roads, bridges, and agricultural crops. The 1972 flood on the Roanoke River, which was a result of Tropical Storm Agnes, was estimated as a 50-year flood. Approximately 400 homes were damaged by flooding from Hurricane Agnes in the Roanoke-Salem area. In the city of Salem, the flood waters crested at 1,022.6 ft. measured just upstream of the Main Street bridge (FEMA, 1993).

On November 5, 1985 a 130-year flood event inundated the study area. This flooding, "the worst flooding in the Roanoke Valley since records have been kept"[1], was caused by the remnants of Hurricane Juan. The flooding inundated much of the downtown area of Roanoke and resulted in 10 deaths. A total of 11 inches of rain fell between Thursday October 31 and the following Monday. The last six inches occurring during the last 24 hours of that five day deluge (The Vinton Messenger, 1995).

1.3 Hydrologic Analyses

Methodology

For this study, the hydrologic study was conducted using SCS methodologies in the U.S. Army Corps of Engineers HEC-1 model. The HEC-1 model was used to develop peak discharges (rate of flow) for a range of recurrence interval events for both existing land use and developed land use conditions. Since possible mitigation measures involve flood control dams, hydrographs (peak flow vs. time) were necessary for the routings.

Development of a hydrologic model to accurately replicate runoff from known rainfall depths requires extensive data. An insufficient number of stream gages and precipitation gages in the study area makes such data scarce however, the available data is sufficient to calibrate the hydrologic models. Precipitation records were evaluated to confirm the use of the SCS Type II 24-hour rainfall distribution for use in the HEC-1 model. Rainfall amounts for the 24-hour storm were obtained from TP-40. This, also, was verified through a review of available precipitation records. The calibration data can be found in a separately published hydrologic addendum to this report. In the City of Roanoke, the 24-hour rainfall amounts are shown in Table 1.4.

[1]Richmond Times Dispatch, Nov. 5, 1995

Table 1.4 Precipitation Values for 24-hour Storm in the City of Roanoke

Storm	Precipitation (in)
2-year	3.5
5-year	4.4
10-year	5.1
25-year	5.9
50-year	6.7
100-year	7.5

Flood discharges are directly related to runoff. The volume of runoff depends on numerous factors of which rainfall volume is paramount. For very large watersheds the volume of runoff from one storm event may depend on residual effects of recently occurring storms. In many analyses hydrologists usually assume that the current storm's runoff is independent of previous storm events.

Another common assumption in hydrologic modeling is that the rainfall available for runoff is separated into three parts; direct runoff, initial abstraction, and losses. The initial abstraction consists mainly of interception, infiltration and surface storage. Factors that affect the split between losses and runoff include the volume of rainfall, land cover and use, soil type, and antecedent moisture conditions. Because of the large number of factors that affect the separation of rainfall into direct runoff and losses, the process of hydrologic modeling involves the acceptance of some simplifying assumptions. These simplifying assumptions are incorporated into SCS's TR-55 methodologies/reference for synthetically converting rainfall to runoff.

A curve number is an index that represents the combination of a hydrologic soil group and a land use and treatment class and is found to be a function of three factors; hydrologic soil group, the cover complex and antecedent moisture conditions. The runoff curve number method was developed based on 24 hr. rainfall runoff data. It limits itself to the calculation of runoff depth and does not explicitly take into account the time variation of rainfall intensity.

Use of a unit hydrograph and the hydrologic technique of hydrograph convolution[2], used in conjunction with the curve number, will account for temporal variations of rainfall. The unit hydrograph represents a unit volume of runoff for a specific unit storm duration. The SCS has developed a synthetic unit hydrograph that has wide range acceptance. A unit hydrograph has meaning only in connection with a given storm duration. Therefore, a watershed can have several unit hydrographs, each for a different rainfall duration. Once a unit hydrograph for a given duration has been determined, runoff hydrographs can be derived using various hydrologic techniques. However, because the SCS uses uniform 24 hr. storm durations, one single unit hydrograph can be used for storms of different recurrence intervals.

The Soil Conservation Service has developed four standard 24 hour temporal synthetic rainfall patterns based on extensive nationwide data, Type I, IA, II and III. The 24 hr. constant duration was selected because most rainfall data is reported on a 24 hr. basis. As noted earlier, of the four standards, type II is most applicable to this study area.

Another factor that can have a significant impact on the rainfall volume is the time of concentration, t_c. SCS procedures divide the time of concentration into three travel time segments; overland flow, shallow concentrated flow and open channel flow. Each segment of flow has an appropriate Manning's roughness coefficient according to the type of land cover. This roughness coefficient is a measure of the resistance to flow as the runoff travels its course. Higher roughness coefficients tend to increase the time of concentration.

All of these hydrologic parameters (i.e., SCS 24-hour type II rainfall distribution for the design storm, curve number, SCS unit hydrograph and segmented time of concentration) are a collection of simplified procedures to calculate peak discharges and runoff hydrographs. These parameters and methodology are more specifically referred to as the TR-55 method (USDA, 1986).

Curve numbers for the study area were assembled from aerial photographs dated March, 1995, existing zoning maps and comprehensive land use plans supplied by the participating jurisdictions. Topographic information is based on; 1"=200' scale maps with 2 ft. contour intervals from the City of Salem, 1"=500' scale maps with 5 ft. contour intervals from the 5th PDC for most of the watershed study area, and 1"=2000' ft. USGS quadrangle maps for the areas around the fringe of the watershed. As a result of the calibration analysis published in the hydrologic addendum to this report, a Type I antecedent moisture condition was used in the determination of curve numbers for this study.

[2]Hydrograph convolution is the process of translating precipitation excess into a runoff hydrograph through linear super positioning of a unit hydrograph.

Subbasins within the watershed averaged approximately 250 acres. Criteria used to establish subbasin boundaries is based on critical locations where hydrographs and peak flows are specifically needed. Examples of critical locations include confluences of major tributaries, selected hydraulic structures or locations where flows were previously established by other studies and reports. Comparison of flows computed in this study with previously established flows serves as a means of comparison and calibration. Other factors such as land uses and terrain slope were a consideration but are much less of a priority in establishing subbasin boundaries.

There are approximately 400 subbasins within the study area. These subbasins are delineated on Figure 1 located in back cover of the report. Over 90% of the watershed study area was mapped with hydrologic soils. Unmapped areas were assumed to be the same hydrologic soil group as the adjacent soil or the most prevalent adjacent soil when the unmapped area was bounded by several hydrologic soil groups. Most unmapped areas occurred along the Interstate 81 corridor and on mountain tops. Soil information was available in digital format for all of the watershed area except for the area in Botetourt County. This soil information was digitized from 1"=500' scale maps. The ARC/INFO Geographic Information System was used as the digital data base for the hydrologic calculations.

Aerial photographs were taken and interpreted for existing land uses corresponding to those specific land uses listed in TR-55. This information was digitized in ARC/INFO format and combined with hydrologic soil information to generate curve numbers. Developed land uses were obtained from jurisdictional comprehensive land use plans and correspondence with local planning offices. Figures 3 and 4 in the back cover show the existing and proposed land uses used in this study.

Times of concentration for each subbasin was computed based on segmented travel times for the three types of flow conditions. As per an SCS unpublished dictum, overland flow lengths were kept to a maximum of 100 feet. In general those subbasins where the flow path originated in large wooded or heavily vegetated areas had overland flowpath lengths of 100 ft. Subbasins where the t_c flowpath originated in residential areas had overland flowpath lengths of 50 ft. or less. Shallow concentrated flow path segments have variable lengths among the subbasins and in general begin where overland flow ends and the streamlines for streams begin. Average shallow concentrated flow lengths average about 1000 ft. Channel flow sections were field identified. HEC-1 models were developed from the basin input data and run for existing and developed conditions (Year 2020) discharges. Models were run for the 2-, 5-, 10-, 25-, 50-

and 100-year events. Results per watershed are presented in Chapter 2 with all technical back-up in a separately published technical addendum.

1.4 Hydraulic Analyses

Methodology

Flood elevations for the existing and developed conditions (Year 2020) 2-, 5-, 10-, 25-, 50-, and 100-year storm events were determined by inputting the corresponding runoff discharges computed from the HEC-1 hydrologic model into the Corps of Engineers' HEC-2 Water Surface Profile computer program. As the contributing watershed area increases in the downstream direction so does the storm water runoff. To accurately model the floodwater elevations through a stream valley, discharges in the HEC-2 model must be changed to reflect the increase of the runoff discharges as the downstream distance increases. In the HEC-2 model, discharges are changed at cross sections upstream and downstream of the confluence with major tributaries and at major hydraulic structures. Additionally, engineering judgment is used to change discharges elsewhere in the model. Therefore, computed water surface elevations are based on discrete intervals of a stream reach where the discharges remain constant. This is consistent with common engineering practice.

The FEMA HEC-2 models are used as a basis for the water surface profile models in this study. These FEMA models were revised to reflect current stream valley conditions. Discharges were revised to reflect the results of the HEC-1 hydrologic model, sizes of hydraulic structures were revised to reflect the data obtained from recent field measurements, cross section elevations were updated per the aerial topography specifically obtained for this report, and when necessary bridge data was revised. Aerial survey of the stream areas was done by Barton Aerial Technologies, Inc. in March 1995. Aerial digitized cross sections were obtained from this survey for input into the HEC-2 model. Manning's roughness coefficients (i.e., Manning's n coefficient) for the stream channel and overbank areas were based on field verification. The 100-year elevations for existing and developed conditions (Year 2020) discharges and the 100-year developed conditions (Year 2020) floodplain are presented on plan-profile sheets located in Chapter 2. A hydraulic technical addendum will be published separately.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. However, debris blockage is typically not included in hydraulic studies due to the lack of historical documentation. For this study to more accurately reflect existing conditions, debris blockage was included where historic photographs or records were sufficient to estimate the amount and/or the impact of debris blockage. When sufficient historical data was available, structures, i.e., bridges and culverts, were categorized as either low, medium or high debris potential and bridge/culvert opening areas were reduced by 10%, 25%, and 50% respectively.

If no data was available on debris blockage for a stream, no reduction in bridge areas was included in the hydraulic model because FEMA and other regulatory agencies require substantial documentation of debris blockage to accept reduced bridge areas.

1.5 Flood Hazard Mitigation

Identification of Flood Hazards

To conduct the flood hazard mitigation evaluation, flood profiles and floodplains were developed along each stream for a range of recurrence interval events for both existing and developed conditions (Year 2020) land uses. Residential structures located in the various floodplains were identified and a determination was made as to the cause of the flooding:

- excessive flow
- blockage or obstruction
- proximity of structures to stream
- combination of above.

Possible solutions to reduce or eliminate flooding at residential structures were screened to determine those that would reduce the severity of flooding. Possible solutions which were considered include:

- flow reduction (ex. detention and flood control facilities)
- flood protection structures (ex. levees)
- obstruction removal (ex. stream crossing enlargement or debris blockage improvement)
- conversion of floodprone areas to greenways by relocating floodprone structures
- individual relocations
- floodproofing
- regulatory controls to mitigate potential future flood damages.

Roads that were inundated by storms with a 10-year or more frequent recurrence interval were also identified. These structures do not meet current VDOT requirements for road design, and could present a hazard during flooding conditions. Possible solutions in these conditions were flow reduction using upstream stormwater management control, enlarging the road crossing structure, or raising the road where backwater is a problem.

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were determined for each study watershed. These measures include retrofitting existing facilities to reduce or eliminate flooding and implementing new flood mitigation projects. Examples of retrofitting existing facilities include the retrofit of existing lakes and ponds and road embankments, residential relocation, floodproofing, debris deflectors and collectors and flap gates. New projects that will eliminate or reduce flooding include flood control dams, levees, bridge/culvert replacement, channel widening, greenways and new pipes.

Retrofits of existing structures to form stormwater management ponds were primarily identified at existing road embankments. The road embankment was converted to a dam by adding a riser structure to the upstream end of the culvert. This can be done fairly cheaply but there are geotechnical and VDOT approval considerations.

New stormwater management pond sites were located to best take into account existing topography and land uses. The ponds were placed into the hydrologic models using approximations of storage volume and elevation-discharge relationships. The effects of the ponds on downstream discharges were analyzed and summarized in Chapter 2.

Debris problems can be solved by a stormwater management pond upstream which would collect debris and prevent it from clogging downstream structures. If an upstream pond was not possible, it was generally recommended to periodically clear the stream of debris and brush. Trash racks and debris deflectors were also considered.

Culvert and bridge replacement were recommended at road crossings to meet 10-year capacity requirements or to alleviate structure flooding upstream of the road. The culvert nomographs prepared by the Federal Highway Administration were used to determine a box culvert size that would pass the 10-year storm with the desired headwater. In cases where backwater overtops a road, it was recommended that the road be raised and the culvert enlarged if necessary to prevent increased flood elevations upstream.

Floodproofing is recommended for many of the structures subject to periodic flooding. These structures were identified on the workmaps and categorized according to flooding depths for the 100-year storm. The workmaps are included in an addendum to this report. The floodproofing categories are shown below:

Floodproofing Category	Determining Factor	Action Recommended
1	100-year flood depth >8'	Purchase or relocate
2	100-year flood depth 3-8'	Elevate, relocate or purchase
3	100-year flood depth <3'	Dry floodproof or elevate

A category 1 house where flooding is greater than 8' was recommended to be purchased or relocated because this depth of flooding usually undermines the structure. For category 2, it is recommended to elevate, relocate or purchase the structure, because these depths are too great to perform a dry floodproofing. For depths less than 3' (Category 3) it is recommended that the structure be dry floodproofed or elevated, since dry floodproofing is a feasible option at this depth of flooding.

Flood Hazard Mitigation Measure Evaluation

Each mitigation measure was evaluated for its effectiveness in reducing flooding and for engineering feasibility. A rating system for projects was developed that considers the number and type of structures relieved by the project, the estimated project cost, the design storm (or frequency of problem), the environmental impact, the potential funding sources and the permittability of the proposed project. Table 1.5 lists the rating criteria and weights and the scoring criteria:

Table 1.5 Engineering Feasibility Rating Criteria

Engineering Feasibility		
Criteria	**Scoring Criteria**	**Rating**
Number of Structures/ Public Facilities Relieved by Project for the Design Storm (Weight = 4)	> 20 structures	10
	6-20 structures	7
	Transportation arterial	5
	Collector street or 0-5 structures	3
	Residential streets or alleys	1
Engineering Feasibility		
Criteria	**Scoring Criteria**	**Rating**
Project Cost (Weight = 4)	< $10,000	10
	$10,000 - $50,000	8
	$50,000 - $100,000	6
	$100,000 - $250,000	4
	$250,000 - $500,000	2
	>$500,000	1
Design Storm (Weight = 2)	2-year	10
	10-year	5
	100-year	1
Environmental Impact (Weight = 2)	Positive impact on water quality	10
	Minimal impact on water quality	6
	Negative impact on water quality	1
Potential Funding Source (Weight = 1)	Funded by others (e.g., COE, VDOT, grants)	10
	Community funded + low interest loans or grants possible	7
	Community funded	5
	Owner funded + low interest loans or grants possible	3
	Owner funded	1
Permittability (Weight = 1)	Minimal permit problems	10
	Average permit problems	5
	Difficult permit problems	1

Intangible factors were also identified for evaluation by the various communities. These factors include: public acceptability, health and safety, aesthetics, convenience, and multiple uses. Table 1.6 lists the suggested ratings for these factors.

Table 1.6 Rating Criteria for Intangible Factors

Intangible Factors		
Criteria	**Scoring Criteria**	**Rating**
Public Acceptability (Weight = 4)	Project is strongly supported by the public	10
	Project is acceptable to the public	5
	Public is against the project	1
Health and Safety (Weight = 4)	Project poses minimal risks to the public	10
	Project poses some risk to the public	5
	Project poses significant risks to the public	1
Aesthetics (Weight = 1)	Project enhances aesthetics of nearby area	10
	Project has no impact on aesthetics	5
	Project adversely impacts aesthetics of nearby areas	1
Convenience (e.g. impact on travel times, etc.) (Weight = 1)	Project enhances convenience	10
	Project does not impact convenience	5
	Project adversely affects convenience	1
Multiple Uses (Weight = 1)	Project can serve multiple uses	10
	Project is only for flood hazard mitigation	5
	Project adversely impacts land use	1

These intangible factors were not included in the project ratings presented in this report. The intangible factors can be revised or used by the communities as needed. The flood hazard mitigation projects are presented in Chapter 2 and the project ratings are in Chapter 3.

Specifics for each watershed are presented in Chapter 2. The Watershed Plans are presented in Chapter 3. All technical back-up to the Alternative Evaluation is included in separately published technical addendum.

CHAPTER 2 - INDIVIDUAL WATERSHEDS

2.1 BACK CREEK WATERSHED

Basin Description

The Back Creek watershed is a 58.7 square mile drainage basin located in southeast Roanoke County, Virginia. The watershed has a length of about 16.5 miles and a maximum width of about 5.5 miles near center. The Back Creek watershed originates in the Blue Ridge Mountains on Poor Mountain at an elevation of approximately 3600 feet above sea level and flows in a northeasterly direction for about 25 miles to its confluence with the Roanoke River near the border between Roanoke, Bedford and Franklin Counties.

The southern watershed boundary of Back Creek serves as the political boundary between Roanoke and Franklin Counties for a portion of its length. The Back Creek watershed is mostly undeveloped consisting of woods, agricultural areas and scattered single family residences. There is more residential development in the subbasins closer to the City of Roanoke and along U.S. Routes 220 and 221. The Blue Ridge Parkway runs through the watershed. Developed conditions (Year 2020) land use is a combination of rural village and rural preserve with some low density residential development.

A tabulation of the Back Creek drainage basin areas is presented below:

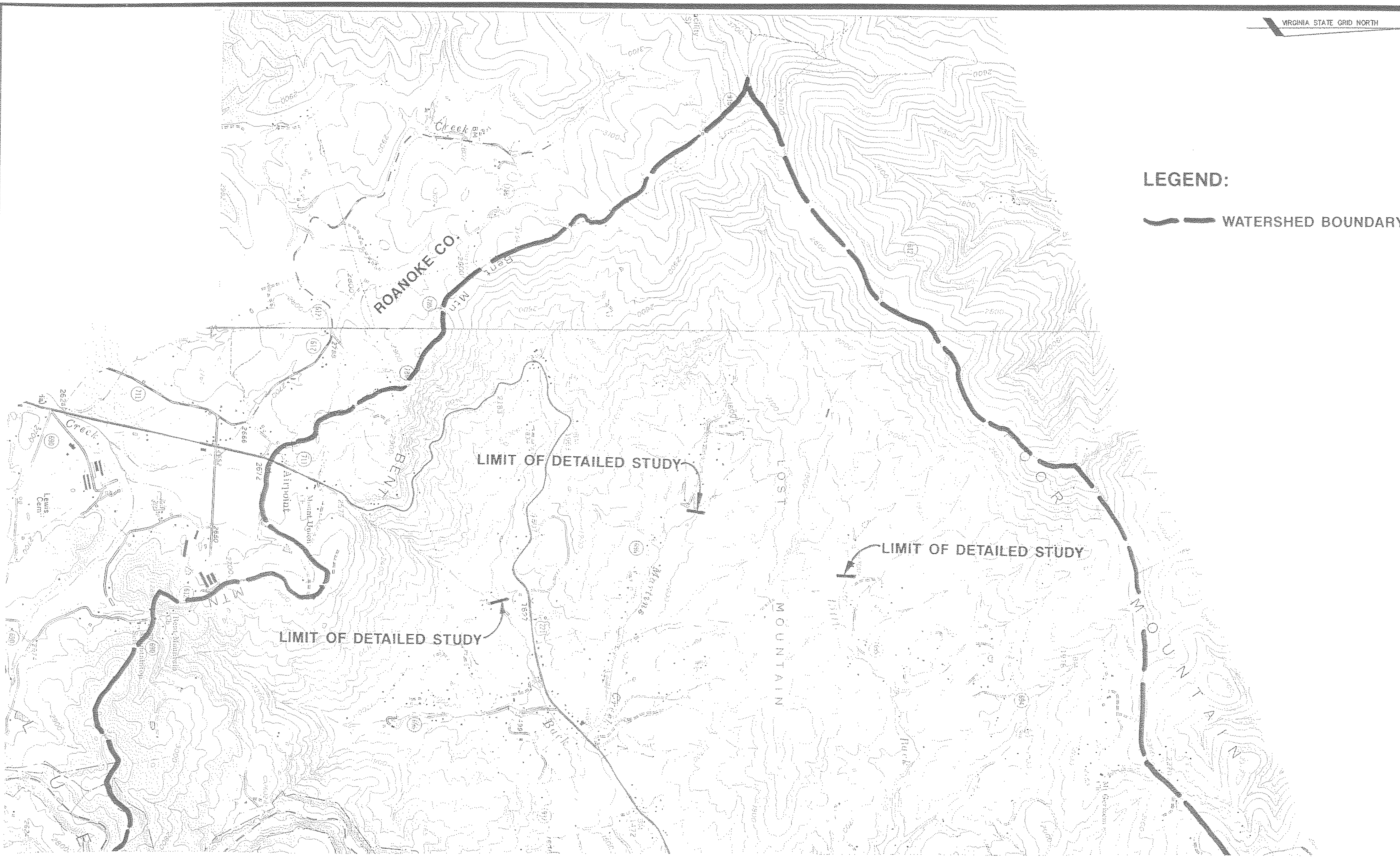
Location	Distance Above Mouth of Back Creek (feet)	Drainage Area(sq. mi.)
Mouth of Back Creek	0	58.7
Jae Valley Road - State Route 116	26,500	53.7
Brandy Road - State Route 666	37,800	48.5
Downstream from Confluence of Back Creek Tributary A	54,200	44.9
Back Creek Road - State Route 676	67,700	36.0
Norfolk & Western Railroad	73,400	31.0
Downstream from Confluence of Back Creek Tributary B	92,000	25.9
Poage Valley Road - State Route 690	112,400	16.0
Downstream from Confluence of Little Back Creek	119,700	11.0
Downstream from Confluence of Martins Creek	127,800	5.9
Apple Grove Lane - State Route 696	128,900	4.1

Subbasin Description

There are four significant streams that drain the Back Creek watershed: Martins Creek, Little Back Creek, and Back Creek Tributaries A and B. Martins Creek, Little Back Creek and Back Creek Tributary B all lie entirely within Roanoke County. The very upstream reaches of Back Creek Tributary A are located in the City of Roanoke but the majority of the watershed is located in Roanoke County. The streams and related subbasins are shown in Figure 2.1.1. A tabulation of the study lengths and subbasin drainage areas is presented below followed by a brief summary of the Back Creek tributaries:

Stream	Study Length (feet)	Drainage Area (sq. mi.)
Martins Creek	6,500	1.7
Little Back Creek	13,400	4.0
Back Creek Tributary B	5,000	2.4
Back Creek Tributary A	11,900	3.5

Martins Creek is located in the western part of the Back Creek watershed. It originates on Poor Mountain and flows southeast to its confluence with Back Creek which is approximately 24 miles upstream of the confluence of Back Creek with the Roanoke River. The watershed is mostly wooded with some agricultural and scattered residential development. Developed land use is primarily rural village with some low density residential and village center



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BACK CKEEK WATERSHED
WATERSHED BOUNDARY
FIFTH PLANNING DISTRICT COMMISSION
ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.1.1

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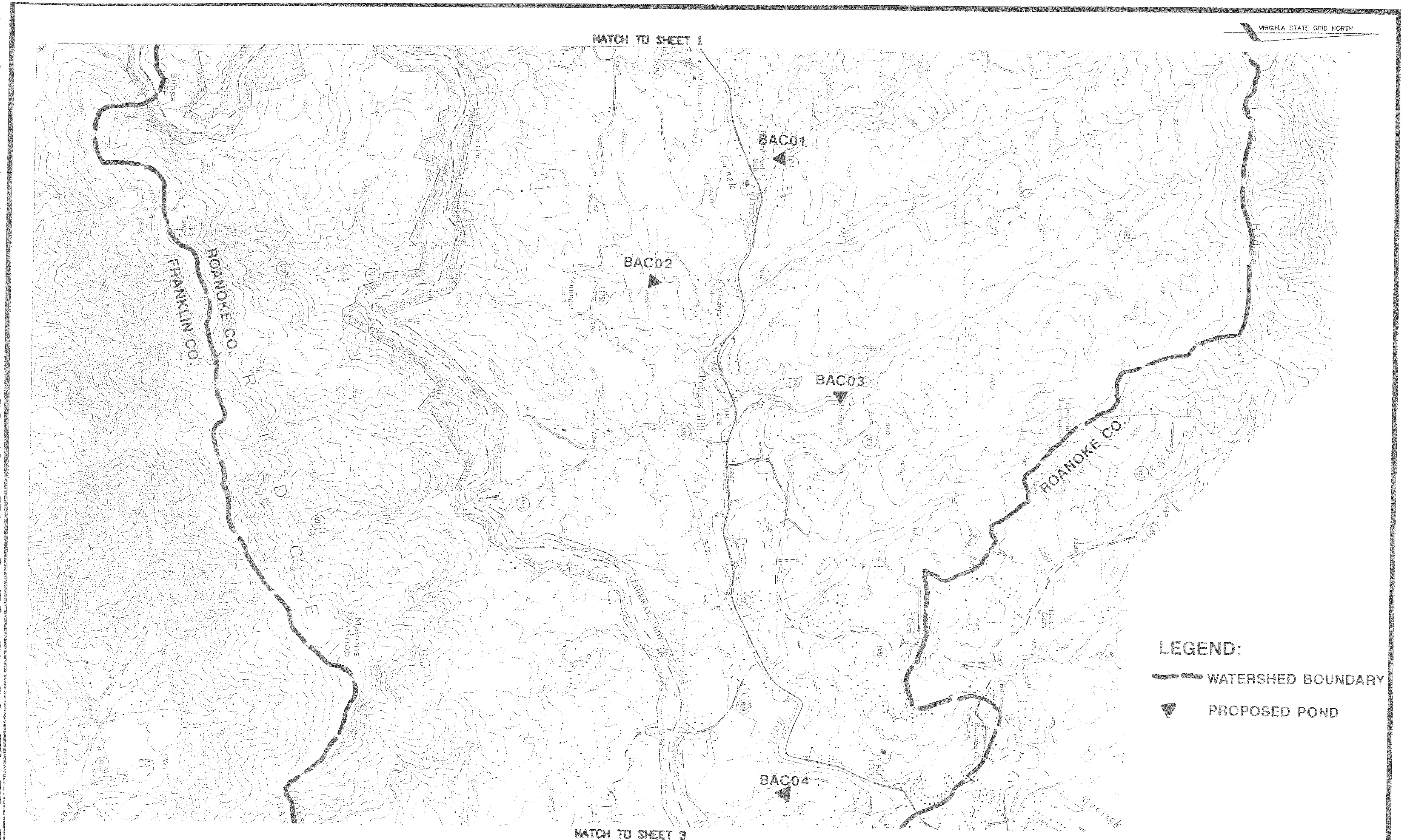
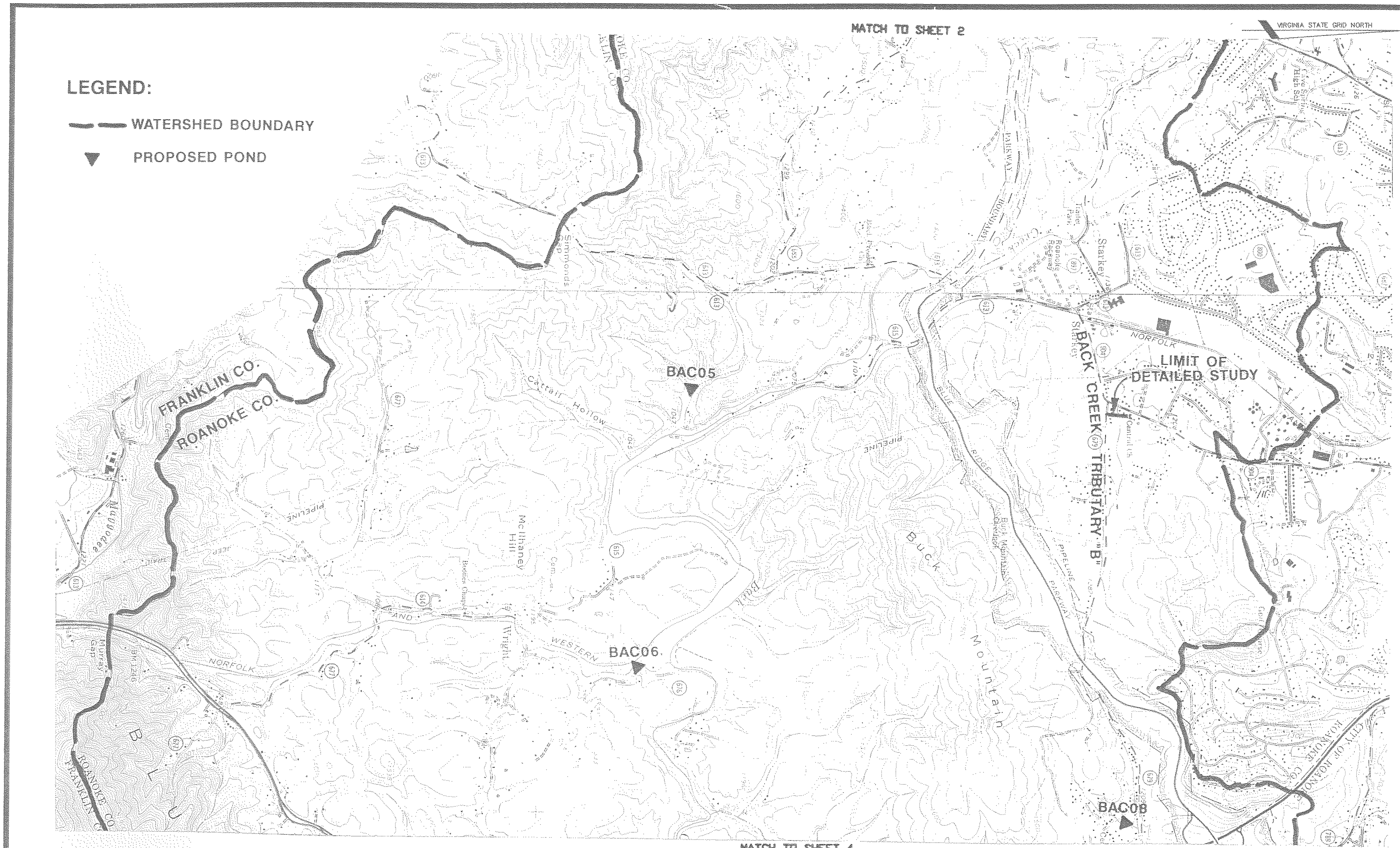
Sheet 1 of 5



Dewberry & Davis Architects Engineers Planners Surveyors 8401 Arlington Boulevard Fairfax, Virginia 22031 (703) 849-0100	BACK CKEEK WATERSHED LOCATION OF PROPOSED STORMWATER IMPROVEMENTS FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA	ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN Figure 2.1.1 (Cont'd.)	Drawn By: GRO Date: 9/96 Checked By: TJL Date: 9/96	Scale: 1" = 2000' Sheet 2 of 5



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BACK CKEEK WATERSHED
LOCATION OF PROPOSED STORMWATER IMPROVEMENTS
FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN
Figure 2.1.1 (Cont'd.)

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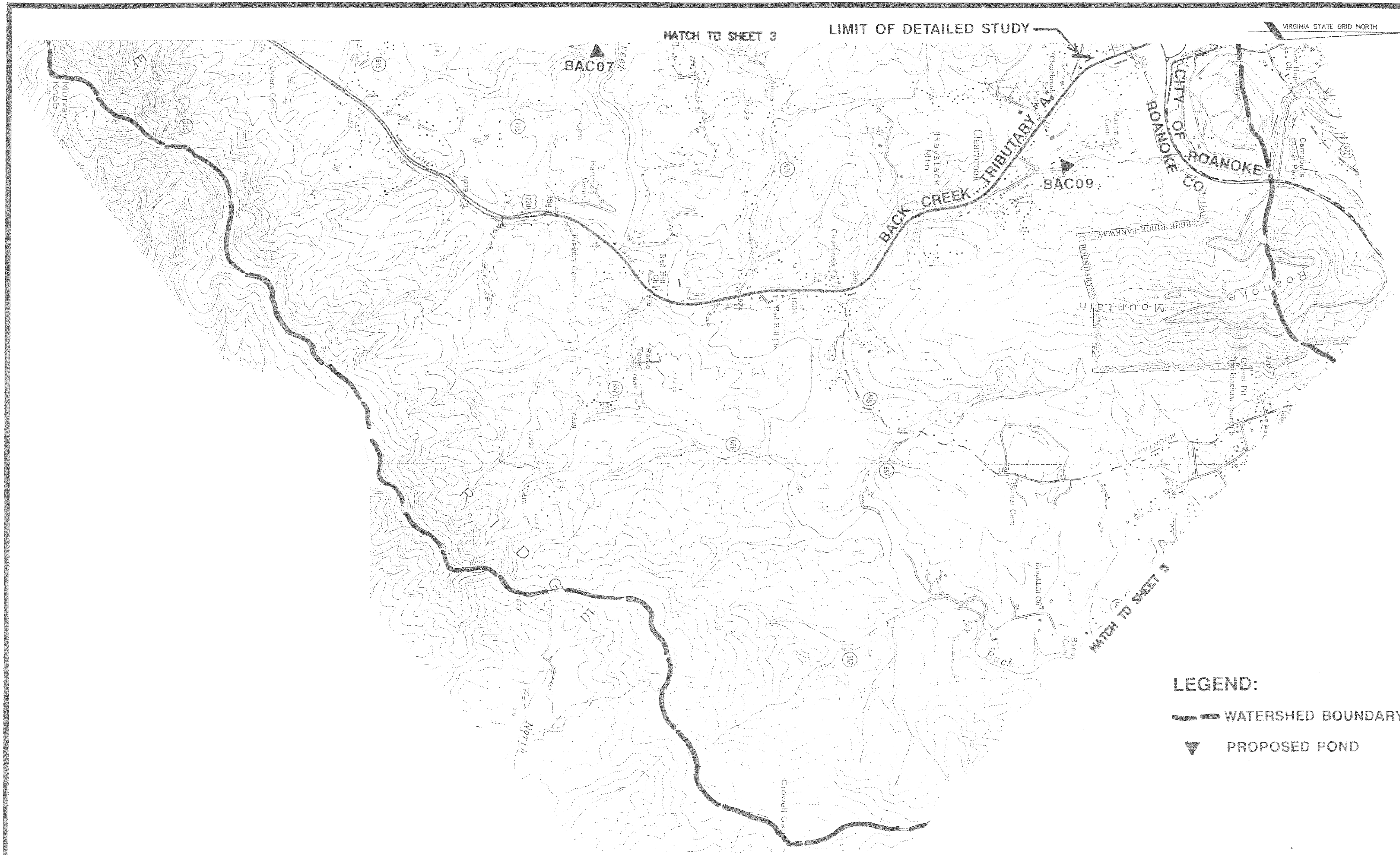

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BACK CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.1.1 (Cont'd.)

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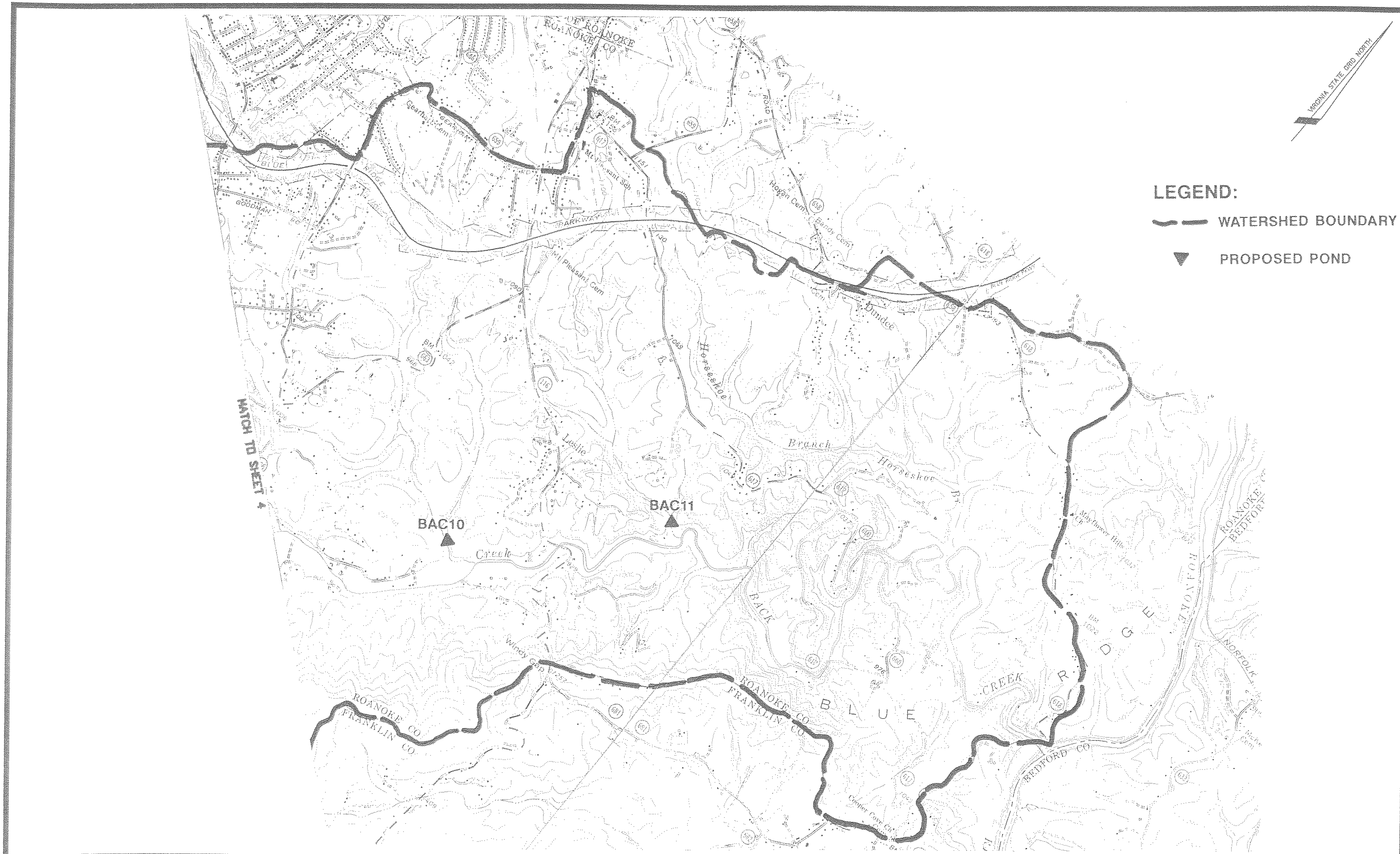

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BACK CKEEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.1.1 (Cont'd.)

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Sheet 5 of 5

development.

Little Back Creek is also located in the western part of the Back Creek watershed and is located northeast of Martins Creek. It converges with Back Creek approximately 22.5 miles upstream of the confluence of Back Creek with the Roanoke River. The Little Back Creek watershed also originates on Poor Mountain and flows southeast for approximately 3.5 miles to its confluence with Back Creek. The watershed is mostly wooded with some agricultural and scattered residential development. Developed conditions (Year 2020) land uses in this watershed are mainly rural village with low density residential, industrial and village center development.

Back Creek Tributary B is located in the north central part of the Back Creek watershed. It originates in the Hunting Hills Golf Course south of the City of Roanoke. It joins Back Creek about 17.5 miles upstream from the confluence of Back Creek with the Roanoke River near Starkey and is approximately 2 miles in length. This watershed is more developed than the rest of the Back Creek watershed because of its proximity to the City of Roanoke and its location along Starkey Road - State Route 904. There are residential subdivisions and commercial/ industrial areas along Starkey Road. The watershed is a combination of woods and open space and residential development with some commercial/industrial and agricultural development. Developed land use is a mixture of low, medium and high density residential areas, open space, woods and rural village.

Back Creek Tributary A is also located in the north central part of the Back Creek watershed. It originates near the intersection of Rocky Mount Road - U.S. Route 220 with the Blue Ridge Parkway. It joins Back Creek about 10.3 miles upstream of the confluence of Back Creek with the Roanoke River. This watershed is mostly undeveloped with some scattered residential areas along Rocky Mount Road. Developed land use is mostly rural village with low density residential.

Existing Land Use Distribution

The Back Creek watershed contains fourteen existing specific land uses, but only 3 uses generally predominate: woods, agricultural and residential areas. Approximately 75% of the watershed is comprised of wooded areas. Agricultural areas and residential areas of various densities each comprise approximately 10% of the watershed. The remaining 5% of the watershed consists of pasture, brush and open space.

Developed Land Use Distribution

The Back Creek watershed contains fourteen developed specific land uses, but only three uses predominate: rural village, rural preserve and low density residential development. Approximately 40% of the developed conditions (Year 2020) watershed is comprised of rural village. Rural preserve areas comprise approximately 30% of the developed conditions (Year 2020) watershed. Low density residential development comprises approximately 15% of the developed conditions (Year 2020) watershed. The remaining 15% of the watershed consists of surface water, open space, industrial development, woods, village center and medium and high density residential areas.

Hydrology

The discharges for Back Creek and its tributaries were determined using the procedures described in Chapter 1. No substantial storage areas were found on Back Creek, therefore there are no reservoir routings in the model. The Back Creek model includes 85 subbasins, 14 of which cover Martins Creek, Little Back Creek and Back Creek Tributaries A & B.

Existing conditions discharges on Back Creek are increased at the mouth by almost 5 times for the 2-year storm, by almost 2 times for the 10-year storm and by 100% for the 100-year storm under developed conditions (Year 2020). Discharges on Martins Creek and Little Back Creek increase by almost 3 times for the 100-year storm and discharges on Back Creek Tributary A increase by over 100% for the 100-year storm. These increases occur because of the change from wooded areas to rural village and rural preserve in the developed conditions (Year 2020) watershed. Existing conditions discharges on Back Creek Tributary B increase by 100% for the 2-year storm and by 25% for the 100-year storm. The increase on Back Creek Tributary B is caused by an increase in residential development in the watershed.

Flooding

History of Flooding

High water marks and measured flood flows were not available for Back Creek for the 1985 and 1992 floods. These high water marks and flows were obtained at the USGS gaging site near Dundee. This data was used to calibrate and verify the hydrologic and hydraulic models of this watershed..

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Back Creek and its tributaries.

Flooding Problems

Flooding problems along Back Creek, Martins Creek, Little Back Creek and Back Creek Tributaries A & B were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

On Back Creek, flooding is scattered throughout the length of the stream. Two areas that experience house flooding are between Merriman Road and Coleman Road and between Cotton Hill Road and Old Mill Road. The tributaries to Back Creek also experience scattered house flooding. The flooding problems and possible solutions are summarized below in Table 2.1.1.

Floodplain maps and flood profiles for Back Creek, Martins Creek, Little Back Creek, and Back Creek Tributaries A and B are presented in Volume 2 of this report.

Back Creek

Table 2.1.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 x-section)	Problem(s)				Possible Solutions
	Existing Conditions		Developed Conditions		
Building/House Flooding					
Mouth to Pitzer Road - State Route 617 (108-16197)	Storm 2-year 10-year 100-year	# of Houses in flood area 0 0 0	Storm 2-year 10-year 100-year	# of Houses in flood area 0 0 2	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Pitzer Road to Jae Valley Drive - State Route 116 (16197-26787)	Storm 2-year 10-year 100-year	# of Houses in flood area 0 0 1	Storm 2-year 10-year 100-year	# of Houses in flood area 0 1 4	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Jae Valley Drive to downstream Bandy Road crossing - State Route 666 (26787-38107)	Storm 2-year 10-year 100-year	# of Houses in flood area 0 1 9	Storm 2-year 10-year 100-year	# of Houses in flood area 1 8 12	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.1.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 x-section)	Problem(s)				Possible Solutions
	Existing Conditions		Developed Conditions		
	Storm	# of Houses in flood area	Storm	# of Houses in flood area	
Downstream Bandy Road crossing to upstream Bandy Road crossing (38108-47072)	2-year 10-year 100-year	0 0 3	2-year 10-year 100-year	0 1 3	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Upstream Bandy Road crossing to Franklin Road - U.S. Route 220 (47072-55496)	2-year 10-year 100-year	0 0 1	Same as existing		Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Franklin Road to Back Creek Road - State Route 676 (55496-68314)	2-year 10-year 100-year	0 0 1	2-year 10-year 100-year	0 2 6	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Back Creek Road to Starlight Lane - State Route 615 (68314-83838)	2-year 10-year 100-year	0 0 2	2-year 10-year 100-year	0 1 3	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Starlight Lane to Merriman Road - State Route 613 (83838-90232)	2-year 10-year 100-year	0 0 4	2-year 10-year 100-year	0 2 4	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Merriman Road to Coleman Road - State Route 735 (90232-102197)	2-year 10-year 100-year	1 5 17	2-year 10-year 100-year	8 18 26	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Coleman Road to Cotton Hill Road - State Route 688 (102197-107214)	2-year 10-year 100-year	0 0 3	2-year 10-year 100-year	0 3 5	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Cotton Hill Road to Poage Valley Road Extension - State Route 690 (107214-113247)	2-year 10-year 100-year	0 1 3	2-year 10-year 100-year	1 6 15	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.1.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 x-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Poage Valley Road Extension to Old Mill Road - State Route 752 (113247-115820)	Storm — # of Houses in flood area 2-year — 0 10-year — 3 100-year — 8	Storm — # of Houses in flood area 2-year — 7 10-year — 10 100-year — 13	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Old Mill Road to Old Bent Mountain Road - State Route 752 (115820-124941)	Storm — # of Houses in flood area 2-year — 0 10-year — 1 100-year — 8	Storm — # of Houses in flood area 2-year — 2 10-year — 10 100-year — 18	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Old Bent Mountain Road to Five Oaks Road (124941-128173)	Storm — # of Houses in flood area 2-year — 0 10-year — 0 100-year — 1	Storm — # of Houses in flood area 2-year — 0 10-year — 1 100-year — 2	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Five Oaks Road to Apple Grove Road - State Route 696 (128173-129996)	Storm — # of Houses in flood area 2-year — 3 10-year — 8 100-year — 13	Storm — # of Houses in flood area 2-year — 9 10-year — 13 100-year — 13	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Apple Grove Road to Limit of Study (129996-132865)	Storm — # of Houses in flood area 2-year — 1 10-year — 1 100-year — 2	Storm — # of Houses in flood area 2-year — 1 10-year — 2 100-year — 3	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Winter Drive - State Route 657 (57633)	None	5-year overtops road	Enlarge structure and/or raise road
Starlight Lane - State Route 615 (83838)	None	5-year overtops road	Raise road because of backwater; enlarge structure
Coleman Road - State Route 735 (102197)	None	5-year overtops road	Enlarge structure and/or raise road
Old Bent Mountain Road - State Route 752 (124941)	None	5-year overtops road	Enlarge structure and/or raise road
Five Oaks Road (128173)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Apple Grove Road - State Route 696 (129996)	None	5-year overtops road	Enlarge structure and/or raise road
Moonlight Lane (130802)	None	5-year overtops road	Enlarge structure and/or raise road

Martins Creek

Table 2.1.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth of Martin Creek to Carriage Hills Drive (000-964)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Storm / # of Buildings in flood area 2-year 1 10-year 1 100-year 1	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Carriage Hills Drive to Stationing 3276 (964-3276)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 0	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 1	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Stationing 3276 to Stationing 6345 (3276-6345)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 1	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 1	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Carriage Hills Drive (914-964)	None	10-year overtops road	Enlarge structure and/or raise road
Martin Creek Road (Various locations)	10-year overtops road	2-year overtops road	Raise road

Little Back Creek

Table 2.1.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Bent Mtn. Road to Private Drive #4 (125-4142)	Storm / # of Buildings in flood area 2-year 1 10-year 3 100-year 8	Storm / # of Buildings in flood area 2-year 7 10-year 11 100-year 11	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Private Drive #2 to Private Drive #5 (4142-8662)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 1	Storm / # of Buildings in flood area 2-year 1 10-year 2 100-year 2	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Private Drive #5 to Lost Mtn. Road (8662-13680)	Storm / # of Buildings in flood area 2-year 1 10-year 1 100-year 3	Storm / # of Buildings in flood area 2-year 2 10-year 4 100-year 6	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Bent Mtn. Road (125)	100-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Lost Mtn. Road	50-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Rte 694 (various locations)	10-year and 100-year overtops road	2-year, 10-year and 100-year overtops road	Raise road

Back Creek Tributary A

Table 2.1.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		POSSIBLE SOLUTIONS
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth of Tributary A to Franklin Road (Rte 220) (000-2992)	Storm / # of Buildings in flood area 2-year 1 10-year 6 100-year 12	Storm / # of Buildings in flood area 2-year 7 10-year 12 100-year 15	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Franklin Road (Rte 220) to Brethren Road (2992-3905)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 2	Storm / # of Buildings in flood area 2-year 0 10-year 2 100-year 2	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Brethren Road to Franklin Road (Rte 220) (3905-9504)	Storm / # of Buildings in flood area 2-year 0 10-year 5 100-year 12	Storm / # of Buildings in flood area 2-year 4 10-year 11 100-year 15	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Franklin Road (Rte 220) to Headwaters (9504-11961)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 2	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 3	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Franklin Road, Rte 220 (2918-2992)	100-year overtops road	10-year overtops road	Enlarge structure and/or raise road
Brethren Road (3889-3905)	25-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Franklin Road, Rte 220 (9429-9504)	50-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Clear Brook Lane (11,011-11,027)	25-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Stable Road, Rte 766 (11,591-11,617)	50-year overtops road	10-year overtops road	Enlarge structure and/or raise road

Back Creek Tributary B

Table 2.1.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth of Tributary B to Merriman Road (908-1938)	Storm / # of Buildings in flood area 2-year 3 10-year 10 100-year 19	Storm / # of Buildings in flood area 2-year 4 10-year 13 100-year 19	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Merriman Road to upstream of Norfolk & Western Railroad (1938-3023)	Storm / # of Buildings in flood area 2-year 2 10-year 4 100-year 9	Storm / # of Buildings in flood area 2-year 2 10-year 6 100-year 9	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Downstream of Crescent Boulevard to upstream of Starkey Road (3654-5076)	Storm / # of Buildings in flood area 2-year 2 10-year 13 100-year 19	Storm / # of Buildings in flood area 2-year 4 10-year 13 100-year 19	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Crescent Boulevard (4180)	5-year overtops road	Same as existing	Enlarge structure and/or raise road
Starkey Road (5020)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Back Creek and its tributaries are mostly undeveloped and therefore there are no concentrated flooding problems. There is scattered flooding of residences along Back Creek and its tributaries. Discharges in the Back Creek watershed will increase significantly with the development planned for this watershed. Future development should be kept outside of the developed conditions (Year 2020) floodplain to ensure that flooding problems are not created. To control the increased runoff caused by development, several sites for stormwater management were located. The locations of these sites are on the tributaries to Back Creek because a pond on the main stem of Back Creek would have to be very large to control the flow and would be difficult to permit.

The pond sites are summarized below and shown in Figure 2.1.1:

Site Description	Comments
BAC01 - on Little Back Creek upstream of Confluence with Back Creek	Would require relocation of several houses and a portion of Twelve O'Clock Knob Road - State Route 694. Controls ~ 4 mi^2.
BAC02 - on tributary southwest of intersection of Old Mill Road - State Route 752 and Bent Mountain Road - U.S. Route 221	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 1 mi^2.
BAC03 - on tributary west of Corntassel Lane - State Route 923	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 1 mi^2.

BAC04 - on tributary southwest of Coleman Road - State Route 735	Would require relocation of several houses and a portion of Coleman Road. Controls ~ 1 mi^2.
BAC05 - on tributary east of intersection of Merriman Road - State Route 613 and Cotton Hill Road - State Route 688	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 2 mi^2.
BAC06 - on tributary northeast of Wright along Back Creek Road - State Route 676	Would need to relocate a portion of Back Creek Road and several houses. Controls ~ 4 mi^2.
BAC07 - on tributary west of Pine Needle Drive - State Route 715	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 1.4 mi^2.
BAC08 - on Back Creek Tributary A near intersection of Buck Mountain Road - State Route 679 and Saddlewood Road	May need to relocate some houses. Would mitigate flooding hazard in Clearbrook. Controls ~ 0.5 mi^2.
BAC09 - in Back Creek Tributary A watershed north of Clearbrook Lane - State Route 674	May need to relocate some houses. Would mitigate flooding hazard in Clearbrook. Controls ~ 0.5 mi^2.
BAC10 - on tributary southwest of Leslie	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 3 mi^2.
BAC11 - on tributary east of Leslie	Would not need to relocate roads or houses as estimated from USGS quadrangle map. Controls ~ 1 mi^2.

The above ponds would help control the increased discharges in the Back Creek watershed, but because of the size and the proposed increase in development, it would be difficult to control all of the increase in stormwater runoff. The above ponds can be used as regional facilities in the developing areas and onsite detention can be used to control discharges in areas not draining to one of the proposed stormwater management facilities. The developed conditions (Year 2020) floodplain is significantly larger than the existing conditions floodplain because of the proposed development in this watershed. All future development should be kept outside of the developed conditions (Year 2020) 100-year floodplain to minimize future flooding problems.

On all of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or relocation was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.2 Barnhardt Creek Watershed

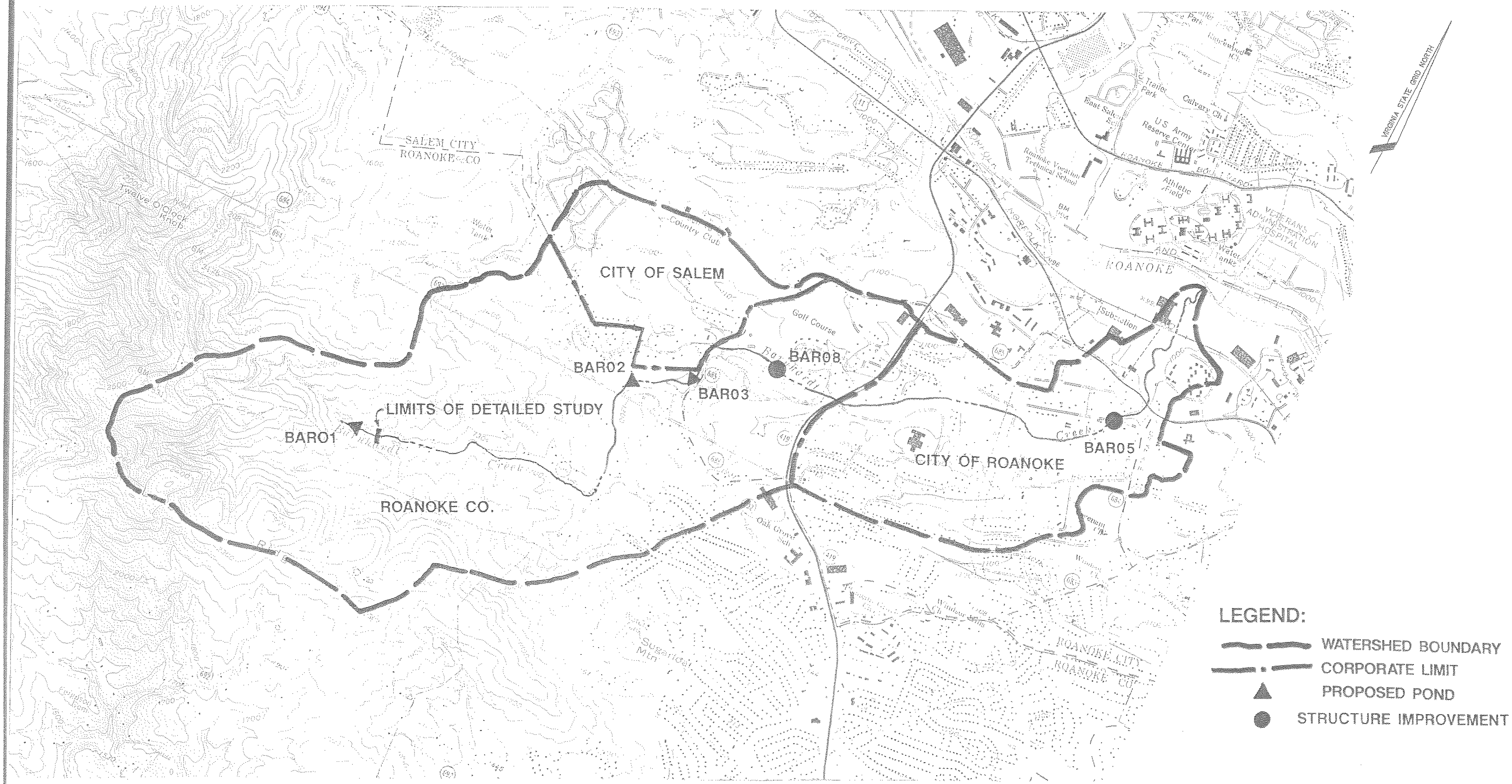
Basin Description

The Barnhardt Creek watershed is a 4.2 square mile drainage basin located in south central Roanoke County, southern Salem and southwestern Roanoke City. It lies wholly within Roanoke County and the Cities of Roanoke and Salem. The watershed is oblong and has a length of about 4.5 miles and a maximum width of about 1.5 miles near its center. The Barnhardt Creek watershed originates on Poor Mountain at an elevation of approximately 2700 feet above sea level and flows in a northeasterly direction for about five miles to its confluence with the Roanoke River at the boundary between the Cities of Salem and Roanoke. The stream and related subbasins are shown in Figure 2.2.1.

Barnhardt Creek serves as the political boundary between the City of Roanoke, the City of Salem and Roanoke County for a portion of its length. The upstream reaches of Barnhardt Creek are primarily undeveloped with scattered single family residences along State Route 686. The watershed becomes more developed downstream, especially downstream of State Route 419, Electric Road. The watershed also contains commercial development in scattered areas. Future land use consists primarily of rural village in the upstream basins while the downstream basins are primarily medium and high density residential areas and neighborhood conservation areas.

A tabulation of the Barnhardt Creek Drainage basin areas is presented below:

Location	Distance Above Mouth of Barnhardt Creek (feet)	Drainage Area (sq. mi.)
Mouth of Barnhardt Creek	0	4.2
U. S. Route 11 - Brandon Avenue	3,400	4.0
State Route 419 - Electric Road	11,100	3.1
Upstream of State Route 685 - Keagy Road	14,100	2.3



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BARNHARDT CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

Figure 2.2.1

Drawn By: GRO	Date: 01/97
Checked By: TJL	Date: 01/97
Scale: 1"=2000'	Sheet 1 of 1

State Route 686 - Grandin Road Extended	20,100	1.3

Existing Land Use Distribution

The Barnhardt Creek watershed contains fifteen existing specific land uses, but only 4 uses generally predominate: woods, ½ acre residential lots, 1/4 acre residential lots and open space. Approximately 50% of the watershed is comprised of wooded areas, especially in the upstream subbasins of Barnhardt Creek. The ½ acre residential lots comprise approximately 20% of the watershed. Open space and 1/4 acre residential lots each comprise about 10% of the watershed. The remaining 10% of the watershed consists of agricultural, commercial and residential areas of various densities.

Developed Land Use Distribution

The Barnhardt Creek watershed contains 11 developed specific land uses, but only five uses predominate: rural village, medium and high density residential areas, neighborhood conservation areas and commercial development. Approximately 30% of the developed conditions (Year 2020) watershed is planned to be rural village which is located in the areas upstream of State Route 685, Keagy Road. Residential areas, which include low, medium and high density residential zones, generalized development zones and neighborhood conservation zones, comprise approximately 50% of the developed conditions (Year 2020) watershed. Commercial areas comprise about 10% of the developed conditions (Year 2020) watershed. The remaining 10% of the watershed consists of open space, industrial areas and various ponds located within the watershed.

Hydrology

The Barnhardt Creek watershed was divided into 13 subbasins for the hydrologic analysis. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Barnhardt Creek, 2-year discharges increase by 135%, 10-year discharges increase by 85% and 100-year discharges increase by 70% under developed conditions (Year 2020). These increases are due to the increase in high density residential and commercial development. The planned rural village development in the wooded areas in the upstream basins also contribute to the increase in discharges.

Flooding

History of Flooding

High water marks were provided by Roanoke City for Barnhardt Creek. The high water marks were used to verify the hydraulic models for this stream.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Barnhardt Creek. No debris blockage information for structures along Barnhardt Creek was available.

Flooding Problems

Flooding problems along Barnhardt Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 30 homes along Barnhardt Creek including more than 20 that are inundated by a 10-year storm. One of the major flooding problems on Barnhardt Creek is upstream of Cravens Creek Road. Another is upstream of Electric Road - State Route 419 in the Farmingdale subdivision along Lakemont Drive. The Meadow Creek subdivision also experiences house flooding both upstream and downstream of Meadow Creek Drive. Table 2.2.1 summarizes the flooding problems found on Barnhardt Creek for both existing and developed conditions (Year 2020).

Floodplain maps and flood profiles for Barnhardt Creek are presented in Volume 2 of this report.

Table 2.2.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
House/Building Flooding			
Mouth to Norfolk & Western Railroad (1333-1540)	Storm # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Same as existing	Floodproof and/or relocate
Brandon Avenue to Cravens Creek Road (3721-4779)	Storm # of Houses in flood area 2-year 0 10-year 0 100-year 1	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 1	Enlarge Brandon Ave. structure downstream; Floodproof and/or relocate; Upstream detention
Cravens Creek Road to Crestmoor Road (4779-7520)	Storm # of Houses in flood area 2-year 7 10-year 9 100-year 9	Storm # of Houses in flood area 2-year 7 10-year 10 100-year 11	Enlarge Cravens Creek Road structure downstream; Floodproof and/or relocate; Upstream detention to reduce frequency of flooding
Crestmoor Road to Electric Road - State Route 419 - Medmont Lake subdivision (7520-11765)	Storm # of Houses in flood area 2-year 0 10-year 2 100-year 3	Storm # of Houses in flood area 2-year 0 10-year 3 100-year 3	Floodproof and/or relocate; Upstream detention
Electric Road - State Route 419 to Keagy Road - Farmingdale Subdivision (11765-14678)	Storm # of Houses in flood area 2-year 1 10-year 4 100-year 10	Storm # of Houses in flood area 2-year 3 10-year 9 100-year 15	Enlarge Electric Road structure downstream; Upstream detention to reduce frequency of flooding; Floodproof and/or relocate
Keagy Road to Meadow Creek subdivision (14678-17978)	Storm # of Houses in flood area 2-year 0 10-year 0 100-year 1	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 3	Floodproof and/or relocate; Upstream detention to reduce frequency of flooding
Meadow Creek subdivision (17978-18970)	Storm # of Houses in flood area 2-year 3 10-year 9 100-year 10	Storm # of Houses in flood area 2-year 4 10-year 9 100-year 11	Floodproof and/or relocate; Upstream detention to reduce frequency of flooding; For houses upstream of Meadow Creek Drive structure, enlarge structure
Meadow Creek subdivision to Grandin Road Extension (18970-20800)	Storm # of Houses in flood area 2-year 0 10-year 0 100-year 1	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 1	Floodproof and/or relocate; Upstream detention to reduce frequency of flooding

Table 2.2.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Road Overtopping			
Brandon Avenue - U.S. Route 11 (3685)	25-year overtops road	5-yr overtops road	Enlarge structure and/or raise road; Upstream detention
Deyerle Road between Brandon Ave. & Cravens Creek Road (3774-4724)	None	10-year inundates road	Raise road; upstream detention; Enlarge Brandon Avenue structure downstream
Cravens Creek Road - State Route 784 (4744)	2-year overtops road	Same as existing	Enlarge structure and/or raise road
Electric Road - State Route 419 (11725)	None	10-yr overtops road	Enlarge structure and/or raise road; upstream detention
Lakemont Drive (13103)	5-yr overtops road	2-yr overtops road	Enlarge Electric Road downstream because of backwater, raise road, upstream detention
Keagy Road - State Route 685 (14632)	None	5-yr overtops road	Enlarge structure and/or raise road
Meadow Creek Drive (18848)	None	5-yr overtops road	Enlarge structure and/or raise road; upstream detention
Grandin Road Extension - State Route 686 (20749)	2-yr overtops road	Same as existing	Enlarge structure and/or raise road; upstream detention

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for Barnhardt Creek. The areas of flooding are scattered but some areas of concentrated flooding are upstream of **Cravens Creek Road** (State Route 784), between Electric Road (State Route 419) and Keagy Road in the **Farmingdale** subdivision, and in the **Meadow Creek** subdivision in the vicinity of Meadow Creek Drive. One possibility for alleviating this flooding is to floodproof the homes where possible and to relocate or purchase the others.

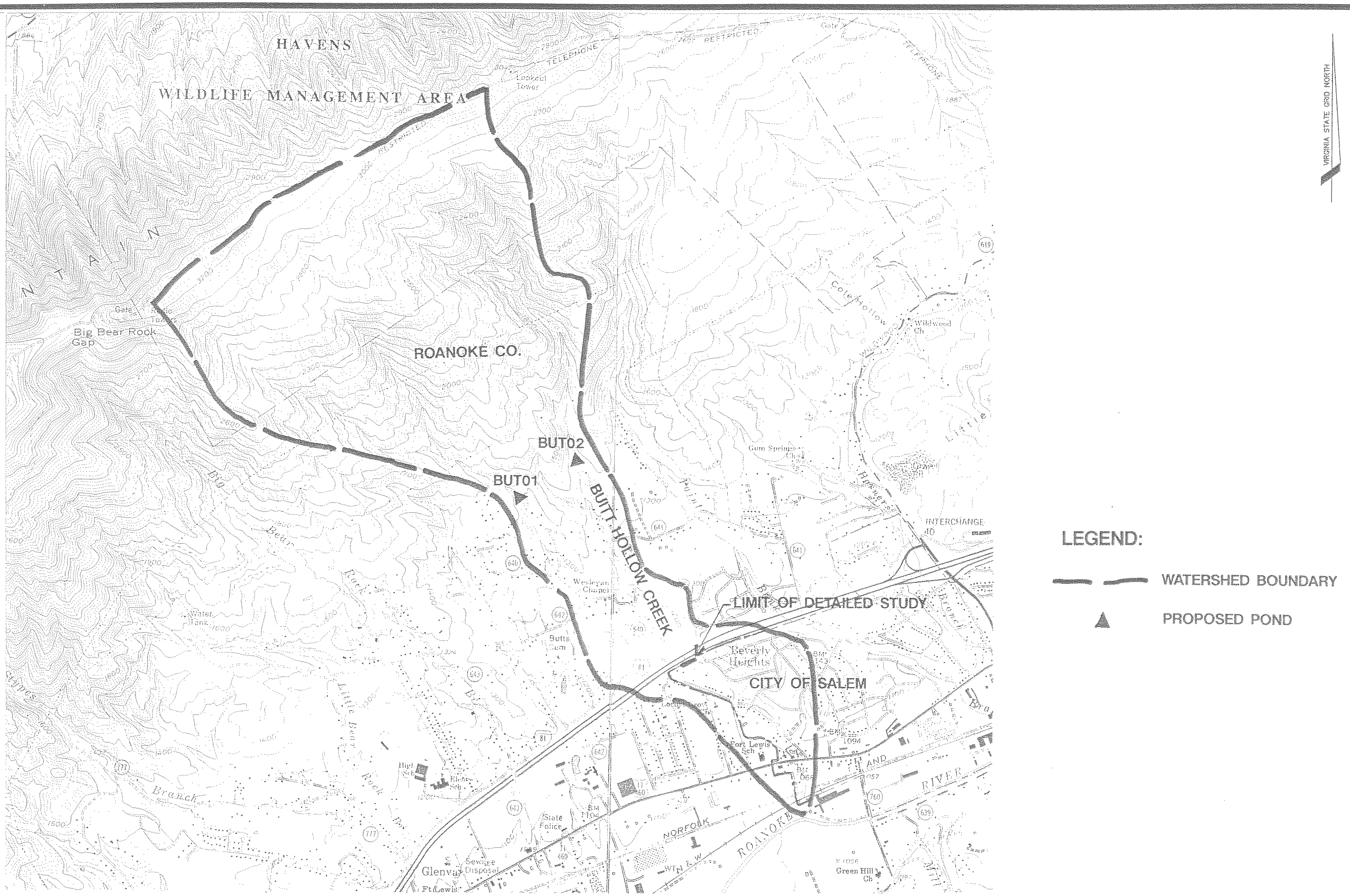
Another possibility is to reduce flood discharges by detaining storm flows in ponds upstream of the flooded areas. Several sites in the Barnhardt Creek watershed were analyzed as flood control sites. These pond sites are tabulated below:

Possible Pond Sites to Mitigate Flooding on Barnhardt Creek

Site Description	Comments
BAR01 - Approximately 1 mile upstream of Grandin Road Extended (State Route 686)	Pond reduces 10-year by 70% at pond, 30% at Meadow Creek Drive and 10% at mouth and reduces 100-year by 80% at pond, 30% at Meadow Creek Drive and 15% at mouth. The assumed dam was 70' high and would require a state permit, however better topography in the area and letting the 100-year pass through could reduce the dam height.
Site A - Approximately 700' downstream of Grandin Road Extended	4 houses outside of floodplain would need to be purchased and portion of Grandin Road relocated - NOT ANALYZED
BAR02 - Approximately 1600' downstream of Meadow Creek Drive	Reduces 10-year by 25% at Farmingdale subdivision and 15% at mouth and reduces 100-year by 30% at Farmingdale subdivision and 25% at mouth - dam height is limited to 25' because of houses upstream of site
BAR03 - Approximately 800' upstream of Keagy Road (State Route 685)	Pond reduces 10-year by 40% at Farmingdale subdivision and 25% at mouth and reduces 100-year by 50% at Farmingdale subdivision and 40% at mouth - dam height is about 25' and storage area is greater than 50 ac-ft so it may require a state permit - would also require relocation of a portion of Keagy Road and purchase of 2-3 houses
Site B - Approximately 1600' upstream of Crestmoor Road	Backwater from dam would interfere with tailwater at Electric Road - NOT ANALYZED
BAR01 & BAR02	Reduces 10-year by 30% at Farmingdale subdivision and 20% at mouth and reduces 100-year by 40% at Farmingdale and 30% at mouth.
BAR01 & BAR03	Reduces 10-year by 40% at Farmingdale and 25% at mouth and reduces 100-year by 50% at Farmingdale and 40% at mouth - reductions downstream of BAR03 are the same as those without BAR01
BAR02 & BAR03	Reduces 10-year by 40% at Farmingdale and 30% at mouth and reduces 100-year by 55% at Farmingdale and 40% at mouth - reductions about the same as those without BAR02
BAR01, BAR02 & BAR03	Reduces 10-year by 40% at Farmingdale and 30% at mouth and reduces 100-year by 55% at Farmingdale and 40% at mouth - reductions about the same as BAR03 alone

Upstream of **Cravens Creek Road**, BAR03 provides the greatest reduction in discharges. No combination of the ponds results in removal of all of the houses from the 100-year floodplain. Upstream detention can be used to reduce the frequency of inundation. In the **Farmingdale** subdivision upstream of Electric Road, BAR03 also provides the greatest reduction in discharges. The addition of BAR01 and BAR02 with BAR03 results in a minor increase in flow reductions. BAR03 has a great impact at the **Farmingdale** subdivision and would remove half of the houses from the 100-year floodplain. BAR01 is the only pond that would impact discharges in the **Meadow Creek** subdivision. However it does not reduce discharges enough to remove a significant number of homes from the 100-year floodplain, although it could reduce the frequency of flooding at this location. The proposed pond sites are shown in Figure 2.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and tabulation of benefits.



LEGEND:

WATERSHED BOUNDARY

▲ PROPOSED POND

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BUTT HOLLOW BROOK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.3.1

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1"=2000'

Sheet 1 of 1

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Butt Hollow Creek. No debris blockage information for structures along Butt Hollow Creek was available.

Flooding Problems

Flooding problems along Butt Hollow Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 30 homes along Butt Hollow Creek including more than 10 that are also inundated by a 10-year storm. The major flooding problems on Butt Hollow Creek are at Routes 11/460 and Butt Hollow Road. Table 2.3.1 summarizes the flooding problems found on Butt Hollow Creek for both existing and developed conditions (Year 2020).

Floodplain maps and flood profiles for Butt Hollow Creek are presented in Volume 2 of this report.

Table 2.3.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	**Developed Conditions**	
Building/House Flooding			
Norfolk & Western Railroad to U.S. Route 11 & 460 (795-1567)	Storm / # of Buildings in flood area 2-year: 2 10-year: 2 100-year: 5	Storm / # of Buildings in flood area 2-year: 2 10-year: 2 100-year: 6	Floodproof relocate and/or purchase; Upstream detention to reduce frequency of flooding
U.S. Route 11 & 460 to Butt Hollow Road (1567-3636)	Storm / # of Houses in flood area 2-year: 4 10-year: 11 100-year: 22	Same as existing	Floodproof relocate and/or purchase; Upstream detention to reduce frequency of flooding
Butt Hollow Road to Cross Section 4875 (3636-4875)	Storm / # of Buildings in flood area 2-year: 0 10-year: 1 100-year: 2	Same as existing	Floodproof relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Butt Hollow Road (3616-3636)	2-year storm overtops road	Same as existing	Enlarge structure and/or raise road

Flood hazard mitigation measures were analyzed for Butt Hollow Creek. The areas of flooding are scattered but some areas of concentrated flooding are upstream of West Main Street - U. S. Routes 11 & 460 and along Butt Hollow Road. One possibility for alleviating this flooding is to floodproof the homes where possible and to relocate or purchase the others.

Another possibility is to reduce flood discharges by detaining storm flows in ponds upstream of the flooded areas. Two sites in the Butt Hollow Creek watershed were analyzed as flood control sites. These pond sites are tabulated below:

Possible Pond Sites to Mitigate Flooding on Butt Hollow Creek

Site Description	Comments
BUT01 - upstream of Lee Road near Williams Drive	Pond would reduce 10-year discharges by ~ 15% and 100-year discharges by ~ 20% at Butt Hollow Road and would reduce 100-year discharges by ~ 10% at the mouth
BUT02 - upstream of Booher Drive adjacent to Joe Carroll Road	Pond would reduce 10-year discharges by ~ 20% and 100-year discharges by ~ 15% at Butt Hollow Road and would reduce 100-year discharges by ~ 15% at the mouth
BUT01 & BUT02	Ponds would reduce 10-year discharges by ~ 20% and 100-year discharges by ~ 25% at Butt Hollow Road and would reduce 100-year discharges by ~ 30% at the mouth

The combination of both ponds provides the most downstream benefit. The proposed pond sites are shown in Figure 2.3.1.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and tabulation of benefits.

2.4 Carvin Creek Watershed

Basin Description

The Carvin Creek watershed is a 28 square mile drainage basin located in northeast Roanoke County, northern Roanoke City and the northern portion of the watershed is located in Botetourt County, Virginia. The watershed is fan shaped and has a length of about 9 miles and a maximum width of about 4.4 miles near its headwaters. The Carvin Creek watershed originates on Tinker Mountain at an elevation of approximately 3200 feet above sea level and flows in a northeasterly direction for about three miles to the Carvin Cove Reservoir which is a supply for public drinking water. The Creek then flows southeast for approximately six miles to its confluence with Tinker Creek.

Carvin Creek serves as the political boundary between the City of Roanoke and Roanoke County for a portion of its length. The upstream reaches of Carvin Creek are undeveloped and mainly wooded. Immediately south of Interstate 81 along Carvin Creek is an agricultural area. Further downstream the land use becomes more developed and includes some residential and commercial development. South of Route 11, the development along Carvin Creek becomes primarily single family residential. An area of commercial development is located north of Hershberger Road. Future land use includes more industrial development, but the majority of the watershed, especially the areas upstream of Interstate 81 remain undeveloped.

A tabulation of the Carvin Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Carvin Creek (feet)	Drainage Area(sq. mi.)
Mouth of Carvin Creek	0	28.0
Downstream from Confluence of West Fork Carvin Creek	9,900	26.8
State Route 115 - Plantation Road	18,300	20.4
U.S. Route 11 - Peters Creek Road	23,400	19.7
Interstate 81	28,500	18.5
Carvin Cove Reservoir	32,000	17.5

Subbasin Description

There are two significant streams that drain the Carvin Creek watershed, West Fork Carvin Creek and Deer Branch. Deer Branch lies entirely within Roanoke County and West Fork Carvin Creek is located in Roanoke County with small portions located in the City of Roanoke. The streams and related subbasins are shown in Figure 2.4.1. A tabulation of the study lengths and subbasin drainage areas is presented below followed by a brief summary of the Carvin Creek tributaries:

Stream	Study Length (feet)	Drainage Area (sq. mi.)
West Fork Carvin Creek	17,500	6.0
Deer Creek	7,000	1.7

West Fork Carvin Creek originates on Green Ridge Mountain and flows southeast to its confluence with Carvin Creek which is approximately 1.9 miles upstream of the confluence of Carvin Creek with Tinker Creek. The 6 square mile watershed measured at the confluence of Carvin Creek includes the 1.7 square mile Deer Branch watershed. The watershed is primarily undeveloped but has some development consisting mainly of residential 1/4 acre lots and commercial uses. Future conditions land uses consist mainly of industrial development, open space, residential development and rural preserve areas.

Deer Branch is located in the central portion of the Carvin Creek watershed and is located east of West Fork Carvin Creek. It converges with West Fork Carvin Creek approximately 1700 feet upstream of the confluence of West Fork Carvin Creek with Carvin Creek. The Deer Branch watershed, located north of the City of Roanoke, originates on Green Ridge Mountain and flows south for approximately 2.3 miles to its confluence with West Fork Carvin Creek. The watershed is partly developed with residential development (mostly 1/4 acre lots) and some commercial and wooded areas. Future conditions land uses in this watershed are mainly residential development.

Existing Land Use Distribution

The Carvin Creek watershed contains fifteen existing specific land uses, but only 5 uses generally predominate: woods, agriculture and pasture, open water, 1/4 acre residential lots and commercial. Approximately 75% of the watershed is comprised of wooded areas, especially in the upstream subbasins of Carvin Creek. The residential portion comprises approximately 10% of the watershed. Agricultural and pasture, open water and commercial land uses each comprise about 5% of the watershed.

Developed Land Use Distribution

The Carvin Creek watershed contains 14 developed specific land uses, but only four uses predominate: woods, residential areas, open areas and industrial development. Approximately 50% of the developed conditions (Year 2020) watershed is comprised of wooded areas which are located upstream of Interstate 81. Residential areas, which include low, medium and high density residential zones, generalized development zones and neighborhood conservation zones, comprise approximately 15% of the developed conditions (Year 2020) watershed. Open space comprises about 15% and industrial areas comprise about 10% of the developed conditions (Year 2020) watershed. The remaining 10% of the watershed consists of commercial areas, rural preserve, agricultural areas and the Carvin Cove Reservoir.

Hydrology

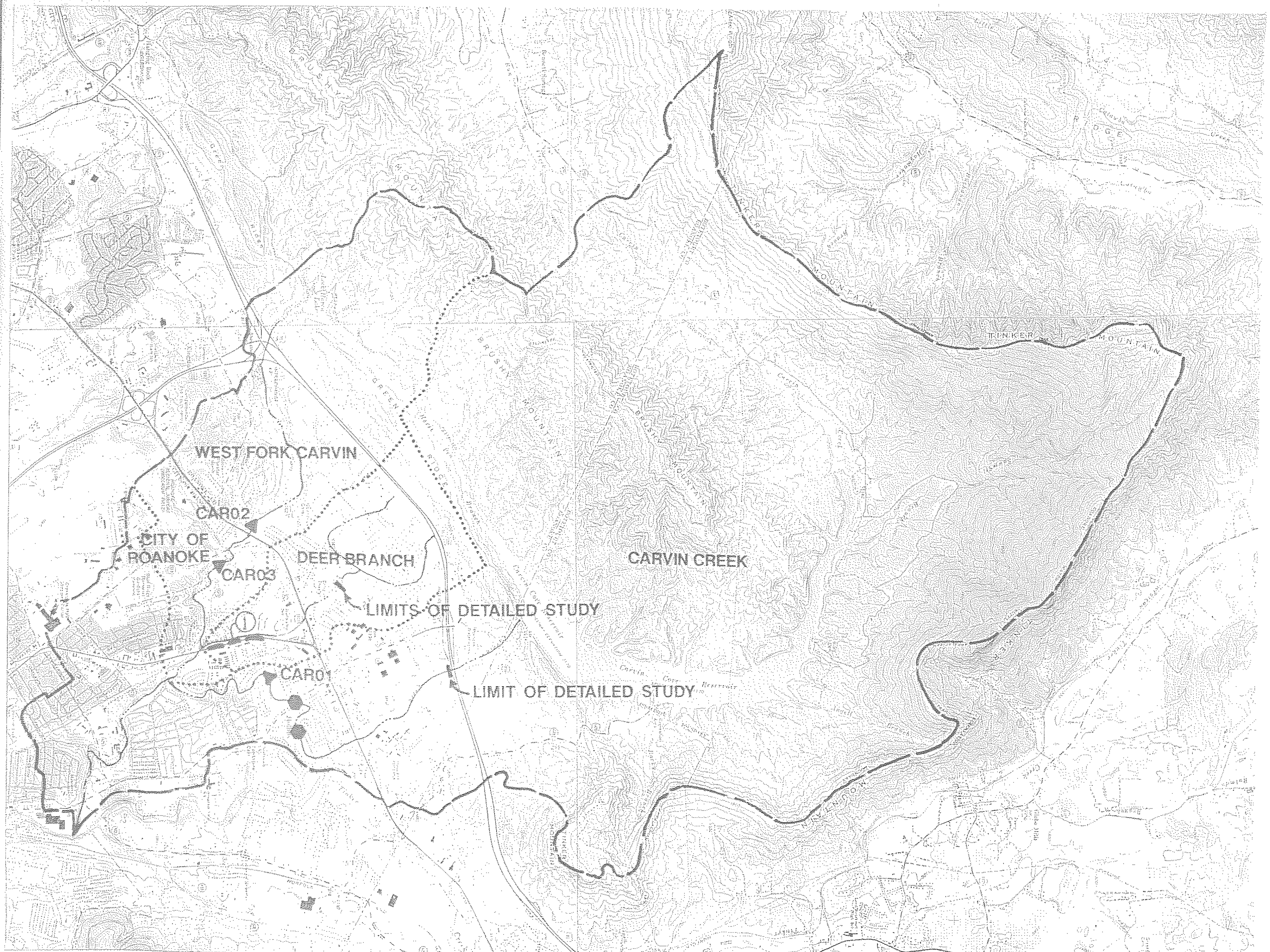
The discharges for Carvin Creek and its tributaries were determined using the procedures described in Chapter 1. On Carvin Creek, a routing is performed in the HEC-1 model at the Carvin Cove Reservoir to account for the storage at this facility. The Carvin Cove Reservoir reduces discharges by 60% just downstream of the facility. A storage routing was also added to the model to reflect the storage area upstream of Interstate 81 on Carvin Creek. However, the peak outflow from the Carvin Cove Reservoir which is immediately upstream of Interstate 81 is constant for several hours without a peak in the hydrograph to further attenuate at the Interstate 81 storage area. Therefore discharges at Interstate 81 remain the same as the discharges from the Carvin Cove Reservoir.

Existing conditions discharges on Carvin Creek are increased at the mouth by 70% for the 2-year storm and by 30% for the 100-year storm under developed conditions (Year 2020). Discharges on West Fork Carvin Creek are increased by 60% for the 2-year and by 30% for the 100-year storm under developed conditions (Year 2020). Both of these increases occur because of the increase in industrial and residential development. An increase in planned residential development in the Deer Branch watershed causes an increase under developed conditions (Year 2020) of 60% for the 2-year and 30% for the 100-year.

Flooding

History of Flooding

A 1980 study by the U.S. Army Corps of Engineers found that average annual flood damages to the Sun Valley



VIRGINIA STATE GRID NORTH

LEGEND

- WATERSHED BOUNDARY
- SUBSHED BOUNDARY
- PROPOSED POND
- DEBRIS CONTROL STRUCTURE
- LEVEE

NOTE: ① U.S. ROUTE 11 SUBJECT TO 2-YEAR FLOODING-RAISE ROAD IN THIS AREA.

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CARVIN CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.4.1

Drawn By: GRD Date: 6/96
Checked By: TJL Date: 6/96

Scale: 1"=4000'

subdivision along Carvin Creek were about $244,000. This area is a major flooding problem in Roanoke County with approximately 100 houses located within the 100-year floodplain and many other houses flooded by storms with lower return frequencies.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Carvin Creek and its tributaries. Structures were categorized as having a low, medium or high potential for debris blockage based on past experience. The bridge opening areas for low, medium and high debris potential were reduced by 10%, 25% or 50%, respectively. The majority of the debris problems in the Carvin Creek watershed are caused by trees blocking the entrances of stream crossing structures. None of the structures on West Fork Carvin Creek or Deer Branch experience documented debris problems, therefore the effects of debris were not included in the analyses of these streams. Summarized below are the debris blockage potentials for structures along Carvin Creek.

Debris Blockage Potential on Carvin Creek

Crossing	Structure Type	Percentage of Blockage
Plantation Road, Route 115	4-10'x10' RCBC with guardrail	50%
John Richardson Road	single span steel bridge 50' x 16' with guardrail	10%
Hershberger Road	4-11'x10' RCBC	50%
Verndale Drive	s.s. concrete bridge 23'x10' with guardrail	25%
Plantation Road, Route 115	4-8'x10' RCBC	50%
Peyton Street	concrete bridge 31'x8' with 1' pier	25%
Hugh Avenue	s.s. steel bridge 28'x8' with guardrail	25%
Williamson Road, Route 220	s.s. steel bridge 75'x8' with guardrail	0%

Flooding Problems

Flooding problems along Carvin Creek, West Fork Carvin Creek, and Deer Branch, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem in the Carvin Creek watershed is in the Sun Valley subdivision located on the main stem of Carvin Creek. Approximately 100 houses are located in the 100-year floodplain including more than 25 that are inundated by a 10-year storm. Another problem in the Carvin Creek watershed is in the Summerdean subdivision where debris blockage problems at Plantation Road and Peyton Street increase the flood elevations enough to inundate several more houses. The major flooding problem on West Fork Carvin Creek is in the Captains Grove subdivision where 7 houses are located in the 100-year floodplain. On Deer Branch, the worst flooding problem is on U.S. Route 11 just upstream of the confluence of Deer Branch with West Fork Carvin Creek. At this location U.S. Route 11 is flooded by the 2-year storm for approximately 1000 feet of the road. The flooding problems and possible solutions are summarized below in Table 2.4.1.

Floodplain maps and flood profiles for Carvin Creek, West Fork Carvin Creek, and Deer Branch, are presented in Volume 2 of this report.

Carvin Creek

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
From mouth of Carvin Creek to Plantation Road - State Route 115, downstream crossing (464-1605)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 3	Same as existing	Floodproof and/or relocate; Construct levee along swale
Plantation Road - State Route 115, downstream crossing to John Richardson Road (1605-3766)	Storm / # of Houses in flood area 2-year 0 10-year 2 100-year 4	Same as existing	Floodproof and/or relocate
Hershberger Road to Sun Valley subdivision (4576-6916)	Storm / # of Houses in flood area 2-year 0 10-year 1 100-year 1	Same as existing	Floodproof and/or relocate
Sun Valley subdivision, 3000' downstream and 1000' upstream of Verndale Road (6916-10715)	Storm / # of Houses in flood area 2-year 2 10-year 27 100-year 98	Storm / # of Houses in flood area 2-year 13 10-year 37 100-year 111	Provide upstream detention on Carvin Creek and West Fork Carvin Creek (could remove 30-50 houses from 100-year floodplain.); floodproof and/or relocate houses; levee (not eligible for COE funding)
Sun Valley subdivision to Plantation Road - State Route 115, upstream crossing (10715-18477)	none	Storm / # of Houses in flood area 2-year 0 10-year 0 100-year 3	Floodproof and/or relocate; Upstream detention
Plantation Road to Peyton Street - Summerdean subdivision (18477-19994)	Storm / # of Houses in flood area 10-year 0 50-year 16 100-year 16 Without Debris Storm / # of Houses in flood area 10-year 0 50-year 4 100-year 12	Storm / # of Houses in flood area 10-year 8 50-year 17 100-year 18 Without Debris Storm / # of Houses in flood area 10-year 0 50-year 12 100-year 15	Reduce debris blockage; Floodproof and/or relocate houses; Upstream detention to reduce frequency of flooding

Table 2.4.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Peyton Street to Hugh Avenue (20100-21486)	Storm — # of Houses in flood area 10-year — 0 50-year — 6 + 2 sheds 100-year — 11 + 2 sheds Without Debris Storm — # of Houses in flood area 10-year — 0 50-year — 1 + 1 shed 100-year — 1 + 1 shed	Storm — # of Houses in flood area 10-year — 1 50-year — 8 + 2 sheds 100-year — 11 + 2 sheds Without Debris Storm — # of Houses in flood area 10-year — 1 50-year — 1 + 2 sheds 100-year — 4 + 2 sheds	Reduce debris blockage; Enlarge Peyton street structure downstream
Hugh Avenue to Peters Creek Road - U.S. Routes 11/220 (21605-23465)	Storm — # of Houses in flood area 2-year — 0 10-year — 1 100-year — 2	Storm — # of Houses in flood area 2-year — 0 10-year — 2 100-year — 3	Floodproof and/or relocate
Peters Creek Road to Interstate 81 - Hollins College (23465-27726)	Storm — # of Buildings in flood area 2-year — 0 10-year — 0 100-year — 2	Storm — # of Buildings in flood area 2-year — 0 10-year — 0 100-year — 6	Floodproof and/or relocate
Road Overtopping			
Plantation Road - Route 115, downstream crossing (1605)	Road overtopped by 10-year with debris blockage, by 25-year with no debris	Road overtopped by 5-year with and without debris blockage	Reduce debris blockage; Enlarge structure and/or raise road
Hershberger Road (4576)	Debris Blockage; 10-year overtops road, 25-year overtops with no debris	Debris Blockage, 5-year overtops road, 10-year overtops with no debris	Reduce debris blockage; Enlarge structure and/or raise road
Verndale Road (9613)	5-year overtops road with and without debris blockage	2-year overtops road with debris blockage, 5-year overtops with no debris	Raise road because of backwater; enlarge structure to mitigate upstream impact.
Plantation Road - Route 115, upstream crossing (18477)	none	25-year overtops with debris blockage	Reduce debris blockage
Hugh Avenue (21605)	10-year overtops road.	5-year overtops road	Enlarge structure and/or raise road

West Fork Carvin Creek

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-SECTION)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Williamson Road - U.S. Route 11 (31-1907)	Storm — # of Buildings in flood area 2-year — 0 10-year — 1 100-year — 2	Same as existing	Upstream detention; Floodproof and/or relocate
Williamson Road - U.S. Route 11 to Airport Drop Structure - Captains Grove subdivision (1907-5714)	Storm — # of Houses in flood area 2-year — 0 10-year — 2 100-year — 8	Storm — # of Houses in flood area 2-year — 0 10-year — 6 100-year — 8	Upstream detention; Build 5-6' high levee; Floodproof and/or relocate
Airport Drop Structure to Airport Road - State Route 118 (5714-7253)	Storm — # of Houses in flood area 2-year — 0 10-year — 1 100-year — 1	Same as existing	Upstream detention; Floodproof and/or relocate
Airport Road to Peters Creek Road (7253-8496)	Storm — # of Houses in flood area 2-year — 0 10-year — 0 100-year — 1	Storm — # of Houses in flood area 2-year — 0 10-year — 1 100-year — 1	Upstream detention; Floodproof and/or relocate
Bobby Drive to Interstate 81 (11031-17501)	Storm — # of Buildings in flood area 2-year — 0 10-year — 0 100-year — 1	Storm — # of Buildings in flood area 2-year — 0 10-year — 0 100-year — 2	Enlarge structure at private road or convert to low flow crossing
Road Overtopping			
Williamson Road - U.S. Route 11 (1907)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road; upstream detention
Airport Road - State Route 118 (7253)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road; upstream detention
Bobby Drive (11031)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road

Deer Branch

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Plymouth Drive (236-1477)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Same as existing	Floodproof and/or relocate
Plymouth Drive to Friendship Manor entrance roads (1477-2593)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 3	Storm / # of Buildings in flood area 2-year 1 10-year 2 100-year 3	Enlarge Plymouth Drive structure downstream; floodproof and/or relocate
Friendship Manor entrance roads to Peters Creek Road - State Route 117 (2593-4781)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Storm / # of Buildings in flood area 2-year 1 10-year 1 100-year 1	Floodproof and/or relocate
Peters Creek Road - State Route 117 to Limit of Study (4781-6992)	Storm / # of Buildings in flood area 2-year 2 10-year 4 100-year 5	Same as existing	Floodproof and/or relocate
Road Overtopping			
Williamson Road - U.S. Route 11 from mouth to Plymouth Drive (236-1477)	2-year inundates road	Same as existing	Raise road
Church entrance road (792)	None	10-year overtops road	Enlarge structure
Plymouth Drive (1477)	2-year overtops road	Same as existing	Enlarge structure
Friendship Manor entrance roads (2593)	2-year overtops one road, 5-year overtops the other	2-year overtops both roads	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for the major flooding problems for Carvin Creek and its tributaries. The areas of focus were the **Sun Valley** subdivision on Carvin Creek, the **Summerdean** subdivision upstream of Plantation Road on Carvin Creek, the **Captains Grove** subdivision on West Fork Carvin Creek and **U.S. Route 11** along Deer Branch.

The **Sun Valley** subdivision could possibly be protected by a levee but this alternative was ruled out by the U.S. Army Corps of Engineers and is not eligible for funding. In order to reduce flooding at this site, three stormwater management pond sites to detain flood flows were investigated upstream of the Sun Valley subdivision. Two of the pond sites also reduce flooding in the **Captains Grove** subdivision on West Fork Carvin Creek. The pond sites analyzed are summarized below and shown in Figure 2.4.2:

Site Description	Comments
CAR01 - approximately 2500' downstream of Plantation Road (upstream crossing) on Carvin Creek	Reduces all discharges by approximately 20% at the Sun Valley subdivision
CAR02 - upstream of Peters Creek Road on West Fork Carvin Creek	Reduces all discharges by approximately 15 at the Sun Valley subdivision and reduces all discharges by approximately 20% on West Fork Carvin Creek; VDOT issues; >25' high so requires state permit
CAR03 - retrofit of the airport drop structure on West Fork Carvin Creek	Reduces all discharges by approximately 5% at the Sun Valley subdivision and by approximately 10% on West Fork Carvin Creek
CAR02 & CAR03	Reduce all discharges by approximately 20% at the Sun Valley subdivision and by 20-30% on West Fork Carvin Creek
CAR01 & CAR03 - pond on Carvin Creek & retrofit of Airport Drop structure	Reduce all discharges by approximately 20% at the Sun Valley subdivision - about the same as CAR01 alone
CAR01, CAR02 & CAR03	Reduce all discharges by 25-35% at the Sun Valley subdivision, would remove about 50 houses from the 100-year floodplain

The upstream ponds cannot totally mitigate the flood hazard at the Sun Valley subdivision. Approximately 50 houses would remain in the 100-year floodplain though they would not be flooded as frequently (i.e. by the 2 & 5 year storms). These remaining homes would have to be purchased, relocated or floodproofed based on the flooding depths.

The flooding situation at the **Summerdean** subdivision is not impacted by CAR01 because this pond is downstream of the subdivision. There are no effective or practical locations for stormwater management ponds upstream of the subdivision. The flooding potential at Summerdean is increased because of debris blockage problems at Plantation Road and Peyton Street. The flooding mitigation measures at this site are to increase the structure sizes at these roads and to reduce debris blockage by clearing the creek and banks upstream of the site.

Route 11 along Deer Branch experiences by the 2-year storm. No feasible pond sites were found on Deer Branch, to mitigate this flood hazard. Therefore, the road would need to be raised to prevent the frequent flooding of this area **(Project CAR04)**.

On all of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or relocation was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.5 COLE HOLLOW BROOK WATERSHED

Basin Description

The Cole Hollow Brook watershed is a 5.9 square mile drainage basin located primarily in north central Roanoke County, Virginia with the southern portion of the watershed located in the City of Salem, Virginia. The watershed is oblong and has a length of about 3.5 miles and a maximum width of about 2.5 miles near its center. The Cole Hollow Brook watershed originates on Ft. Lewis Mountain at an elevation of approximately 3020 feet above sea level. The stream channel flows in a southwesterly then southeasterly direction for about 4 miles until its confluence with the Roanoke River in Salem.

Cole Hollow Brook, located in the east-central sector of the watershed, serves as the political boundary between the City of Salem and Roanoke County for a portion of its length. The upstream reaches of Cole Hollow Brook are largely undeveloped and wooded with scattered single family residences along VA Route 619. Areas along Cole Hollow Brook are relatively undeveloped until the Interstate 81 crossing. Downstream of Interstate 81, residential development is prevalent until the stream crosses US Routes 11 & 460 where the land use becomes more developed and includes some commercial areas in the City of Salem.

A tabulation of the Cole Hollow Brook drainage basin areas is presented below:

Location	Distance Above Confluence with Roanoke River (feet)	Drainage Area(sq. mi.)
Mouth of Cole Hollow Brook	0	5.9
Downstream of confluence of Paint Bank Branch	2,500	5.3
US Routes 11 & 460	3,800	3.8
Interstate 81	6,800	3.5
VA Route 714 - Gum Springs Road	8,700	3.0
Zana Road	14,300	1.6

Subbasin Description

There is one significant stream that drains to the Cole Hollow Brook watershed, Paint Back Branch. Paint Bank Branch is located along the western edge of the Cole Hollow Brook watershed. It converges with Cole Hollow Brook approximately 2500 feet upstream from the Roanoke River. The streams are shown in Figure 2.5.1. A tabulation of the subbasin drainage area is presented below followed by a brief summary of the Cole Hollow Brook tributaries:

Stream	Drainage Area (sq. mi.)
Paint Bank Branch	1.5

Paint Bank Branch originates on Ft. Lewis Mountain at an elevation of approximately 2800 feet above sea level and flows in a southeasterly direction for about 3.8 miles until its confluence with Cole Hollow Brook south of US Routes 11 & 460 in Salem. The Paint Bank Branch watershed is very narrow with a maximum width of about 0.5 miles. The upstream portion of the watershed is largely undeveloped wooded area. Downstream of VA Route 641 residential development increases. Downstream of Interstate 81 the watershed is largely residential until US Routes 11 & 460 where commercial development is prevalent.

Existing Land Use Distribution

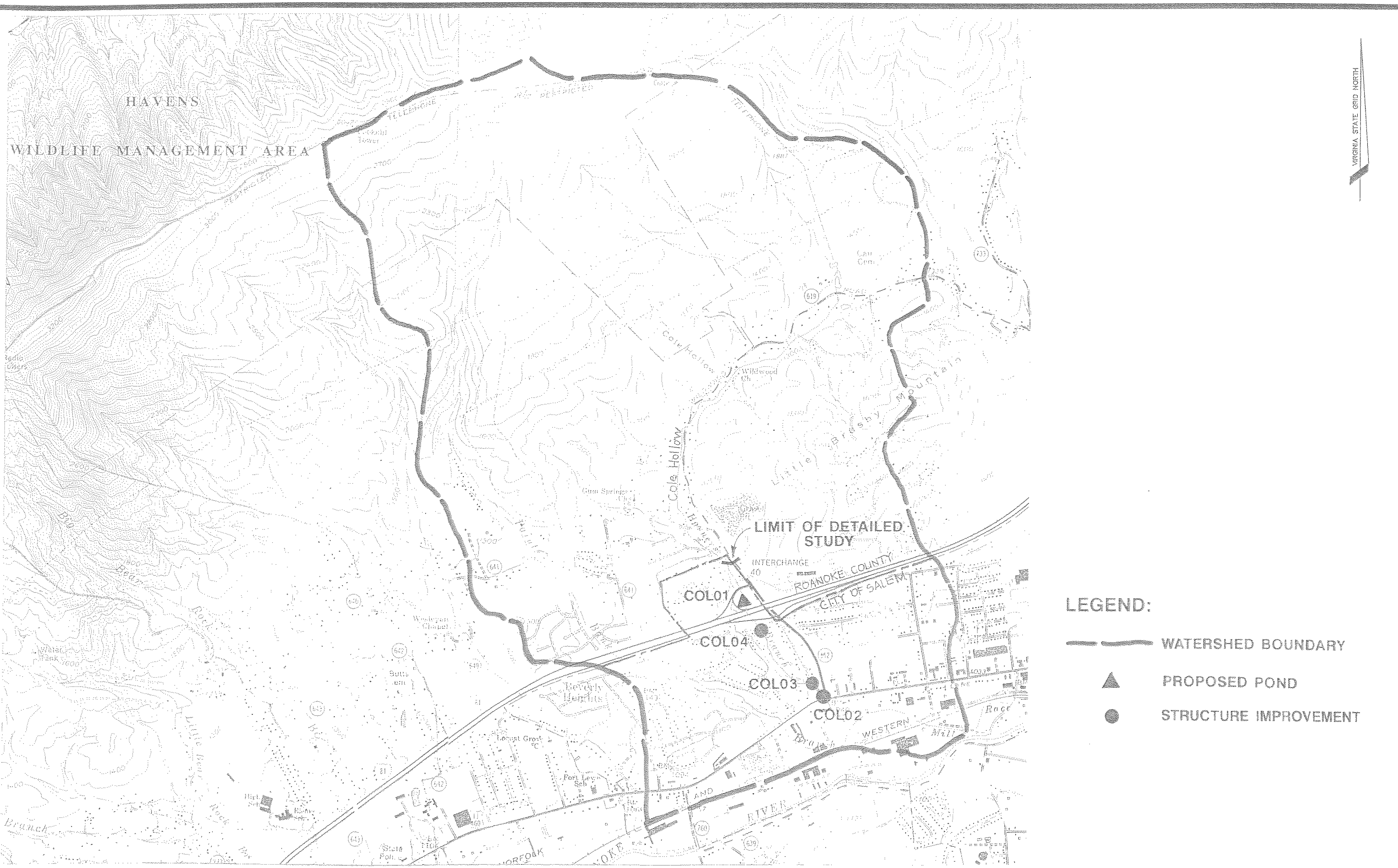
The Cole Hollow Brook watershed contains several specific land uses, but the land uses that predominate are: woods, open areas, residential areas, agricultural and commercial development. Approximately 70% of the watershed is comprised of wooded areas and open space, especially upstream of Interstate 81. The residential portion comprises approximately 20% of the watershed. Agricultural and commercial land uses each comprise about 5% of the watershed.

Developed Land Use Distribution

The Cole Hollow Brook watershed contains 10 developed specific land uses, but only three uses predominate: high density residential, rural preserve and parks and open space. As with the existing land use distribution, the developed land use distribution in the watershed is divided by Interstate 81. Approximately 60% of the watershed is planned to be rural preserve, mostly upstream of Interstate 81. High density residential areas and parks and open space each comprise about 15% of the watershed. The remaining 10% of the watershed consists of low and medium density residential areas, commercial and industrial development, planned development areas and neighborhood conservation areas.

Hydrology

The discharges for Cole Hollow Brook and its tributaries were determined using the procedures described in Chapter 1. The Cole Hollow Brook watershed was divided into 22 subbasins for the hydrologic analysis. Existing conditions discharges on Cole Hollow Brook are increased at the mouth by 95% for the 2-year storm, and by 40% for the 100-year storm under developed conditions (Year 2020). These increases are due to the increase in residential and commercial development occurring mostly in the Paint Bank Branch watershed and the Cole Hollow Brook watershed south of Interstate 81.



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COLE HOLLOW WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION
ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.5.1

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1"=2000'
Sheet 1 of 1

Flooding

History of Flooding

High water marks and measured flood flows were not available for Cole Hollow Brook.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Cole Hollow Brook. No debris blockage information for structures along Cole Hollow Brook was available.

Flooding Problems

Flooding problems along Cole Hollow Brook for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 45 buildings/homes along Cole Hollow Brook including more than 10 that are inundated by a 10-year storm. One of the major flooding problems on Cole Hollow Brook is upstream of West Main Street. Another is downstream of Interstate 81 in the Mitchell subdivision along Windsor Avenue. Table 2.5.1 summarizes the flooding problems found on Cole Hollow Brook for both existing and developed conditions (Year 2020).

Floodplain maps and flood profiles for Cole Hollow Brook are presented in Volume 2 of this report.

Cole Hollow Brook

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Between Railroad & West Main St (1362-3737)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 7	Storm / # of Buildings in flood area 2-year 0 10-year 5 100-year 8	Floodproof and/or relocate; Upstream detention to reduce frequency of flooding
Upstream of West Main Street (4108-5153)	Storm / # of Buildings in flood area 2-year 0 10-year 6 100-year 16	Same as existing	Floodproof and/or relocate; Upstream detention to reduce frequency of flooding; Enlarge West Main Street structure
Windsor Avenue, downstream of I-81 (5756-6447)	Storm / # of Houses in flood area 2-year 0 10-year 5 100-year 20	Same as existing	Floodproof and/or relocate;; Upstream detention to reduce frequency of flooding

Table 2.4.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Road Overtopping			
West Main Street	5-year storm overtops	Same as existing	Enlarge structure and/or raise road
Horner Lane	2-year storm overtops	Same as existing	Enlarge structure and/or raise road
Windsor Lane	5-year storm overtops	Same as existing	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Upstream detention was analyzed as an alternative to reduce flooding along Cole Hollow Branch, especially to relieve the flooding problems in the Mitchell subdivision and upstream of West Main Street. One pond site was investigated on Cole Hollow Branch in the Interstate 81 interchange with Horner Lane - State Route 619. No pond site upstream of Interstate 81 on Cole Hollow Branch was feasible because Wildwood Road parallels the stream. Downstream of Interstate 81, the watershed is too developed and no practical pond sites were found. No practical pond sites were found on Paint Bank Branch because of development along the stream. The pond site analyzed is summarized below and shown in Figure 2.5.1.

Site Description	Comments
COL01 - in Interstate 81 interchange with Horner Lane - State Route 619	Reduces 2-, 10-, and 100-year discharges by approximately 5%, 60%, and 15% at Interstate 81, 10%, 50% and 15% at West Main Street and 0%, 15% and 10% at the mouth, respectively. Dam could possibly require a state permit. Coordination with VDOT needed

COL01 at Interstate 81 provides enough detention to remove several houses from the 10-year floodplain and to increase the capacity of downstream road crossings for the 10-year storm.

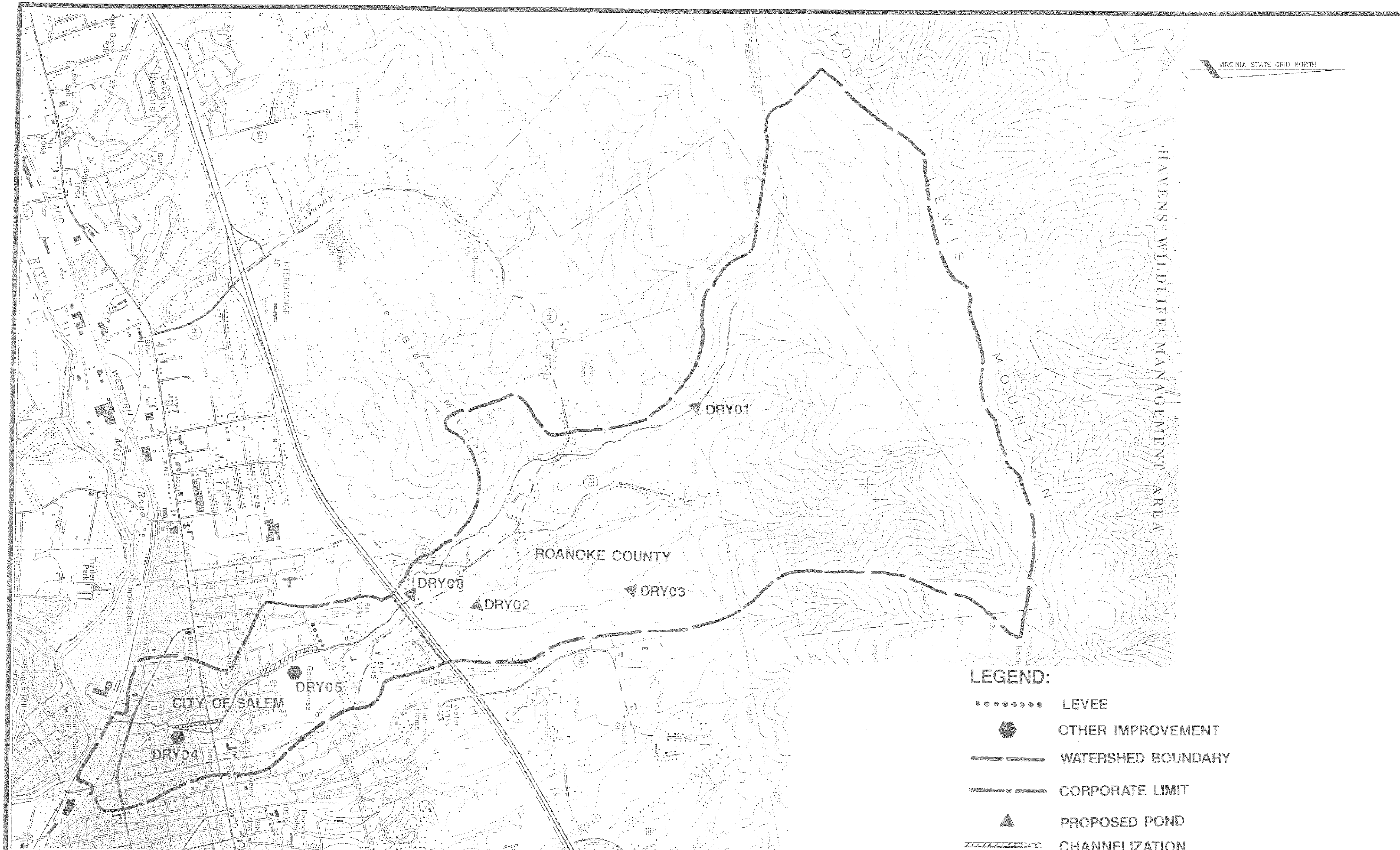
Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.6 Dry Branch Watershed

Basin Description

The Dry Branch watershed is a 4.5 square mile drainage basin located primarily in north central Roanoke County and the southern portion of the watershed is in northern Salem. It lies wholly within Roanoke County and the City of Salem. The watershed is fan shaped and has a length of about 4.5 miles and a maximum width of about 2 miles near its center. The Dry Branch watershed originates on Fort Lewis Mountain at an elevation of approximately 2900 feet above sea level and flows in a southeasterly direction for about four miles to its confluence with the Roanoke River in Salem.

The upstream reaches of Dry Branch are undeveloped with scattered single family residences along Wildwood Road and Richland Hill Road - State Routes 619 and 733. Areas along the main stem of Dry Branch are relatively undeveloped until the Interstate 81 crossing. Downstream of Interstate 81, the stream is located in the developed areas of the City of Salem and the watershed has a mixture of high density residential and commercial development. Developed conditions (Year 2020) land use consists primarily of rural preserve areas and open space in the upstream areas and high density residential and commercial development downstream of Interstate 81. The stream and related subbasins are shown in Figure 2.6.1.



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DRY BRANCH WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN

Figure 2.6.1

Drawn By: GRD Date: 7/96
Checked By: TJL Date: 7/96
Scale: 1"=2000'

A tabulation of the Dry Branch Drainage basin areas is presented below:

Location	Distance Above Mouth of Dry Branch (feet)	Drainage Area (sq. mi.)
Mouth of Dry Branch	0	4.5
4th Street - Alternate U.S. Routes 11 & 460	2,200	4.3
West Main Street - U.S. Routes 11 & 460	4,200	4.2
Carrollton Avenue	7,800	3.8
Interstate 81	10,300	3.7
Goodwin Avenue - State Route 635	11,800	2.1
Wildwood Road - State Route 619	15,300	1.8

Existing Land Use Distribution

The Dry Branch watershed contains eight existing specific land uses, but only 2 uses generally predominate: woods and 1/4 acre residential lots. Approximately 75% of the watershed is comprised of wooded areas, especially in the upstream subbasins of Dry Branch. The 1/4 acre residential lots comprise approximately 10% of the watershed. The remaining 15% of the watershed consists of open space, commercial, agricultural and residential areas of various densities.

Developed Land Use Distribution

The Dry Branch watershed contains 12 developed specific land uses, but only six uses predominate: rural preserve, open space, commercial, institutional, high density residential and neighborhood conservation areas. Approximately 50% of the developed conditions (Year 2020) watershed is planned to be rural preserve which is located in the areas upstream of Interstate 81. Open space comprises approximately 25% of the developed conditions (Year 2020) watershed. Commercial, institutional, high density residential and neighborhood conservation areas each comprise about 5% of the developed conditions (Year 2020) watershed. The remaining 5% of the watershed consists of industrial, woods, surface water and low and medium density residential areas.

Hydrology

The Dry Branch watershed was divided into 13 subbasins for the hydrologic analysis. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Dry Branch, 2-year discharges increase by 70%, 10-year discharges increase by 40% and 100-year discharges increase by 20% under developed conditions (Year 2020). These increases are mostly due to the change from wooded areas to rural preserve areas in the upstream subbasins.

Flooding

History of Flooding

High water marks were provided by the City of Salem for Dry Branch. Those high water marks were used to verify the computed flood elevations for Dry Branch.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Dry Branch. No debris blockage information for structures along Dry Branch was available.

Flooding Problems

Flooding problems along Dry Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 150 homes along Dry Branch including more than 60 that are also inundated by a 10-year storm. The major flooding problems on Dry Branch are in the **Hockman** and **Cameron Court** Subdivisions. Table 2.6.1 summarizes the flooding problems found on Dry Branch for both existing and developed conditions (Year 2020).

Floodplain maps and flood profiles for Dry Branch are presented in Volume 2 of this report.

Table 2.6.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Along 4th Street (2070- 2298)	Storm / # of Buildings in flood area 2-year: 0 10-year: 2 100-year: 17	Storm / # of Buildings in flood area 2-year: 1 10-year: 3 100-year: 22	Floodproof and/or relocate
Hockman Subdivision (2466-3652)	Storm / # of Houses in flood area 2-year: 0 10-year: 10 100-year: 38	Storm / # of Houses in flood area 2-year: 2 10-year: 25 100-year: 44	Floodproof and/or relocate; Upstream detention
Along West Main Street (3867-4312)	Storm / # of Buildings in flood area 2-year: 0 10-year: 4 100-year: 13	Storm / # of Buildings in flood area 2-year: 0 10-year: 10 100-year: 13	Floodproof and/or relocate; Upstream detention
Langhorne Place Subdivision (4819)	Storm / # of Houses in flood area 2-year: 0 10-year: 0 100-year: 3	Same as existing	Floodproof and/or relocate; Upstream detention
Wiley Court Subdivision (5396)	Storm / # of Houses in flood area 2-year: 0 10-year: 0 100-year: 3	Storm / # of Houses in flood area 2-year: 0 10-year: 0 100-year: 4	Floodproof; Upstream detention
Cameron Court Subdivision (6873-7596)	Storm / # of Houses in flood area 2-year: 0 10-year: 40 100-year: 56	Storm / # of Houses in flood area 2-year: 0 10-year: 52 100-year: 80	Floodproof and/or relocate; Upstream detention
Upstream of Carrollton Avenue (8963)	Storm / # of Houses in flood area 2-year: 0 10-year: 0 100-year: 2	Same as existing	Relocate; Upstream detention

Table 2.6.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Along Goodwin Avenue (1163-11882)	Storm — # of Houses in flood area 2-year — 0 10-year — 4 100-year — 5	Same as existing	Relocate; Upstream detention
Between Goodman Avenue & Wildwood Road (11882-15743)	Storm — # of Houses in flood area 2-year — 0 10-year — 2 100-year — 12	Storm — # of Houses in flood area 2-year — 0 10-year — 7 100-year — 14	Floodproof and/or relocate; Upstream detention
Road Overtopping			
West Burrel Street (3702)	5-year storm overtops road	Same as existing	Raise road because of backwater
Carrollton Avenue (7715)	10-year storm overtops road	5-year storm overtops road	Enlarge and/or raise road
Goodwin Avenue (11784)	10-year storm overtops road	5-year storm overtops road	Raise road because of backwater
Frosty Lane (15261)	10-year storm overtops road	5-year storm overtops road	Raise road because of backwater

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for Dry Branch. The areas of flooding are scattered but some areas of concentrated flooding are in the **Hockman** and **Cameron Court** subdivisions. One possibility for alleviating this flooding is to floodproof the homes where possible and to relocate or purchase the others.

Another possibility is to reduce flood discharges by detaining storm flows in ponds upstream of the flooded areas. Several sites in the Dry Branch watershed were analyzed as flood control sites. These pond sites are tabulated below:

Possible Pond Sites to Mitigate Flooding on Dry Branch

Site Description	Comments
DRY01 - Approximately 4000' upstream of Wildwood Road - State Route 419	Pond reduces 2-year by ~ 30% at I81, 20% at Carrollton Road and 0% at 4th Street, reduces 10-year by ~ 40% at I81, Carrollton Road and 4th Street and reduces 100-year by ~ 15% at I81, Carrollton Road and 4th Street. The assumed dam was ~ 40' high and would require a state permit, however better topography in the area could reduce the dam height.

DRY02 - Approximately 100' upstream of Waldheim Road on County/Salem border - just inside city limits	Pond has minimal impact on 2-year, reduces 10-year by ~ 5% at I81, Carrollton Road and 4th Street and reduces 100-year by ~ 5% at I81, Carrollton Road and 4th Street. The assumed dam was ~ 25' high and may require a state permit, however better topography in the area could reduce the dam height.
DRY03 - Approximately 4500' upstream of Waldheim Road, alongside Dunrovin Lane	Pond reduces 2-year by ~ 5% at I81, and has minimal impact at Carrollton Road and 4th Street, reduces 10-year by ~ 15% and reduces 100-year by ~ 15% at I81, Carrollton Road and 4th Street. The assumed dam was ~ 35' high and may require a state permit, however better topography in the area could reduce the dam height.
DRY08 - just upstream of Interstate 81	Pond reduces 2-year by ~ 40% at I81, 40% at West Main Street and has no impact at 4th Street, reduces 10-year by ~ 40% at I81, West Main Street and 4th Street and reduces 100-year by ~ 10% at I81, Carrollton Road and 4th Street. The pond would require closing off Wildwood Road at I81 and filling in the overpass and the purchase of one home.
DRY01 & DRY02	Reduces 2-, 10-, and 100-year slightly more than Pond DRY01 alone
DRY01 & DRY03	Ponds reduce 2-year by ~ 30% at I81, 25% at Carrollton Road and 0% at 4th Street, reduce 10-year by ~ 65% at I81, 60% at Carrollton Road and 45% at 4th Street and reduces 100-year by ~ 15% at I81, and 20% at Carrollton Road and 4th Street.
DRY02 & DRY03	Ponds reduce 2-, 10- and 100-year slightly more than DRY03 alone
DRY01, DRY02 & DRY03	Ponds reduce 2-year by ~ 30% at I81, 25% at Carrollton Road and 0% at 4th Street, reduce 10-year by ~ 70% at I81, 65% at Carrollton Road and 55% at 4th Street and reduces 100-year by ~ 15% at I81, and 20% at Carrollton Road and 4th Street. 2- and 100-year reductions are about the same as DRY01 and DRY03 and 10-year reductions are slightly more.
DRY01 and DRY08	Ponds reduce 2-year by ~ 40% at I81, 0% at Carrollton Road and 0% at 4th Street, reduce 10-year by ~ 75% at I81, 75% at Carrollton Road and 55% at 4th Street and reduces 100-year by ~ 25% at I81, Carrollton Road and 4th Street. 2-year reductions are about the same as DRY08 alone and 10- and 100-year reductions are significantly more.

In the **Hockman** and **Cameron Court** subdivisions, Ponds DRY01 and DRY08 have the greatest impact on discharges. Upstream detention does not provide enough storage to remove all of the houses from the 100-year floodplain but can be used to reduce the frequency of inundation. The addition of DRY02 and DRY03 with DRY01 and DRY08 results in a minor increase in reductions although DRY03 has a greater impact than DRY02. The proposed pond sites are shown in Figure 2.6.1.

Two other projects were proposed to relieve flooding in the **Hockman** and **Cameron Court** subdivisions. In the **Hockman** subdivision, a channel diversion (**DRY04**) is proposed which also includes the relocation and replacement of structures at West Main Street and West Burwell Street. In the **Cameron Court** subdivision, several mitigation measures are proposed (**DRY05**): a levee upstream of Carrollton Avenue, enlargement of the culvert at Carrollton Avenue and enlarging the channel downstream of Carrollton Avenue.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and tabulation of benefits.

2.7 GISH BRANCH WATERSHED

Basin Description

The Gish Branch watershed is a 2 square mile drainage basin located in north central Roanoke County and north central Salem. It lies wholly within Roanoke County and the City of Salem. The watershed is fan shaped and has a length of about 3.5 miles and a maximum width of about 1.5 miles near its headwaters. The Gish branch watershed originates on Fort Lewis Mountain near the Lewis Radio Facility at an elevation of approximately 3080 feet above sea level and flows in a southeasterly direction for about 3.5 miles until its confluence with Mason Creek in Salem.

Gish Branch is a major tributary to Mason Creek (see Section 2.10). Upstream of North Mill Road - State Route 631, the Gish Branch watershed is largely undeveloped and covered with woods. Downstream of North Mill Road, the watershed has commercial development which is part of the City of Salem. Developed land use consists primarily of rural preserve areas upstream of Interstate 81 and commercial areas downstream of Interstate 81. The stream and contributing area is shown in Figure 2.7.1.

A tabulation of the Gish Branch Drainage basin areas is presented below:

Location	Distance Above Mouth of Gish Branch (feet)	Drainage Area (sq. mi.)
Mouth of Gish Branch	0	2.0
Kessler Mill Road - State Route 630	500	2.0
North Mill Road - State Route 631	5,500	1.4
Interstate 81	10,000	0.9

Existing Land Use Distribution

The Gish Branch watershed contains eight existing specific land uses, but only 2 uses generally predominate: woods and commercial areas. Approximately 60% of the watershed is comprised of wooded areas, especially in the upstream subbasins of Gish Branch. Commercial development comprises approximately 20% of the watershed primarily in the downstream subbasins of Gish Branch. The remaining 20% of the watershed consists of agricultural, open space, paved areas and residential areas of various densities.

Developed Land Use Distribution

The Gish Branch watershed contains 10 developed specific land uses, but only three uses predominate: commercial development, rural preserve areas and planned development areas. Approximately 45% of the developed conditions (Year 2020) watershed is comprised of commercial development located in the areas downstream of Interstate 81. Rural preserve areas which are located upstream of Interstate 81 comprise approximately 30% of the developed conditions (Year 2020) watershed. Planned development areas comprise about 10% of the developed conditions (Year 2020) watershed. The remaining 15% of the watershed consists of neighborhood conservation areas, residential areas, industrial development, open space and institutional areas.

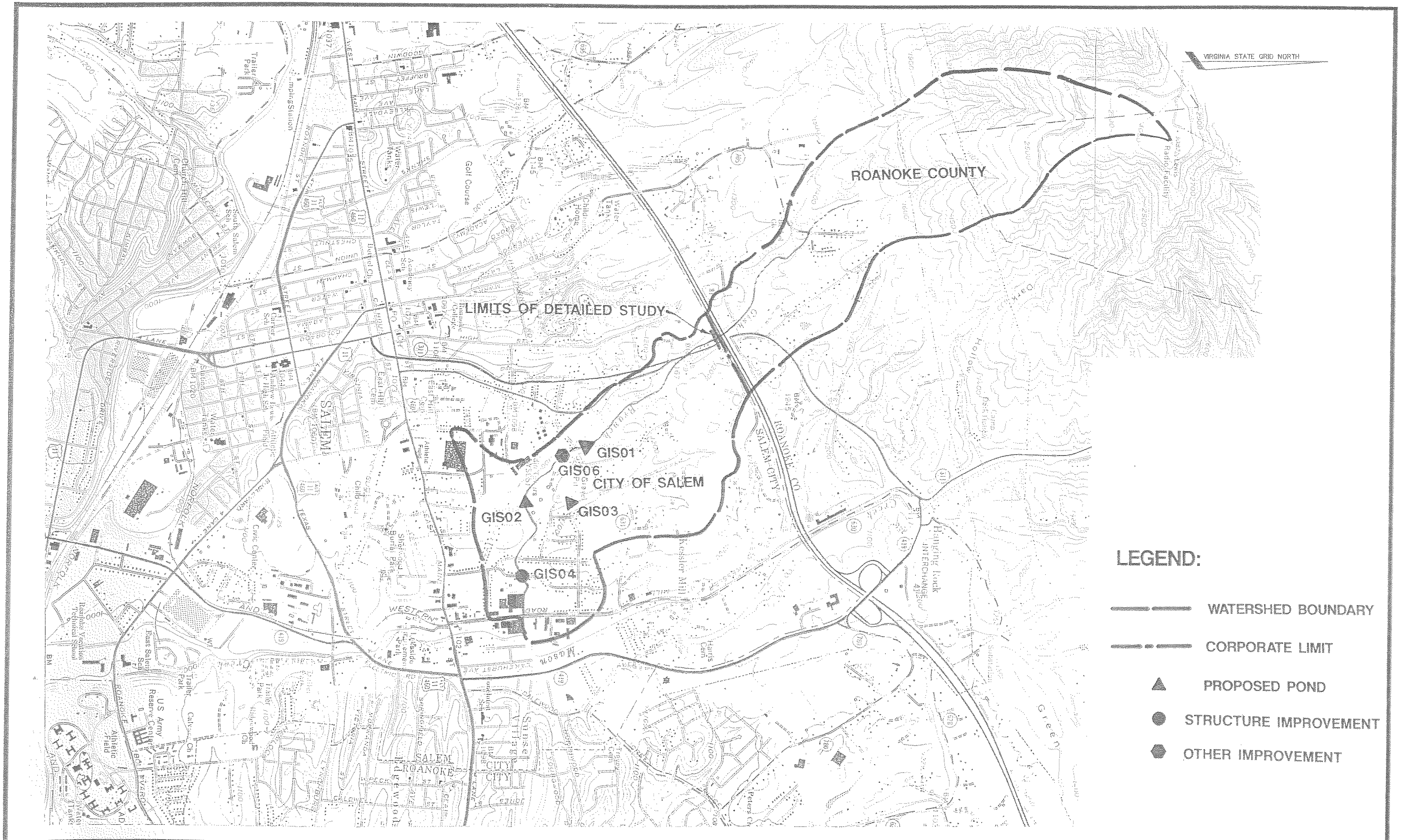
Hydrology

The Gish Branch watershed was divided into 15 subbasins for the hydrologic analysis. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Gish Branch, 2-year discharges increase by 100%, 10-year discharges increase by 63% and 100-year discharges increase by 37% under developed conditions (Year 2020). These increases are due to the increase in commercial and residential development and the change from woodland to rural preserve in the upstream subbasins.

Flooding

History of Flooding

High water marks and measured flood flows were not available for Gish Branch.



Dewberry & Davis Architects Engineers Planners Surveyors 8401 Arlington Boulevard Fairfax, Virginia 22031 (703) 849-0100	GISH BRANCH WATERSHED LOCATION OF PROPOSED STORMWATER IMPROVEMENTS FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA	ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN Figure 2.7.1	Drawn By: GRD Date: 7/96 Checked By: TJL Date: 7/96	Scale: 1"=2000'

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Gish Branch. No debris blockage information for structures along Gish Branch was available.

Flooding Problems

Flooding problems along Gish Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 11 homes along Gish Branch including more than 8 that are inundated by a 10-year storm. One of the major flooding problems on Gish Branch is upstream of **Kessler Mill Road** where several homes and a commercial building are inundated by a 10-year storm. Table 2.7.1 summarizes the flooding problems found on Gish Branch for both existing and developed conditions (Year 2020).

Floodplain maps and flood profiles for Gish Branch are presented in Volume 2 of this report.

Table 2.7.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Kessler Mill Road to upstream of Parkdale Drive (472-2862)	Storm / # of Houses in flood area 2-year 3 10-year 8 100-year 8	Storm / # of Houses in flood area 2-year 3 10-year 8 100-year 9	Floodproof and/or relocate; Enlarge road crossings downstream; Upstream detention
Upstream of Parkdale Drive to North Mill Road (2862-5506)	Storm / # of Houses in flood area 2-year 0 10-year 1 100-year 2	Storm / # of Houses in flood area 2-year 0 10-year 2 100-year 3	Floodproof and/or relocate; Remove railroad fill downstream; Upstream detention
North Mill Road to Thompson Memorial Drive (5506-9192)	Storm / # of Houses in flood area 2-year 0 10-year 0 100-year 1	Same as existing	Floodproof and/or relocate; Upstream detention
Thompson Memorial Drive to Interstate 81 (9192-10001)	Storm / # of Houses in flood area 2-year 0 10-year 0 100-year 1	Same as existing	Floodproof and/or relocate; Upstream detention
Road Overtopping			
Chamberlain Lane	2-year overtops road	Same as existing	Raise low point in road 3' to get above 10-year and increase culvert opening
Parkdale Drive	2-year overtops road	Same as existing	Raise low point in road 3' to get above 10-year and increase culvert opening

Flood Hazard Mitigation Measures

Three stormwater management pond sites were analyzed on Gish Branch. These ponds were analyzed to determine their effect on flooding upstream of **Kessler Mill Road** and on flood discharges on Mason Creek. The pond sites are summarized below:

Possible Pond Sites to Mitigate Flooding on Gish Branch

Site Description	Comments
GIS01 - just upstream of Edgebrook Road	Pond reduces 10-year by ~ 2% and 100-year by ~ 15% at North Mill Road and has no impact further downstream
GIS02 - ~ 2000' downstream of North Mill Road on Gish Branch next to radio station	Pond reduces 2-, 10-, and 100-year by ~ 50% at Chamberlain Lane and by ~ 40% at the mouth. Pond would require relocation of 2 radio antennas
GIS03 - on tributary to Gish Branch downstream of old railroad embankment	Pond reduces 2-year by ~ 30% and 10-year by ~ 20% at Chamberlain Lane and reduces 2-year by ~ 30%, 10-year by ~ 25% and 100-year by ~ 5% at the mouth. Pond would require removal of railroad fill.
GIS01 & GIS02	Reductions are the same as GIS01 and GIS02 alone
GIS01 & GIS03	Reductions for the 2- and 10-year are the same as GIS01 and GIS03 alone. 100-year is reduced by ~15% at North Mill Road, by ~ 10% at Chamberlain Lane and by ~ 15% at the mouth.
GIS02 & GIS03	2-, 10- & 100-year are reduced by ~ 70% at Chamberlain Lane and by ~ 60% at the mouth
GIS01, GIS02 & GIS03	Reductions at North Mill Road are the same as GIS01 alone. Reductions at Chamberlain Lane and the mouth are the same as GIS02 & GIS03 above

Pond **GIS02** provides the greatest reduction in discharges at **Kessler Mill Road**. The addition of **GIS03** increases the reduction by another 20%. **GIS01** provides minimal benefit for the 10-and 100-year at North Mill Road but would not remove these homes from the floodplain completely. The proposed pond sites are shown on Figure 2.7.1.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and tabulation of benefits.

2.8 Glade Creek Watershed

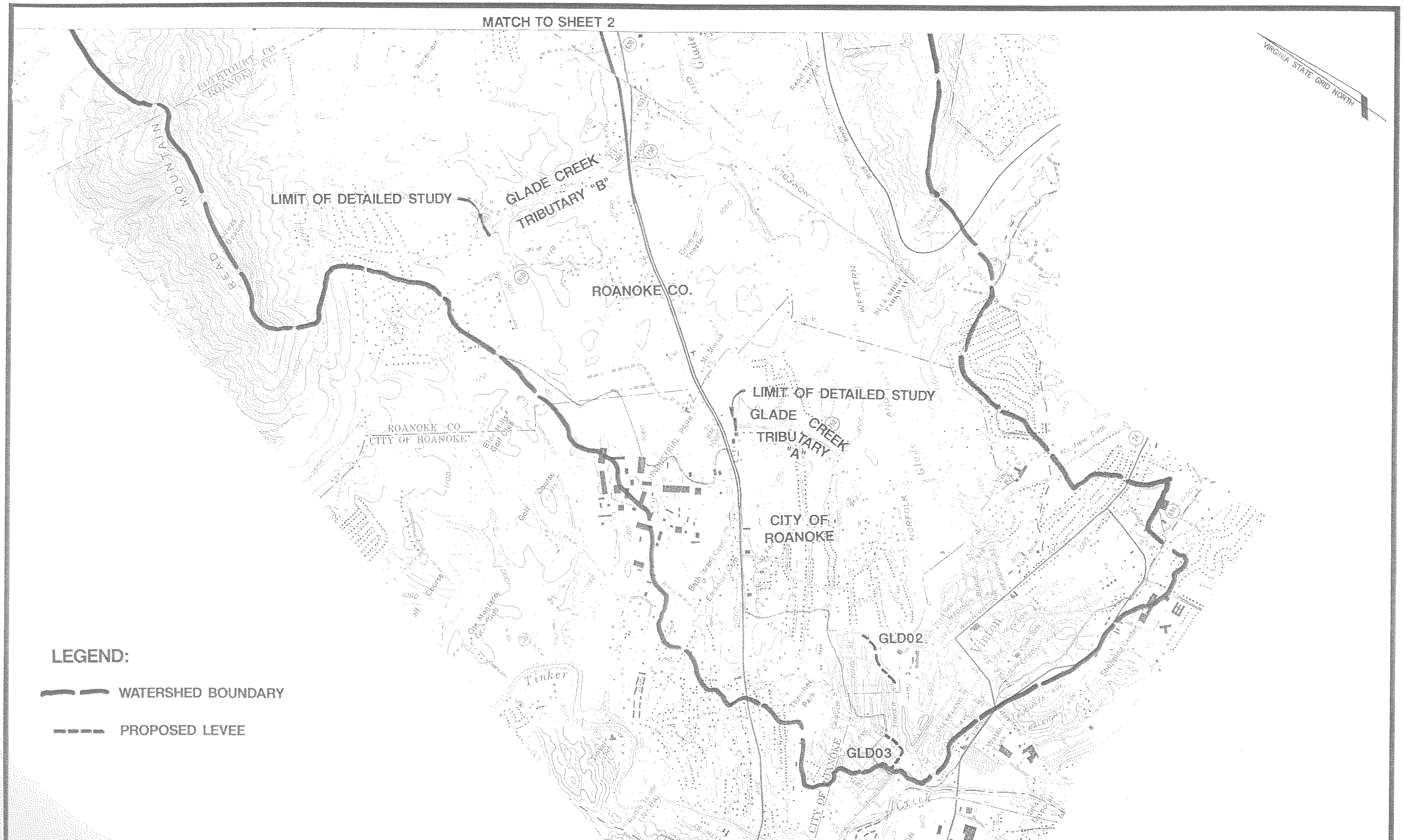
Basin Description

The Glade Creek watershed is a 33 square mile drainage basin located in northeast Roanoke County, northeast Roanoke City and northwest Vinton with the northern portion of the watershed located in Botetourt County, Virginia. The watershed is fan shaped and has a length of about 10 miles and a maximum width of about 5.5 miles near its headwaters. Glade Creek originates in the Blue Ridge Mountains near Curry Gap at an elevation of approximately 2500 feet above sea level and flows in a southwesterly direction for about eleven miles to its confluence with Tinker Creek at the border of the City of Roanoke and the Town of Vinton.

Glade Creek serves as the political boundary between the City of Roanoke and the Town of Vinton for a portion of its length. The upstream reaches of Glade Creek are mostly undeveloped and with scattered single family residences along major roads. Areas along the Glade Creek are relatively undeveloped until the stream enters the Town of Vinton. The land uses along the mainstem of Glade Creek are mostly wooded and agricultural except within the Town of Vinton where the land use is mostly commercial. Developed conditions (Year 2020) in the watershed reflect an increase in commercial, industrial and residential development. Glade Creek and its contributing areas are shown in Figure 2.8.1.

A tabulation of the Glade Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Glade Creek (feet)	Drainage Area (sq. mi.)
Mouth of Glade Creek	0	33.0
Downstream from Confluence of Glade Creek Tributary A	6,400	30.7
Downstream from Confluence of Glade Creek Tributary B	19,900	27.8
Downstream from Confluence of Cook Creek	25,700	24.8



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GLADE CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION | ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.8.1

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1"=2000'
Sheet 1 of 3

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GLADE CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.8.1 (Cont'd.)

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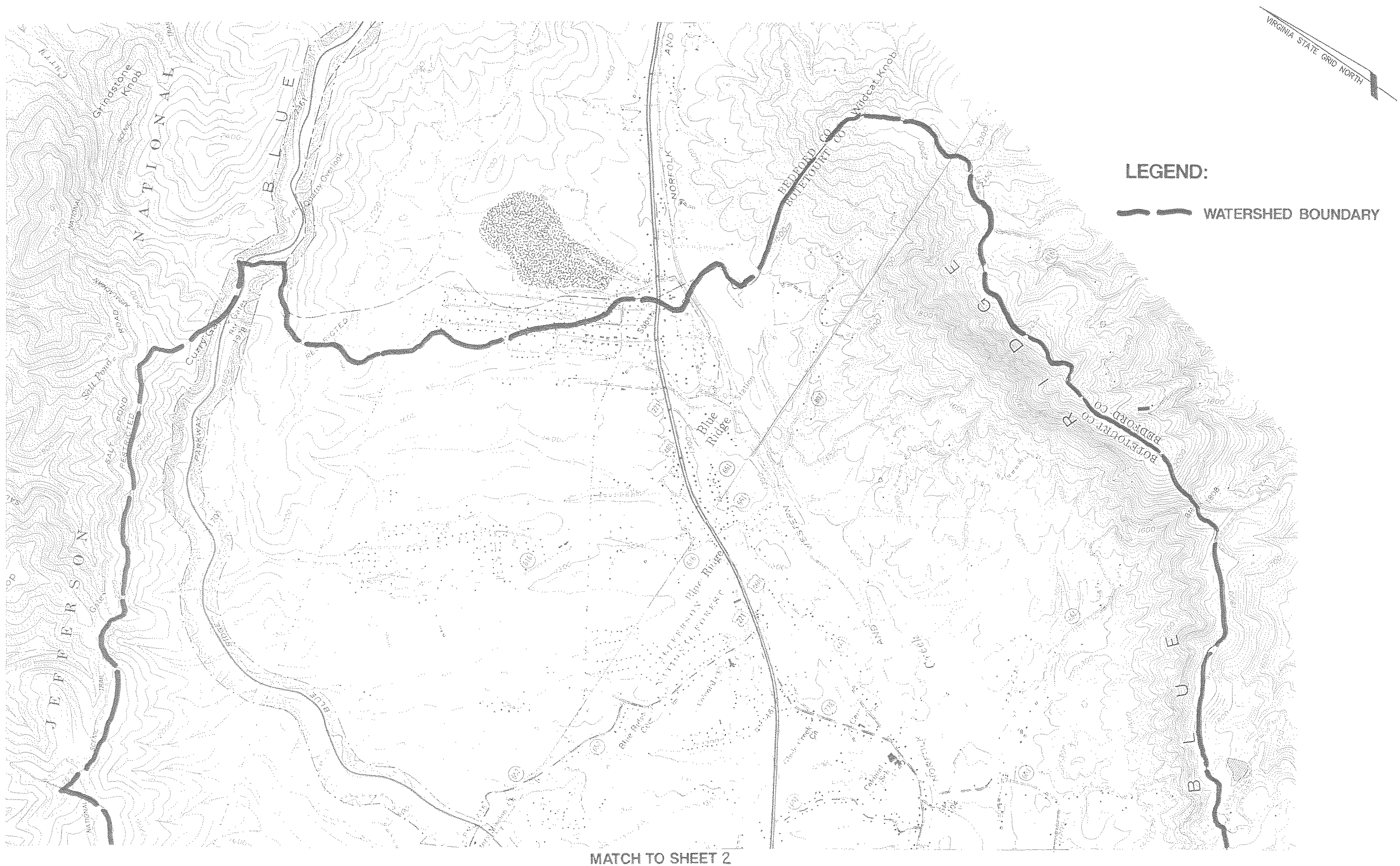

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GLADE CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.8.1 (Cont'd.)

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1"=2000'

Sheet 3 of 3

Downstream from Confluence of Laymantown Creek	32,900	19.0

Subbasin Description

There are several significant streams that drain the Glade Creek watershed including: Cook Creek, Coyner Branch, Laymantown Creek and Glade Creek Tributaries A and B. Of these, Coyner Branch and Laymantown Creek lie outside of Roanoke County in Botetourt County. Cook Creek is located in both Roanoke and Botetourt Counties. Glade Creek Tributary A is located in the City of Roanoke and Roanoke County while Tributary B is located wholly within Roanoke County. The streams and related subbasins are shown in Figure 2.8.1. A tabulation of the subbasin drainage areas is presented below followed by a brief summary of Glade Creek and its tributaries:

Stream	Distance above Confluence with Tinker Creek (feet)	Drainage Area (sq. mi.)
Laymantown Creek	32,900	5.1
Coyner Branch	31,900	1.3
Cook Creek	25,700	3.6
Glade Creek Tributary B	19,900	1.6
Glade Creek Tributary A	6,400	1.3

Laymantown Creek is a tributary located in southeast Botetourt County which joins Glade Creek approximately 6.2 miles upstream of the confluence of Glade Creek with Tinker Creek. The existing watershed is mostly undeveloped, consisting of woods, brush and agricultural areas. There are also some scattered residential areas in the watershed. Developed conditions (Year 2020) land uses consist mainly of medium density residential development, woods, agriculture and a commercial area along U.S. Route 460.

Coyner Branch is also located in southeast Botetourt County, south of the Laymantown Creek watershed. It joins with Glade Creek approximately 6 miles upstream of the confluence of Glade Creek with Tinker Creek. The existing watershed is mainly undeveloped consisting of woods, agricultural areas and scattered residential development. The developed conditions (Year 2020) watershed is consists mainly of agricultural areas, industrial development, medium density residential development and woods.

Cook Creek is a major tributary of Glade Creek located in the western central portion of the Glade Creek watershed. It converges with Glade Creek approximately 5 miles upstream of the confluence of Glade Creek with Tinker Creek. The Cook Creek watershed is mostly undeveloped. There are areas of residential development, especially in the downstream portion of the watershed, including the Huntridge and Applewood Subdivisions. The developed conditions (Year 2020) watershed consists of woods, medium and high density residential areas, and planned residential development zones.

Glade Creek Tributary A is another notable tributary located along King Street in the City of Roanoke. Glade Creek Tributary A joins with Glade Creek near the Norfolk & Western Railroad crossing approximately one mile upstream of the confluence of Glade Creek with Tinker Creek. The existing watershed has a mixture of land uses: pasture, residential and industrial areas along U.S. Routes 221 and 460. The residential areas comprise about 30% of the existing watershed and include the Idylwild Park and Brattonlawn Subdivisions. Industrial development comprises about 20% of the watershed and includes the Statesman Industrial Park. Developed conditions (Year 2020) in the watershed consist of high density residential areas, industrial and commercial development.

Glade Creek Tributary B is located southeast of Read Mountain north of the City of Roanoke. It joins Glade Creek about 3.8 miles upstream from the confluence of Glade Creek with Tinker Creek and is approximately 2 miles in length. Most of the terrain in the northwest portion of the watershed is mountainous, with wooded upland areas. The watershed is mostly undeveloped consisting of wooded areas and about 30% of the watershed has scattered residential development. The developed conditions (Year 2020) watershed consists of medium and high density residential areas, and planned residential development zones.

Existing Land Use Distribution

The Glade Creek watershed contains fifteen existing specific land uses, but only 4 uses generally predominate, they include woods, agriculture, 1/2 acre and 1/4 acre residential lots and commercial. Approximately 50% of the watershed is comprised of wooded areas, especially in the upstream subbasins of Glade Creek. Agricultural areas comprise about 20% of the watershed. The residential portion comprises approximately 15% of the watershed and commercial areas comprise about 5% of the watershed. The remaining 10% of the watershed consists of pasture, brush, industrial development and open space.

Developed Land Use Distribution

The Glade Creek watershed contains fifteen developed specific land uses, but only 5 uses generally predominate: woods, agriculture, medium and high density residential development and industrial. Approximately 25% of the watershed is planned to remain wooded and approximately 20% is planned to remain agricultural. Medium density residential development comprises approximately 15% of the watershed while high density residential and industrial development each comprise approximately 10% of the watershed. The remaining 20% of the watershed consists of commercial development, low density residential development and planned development and rural preserve areas.

Hydrology

The Glade Creek watershed was divided into 54 subbasins for the hydrologic analysis. Six of these subbasins cover Glade Creek Tributaries A and B and Cook Creek. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Glade Creek, 2-year discharges increase by 85%, 10-year discharges increase by 50% and 100-year discharges increase by 30% under developed conditions (Year 2020). These increases are due to planned development areas in the watershed and increased residential, commercial and industrial development.

Flooding

History of Flooding

The May 1985, Feasibility Study by CDM states that the intersection of Walnut Avenue and Fifth Street located near the confluence of Glade Creek with Tinker Creek is the most severe flooding problem in the Town of Vinton. No high water marks or recorded flood flows were available for Glade Creek.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Glade Creek and its tributaries. No debris blockage information on Glade Creek was available.

Flooding Problems

Flooding problems for both existing and developed land use conditions along Glade Creek, Cook Creek, and Glade Creek Tributaries A and B, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem on Glade Creek is in the Town of Vinton upstream of the confluence of Glade Creek with Tinker Creek. From just upstream of Gus W. Nicks Boulevard to the confluence there are approximately 100 houses in the developed conditions (Year 2020) 100-year floodplain and 50 of which are inundated by the 10-year storm. The flooding problems and possible solutions are summarized below in Table 2.8.1.

Floodplain maps and flood profiles for Glade Creek, Cook Creek, and Glade Creek Tributaries A and B, are presented in Volume 2 of this report.

Table 2.8.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
From confluence with Tinker Creek to Walnut Avenue (149-914)	Storm / # of Buildings in flood area 2-year 0 10-year 8 100-year 15	Storm / # of Buildings in flood area 2-year 1 10-year 12 100-year 15	Floodproof, relocate and/or purchase; Levee
From Walnut Avenue to Vale Avenue - along Tinker and Kermit Avenues (914-2643)	Storm / # of Buildings in flood area 2-year 0 10-year 17 100-year 35	Storm / # of Buildings in flood area 2-year 5 10-year 25 100-year 39	Floodproof, relocate and/or purchase; Levee
From Vale Avenue to Gus W. Nicks Boulevard - along Dunkirk Avenue (2643-4145)	Storm / # of Buildings in flood area 2-year 0 10-year 4 100-year 24	Storm / # of Buildings in flood area 2-year 1 10-year 12 100-year 29	Levee with flap gate to prevent backwater on Dunkirk Avenue; Floodproof, relocate and/or purchase
Gus W. Nicks Boulevard to Berkley Road (4145-8256)	Storm / # of Buildings in flood area 2-year 0 10-year 4 100-year 13	Storm / # of Buildings in flood area 2-year 0 10-year 7 100-year 15	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Berkley Road to Bridge State Road (8256-24525)	Storm / # of Buildings in flood area 2-year 1 10-year 3 100-year 3	Storm / # of Buildings in flood area 2-year 3 10-year 3 100-year 3	Floodproof, relocate and/or purchase ; Upstream detention to reduce frequency of flooding
Bridge State Road to Glade Creek Road - State Route 636 (24525-27827)	Storm / # of Houses in flood area 2-year 0 10-year 4 100-year 7	Storm / # of Houses in flood area 2-year 3 10-year 5 100-year 8	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Walnut Avenue (914)	2-year overtops road	Same as existing	Raise road because of backwater
Norfolk and Western Railroad (1003)	25-year overtops railroad	10-year overtops railroad	Raise railroad because of backwater
Tinker Avenue (1102-2643)	None	10-year inundates road	Raise road
Vale Avenue (3550)	2-year inundates road	Same as existing	Raise road

Table 2.8.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Gus W. Nicks Boulevard (4016)	25-year overtops road	10-year overtops road	Raise road because of backwater
Berkley Road along stream (7173-7887)	10-year inundates road	Same as existing	Raise road
Glade Creek Road - State Route 636 (27827)	10-year overtops road	5-year overtops road	Raise road because of backwater

Cook Creek

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Downstream of Bonsack Road (296-687)	Storm / # of Buildings in flood area 2-year 0 10-year 2 100-year 7	Same as existing	Floodproof and/or relocate
Upstream of Bonsack Road (917-1333)	Storm / # of Buildings in flood area 2-year 0 10-year 2 100-year 7	Storm / # of Buildings in flood area 2-year 0 10-year 4 100-year 7	Upstream detention; Construct levee; Floodproof and/or relocate
Upstream of Crumpacker Avenue (4385)	none	House flooded by 100-year storm	Floodproof

Glade Creek Tributary A

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Berkley Road (250-2817)	Storm / # of Houses in flood area 2-year 1 10-year 2 100-year 3	Storm / # of Houses in flood area 2-year 1 10-year 2 100-year 4	Floodproof , relocate and/or purchase
Berkley Road to Belle Avenue (2817-3887)	Storm / # of Houses in flood area 2-year 1 10-year 1 100-year 1	Same as existing	Floodproof, relocate and/or purchase
Road Overtopping			
Berkley Road - State Route 653 (2817)	2-year overtops road	Same as existing	Enlarge structure and/or raise road
King Street - State Route 653 (3374-4531, 5264-5774, 6677-6820)	2-year inundates road	Same as existing	Raise road; Levee along stream
Glade View Drive (3488)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Dogwood Hill Road (3796)	2-year overtops road	Same as existing	Enlarge structure to reduce backwater problems upstream
Belle Avenue - State Route 758 (3887)	2-year overtops road	Same as existing	Raise road because of backwater
Spring Tree Drive (6392)	25-year overtops road	10-year overtops road	Enlarge structure to reduce backwater problems upstream
Shopping Center Access Road	2-year overtops road	Same as existing	Raise road because of backwater

Site F - In Botetourt County on Laymantown Creek upstream of State Route 658	Would require relocation of a significant amount of State Route 658 and purchase of several houses - this alternative was NOT ANALYZED further because of the major disturbance to State Route 658

Several different alternatives were analyzed with Basins A, B, C and D by themselves and in combination to determine their impact on downstream discharges. All of the alternatives resulted in a reduction of discharges on Glade Creek at its confluence with Tributary A by 5-10%. Because Site A1 has the least impact on existing roads and houses, it is the best choice to achieve this reduction. However, this flood control will not significantly impact discharges in the Town of Vinton where the flooding problem is the greatest.

To address the flooding problems in the downstream portion of Glade Creek, other flood hazard mitigation measures are needed. The Dunkirk Avenue area is impacted by backwater from Glade Creek. Raising Kermit Avenue to act as a levee could protect this area from backwater (**GLD02**). Another area impacted by backwater is just upstream of the Norfolk & Western Railroad along Tinker Avenue. Raising Tinker Avenue to act as a levee would also protect some areas from flooding (**GLD03**). Flap gates on the storm sewers in this area would also prevent backwater problems through the storm sewers (**GLD04**). The structures that are still subject to flooding after the implementation of these measures should be floodproofed.

On Cook Creek, one pond site (**GLD01**) was analyzed upstream of Challenger Avenue to relieve flooding downstream. This pond reduces discharges at Challenger Avenue by approximately 45% for the 2-year storm, 60% for the 10-year storm and 15% for the 100-year storm. This pond would remove approximately 6 structures from the 10-year floodplain. The pond has no impact on discharges on the main stem of Glade Creek.

No pond sites were located on Glade Creek Tributary A because of the small number of houses flooded along this stream and because a pond on this tributary would have minimal impact on discharges on Glade Creek.

On all of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or purchase was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size. The recommended mitigation measures are summarized in Table 2.8.1.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.9 LICK RUN WATERSHED

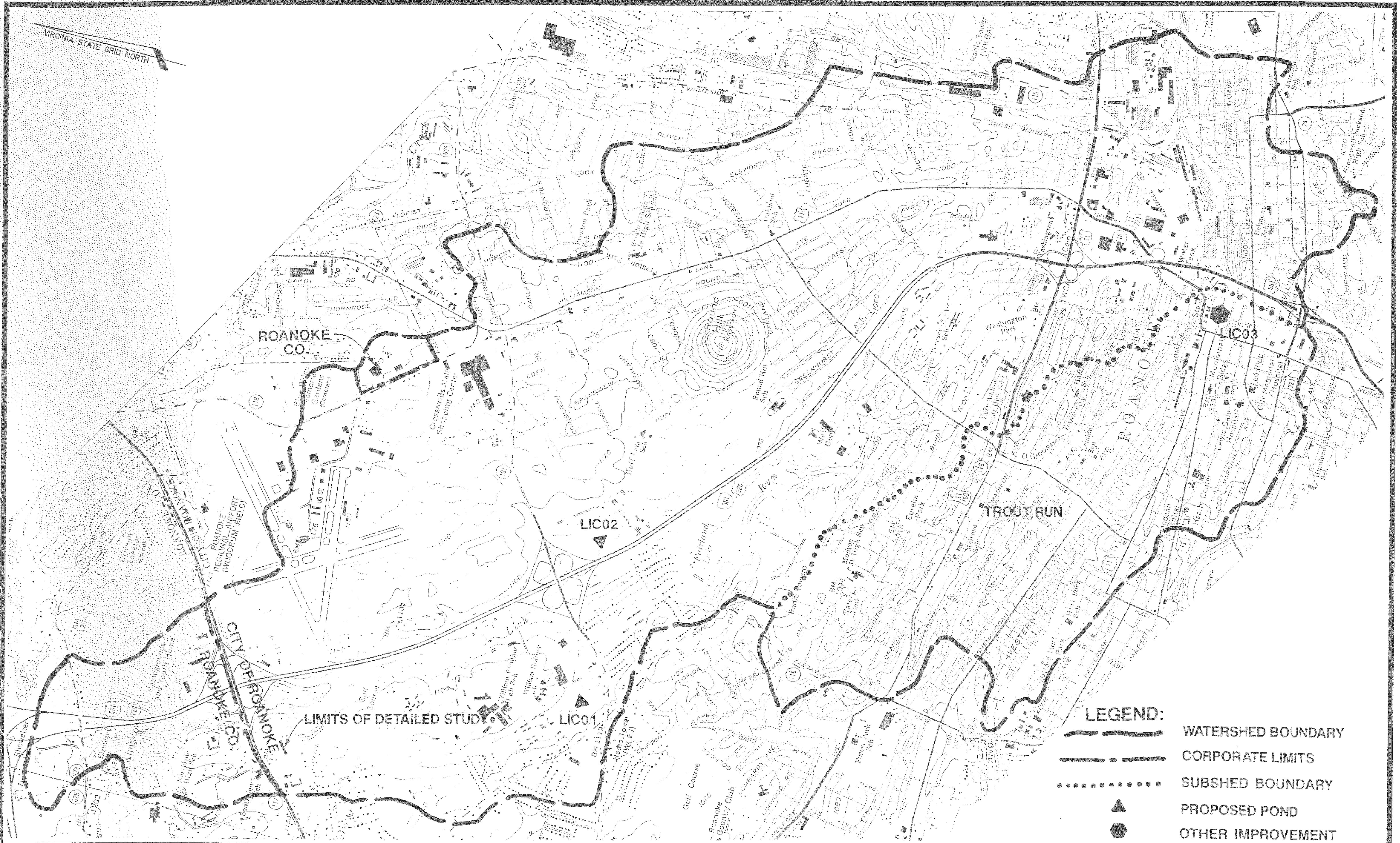
Basin Description

The Lick Run watershed is a 7.8 square mile drainage basin located primarily in north central Roanoke City with the northern portion in north central Roanoke County, Virginia. The watershed is narrow and has a length of about 5.5 miles and a maximum width of about 2 miles near its mouth. The Lick Run watershed originates at the Interstate 81/U.S. Route 11 interchange at an elevation of approximately 1200 feet above sea level and flows in a southeasterly direction for about 7.5 miles until its confluence with Tinker Creek. Lick Run and its contributing areas are shown on Figure 2.9.1.

The upstream reaches of the Lick Run watershed are primarily open space with some commercial and industrial development, while the downstream portion of the watershed is developed, consisting of subdivisions, commercial and industrial land uses and rail yards. Developed land use includes high density residential, commercial and industrial development.

A tabulation of the Lick Run drainage basin areas is presented below:

Location	Distance Above Mouth of Lick Run (feet)	Drainage Area(sq. mi.)
Mouth of Lick Run	0	8.7
Upstream from Confluence of Trout Run	13,000	6.3
State Route 101 - Hershberger Road	26,050	1.6
U.S. Route 11 - Peters Creek Road	35,000	0.3



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LICK RUN WATERSHED
LOCATION OF PROPOSED STORMWATER IMPROVEMENTS
FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.9.1

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Subbasin Description

There is one significant stream that drains the Lick Run watershed, Trout Run. Trout Run lies entirely within the City of Roanoke. The streams and related subbasins are shown in Figure 2.9.1. A tabulation of the study length and subbasin drainage area is presented below followed by a brief summary of Trout Run:

Stream	Study Length (feet)	Drainage Area (sq. mi.)
Trout Run	5,000	2.4

Trout Run originates near Washington Heights in the City of Roanoke and flows southeast to its confluence with Lick Run which is approximately 0.9 miles upstream of the confluence of Lick Run with Tinker Creek. Trout Run is a highly urbanized stream channel that is located in the southern part of the Lick Run watershed. During storm events, the flooding along Trout Run consists mainly of overland flow. The watershed is comprised of mostly industrial development, 1/4 acre residential lots and open space. Developed conditions (Year 2020) land uses consist mainly of high density residential with commercial and industrial development.

Existing Land Use Distribution

The Lick Run watershed contains thirteen existing specific land uses, but only 6 uses generally predominate: 1/4 acre residential lots, open space, industrial development, agriculture, commercial and paved areas. Approximately 25% of the watershed is comprised of 1/4 acre residential lots. Open space comprises approximately 20% of the watershed. Industrial development and agriculture each comprise approximately 15% of the watershed. Commercial development and paved areas each comprise approximately 10% of the watershed. The remaining 5% of the watershed includes residential areas of various densities, railroad yards and wooded areas.

Developed Land Use Distribution

The Lick Run watershed contains 9 developed specific land uses, but only four uses predominate: high density residential areas, industrial development, commercial areas, and open space. Approximately 50% of the developed conditions (Year 2020) watershed is comprised of high density residential areas. Industrial development comprise approximately 20% of the developed conditions (Year 2020) watershed. Commercial development comprises about 15% and open space comprises about 10% of the developed conditions (Year 2020) watershed. The remaining 5% of the watershed consists of low density residential areas, core areas of the City of Roanoke, planned development areas and woods.

Hydrology

The discharges for Lick Run and its tributaries were determined using the procedures described in Chapter 1. The area upstream of the Washington Park culvert stores a large amount of flow and is included as a storage routing in the HEC-1 model. Existing conditions discharges on Lick Run are increased at the mouth by 30% for the 2-year storm and by 15% for the 100-year storm under developed conditions (Year 2020). Discharges on Trout Run are increased by 30% for the 2-year and by 10% for the 100-year storm under developed conditions (Year 2020). Both of these increases occur because of the increase in industrial and residential development.

Flooding

History of Flooding

Much of the central business district of Roanoke is subject to flooding by Lick Run. The Williamson Road area has exhibited some of the most severe and continuing local flooding problems in the City of Roanoke. Areas upstream of Washington Park have also been subject to flooding. High water marks along Lick Run were used to verify the computed flood elevations.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Lick Run and its tributaries. No information was available about debris blockage on Lick Run or Trout Run.

Flooding Problems

Flooding problems along Lick Run and Trout Run, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem in the Lick Run watershed is overland flooding along Lick Run and Trout Run in the City of Roanoke where both streams are contained underground in the storm sewer system for the city of Roanoke.

The culverts are undersized and the 2-year storm overtops the culverts and creates a wide shallow floodplain. The overflow of the two streams tie-in together at the Williamson Road, U.S. Route 481, Norfolk & Western Railway interchange area. All of the flooding problems and possible solutions are summarized below in Table 2.9.1.

Floodplain maps and flood profiles for Lick Run and Trout Run are presented in Volume 2 of this report.

Lick Run

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Confluence with Roanoke River to U.S. Route 220 (172-6000)	Storm / # of Buildings in flood area 2-year 9 10-year 64 100-year 76	Storm / # of Buildings in flood area 2-year 27 10-year 70 100-year 78	Floodproof, relocate and/or purchase; Enlarge stream channel
Overland Flow Area at Confluence of Trout Run - see Trout Run table			
U.S. Route 220 to Patton Avenue (7000-7960)	Storm / # of Buildings in flood area 2-year 1 10-year 3 100-year 18	Same as existing	Floodproof, relocate and/or purchase; Enlarge storm sewer system
Washington Park culvert to 10th Street (12623-14683)	Storm / # of Houses in flood area 2-year 0 10-year 0 100-year 14	Storm / # of Buildings in flood area 2-year 0 10-year 2 100-year 16	Floodproof, relocate and/or purchase; Enlarge Washington Park culvert
Upstream of 10th Street (14683-15746)	Storm / # of Buildings in flood area 2-year 3 10-year 4 100-year 10	Storm / # of Buildings in flood area 2-year 3 10-year 4 100-year 13	Floodproof, relocate and/or purchase; Upstream detention

Table 2.4.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Norris Drive in Heritage Acres subdivision (19130)	Storm / # of Houses in flood area 2-year 0 10-year 3 100-year 6	Storm / # of Houses in flood area 2-year 0 10-year 4 100-year 6	Floodproof, relocate and/or purchase; Upstream detention
Brooklyn Drive in Fairland subdivision (23123-24678)	Storm / # of Houses in flood area 2-year 4 10-year 6 100-year 8	Storm / # of Houses in flood area 2-year 5 10-year 6 100-year 8	Floodproof, relocate and/or purchase; Upstream detention
Upstream of Sioux Ridge Road (34794-35009)	Storm / # of Houses in flood area 2-year 0 10-year 3 100-year 3	Storm / # of Houses in flood area 2-year 1 10-year 3 100-year 3	Floodproof, relocate and/or purchase; Upstream detention; Enlarge Sioux Ridge Road structure downstream
Road Overtopping			
Civic Center Access Road (8729)	5-year overtops road	2-year overtops road	Raise road and enlarge structure because of backwater
Orange Avenue - U.S. Routes 11/460 (10390)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road
10th Street (14591)	2-year overtops road	Same as existing	Enlarge structure and raise road because of backwater; enlarge Washington Park culvert downstream
Brooklyn Drive and Aspen Street (23739-24678)	2-year inundates road	Same as existing	Raise roads
Access Road (27679)	5-year overtops road	Same as existing	Enlarge structure and/or raise road
Frontage Road (31274)	5-year overtops road	Same as existing	Enlarge structure and/or raise road
Sioux Ridge Road (34743)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road

Trout Run

Table 2.9.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Confluence with Lick Run to Wometco Site - Roanoke Central Business District (0-2078)	Storm / # of Buildings in flood area 2-year 0 10-year 28 100-year 45	Storm / # of Buildings in flood area 2-year 0 10-year 32 100-year 47	Floodproof, relocate and/or purchase; Enlarge storm sewer system
Wometco Site to 5th Street (2078-3602)	Storm / # of Buildings in flood area 2-year 0 10-year 2 100-year 3	Same as existing	Floodproof, relocate and/or purchase; Enlarge storm sewer or bypass channel
5th Street to end of study (3602-4813)	Storm / # of Buildings in flood area 2-year 6 10-year 20 100-year 24	Storm / # of Buildings in flood area 2-year 14 10-year 23 100-year 26	Floodproof, relocate and/or purchase; Enlarge storm sewer or channel
Road Overtopping			
6th Street (4330)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road
7th Street (4799)	2-year overtops road	Same as existing	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for the major flooding problems for Lick Run and Trout Run. The areas of focus were the overland flooding areas along the culverts that contain the streams underground.

In order to reduce the flood flows at these sites several pond sites were analyzed in the Lick Run watershed. Only two of the ponds had an impact on downstream discharges. These two pond sites are summarized below and shown in Figure 2.9.1:

Site Description	Comments
LIC01 - upstream of Hershberger Road on western tributary	Pond reduces 100-year discharges by 5% at Fairland Lake and at Washington Park culvert
LIC02 - downstream of Hershberger Road Interchange east of Route 581	Pond reduces 2-year by 30% at Fairland Lake and by 20% at Washington Park culvert

The LIC02 pond has a significant impact on the 2-year discharge but has a less significant impact on less frequent storm discharges. The Washington Park culvert provides significant detention as it exists because of the small pipe size and the large storage area upstream. The ponds upstream of the Washington Park culvert have no effect downstream of this culvert because of this large detention area.

The storage area upstream of the Washington Park culvert does create a significant reduction in downstream discharges; however the backwater from the culvert does inundate some houses in the larger storm events. To prevent this flooding upstream of Washington Park, the existing culvert would have to be enlarged or a bypass channel cut to allow overland relief of the larger storms. These options were not considered feasible because of the large amount of fill over the existing culvert and because of the large amount of cut that would be needed to create a bypass channel. Additionally, these measures would result in greater flooding problems downstream in the central business district of the City of Roanoke. The most practical measure to reduce flooding upstream of Washington Park would be to floodproof or relocate the affected structures.

On both of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or relocation was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.10 MASON CREEK WATERSHED

Basin Description

The Mason Creek watershed is a 29.6 square mile drainage basin (including the Gish Branch watershed) located in north central Roanoke County, eastern Salem, and western Roanoke City. The watershed is fan shaped and has a length of about 8.5 miles and a maximum width of about 9 miles near its headwaters. The Mason Creek watershed originates on Fort Lewis Mountain near Big Bear Rock Gap at an elevation of approximately 3260 feet above sea level and flows in a northeasterly direction for about seven miles to Mason Cove where it turns and flows southeasterly approximately 7.5 miles to its confluence with the Roanoke River in the City of Salem.

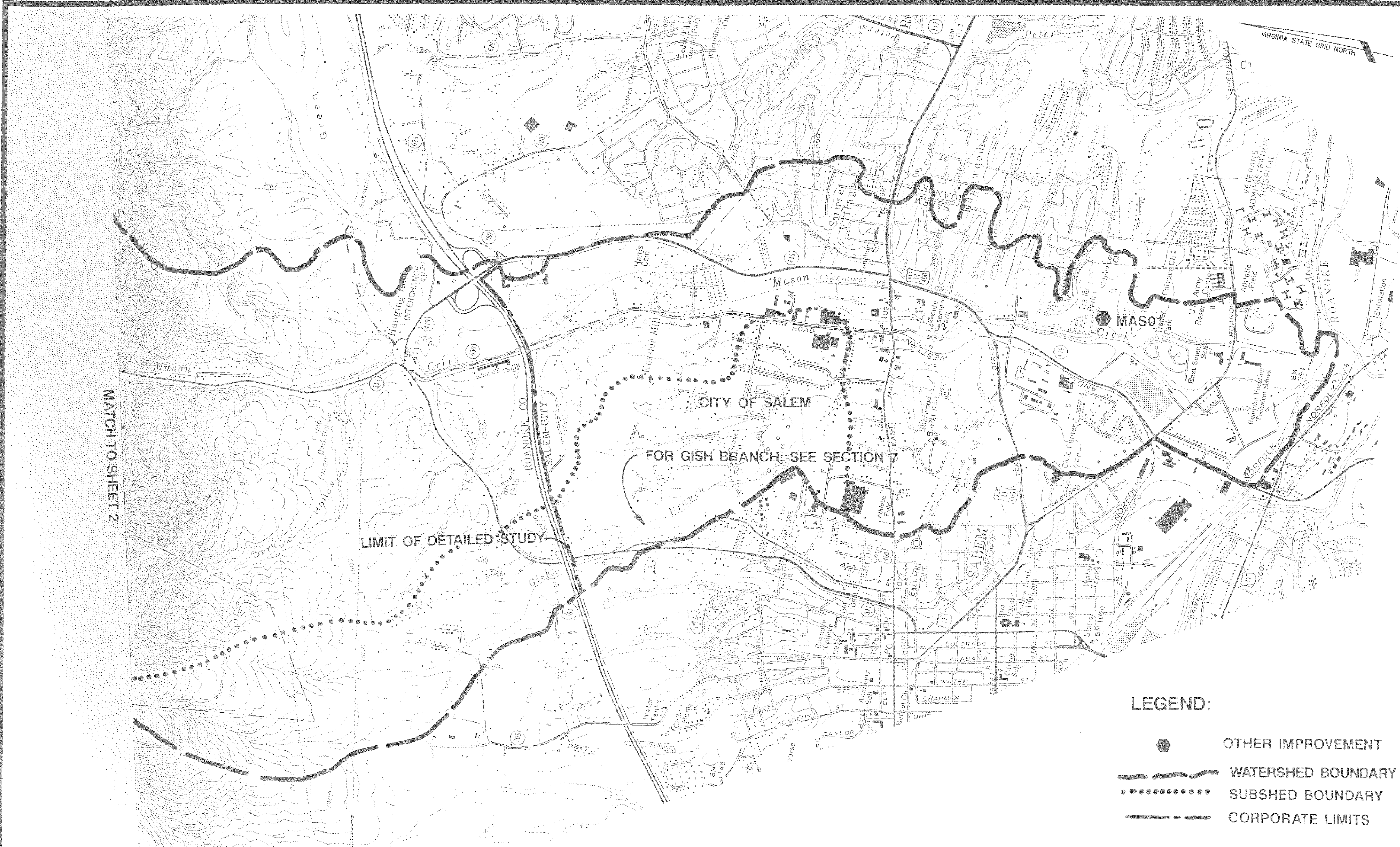
The upstream reaches of **Mason Creek** are largely undeveloped with scattered single family residences along Bradshaw Road - State Route 622. There is an a concentration of residential development along Mason Creek in Mason Cove located north of the City of Salem. Downstream of Mason Cove to Interstate 81 there is scattered residential development along Catawba Valley Drive - State Route 311. Downstream of Interstate 81, Mason Creek enters the City of Salem and there is more residential and commercial development. Future land use is planned to be mostly open space, rural preserve and rural village. Mason Creek and its contributing areas are shown in Figure 2.10.1.

A tabulation of the Mason Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Mason Creek (feet)	Drainage Area(sq. mi.)
Mouth of Mason Creek	0	29.6
Roanoke Boulevard - State Route 742	3,600	29.3
Electric Road - Alternate U.S. Routes 11/460, State Route 419	9,800	28.3
Downstream from Confluence of Gish Branch	14,100	27.5
Interstate 81	23,700	24.0
Downstream from Confluence of Jumping Run Creek	37,800	20.5
Bradshaw Road - State Route 622	61,500	7.1

Subbasin Description

There are two significant streams that drain the Mason Creek watershed, Gish Branch and Jumping Run Creek. Gish Branch is described in Section 2.7. Jumping Run Creek lies entirely within Roanoke County. The streams and related subbasins are shown in Figure 2.10.1. A tabulation of the study lengths and subbasin drainage areas is presented below followed by a brief summary of Jumping Run Creek:



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MASON CREEK WATERSHED

WATERSHED BOUNDARY

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.10.1

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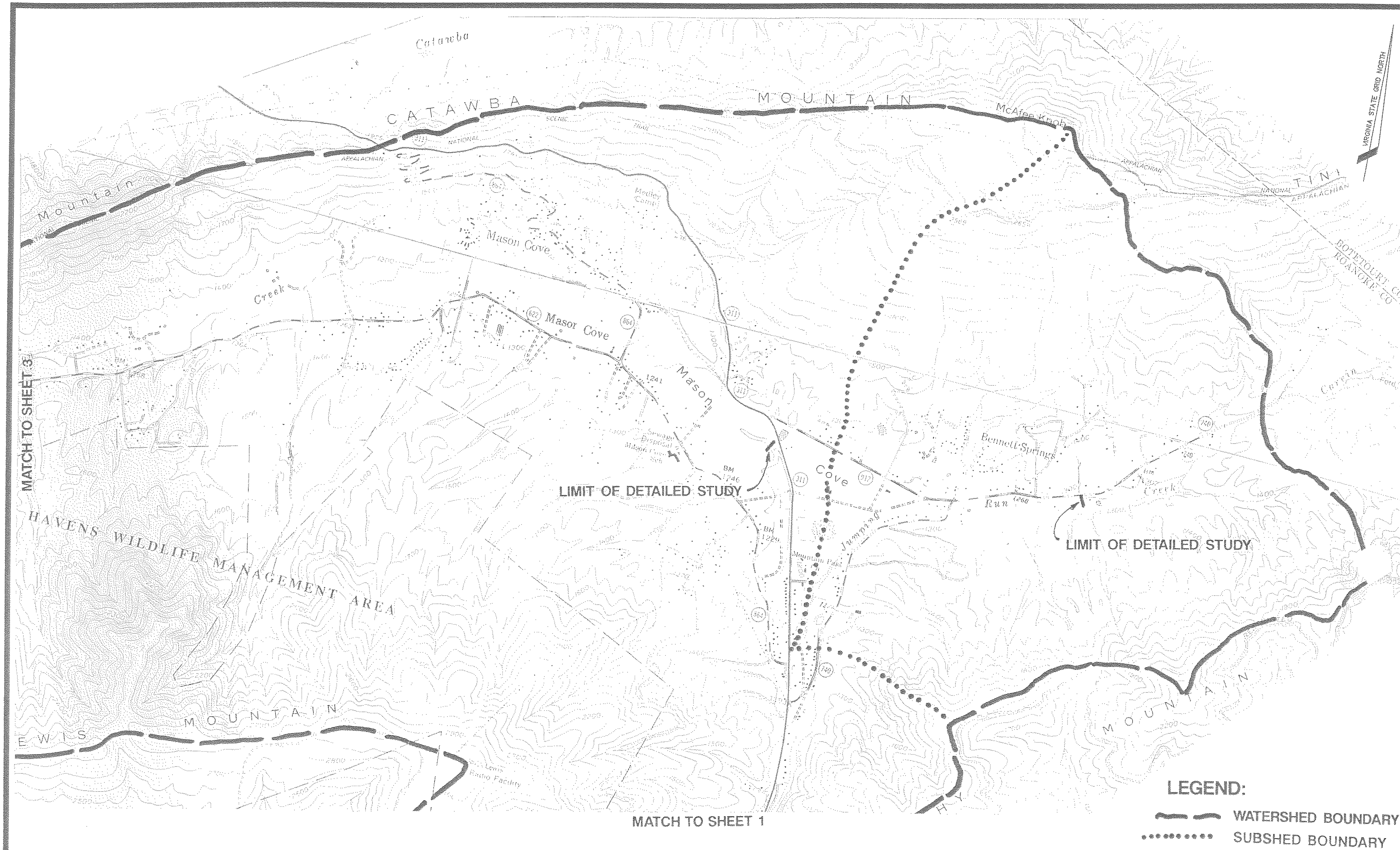


Dewberry & Davis 8401 Arlington Boulevard Fairfax, Virginia 22031 (703) 849-0100 Architects Engineers Planners Surveyors	MASON CREEK WATERSHED WATERSHED BOUNDARY FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA	ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN Figure 2.10.1 (Cont'd.)	Drawn By: GRO Date: 10/96 Checked By: TJL Date: 10/96	Scale: 1"=2000' Sheet 2 of 3

Dewberry & Davis Architects Engineers Planners Surveyors 8401 Arlington Boulevard Fairfax, Virginia 22031 (703) 849-0100	MASON CREEK WATERSHED WATERSHED BOUNDARY FIFTH PLANNING DISTRICT COMMISSION ROANOKE, VIRGINIA	ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN Figure 2.10.1 (Cont'd.)	Drawn By: GRO Date: 10/96 Checked By: TJL Date: 10/96	Scale: 1"=2000' Sheet 3 of 3

Stream	Study Length (feet)	Drainage Area (sq. mi.)
Gish Branch	9,700	2.0
Jumping Run Creek	9,300	4.0

Jumping Run Creek originates on Catawba Mountain and flows southwest to its confluence with Mason Creek which is approximately 7 miles upstream of the confluence of Mason Creek with the Roanoke River. The watershed is mostly undeveloped but has some scattered residential development along Carvin Cove Road - State Route 740, consisting mainly of 2 acre lots. Future conditions land uses consist mainly of rural preserve areas, open space, rural village areas and low density residential development.

Existing Land Use Distribution

The Mason Creek watershed contains fourteen existing specific land uses. Woods is the predominant land use, comprising approximately 80% of the watershed. Approximately 10% of the watershed is comprised of residential areas of various densities. The remaining 10% of the watershed consists of open space, commercial and agricultural areas.

Developed Land Use Distribution

The Mason Creek watershed contains fourteen developed specific land uses, but only four uses predominate: open space, rural preserve, rural village and commercial development. Approximately 35% of the developed conditions (Year 2020) watershed is comprised of open space/parks which are mostly located upstream of Interstate 81. Rural preserve areas comprise approximately 30% of the watershed and these areas are also located upstream of Interstate 81. Rural village and commercial development each comprise about 10% of the developed conditions (Year 2020) watershed. The remaining 15% of the watershed consists of low and high density residential development, planned development areas, surface water, industrial development, neighborhood conservation areas and village center areas.

Hydrology

The discharges for Mason Creek and its tributaries were determined using the procedures described in Chapter 1. The Mason Creek watershed was divided into 70 subbasins for the hydraulic model. Eight of these subbasins are in the Jumping Run Creek watershed and 15 are in the Gish Branch watershed. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Mason Creek, 2-year discharges increase by 90%, 10-year discharges increase by 45% and 100-year discharges increase by 30%. These increases are caused by the wooded watershed changing to open space, rural preserve areas and rural village areas in the upstream watershed and an increase in commercial and residential development in the downstream areas.

Discharges on Jumping Run Creek are increased by 85% for the 2-year, 40% for the 10-year and 25% for the 100-year storm under developed conditions (Year 2020). These increases are caused by the wooded watershed changing to rural preserve, open space, rural village and low density residential development.

Flooding

History of Flooding

High water marks or recorded flood flows were provided by the City of Salem for Mason Creek for several flood events. These high water marks were used to verify the computed flood elevations.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Mason Creek and its tributaries. No data on debris blockage on Mason Creek was available.

Flooding Problems

Flooding problems along Mason Creek and Jumping Run Creek, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

In the downstream portion of Mason Creek, the major flooding problems are at two trailer parks, the **Salem Village** Trailer Park and a trailer park located along **Schrader Street**. These trailer parks are subject to flooding in the 2-year storm. Another major problem in the Mason Creek watershed is in the vicinity of East Main Street where several buildings and houses are inundated by a 10-year storm including **Lakeside Plaza**. The flooding problems and possible solutions are summarized below in Table 2.10.1.

Floodplain maps and flood profiles for Mason Creek and Jumping Run Creek are presented in Volume 2 of this report.

Mason Creek

Table 2.10.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Norfolk Southern Railroad to upstream of Roanoke Boulevard - State Route 742 (1598-3474)	Storm # of Buildings in flood area 2-year 0 10-year 22 100-year 25	Storm # of Buildings in flood area 2-year 7 10-year 24 100-year 26	Enlarge railroad structure downstream; Floodproof, relocate and/or purchase
Salem Village Trailer Park (3957-5952)	Storm # of Trailers in flood area 2-year 18 10-year 130 100-year 130	Storm # of Trailers in flood area 2-year 95 10-year 130 100-year 130	Relocate trailers; Upstream detention to reduce frequency of flooding
Schrader Street Trailer Park (5952-8719)	Storm # of Trailers in flood area 2-year 4 10-year 42 100-year 94	Storm # of Trailers in flood area 2-year 30 10-year 60 100-year 100	Relocate trailers; Upstream detention to reduce frequency of flooding
Downstream of Lynchburg Turnpike - State Route 1431 to Electric Road - State Route 419 (8719-9641)	Storm # of Buildings in flood area 2-year 0 10-year 2 100-year 4	Storm # of Buildings in flood area 2-year 1 10-year 2 100-year 5	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Electric Road to downstream of East Main Street - U.S. Route 460 (9733-11268)	Storm # of Buildings in flood area 2-year 0 10-year 4 100-year 8	Storm # of Buildings in flood area 2-year 4 10-year 5 100-year 8	Floodproof, relocate and/or purchase; Enlarge structure at Electric Road; Upstream detention to reduce frequency of flooding
Schneider Drive Trailer Court (11268-12288)	Storm # of Trailers in flood area 2-year 0 10-year 8 100-year 20	Storm # of Trailers in flood area 2-year 0 10-year 13 100-year 24	Relocate trailers; Upstream detention to reduce frequency of flooding

Table 2.10.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)						Possible Solutions
	Existing Conditions			Developed Conditions			
Downstream of East Main Street to Garst Street - **Lakeside Plaza** Area (11268-17860)	Storm	# of Buildings	# of Houses in flood area	Storm	# of Buildings	# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year	3	8	2-year	14	14	
	10-year	15	23	10-year	19	46	
	100-year	19	78	100-year	22	105	
Garst Street to Interstate 81 (17860-23578)	Storm		# of Houses in flood area	Storm		# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		5	2-year		9	
	10-year		19	10-year		21	
	100-year		22	100-year		23	
Interstate 81 to North Electric Road - State Route 419 (23578-26684)	Storm		# of Buildings in flood area	Storm		# of Buildings in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		0	2-year		0	
	10-year		3	10-year		3	
	100-year		4	100-year		10	
North Electric Road to Janee Drive - State Route 765 (26684-32008)	Storm		# of Houses in flood area	Storm		# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		1	2-year		5	
	10-year		11	10-year		14	
	100-year		16	100-year		16	
Janee Drive to Carvins Cove Road - State Route 740 (32008-36474)	Storm		# of Houses in flood area	Storm		# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		9	2-year		14	
	10-year		13	10-year		15	
	100-year		13	100-year		17	
Carvins Cove Road to Catawba Valley Road - State Route 311 (36474-37934)	Storm		# of Houses in flood area	Storm		# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		0	2-year		1	
	10-year		10	10-year		13	
	100-year		21	100-year		22	
Catawba Valley Road to Plunkett Road (37934-42433)	Storm		# of Houses in flood area	Storm		# of Houses in flood area	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
	2-year		0	2-year		0	
	10-year		19	10-year		27	
	100-year		38	100-year		40	
Road Overtopping							
Roanoke Boulevard - State Route 742 (3474)	10-year overtops road			5-year overtops road			Enlarge structure and/or raise road
Lynchburg Turnpike - State Route 1431 (8914)	10-year overtops road			5-year overtops road			Enlarge structure and/or raise road
East Main Street - U.S. Route 460 (12288)	5-year overtops road			Same as existing			Raise road because of backwater

Table 2.10.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Garst Street (17860)	5-year overtops road	Same as existing	Raise road because of backwater
Epperly Lane (22253)	2-year overtops road	Same as existing	Raise road because of backwater
Dutch Oven Road - State Route 863 (26849)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road
Janee Drive - State Route 765 (32008)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road

Jumping Run Creek

Table 2.10.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Carvins Cove Road - State Route 740 (278-5764)	Storm / # of Houses in flood area 2-year 0 10-year 13 100-year 23	Storm / # of Houses in flood area 2-year 2 10-year 15 100-year 27	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Carvins Cove Road to Limit of Study (5764-9284)	Storm / # of Houses in flood area 2-year 2 10-year 4 100-year 4	Storm / # of Houses in flood area 2-year 3 10-year 4 100-year 4	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Carvins Cove Road - State Route 740 (3430)	2-year inundates road	Same as existing	Raise road; levee along stream
Carvins Cove Road - State Route 740 (5764)	5-year overtops road	Same as existing	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for the major flooding problems for Mason Creek and Jumping Run Creek. One area of focus was near **Lakeside Plaza** upstream of East Main Street, however there are flooding problems scattered throughout the studied reach of Mason Creek. The three trailer parks that are located in the Mason Creek floodplain, **Salem Village**, **Schrader Street** and Schneider Street, should be inspected to insure that the trailers are tied down appropriately and if possible, located to higher ground.

The Mason Creek watershed was analyzed to locate possible stormwater pond sites. Because the areas downstream of Interstate 81 are fairly developed, no pond sites were possible in that area. Upstream of Interstate 81, Mason Creek parallels Catawba Valley Drive - State Route 311 and Bradshaw Road - State Route 622 and has many homes adjacent to the stream. Jumping Run Creek parallels Carvins Cove Road - State Route 740 and also has many houses along the stream. Because of the proximity of the streams to these roads and houses, placement of any pond would require the relocation of the roads which would be difficult because of the steepness of the surrounding terrain. Ponds located on the small tributaries that feed to Mason Creek in the upstream watershed would have to be numerous to impact discharges in the downstream watershed where there are the most flooding problems. Pond sites were investigated on Gish Branch but these had minimal impact on discharges on Mason Creek.

Since no viable pond sites were located, the best mitigation measure on this stream is to perform floodproofing and to develop a flood hazard warning system. On both of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or relocation was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.11 Mudlick Creek Watershed

Basin Description

The Mudlick Creek watershed is a 9.6 square mile drainage basin located in east central Roanoke County and southeast Roanoke City. It lies wholly within Roanoke County and the City of Roanoke. The watershed is fan shaped and has a length of about 4.5 miles and a maximum width of about 3.5 miles near its headwaters. The Mudlick Creek basin originates on Long Ridge near Poor Mountain at an elevation of approximately 2300 feet above sea level and flows in a southeasterly direction for about 1.7 miles and then flows northeasterly for about 4.5 miles until its confluence with the Roanoke River in Roanoke.

The main stem of **Mudlick Creek** serves as the political boundary between the City of Roanoke and Roanoke County for a portion of its length. The upstream reaches of Mudlick Creek are largely undeveloped with scattered single family residences along VA Route 689. Areas along the main stem of Mudlick Creek are relatively undeveloped until Farmington Drive. Downstream of Farmington Drive the land use along Mudlick Creek is primarily residential with some scattered commercial development. Developed land use is planned to be primarily high density residential development and rural villages with some commercial and lower density residential development.

A tabulation of the Mudlick Creek Drainage basin areas is presented below:

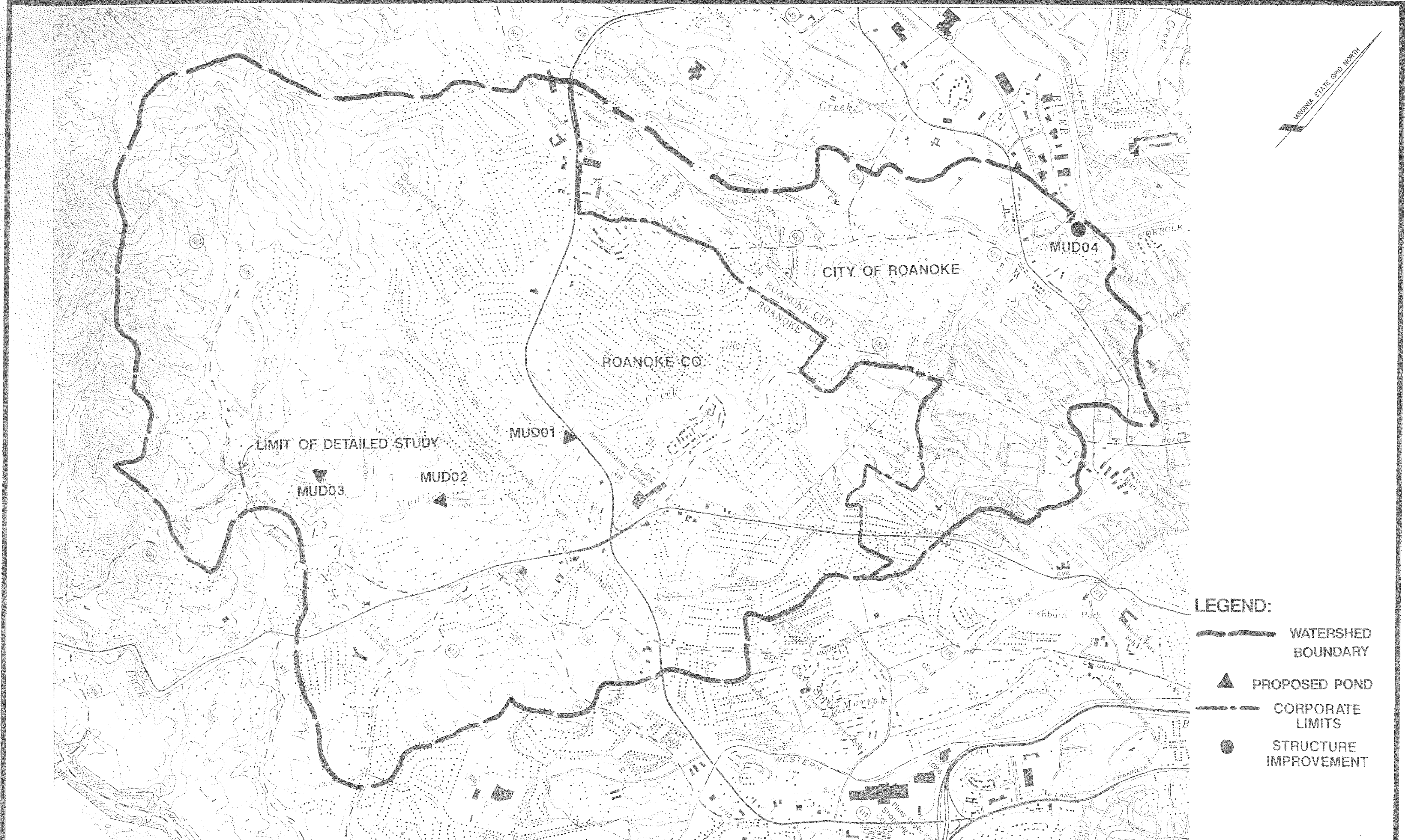
Location	Distance Above Mouth of Mudlick Creek (feet)	Drainage Area (sq. mi.)
Mouth of Mudlick Creek	0	9.6
Downstream from Confluence of Murdock Creek	2,000	9.4
Halevan Road	15,100	6.4
Downstream from Confluence of West Mudlick Creek	18,900	5.3
VA Route 419	20,900	4.2

Subbasin Description

There are two significant streams that drains to the Mudlick Creek watershed, West Mudlick Creek and Murdock Creek. West Mudlick Creek lies entirely within Roanoke County and Murdock Creek is mostly located in the City of Roanoke with the very upstream area in Roanoke County. The streams and related subbasins are shown in Figure 2.11.1. Listed below is a brief summary of the Mudlick Creek tributaries. A tabulation of the subbasin drainage areas is presented below:

Location	Drainage Area at Mouth (sq. mi.)
West Mudlick Creek	1.0
Murdock Creek	0.8

West Mudlick Creek is located in the western portion of the Mudlick Creek watershed. It converges with Mudlick Creek approximately 1800 feet downstream of VA Route 419. The West Mudlick Creek watershed is undeveloped in



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MUDLICK CKEEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.11.1

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1"=2000'
Sheet 1 of 1

the upstream portion and has mainly residential development in the downstream areas. There is an area of commercial development in the center of the watershed just upstream of VA Route 419. The future land use in the West Mudlick Creek subbasin is planned for high density residential, neighborhood preservation areas and rural villages.

Murdock Creek is located in the northwestern portion of the Mudlick Creek watershed. It converges with Mudlick Creek approximately 2000 feet upstream of the confluence of Mudlick Creek with the Roanoke River. The Murdock Creek watershed is mostly developed with residential areas with some commercial areas in the upstream portion of the watershed. Future planned land uses are the same as existing, since the watershed is mostly developed.

Existing Land Use Distribution

The Mudlick Creek watershed contains thirteen existing specific land uses, but only 5 uses generally predominate: woods, agriculture, 1/3 and 1/4 acre residential and commercial. Approximately 25% of the watershed is comprised of wooded areas and 50% is 1/4 acre residential lots. Agricultural, commercial and 1/3 acre residential each comprise about 5% of the watershed. The remaining 10% of the watershed consists of the other 8 land uses which include pasture, brush, open space, paved areas, and 1/8-, 1/2-, 1-, and 2-acre residential areas.

Developed Land Use Distribution

The Mudlick Creek watershed contains 11 developed specific land uses, but only four uses predominate: high density residential, rural village, medium density residential and commercial. Approximately 50% of the developed conditions (Year 2020) watershed is comprised of high density residential areas. Areas planned to be part of the Back Creek rural village comprise approximately 15% of the future conditions watershed. Commercial and medium density residential development each comprise about 10% of the future watershed. The remaining 15% of the watershed consists of neighborhood preservation areas, low density residential development, woods and open space.

Hydrology

The Mudlick Creek watershed was divided into 14 subbasins for the hydrologic analysis. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Mudlick Creek, 2-year discharges increase by 50%, 10-year discharges increase by 30% and 100-year discharges increase by 20% under developed conditions (Year 2020). These increases are due to the increase in residential and commercial development.

Flooding

History of Flooding

The "Feasibility Study for a Roanoke Valley Comprehensive Stormwater Management Program", prepared by CDM in May 1985 states that local drainage problems in the vicinity of South Park Circle included streambank erosion, exposed sewers, and collapsing foundations. These local problems were attributed to development in the watershed without appropriate stormwater controls. High water marks and recorded flood flows were not available for Mudlick Creek.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Mudlick Creek. No information on debris blockage of structures on Mudlick Creek was available.

Flooding Problems

Flooding problems along Mudlick Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval. Buildings located in the floodplain were identified as well as overtopped roads.

There are several areas of house flooding on Mudlick Creek which are scattered along the stream. The major flooding areas on Mudlick Creek are located downstream of **Brandon** Avenue, downstream of Grandin Road in the **Westhampton/Rosalind Hills** subdivisions and along **South Park Circle** in the Southwoods subdivision. There are approximately 60 houses in the 100-year floodplain of Mudlick Creek of which 40 are also inundated by the 10-year storm. Table 2.11.1 summarizes the flooding problems which were found in the Mudlick Creek watershed.

Table 2.11.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Norfolk & Western Railroad to **Brandon** Avenue - U.S. Route 11 (760-1989)	Storm # of Houses in flood area 2-year 0 10-year 6 100-year 9	Storm # of Houses in flood area 2-year 1 10-year 6 100-year 9	Enlarge Railroad structure downstream; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Mudlick Road to Grandin Road - **Rosalind Hills/Westhampton** subdivisions (2937-7880)	Storm # of Houses in flood area 2-year 0 10-year 3 100-year 10	Storm # of Houses in flood area 2-year 0 10-year 8 100-year 13	Levee around cul-de-sac in Rosalind Hills; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Grandin Road to Garst Mill Road - Windsor Park subdivision (7880-10815)	Storm # of Houses in flood area 2-year 0 10-year 5 100-year 6	Storm # of Houses in flood area 2-year 0 10-year 5 100-year 10	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Garst Mill Rd. To South Park Circle (10815-13763)	Storm # of Houses in flood area 2-year 0 10-year 4 100-year 7	Storm # of Houses in flood area 2-year 0 10-year 6 100-year 10	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
South Park Circle in Southwoods Subdivision (13763-14601)	Storm # of Houses in flood area 2-year 0 10-year 10 100-year 14	Storm # of Houses in flood area 2-year 0 10-year 13 100-year 14	Levee along Mudlick to prevent backwater; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
South Park Circle to Halevan Rd. (14601-15340)	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 2	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Halevan Road to Crest Hill Dr. (15340-18885)	Storm # of Houses in flood area 2-year 0 10-year 0 100-year 1	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Crest Hill Dr. to Electric Road - Cresthill Subdivision (18936-19386)	Storm # of Houses in flood area 2-year 1 10-year 5 100-year 6	Storm # of Houses in flood area 2-year 1 10-year 5 100-year 8	Enlarge Crest Hill Dr. structure downstream; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.11.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
McVitty Rd to Farmington Drive (22107-24548)	Storm / # of Houses in flood area 2-year 0 10-year 2 100-year 2	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Farmington Drive to Canter Road (24548-27478)	Storm / # of Houses in flood area 2-year 0 10-year 1 100-year 1	Same as existing	Enlarge Farmington Drive structure downstream; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Canter Rd to Limit of Study - Canterbury Park Subdivision (27478-31077)	Storm / # of Houses in flood area 2-year 0 10-year 1 100-year 2	Storm / # of Houses in flood area 2-year 1 10-year 2 100-year 3	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Edgewood Road adjacent to Mudlick Creek (1255-1989)	10-year inundates road	Same as existing	Enlarge railroad structure downstream; build levee along stream; raise road
Brandon Ave. - U.S. Route 11 (1989)	10-year overtops road	5-year overtops road	Enlarge railroad structure downstream; Enlarge structure and/or raise road
Mudlick Road (2222)	5-year overtops road	Same as existing	Enlarge structure and/or raise road
Grandin Road - Route 686 (7880)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Halevan Road - Route 1361 (15340)	2-year overtops road	Same as existing	Enlarge structure and/or raise road
Halevan Rd. adjacent to Mudlick Cr. (15380-16936)	10-year inundates road	Same as existing	Raise road
Crest Hill Dr. - Route 1658 (18885)	2-year overtops road	Same as existing	Enlarge structure and/or raise road
McVitty Rd (21826)	10-year overtops road	Same as existing	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Upstream detention was analyzed as an alternative to reduce flooding along Mudlick Creek, especially at the major flooding problems located downstream of **Brandon** Avenue, at the **Rosalind Hills/Westhampton** subdivisions, and at **South Park Circle** in the Southwoods subdivision. In order to reduce flooding on Mudlick Creek, four stormwater management pond sites were investigated and three of these were analyzed in the hydrologic model. The pond sites investigated are summarized below and shown in Figure 2.11.1.

Site Description	Comments
Site A - Approximately 1500' upstream of Halevan Road near the Windsor West subdivision	Pond would inundate several homes in Windsor West and would cause backwater problems at Crest Hill Drive - NOT ANALYZED
MUD01 - upstream of Electric Road	Reduces 2-, 10- and 100-year discharges by approximately 70%, 60%, 30% at Electric Road, 25%, 30% and 35% at South Park Circle and Rosalind Hills and 10%, 15% and 20% at the mouth, respectively. Dam would require a state permit and relocation of a portion of McVitty Road and 2 houses.
MUD02 - approximately 800' upstream of Farmington Drive	At Electric Road, reduces 2-, 10- and 100-year discharges by 5%, 20% and 30%, respectively. At South Park Circle and Rosalind Hills, reduces 10- and 100-year by 5% and 10%, respectively. At mouth, reduces 100-year by 5%. Dam would need a state permit.
MUD03 - approximately 700' upstream of Canter Road	At Electric Road, reduces 2-, 10- and 100-year discharges by approximately 5%, 15% and 5%, respectively. At South Park Circle and Rosalind Hills, reduces 100-year by approximately 5%. The pond has no impact on discharges at the mouth.
MUD01 & MUD02	At Electric Road, 2-, and 10- year discharges are reduced by approximately 70% and 100-year discharges are reduced approximately 60%. Downstream of Electric Road reductions are the same as MUD01 alone.
MUD01 & MUD03	Discharges at Electric Road are reduced a little more than MUD01 alone and further downstream reductions are the same as MUD01 alone.
MUD02 & MUD03	Reductions are the same as MUD02 alone.
MUD01, MUD02 & MUD03	Reductions are the same as MUD01 & MUD02.

MUD01 at Electric Road provides the most downstream reduction in discharges on this stream, however it would require coordination with VDOT and the DSWC and the relocation of a portion of McVitty road which crosses Mudlick Creek just upstream of Electric Road. MUD02 and MUD03 do not provide much flood protection to justify their expense.

On Mudlick Creek there are other areas of scattered structures subject to flooding for which floodproofing was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size. These road crossings can be replaced or raised based on their usage and severity of flooding.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.12 MURRAY RUN WATERSHED

Basin Description

The Murray Run watershed is a 2.9 square mile drainage basin mostly located in south central Roanoke County and southeast Roanoke City. It lies wholly within Roanoke County and the City of Roanoke. The watershed is oblong and has a length of about 4 miles and a maximum width of about 1 miles near its center. The Murray Run watershed originates south of Roanoke and north of Starkey at an elevation of approximately 1400 feet above sea level and flows in a northeasterly direction for about four miles to its confluence with the Roanoke River in Roanoke. Murray Run and its contributing areas are shown in Figure 2.12.1.

Murray Run flows through Roanoke County until it reaches Ogden Road - State Route 681 where it enters the City of Roanoke. The Murray Run watershed is mostly developed with residential subdivisions, a few of the larger areas are Alsom Park, Green Valley, Fralen Park and Lakewood. There are scattered wooded and open space areas. There is also a concentration of commercial development along the Roy L. Webber Expressway - U.S. Route 220 and Electric Road - State Route 419. The developed land use conditions in the watershed are primarily high density residential development with parks and commercial areas.

A tabulation of the Murray Run Drainage basin areas is presented below:

Location	Distance Above Mouth of Murray Run (feet)	Drainage Area (sq. mi.)
Mouth of Murray Run	0	2.9
U. S. Route 221 - Brambleton Avenue - Downstream Crossing	4,000	2.3
U. S. Route 221 - Brambleton Avenue - Upstream Crossing	8,400	1.9
State Route 720 - Colonial Avenue	12,000	1.4
State Route 419 - Electric Road	19,000	0.5

Existing Land Use Distribution

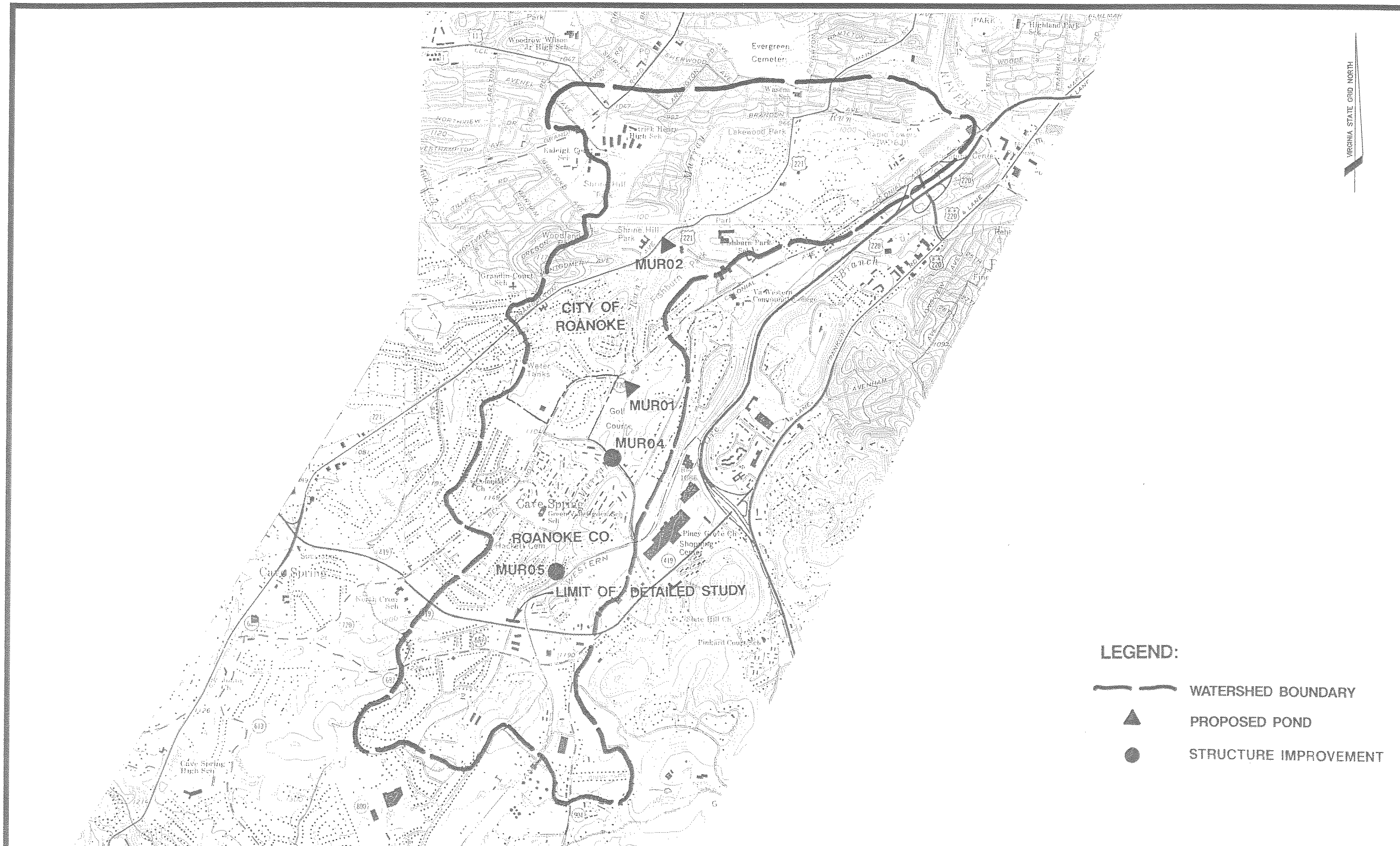
The Murray Run watershed contains ten existing specific land uses, but 6 uses generally predominate: 1/4, 1/3 and 1/8 acre residential lots, woods, open space and commercial development. Approximately 40% of the watershed is comprised of 1/4 acre residential lots. The 1/3 acre and 1/8 acre residential lots, woods, open space and commercial development each comprise about 10% of the watershed. The remaining 10% of the watershed consists of industrial development, paved areas, ½ acre residential lots and brush.

Developed Land Use Distribution

The Murray Run watershed contains 10 developed specific land uses, but only three uses predominate: high density residential development, open space and commercial development. Approximately 60% of the developed conditions (Year 2020) watershed is planned to be high density residential areas. Parks/open space and commercial development each comprise about 10% of the developed conditions (Year 2020) watershed. The remaining 20% of the watershed consists of industrial areas, planned development areas, neighborhood conservation zones and woods.

Hydrology

The Murray Run watershed was divided into 6 subbasins for the hydrologic analysis. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Murray Run, 2-year discharges increase by 45%, 10-year discharges increase by 30% and 100-year discharges increase by 20% under developed conditions (Year 2020). These increases are due to the increase in high density residential areas and planned development areas.



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MURRAY RUN WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.12.1

Drawn By: GRO Date: 10/96
Checked By: TJL Date: 10/96

Scale: 1" = 2000'

Sheet 1 of 1

Flooding

History of Flooding

High water marks and measured flood flows were not available for Murray Run.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Murray Run. No data on debris blockage potentials for structures along Murray Run was available.

Flooding Problems

Flooding problems along Murray Run for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

One of the major flooding problems on Murray Run is upstream of **Brandon Avenue** where 17 houses are in the 100-year floodplain including 13 that are inundated by a 10-year storm. Another is located both upstream and downstream of West Road in the **Lakewood** subdivision where 12 houses are in the 100-year floodplain including 10 that are inundated by a 10-year storm. Several of the **Pebble Creek Apartments** located upstream of Ogden Road are also located in the 10 and 100-year floodplain. Upstream of Crawford Road in the **Green Valley** subdivision 5 houses are flooded by an 100-year storm and 4 of these are also flooded by a 10-year storm. The flooding problems and possible solutions for Murray Run are summarized in Table 2.12.1:

Floodplain maps and flood profiles for Murray Run are presented in Volume 2 of this report.

Table 2.12.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

<table>
<tr><th rowspan="2">Location
(HEC-2 X-section)</th><th colspan="2">Problem(s)</th><th rowspan="2">Possible Solutions</th></tr>
<tr><th>Existing
Conditions</th><th>Developed
Conditions</th></tr>
<tr><td colspan="4">Building/House Flooding</td></tr>
<tr><td>Mouth to Brambleton Avenue (downstream crossing) - Brandon Avenue area (587-3788)</td><td>Storm # of Buildings in flood area
2-year 3
10-year 14
100-year 21</td><td>Storm # of Buildings in flood area
2-year 4
10-year 17
100-year 22</td><td>Floodproof and/or relocate, for buildings upstream of Brandon Avenue enlarging Brandon Avenue structure will reduce flood depths, levee is possible upstream of Brandon Avenue; Upstream detention to reduce frequency of flooding</td></tr>
<tr><td>Lakewood Subdivision - near West Road (5792-7221)</td><td>Storm # of Houses in flood area
2-year 1
10-year 10
100-year 12</td><td>Storm # of Houses in flood area
2-year 2
10-year 12
100-year 12</td><td>Downstream of West Road floodproof and/or relocate. Upstream of West Road enlarge West Road structure, floodproof and/or relocate; Upstream detention to reduce frequency of flooding</td></tr>
<tr><td>Downstream of Brambleton Avenue, upstream crossing to Colonial Avenue (7971-12128)</td><td>Storm # of Houses in flood area
2-year 1
10-year 1
100-year 3</td><td>Storm # of Houses in flood area
2-year 1
10-year 2
100-year 3</td><td>Enlarge private drive structure downstream, relocate and/or floodproof; Upstream detention to reduce frequency of flooding</td></tr>
<tr><td>Pebble Creek Apartments - upstream of Ogden Road - State Route 681 (14936-16026)</td><td>Storm # of Buildings in flood area
2-year 2
10-year 9
100-year 10</td><td>Storm # of Buildings in flood area
2-year 2
10-year 9
100-year 11</td><td>Enlarge Ogden Road structure downstream, Floodproof ad/or relocate; Upstream detention to reduce frequency of flooding</td></tr>
<tr><td>Green Valley Subdivision, downstream & upstream of Crawford Road (17158-18445)</td><td>Storm # of Buildings in flood area
2-year 1
10-year 4
100-year 7</td><td>Storm # of Buildings in flood area
2-year 2
10-year 5
100-year 9</td><td>Downstream of Crawford Road floodproof and/.or relocate. Upstream of Crawford Road enlarge Crawford Road structure, floodproof and/or relocate; Upstream detention to reduce frequency of flooding.</td></tr>
<tr><td colspan="4">Road Overtopping</td></tr>
<tr><td>Brandon Avenue (1130)</td><td>5-year overtops road</td><td>Same as existing</td><td>Enlarge structure, raise road</td></tr>
<tr><td>Brambleton Avenue - U.S. Route 221, downstream crossing (4098)</td><td>10-year overtops road</td><td>5-year overtops road</td><td>Enlarge structure, raise road</td></tr>
<tr><td>Brandon Avenue upstream of Brambleton (4136-4596)</td><td>None</td><td>10-year floods road</td><td>Raise road</td></tr>
<tr><td>West Road (6714)</td><td>2-year overtops road</td><td>Same as existing</td><td>Raise road because of backwater, enlarge structure</td></tr>
<tr><td>Brambleton Avenue - U.S. Route 221, upstream crossing (8449)</td><td>2-year overtops road</td><td>Same as existing</td><td>Raise road because of backwater, enlarge structure</td></tr>
<tr><td>Colonial Avenue - State Route 720 (12184)</td><td>10-year overtops road</td><td>5-year overtops road</td><td>Enlarge structure, raise road</td></tr>
<tr><td>Ogden Road - State Route 681 (14795)</td><td>2-year overtops road</td><td>Same as existing</td><td>Enlarge Structure</td></tr>
</table>

Table 2.12.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Crawford Road (18037)	2-year overtops road	Same as existing	Enlarge structure

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for Murray Run. The existing conditions 100-year storm floods about 50 homes along Murray Run including 40 which are inundated by a 10-year storm. With developed conditions (Year 2020) discharges, 60 homes are flooded by the 100-year storm and 45 of these are also flooded by a 10-year storm. The major flooding areas are located upstream of **Brandon** Avenue, near West Road in the **Lakewood** subdivision, at the **Pebble Creek** Apartments upstream of Ogden Road and in the **Green Valley** subdivision near Crawford Road. In order to reduce the flood flows at these locations several pond sites were analyzed in the Murray Run watershed. These pond sites are tabulated below:

Possible Pond Sites to Mitigate Flooding on Murray Run

Site Description	Comments
Site A - Upstream of Electric Road - State Route 419	No feasible pond sites were found in this area upstream of the Green Valley subdivision and Pebble Creek Apartments because of the developed nature of this watershed.
Site B - Upstream of the downstream Brambleton Road crossing in Lakewood Park	A pond in this area would require the raising of Brandon Road along the north side of the pond and could also impact upstream buildings therefore a pond in this area was NOT ANALYZED further
MUR01 - Upstream of Colonial Avenue in Jefferson Park	This pond reduces the 2-year discharges by approximately 30% at Lakewood and 15% at Brandon Avenue. The 10- and 100-year discharges are reduced by approximately 20% at Lakewood and 5% at Brandon Avenue.
MUR02 - Upstream of the upstream Brambleton Avenue crossing in Fishburn Park	This pond reduces 2- and 10-year flows by approximately 40% at Lakewood and 20-25% at Brandon Avenue. 100-year discharges are reduced by approximately 10% at Lakewood and 25% at Brandon Avenue.
MUR01 & MUR02	These ponds reduce all discharges at Lakewood by approximately 50%. At Brandon Avenue, the discharges are reduced by 25-35%.

Either pond is a good location for flood detention and will reduce the flooding frequency in the **Lakewood** subdivision and upstream of **Brandon Avenue**, but MUR02 provides greater downstream benefits than MUR01. A combination of both ponds does not provide enough additional benefit to justify the expense.

The flooding upstream of the proposed pond at the **Pebble Creek** Apartments and in the **Green Valley** Subdivision can be reduced enlarging the structures at Ogden and Crawford Roads but some of the buildings will still have to be floodproofed, relocated or purchased.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.13 Ore Branch Watershed

Basin Description

The Ore Branch watershed is a 4.1 square mile drainage basin mostly located in south central Roanoke County and south central Roanoke City. It lies wholly within Roanoke County and the City of Roanoke. The watershed is fan shaped and has a length of about 3.5 miles and a maximum width of about 2 miles near its center. The Ore Branch watershed originates south of Roanoke near Chestnut Ridge at an elevation of approximately 1700 feet above sea level and flows in a northeasterly direction for about 2.5 miles to its confluence with the Roanoke River in Roanoke. The stream and its contributing areas are shown in Figure 2.13.1.

Ore Branch flows from south of the Tanglewood Mall northeast to its confluence with the Roanoke River. The Ore Branch watershed is a combination of woods, commercial development and residential subdivisions of various densities. Some of the subdivisions located in the Ore Branch watershed are Hunting Hills, Southern Hills and Prospect Park. There are scattered wooded and open space areas located mostly in the upstream areas. There is also a concentration of commercial development along the Electric Road - State Route 419 and the Roy L. Webber Expressway - U.S. Route 220. The developed land use conditions in the watershed are primarily high density residential development with open space and commercial areas.

A tabulation of the Ore Branch Drainage basin areas is presented below:

Location	Distance Above Mouth of Ore Branch (feet)	Drainage Area (sq. mi.)
Mouth of Ore Branch	0	4.1
Monju Street	2,900	3.8
Downstream from Confluence of Ore Branch Tributary	11,300	2.6

Subbasin Description

The Ore Branch Tributary is the only significant tributary that drains the Ore Branch watershed. This tributary is located in the southeast part of the Ore Branch watershed. It converges with Ore Branch approximately 2 miles upstream of the confluence of Ore Branch with the Roanoke River near the Tanglewood Mall. The Ore Branch tributary drains about half of the Ore Branch watershed, 2 square miles. The Ore Branch Tributary watershed is more wooded than the rest of the Ore Branch watershed and also has residential development of various densities and commercial development. The developed conditions (Year 2020) in the Ore Branch Tributary watershed consists mostly of high density residential with open space, commercial development and neighborhood conservation areas.

Existing Land Use Distribution

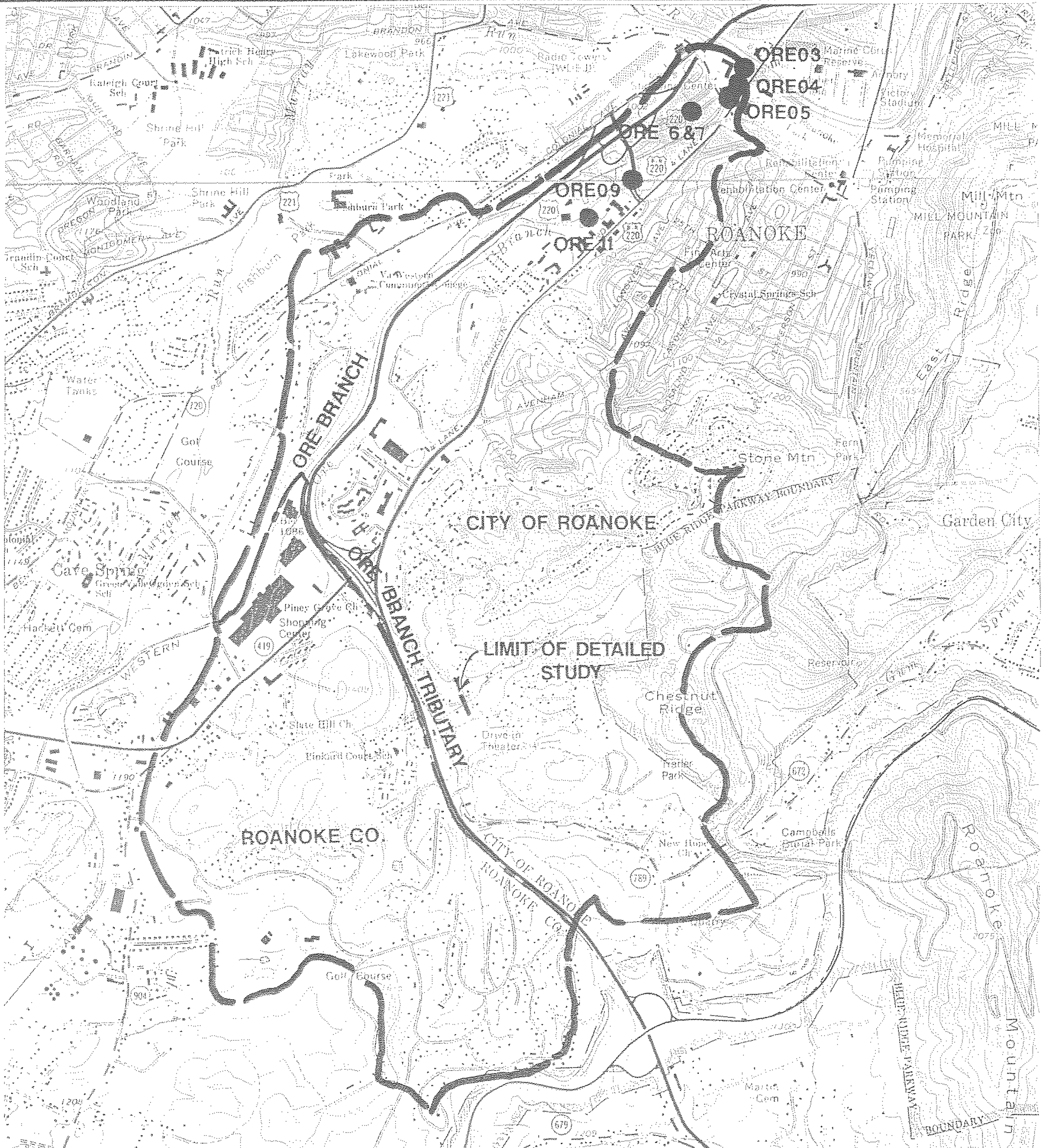
The Ore Branch watershed contains fourteen existing specific land uses, but four uses generally predominate: woods, commercial development, 1/4 and 1/2 acre residential lots. Approximately 30% of the watershed is comprised of wooded areas. Commercial areas comprise approximately 20% of the watershed. 1/4 acre lots and 1/2 acre residential lots each comprise approximately 15% of the watershed. 1/8 acre residential lots, 1/3 acre residential lots and paved areas each comprise approximately 5% of the watershed. The remaining 5% of the watershed consists of open space and 1 acre lots.

Developed Land Use Distribution

The Ore Branch watershed contains eleven developed specific land uses, but only five uses predominate: high density residential development, commercial development, open space, neighborhood conservation areas and development areas. Approximately 45% of the developed conditions (Year 2020) watershed is planned to be high density residential areas. Commercial development comprises approximately 20% of the developed conditions (Year 2020) watershed. Parks/open space comprises about 15% of the developed conditions (Year 2020) watershed. Approximately 10% of the watershed is planned to be neighborhood conservation areas and 5% is planned development areas. The remaining 5% of the watershed consists of woods and low and medium density residential areas.

Hydrology

The Ore Branch watershed was divided into 8 subbasins for the hydrologic analysis. Four of these subbasins cover the Ore Branch Tributary. No substantial storage areas are located on the stream therefore no reservoir routings are included in the model. At the mouth of Ore Branch, 2-year discharges increase by approximately 20%, 10-year



VIRGINIA STATE GRID NORTH

LEGEND:

- WATERSHED BOUNDARY
- STRUCTURE IMPROVEMENT
- CORPORATE LIMITS

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ORE BRANCH WATERSHED

WATERSHED BOUNDARY

FIFTH PLANNING DISTRICT COMMISSION — ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.13.1

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Scale: 1"=2000'
Sheet 1 of 1

discharges increase by approximately 15% and 100-year discharges increase by approximately 10% under developed conditions (Year 2020). These increases are due to the increase in high density residential areas and planned development areas.

Flooding

History of Flooding

High water marks and measured flood flows were not available for Ore Branch.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Ore Branch. No data on debris blockage potentials for structures along Ore Branch was available.

Flooding Problems

Flooding problems along Ore Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. The flooding problems and possible solutions for Ore Branch are summarized in Table 2.13.1:

Floodplain maps and flood profiles for Ore Branch are presented in Volume 2 of this report.

Table 2.13.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Brandon Avenue (7-750)	Storm # of Buildings in flood area 2-year 3 10-year 10 100-year 10	Storm # of Buildings in flood area 2-year 5 10-year 10 100-year 10	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Brandon Avenue to Wonju Street (750-2900)	Storm # of Buildings in flood area 2-year 15 10-year 21 100-year 29	Storm # of Buildings in flood area 2-year 17 10-year 21 100-year 29	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Wonju Street to upstream of Recycling Yard (750-5006)	Storm # of Buildings in flood area 2-year 4 10-year 6 100-year 14	Storm # of Buildings in flood area 2-year 5 10-year 6 100-year 14	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.13.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Electric Road to Limit of Study (12882-16015)	Storm / # of Buildings in flood area 2-year 0 10-year 3 100-year 9	Storm / # of Buildings in flood area 2-year 0 10-year 3 100-year 9	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Wiley Drive (16-44)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Holiday Inn Bridge (180-250)	5-year overtops road	2-year overtops road	Raise road because of backwater and enlarge structure
Brandon Avenue (724-827)	2-year overtops road	Same as existing	Raise road because of backwater and enlarge structure
Building Over Ore Branch (1529-1589)	5-year overtops road	Same as existing	Enlarge structure and/or raise building
Holdrens Warehouse, Downstream (1815-1845)	2-year overtops road	Same as existing	Enlarge structure and/or raise road
Holdrens Warehouse, Upstream (2130-2166)	5-year overtops road	2-year overtops road	Raise road because of backwater and enlarge structure
Private Lumber Company (2478-2499)	2-year overtops road	Same as existing	Raise road because of backwater and enlarge structure
Wonju Street (2823-2966)	10-year overtops road	Same as existing	Enlarge structure and/or raise road
Broadway Avenue (3136-3166)	2-year overtops road	Same as existing	Raise road because of backwater and enlarge structure
Parking Lot Culvert (3278-3582)	2-year overtops road	Same as existing	Enlarge structure
Recycling Yard Culvert (4173-4953)	2-year overtops road	Same as existing	Enlarge structure

Flood Hazard Mitigation Measures

The major flooding problem in the Ore Branch watershed is downstream of the recycling yard near the confluence of Ore Branch with the Roanoke River. This area is developed with commercial/industrial buildings. Approximately 50 of these buildings are flooded by a 100-year storm, of which 40 are also flooded by a 10-year storm and 20 by a 2-year storm. Several pond sites were analyzed in the upstream portion of the watershed to reduce flows in this area. These pond sites are tabulated below:

Possible Pond Sites to Mitigate Flooding on Ore Branch

Site Description	Comments
ORE01 - upstream of Crossbow Circle	Pond in this area only reduces discharges at mouth by 1%
ORE02 - upstream of end of Southern Hills Drive	Pond in this area only reduces discharges at mouth by 1-2%

Although these ponds are in the best pond locations in the watershed, they do not impact discharges in the problem area near the mouth of Ore Branch. Therefore, these ponds are not recommended for this watershed. There are no other pond locations closer to the flooding problem because the watershed is steep and the stream is narrow and follows the Roy L. Webber Expressway for a significant portion of its length.

Increasing the stream crossing sizes throughout this downstream area would reduce the frequency of flooding of some of the buildings, but the buildings would still have to be floodproofed to protect from the less frequent storms.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.14 PETERS CREEK WATERSHED

Basin Description

The Peters Creek watershed is a 9 square mile drainage basin located in central Roanoke County, northwest Roanoke City and northeast Salem. The watershed has a length of about 6 miles and a maximum width of about 2 miles near center. The Peters Creek watershed originates on Brushy Mountain at an elevation of approximately 2380 feet above sea level and flows in a southeasterly direction for about 6 miles to its confluence with the Roanoke River in Roanoke.

The upstream reaches of Peters Creek especially the areas upstream of Interstate 81 are largely undeveloped with scattered single family residences and agricultural areas. There is more residential development in the subbasins closer to the City of Roanoke downstream of Interstate 81 and along Peters Creek Road - State Route 117 and Melrose Avenue - U.S. Route 460. Developed conditions (Year 2020) land use is a combination of high density residential development, planned development areas, open space and rural preserve.

A tabulation of the Peters Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Peters Creek (feet)	Drainage Area(sq. mi.)
Mouth of Peters Creek	0	9.0
Shenandoah Avenue	5,600	8.4
Salem Turnpike	9,800	7.9
Melrose Avenue - U.S. Route 460	14,000	7.0
Downstream from Confluence of Peters Creek Tributary C	17,750	6.0
Cove Road - State Route 480	22,200	3.7
Downstream from Confluence of Peters Creek Tributary A & B	27,400	3.0

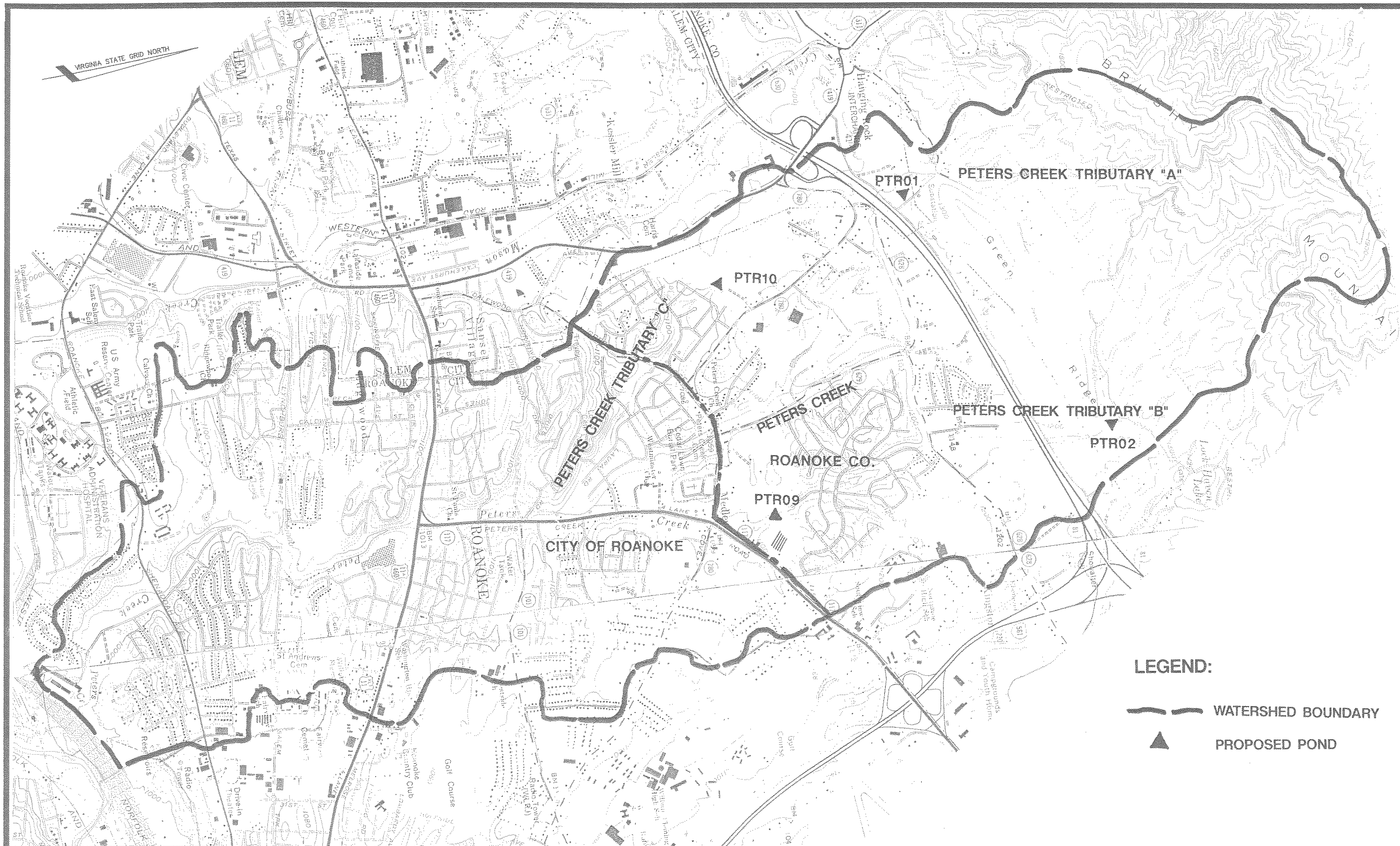
Subbasin Description

There are three significant streams that drain the Peters Creek watershed: Peters Creek Tributariey A, B and C. Peters Creek Tributaries A and B both lie entirely within Roanoke County. Peters Creek Tributary C upstream of Green Ridge Road is located in the Roanoke County and downstream of Green Ridge Road the stream is located in the City of Roanoke. The streams and related subbasins are shown in Figure 2.14.1. A tabulation of the study lengths and subbasin drainage areas is presented below followed by a brief summary of the Peters Creek tributaries:

Stream	Study Length (feet)	Drainage Area (sq. mi.)
Peters Creek Tributary A	5,300	1.0
Peters Creek Tributary B	2,100	2.0
Peters Creek Tributary C	5,800	0.9

Peters Creek Tributary A is located in the northwestern part of the Peters Creek watershed. It originates on Brushy Mountain and flows southeast to its confluence with Peters Creek Tributary B to form Peters Creek which is approximately 5 miles upstream of the confluence of Peters Creek with the Roanoke River. The watershed is mostly wooded with some agricultural areas and an area of commercial development just upstream of Interstate 81. Developed land use is primarily rural preserve and planned development areas with some commercial development, open space, low density residential and neighborhood conservation areas.

Peters Creek Tributary B is located in the northeastern part of the Peters Creek watershed and is just east of Peters



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PETERS CREEK WATERSHED

LOCATION OF PROPOSED STORMWATER IMPROVEMENTS

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.14.1

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Sheet 1 of 1

Creek Tributary A. The Peters Creek Tributary B watershed also originates on Brushy Mountain and flows southwest for approximately 1 mile to its confluence with Peters Creek Tributary A. It converges with Peters Creek Tributary A to form Peters Creek approximately 5 miles upstream of the confluence of Peters Creek with the Roanoke River. The watershed is mostly wooded with some agricultural and 1/4 acre lots. Developed conditions (Year 2020) land uses in this watershed are mainly open space and planned development areas with rural preserve areas and high density residential development.

Peters Creek Tributary C is located in the western part of the Peters Creek watershed south of Peters Creek Tributary A. It originates near Hanging Rock, north of the Interstate 81/Electric Road (State Route 419) interchange. It joins Peters Creek about 3.5 miles upstream from the confluence of Peters Creek with the Roanoke River. This watershed is more developed than the other tributaries because of its proximity to the City of Roanoke. The watershed consists mostly of 1/4 acre lots, agricultural areas and woods. The watershed drains the Montclair Estates and Norwood Forest subdivisions. Developed land use is a mixture of neighborhood conservation areas, high density residential development, planned development areas and commercial development.

Existing Land Use Distribution

The Peters Creek watershed contains fourteen existing specific land uses, but only 2 uses generally predominate: 1/4 acre lots and woods. Approximately 40% of the watershed is comprised of 1/4 acre lots. Wooded areas comprise approximately 35% of the watershed. Agricultural, commercial, open space and paved areas each comprise approximately 5% of the watershed. The remaining 5% of the watershed consists of brush, industrial areas, and 1 and 2 acre lots.

Developed Land Use Distribution

The Peters Creek watershed contains twelve developed specific land uses, but only four uses predominate: high density residential, planned development, open space and rural preserve areas. Approximately 45% of the developed conditions (Year 2020) watershed is comprised of high density residential areas. Planned development areas comprise approximately 15% of the developed conditions (Year 2020) watershed. Open space and rural preserve areas each comprise approximately 10% of the developed conditions (Year 2020) watershed. Commercial and neighborhood conservation areas each comprise approximately 5% of the watershed. The remaining 10% of the watershed consists of low density residential, industrial, woods, and core areas.

Hydrology

The discharges for Peters Creek and its tributaries were determined using the procedures described in Chapter 1. Storage routings were included in the model on Peters Creek Tributaries A and B at the Interstate 81 crossings. The Peters Creek model includes 26 subbasins, 9 of which cover Peters Creek Tributaries A, B and C.

Existing conditions discharges on Peters Creek are increased at the mouth by 30% for the 2-year storm, by 20% for the 10-year storm and by 15% for the 100-year storm under developed conditions (Year 2020). Discharges on Peters Creek Tributary A increase by 15% for the 100-year storrm. Existing conditions discharges on Peters Creek Tributary B increase by 40% for the 2-year storm and by 25% for the 100-year storm. Existing conditions discharges on Peters Creek Tributary C increase by 30% for the 2-year storm and by 10% for the 100-year storm. These increases are caused by increased development in the watershed.

Flooding

History of Flooding

High water marks were available within Roanoke City for Peters Creek. These high water marks were used to verify computed flood elevations.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Peters Creek and its tributaries. No debris blockage information for structures along Peters Creek was available.

Flooding Problems

Flooding problems along Peters Creek and Peters Creek Tributaries A, B and C were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. The major flooding problem in the Peters Creek watershed are upstream of Westside Boulevard, upstream of Melrose Avenue and in the vicinity of Northwood Drive. The flooding problems and possible solutions are summarized below in Table 2.5.1.

Floodplain maps and flood profiles for Peters Creek and Peters Creek Tributaries A, B and C are presented in Volume 2 of this report.

Peters Creek

Table 2.14.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Westside Boulevard (0-2980)	Storm / # of Buildings in flood area 2-year: 0 10-year: 1 100-year: 2	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Westside Boulevard to Shenandoah Avenue (2980-5936)	Storm / # of Buildings in flood area 2-year: 0 10-year: 17 100-year: 32	Storm / # of Buildings in flood area 2-year: 2 10-year: 24 100-year: 32	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Washington Heights - Shenandoah Avenue to Salem Turnpike (5936-10200)	Storm / # of Houses in flood area 2-year: 0 10-year: 3 100-year: 22	Storm / # of Houses in flood area 2-year: 0 10-year: 6 100-year: 23	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Salem Turnpike to Melrose Avenue (10200-14500)	Storm / # of Houses in flood area 2-year: 0 10-year: 2 100-year: 3	Storm / # of Houses in flood area 2-year: 2 10-year: 2 100-year: 4	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Melrose Avenue to Peters Creek Road (14500-15200)	Storm / # of Buildings in flood area 2-year: 0 10-year: 8 100-year: 20	Storm / # of Buildings in flood area 2-year: 0 10-year: 10 100-year: 22	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.14.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Peters Creek Road to Shenandoah Bible College Access Road (15200-17000)	Storm — # of Buildings in flood area 2-year — 1 10-year — 6 100-year — 9	Storm — # of Buildings in flood area 2-year — 1 10-year — 7 100-year — 9	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Shenandoah Bible College Access Road to Peach Tree Drive (17000-17500)	Storm — # of Houses in flood area 2-year — 0 10-year — 0 100-year — 2	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Peach Tree Drive to Northwood Drive (17500-19600)	Storm — # of Buildings in flood area 2-year — 10 10-year — 27 100-year — 33	Storm — # of Buildings in flood area 2-year — 14 10-year — 28 100-year — 36	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Northwood Drive to Green Ridge Road (19600-22700)	Storm — # of Buildings in flood area 2-year — 2 10-year — 12 100-year — 36	Storm — # of Buildings in flood area 2-year — 6 10-year — 12 100-year — 39	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Green Ridge Road to Limit of Study (22700-27824)	Storm — # of Houses in flood area 2-year — 1 10-year — 4 100-year — 7	Storm — # of Houses in flood area 2-year — 2 10-year — 5 100-year — 7	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Westside Boulevard (2980)	2-year overtops road	Same as existing	Raise road because of backwater
Peters Creek Road (14984)	5-year overtops road	Same as existing	Raise road because of backwater, enlarge Mack Truck private entrance downstream
Shenandoah Bible College Access Road (17086)	2-year overtops road	Same as existing	Raise road because of backwater
Peach Tree Drive (17494)	10-year overtops road	Same as existing	Enlarge structure and/or raise road
Northwood Drive (19671)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Green Ridge Road (22702)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road

Peters Creek Tributary A

Table 2.14.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Confluence with Peters Creek Tributary B to Interstate 81 (30-3465)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Storm / # of Buildings in flood area 2-year 1 10-year 1 100-year 2	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Upstream of Interstate 81 (4697)	Storm / # of Buildings in flood area 2-year 0 10-year 1 100-year 1	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Unity Church Drive (84)	None	10-year overtops road	Enlarge structure and/or raise road
Green Ridge Road - State Route 628 (369-2634)	2-year inundates road	Same as existing	Raise road
Green Ridge Road - State Route 628 (2772)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Loch Haven Drive - State Route 1894 (3950)	5-year overtops road	Same as existing	Raise road because of backwater
Timberview Road - State Route 1404 (5300)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road

Peters Creek Tributary B

Table 2.14.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Confluence with Peters Creek Tributary A to Ram Drive (11-2114)	Storm / # of Buildings in flood area 2-year 0 10-year 0 100-year 4	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Green Ridge Road - State Route 629 (84)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Wood Haven Road - State Route 628 (1400-1800)	10-year inundates road	Same as existing	Raise road

Peters Creek Tributary C

Table 2.14.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Northwood Drive - North Norwood subdivision (402-1439)	Storm / # of Houses in flood area 2-year 1 10-year 3 100-year 8	Storm / # of Houses in flood area 2-year 1 10-year 3 100-year 9	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Northwood Drive to Elva Road - North Norwood subdivision (1439-3004)	Storm / # of Houses in flood area 2-year 0 10-year 4 100-year 12	Storm / # of Houses in flood area 2-year 0 10-year 5 100-year 12	Enlarge Northwood Drive structure; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Elva Road to Green Ridge Road - Glendale subdivision (3004-4472)	Storm / # of Houses in flood area 2-year 0 10-year 0 100-year 10	Same as existing	Enlarge Elva Road structure; Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.14.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Green Ridge Road to Embassy Drive - Montclair Estates subdivision (4472-5823)	Storm / # of Houses in flood area 2-year / 0 10-year / 3 100-year / 12	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Laura Drive (567-1151)	10-year inundates road	Same as existing	Raise road
Northwood Drive (1439)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Green Ridge Road (4472)	5-year overtops road	2-year overtops road	Enlarge structure and/or raise road
Embassy Drive (5823)	5-year overtops road	Same as existing	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for the major flooding problems for Peters Creek and its tributaries.

The pond sites analyzed are summarized below and shown in Figure 2.14.2:

Site Description	Comments
PTR01 - pond on Peters Creek Tributary A upstream of Interstate 81	Reduces 2- and 10-year flows by 5% at confluence with Tributary B and at Green Ridge Road
PTR02 - Pond on Peters Creek Tributary B upstream of Interstate 81	Reduces 2-, 10- and 100-year flows by ~ 10%, 15% and 35% at confluence with Tributary A and by ~ 10%, 10% and 25% at Green Ridge Road. Pond would require relocation of a building and part of State Route 1404.
PTR09 - Lower North Detention Basin	Pond planned by the City of Roanoke
PTR10 - Montclair Detention Basin	Pond planned by the City of Roanoke
PTR09 & PTR10	Reduces 2-, 10- and 100-year flows by ~ 5%, 15% and 10% at East Main Street and by ~ 2%, 10% and 10% at confluence with Roanoke River
PTR01, PTR02, PTR09 & PTR10	Reduces 2-, 10- and 100-year flows by ~ 15%, 15% and 30% at Green Ridge Road, by ~ 10%, 20% and 20% at East Main Street and by ~ 2%, 15% and 15% at confluence with Roanoke River

On all of the streams, there are scattered buildings and residences subject to flooding for which floodproofing or relocation was recommended. Also many roads are inundated by the 10-year storm, where it was recommended to raise the road or enlarge the structure size.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.15 TINKER CREEK WATERSHED

Basin Description

The Tinker Creek watershed is a 112 square mile drainage basin located in northeast Roanoke County, northeast Roanoke City, northwest Vinton and southeast Botetourt County, Virginia. The watershed is fan shaped and has a length of about 12 miles and a maximum width of about 10 miles near its headwaters. The Tinker Creek watershed originates on Tinker Mountain near Mt. Union, Virginia at an elevation of approximately 2400 feet above sea level and flows in a southerly direction for about eleven miles until its confluence with the Roanoke River at the border between the City of Roanoke and the Town of Vinton.

The upstream reaches of **Tinker Creek** are primarily rural in nature with wooded and agricultural areas while the downstream portion of the watershed is mostly developed, consisting of wooded areas, subdivisions and some urban areas of the City of Roanoke. Upstream of Interstate 81, the Tinker Creek watershed is mostly undeveloped with wooded and agricultural areas. Downstream of Interstate 81 to the confluence of Carvin Creek, residential development increases and there are scattered commercial areas along Williamson Road - U.S. Route 11. Downstream of the confluence of Carvin Creek, the watershed is primarily residential development until Orange Avenue - U.S. Routes 221/460. Downstream of Orange Avenue the watershed has a combination of commercial and residential development until the confluence of Tinker Creek with the Roanoke River. Tinker Creek and its tributaries are shown in Figure 2.15.1.

A tabulation of the Tinker Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Tinker Creek (feet)	Drainage Area(sq. mi.)
Mouth of Tinker Creek	0	112
Downstream from Confluence of Glade Creek	4,320	102.9
Orange Avenue - U.S. Routes 221/460	9,550	65.6
Downstream from Confluence of Carvin Creek	28,600	61.1
Williamson Road - U.S. Route 11	50,300	29.9
Interstate 81	65,500	22.6

Subbasin Description

There are three significant streams that drain the Tinker Creek watershed: Carvin Creek, Glade Creek and Lick Run. Carvin Creek and its tributaries are described in Section 2.4. Glade Creek and its tributaries are described in Section 2.8. Lick Run and its tributary, Trout Run, are described in Section 2.9. A tabulation of the study lengths and subbasin drainage areas is presented below:

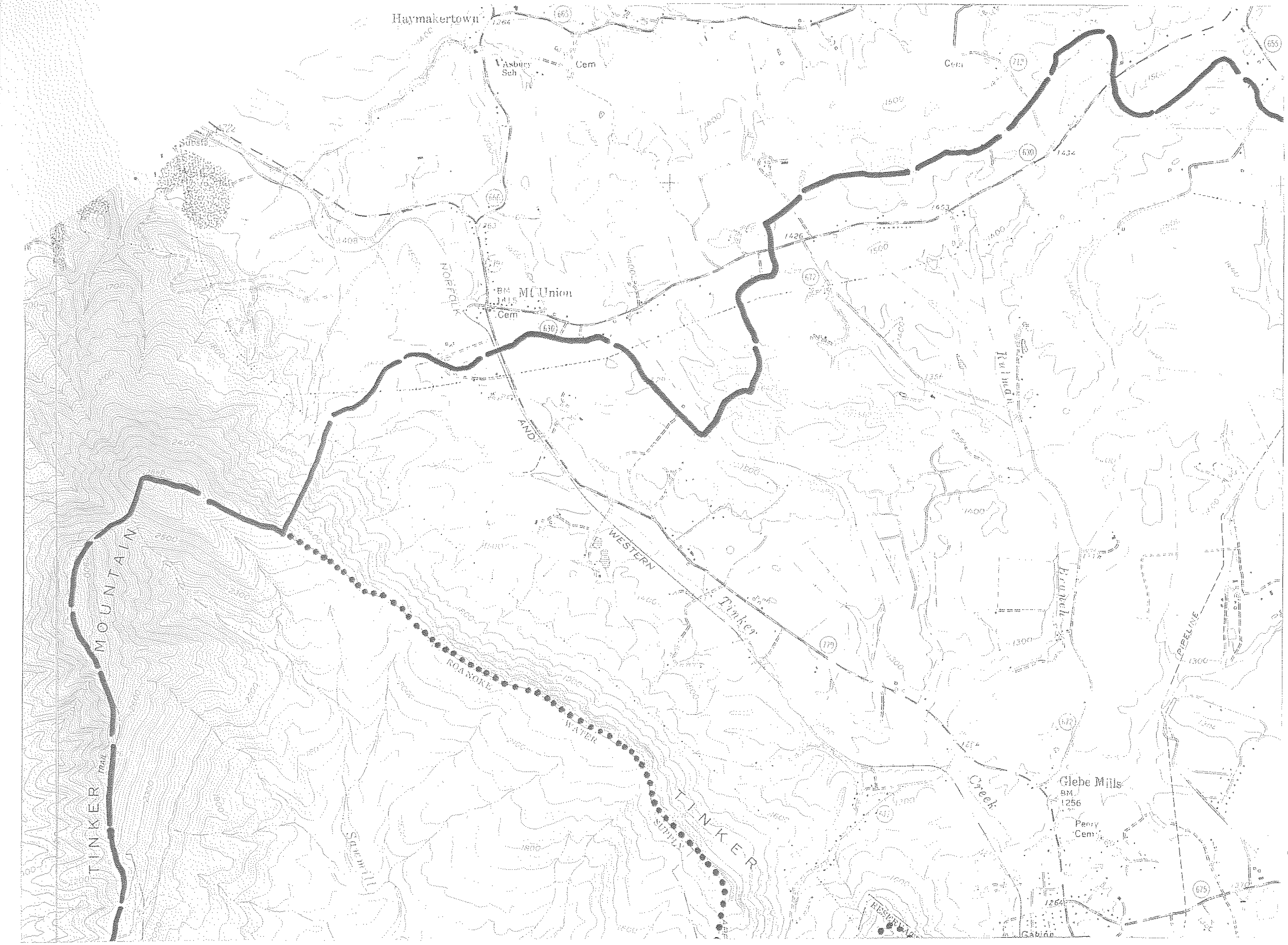
Stream	Study Length (feet)	Drainage Area (sq. mi.)
Carvin Creek	28,300	28
Glade Creek	28,000	33
Lick Run	35,200	8.7

Existing Land Use Distribution

The Tinker Creek watershed contains sixteen existing specific land uses but only 3 predominate: woods, agriculture and 1/4 acre lots. Approximately 50% of the watershed is wooded. Agricultural areas comprise approximately 25% of the watershed. Approximately 10% of the watershed is comprised of 1/4 acre lots. The remaining 15% of the watershed consists mainly of open space, commercial areas, 1/2 acre lots and industial areas.

Developed Land Use Distribution

The Tinker Creek watershed contains fifteen developed specific land uses, but five uses predominate: woods, agriculture areas, industial areas, and medium and high density residential areas. Approximately 25% of the developed



MATCH TO SHEET 2

MATCH TO SHEET 3

LEGEND:

- WATERSHED BOUNDARY
- SUBSHED BOUNDARY
- CORPORATE LIMITS

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TINKER CREEK WATERSHED

WATERSHED BOUNDARY

FIFTH PLANNING DISTRICT COMMISSION

ROANOKE, VIRGINIA

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.15.1

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Sheet 1 of 9

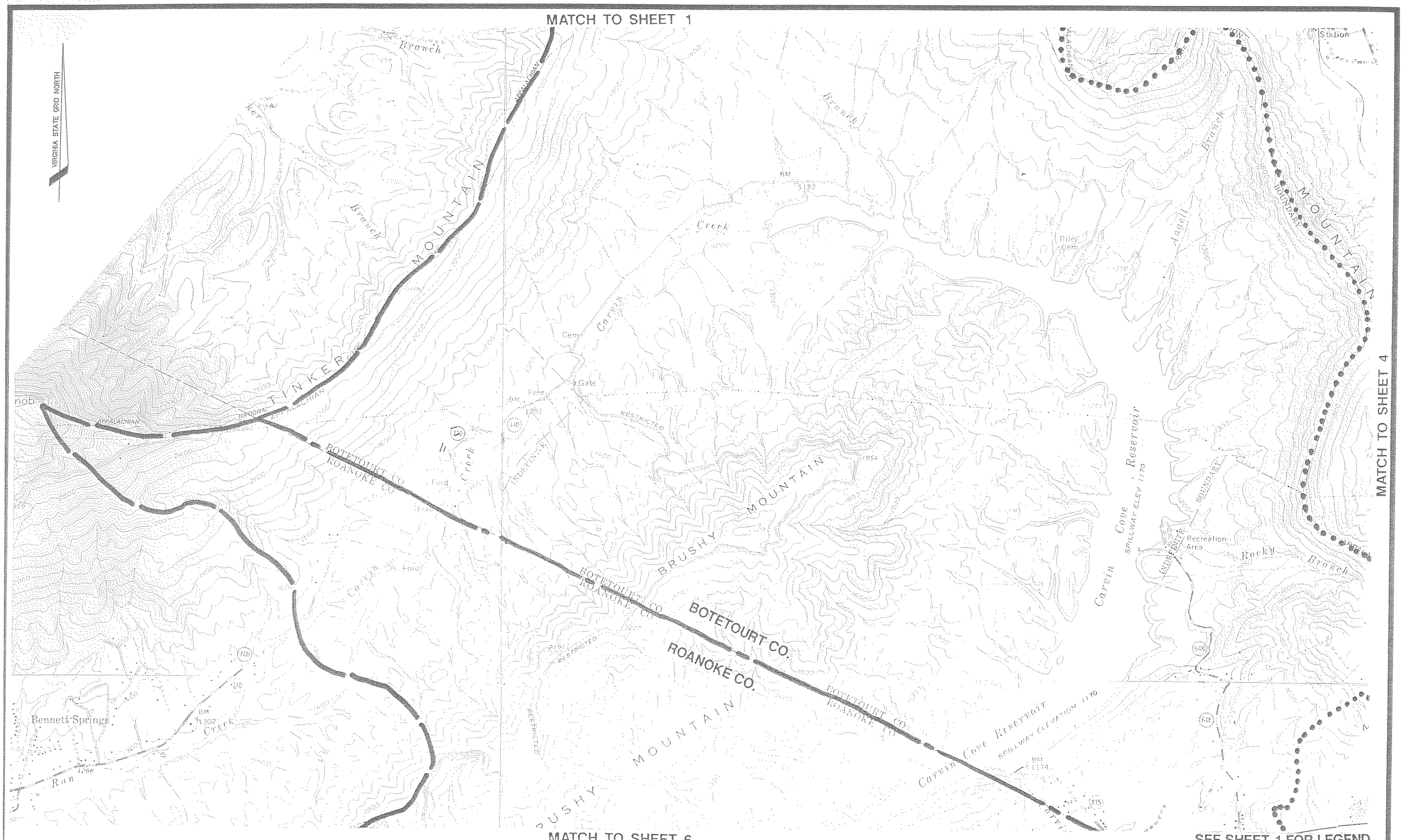
VIRGINIA STATE GRID NORTH

MATCH TO SHEET 1

MATCH TO SHEET 4

SEE SHEET 1 FOR LEGEND.

Dewberry & Davis Architects Engineers Planners Surveyors 8401 Arlington Boulevard Fairfax, Virginia 22031 (703) 849-0100	TINKER CREEK WATERSHED *WATERSHED BOUNDARY* FIFTH PLANNING DISTRICT COMMISSION ROANOKE, VIRGINIA	ROANOKE VALLEY REGIONAL STORMWATER MANAGEMENT PLAN Figure 2.15.1 (Cont'd.)	Drawn By: GRO Date: 01/97 Checked By: TJL Date: 01/97	Scale: 1"=2000' Sheet 2 of 9



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TINKER CREEK WATERSHED

WATERSHED BOUNDARY

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ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN
Figure 2.15.1 (Cont'd.)

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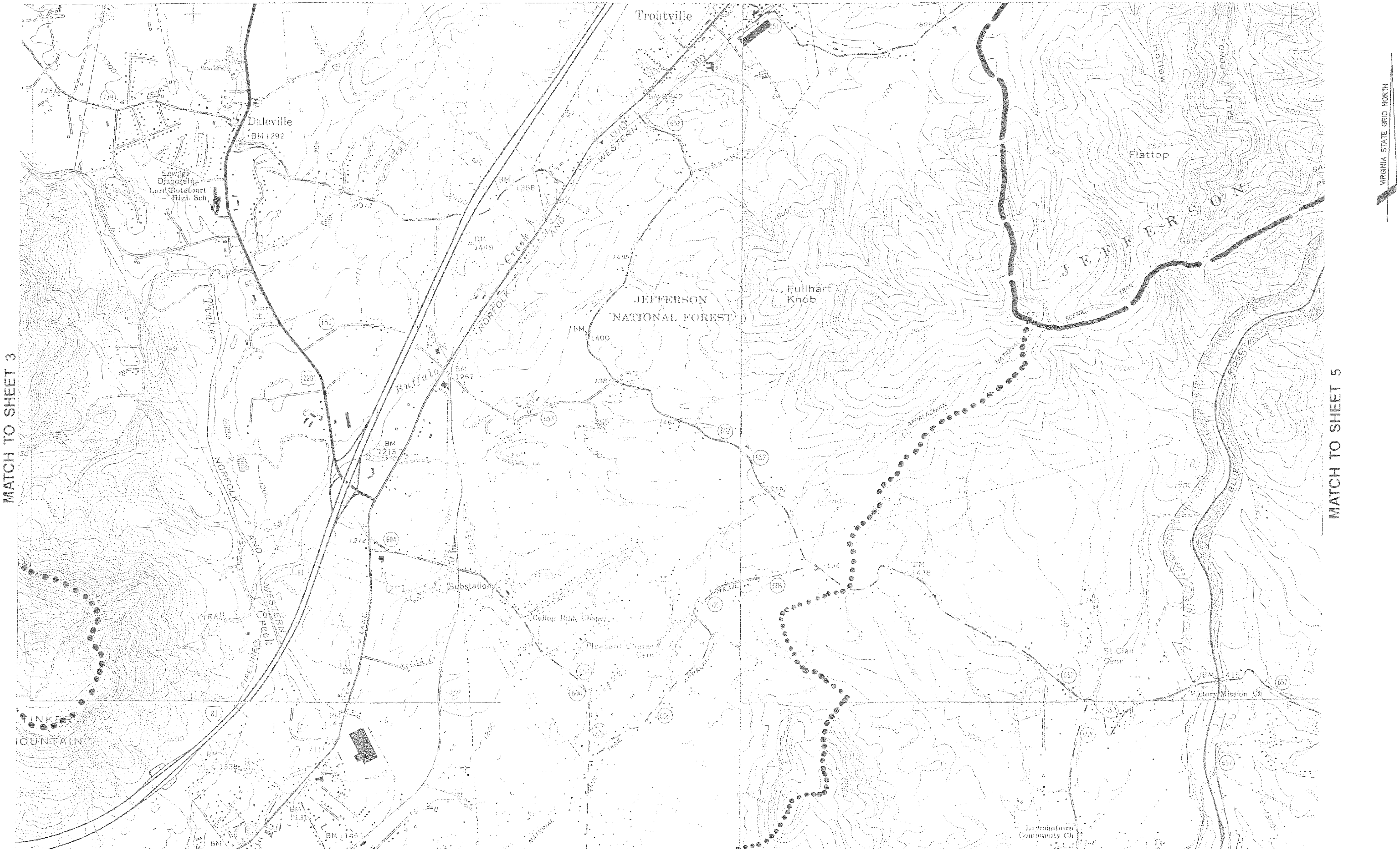

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Figure 2.15.1 (Cont'd.)

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Sheet 4 of 9

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Figure 2.15.1 (Cont'd.)

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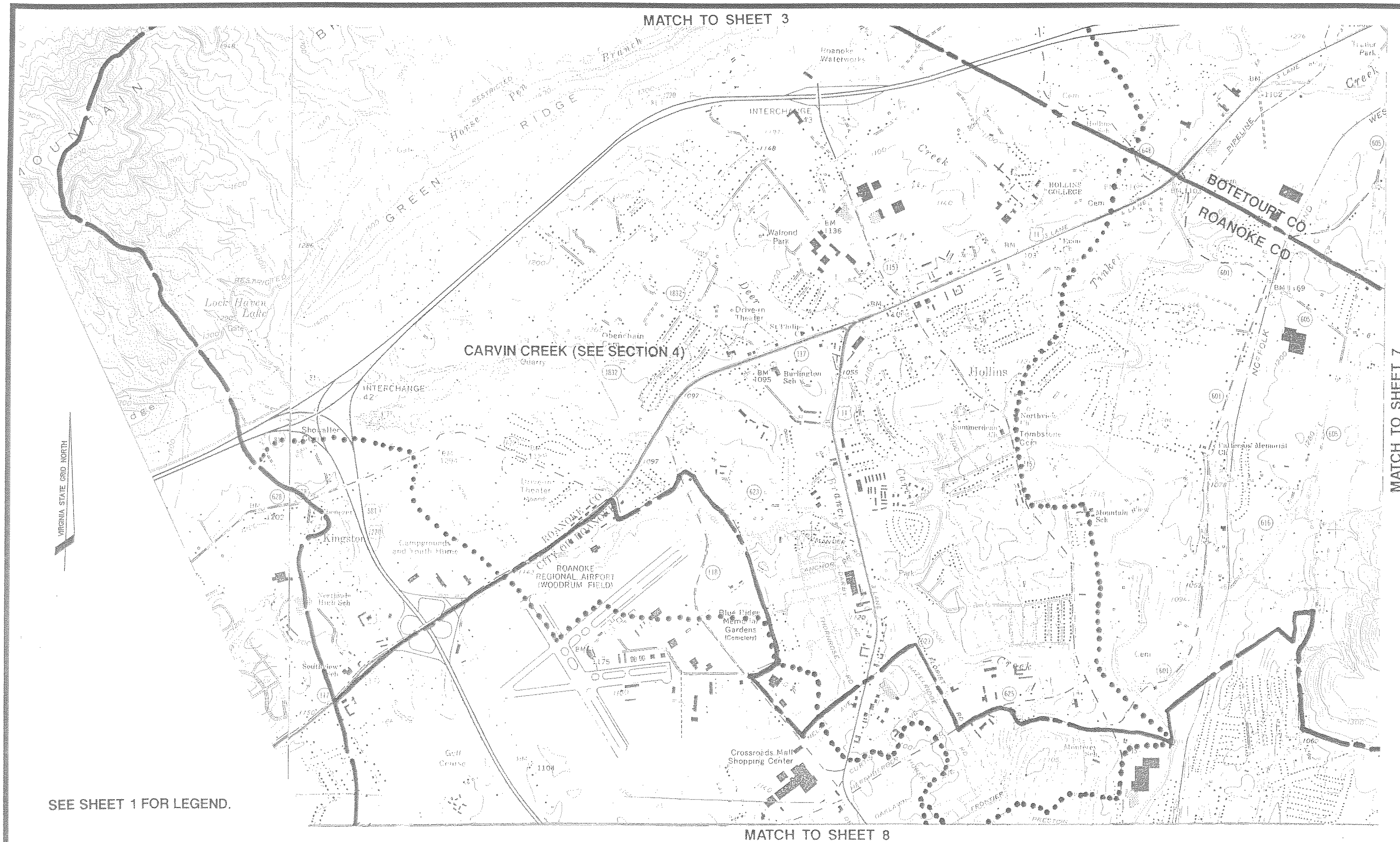

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Figure 2.15.1 (Cont'd.)

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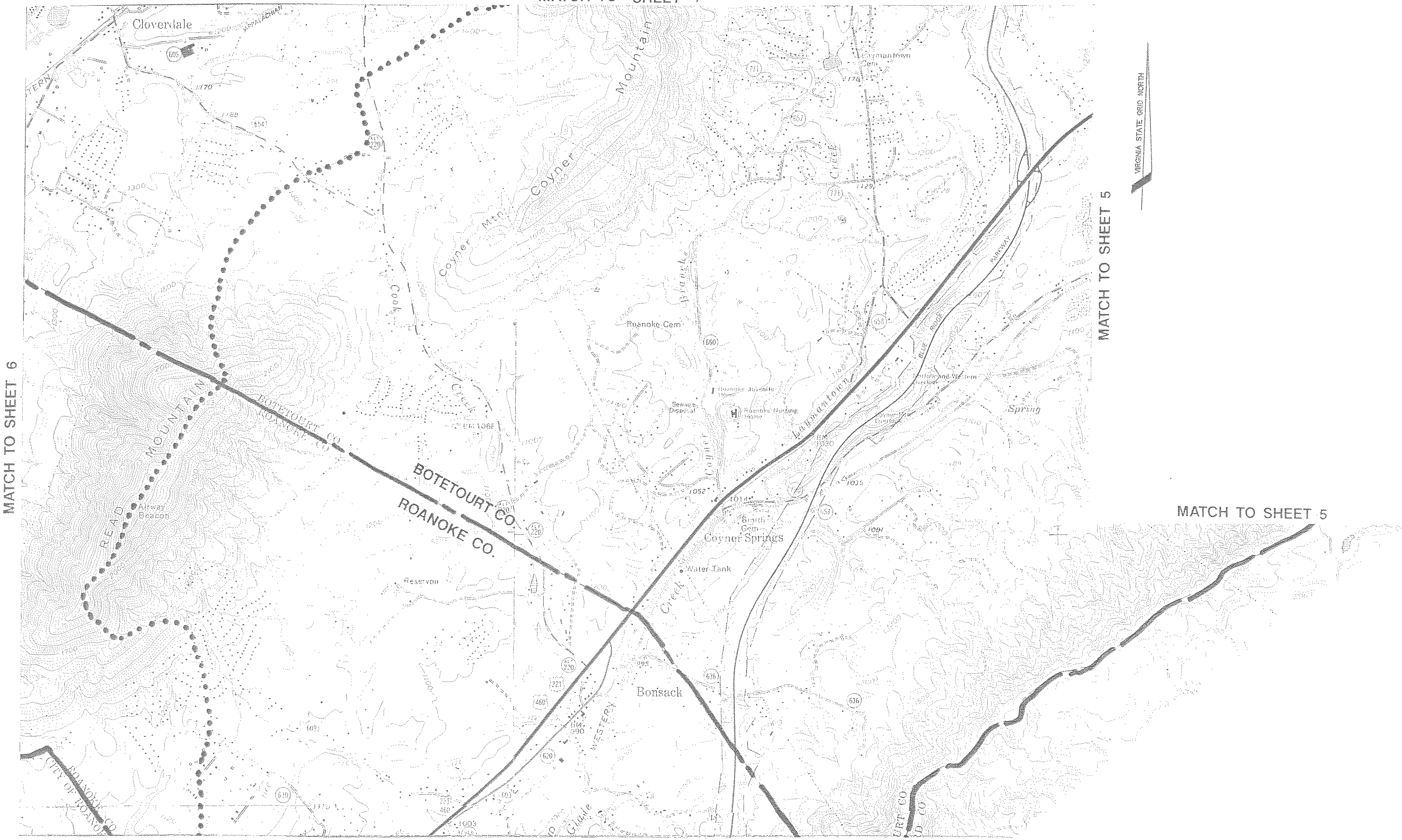

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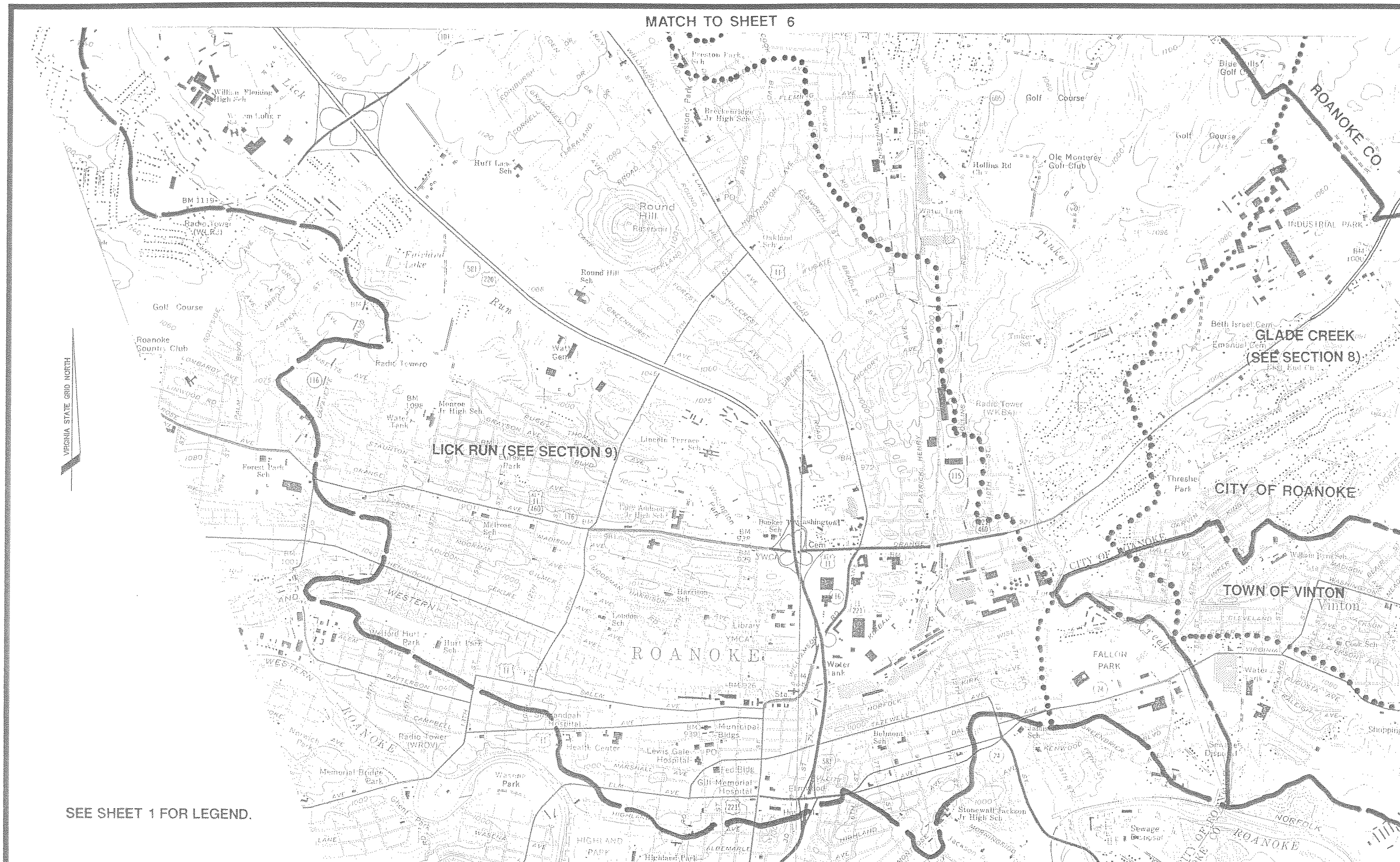

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STORMWATER MANAGEMENT PLAN
Figure 2.15.1 (Cont'd.)

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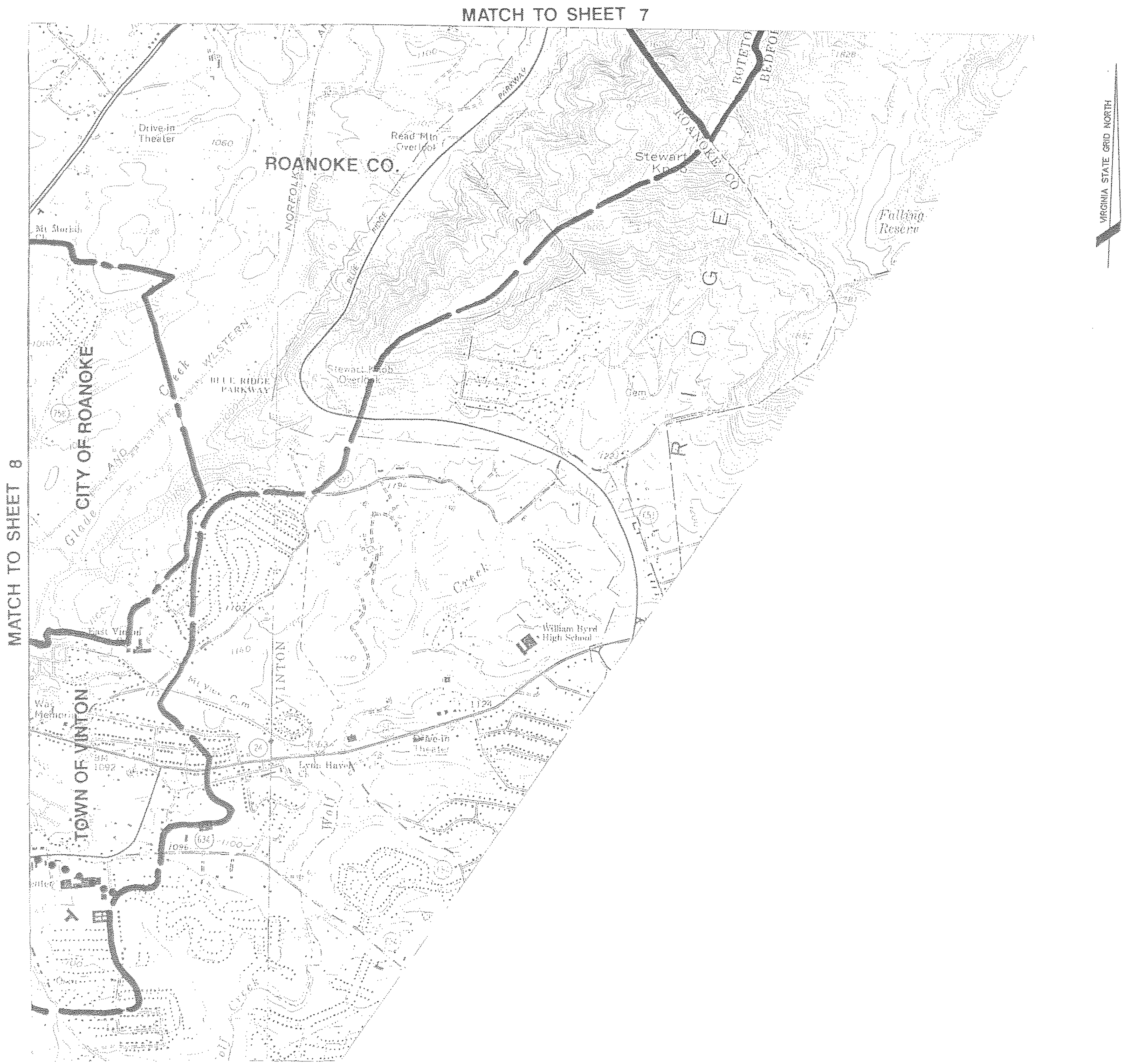

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STORMWATER MANAGEMENT PLAN
Figure 2.15.1 (Cont'd.)

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conditions (Year 2020) watershed is comprised of wooded areas which are mostly located in the upstream subbasins. Agriculture areas comprise approximately 20% of the watershed also mostly in the upstream subbasins. Industrial areas comprise approximately 15% of the developed conditions (Year 2020) watershed. Medium and high density residential development each comprise about 10% of the watershed. Commercial areas, low density residential areas and open space each comprise about 5% of the watershed. The remaining 5% of the watershed consists mainly of planned development areas and rural preserve areas.

Hydrology

The discharges for Tinker Creek and its tributaries were determined using the procedures described in Chapter 1. The Tinker Creek watershed was divided into 154 subbasins for the hydraulic model. Seventeen of these subbasins are in the Lick Run watershed, 54 are in the Glade Creek watershed and 27 are in the Carvin Creek watershed. A reservoir routing is included for the Carvin Cove Reservoir as described in Section 2.4. At the mouth of Tinker Creek, 2-year discharges increase by 60%, 10-year discharges increase by 25% and 100-year discharges increase by 20%. These increases are caused by increased development in the watershed.

Flooding

History of Flooding

Flood hydrographs were available from the USGS gate on Timber Creek near Dateville in Botetourt County. Hydrographs from this site were used to calibrate the hydrologic model of Tinker Creek watershed.

Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Tinker Creek and its tributaries. No data on debris blockage on Tinker Creek was available.

Flooding Problems

Flooding problems along Tinker Creek, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

Along Tinker Creek, the major flooding problem is located upstream of Dale Avenue near the confluence of Glade Creek. The flooding problems and possible solutions are summarized below in Table 2.15.1. Floodplain maps and flood profiles for Tinker Creek are presented in Volume 2 of this report.

Tinker Creek

Table 2.15.1 Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Mouth to Dale Avenue - State Route 24 (21-3674)	Storm # of Buildings in flood area 2-year 0 10-year 1 100-year 7	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Dale Avenue to Wise Avenue (3674-5651)	Storm # of Buildings in flood area 2-year 0 10-year 20 100-year 46	Storm # of Buildings in flood area 2-year 0 10-year 25 100-year 56	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Wise Avenue to Orange Avenue (5651-9595)	Storm # of Buildings in flood area 2-year 0 10-year 2 100-year 26	Storm # of Buildings in flood area 2-year 0 10-year 2 100-year 35	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Orange Avenue to 13th Street (9595-13366)	Storm # of Buildings in flood area 2-year 0 10-year 3 100-year 7	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
13th Street to Old Mountain Road - State Route 605 (13366-21082)	Storm # of Buildings in flood area 2-year 0 10-year 0 100-year 2	Same as existing	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Old Mountain Road to Preston Avenue (21082-26040)	Storm # of Houses in flood area 2-year 0 10-year 6 100-year 12	Storm # of Houses in flood area 2-year 1 10-year 6 100-year 13	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Preston Avenue to Hollins Road - State Route 601 (26040-29843)	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 4	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 5	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Hollins Road to Clearwater Avenue (29843-41585)	Storm # of Houses in flood area 2-year 1 10-year 7 100-year 14	Storm # of Houses in flood area 2-year 3 10-year 8 100-year 14	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding

Table 2.15.1 **Flooding Problems for Existing and Developed Land Use Conditions Discharges**

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Clearwater Avenue to Ardmore Avenue (41585-44093)	Storm # of Houses in flood area 2-year 0 10-year 1 100-year 5	Storm # of Houses in flood area 2-year 0 10-year 3 100-year 5	Floodproof, relocate and/or purchase; Enlarge Clearwater Avenue structure downstream; Upstream detention to reduce frequency of flooding
Ardmore Avenue to Williamson Road - U.S. Route 11 (44093-50161)	Storm # of Buildings in flood area 2-year 0 10-year 3 100-year 11	Storm # of Buildings in flood area 2-year 0 10-year 6 100-year 14	Floodproof, relocate and/or purchase; Upstream detention to reduce frequency of flooding
Road Overtopping			
Dale Avenue - State Route 24 (3562)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road
Wise Avenue (5651)	2-year overtops road	Same as existing	Enlarge structure and raise road because of backwater
13th Street	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road
Tinker Creek Lane - (18000-20932)	10-year inundates road	2-year inundates road	Raise road
Summer View Drive (50006)	25-year overtops road	10-year overtops road	Enlarge structure and/or raise road

Flood Hazard Mitigation Measures

Flood hazard mitigation measures were analyzed for the major flooding problems on Tinker Creek. One area of focus was upstream of Dale Avenue near the confluence of Glade Creek, however there are flooding problems scattered throughout the studied reach of Tinker Creek.

The Tinker Creek watershed was analyzed to locate possible stormwater pond sites. Several pond sites were located throughout the watershed and then analyzed to determine their impact on flooding problems. The feasible pond sites were located in the upper portion of the Tinker Creek watershed which is less developed than the downstream areas. It was determined that the feasible pond sites did not have an impact on the flooding areas and that stormwater management ponds are not a viable solution in the Tinker Creek watershed.

Chapter 3 tabulates the recommended flood hazard mitigation in the Watershed Plan, which presents magnitude costs, priority plans and a tabulation of benefits.

2.16 Wolf Creek Watershed

Basin Description

The Wolf Creek watershed is a 4.9 square mile drainage basin located in eastern Roanoke County, Virginia and east Vinton. It lies mostly within Roanoke County and the Town of Vinton, Virginia with some of the headwaters extending into Bedford County. The Wolf Creek basin originates in the Blue Ridge Mountains at Stewart Knob at an elevation of approximately 2435 feet above sea level and flows in a southwesterly direction for about four miles until its confluence with Roanoke River in Vinton. The watershed is oblong and has a length of about 4 miles and a maximum width of about 2 miles near its center. The stream and contributing areas are shown in Figure 2.16.1.

The main stem of **Wolf Creek** serves as the political boundary between the Town of Vinton and Roanoke County for a portion of its length. The upstream reaches of Wolf Creek are mostly undeveloped consisting of wooded areas and pasture with some single family residential areas off of the Blue Ridge Parkway. As the stream continues southwesterly, the level of residential development increases until Stewartsville Road where there is an area of commercial development along the stream. Downstream of Stewartsville Road there is more residential development but the areas adjacent to the creek have not been developed and are mainly wooded. Future land use is planned to be a combination of rural preserve and residential areas.

A tabulation of the Wolf Creek drainage basin areas is presented below:

Location	Distance Above Mouth of Wolf Creek (feet)	Drainage Area (sq. mi.)
Mouth of Wolf Creek	0	4.9
VA Route 634 - Hardy Road	8,400	3.8
Va Route 24 - Stewartsville Road	11,700	3.0
Blue Ridge Parkway	18,600	0.5

Existing Land Use Distribution

The Wolf Creek watershed contains eleven existing specific land uses, but only 5 uses generally predominate: woods, agriculture, and 1/2-, 1/3- and 1/4-acre residential lots. Approximately 40% of the watershed is comprised of wooded areas, 20% is agricultural and 25% is 1/4-acre residential. 1/2- and 1/3- acre residential land uses each comprise about 5% of the watershed. The remaining 5% of the watershed consists of the other 6 land uses which include pasture, commercial, open space, 1- and 2- acre residential and paved areas.

Developed Land Use Distribution

The Wolf Creek watershed contains 11 developed specific land uses, but only five uses predominate: rural preserve, neighborhood conservation areas and low, medium and high density residential areas. Approximately 25% of the developed conditions (Year 2020) watershed is comprised of rural preserve areas. Residential areas comprise 45% of the watershed of which 20% is low density, 15% is high density and 10% is medium density. About 15% of the watershed is planned to be neighborhood conservation areas. The remaining 15% of the watershed consists of open space commercial areas, woods, and village center areas.

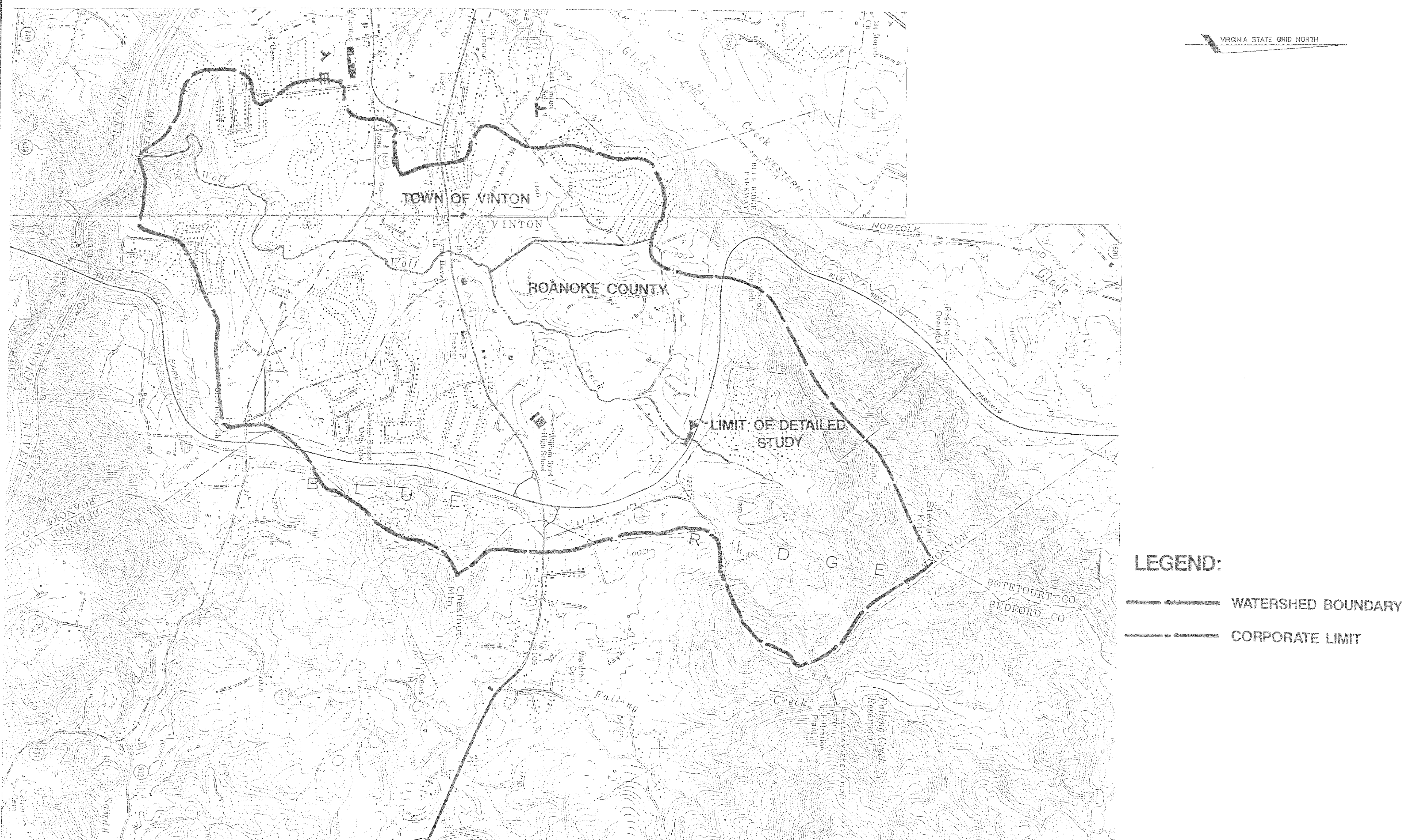
Hydrology

The discharges for Wolf Creek were determined using the procedures described in Chapter 1. The watershed was divided into 12 subbasins. Existing conditions discharges on Wolf Creek are increased at the mouth by 90% for the 2-year storm, 40% for the 10-year storm and 25% for the 100-year storm under developed conditions (Year 2020). This increase is caused by the increase in residential development in the watershed.

Flooding

History of Flooding

No recorded flood discharges or high water marks were available on Wolf Creek.



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WOLF CREEK WATERSHED

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STORMWATER MANAGEMENT PLAN

Figure 2.16.1

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Debris Blockage

Debris blockage of structures can have a significant impact on upstream flooding. Community officials were contacted about debris blockage on Wolf Creek and its tributaries. It was determined that Wolf Creek is not subject to significant debris blockage, therefore debris blockage was not analyzed on this stream.

Flooding Problems

Flooding problems along Wolf Creek for both existing and future land use conditions were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

No significant areas of flooding were identified on Wolf Creek. Several roads are overtopped by the 10-year flood and one house is partially within the 100-year floodplain. Table 2.16.1 summarizes these flooding problems.

Floodplain maps and flood profiles for Wolf Creek are presented in Volume 2 of this report. These maps and profiles depict 100-year recurrence interval flooding conditions for future land use conditions.

Table 2.16.1 - Flooding Problems for Existing and Developed Land Use Conditions Discharges

Location (HEC-2 X-section)	Problem(s)		Possible Solutions
	Existing Conditions	Developed Conditions	
Building/House Flooding			
Niagara Road to Wolf Creek Drive (1887-7514)	Storm — # of Sheds in flood area 2-year — 0 10-year — 2 100-year — 3	Same as existing	Relocate and/or floodproof
Wolf Creek Drive to Hardy Road (7756-8265)	None	Storm — # of Houses in flood area 2-year — 0 10-year — 0 100-year — 1	Floodproof and/or elevate; Upstream detention to reduce frequency of flooding
Road Overtopping			
Niagara Road (1887)	5-year overtops road	Same as existing	Enlarge structure and/or raise road
Hardy Drive (8482)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road
Mountain View Road (17865)	10-year overtops road	5-year overtops road	Enlarge structure and/or raise road

Note: Unmodeled structure at Spring Grove Drive between cross sections 14145 and 14475. Upstream structures may be impacted.

Flood Hazard Mitigation Measures

The major flooding problem on Wolf Creek involves flooding of three roads. There is no significant house or building flooding or debris problems. The solution to the road flooding is to enlarge the structures or to raise the roads to prevent future flooding. There were no good stormwater detention sites on Wolf Creek because of the steep slope of the stream.

CHAPTER 3 - WATERSHED PLAN

The Watershed Plan was developed using the flood mitigation analysis described in Chapter 1. The Watershed Plan includes both retrofitting existing facilities to address existing flooding problems and construction of new flood mitigation measures. Retrofitting existing structures, such as adding trash racks to culverts subject to debris blockage and modifying existing structures to provide stormwater detention, can be carried out with minimal effort and cost as compared to implementing new flood mitigation measures. New flood mitigation measures will require further engineering analysis and in the case of flood control dams, the purchase of land rights to construct the facility.

Plan Development

The watershed plan lists proposed projects for each watershed. The projects include stormwater management ponds, road improvements, levees, debris control measures and floodproofing. Except for floodproofing projects, a cost estimate was prepared for each proposed project and the projects were rated to determine the priority within each watershed. The cost estimates, ratings and details on the rating system are included in a separately published addendum to this report. The ratings shown in the watershed plans are based on engineering feasibility and include several criteria: number of structures relieved by the project, the project cost, design storm, environmental impact, potential funding source and permittability of the project. Other intangible criteria are shown in the addendum and will be rated by each community as needed. The approximate number of structures recommended for floodproofing is also included in the watershed plan.

Floodproofing

Many structures are subject to periodic flooding where floodproofing, elevation, relocation or acquisition are the most viable flood mitigation solution. An estimate of the number of structures for which these actions are warranted has been prepared and is included in each watershed plan. For these structures it is recommended that GPS elevation certificates be prepared to further define the appropriate mitigation strategy. The costs for floodproofing are not included in the watershed plan. This section presents estimated costs for different floodproofing options which can be used by the communities to determine the viability of floodproofing alternatives.

The floodproofing options were divided into three categories based on depth of flooding. These categories are presented below:

Floodproofing Category	Determining Factor	Action Recommended	Range of Costs
1	100-year flood depth >8'	Purchase or relocate	$50,000 - $125,000
2	100-year flood depth 3-8'	Elevate, relocate or purchase	$25,000 - $125,000
3	100-year flood depth <3'	Dry floodproof or elevate	$12,000 - $25,000

The floodproofing category for each building to be floodproofed was shown on the workmap and a total count of the buildings to be floodproofed are included in the watershed plans for each stream.

The costs for floodproofing vary greatly among the floodproofing options. A description of each floodproofing option and an estimated cost follows.

Floodproofing Option	Description	Estimated Cost
Purchase	Buy and demolish the flood prone structure and moving the inhabitants to another structure which is not flood prone	$125,000
Relocate	Move the entire home out of the floodplain, which involves placing it on supports and then onto a truck bed and transporting it to a new site located outside of the floodplain	$50,000
Elevate	Raise an entire structure above the flood hazard, which involves placing a cradle of steel beams under the structure, using jacks to raise the structure to the desired height, constructing a new elevated foundation for the structure and then lowering the structure onto its new foundation. Houses with basements are more difficult to elevate because the utilities must be floodproofed and the old basement must be filled and is therefore unusable.	$25,000

Dry Floodproof	Combine adjustments and/or additions of features to buildings that eliminate or reduce the potential for flood damage by keeping floodwaters out of the structure. Some of the possible adjustments include: installing watertight shields for doors and windows, reinforcing walls, using of membranes and other sealants to reduce seepage, and installing drainage collection systems and check valves. This option usually requires the property owner to be responsible for installing some of the dry floodproofing measures during a flood event.	$12,000

The floodproofing alternative to be used for a specific floodprone structure will depend on the depth of flooding, cost and property owner preferences. Therefore, each structure to be floodproofed should be addressed on a case by case basis.

3.1 BACK CREEK WATERSHED PLAN

The watershed plan for Back Creek includes several stormwater management ponds, road and culvert improvements, and other flood mitigation measures. The ponds and other flood hazard mitigation measures are described in greater detail in Section 2.1 of this report and are also shown on Figure 2.1.1. The Back Creek watershed is relatively undeveloped so existing flooding problems are scattered along the stream and its tributaries. The ponds recommended were located in areas of future development and will help mitigate the increase in discharges caused by this development. The roads identified for improvements are roads that are overtopped or inundated under existing conditions. The projects in order of priority based on the rating system are shown in Table 3.1.1.

Table 3.1.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
BAC16	Raising and enlarging the Starkey Road Crossing - State Route 904 on Back Creek Tributary B to meet 10-year requirements	67	$120,000
BAC11	Stormwater management pond on tributary east of Leslie	46	$620,000
BAC15	Raising and enlarging the Crescent Boulevard Crossing on Back Creek Tributary B to meet 10-year requirements	59	$110,000
BAC12	Raising and enlarging the Five Oaks Road crossing on Back Creek to meet 10-year requirements	57	$120,000
BAC13	Raising Martins Creek Road along Martins Creet to prevent flooding of the road during a 10-year storm	51	$270,000
BAC14	Raising Twelve O'Clock Knob Road along Little Back Creek to prevent flooding of the road during a 10-year storm	51	$360,000
BAC08	Stormwater management pond on tributary to Back Creek Tributary A near intersection of Buck Mountain Road (State Route 679) and Saddlewood Road	50	$350,000
BAC09	Stormwater management pond on tributary to Back Creek Tributary A north of Clearbrook Lane (State Route 674)	50	$470,000
BAC10	Stormwater management pond on tributary southwest of Leslie	46	$1,310,000
BAC02	Stormwater management pond on tributary southwest of intersection of Old Mill Road and Bent Mountain Road	46	$710,000
BAC07	Stormwater management pond on tributary west of Pine Needle Drive (State Route 715)	46	$720,000
BAC05	Stormwater management pond on tributary east of intersection of Merriman Road (State Route 613) and Cotton Hill Road (State Route 688)	46	$750,000
BAC03	Stormwater management pond on tributary west of Corntassel Lane - State Route 923	46	$810,000
BAC04	Stormwater management pond on tributary southwest of Coleman Road - State Route 735	46	$940,000
BAC01	Stormwater management pond on Little Back Creek upstream of confluence with Back Creek	46	$1,130,000
BAC06	Stormwater management pond on tributary northeast of Wright along Back Creek Road (State Route 676)	46	$1,250,000
		TOTAL	$10,040,000

Floodproofing

The number of buildings to be floodproofed on each stream for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Back Creek	1	48
	2	51
	3	31
Martins Creek	1	0
	2	1
	3	2
Little Back Creek	1	1
	2	13
	3	5
Back Creek Tributary A	1	3
	2	23
	3	9
Back Creek Tributary B	1	0
	2	14
	3	33
	Total	234

If the proposed ponds are built, approximately 70 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.2 BARNHARDT CREEK WATERSHED PLAN

The watershed plan for Barnhardt Creek includes bridge and culvert improvements, and other flood mitigation measures. Three ponds were also investigated but are not cost effective as shown in the table below. These ponds are described in greater detail in Section 2.4 of this report and are also shown on Figure 2.4.1. The major flooding problem in the Barnhardt Creek watershed is upstream of Electric Road - State Route 419 in the Farmingdale subdivision along Lakemont Drive. Construction of all three ponds will remove approximately 8 houses from the 10-year floodplain. Because of this low number of houses removed from the floodplain and the high cost, the ponds do not rate very high in the priority table below. In this watershed floodproofing of the houses is recommended over the construction of the ponds. The projects in order of priority based on the rating system are shown in Table 3.2.1.

Table 3.2.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
BAR09	Enlarging Keagy Road Crossing to meet 10-year requirements	75	$90,000
BAR08	Raising and Enlarging Lakemont Drive to meet 10-year requirements and to remove upstream houses from 10-year floodplain	67	$220,000
BAR07	Enlarging Electric Road Crossing to meet 10-year requirements	67	$280,000
BAR11	Raising and Enlarging Grandin Road Extended to meet 10-year requirements	67	$90,000
BAR05	Enlarging Cravens Creek Road Crossing to meet 10-year requirements and to remove upstream houses from 10-year floodplain	67	$210,000
BAR10	Enlarging Meadow Creek Drive Crossing to meet 10-year requirements	59	$140,000
BAR03	Pond ~ 800' upstream of Keagy Road removes 1-5 houses and roads from 10-year floodplain	54	$2,820,000

Project	Description	Rating	Estimated Cost
BAR02	Pond ~ 1600' downstream of Meadow Creek Drive removes 1-5 houses from 10-year floodplain	46	$1,030,000
BAR01*	Pond ~ 1 mile upstream of Grandin Road Extended removes 1-5 houses from 10-year floodplain	46	$4,110,000
		TOTAL	$9,210,000

* Shaded project is not recommended and is not included in total but is shown for informational purposes only.

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Barnhardt Creek	1	4
	2	26
	3	16
	Total	46

If the proposed ponds are built, approximately 15 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.3 BUTT HOLLOW CREEK WATERSHED PLAN

The watershed plan for Butt Hollow Creek includes two stormwater management ponds and a culvert improvement. The ponds are described in greater detail in Section 2.3 of this report and are also shown on Figure 2.3.1. Butt Hollow Creek experiences some scattered flooding problems along West Main Street and Butt Hollow Road. The projects in order of priority based on the rating system are shown in Table 3.3.1.

Table 3.3.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
BUT03	Raising and Enlarging the Butt Hollow Road crossing to meet 10-year requirements and to prevent the 2-year storm from overtopping the road	77	$50,000
BUT02	Pond upstream of Booher Drive to remove 1-5 houses from the 100-year floodplain	50	$910,000
BUT01	Pond upstream of Lee Road to remove 1-5 houses from the 100-year floodplain	50	$1,220,000
		TOTAL	$2,180,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Butt Hollow Creek	1	0
	2	4
	3	26
	Total	30

If the proposed ponds are built, approximately 10 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.4 CARVIN CREEK WATERSHED PLAN

The watershed plan for Carvin Creek includes three stormwater management ponds, one on Carvin Creek and two on West Fork Carvin Creek, bridge and culvert improvements, and other flood mitigation measures. These ponds are described in greater detail in Section 2.4 of this report and are also shown on Figure 2.4.1. The major flooding problem in the Carvin Creek watershed is in the Sun Valley subdivision. Construction of all three ponds will remove approximately 50 houses from the 100-year floodplain. The projects in order of priority based on the rating system are shown in Table 3.4.1.

Table 3.4.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
CAR09	Clearing and snagging Carvin Creek upstream of Plantation Road to control debris	97	$30,000
CAR03	Retrofit of Airport drop structure on West Fork Carvin Creek into a stormwater management pond	75	$400,000
CAR02	Stormwater management pond on West Fork Carvin Creek upstream of Peters Creek Road, retrofit of existing culvert	74	$1,300,000
CAR01	Stormwater management pond on Carvin Creek ~ 2500' downstream of upstream Plantation Road crossing	74	$810,000
CAR05	Enlarging downstream Plantation Road crossing on Carvin Creek to meet 10-year design requirement	67	$110,000
CAR08	Enlarging Hugh Avenue crossing on Carvin Creek to meet 10-year design requirement	67	$70,000
CAR10	Enlarging Bobby Drive crossing on West Fork Carvin Creek to meet 10-year design requirement	67	$80,000
CAR06	Enlarging Hershberger Road Crossing on Carvin Creek to meet 10-year design requirement	67	$190,000
CAR04	Raising U.S. Route 11 along Deer Branch to prevent frequent inundation of road	67	$350,000
CAR07	Raising and enlarging Verndale Road crossing on Carvin Creek to meet 10-year design requirement	59	$150,000
CAR13	Enlarging Friendship Manor Entrance Road crossings on Deer Branch to meet 10-year design requirement	59	$170,000
CAR12	Enlarging Plymouth Drive crossing on Deer Branch to meet 10-year design requirement and relieve upstream structure flooding	59	$220,000
CAR11	Enlarging Church Entrance Road crossing on Deer Branch to meet 10-year design requirement	53	$130,000
		TOTAL	$4,010,000

Floodproofing

The number of buildings to be floodproofed on each stream for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Carvin Creek	1	23
	2	60
	3	67

Stream	Floodproofing Category	Number of Buildings
West Fork Carvin Creek	1	0
	2	0
	3	14
Deer Branch	1	0
	2	0
	3	10
	Total	174

If the proposed ponds are built, approximately 75 of the structures would not need to be floodproofed. The building identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.5 Cole Hollow Brook Watershed Plan

The watershed plan for Cole Hollow Brook includes a stormwater management pond, bridge and culvert improvements, and other flood mitigation measures. The pond is described in greater detail in Section 2.5 of this report and is also shown on Figure 2.5.1. The major flooding problems in the Cole Hollow Brook watershed are upstream of West Main Street and in the Mitchell subdivision downstream of Interstate 81. The projects in order of priority based on the rating system are shown in Table 3.5.1.

Table 3.5.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
COL04	Raising and Enlarging Windsor Lane Crossing to meet 10-year requirements and remove 1-5 structures from 10-year floodplain	75	$40,000
COL02	Enlarging West Main Street Crossing to meet 10-year requirements and remove 1-5 structures from 10-year floodplain	75	$150,000
COL01	Stormwater Management Pond in Interstate 81 Interchange with Horner Lane - State Route 619 to remove 6-20 structures from the 10-year floodplain	66	$380,000
COL03	Enlarging Horner Lane Crossing to meet 10-year requirements and remove 1-5 structures from 10-year floodplain	59	$120,000
		TOTAL	$690,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Cole Hollow Brook	1	0
	2	9
	3	35
	Total	44

If the proposed pond is built, approximately 10 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.6 DRY BRANCH WATERSHED PLAN

The watershed plan for Dry Branch includes stormwater management ponds, bridge and culvert improvements, and other flood mitigation measures. Three ponds were investigated but one is not cost effective as shown in the table below. These ponds are described in greater detail in Section 2.6 of this report and are also shown on Figure 2.6.1. The major flooding problems in the Dry Branch watershed are in the Hockman and Cameron Court subdivisions. Pond DRY01 would remove approximately 25 houses from the 10-year floodplain and Pond DRY03 would remove approximately 10 houses from the 10-year floodplain. The projects in order of priority based on the rating system are shown in Table 3.6.1.

Table 3.6.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
DRY05	Levee upstream of Carrollton Avenue, replacement of culvert at Carrollton Avenue & channelization downstream to remove over 20 houses from the 10-year floodplain	78	$640,000
DRY06	Raising and enlarging Goodwin Avenue Crossing to meet 10-year requirements	75	$50,000
DRY08	Pond upstream of Interstate 81 to remove over 20 houses from the 10-year floodplain	74	$1,190,000
DRY01	Stormwater management pond to remove ~ 25 houses from 10-year floodplain	74	$1,560,000
DRY07	Raising and Enlarging Frosty Lane Crossing to meet 10-year requirements	67	$80,000
DRY04	Channel diversion from West Main Street to downstream of West Burwell Street to remove 6-20 structures from the 10-year floodplain	66	$1,040,000
DRY03	Stormwater management pond to remove ~ 10 houses from the 10-year floodplain	62	$1,180,000
DRY02*	Stormwater management pond to reduce 10-year discharges	46	$880,000
		TOTAL	$6,620,000

* Shaded project is not recommended and is shown for informational purposes only. Not included in total.

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Dry Branch	1	10
	2	80
	3	97
	Total	187

If the proposed ponds are built, approximately 30 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.7 GISH BRANCH WATERSHED PLAN

The watershed plan for Gish Branch includes stormwater management ponds, bridge and culvert improvements, and other flood mitigation measures. Three ponds were investigated but they are not cost effective as shown in the table below. These ponds are described in greater detail in Section 2.7 of this report and are also shown on Figure 2.7.1. The major flooding problem in the Gish Branch watershed is upstream of Kessler Mill Road - State Route 630. Construction of all three ponds will remove approximately 7 houses from the 10-year floodplain. Because of this low number of houses removed from the floodplain and the high cost, the ponds do not rate very high in the priority table below. In this watershed floodproofing of the houses is recommended over the construction of the ponds. The projects in order of priority based on the rating system are shown in Table 3.7.1.

Table 3.7.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
GIS04	Raising and enlarging Chamberlain Lane crossing to meet 10-year requirements and remove upstream houses from 10-year floodplain	67	$120,000
GIS05	Raising and enlarging Parkdale Drive crossing to meet 10-year requirements	67	$90,000
GIS02	Stormwater Management pond to remove ~ 7 houses from 10-year floodplain	62	$2,440,000
GIS06	Removing railroad fill downstream of North Mill Road to remove 2 houses from 10-year floodplain	59	$350,000
GIS03*	Pond to remove 1-5 houses from 10-year floodplain	46	$690,000
GIS01*	Pond to remove 3 houses from 100-year floodplain	38	$690,000
		TOTAL	$4,380,000

* Shaded projects are shown for informational purposes only and are not recommended. Not included in total.

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Gish Branch	1	0
	2	5
	3	9
	Total	14

If the proposed pond is built, approximately 4 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.8 GLADE CREEK WATERSHED PLAN

The watershed plan for Glade Creek includes a stormwater management pond on Cook Creek, road and culvert improvements, and other flood mitigation measures. The ponds and other flood hazard mitigation measures are described in greater detail in Section 2.8 of this report and are also shown on Figure 2.8.1. The major flooding problem in the Glade Creek watershed is near the mouth downstream of Gus W. Nicks Boulevard. This problem area is not impacted by upstream ponds, so other flood hazard mitigation measures are recommended. The projects in order of priority based on the rating system are shown in Table 3.8.1.

Table 3.8.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
GLD04	Adding flap gates to storm sewers within the Town of Vinton to reduce house flooding	75	$310,000
GLD02	Raising Tinker/Kermit Avenue along Glade Creek to act as a levee to protect houses along Dunkirk Avenue from backwater flooding	74	$330,000
GLD12	Raising and enlarging Dogwood Hill Road crossing on Glade Creek Tributary A to meet 10-year requirement	67	$80,000
GLD03	Raising Tinker Avenue upstream of Norfolk & Western railroad on Glade Creek to act as a levee to remove ~ 6 buildings from the 100-year floodplain	62	$340,000
GLD01	Pond upstream of Challenger Avenue on Cook Creek to remove ~ 6 houses from 10-year floodplain	62	$1,640,000
GLD11	Raising and enlarging Glade View Drive Crossing on Glade Creek Tributary A to meet 10-year requirement	59	$140,000

Project	Description	Rating	Estimated Cost
GLD14	Enlarging Spring Tree Drive Crossing on Glade Creek Tributary A to meet 10-year requirement	59	$130,000
GLD09	Raising and enlarging Berkley Road on Glade Creek Tributary A to meet 10-year requirement	59	$160,000
GLD07	Raising Berkley Road along Glade Creek to meet 10-year requirements	59	$160,000
GLD13	Raising and enlarging Belle Avenue crossing on Glade Creek Tributary A to meet 10-year requirement	59	$180,000
GLD08	Raising Glade Creek Road on Glade Creek to meet 10-year requirement	59	$180,000
GLD15	Enlarging Shopping Center Access Road on Glade Creek Tributary A to meet 10-year requirement	53	$110,000
GLD10	Raising King Street along Glade Creek Tributary A to meet 10-year requirement	51	$350,000
GLD06	Raising Gus W. Nicks Boulevard on Glade Creek to meet 10-year requirements	51	$390,000
GLD05	Raising Walnut Avenue on Glade Creek to meet 10-year requirement	47	$1,390,000
		TOTAL	$5,890,000

Floodproofing

The number of buildings to be floodproofed on each stream for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Glade Creek	1	47
	2	44
	3	18
Cook Creek	1	3
	2	6
	3	5
Glade Creek Tributary A	1	0
	2	3
	3	2
Glade Creek Tributary B	1	0
	2	3
	3	7
	Total	138

If the proposed levees are built along Glade Creek, approximately 40 structures would not need to be floodproofed. If the proposed pond on Cook Creek is built, approximately 3 houses would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.09 Lick Run Watershed Plan

The watershed plan for Lick Run includes bridge and culvert improverments and other flood mitigation measures. The major flooding problem in the Lick Run watershed is at the confluence of Lick and Trout Run near Williamson Road. The projects in order of priority based on the rating system are shown in Table 3.09.1.

Table 3.09.1 Recommended Projects for Watershed Plan

PROJECT	DESCRIPTION	RATING	ESTIMATED COST
LIC03	Enlarging storm sewer system near Williamson Road and Norfolk & Western Railroad to carry 100-year flow and prevent flooding of central business district	84	$5,220,000
LIC04	Raising and enlarging 10th Street crossing to meet 10-year requirements	67	$320,000
LIC06	Enlarging Frontage Road Crossing to meet 10-year requirements	59	$110,000
LIC07	Enlarging Sioux Ridge Road Crossing to meet 10-year requirements and relieve structure flooding	59	$120,000
LIC05	Enlarging Sheraton Access Road crossing to meet 10-year requirements	55	$130,000
LIC02	Pond downstream of Hershberger Road Interchange east of Route 581	46	$870,000
LIC01	Pond upstream of Hershberger Road on western tributary	46	$950,000
		TOTAL	$7,720,000

* Shaded projects are shown for informational purposes only and are not recommended. Not included in total.

Floodproofing

The number of buildings to be floodproofed on each stream for each category of floodproofing are summarized below.

Stream	Floodproofing Category	Number of Buildings
Lick Run	1	41
	2	64
	3	37
Trout Run	1	0
	2	59
	3	17
	Total	218

The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.10 Mason Creek Watershed Plan

The watershed plan for Mason Creek includes bridge and culvert improvements and other flood mitigation measures. No feasible pond sites were found in the Mason Creek watershed because of the proximity of the creek to Catawba Valley Drive - State Route 311. The major flooding problem in the Mason Creek watershed is near the Lakeside Plaza and in several trailer parks along the stream. The projects in order of priority based on the rating system are shown in Table 3.10.1.

Table 3.11.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
MUD04	Enlarging Norfolk and Western Railroad Crossing removes upstream roads and 1-5 structures from 10-year floodplain	75	$170,000
MUD05	Raising and Enlarging Mudlick Road Crossing to meet 10-year requirements	67	$160,000
MUD01	Stormwater Management Pond upstream of Electric Road removes 6-20 houses from 10-year floodplain	62	$3,190,000
MUD06	Raising and Enlarging Halevan Road Crossing to meet 10-year requirements	59	$150,000
MUD07	Enlarging Crest Hill Drive Crossing to meet 10-year requirements	59	$160,000
MUD02*	Pond ~ 800' upstream of Farmington Drive removes 1-5 houses from 10-year floodplain	46	$2,250,000
MUD03*	Pond ~ 700' upstream of Canter Road removes 1-5 houses from 10-year floodplain	46	$1,690,000
		TOTAL	$3,670,000

* Shaded projects are shown for informational purposes only and are not recommended. Not included in total.

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Mudlick Creek	1	1
	2	38
	3	34
	Total	73

If the proposed pond MUD01 is built, approximately 10 of the above structures would not need to be floodproofed. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.12 MURRAY RUN WATERSHED PLAN

The watershed plan for Murray Run includes two stormwater management ponds, bridge and culvert improvements, and other flood mitigation measures. The ponds are described in greater detail in Section 2.12 of this report and are also shown on Figure 2.12.1. Murray Run experiences many scattered flooding problems along Brandon Avenue, in the Lakewood subdivision, at the Pebble Creek Apartments and in the Green Valley subdivision. The projects in order of priority based on the rating system are shown in Table 3.12.1.

Table 3.12.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
MUR04	Enlarging Ogden Road Crossing to meet 10-year requirements and to remove some of the upstream apartments from the 10-year floodplain	67	$100,000
MUR03	Enlarging West Road Crossing to meet 10-year requirements	67	$80,000

Project	Description	Rating	Estimated Cost
MUR05	Enlarging Crawford Road Crossing to meet 10-year requirements and to remove some of the upstream houses from the 10-year floodplain	67	$180,000
MUR01	Stormwater Management Pond upstream of Colonial Avenue in Jefferson Park in combination with MUR02 removes approximately 20 houses from the 10-year floodplain	62	$2,120,000
MUR02	Stormwater Management Pond upstream of the upstream Brambleton Avenue Crossing in Fishburn Park (see above)	62	$1,680,000
		TOTAL	$4,160,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Murray Run	1	2
	2	9
	3	46
	Total	57

If the proposed ponds, MUR01 and MUR02, are built, approximately 5 of the above structures would not need to be floodproofed and depths of flooding on the other structures would be decreased. The buildings identified for the various categories of floodproofing are identified on the workmaps submitted as an addendum to this report.

3.13 Ore Branch Watershed Plan

The watershed plan for Ore Branch includes bridge and culvert improvements and other flood mitigation measures. Two ponds were analyzed (ORE01 and ORE02) but are not recommended in this watershed plan because they did not reduce flood discharges in the problem area near the mouth of Ore Branch. These ponds are described in greater detail in Section 2.13 of this report. Ore Branch experiences flooding of commercial and industrial areas near its confluence with the Roanoke River. There is some flooding of residential areas upstream of Griffin Road. The projects in order of priority based on the rating system are shown in Table 3.13.1.

Table 3.13.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
ORE10	Raising and Enlarging Broadway Avenue Crossing to meet 10-year	67	$70,000
ORE03	Raising and Enlarging Wiley Drive Crossing to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	67	$120,000
ORE09	Enlarging Wonju Street Crossing to remove some upstream buildings from the 2- and 10-year floodplains	75	$170,000
ORE06	Raising and Enlarging Downstream Holdrens Warehouse Crossings to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	71	$90,000
ORE07	Raising and Enlarging Upstream Warehouse Crossings to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	63	$120,000
ORE08	Raising and Enlarging Private Lumber Company Crossing to meet 10-year requirements	63	$80,000
ORE05	Raising and Enlarging Brandon Avenue Crossing to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	59	$270,000

Project	Description	Rating	Estimated Cost
ORE04	Raising and Enlarging Holiday Inn Bridge to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	55	$280,000
ORE11	Enlarging Parking Lot Culvert to meet 10-year requirements and to remove some upstream buildings from the 2- and 10-year floodplains	55	$410,000
ORE12*	Enlarging Recycling Yard Culvert to meet 10-year requirements	41	$1,110,000
		TOTAL	$1,610,000

* Shaded project not recommended but shown for informational purposes and not included in total

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Ore Branch	1	10
	2	27
	3	25
	Total	62

The buildings identified for the various categories of floodproofing are mostly commercial and industrial businesses and are identified on the workmaps submitted as an addendum to this report.

3.14 PETERS CREEK WATERSHED PLAN

The watershed plan for Peters Creek includes bridge and culvert improvements and other flood hazard mitigation measures. The projects in order of priority based on the rating system are shown in Figure 3.14.1.

Table 3.14.1 Recommended Projects for Watershed Plan

Project	Description	Rating	Estimated Cost
PTR12	Raising Woodhaven Road along Peters Creek Tributary B to meet 10-year requirements	75	$80,000
PTR20	Enlarging Timberview Road Crossing on Peters Creek Tributary A to meet 10-year requirements	75	$80,000
PTR09	Lower North Detention Basin	74	$750,000
PTR10	Montclair Detention Basin	74	$750,000
PTR14	Enlarging Northwood Drive Crossing on Peters Creek Tributary C to meet 10-year requirements	67	$60,000
PTR17	Enlarging Unity Church Drive Crossing on Peters Creek Tributary A to meet 10-year requirements	67	$60,000
PTR04	Raising and Enlarging Green Ridge Road Crossing to meet 10-year requirements	67	$100,000
PTR15	Raising and Enlarging Green Ridge Road Crossing on Peters Creek Tributary C to meet 10-year requirements	67	$110,000
PTR11	Enlarging Green Ridge Road Crossing on Peters Creek Tributary B to meet 10-year requirements	67	$190,000
PTR05	Raising and Enlarging Peters Creek Road Crossing to meet 10-year requirements	63	$510,000
PTR01	Pond on Peters Creek Tributary A upstream of Interstate 81	62	$790,000
PTR02	Pond on Peters Creek Tributary B upstream of Interstate 81	62	$980,000

Project	Description	Rating	Estimated Cost
PTR13	Raising Laura Drive along Peters Creek Tributary C to meet 10-year requirements	59	$110,000
PTR07	Raising and enlarging Peach Tree Drive crossing to meet 10-year requirements	59	$140,000
PTR08	Raising and enlarging Northwood Drive crossing to meet 10-year requirements	59	$140,000
PTR19	Raising Loch Haven Road Crossing on Peters Creek Tributary A to meet 10-year requirements	59	$130,000
PTR03	Raising and enlarging Westside Boulevard crossing to meet 10-year requirements	59	$160,000
PTR18	Raising Green Ridge Road along Peters Creek Tributary A and Enlarging Green Ridge Road Crossing on Peters Creek Tributary A to meet 10-year requirements	55	$510,000
PTR06	Raising and enlarging Shenandoah Bible College Access Road crossing to meet 10-year requirements	55	$160,000
PTR16	Enlarging Embassy Drive Crossing on Peters Creek Tributary C to meet 10-year requirements	51	$370,000
		TOTAL	$6,180,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Peters Creek	1	1
	2	87
	3	88
Peters Creek Tributary A	1	0
	2	0
	3	3
Peters Creek Tributary B	1	0
	2	0
	3	4
Peters Creek Tributary C	1	0
	2	1
	3	42
	Total	226

The buildings identified for floodproofing are identified on the workmaps submitted as an addendum to this report.

3.15 TINKER CREEK WATERSHED PLAN

The watershed plan for Tinker Creek includes bridge and culvert improvements and other flood hazard mitigation measures. The projects in order of priority based on the rating system are shown in Figure 3.15.1.

Table 3.15.1 **Recommended Projects for Watershed Plan**

Project	Description	Rating	Estimated Cost
TKR01	Raising Dale Avenue Crossing to meet 10-year requirements	75	$220,000
TKR06	Raising Summerview Drive Crossing to meet 10-year requirements	59	$180,000
TKR02	Raising and Enlarging 13th Street Crossing to meet 10-year requirements	51	$400,000
TKR03	Raising Tinker Creek Lane along Tinker Creek to meet 10-year requirements	51	$360,000
		TOTAL	$1,390,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Tinker Creek	1	36
	2	63
	3	59
	Total	158

The buildings identified for floodproofing are identified on the workmaps submitted as an addendum to this report.

3.16 WOLF CREEK WATERSHED PLAN

The watershed plan for Wolf Creek includes bridge and culvert improvements and one structure to be floodproofed. The projects in order of priority based on the rating system are shown in Table 3.16.1.

Table 3.16.1 **Recommended Projects for Watershed Plan**

Project	Description	Rating	Estimated Cost
WLF03	Enlarging Mountain View Road Crossing to meet 10-year requirements	75	$50,000
WLF01	Enlarging Niagara Road Crossing to meet 10-year requirements	67	$50,000
WLF02	Enlarging Hardy Road Crossing to meet 10-year requirements	67	$200,000
		TOTAL	$300,000

Floodproofing

The number of buildings to be floodproofed for each category of floodproofing are summarized below:

Stream	Floodproofing Category	Number of Buildings
Wolf Creek	1	0
	2	0
	3	1
	Total	1

The building identified for floodproofing is identified on the workmaps submitted as an addendum to this report.

CHAPTER 4 - REGULATORY ISSUES

Projects that involve construction in waterways are typically regulated by the U.S. Army Corps of Engineers under the Clean Water Act. Section 404 of the act requires a permit for the discharge of dredged or fill material into the Waters of the United States. The "Waters of the U.S." include perennial and intermittent streams -- anything with an ordinary high water mark -- as well as wetlands. The presence of a defined channel or "bed and bank" situation is often used to classify a stream as Waters of the U.S. Wetlands are defined by the Corps and the Environmental Protection Agency (EPA) as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." Wetlands are delineated in the field through the application of the methodology in the 1987 Corps of Engineers Wetlands Delineation Manual. This methodology requires that field indicators of hydrophytic vegetation, hydric soils and wetlands hydrology must be present for an area to be identified as a wetland.

A review of available information along with a reconnaissance-level field investigation was undertaken to determine the presence and general extent of Waters of the U.S. that could be affected by the various projects under evaluation. Information reviewed included the U.S.G.S. 7 ½ minute topographic quadrangles to determine whether the particular waterway had been mapped as a perennial or intermittent stream and the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) mapping. The NWI maps use the U.S.G.S. 7 ½ minute quadrangles as a base map and depict wetland areas identified through the use of color infrared aerial photographs. The NWI mapping for the Roanoke area was developed through the interpretation of photographs at a scale of 1:58000 (1" = 4833') taken in April 1982. Wetlands are identified through vegetation, visible hydrology and geography and the maps note that they may not include "small wetlands and those obscured by dense forest cover". The following tabulation summarizes the information obtained from our review of the U.S.G.S. and NWI maps.

Watershed	Facility	U.S.G.S.	NWI	Field Reviewed	Comments
Back Creek	BAC01	Perennial	----	✓	Volume limited by parallel road
	BAC02	Intermittent	----	✓	
	BAC03	Perennial	----	✓	Henry Farms Road
	BAC04	Intermittent	----	✓	Small wetland at base of slope
	BAC05	Intermittent	----	✓	Back Creek itself is R3UB in this area
	BAC06	Intermittent	----	✓	Back Creek itself is R3UB in this area
Back Creek	BAC07	Intermittent	----	✓	Back Creek itself is R3UB in this area
	BAC08	Intermittent	----	✓	Back Creek itself is R3UB in this area
	BAC09	Intermittent	----	✓	Good volume in swale beside Amanda Lane
	BAC10	Intermittent	----	✓	
Barnhardt Creek	BAR02	Intermittent	----	✓	Wide valley section
	BAR03	Intermittent	----	✓	Existing residence along stream
	BAR05 (culvert)	Perennial	----	✓	Flat area, many homes with flooding problems
Butt Hollow Creek	BUT01	Intermittent	----	✓	
	BUT02	Intermittent	----	✓	

Watershed	Facility	U.S.G.S.	NWI	Field Reviewed	Comments
Carvin Creek	CAR01	Perennial	R3UBH	✓	Mature woodlands; sanitary sewer along stream
	CAR02	Ponded/ Intermittent	----	✓	U/S of Peters Creek Road
	CAR03	Intermittent	----	✓	Existing structure at airport
	CAR04	Intermittent	----		
(culverts)	CAR06	Perennial	R3UBH	✓	Existing quad culverts
(clear & snag)	CAR09	Perennial	R3UBH		
Cole Hollow	COL01	Perennial	----	✓	Existing interchange
Dry Branch	DRY01	Intermittent	----	✓	Adequate storage in hollow
	DRY03	Intermittent	----	✓	Hanging Rock, G.C.
Gish Branch	GIS02	Intermittent *	----	✓	*Downstream of a perennial reach per U.S.G.S. quad
Glade Creek	GLD01	Intermittent	----	✓	Modified channel in this area
Lick Run	LIC04	Intermittent	----	✓	Twin 54" pipes take drainage under new development
Mudlick Creek	MUD01	Perennial	----	✓	Existing residence in floodplain
Murray Run	MUR01	Intermittent	----	✓	New sanitary sewer
	MUR02	Intermittent	----	✓	In public park
Ore Branch	ORE03	----	----	✓	
	ORE04	----	----	✓	Deep, steep hollow behind Kmart
Peters Creek	PTR01	Intermittent	----	✓	Open location, recreational facility
	PTR02	Intermittent	----	✓	Small wetland area noted in field

Watershed	Facility	U.S.G.S.	NWI	Field Reviewed	Comments
Tinker Creek	TKR01	Intermittent	R3UBH	✓	Open floodplain; large stream
	TKR02	Perennial	----	✓	PFOIA/PEMIA upstream
	TKR08	Perennial	----	✓	
	TKR05	Intermittent	----	✓	Small wetland area d/s from road
	TKR04	Intermittent	----	✓	P5S1Fh downstream
	TKR06	Intermittent	----	✓	
	TKR07	Intermittent	----	✓	Small existing pond on site

As can be seen from the tabulation, the majority of the proposed projects are on intermittent streams. Twelve are proposed for streams designated as perennial by the U.S.G.S., while six are located in swales or drainageways with no U.S.G.S. designation. Forty-nine sites being evaluated as potential project locations in the summer of 1996 were reviewed in the field. The purpose of the reconnaissance-level investigation was to corroborate the U.S.G.S. and NWI designations as well as to note the presence of any vegetated wetlands that were not depicted on the NWI mapping.

The review of the NWI mapping indicated that few wetlands would be impacted by the proposed project and our field investigation supported that conclusion. The NWI mapping depicts vegetated wetlands at or near only two of the proposed project sites. These are TKR02 and TKR04. Small, primarily emergent wetlands were noted during our field investigation at PTR02, BAC04 and TKR05. Any of these areas could be impacted by the facilities proposed at these locations; measures to avoid or minimize impacts at these locations should be evaluated during the final design of these projects.

While very few of the proposed project locations had vegetated wetlands present, the fact that nearly all of them had a defined channel (bed and bank) qualifies them as Waters of the U.S. Thus, impacts to these waterways, whether it is from the construction of embankments for detention facilities, or from the fills for new culverts will require authorization from the Corps of Engineers. Since the Corps of Engineers' jurisdiction under the Clean Water Act is very broad, they have adopted a number of general permits that authorize certain activities in the Waters of the U.S. One group of general permits is known as the Nationwide Permits (NWP); the NWPs and their possible application to the projects being studied in Roanoke are described below.

The NWPs are a type of general permit issued by the Corps designed to regulate certain activities having minimal impact with little, if any, delay or paperwork. The NWPs are evaluated every five years and are either reissued, modified, revoked or new ones issued. The current NWP program expires in January 1997 and a new program will be in place by that time. Under the current NWP program, there are two permits that are particularly applicable to the type of projects being evaluated.

NWP 26 allows for the discharge of dredged or fill material into headwaters or isolated Waters of the U.S. Headwaters are defined as nontidal rivers, streams, their impoundments and adjacent wetlands that are upstream of the point along the river or streams where the average annual flow is less than five cubic feet per second. In Virginia, this has been equated to these waterbodies having a contributing drainage area of less than five square miles. Thus, the majority of the projects being evaluated are located in the headwaters.

NWP 26 currently allows for impacts of up to one acre with no notification to the Corps of Engineers. Projects impacting between one and ten acres require notification, while those that impact over ten acres require individual permit review. Notification requirements include contacting the U.S. Fish & Wildlife Service and Virginia Department of Historic Resources for information on endangered/threatened species and archaeologic (historic) resources that could be affected by the proposed project. However, these are included with the conditions that must be met for any NWP to be valid, so it is prudent to coordinate the proposed projects with these agencies under any application of the NWP.

A number of the proposed projects were reviewed in the field on August 21, 1996 with Mr. Thomas Leedon of the Norfolk District Corps of Engineers, Christiansburg field office. He concurred that while very few of the proposed projects would impact vegetated wetlands, the majority were sited on waterways classified as Waters of the U.S. and therefore required authorization. He also stated that NWP 26 would be the most expedient means of authorizing the projects; the only question would be whether the projects are reviewed individually, by stream or watershed, or as one entire project. The Corps must consider the cumulative impact of the individual projects, each of which may only have a minimal impact, in their decision process. As designs of the individual projects move forward, it is recommended that Mr. Leedon be contacted for verification that any impacts to the Waters of the U.S. are authorized by NWP 26.

New road crossings can be authorized by NWP 14. This NWP has a number of provisions that must be met in order for it to apply. The key provisions are briefly summarized below.

- The width of the fill is limited to the minimum necessary for the crossing.
- No more than ⅓ acre of waters of the U.S. can be filled at a crossing.
- The linear extent of the fill in special aquatic sites, including wetlands, cannot exceed 200 feet.
- Fills in special aquatic sites require notification to the Corps.

In addition to the provisions of each NWP, all the NWPs have conditions that must be met in order for the authorization to be valid. A copy of the current NWPs 14 and 26, with their attendant conditions is included in the appendices.

The Virginia Department of Environmental Quality has issued Water Quality Certifications to the Corps for NWPs 14 and 26. These certifications also contain conditions that must be met. If a particular project does not comply with one or more of the DEQ conditions, an individual water quality certification, in the form of a Virginia Water Protection Permit, must be obtained. Copies of the DEQ certifications for NWPs 14 and 26 are also included in the appendices.