INTEGRATED Science & Engineering

TECHNICAL MEMORANDUM

Cherokee County
Future Conditions Floodplain Development

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Cherokee County

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PURPOSE AND SCOPE

Integrated Science and Engineering, Inc. (ISE) has developed Future Conditions Floodplains to assist Cherokee County with compliance with the new requirements set forth by the Metropolitan North Georgia Water Planning District (MNGWPD) specifically the MNGWPD Model Floodplain Management/Flood Damage Prevention Ordinance dated February 2, 2006. The requirements that are unique to the MNGWPD Model Ordinance are as follows:

- Establishment of a “Regulatory Flood” based on the future condition hydrology data as determined by the County’s future land use plan. Please note that this term differs from the existing FEMA term related to the “regulatory flood”.
- Applying the flood hazard determinations to streams with a drainage area of 100 acres or more.
- Establishment of elevations for the regulation of residential and non-residential structures in and adjacent to the flood hazard areas.

This study includes all streams in the County that have a drainage area in excess of 100 acres with the exception of the following named streams / rivers:

- Etowah River
- Little River
- Long Swamp Creek
- Shoal Creek
- Salacoa Creek
- Sharp Mountain Creek

These streams / rivers have significant drainage basins located outside of the County. Based on discussions with MNGWPD staff, the MNGWPD has not formulated a formal policy on these cross-jurisdictional water bodies / watersheds. However, the staff did indicate that the District’s primary concern was not the major rivers like the Etowah River and Little River but rather the smaller watersheds that have not traditionally been strictly regulated with regard to floodplain management due to outdated flood maps, or lack of floodplain delineations. As such, it is our recommendation that the County wait until the District clarifies its position on these rivers and future conditions floodplain development and proceed with the other smaller local streams within these watersheds. As a policy, the County may want to consider adopting the 500-year FEMA floodplains for these six rivers until such time as the District defines a more formal policy for the large river systems.

ISE has prepared this Technical Memorandum to provide Cherokee County with the technical basis and methodologies used for development of the County’s Future Conditions Floodplain.

WATERSHED DELINEATION AND NAMING

ISE identified 11 major watershed basins within Cherokee County. The drainage basins were delineated such that the drainage channels where the regulatory framework of the MNGWPD Model Ordinance will apply were identified. In simpler terms, all drainage channels in the County that have a drainage area of at least 100 acres as well as those that encompass 640 acres or more were delineated except for those streams within the corporate boundaries of the Cities of Canton, Woodstock and Holly Springs.

Drainage basin delineations were performed using USGS 7.5 minute topographic mapping as well as the County's recent LiDAR topography. Streamlines were delineated using the LiDAR topographic mapping.

Within each major basin, individual drainage basins were delineated and named. Each major basin was assigned a unique identification code consisting of two or more letters. Drainage basins were then delineated. The naming convention for the drainage basin uses a sequential numbering system that is added to the major basin identifier. This number reflects the position of the sub-watershed within the major basin. If the sub-watershed includes a name stream, the stream name (as shown on the USGS quadrangle maps) is also included in the naming system. For example, Little Shoal Creek is designated as ShC_03 Little Shoal Creek. This designation shows that Little Shoal Creek is in the Shoal Creek Watershed, and is the third drainage basin upstream of the confluence of Shoal Creek and Etowah River. This naming convention was used throughout the study. Table 1 summarizes the major watershed and shows the identification code for each one.

Table 1 Major Watersheds of Cherokee County

Major Watersheds	Identification Code	Drainage Basins within the Major Watershed
Boston Creek	BC	4
Cobb Creek	CbbC	2
Etowah River	ER	73
Hawks Branch	HB	1
Little River	LR	41
Long Swamp Creek	LSC	9
Pine Log Creek	PLC	3
Salacoa Creek	SaC	12
Sharp Mountain Creek	SMC	15
Shoal Creek	ShC	27
Stamp Creek	StC	4

Each drainage basin was further divided into sub-basins. Sub-basin delineation was based on manmade and natural features, and was performed in such a manner as to provide the appropriate design points for the hydrologic and hydraulic analyses.

HYDROLOGIC ANALYSIS

ISE calculated future land use condition flows by estimating the impervious surface coverage for the future land use conditions based on the future land use maps from Cherokee County and the surrounding counties. The USGS regression equations were then used estimate the future conditions 100-year discharge.

Future Land Use

Future land use maps were obtained for Cherokee County. Several of the streams that fall under the provisions of the MNGWPD ordinance receive stormwater discharges from areas outside of the county. Therefore, ISE also obtained future land use maps from Bartow, Pickens, Dawson, Forsyth, Fulton and Cobb counties.

Impervious areas were estimated based on the land use categories in the Future Land Use Maps. The land use maps were clipped to the delineated sub-basins. Impervious percentages were then assigned to each separate land us category based generally on information contained in the Georgia Stromwater Management Manual, Vol. 2, 1st Edition (GSMM).

Figure 1 shows the extent of the future land use coverage, including areas outside of Cherokee County. Table 2 lists the future land use categories and the assumed impervious percentage for each.

Figure 1 Future Land Use

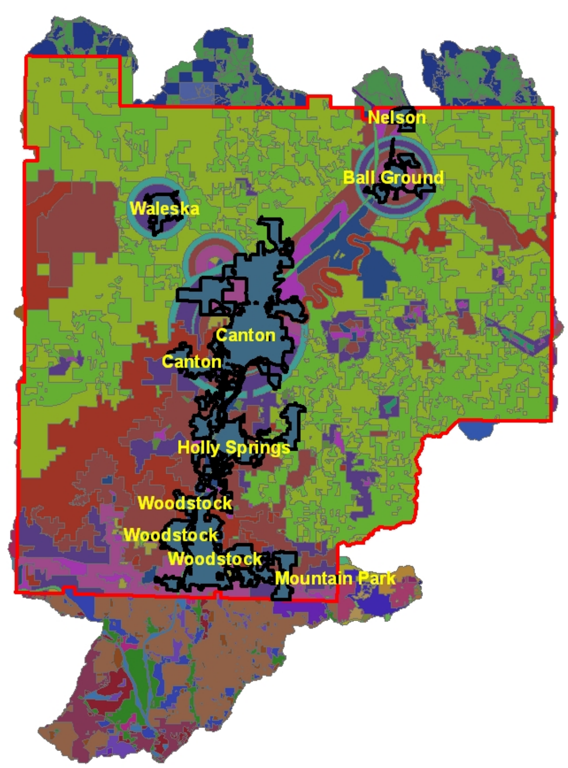


Table 2 Future Land Use

County/City	Future Land Use	% Impervious
Alpharetta	Alpharetta - Commercial	85.0%
Bartow County	Bartow - Agriculture/Forestry	1.0%
	Bartow - Industrial	72.0%
	Bartow - Park/Recreation/Conservation	0.5%
	Bartow - Rural Estate	12.0%
Cherokee County	Cherokee - Activity Center	78.0%
	Cherokee - Agriculture/Forestry	1.0%
	Cherokee - Commercial	85.0%
	Cherokee - Industrial	72.0%
	Cherokee - Park/Recreation/Conservation	0.5%
	Cherokee - Public/Intitutional	78.0%
	Cherokee - Residential High Density (2.2-4.0 dua)	30.0%
	Cherokee - Residential Low Density (0.0-1.1 dua)	12.0%
	Cherokee - Residential Medium Density (1.1-2.2 dua)	23.0%
	Cherokee - Residential Multi-Family	65.0%
	Cherokee - Transition Zone	6.0%
	Cherokee - Transportation/Communication/Utilities	65.0%
	Cherokee - Undeveloped	1.0%
	Cherokee - Urban	26.0%
Cobb County	Cobb - City	26.0%
	Cobb - Commercial	85.0%
	Cobb - High Density Residential	30.0%
	Cobb - Industrial	72.0%
	Cobb - Low Density Residential	12.0%
	Cobb - Medium Density Residential	23.0%
	Cobb - Park/Recreation/Conservation	0.5%
	Cobb - Public Institution	78.0%
	Cobb - Transportation/Communication/Utilities	65.0%
	Cobb - Very Low Density Residential	12.0%
Dawson County	Dawson - Planned Community Residential	23.0%
	Dawson - Rural Residential	12.0%
Forsythe County	Forsythe - Commercial	85.0%
	Forsythe - High Density Residential	30.0%
	Forsythe - Low Density Residential	12.0%
	Forsythe - Medium Density Residential	23.0%
	Forsythe - Park/Recreation/Conservation	0.5%
	Forsythe - Public Institution	78.0%
Fulton County	Fulton - Low Density Residential	12.0%
	Fulton - Medium Density Residential	23.0%
Milton	Milton - 1 Unit/Acre or Less Residential	12.0%
Pickens County	Pickens - Agriculture/Forestry	1.0%
	Pickens - Commercial	85.0%

County/City	Future Land Use	% Impervious
	Pickens - Industry	72.0%
	Pickens - Park/Recreation/Conservation	0.5%
	Pickens - Public/Institutional	78.0%
	Pickens - Residential	12.0%
	Pickens - Transportation/Communication/Utilities	65.0%
	Pickens - Undeveloped	1.0%
Roswell	Roswell - Commercial	85.0%
	Roswell - Estate Medium Residential (.6-1 units per acre)	16.0%
	Roswell - Estate Residential (0.5 units per acre)	12.0%
	Roswell - Low Density Residential (1-1.5 units per acre)	23.0%
	Roswell - Medium Density Residential (3-5 units per acre)	38.0%
	Roswell - Parks/Recreation/Open Space	0.5%
	Roswell - Public Institutional	78.0%
	Roswell - Suburban Residential (2-2.5 units per acre)	30.0%

Regression Equations

Traditionally, engineers have estimated flow rates based on existing land use and other stormwater controls in place. However, the requirements of the ordinance require that the County estimate the flows based on future land use conditions. Given the requirements, the most feasible means of developing the peak runoff rates is the use of the USGS regression equations as documented in Section 2.1.6 of the Georgia Stormwater Management Manual (GSMM) Volume 2, 1st Edition. The inputs for this method are drainage basin size and estimated impervious surface coverage. The existing drainage basins were used since they are not likely to change significantly, and the impervious surface coverage was estimated as described above. The only disadvantage to this method is the fact that the method has a 19.1 square mile limit for watershed size. As such, estimating flows for very large watersheds is somewhat problematic.

HYDRAULIC ANALYSIS

The hydraulic analysis is dependant on the input of physical parameters to simulate flow conditions in the floodplain. Data such as floodplain cross section geometry, roughness coefficients, culvert and roadway profiles and ineffective flow areas were incorporated into the models to obtain a realistic representation of the streams.

ArcGIS Processing of Physical Geometry

ArcGIS 9 *(ESRI ArcMap 9.2, 2006)* and HEC-GeoRas (US Army Corps of Engineers, Version 4, September 2005) were used extensively to process the physical data in a GIS based environment. Cherokee County LiDAR topography was used within ArcGIS to generate many of the required physical parameters.

Cross sections are located at key locations to characterize the flow carrying capability of the stream and its adjacent floodplain. Whenever possible, cross sections extend across the entire floodplain and are perpendicular to the anticipated flow paths. Cross section spacing, or reach length, are determined by changes in the typical geometry of the stream and floodplain due to changes in slope, uniformity of cross section shape or roughness.

ISE conducted a limited culvert inventory to obtain the size and type of the culverts and bridges located on the modeled streams. Culvert and roadway embankment profile data was obtained from the LiDAR topography in the same manner as the cross section geometry.

LiDAR topography was used to generate a 3D surface within ArcGIS. The HEC-GeoRAS extension used the cross section and stream centerlines to extract the physical data necessary to construct the hydraulic model. The data was then exported from ArcGIS into the HEC-RAS model.

Stream and Cross Section Coefficients

Roughness Coefficients, referred to as Manning's "n" values, provide a way to mathematically simulate the resistance of various type of surfaces and vegetation cover to the flow of water. The Manning's "n" values are dependent on such features as the regularity of the channel or over-bank geometry, vegetative cover, presence of obstructions (i.e. houses or debris clogs), among others. All roughness coefficients used for this study are in accordance with the *Georgia Stormwater Management Manual Vol.2, 1st Edition* (GSMM), Chapter 4 "Stormwater Drainage System Design", Table 4.4-5. Manning's "n" values were added for the left over-bank, channel, and right over-bank segments of each cross section after the data was exported from ArcGIS to HEC-RAS.

Manning's "n" values range from 0.03 to 0.07 for the channels in Cherokee County. An "n" value of 0.03 is used for a straight, clean channel covered with short grass. This type of channel is typically found in urbanized areas. An "n" value of 0.07 is used to describe winding or meandering channels, have large portions of the channel covered with large diameter trees or brush, have a high degree of variation in channel geometry from one cross section to the next, and have a high degree of debris accumulation in the channel.

The overbank roughness coefficients range from 0.035 to 0.1. The smoothest value of 0.035 is somewhat atypical for overbanks and is only used for areas that are flat and have little if any flow obstruction cause by vegetative cover. These areas are found exclusively in the highly urbanized areas of the County. An example of this type of terrain would be a yard or a golf course. A large portion of the cross sections used for the hydraulic analysis have an "n" value of 0.1 for the overbank areas. This value is used in heavily wooded areas where the large diameter trees cause a significant resistance or obstruction to the flow.

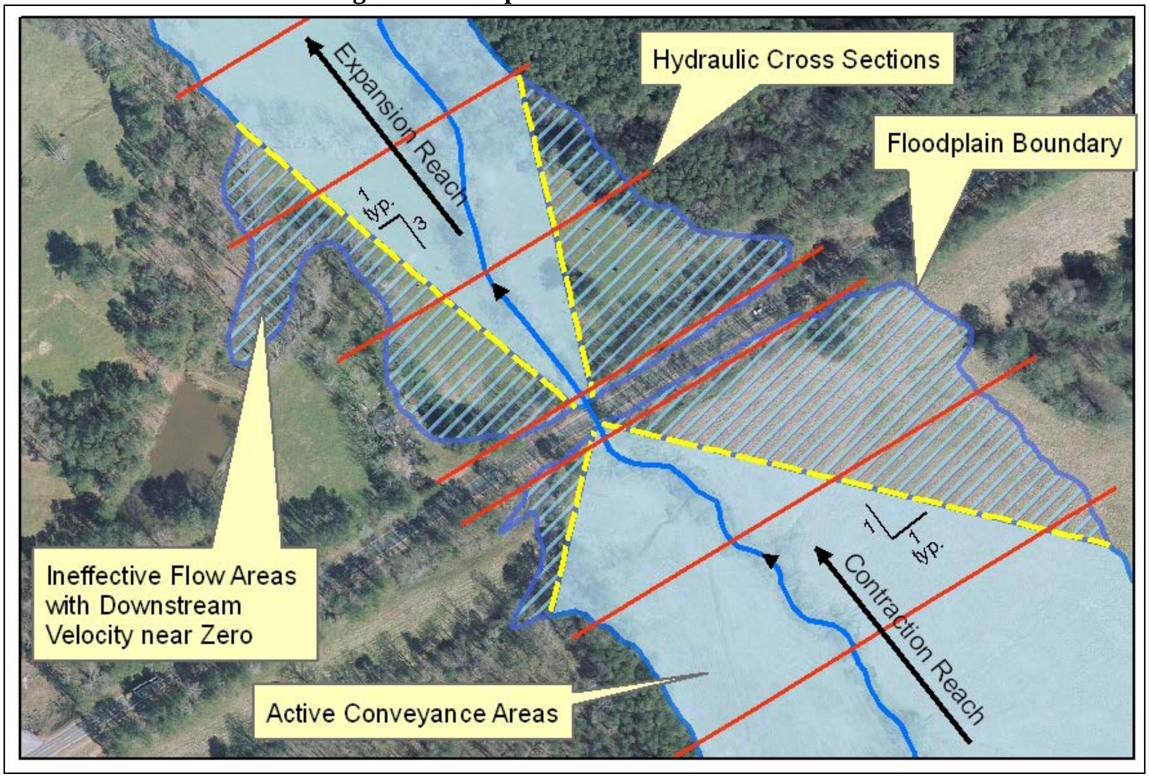
Another factor that influences the hydraulic operation of a stream is the expansion and contraction of the flow between cross section. Such expansion and contraction may be due to nature features such as a hill slope, or due to manmade features such as a culvert. For “natural” or unobstructed cross sections, the expansion coefficients range from 0.1 to 0.3, and the contraction coefficients range from 0.3-0.5. Upstream of the modeled culverts, the coefficients were raised to 0.6 for expansion and 0.8 for contraction to simulate the increase in turbulence caused by the manmade encroachments.

Ineffective Flow Areas

Ineffective flow areas are portions of cross sections that are inundated but do not contribute to the active conveyance of the stream network. There is water in the ineffective flow areas, but the velocity of the water, in the downstream direction, is close to zero. Ineffective flow areas are especially prevalent in the vicinity of structures such as bridges and culverts. As the water approaches a structure, the total floodplain width that contributes to the conveyance of the flood (the effective top width) contracts. Most studies accept that the contraction rate of the effective flow width is at a 1:1 ratio. Likewise, and expansion in the effective flow width occurs downstream of the structure. Various studies put the expansion rate of the effective flow width from the structure at a ratio of 1:1 to 4:1 (units longitudinal to 1 unit lateral). The U.S. Army Corps of Engineers, Hydrologic Engineering Center recommends that an expansion rate of 3:1 to 4:1 be used with the HEC-RAS model. Given the relatively steep slope of the streams within the study area and the relatively high velocities of the channel, ratios of 1:1 for contraction and 3:1 for expansion were used to block out ineffective flow areas of individual cross sections. An example of ineffective flow areas is shown in Figure 1.

It should be noted that the use of ineffective flow areas for this study is generally limited to the culverts and bridges with high embankments. Once the floodwaters inundate a structure such as a culvert (i.e. overtop the roadway), the degree of contraction of the effective top width decreases dramatically.

Figure 2 Example of Ineffective Flow Areas



HEC-RAS

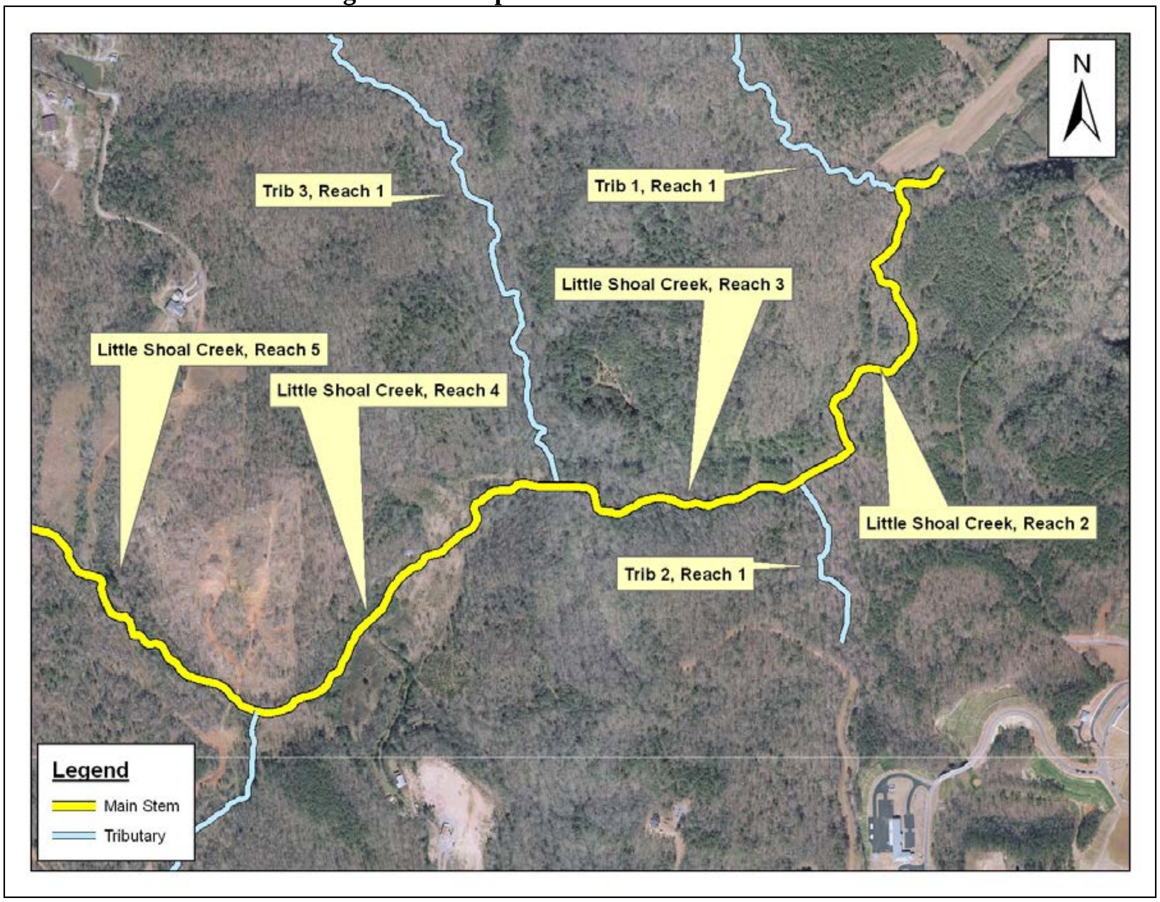
HEC-RAS is a one-dimensional hydraulic analysis system that contains components for steady flow water surface profile computations, unsteady flow simulation and movable boundary sediment transport computations. Only the one-dimensional steady flow portion of the HEC-RAS software was used for this study. The steady flow component of HEC-RAS is capable of modeling sub-critical, super-critical and mixed flow regime water surface profiles within a dendritic stream system or a single river reach. For this analysis, the water surface profiles were completed using the sub-critical flow regime computations.

The HEC-RAS models representing the exiting hydraulic conditions within the selected streams were executed using the 100-year Future Conditions discharge as described earlier.

River and Reach Naming Conventions

Each stream segment in the hydraulic model must be identified by a unique combination of a river name and reach name. The naming convention adopted for the modeled streams is similar to the naming for the hydrologic sub-basins. The stream name is used for the river name of the main stem of the stream network whenever possible. If the stream is not a named stream, then the sub-basin designator is used for the stream name. The tributaries are named numbers that reflect the position of the tributary from the downstream confluence of the main stem. Therefore, Tributary 2 (or Trib 2) would be the second tributary of a stream network. Figure 2 shows an example of the river and reach naming system for the Little Shoal Creek watershed (ShC_03).

Figure 3 Example of River and Reach Names



FLOODPLAIN DELINEATION & MAPPING

ISE utilized the LiDAR topographic data to map the future conditions floodplain and building restriction elevations. A best fit technique was used to adjust the floodplain limits based on review of the hydrologic and hydraulic data as well as the topographic contour data.

Future Conditions Floodplains

Water surface profiles generated by the HEC-RAS models were imported into ArcGIS. The HEC-GeoRAS utility was used to create the initial delineation of the future condition floodplains. The floodplains were checked for inaccuracies cause by differences in the spatial projections and interpolations between the ArcGIS and HEC-RAS software. Edits were made to obtain the final floodplain delineation by comparing the floodplain polygons to the LiDAR topography.

Regulatory Future Conditions Floodplain Elevations

During the floodplain delineation process a shapefile is generated that contains the hydraulic cross section lines used to compute the water surface profile. The attributes of each cross section include the river station and future conditions 100-year water surface elevation.

FIS 500-year Floodplain Delineation

As described previously, no modeling was performed on the six largest streams that have significant drainage are outside the county. However, the County may want to consider adopting the 500-year FEMA floodplains for these six rivers until such time as the District defines a more formal policy for the large river systems.

Portions of Etowah River, Little River and Allatoona Lake are included in the County's Flood Insurance Study (FIS). The downstream reaches of these streams were studied by detailed methods for the original FIS. The 500-year floodplain was delineated using the water surface profiles shown in the FIS and the County's LiDAR topography.

Approximate 500-year Floodplains

To establish a regulatory boundary for the remainder of the streams, the FIS 500-year floodplains were extended upstream to the county boundary. Flows rates and flow depths were estimated using approximate methods based on Manning's equation and the LiDAR topographic mapping. Table 2 shows the six major streams that are not modeled in detail, and the type of 500-year floodplain shown on the floodplain mapping.

Table 3 500-year Floodplains

Named Stream	Type
Allatoona Lake	FIS 500-year
Etowah River Allatoona Lake to approx 8.3 miles upstream of I-575	FIS 500-year
Little River Allatoona Lake to approx. 1.2 upstream of the confluence with Rocky Creek	FIS 500-year
Etwoah River Approx. 8.3 miles upstream of I-575 to County boundary	Approx. 500-year
Little River Approx. 1.2 upstream of the confluence with Rocky Creek to beginning of Future Conditions 100-year study	Approx. 500-year
Long Swamp Creek	Approx. 500-year
Shoal Creek	Approx. 500-year
Salacoa Creek	Approx. 500-year
Sharp Mountain Creek	Approx. 500-year