Neuse River Phase I Watershed Assessment

A review of existing stream and BMP outfall conditions and potential restoration opportunity in portions of the Neuse River Watershed within the Town of Morrisville

Prepared for:
Town of Morrisville

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Stantec Consulting Services Inc.

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Sign-off Sheet

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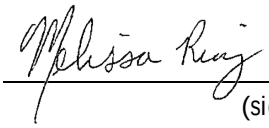
Prepared by  (signature)

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Reviewed by  (signature)

Alex Baldwin

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Glossary

Bankfull Depth – the channel at the top-of bank or point from where water begins to overflow onto a floodplain.

Bankfull Discharge - the stream flow when the height of the water just reaches the top of the banks, is often used as the channel-forming discharge.

Bank Height Ratio - the ratio of maximum depth from top of low bank to maximum depth from bankfull stage measured at a riffle cross-section.

Bed Scour – the removal of material from the bed of the river from streamflow.

Composite Sample – a sample which consists of a mixture of several individual grab samples collected at regular and specified time periods, each sample taken in proportion to the amount of flow at that time.

Confluence – the junction of two streams.

Cross-sectional area – stream width multiplied by average water depth.

Dimension – the two dimensional, cross-sectional profile of a stream channel.

Dry Pond – or detention basin – an excavated area installed to protect against flooding and, in some cases, downstream erosion by storing stormwater for a limited period of time. No permanent pool of water exists. A dry detention basin is used to manage water quantity, but has a limited effectiveness in protecting water quality.

Ecoregion - large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions.

Entrenchment Ratio - the ratio of flood-prone width to bankfull channel width measured at a riffle cross-section. The flood-prone width is measured perpendicular to valley flow direction at the elevation of twice the maximum depth at bankfull in a riffle.

Ephemeral Stream – are features that only carry stormwater in direct response to precipitation. They may have a well-defined channel and they typically lack the biological, hydrological, and physical characteristics commonly associated with intermittent or continuous conveyances of water. These features are typically not regulated by NC DWR or the U.S. Army Corps of Engineers.

Floodplain – an area of low lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

Floodprone Width – the valley width at the floodprone depth

Floodprone Depth – is equal to two times the bankfull depth

Grab Sample – a single sample or measurement taken at a specific time.

Hydric Soil –soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile.

Hydrologic Unit Code (HUC) – a sequence of numbers that identify a drainage basin.

Intermittent Stream - have a well-defined channel that contains water for only part of the year (typically during winter and spring). The flow may be heavily supplemented by stormwater. When dry, they typically lack the biological and hydrological characteristics commonly associated with continuous conveyances of water. These features are regulated by NC DWR and typically regulated by the U.S. Army Corps of Engineers.

Level Spreader – an erosion control device designed to reduce water pollution by mitigating the impact of high-velocity stormwater surface runoff. It usually consists of a poured concrete linear structure constructed perpendicular to surface runoff and has a uniform slope of zero percent.

Nutrient – in terms of water quality, nutrient generally refers to nitrogen and phosphorus. Phosphorus is typically monitored in the form of total phosphorus (TP), while nitrogen can be monitored in many forms including total nitrogen (TN), ammonia (NH4), nitrate/nitrite (NO3/NO2), and total Kjeldahl nitrogen (TKN).

Nutrient Concentration – the amount of nitrogen or phosphorus in a defined volume of water, such as "milligrams of nitrogen per liter of water."

Nutrient Load – the total amount of nitrogen or phosphorus entering the water during a given time, such as "tons of nitrogen per year."

Morphology – the form and structure of stream and river channels.

Outfall – the discharge point of concentrated flow of water into another body of water. In this study an outfall refers to locations where stormwater empties into streams. The outfall may contain an outfall structure which controls the release of flow from a stormwater BMP and an outfall channel which connects the structure to a stream.

Pattern – the sinuosity or meander geometry of a stream.

Perennial Stream - have a well-defined channel that contains water year round during a year with normal rainfall. Groundwater is the primary source of water, but they also carry stormwater. They exhibit the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water. These features are regulated by NC DWR and typically regulated by the U.S. Army Corps of Engineers.

Profile –the longitudinal slope of a channel.

Reach Break – A reach is a length of channel with homogeneous hydrologic and physical characteristics. A reach break marks the boundary between adjoining reaches.

Reference Reach – an undisturbed stream used to develop natural channel design criteria upon which stream restoration parameters are based.

Sediment Basin - a temporary pond built on a construction site to capture eroded or disturbed soil that is washed off during rain storms, and protect the water quality of nearby waterbodies.

Shear Stress – a stress state where the stress is parallel to the surface of the material (i.e. along the stream bank).

Sinuosity – the length of a stream channel from an upstream point to a downstream point divided by the straight line distance between the same two points.

Step-Pool – step pool stream morphology is defined by a regular series of steps and corresponding pools, similar to a staircase in the bed of the stream.

Stream Buffer –or riparian buffer, riparian corridor – a natural or vegetated area measured landward from the top of the defining edge of the stream channel.

Stream Enhancement – may not involve the re-establishment of profile, but may use bank stabilization techniques and stabilization structures to stabilize a stream.

Stream Restoration – the re-establishment of the general structure, function and self-sustaining behavior of a stream system that existed prior to disturbance. Restoration includes a broad range of measures, including installation of structures and planting of vegetation to protect streambanks and provide habitat; and the reshaping or replacement of unstable stream reaches into appropriately designed functional streams and associated floodplains

Substrate – the stream bed material, such as silt, clay, gravel, cobble, or bedrock.

Water Surface Slope – the slope from the elevation of the water surface at the top of a riffle to the top of another riffle at least 20 bankfull widths downstream.

Width to Depth Ratio – dimension of bankfull channel width to bankfull mean depth.

1.0 BACKGROUND

This study involves the assessment of stream and stormwater outfall stability on a number of subbasins (25, 29, 31, 32, 36, and 38) in the Town of Morrisville (Town) (Figure 5). Recently, the Town undertook a similar study of stormwater outfall stability in the Kit Creek watershed in order to provide information to develop programs in anticipation of implementation of the Jordan Lake Nutrient Management Strategy. That project covered the Town's jurisdiction within the Jordan Lake Watershed. The remaining land within the Town's boundary drains to Lake Crabtree within the Neuse River watershed. Since 1998, the Neuse River and all other surface waters within the Neuse River Basin have been subject to a set of regulations known as the Neuse Basin Nutrient Strategy or Neuse Rules. The strategy includes an overall nitrogen reduction goal of 30% over baseline conditions (1991-1995) and the implementation of stormwater management measures. It also stipulates a requirement of 50 feet of riparian buffer protection on both sides of a stream or waterbody.

The Neuse Rules focus on nitrogen and stormwater removal. However, there are many pollutants of concern with many sources in watersheds. This study focuses on the connection between outfalls and streams as a source of pollution. Unstable, incising streams can impact stormwater outfalls, leading to erosion and potential undercutting of outfall structures. Also, instability of stormwater outfalls can increase erosion of outfall channels, increasing pollutant loads to receiving streams.

1.1 WATERSHED DESCRIPTION

Lake Crabtree is a 520-acre flood control reservoir that was constructed in 1989. It is situated south of I-40 between Aviation Parkway and Weston Parkway (Figure 1). The Lake's watershed, USGS 14-digit HUC 03020201080010, drains 25,957 acres (40.6 square miles). The watershed includes Raleigh-Durham International Airport (RDU) to the north, along with portions of Durham County and the City of Raleigh. To the south and west, the watershed drains portions of the Towns of Apex, Cary, and Morrisville. Approximately 5,000 acres (7.8 square miles) of the Lake Crabtree watershed fall within the Town limits of Morrisville. This is equal to about 19% of the watershed.

The study area for this project focused on a portion of the Town's Lake Crabtree watershed located to the west of the lake. The 1,051 acre study area is generally bounded by Aviation Parkway to the southeast, International Drive and Chapel Hill Road to the west, Watkins Road and Airport Boulevard to the north, and Stirrup Iron Creek to the east (Figure 1). Crabtree Lake and Stirrup Iron Creek are the only named hydrologic features with the study area. All other streams are unnamed tributaries.

The study area watershed lies on the edge of the Triassic Basin of the Piedmont ecoregion. Streams in the Triassic Basin typically have low base flows and are low to moderate gradient with mostly sand and clay substrates. According to the USDA Soil Survey for Wake County (1970),

streams in the study area and surrounding floodplains are underlain with Altavista, Chewacla, Congaree, Creedmoor, Mayodan, Pinkston, Warne, White Store, and Worsham soils. Of these, only the Wehadkee and Worsham soils are hydric, and Altavista, Congaree, Chewacla, and Warne soils have minor hydric soil inclusions. Refer to Figure 2 for soils in the study area.

Topography in the Triassic Basin consists of low rounded hills and ridges. This is true of the undeveloped portions of the study area (450 acres/43%). However, developed parcels have been deforested and graded for industrial parks resulting in large areas with little to no topography. Topography is also distinct along the eastern edge of the study area where a steep bluff overlooks the wide floodplain of Stirrup Iron Creek and Brier Creek. The prominent bluff marks the boundary between the Triassic ecoregion and the Northern Outer Piedmont ecoregion.

Prior to the early 1980s the study area was completely undeveloped. Between 1983 and 1998 almost all of the development that is present today was constructed (Figure 3). Since 1998 there has been little change in land use. New developments include a few new buildings on Trans Air Drive, two on Aviation Parkway and a gas station on Chapel Hill Road. The forested areas remain as one of the largest undeveloped areas in Morrisville. The Town has designated this area and most of the study area as part of the Airport Noise Overlay District which restricted sensitive land uses due to the close proximity of RDU. Nonresidential uses, such as offices, retail and industrial facilities are allowed in the district.

A number of roadway projects have been planned for the study area. Within a few years, construction will begin on McCrimmon Parkway to connect Evans Road both to Airport Road and Perimeter Park Drive, and end at Chapel Hill Road. Other planned road projects include extensions of Southport Road and Dominion Road (Morrisville East Connector) west to Chapel Hill Road, and International Drive north to Airport Boulevard (Figure 4 Future Roadways from the 2009 Morrisville Transportation Plan). These projects will open up the remainder of the watershed to further industrial development. The Town plans to set aside land for a park along Stirrup Iron Creek.

1.2 REGULATIONS AND ORDINANCES

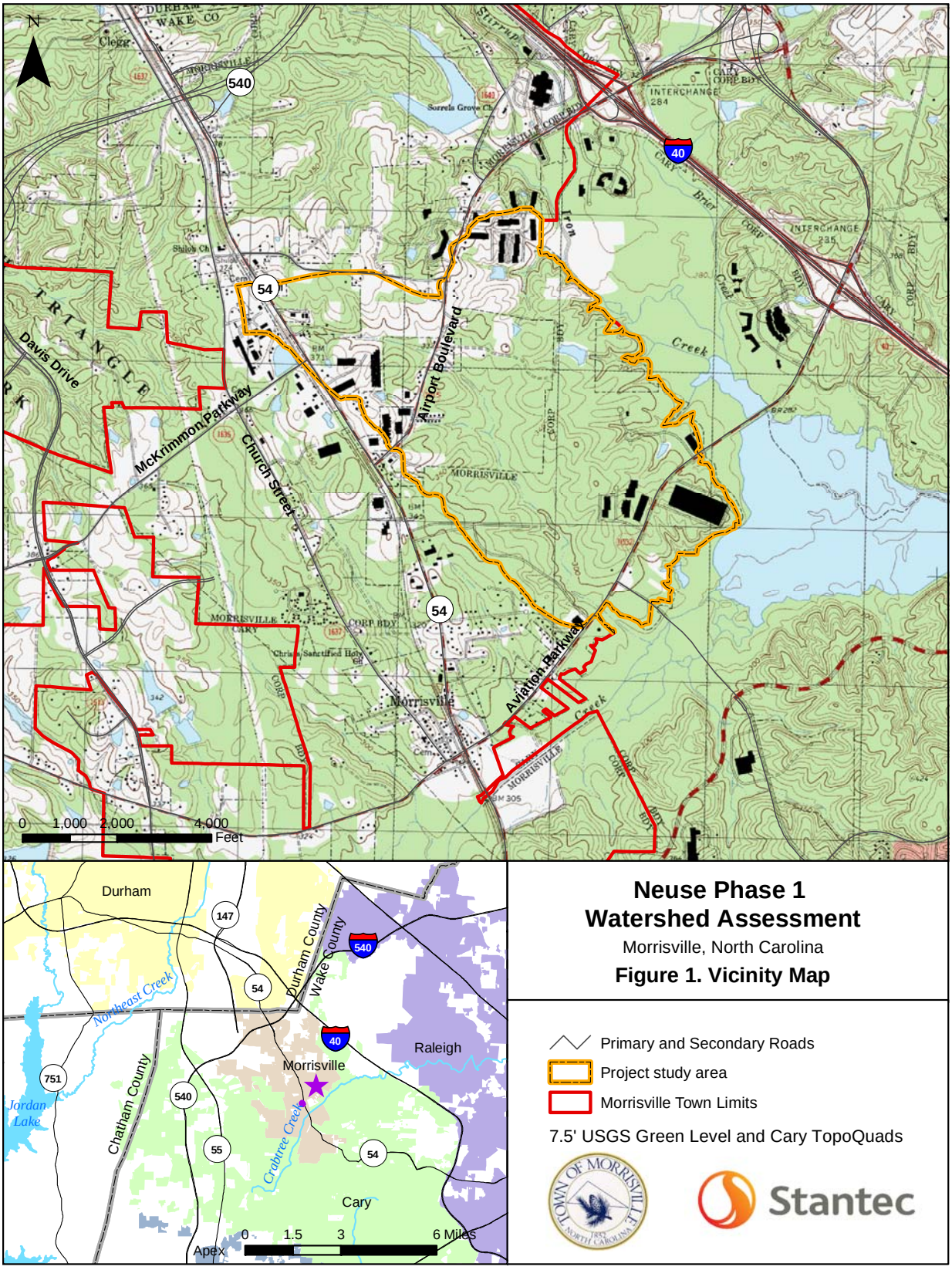
The Town recently adopted a Unified Development Ordinance (UDO) that consolidates many of the existing Town ordinances. Prior to the adoption of the UDO, the Town had a number of regulations and ordinances in place to regulate stormwater and protect surface waters by maintaining predevelopment runoff characteristics in a post-development site. These measures aimed to reduce stream channel erosion, pollution, sedimentation, and local flooding. These ordinances, now within the UDO, are briefly described below and web links are provided to the appropriate articles of the UDO.

Article 7 of the UDO covers stormwater management and aims to manage and minimize the effects of stormwater runoff from development sites, as well as comply with the Town's Phase II stormwater permit. The article establishes a "set of water quality and quantity regulations to

meet the requirements of state and federal law regarding control of stormwater runoff and discharge for development and redevelopment" (Morrisville 2014, http://www.townofmorrisville.org/DocumentCenter/View/7587). Language prohibiting illicit discharges and connections are also contained in this article. The article refers to the use of the Town's Design Manual which contains a chapter focused on stormwater quality management including technical specifications and standards (Morrisville 2014, http://www.ci.morrisville.nc.us/DocumentCenter/View/7804). Additionally, the manual has a Best Management Practices section which requires annual operation and maintenance (O&M) reports from BMP owners. The manual is currently in draft form and under public review.

As of 2005, the Town began cataloging their stormwater drainage system using GIS. Since 2005, as-built files have been used to update the map. An update to the field inventory was completed in 2013.

Riparian buffer regulations, described in Article 6 of the UDO, aim to protect and preserve existing riparian buffers along intermittent streams, perennial streams, lakes, reservoirs, and ponds within the Neuse River and Jordan Lake watersheds. The article divides the buffers into two zones. Zone One is comprised of the first 30 feet from the stream and is required to consist of undisturbed vegetation. Zone Two is comprised of an additional 20 feet from Zone One. Grading and revegetation is allowed within Zone Two provided that it does not adversely affect the vegetation in Zone One. All concentrated flow must be dispersed (i.e. 'diffuse flow') before entering Zone Two. Riparian buffers within the Lake Crabtree watershed have been regulated since 1998 when the State enacted the Neuse Basin regulations.



Neuse Phase 1 Watershed Assessment

Morrisville, North Carolina

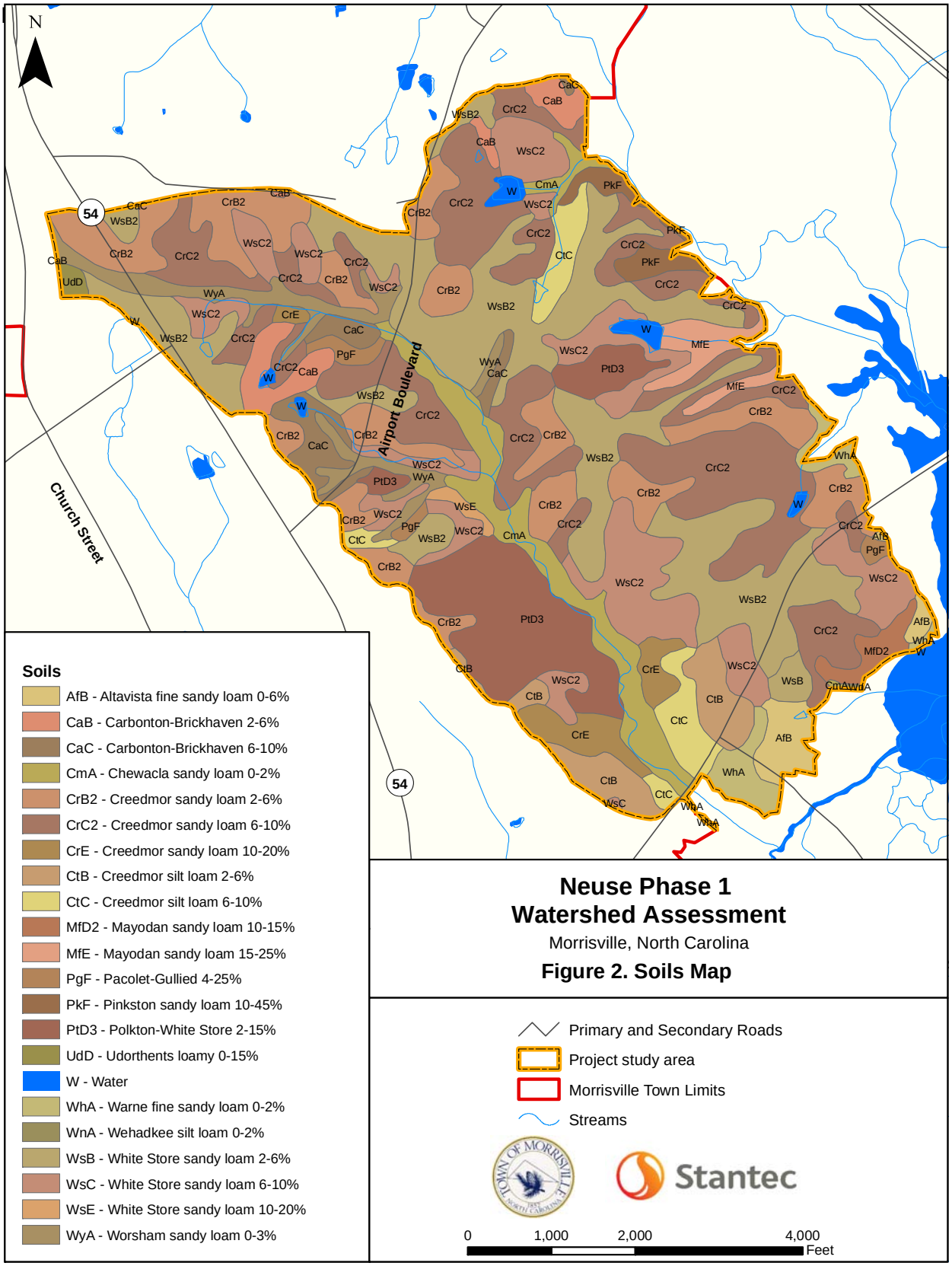
Figure 1. Vicinity Map

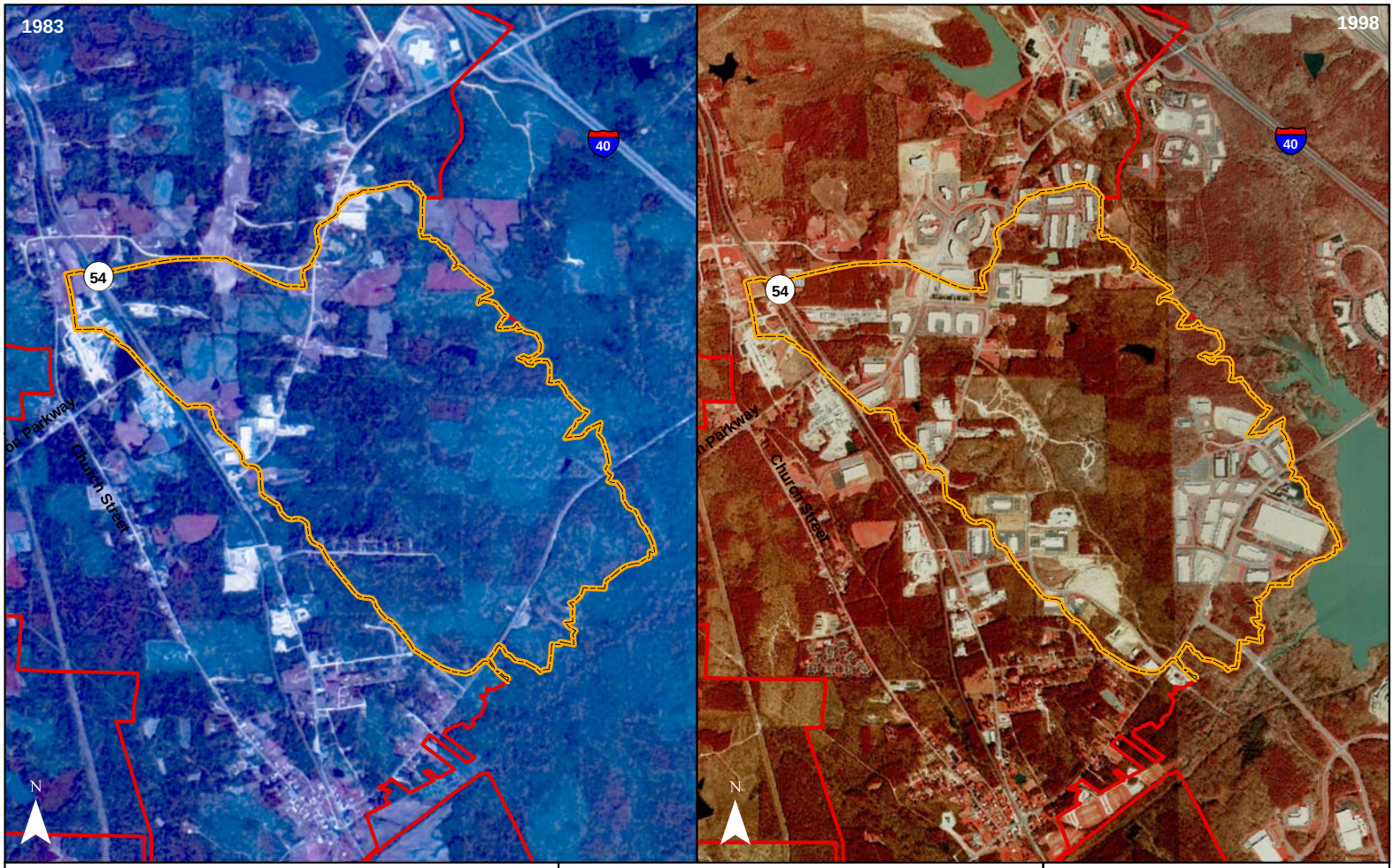
Primary and Secondary Roads

Project study area

Morrisville Town Limits

7.5' USGS Green Level and Cary TopoQuads


N
54
Airport Boulevard
Church Street
Soils
AfB - Altavista fine sandy loam 0-6%
CaB - Carbonton-Brickhaven 2-6%
CaC - Carbonton-Brickhaven 6-10%
CmA - Chewacla sandy loam 0-2%
CrB2 - Creedmor sandy loam 2-6%
CrC2 - Creedmor sandy loam 6-10%
CrE - Creedmor sandy loam 10-20%
CtB - Creedmor silt loam 2-6%
CtC - Creedmor silt loam 6-10%
MfD2 - Mayodan sandy loam 10-15%
MfE - Mayodan sandy loam 15-25%
PgF - Pacolet-Gullied 4-25%
PkF - Pinkston sandy loam 10-45%
PtD3 - Polkton-White Store 2-15%
UdD - Udorthents loamy 0-15%
W - Water
WhA - Warne fine sandy loam 0-2%
WnA - Wehadkee silt loam 0-2%
WsB - White Store sandy loam 2-6%
WsC - White Store sandy loam 6-10%
WsE - White Store sandy loam 10-20%
WyA - Worsham sandy loam 0-3%
Neuse Phase 1
Watershed Assessment
Morrisville, North Carolina
Figure 2. Soils Map
Primary and Secondary Roads
Project study area
Morrisville Town Limits
Streams
Stantec
0
1,000
2,000
4,000
Feet



Neuse Phase 1 Watershed Assessment
Morrisville, North Carolina

Figure 3. Land Use Comparison Map

Stantec

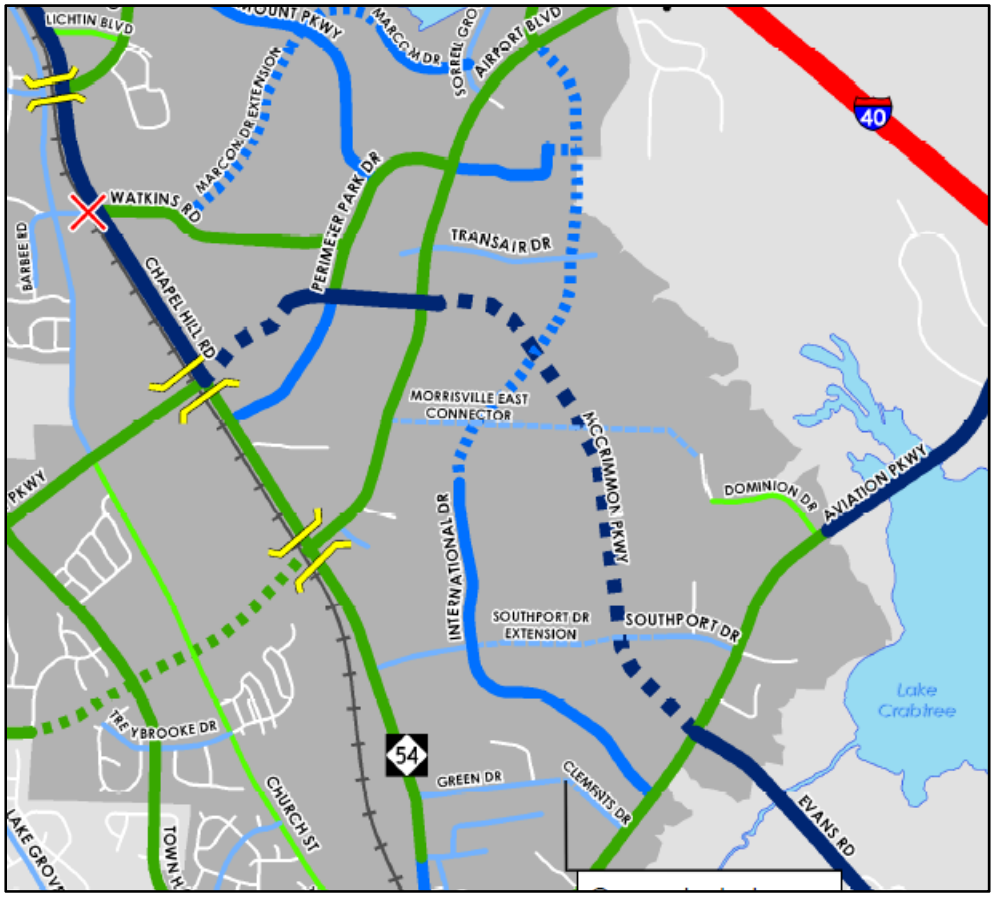


Figure 4. Future Roadways (Morrisville, 2009)

2.0 EXISTING CONDITIONS

As the study area was developed, streams were piped and inlets and outfalls were put into place. Streams were likely piped or channelized as individual lots were developed rather than as part of an overall stormwater plan. The result is a patchwork of short sections of open channel surrounded by a closed stormwater system in the developed areas of the watershed. In addition, there are very few stormwater BMPs in the study area due to the time period that construction occurred.

During the spring of 2014, field surveys were conducted to assess streams, stream buffers, and outfall integrity throughout the study area. These three factors were assessed in order to identify areas of degradation along with the degree of degradation and the possibility for improvement or restoration.

2.1 STREAM ASSESSMENT

Visual assessments of existing stream conditions were conducted along all streams in the Neuse River Basin Phase study area within the Town limits. Additionally, streams were visually assessed downstream of the Town limits to investigate stream issues with the potential to migrate upstream. The extent of the visual assessment outside of the Town limits extended 0.5 miles downstream, or until permanent grade control was encountered, including road crossings or bedrock in the stream bed. In many instances, the assessment ended where backwater began from Lake Crabtree and the Stirrup Iron Creek floodplain wetlands just outside of the Town limits. The visual assessment included investigating parameters such as stream origin, valley type, substrate, slope, Rosgen classification, morphology, bank erosion, stream habitat, and stream stability. Streams were broken into reaches when significant changes in any of these factors were observed. In general, reaches were assigned to a category of stable, moderately stable, or unstable. An example visual assessment form is included in Appendix A.

The jurisdictional stream origin [ephemeral/intermittent (E/I) break] was determined for all streams using the NC Division of Water Quality Methodology for Identification of Intermittent and Perennial Streams and Their Origins (NCDWQ 2010). NCDWQ stream identification forms were completed for all streams encountered during the field investigation and the E/I location (origin) was recorded using a mapping grade (sub-meter) GPS. NCDWQ forms are included in Appendix A. Refer to Figure 5 for the E/I break for all streams. The Town's stormwater inventory GIS data for streams, channels, culvert, culvert barrel, pipes, and pipe barrel layers, were used as a base for the field investigation. The stream and channel layers mapped many of the same features, but neither was complete. Upon completion of the field investigation, streams not accounted for in the channel inventory were added to the channel GIS layer. All entries in the Town's channel layer were classified as ephemeral or as intermittent/perennial. This data can be used to represent the locations and extents of all waterways in the study area as well as streams that are subject to Section 401/404 of the Clean Water Act. This study did not include mapping of other jurisdictional waters including wetlands. Therefore, the data should not be used in lieu of a field visit or as a final delineation of jurisdictional features. Other information included in the channel layer is the presence or absence on the USGS 7.5' topoquad or NRCS Soil Survey in order to help determine where the Neuse Buffer Rules apply.

In general, most streams were found to be in somewhat stable condition with low to moderate bank erosion. Unstable streams include Reaches 2-1, 2-2, 5-1, 1b, 1j, 1k, 1l, 1n, 1o, 6b. Refer to Table 1 and Figure 5 for the assessment of the current stability of stream reaches in the watershed. Photos of the unstable reaches are included in Section 3.1. The unstable streams are located in urban watersheds where natural stream functions have been altered by channelization, stormwater discharges, floodplain filling, streambank armoring, and loss of riparian vegetation. The resulting stream channels are mostly incised down to bedrock or resistant clay layers with minimal active floodplains and narrow vegetated riparian corridors. Observed impacts on many of the unstable reaches include eroding streambanks, sediment deposition, poor aquatic habitat, and degraded water quality.

Photo 1 Reach 2c, example of a stable stream in the study area

Streambank instability typically results from bank erosion during high flow events. Contributing factors are high banks resulting from channel incision, lack of deep-rooted vegetation, and highly erodible soil materials in the streambank. Local instability can also occur in isolated locations as a result of channel constrictions or flow obstructions (culverts, utility crossings, debris, or other structures). Streambanks are eroded by flowing water or by collapse (mass failure). Collapse typically occurs when a bank is undercut by moving water and the strength of bank materials is insufficient to resist gravitational forces. Banks that are collapsing or about to collapse are considered geotechnically unstable. Many of the unstable streams in this watershed are actively eroding, contributing to downstream sedimentation and habitat degradation.

Based on typical channel morphology measurements, the Rosgen (1996) stream classification system was applied to each reach. The unstable streams all fell within the Rosgen classification of a G stream type, indicating severe entrenchment, lack of floodplain connection, and high shear stress and stream power during flood flows. The more stable streams were classified as either C or E stream types, which exhibit better floodplain access and lower shear stresses. The Rosgen stream classification system uses five delineative criteria: entrenchment ratio, width to depth ratio, water surface slope, sinuosity, and channel bed materials.

Low entrenchment ratios indicate that flood flows above bankfull discharge are carried in a narrow corridor, potentially causing erosion. Large entrenchment ratios indicate a wide floodplain that will dissipate energy during floods. Bank height ratio is another important parameter in determining the degree of channel incision and effectiveness of the active floodplain in dissipating energy during high flows. Bank height ratios greater than 1.5 indicate potentially severe bank instability resulting from high shear stresses experienced during high flows, especially where streambanks are not well protected by vegetation.

The unstable streams in the study area have entrenchment ratios less than 1.4 and bank height ratios ranging from 2 to 6, indicating severe incision, lack of floodplain connection, and high potential for future bank erosion and headcutting. Typical stream restoration projects are designed with entrenchment ratios of at least 5 and bank height ratios of 1 to optimize floodplain energy dissipation and other functions. Refer to Table 1 for the geomorphic parameters assessed for all streams in the study area.

Table 1 Stream existing conditions in the Neuse River Basin Phase I Watershed

Reach	Assessed Length (ft)	Length within Town Limits	Rosgen Classification	Stability	Bank Erosion	Habitat
1-1	782	83	G	Moderately Stable	Moderate	Fair
1-2	8360	8360	G	Moderately Stable	Moderate	Fair
1-3	1374	1374	G	Moderately Stable	Moderate	Fair
1-4	932	932	E	Stable	Low	Fair
1a[1]	146	146	E	Stable	Low	Fair
1b	155	155	G	Unstable	High	Poor
1c	831	831	E / G	Moderately Stable	Moderate	Fair
1d	882	882	E / G	Moderately Stable	Moderate	Fair
1e	1192	1192	E / G	Moderately Stable	Moderate	Fair
1f	448	448	E / G	Moderately Stable	Moderate	Fair
1f-a	622	622	E / G	Moderately Stable	Moderate	Fair
1g	268	268	E / G	Moderately Stable	Moderate	Fair
1h	682	682	E / G	Moderately Stable	Moderate	Fair
1i	325	325	E / G	Moderately Stable	Moderate	Fair
1j	1242	1242	G	Unstable	High	Poor
1j-a	564	564	E / G	Moderately Stable	Moderate	Fair
1k	269	269	G	Unstable	High	Poor
1l	98	98	G	Unstable	High	Poor
1m	103	103	E / G	Moderately Stable	Moderate	Fair
1n	108	108	G	Unstable	High	Poor
1o	52	52	G	Unstable	High	Poor
2-1	939	195	E / G	Unstable	Moderate	Poor
2-2	666	666	E / D	Unstable	High	Poor
2a[1]	189	96	E / G	Moderately Stable	Moderate	Fair
2c	1917	1917	E / D	Stable	Low	Good
2c-a	140	140	E	Moderately Stable	Moderate	Fair
2c-b	573	573	E / G	Moderately Stable	Moderate	Fair

Reach	Assessed Length (ft)	Length within Town Limits	Rosgen Classification	Stability	Bank Erosion	Habitat
3-1	233	26	E / G	Moderately Stable	Moderate	Fair
4-1	229	109	E	Stable	Low	Good
5-1	845	491	E / G	Unstable	High	Poor
5a[1]	288	222	E / G	Stable	Low	Fair
5b[1]	407	407	E / G	Stable	Low	Fair
6-1	2099	1496	E/G	Moderately Stable	Moderate	Fair
6a	501	501	E/G	Moderately Stable	Moderate	Fair
6a-a	159	159	E/G	Moderately Stable	Moderate	Fair
6b	155	155	E/G	Unstable	Moderate	Poor
7-1	804	804	E / G	Moderately Stable	Moderate	Fair
8-1	1325	867	E / G	Moderately Stable	Moderate	Fair
8-2	809	809	E	Moderately Stable	Low	Fair
8a	305	305	G	Moderately Stable	Moderate	Fair
9-1[1]	242	15	B	Moderately Stable	Moderate	Fair
Stirrup Iron Creek[2]			E		Moderate	Fair

[1] Reaches 1a, 2a, 5a, 5b, and 9-1 do not appear on the USGS 7.5' topoquad or NRCS Soil Survey and therefore are not subject to buffer rules.
[2] Outside of study area, receiving waters for 7-1, 8-1, and 9-1.

2.2 STREAM BUFFER ASSESSMENT

A stream buffer integrity assessment was conducted for the entire study area. Falling within the watershed of Neuse River, the Lake Crabtree watershed is subject to the Neuse Basin Nutrient Strategy. These rules and the Town's UDO require 50 feet of vegetated buffer on all perennial and intermittent streams. These rules have been in effect since 1998; however, the majority of the developed areas in the watershed were constructed between 1983 and 1998, prior to the adoption of a buffer ordinance. Desktop analyses and a visual assessment in the field were conducted to investigate stream buffer integrity in terms of buffer width and density, and the presence of invasive species in order to identify potential opportunities for buffer restoration or enhancement.

During field investigations, areas of poor buffer width and density, and the location and type of invasive vegetation species were cataloged using a mapping grade GPS. A desktop analysis was also conducted using GIS techniques by applying a 50-foot buffer to the field verified and updated stream/channel layer (see Section 2.1). The field and desktop data were used to create a map of digitized streams, buffer integrity, and observed areas of invasive species (Figure 5).

The field investigation revealed that the majority of the buffers on streams subject to the Neuse Rules in the study area are 50 feet wide. This could be because most of the streams were piped in order to facilitate the placement of large buildings and parking lots. It is impossible to determine how much of the streams that were piped in the past would be considered jurisdictional under current rules and regulations.

Since so much of the developed area is piped, the current origin of the most streams is at the mouth of a pipe. Buffer rules protect 50 feet on both sides of the stream as well as 50 feet above the origin. As such, all of the streams where the end of a pipe serves as the origin have impacted buffers in the upstream direction. Stream buffers are also impacted when the stream flows under roads via culvert. Besides these types of buffer impacts, there are only a few reaches with impervious surfaces within the 50-foot riparian buffer (Table 2). Reaches with impervious surfaces within the riparian buffer include 1i, 1j, 2-1, 2-2, and 2c. In all of these instances the impervious surfaces consist of buildings or small areas of road and parking lots parallel to the stream. Buffer authorizations or variances may have been issued for these impacts or the areas may have been developed prior to the implementation of the Neuse Buffer Rules.

The vegetation within the riparian buffers consisted of forest and herbaceous vegetation (Table 2). The native vegetation in the forested areas consisted of oak hickory forest in areas with gentle to steep terrain. Mesic hardwood forests and small areas of wetland vegetation were found along streams with wider valleys including the lower reaches of Stream 1. The herbaceous vegetation was mainly found in utility right-of-ways (ROWs) of which the majority appear to be sewer. Maintenance in these areas includes mowing and the removal of woody vegetation.

Photo 2. Young oak-hickory forest with more recently harvested area in background

In addition to the forested buffers, a large part of the watershed remains undeveloped. The vegetation in this area varies depending on age since the last harvest of trees. Currently, a portion of the area remains covered in downed trees as it appears deforestation occurred within the last five years. Woody shrubs are just beginning to pop up amid the woody debris. Other areas are covered in pine which gives way to more hardwood species as more time passes since the harvest. A network of wide unpaved roads was found throughout the area. Forestry best management practices appear to be used throughout this area including leaving a buffer along streams. While the buffer is often somewhat narrower than 50-feet it usually extends above the origin of the stream and includes headwater wetlands.

Large stands of invasive species were generally not found in the forested areas. However, invasive species dominated utility line ROWs. Most of the sewer line ROWs in the study area that are located along larger streams with wide floodplains had large areas of *Microstegium vimineum* (stilt grass). Stilt grass seeds are carried by streams and easily establish in disturbed areas such as a newly installed sewer line. Stilt grass was also found in the backwater areas at the confluences of the streams with Lake Crabtree and Stirrup Iron Creek. The only other invasive species worth noting is *Eleagnus umbellata* (autumn olive) which was observed in large clumps at the upstream end of Reach 1-3 and Reach 1k. Autumn olive was also found scattered along other streams, but the populations were not significant enough to quantify.

Photo 3 Invasive species, *Microstegium vimineum*, in sewer line right-of-way (Reach 1a)

Table 2 Stream buffer existing conditions in the Neuse River Phase I Watershed

Reach Name	Stream Buffer (ft) [2]		Composition of Buffer	Impervious Impact in Buffer	Invasive Species
	Right Bank	Left Bank			
1-1	50	50	forest, sewer ROW	road crossing	MV sewer line
1-2	50	50	forest, sewer ROW	road crossing	MV sewer line
1-3	50	50	forest	road crossing	NA
1-4	50	50	forest, sewer ROW	None	MV sewer line, EU 50x50
1a[1]	50	50	forest	origin pipe	NA
1b	50	50	forest	origin pipe	NA
1c	50	50	forest	None	NA
1d	50	50	forest	None	NA
1e	50	50	forest	None	NA
1f	50	50	Forest, sewer	None	MV sewer line
1f-a	50	50	forest	origin pipe	NA
1g	50	50	forest, sewer ROW	origin pipe	MV sewer line
1h	50	50	forest	None	NA
1i	35-50	50	forest, sewer ROW	origin pipe, 130' of building on RB	MV sewer line
1j	50	40-50	forest, sewer ROW	675' industrial yard on LB	MV sewer line
1j-a	50	50	forest, sewer line crossing	none	MV sewer line
1k	50	50	forest	origin pipe	NA
1l	50	50	forest	origin pipe	NA
1m	50	50	forest	none	NA
1n	50	50	forest	none	NA
1o	50	50	forest	origin pipe	NA
2-1	25-50	50	forest	road crossing, 85' of building on RB	NA
2-2	25-50	50	forest, sewer ROW	origin in pipe, 150' of building on RB	MV sewer line
2a[1]	50	50	forest	origin in pipe	NA
2c	50	25-50	forest, sewer ROW	road crossing, 81' of building on LB	MV sewer line
2c-a	50	50	Forest, sewer	none	MV sewer line
2c-b	50	50	forest	road crossing	NA
3-1	50	50	forest, sewer line crossing	origin in pipe	MV sewer line
4-1	50	50	forest, sewer line crossing	origin pipe	MV sewer line
5-1	50	50	forest	origin pipe	NA
5a[1]	50	50	forest	None	NA
5b[1]	50	50	forest	None	NA

Reach Name	Stream Buffer (ft) [2]		Composition of Buffer	Impervious Impact in Buffer	Invasive Species
	Right Bank	Left Bank			
6-1	50	50	forest, sewer ROW		MV sewer line
6a	50	50	forest, sewer ROW	road crossing	MV sewer line
6a-a	50	50	forest	None	NA
6b	50	50	forest, herbaceous in old pond	None	NA
7-1	50	50	forest	origin pipe	NA
8-1	50	50	forest	None	NA
8-2	50	50	forest	None	NA
8a	50	50	forest	None	NA
9-1[1]	50	50	forest, sewer ROW	None	MV sewer line
Stirrup Iron Creek	50	50	forest, sewer ROW, herbaceous plants in wetland	none	MV sewer line

[1] Reaches 1a, 2a, 5a, 5b, and 9-1 do not appear on the USGS 7.5' topoquad or NRCS Soil Survey and therefore are not subject to buffer rules.

[2] Stream Buffer widths of less than 50 feet indicates the presence of impervious surface within 50 feet of the stream

2.3 STORMWATER OUTFALL ASSESSMENT

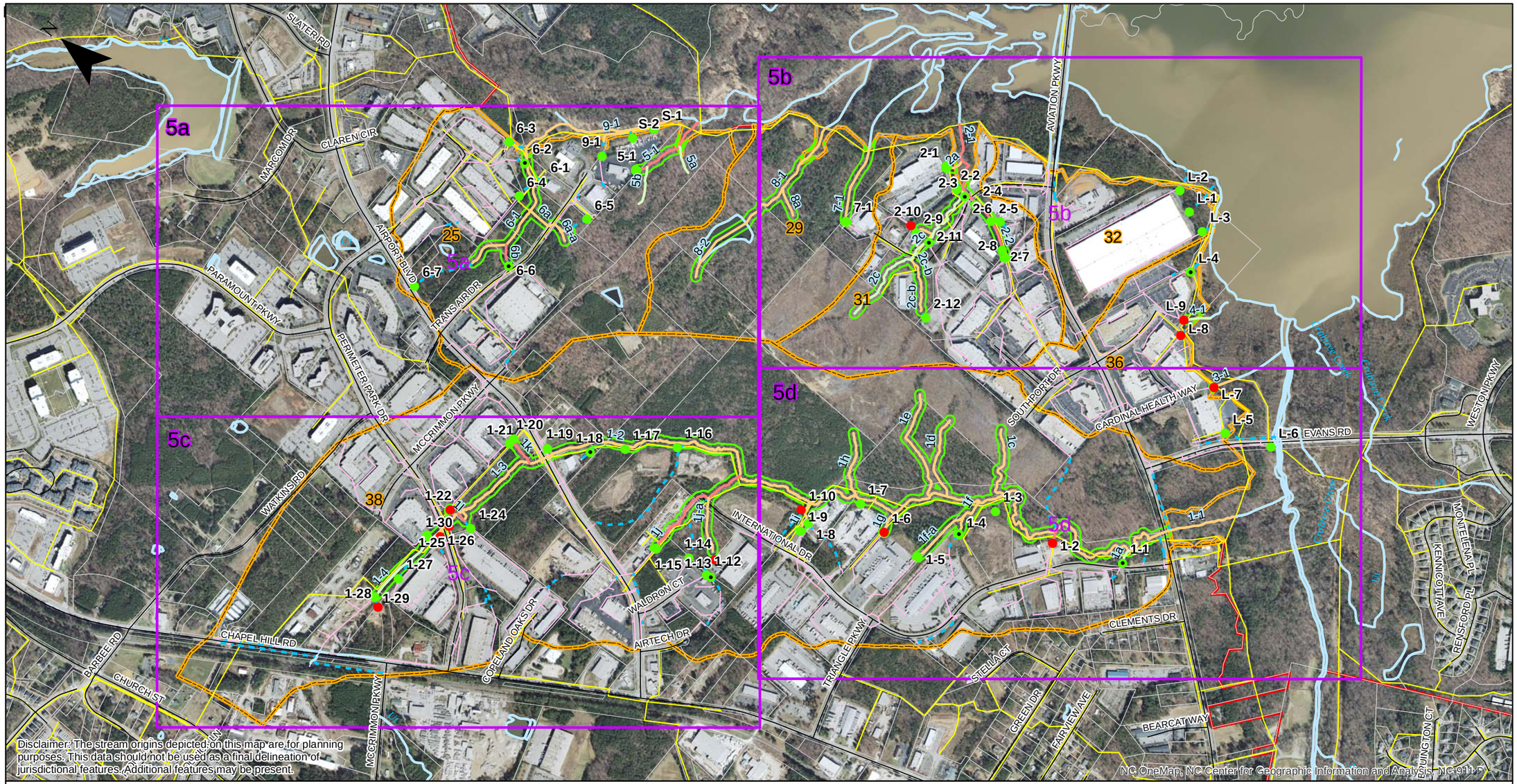
During the field assessment, all stormwater outfalls to streams in the study area were assessed. Those not included in the Town's stormwater inventory were located and cataloged with a mapping grade GPS. Additionally, the drainage source, description, and condition of the outfalls were recorded. In total, 63 outfalls were observed in the study area. Drainage sources included stormwater BMP outfalls, street drainage, and ephemeral ditches. Of the 63 outfalls, 12 were noted to be in poor condition. Poor conditions generally included observed active erosion, unstable outlet channels, headcutting, and undercut outlet structures. The location of all outfalls and their existing condition are depicted in Figure 5. Outfall condition, source, and description are included in Table 3.

Table 3 Stormwater outfall existing conditions in the Neuse Phase I Watershed

Outfall	Receiving Stream	Source	Outfall Condition	Notes
1-1	1a	Street drain	Good	24-inch RCP to rock channel
1-2	1b	Street drain	Poor	24-inch RCP to rock channel, undermining due to scour
1-3	1-2	Wet Pond	Good	24-inch RCP to rock channel
1-4	1f	Wet Pond	Good	36-inch RCP to rock channel
1-5	1f-a	Wetland	Good	24-inch RCP to wetland with cattails
1-6	1g	Street drain	Poor	24-inch RCP to rock channel, undermining due to scour
1-7	1i	Street drain	Good	18-inch CMP to rock channel
1-8	1i	Street drain	Good	24-inch RCP to rock channel
1-9	1i	Street drain	Good	30-inch RCP to rock channel
1-10	1i	Wet Pond	Poor	24-inch RCP to rock channel, undermining due to scour
1-11	1j-a	Pavement runoff	Poor	Concrete flume draining equipment yard, undermining due to scour
1-12	1j-a	Street drain	Good	24-inch RCP to rock channel
1-13	1j-a	Street drain	Good	36-inch RCP to rock channel
1-14	1j-a	Street drain	Good	24-inch RCP to rock channel
1-15	1j	Street drain	Good	30-inch RCP to rock channel
1-16	1-2	Street drain	Good	24-inch RCP to rock channel
1-17	1-2	Street drain	Good	24-inch RCP to rock channel
1-18	1-2	Street drain	Good	24-inch RCP to rock channel

Outfall	Receiving Stream	Source	Outfall Condition	Notes
1-19	1-2	Street drain	Good	24-inch RCP to rock channel
1-20	1k	Street drain	Good	36-inch RCP to rock channel
1-21	1k	Street drain	Good	30-inch RCP to rock channel
1-22	1l	Street drain	Poor	36-inch RCP to rock channel, undermining due to scour
1-23	1l	Street drain	Good	24-inch RCP to rock channel
1-24	1n	Street drain	Good	24-inch RCP to rock channel
1-25	1-3	Street drain	Poor	24-inch RCP to rock channel, undermining due to scour
1-26	1-4	BMP swale	Poor	24-inch RCP to rock channel, undermining due to scour
1-27	1-4	Street drain	Good	24-inch RCP to rock channel level spreader
1-28	1-4	BMP wet pond	Poor	24-inch RCP to rock channel, unstable drop-off at Reach 1-4
1-29	1-4	Street drain	Good	30-inch RCP to rock channel
1-30	1-4	Street drain	Good	36-inch RCP to rock channel
2-1	2a	Street drain	Good	Concrete flume draining parking lot
2-2	2b	Street drain	Good	18-inch CMP to wet pond with rock check dam
2-3	2-1	Street drain	Good	24-inch RCP to rock channel
2-4	2-2	Street drain	Good	18-inch RCP to rock channel
2-5	2-2	Street drain	Good	18-inch RCP to rock channel
2-6	2-2	Street drain	Good	Concrete flume to rock channel
2-7	2-2	Street drain	Good	Concrete flume to rock channel
2-8	2-2	Street drain	Good	36-inch RCP to rock channel
2-9	2c	Street drain	Good	Concrete flume to rock channel
2-10	2ca	Street drain	Poor	18-inch CP, undermined due to scour
2-11	2c	Street drain	Good	18-inch RCP to rock channel
2-12	2cb	Street drain	Good	Concrete flume to rock channel
L-1	Lake	Street drain	Good	Twin 18-inch RCP to rock channel
L-2	Lake	Street drain	Good	36-inch RCP to rock channel, unstable channel downstream in sewer line ROW

Outfall	Receiving Stream	Source	Outfall Condition	Notes
L-3	Lake	Street drain	Good	36-inch RCP to rock channel, unstable channel downstream in sewer line ROW
L-4	Lake	Street drain	Good	24-inch RCP to wetland with cattails
L-5	Lake	Street drain	Good	24-inch RCP to rock channel, dispersed flow in wetland
L-6	Lake	Street drain	Good	24-inch RCP to rock channel, dispersed flow in wetland
L-7	3-1	Street drain	Poor	30-inch RCP to rock channel, unstable channel
L-8	Lake	Street drain	Poor	18-inch RCP to rock channel, unstable channel
L-9	4-1	Street drain	Poor	30-inch RCP to rock channel, unstable channel
5-1	5-1	Street drain	Good	24-inch RCP to rock channel
6-1	6-1	Dry Pond	Good	18-inch RCP to rock channel
6-2	6-1	Street drain	Good	24-inch CMP to rock channel
6-3	6-1	Street drain	Good	18-inch RCP to rock channel
6-4	6-1	Street drain	Good	30-inch RCP to rock channel
6-5	6a	Street drain	Good	18-inch RCP to rock channel
6-6	6b	Street drain	Good	30-inch RCP to rock channel
6-7	6-1	Street drain	Good	18-inch RCP to rock channel
7-1	7-1	Street drain	Good	30-inch RCP to rock channel
9-1	9-1	Street drain	Good	24-inch RCP to rock channel
S-1	Stirrup Iron	Street drain	Good	24-inch RCP to rock channel
S-2	Stirrup Iron	Street drain	Good	24-inch RCP to rock channel



Condition
- Good
- Poor
- Town Owned Outfalls
- Stable Streams
- Moderately Stable Streams
- Unstable Streams
- Ephemeral Streams
- Unassessed Streams
- Pipes and Culverts
- Lakes and Ponds
- Streets
- Sewer Lines
- 50-foot Riparian Buffer
- Property Boundaries
- Morrisville Town Limits
- Atlas Pages
- Neuse P1 Study Area and Subbasin Boundary

Neuse Phase 1 Watershed Assessment

Morrisville, North Carolina

Figure 5. Assessment Overview Map

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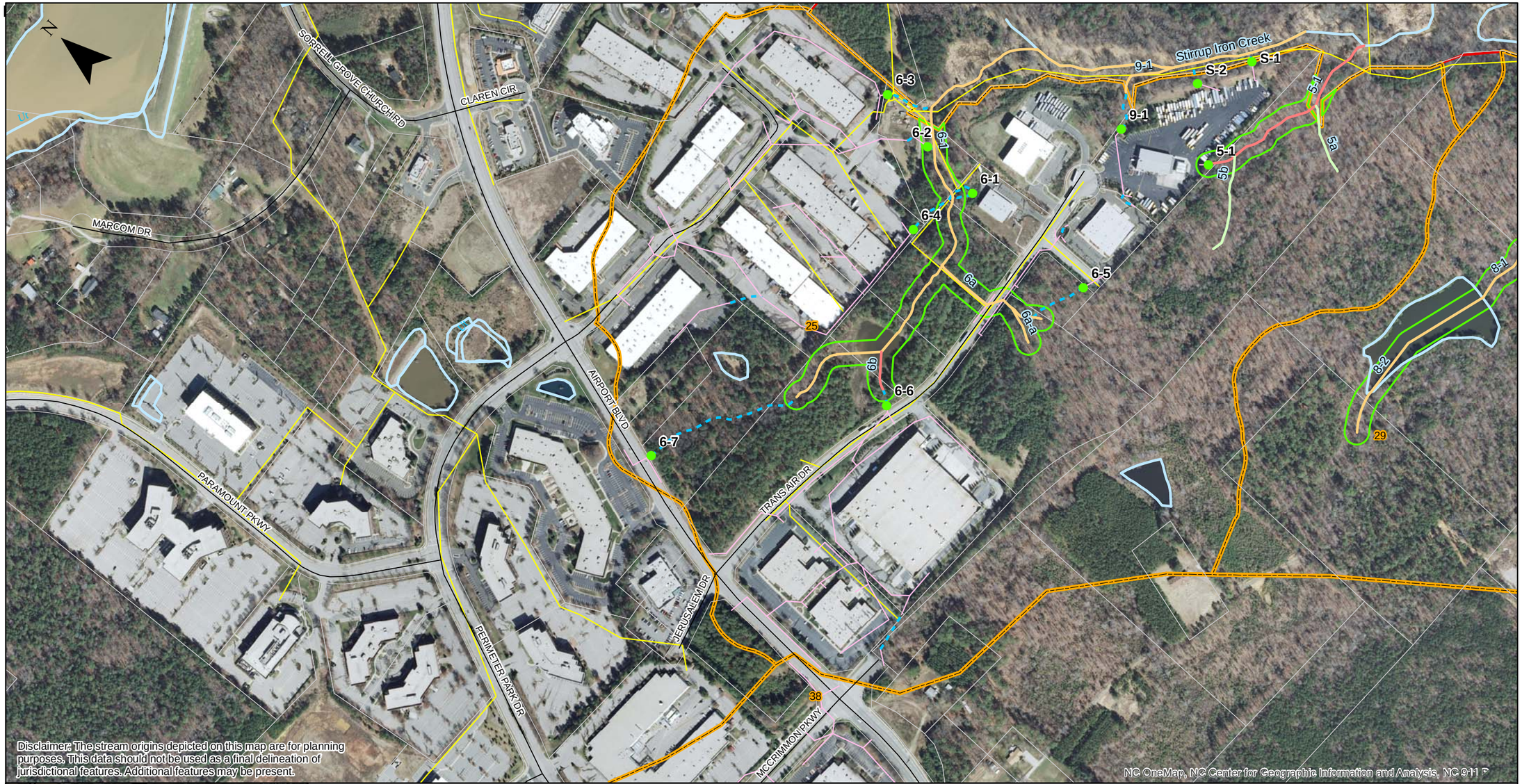
N
SORRELL GROVE CHURCH RD
CLAREN CIR
MARCOM DR
PARAMOUNT PKWY
PERIMETER PARK DR
AIRPORT BLVD
JERUSALEM DR
TRANS AIR DR
MCCRIMMON PKWY
Stirrup Iron Creek
6-1
6-2
6-3
6-4
6-5
6-6
6-7
9-1
S-1
S-2
5-1
5a
5b
6a
6a-a
6b
8-1
8-2
25
29
38
Disclaimer: The stream origins depicted on this map are for planning purposes. This data should not be used as a final delineation of jurisdictional features. Additional features may be present.
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 P
40
54
5a
5b
5c
5d
NC OneMap
Stable Streams
Moderately Stable Streams
Unstable Streams
Ephemeral Streams
Unassessed Streams
Pipes and Culverts
Outfall Condition
Good
Poor
Town Owned Outfalls
Streets
Sewer Lines
Lakes and Ponds
50-foot Riparian Buffer
Property Boundaries
Morrisville Town Limits
Neuse P1 Study Area and Subbasin Boundary
Stantec
Neuse Phase 1 Watershed Assessment
Morrisville, North Carolina
Figure 5a. Detailed Assessment Map
400 200 0 400 Feet

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N
AVIATION PKWY
DOMINION DR
NOVA DR
SOUTHPORT DR
8-1
8a
7-1
29
2-1
2a
2-2
2-3
2-4
2-5
2-6
2-10
2-9
2c-a
2-11
2c
2-12
2c-b
2-7
2-8
31
32
36
38
L-1
L-2
L-3
L-4
L-8
L-9
4-1
Disclaimer: The stream origins depicted on this map are for planning purposes. This data should not be used as a final delineation of jurisdictional features. Additional features may be present.
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 P
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5a
5b
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NC OneMap
Stable Streams
Moderately Stable Streams
Unstable Streams
Ephemeral Streams
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Pipes and Culverts
Outfall Condition
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Poor
Town Owned Outfalls
Streets
Sewer Lines
Lakes and Ponds
50-foot Riparian Buffer
Property Boundaries
Morrisville Town Limits
Neuse P1 Study Area and Subbasin Boundary
TOWN OF MORRISVILLE
Stantec
Neuse Phase 1 Watershed Assessment
Morrisville, North Carolina
Figure 5b. Detailed Assessment Map
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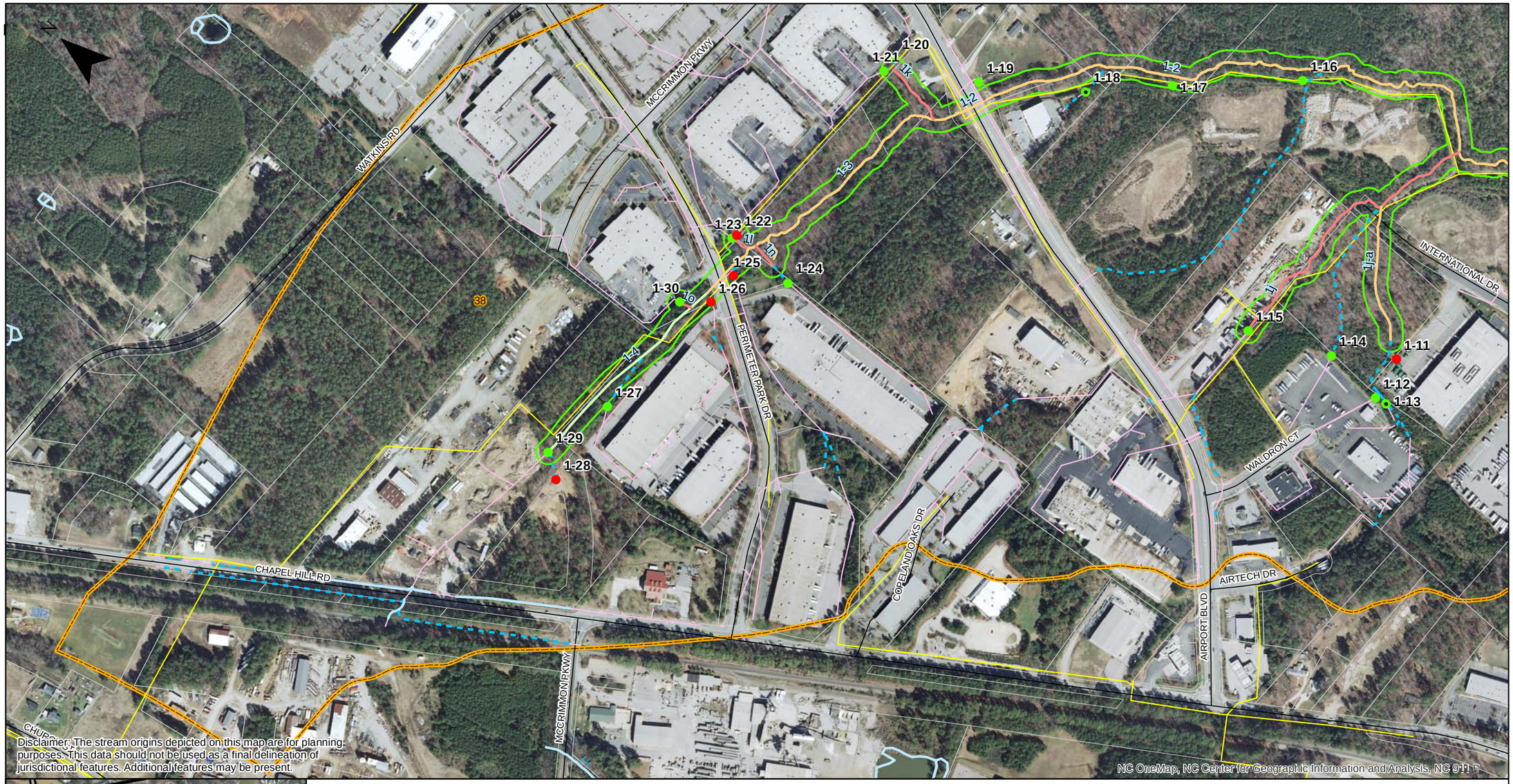

Stable Streams
Moderately Stable Streams
Unstable Streams
Ephemeral Streams
Unassessed Streams
Pipes and Culverts

Outfall Condition
Good
Poor
Town Owned Outfalls
Streets
Sewer Lines

Lakes and Ponds
50-foot Riparian Buffer
Property Boundaries
Morrisville Town Limits
Neuse P1 Study Area and Subbasin Boundary

Stantec

Neuse Phase 1 Watershed Assessment

Morrisville, North Carolina

Figure 5c. Detailed Assessment Map

400 200 0 400 Feet

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31
31
SOUTHPORT DR
36
L-7
3-1
L-5
L-6
EVANS RD
1e
1d
1c
1h
1-2
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1-10
1i
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1-8
1-9
1g
1-6
1-4
1-3
1f
1-5
1b
1-2
1a
1-1
1-1
INTERNATIONAL DR
TRIANGLE PKWY
STELLA CT
GREEN DR
CLEMENTS DR
AVIATION PKWY
Disclaimer: The stream origins depicted on this map are for planning purposes. This data should not be used as a final delineation of jurisdictional features. Additional features may be present.
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 B
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5a
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5c
5d
NC OneMap
Stable Streams
Moderately Stable Streams
Unstable Streams
Ephemeral Streams
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Property Boundaries
Morrisville Town Limits
Neuse P1 Study Area and Subbasin Boundary
TOWN OF MORRISVILLE
Stantec
Neuse Phase 1 Watershed Assessment
Morrisville, North Carolina
Figure 5d. Detailed Assessment Map
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3.0 RESTORATION OPPORTUNITIES

During the field assessment, opportunities for restoring or enhancing streams, stream buffer, and stormwater outfalls were observed. A summary of all restoration/enhancement opportunities is presented in Table 4 below. The opportunities are described in more detail, including general costs and feasibility, in Section 3.1, 3.2, and 3.3. The location of restoration opportunities is included in Figure 5.

Costs for stream restoration opportunities are based on estimates from the North Carolina Ecosystem Enhancement Program of $374 per linear foot of restoration (NCEEP 2014). However, there are several factors affecting cost and the projects may be able to be completed more economically. For example, if projects are not completed for mitigation credit or are conducted using a design-build approach, they may be completed for a lower cost. Also, the length is equal to the length of reach within the Town's jurisdiction but restoration may only be necessary on portions of the reach depending on the location of headcuts and/or other unstable features. Costs provided in this report are planning level estimates and may change based on more detailed information during final design. Additionally, these estimated costs do not incorporate maintenance costs.

Table 4 Restoration opportunities in the Neuse Phase I Watershed

Location	Type	Description	Estimated Cost
Reach 1b	Stream	Priority 1 Restoration	$57,970
Reach 1j	Stream	Priority 1 Restoration	$464,508
Reach 1k	Stream	Priority 1 Restoration	$100,606
Reach 1l	Stream	Priority 1 Restoration	$36,652
Reach 1n	Stream	Priority 1 Restoration	$40,392
Reach 2-1	Stream	Priority 1 Restoration	$72,930
Reach 2-2	Stream	Priority 1 Restoration	$249,084
Reach 5-1	Stream	Priority 1 Restoration	$183,634
Reach 6b	Stream	Priority 1 Restoration	$57,970
Outfall 1-1	Outfall	Rock armoring	$4,000
Outfall 1-6	Outfall	Rock armoring	$4,000
Outfall 1-10	Outfall	Dam stabilization	$10,000

Location	Type	Description	Estimated Cost
Outfall 1-11	Outfall	Rock armoring	$4,000
Outfall 1-22	Outfall	Rock armoring	$4,000
Outfall 1-25	Outfall	Rock armoring	$4,000
Outfall 1-26	Outfall	Rock armoring	$4,000
Outfall 1-28	Outfall	Rock armoring	$4,000
Outfall 2-10	Outfall	Rock armoring	$4,000
Outfall L-7	Outfall	Rock armoring	$4,000
Outfall L-8	Outfall	Rock armoring	$4,000
Outfall L-9	Outfall	Rock armoring	$4,000

3.1 STREAM OPPORTUNITIES

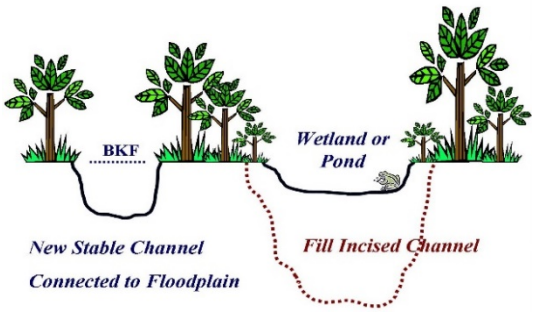
The goal of stream restoration and enhancement is to produce a healthy, sustainable stream system that can maintain stable conditions during the range of hydraulic forces produced by its watershed. Recommendations for stream restoration and enhancement for the study area are based on natural channel design principles, taking into account constraints presented by the existing stream and surrounding land uses. The general approach to restoration and enhancement is to create stable channel morphology (dimension, pattern, and profile) with wide floodplain access during flood (bankfull) flows.

The most critical aspect of stabilizing incised stream channels is to reestablish floodplain access for high flow events. Floodplains function to dissipate energy during high flows by allowing water to spread out and decrease velocity. The result is reduced shear stress in the active channel, resulting in reduced bed scour and streambank erosion. Rosgen (1997) described multiple restoration options (priorities) for addressing incised streams as described below and range from Priority 1 to 4. Priority 1 and 2 Stream Restoration involves restoring dimension, pattern and profile to appropriate and stable conditions. Priorities 3 and 4 are generally regarded as Stream Enhancement where dimension, pattern, or profile are unable to be restored. Enhancement is generally undertaken where site constraints limit the use of full restoration or only minimal work is needed to stabilize the stream and can include activities such as creating a floodplain bench, bioengineering practices, or placement of stream structures. Priority 1 Stream Restoration is proposed for restoration opportunities onsite. All sites have constraints that should be further assessed, including but not limited to: 1) access, 2) property ownership, 3) impacts to existing trees, and 4) potential flooding inundation. Depending on site constraints, Priority 2 Stream Restoration may be used in place of Priority 1. Both Priority 1 and 2 are described in greater detail below. The proposed projects may be considered for mitigation credits.

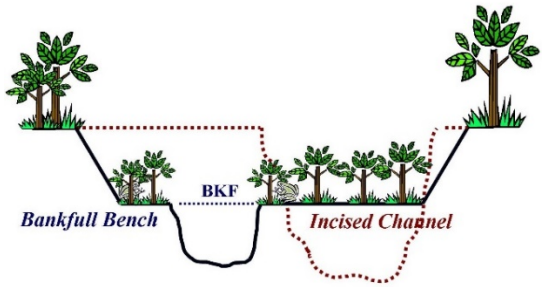
Priority 1 projects replace incised channels with new stable stream channels at a higher elevation, with full access to a wide floodplain at bankfull flows. This is accomplished by excavating a new channel with the appropriate dimension, pattern, and profile based on reference reach data to fit the watershed and valley type. The new channel is typically a

meandering stream with bankfull stage located at the ground surface of the original floodplain. Surrounding land uses can limit the use of a Priority 1 approach if there are concerns about increased flooding or widening the stream corridor. Priority 1 projects typically result in higher flood stages above bankfull discharge in the vicinity of the project and downstream. This approach also requires sufficient land area on one or both sides of the existing incised stream to construct the new meandering channel on the floodplain. For many incised streams, this is the recommended approach to restore optimal stream stability and health.

Priority 1



Priority 2



Priority 2 projects create new stable stream channels and floodplains at or near the existing channel elevation. This is accomplished by excavating a new floodplain and stream channel that can convey the expected range of flows while maintaining stream stability and health. The new channel is typically a meandering stream with bankfull stage located at the elevation of the newly excavated floodplain. A Priority 2 project can produce a long-term stable stream system if designed and constructed properly. Priority 2 projects can be constructed in dry conditions while streamflow continues in its original channel or is diverted (or pumped) around the construction site. A major advantage of the Priority 2 approach is that flooding does not increase and may in some cases decrease as the floodplain is excavated at a lower elevation. Surrounding land uses can limit the use of this approach if there are concerns about widening the stream corridor. This approach is an alternative to Priority 1 when constraints such as potential flooding inundation exist.

Reach 1b was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 155 feet long, extending from Outfall 1-2 down valley to Reach 1-2. The channel is 4 to 8 feet wide and 3 to 4 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $374 per foot or $57,970 for the total reach length.

Reach 1j was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 1,242 feet long, extending from Outfall 1-15 down

valley to Reach 1-3. The channel is 3 to 10 feet wide and 2 to 8 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $464,508 for the total reach length.

Photo 4 Reach 1b

Photo 5 Reach 1j

Reach 1k was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 269 feet long, extending from Outfall 1-20 down valley to Reach 1-4. The channel is 2 to 4 feet wide and 2 to 4 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $100,606 for the total reach length.

Photo 6 Reach 1k

Reach 1l was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 98 feet long, extending from Outfall 1-22 down valley to Reach 1-3. The channel is 5 to 8 feet wide and 4 to 6 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $36,652 for the total reach length.

Photo 7 Reach 1l

Reach 1n was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 108 feet long, extending from Outfall 1-24 down valley to Reach 1-3. The channel is 2 to 5 feet wide and 2 to 4 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $40,392 for the total reach length.

Reach 2-1 was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 195 feet long, extending from Reach 2-2 down valley to a wetland at the edge of Town jurisdiction. The channel is 8 to 15 feet wide and 1 to 6 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $72,930 for the total reach length.

Photo 8 Reach 2-1

Reach 2-2 was visited in April, 2014, and found be incised and widening, with eroding streambanks and active headcutting. Reach 2-2 is approximately 666 feet long, extending from Outfall 2-8 down valley to Reach 2-1. The channel is 2 to 5 feet wide and 1 to 5 feet deep. The valley is narrow and confined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $249,084 for the total reach length.

Photo 9 Reach 2-2

Reach 5-1 was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 491 feet long, extending from Outfall 5-1 down valley to the edge of Town jurisdiction. The channel is 2 to 5 feet wide and 1 to 5 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $183,634 for the total reach length.

Photo 10 Reach 5-1

Reach 6b was visited in April, 2014, and found to be incised with eroding streambanks and active headcutting. The Reach is approximately 155 feet long, extending from its ephemeral origin down valley to Reach 6b. The channel is 3 to 5 feet wide and 3 to 4 feet deep, with a headcut migrating up valley. The valley is wide and unconfined. The recommended restoration approach is Priority 1, consisting of a new channel re-connected to the existing floodplain. The benefits of this restoration opportunity include improved water quality and habitat, reductions in downstream sedimentation, and prevention of continued headcutting. Estimated cost for design, permitting, construction, and planting is $57,970 for the total reach length.

Photo 11 Reach 6b

3.2 BUFFER OPPORTUNITIES

During the stream walk, wooded riparian buffers in good condition were observed throughout much of the study area. Many large areas with herbaceous vegetation and lacking overstory were observed; however, these cannot be reforested as almost all are utility ROWs. On the handful of reaches with riparian buffers less than 50-feet wide due to the construction of impervious surfaces, there are no feasible opportunities to expand the buffer.

Few areas were found with large amounts of invasive species in the stream buffer. However, as development continues, invasive species may continue to spread, especially when used for sediment and erosion control. The Town should promote or require the use of native grasses and herbaceous vegetation for sediment and erosion control of construction sites and utility ROWs. Chapter 6.11 of The North Carolina Erosion and Sediment Control Planning and Design Manual includes a list of native herbaceous species for primary stabilization (Appendix A) (http://portal.ncdenr.org/c/document_library/get_file?uuid=076fbe07-5fd9-4d76-b1d6-2600efde8c99&groupId=38334). In addition, the NCSU Stream Restoration Program has a created a list native plant species for riparian buffers restoration (http://www.bae.ncsu.edu/programs/extension/wqg/srp/piedmont_riparian_species.pdf). The list for the Piedmont Region is also included in Appendix A.

3.3 OUTFALL STABILIZATION OPPORTUNITIES

During the stream walks, 62 stormwater outfalls were assessed for stability and potential impacts to stream health. These outfalls included pipes and channels carrying stormwater discharge from street drainage and best management practices (BMPs). BMP types include dry ponds, wet

ponds, sediment basins, and constructed wetlands. In general, most outfalls were in stable condition, with no evidence of erosion or headcutting between the outfall and the natural stream. Problems observed at 12 of the outfalls included insufficient rock to dissipate energy and prevent scour, headcutting in downstream channels, and undermining of headwalls. All of these outfalls can be stabilized with appropriate rock treatments to improve water quality and stream health while maintaining infrastructure integrity in the drainage network.

401/404 permitting for the treatments would likely not be required, as the outfall itself is not jurisdictional. However, due to proximity of jurisdictional streams and their associated Neuse Buffer Rules it is possible that construction-related clearing within the buffer or necessary outfall protection (rip-rap) may require coordination and/or minor permitting with the US Army Corps of Engineers and NC Division of Water Resources.

Outfall 1-2. This pipe drains a street network to Reach 1b. The pipe is elevated above a scour pool on the floodplain of Reach 1b. The recommendation for stabilization is to add large rock that will maintain position on the streambank to prevent erosion and headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 12 Outfall 1-2

Outfall 1-6. This pipe drains a street network to Reach 1g. The pipe discharges to a conveyance channel that is headcutting toward the outfall, potentially undermining the headwall and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 13 Outfall 1-6

Outfall 1-10. This channel drains a wet pond to Reach 1i. The pond dam is failing due to seepage and overtopping. The recommendation for stabilization is to repair the dam and to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $10,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 14 Outfall 1-10

Photo 15 Outfall 1-10 dam failure

Outfall 1-11. This concrete flume drains a parking lot to Reach 1ja. The flume discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 16 Outfall 1-11

Outfall 1-22. This pipe drains a street network to Reach 1l. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring

rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 17 Outfall 1-22

Outfall 1-25. This pipe drains a parking lot to Reach 1ja. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 18 Outfall 1-25

Outfall 1-26. This pipe drains a parking lot to Reach 1-4. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 19 Outfall 1-26

Outfall 1-28. This pipe drains a wet pond to Reach 1-4. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring

rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 20 Outfall 1-28

Outfall 2-10. This pipe drains a parking lot to Reach 2c-a. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The origin of 2c-a is currently on the downstream side of the headcut. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 21 Outfall 2-10

Outfall L-7. This pipe drains a parking lot to Reach 3-1. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 22 Outfall L-7

Outfall L-8. This pipe drains a parking lot to Lake Crabtree. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and

contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

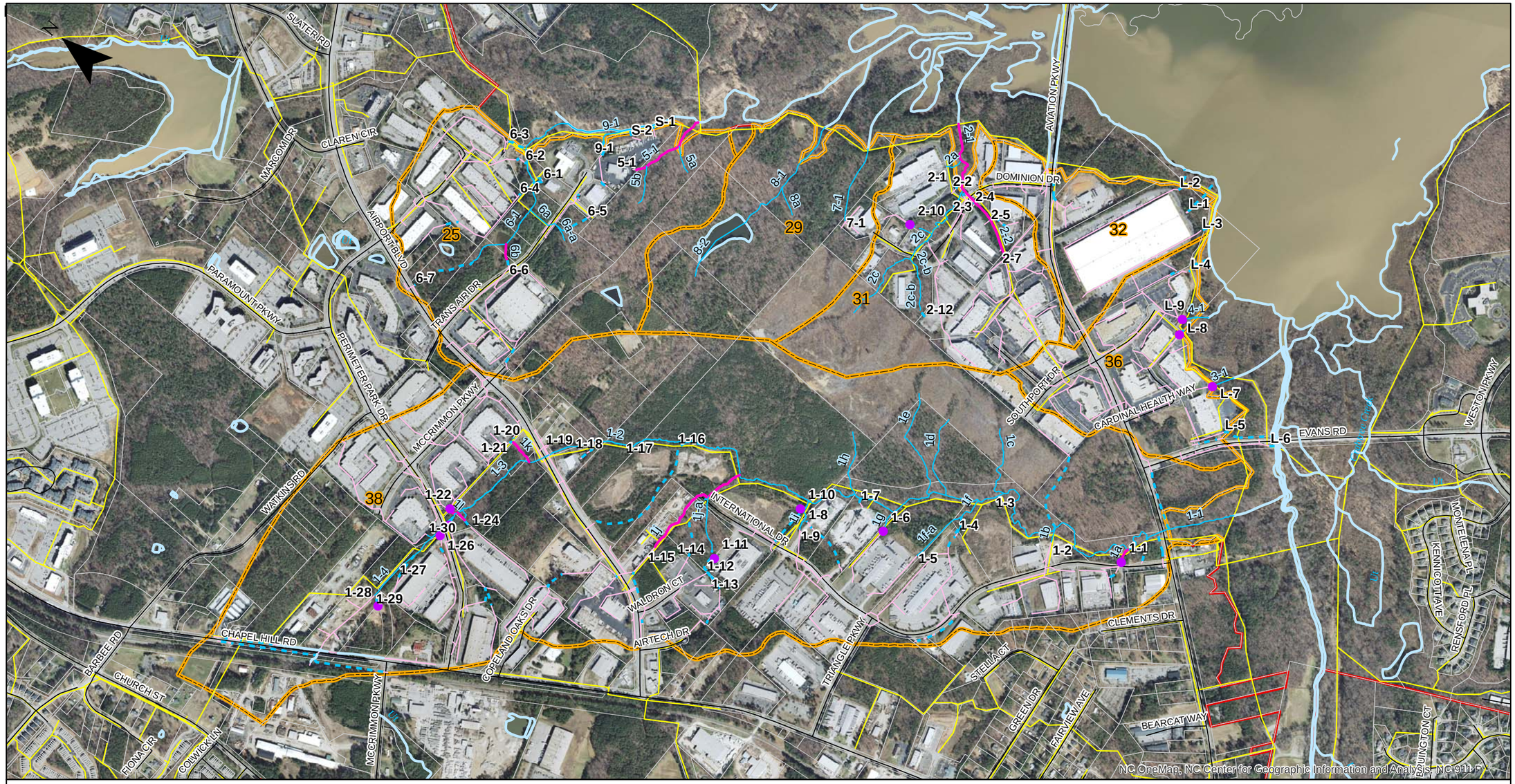
Photo 23 Outfall L-8

Outfall L-9. This pipe drains a parking lot to Reach 4-1. The pipe discharges to a conveyance channel that is actively headcutting toward the outfall, undermining the structure and contributing sediment to the stream. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. Estimated cost of materials and installation is $4,000. This cost is for construction only and assumes that design can be performed by the Town.

Photo 24 Outfall L-9

Channels Downstream of Outfalls L-2 and L-3. Outfall L-2 and L-3 both drain a large warehouse and parking lot. The outfalls are stable and the stormwater discharge flows overland until just upstream of the sewer line ROW. In both cases a channel has started to form. The channels are incised through the ROW and continue to actively headcut towards the outfalls. The recommendation for stabilization is to add armoring rock to the conveyance channel to maintain channel stability and prevent headcutting. The channels are outside of the Town limits and within the Town of Cary's sewer ROW. They have been included in this report since additional headcutting upstream may eventually create a problem in the Town's jurisdiction.

Photo 25 Outfall L-2



- Outfall Opportunities
- Stream Opportunities
- Intermittent and Perennial Streams
- Ephemeral Streams
- Unassessed Streams
- Pipes and Culverts
- Lakes and Ponds
- Streets
- Sewer Lines
- Property Boundaries
- Morrisville Town Limits
- Neuse P1 Study Area and Subbasin Boundary

Stantec

Neuse Phase 1 Watershed Assessment

Morrisville, North Carolina

Figure 6. Restoration Opportunities Map

1,000 500 0 1,000 Feet

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4.0 FUTURE PLANNING NEEDS

In addition to the stream, buffer, and BMP outfall opportunities outlined in this document, several other watershed planning needs exist for the study area. The Town should continue to update and maintain geospatial data for its stormwater inventory. A few unmapped ponds were found during the field investigation that will be added to the inventory. Additionally, the Town should continue to implement its inspection program for the maintenance of all BMPs in the study area. As part of this inspection program, the Town should investigate potential opportunities to upgrade, modify, or retrofit existing stormwater BMPs in the study area. Some of the unmanaged stormwater sources such as street drains which discharge directly into streams should be investigated for stormwater BMP retrofit opportunities. Finally, when the Town begins to search for a park site along Stirrup Iron Creek, as noted on the land use plan, consideration should be given to stream preservation and the protection of water resources.

As noted, land use in the study area is mainly industrial. The Town prohibits illicit discharges to the stormwater system and streams and is working to enforce this regulation through dry weather monitoring. Five industry owners have industrial stormwater permits within the study area and an additional four have certificates of no exposure. Those with permits have stormwater pollution prevention plans that may include monitoring during rain events or other times of the year. While NCDWR regulates these permits, the Town could use the sampling data to better determine where to target funds for BMP improvements and installation.

There are several sources of funding which could be used to implement the opportunities outlined in this report, as well as future watershed initiatives. Sources include:

- Nonpoint Source Section 319 Grant Program (USEPA and NCDWR)
- Clean Water Management Trust Fund (NCDENR)
- State Revolving Fund (USEPA and NCDENR Infrastructure Finance Section)
- Water Resources Development Project Grants (NCDWR)
- Section 206 Aquatic Restoration Grants (USACE)
- Environmental Enhancement Grant Program (NC Attorney General's Office)
- Environmental Education Grants (USEPA)

Funding sources vary by year. NCDENR maintains a list of available financial resources at the state level at: http://www.ncdenr.gov/web/wq/ps/bpu/urw/funding. Additionally, financial resources at the federal level can be viewed at: https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1. These resources should be utilized to investigate available funding sources for a given year.

5.0 REFERENCES

Morrisville, 2009. Morrisville Transportation Plan 2009-2035, Adopted March 24, 2009.

Morrisville, 2014. Morrisville Engineering and Construction Manual, Public Review Draft February 2014. http://www.ci.morrisville.nc.us/DocumentCenter/View/7804

Morrisville, 2014. Morrisville Unified Development Ordinance, Adopted December 10, 2013, Effective July 1, 2014. http://www.ci.morrisville.nc.us/DocumentCenter/View/8701

NCDENR 2013. North Carolina Erosion and Sediment Control Planning and Design Manual Chapter 6.11 – Permanent Seeding. http://portal.ncdenr.org/web/lr/publications#espubs

NCDWQ 2010. Methodology for Identification of Intermittent and Perennial Streams and their Origins, Version 4.11. North Carolina Department of Environment and Natural Resources, Division of Water Quality. Raleigh, NC.

Rosgen, D. L. 1996. Applied River Morphology. Wildland Hydrology Books, Pasoga Springs, Colorado.

Rosgen, D. L. 1997. A Geomorphological Approach to Restoration of Incised Rivers, *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*. S.S.Y Wang, E.J. Langendoen and F.D. Sheilds, Jr. (eds.) ISBN 0-937099-05-8.

USDA 1970. Soil Survey for Wake County, North Carolina. United States Department of Agriculture, Soil Conservation Service.

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Appendix A

A.1 Example Visual Assessment Form

A.2 NCDWQ Forms

A.3 Native Plant Lists

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Appendix A
31 July 2014

A.1 EXAMPLE VISUAL ASSESSMENT FORM

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Stream Assessment for Potential Restoration

Stream name & location	
Assessed by	Site visit date
Watershed area (square miles)	Available buffer width (ft)
Watershed % forest	Stream length (ft)
Watershed % agriculture	Stream width in riffle/run (ft)
Watershed % urban	Depth from top of bank (ft)
Streambed substrate (sand, gravel, cobble, bedrock)	Stream slope (< 2%, 2-4%, > 4%)

Stream Condition and Function: Score from 0 to 4 indicating natural stream integrity and health (circle contributing factors): *0 = extremely poor; 1 = poor; 2 = fair; 3 = good; 4 = excellent*

	Before	**After**
Morphology (channelized, incised, over-wide, cutting into hillslope, head-cutting)		
Bank stability (eroding bends, high banks, steep banks, lack of roots, high stress)		
Bed sediment (embedded with fines, excessive scour, excessive bars)		
Floodplain (disconnected, filled, drained, levees, aggrading)		
Vegetation (natives removed, invasive plants, poor shade and food sources)		
Habitat (poor bedform, poor cover, uniform flow, lack of food & refuge, poor WQ)		
Discharges (stormwater, wastewater, agricultural runoff, livestock, dumping)		
Constraints (roads, bridges, culverts, sewer lines, utilities, property lines)		
Interventions (armoring, piping, filling, dredging)		
Upstream impacts (stormwater, sediment, wastewater, agriculture, roads)		
Total Score		

Comments:

A.2 NCDWQ FORMS

Appendix A
10 July 2014

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NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 1A	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 18	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 8)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

weak

C. Biology (Subtotal = 6)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	0	0.5	(1)	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch: 24" outfall - OUT 1

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 1B	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 29	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 16.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	1	2	(3)
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	0	1	(2)	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 6)				
20. Fibrous roots in streambed	(3)	2	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch: problem area - headcut going under outfall (outfall 2)

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 1C	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 18.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 9.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	(0)	1	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 3)				
20. Fibrous roots in streambed	3	2	(1)	0
21. Rooted upland plants in streambed	3	(2)	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 10	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	(1)	2	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = (3)	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

10; 1st photos

Date: 5/08	**Project/Site:** Stream 1E	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10,5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	(1)	2	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4,5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** F	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 27	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 13.5)	Absent	Weak	Moderate	Strong
1ª. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	0	(1)	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	0	0.5	1	(1.5) culvert
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

ª Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 6)				
20. Fibrous roots in streambed	(3)	2	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** IF-A	**Latitude:**
Evaluator: MR / GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 13)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	(2)	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	0	0.5	1	(1.5) culvert
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 3.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 4)				
20. Fibrous roots in streambed	3	2	(1)	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

starts at OUT-5

berm on LB - 1 photo DS

11:50

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 16	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 13)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	0	(1)	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	0	0.5	1	(1.5)
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 3.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 4)				
20. Fibrous roots in streambed	3	2	(1)	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

EL

EI at OUT6
after 50' rip-rap

2 photos 1DS, 1US

11:25

NC DWQ Stream Identification Form Version 4.11

Date: 5/8	**Project/Site:** 1H	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 19	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	(0)	1	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 4)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	3	(2)	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

12'20

Date: 4/29/14	**Project/Site:** I I	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 21.5	**Stream Determination (circle one)** **Ephemeral Intermittent Perennial**	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 11)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	(0)	1	2	3
6. Depositional bars or benches	0	(1)	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	0	0.5	1	(1.5) culvert
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 3)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	3	2	(1)	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch: OUT 9

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 1 J	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 18.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	(0)	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	(0)	0.5	1	(1.5) culvert
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

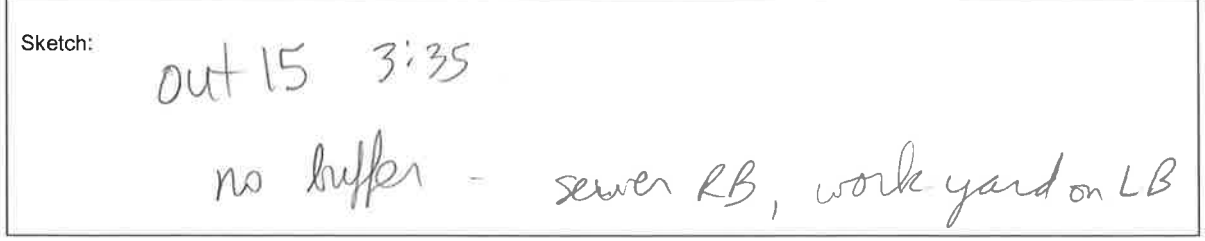
B. Hydrology (Subtotal = 3.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	? unable to verify

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:



NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** IJ-a	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 19.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 8)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	(1)	2	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade control	0	0.5	1	(1.5)
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	0	1	2	(3)
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

unable to verify

C. Biology (Subtotal = 5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** 1K	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 24.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 13)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	(0)	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	(1.5)
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

riprap culverts

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)	Absent	Weak	Moderate	Strong
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)	Absent	Weak	Moderate	Strong
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/14	**Project/Site:** L	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 18.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 8)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	(2)	3
9. Grade controls	0	0.5	1	(1.5)
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

culvert underneath

B. Hydrology (Subtotal = 5.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

OUT 23

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/2014	**Project/Site:** IM	**Latitude:**
Evaluator: MR / GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 23	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 12)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	1	2	(3)
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 3.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = (0)		Yes = 3	

C. Biology (Subtotal = 7.5)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	0	0.5	1	(1.5)
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch: no outfall feeds this channel. headcut at origin

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/2014	**Project/Site:** 1N	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 16.5	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 1.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = (0)		Yes = 3	

C. Biology (Subtotal = 4)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	3	2	(1)	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch: ☆ upstream is almost completely piped, according to soil survey =

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/2014	**Project/Site:** 10	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 23	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	(3)
9. Grade controls	0	0.5	1	(1.5) culvert
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 8.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	1	2	(3)
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 4)				
20. Fibrous roots in streambed	3	2	(1)	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch: outfall 1-30

NC DWQ Stream Identification Form Version 4.11

Date: 4/29/2014	**Project/Site:** 1-4	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 21	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 7)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	(0)	1	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 6.5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	0	0.5	1	(1.5)
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/30/204	**Project/Site:** 2-2	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 23.5	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 9.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	(1)	2	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade control	0	0.5	1	(1.5)
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 7.5)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	0	0.5	1	(1.5)
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/30/2014	**Project/Site:** ZA	**Latitude:**
Evaluator: MR/GJ	**County:** Duke	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 24	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	0	0.5	1	(1.5)
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	(1)	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 6)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

12:19

Date: 5/8/14	**Project/Site:** 2C	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20.75	**Stream Determination (circle one)** **Ephemeral Intermittent Perennial**	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 12.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	0	(0.5)	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 3.25)				
20. Fibrous roots in streambed	3	2	1	(0)
21. Rooted upland plants in streambed	3	(2)	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	0	(0.5)	1	1.5
29. Wetland plants in streambed	FACW = (0.75) OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/2014	**Project/Site:** 2C-a	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 21	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 12)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	(1.5)
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/2014	**Project/Site:** 2c-6	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: 22.5 *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30**	**Stream Determination (circle one)** Ephemeral ~~Intermittent~~ Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 10)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 6)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/30/14	**Project/Site:** 3-1	**Latitude:**
Evaluator: MR / GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 22.5	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	(0)	1	2	3
9. Grade control	0	0.5	1	(1.5)
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
18. Fibrous roots in streambed	3	(2)	(1)	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 4/30/14	**Project/Site:** 4-1	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 23	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 13.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	1	(2)	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 3)				
18. Fibrous roots in streambed	3	2	(1)	0
19. Rooted upland plants in streambed	3	(2)	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/14	**Project/Site:** 5A	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 23.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 13.5)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4.5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	0	(0.5)	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5.5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	0	(0.5)	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/2014	**Project/Site:** 5-B	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 25	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 13.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	2	(3)
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	(2)	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	0	1	2	(3)
8. Headcuts	(0)	1	2	3
9. Grade control	0	0.5	1	(1.5)
10. Natural valley	(0)	0.5	1	1.5
11. Second or greater order channel	No (= 0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	1	(0.5)	(0)
15. Sediment on plants or debris	0	(0.5)	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 5.5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	0	(0.5)	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/19/2014	**Project/Site:** 6-1	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 22	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 14.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	0	1	2	(3)
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	(0.5)	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 3)				
18. Fibrous roots in streambed	3	2	1	(0)
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/19/2014	**Project/Site:** 6a	**Latitude:**
Evaluator: MR / GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 22	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 13)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	(2)	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	(1)	1.5
17. Soil-based evidence of high water table?	No = (0)		Yes = 3	

C. Biology (Subtotal = 5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/19/2014	**Project/Site:** 6a-a	**Latitude:**
Evaluator: MR	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 21	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 13)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	(2)	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = (0)		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 3)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	0	(1)	2	3
14. Leaf litter	1.5	1	0.5	(0)
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	(1)	1.5
17. Soil-based evidence of high water table?	No = (0)		Yes = 3	

C. Biology (Subtotal = 5)				
18. Fibrous roots in streambed	3	(2)	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/19/2014	**Project/Site:** 6b	**Latitude:**
Evaluator: MR/GJ	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 21.5	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 12.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	(0)	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	1	(2)	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	(0.5)	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 2.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	(0)	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 6.5)				
18. Fibrous roots in streambed	(3)	2	1	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	0	(0.5)	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

1:21

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/14	**Project/Site:** 7-1	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 23	**Stream Determination (circle one)** Ephemeral (Intermittent) Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 13.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	2	(3)
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	0	0.5	1	(1.5) culvert
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 4.5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	(3)	2	1	0
21. Rooted upland plants in streambed	3	(2)	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

2:30

NC DWQ Stream Identification Form Version 4.11

Date: 5/8/15	**Project/Site:** 8-2	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 21	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 10.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 5.5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	1	0.5	(0)
15. Sediment on plants or debris	0	0.5	1	(1.5)
16. Organic debris lines or piles	0	0.5	(1)	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	(3)	2	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	(0)	0.5	1	1.5
27. Algae	(0)	0.5	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 5/8	**Project/Site:** 8-a	**Latitude:**
Evaluator: MR/KW	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 21.5	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** e.g. Quad Name:

A. Geomorphology (Subtotal = 11.5)	Absent	Weak	Moderate	Strong
1[a]. Continuity of bed and bank	0	1	(2)	3
2. Sinuosity of channel along thalweg	0	1	(2)	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	(1)	2	3
5. Active/relict floodplain	0	(1)	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade controls	(0)	0.5	1	1.5
10. Natural valley	0	0.5	1	(1.5)
11. Second or greater order channel	No = (0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 5)				
12. Presence of Baseflow	(0)	1	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	1.5	(1)	0.5	0
15. Sediment on plants or debris	0	(0.5)	1	1.5
16. Organic debris lines or piles	0	(0.5)	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = (3)	

C. Biology (Subtotal = 5)				
20. Fibrous roots in streambed	3	(2)	1	0
21. Rooted upland plants in streambed	3	(2)	1	0
22. Macrobenthos (note diversity and abundance)	(0)	1	2	3
23. Aquatic Mollusks	(0)	1	2	3
24. Fish	(0)	0.5	1	1.5
25. Crayfish	(0)	0.5	1	1.5
26. Amphibians	0	(0.5)	1	1.5
27. Algae	0	(0.5)	1	1.5
29. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

* perennial streams may also be identified using other methods. See p. 35 of manual

Notes:

Sketch: stream ends at logging road, no culvert

NC DWQ Stream Identification Form Version 4.11

Date: 5/19/2014	**Project/Site:** 9-1	**Latitude:**
Evaluator: MR	**County:** Wake	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 21.5	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	(3)
2. Sinuosity of channel along thalweg	0	(1)	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	(1)	2	3
4. Particle size of stream substrate	0	1	(2)	3
5. Active/relict floodplain	(0)	1	2	3
6. Depositional bars or benches	(0)	1	2	3
7. Recent alluvial deposits	(0)	1	2	3
8. Headcuts	0	1	2	(3)
9. Grade control	(0)	0.5	1	1.5
10. Natural valley	0	0.5	(1)	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
12. Presence of Baseflow	0	(1)	2	3
13. Iron oxidizing bacteria	(0)	1	2	3
14. Leaf litter	(1.5)	1	0.5	0
15. Sediment on plants or debris	(0)	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	(1)	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 4)				
18. Fibrous roots in streambed	3	2	(1)	0
19. Rooted upland plants in streambed	(3)	2	1	0
20. Macrobenthos (note diversity and abundance)	(0)	1	2	3
21. Aquatic Mollusks	(0)	1	2	3
22. Fish	(0)	0.5	1	1.5
23. Crayfish	(0)	0.5	1	1.5
24. Amphibians	(0)	0.5	1	1.5
25. Algae	(0)	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

A.3 NATIVE PLANT LISTS

Appendix A
10 July 2014

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HERBACEOUS PLANTS-Seeding recommendations for primary stabilization

Successfull development depends on planting date (effectiveness goal: 6 mo. - 3 yrs. without an ongoing maintenance program)

Table 6.11.c

NATIVE SPECIES

					Optimal Planting Dates								
Common Name	Botanical Name / Cultivar	Native / Introduced	See Table 6.11.d for variety seedling rates	Fertilization/ limestone lbs/acre	Mountains	Piedmont	Coastal Plains	Sun/Shade tolerant	Wetlands	Riparian Buffers	Invasive Yes or No	Installation / Maintenance Considerations	Other information, commentary
Switchgrass	*Panicum virgatum /*	N	A	By soil test	12/1-4/15	NR	NR	Sun	NR	Well drained	No	Responds well to	
	Cave-in-Rock									only		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Switchgrass	*Panicum virgatum /*		A	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	NR	Well drained	No	Responds well to	
	Blackwell	N								only		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Switchgrass	*Panicum virgatum /*	N	A	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	NR	Well drained	No	Responds well to	
	Shelter									only		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Switchgrass	*Panicum virgatum /*	N	A	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	Yes	Yes	No	Responds well to	
	Carthage											controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Switchgrass	*Panicum virgatum /*	N	A	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	No	Poorly	No	Responds well to	
	Kanlow									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Switchgrass	*Panicum virgatum /*	N	A	By soil test	NR	12/1 - 5/1	1/1 - 5/1	Sun	No	Poorly	No	Responds well to	
	Alamo									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Indiangrass	*Sorghastrum nutans /*	N	B	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	NR	Well	No	Responds well to	Western coastal plain only
	Rumsey									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Indiangrass	*Sorghastrum nutans /*	N	B	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	NR	Well	No	Responds well to	Western coastal plain only
	Osage									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	

HERBACEOUS PLANTS-Seeding recommendations for primary stabilization

Successfull development depends on planting date (effectiveness goal: 6 mo. - 3 yrs. without an ongoing maintenance program)

Table 6.11.c (con't)

NATIVE SPECIES

					Optimal Planting Dates								
Common Name	Botanical Name / Cultivar	Native / Introduced	See Table 6.11.d for variety seedling rates	Fertilization/ limestone lbs/acre	Mountains	Piedmont	Coastal Plains	Sun/Shade tolerant	Wetlands	Riparian Buffers	Invasive Yes or No	Installation / Maintenance Considerations	Other information, commentary
Indiangrass	*Sorghastrum nutans /*	N	B	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	NR	Well	No	Responds well to controlled	Western coastal plain only
	Cheyenne									drained		burns. Mix with 3 to 5 other seed	
												varieties that have similar soil	
												drainage adaptations.	
Indiangrass	*Sorghastrum nutans /*	N	B	By soil test	NR	12/1 - 5/1	1/1 -5/1	Sun	NR	Well	No	Responds well to	Only Indiangrass adaptable to
	Lomenta									drained		controlled burns. Mix with	Eastern coastal plain (Zone 8)
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Deertongue	*Dichanthelium*	N	C	By soil test	5/1-4/15	5/1 - 4/1	NR	Sun &	Yes	Poorly	No	Responds well to	
	clandestinum / Tioga							Shade		drained to		controlled burns. Mix with	
										drought		3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Big Bluestem	*Andropogon gerardii /*	N	D	By soil test	12/1-4/15	12/1 - 4/1	NR	Sun	NR	Welll	No	Responds well to	Warm season grass
	Rountree									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Big Bluestem	*Andropogon gerardii /*	N	D	By soil test	12/1-4/15	12/1 - 4/1	NR	Sun	NR	Welll	No	Responds well to	Warm season grass
	Kaw									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Big Bluestem	*Andropogon gerardii /*	N	D	By soil test	12/1-4/15	12/1 - 4/1	12/1-5/1	Sun	NR	Welll	No	Responds well to	Warm season grass
	Earl									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Little Bluestem	*Schizachyrium*	N	E	By soil test	12/1-4/15	NR	NR	Sun	NR	Welll	No	Responds well to	Warm season grass
	scoparium / Aldous									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Little Bluestem	*Schizachyrium*	N	E	By soil test	12/1-4/15	12/1 - 4/1	NR	Sun	NR	Welll	No	Responds well to	Warm season grass
	scoparium / Cimmaron									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	

HERBACEOUS PLANTS-Seeding recommendations for primary stabilization

Successfull development depends on planting date (effectiveness goal: 6 mo. - 3 yrs. without an ongoing maintenance program)

Table 6.11.c (con't)

NATIVE SPECIES

					Optimal Planting Dates								
Common Name	Botanical Name / Cultivar	Native / Introduced	See Table 6.11.d for variety seedling rates	Fertilization/ limestone lbs/acre	Mountains	Piedmont	Coastal Plains	Sun/Shade tolerant	Wetlands	Riparian Buffers	Invasive Yes or No	Installation / Maintenance Considerations	Other information, commentary
Little Bluestem	*Schizachyrium*	N	E	By soil test	NR	NR	12/1-4/1	Sun	NR	Welll	No	Responds well to	Warm season grass
	scoparium / Common									drained		controlled burns. Mix with	
												3 to 5 other seed varieties	
												that have similar soil	
												drainage adaptations.	
Sweet Woodreed	*Cinna arundinacea*	N	F	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun &	Yes	Poorly to	No	Mix with 3 to 5 other seed	Warm season grass
								mod. Shade		well drained		varieties that have similar	
												soil drainage adaptations	
Rice Cutgrass	*Leersia oryzoides*	N	G	By soil test	12/1-4/15	12/1 - 4/1	12/1-4/1	Sun	Yes	Poorly	No	Mix with 3 to 5 other seed	Warm season grass
										drained		varieties that have similar	
												soil drainage adaptations	
Indian Woodoats	*Chasmanthium latifolium*	N	H	By soil test	3/1 - 5/15	2/15 - 4/1	2/15-3/20	Sun &	NR	Well	No	Mix with 3 to 5 other seed	Cool season grass
					7/15-8/15	8/15 - 10/15	9/1 - 11/1	mod. Shade		drained		varieties that have similar	
												soil drainage adaptations	
Virginia Wild Rye	*Elymus virginicus*	N	I	By soil test	3/1 - 5/15	2/15 - 4/1	2/15-3/20	Sun &	NR	Well	No	Mix with 3 to 5 other seed	Cool season grass
					7/15-8/15	8/15 - 10/15	9/1 - 11/1	mod. Shade		drained		varieties that have similar	
												soil drainage adaptations	
Eastern Bottlebrush	*Elymus hystrix*	N	J	By soil test	3/1 - 5/15	2/15 - 4/1	NR	Sun &	NR	Well	No	Mix with 3 to 5 other seed	Cool season grass
Grass					7/15-8/15	8/15 - 10/15		mod. Shade		drained		varieties that have similar	
												soil drainage adaptations	
Soft Rush	*Juncus effusus*	N	K	By soil test	12/1 - 5/15	12/1 - 5/1	12/1-4/15	Sun	Yes	Poorly	No	Mix with 3 to 5 other seed	
					8/15-10/15	9/1 - 11/1				drained		varieties that have similar	
												soil drainage adaptations	
Shallow Sedge	*Carex lurida*	N	L	By soil test	12/1 - 5/15	12/1 - 5/1	12/1-4/15	Sun	Yes	Poorly	No	Mix with 3 to 5 other seed	
					8/15-10/15	9/1 - 11/1				drained		varieties that have similar	
												soil drainage adaptations	
Fox Sedge	*Carex vulpinoidea*	N	L	By soil test	12/1 - 5/15	12/1 - 5/1	12/1-4/15	Sun	Yes	Poorly	No	Mix with 3 to 5 other seed	
					8/15-10/15	9/1 - 11/1				drained		varieties that have similar	
												soil drainage adaptations	

NOTE:

1. Seeding rates are for hulled seed unless otherwise noted.
2. Fertilizer & Limestone - rates to be applied in absense of soils tests. Recommended application rate assumes significantly disturbed site soils with little or no residual value.
3. NR means Species not recommended for this region or application area.
4. Native, warm season grasses require six or more months to germinate under optimum conditions. If they are planted in the summer, then a whole year will have to pass before they germinate.
5. Invasive designation as determined by the N.C. Exotic Pest Pant Council and N.C. Native Plant Society .
6. Sprigging is not recommended for immediate stabilization unless terrain is flat, heavymulch is applied and no other immediate stabilization method is practical.
7. Sodding for immediate stabilization - see primary stabilization charts (other information column) and Section 6.12.
8. Long term stabilization can only be accomplished with an adequate, immediate, and primary stabilization program. To achieve long term protective cover with the species listed in

Table 6.11.d

Seed Mixes for Native Species (lbs/ac)
When Mixed with 3, 4, or 5 Other Native Species
(See Table 6.11.a for nurse crop species to be added to these mixes)

	3 Other (total 4 species)	4 Other (total 5 species)	5 Other (total 6 species)
Switch Grasses (A)	3.5 lbs.	3.0 lbs.	2.5 lbs.
Indian Grasses (B)	7.0 lbs.	6.0 lbs.	5.0 lbs.
Deertongue (C)	6.0 lbs.	5.0 lbs.	4.0 lbs.
Big Bluestem (D)	7.0 lbs.	6.0 lbs.	5.0 lbs.
Little Bluestem (E)	7.0 lbs.	6.0 lbs.	5.0 lbs.
Sweet Woodreed (F)	2.5 lbs.	2.0 lbs.	1.5 lbs.
Rice Cutgrass (G)	6.0 lbs.	5.0 lbs.	4.0 lbs.
Indian Woodoats (H)	2.5 lbs.	2.0 lbs.	1.5 lbs.
Virginia Wild Rye (I)	6.0 lbs.	5.0 lbs.	4.0 lbs.
Eastern Bottlebrush Grass (J)	2.5 lbs.	2.0 lbs.	1.5 lbs.
Soft Rush (K)	2.5 lbs.	2.0 lbs.	1.5 lbs.
Sedges (L)	2.5 lbs.	2.0 lbs.	1.5 lbs.

NOTE:
With the native varieties, the seed mix should be in the range of 15 pounds per acre. Depending on availability of native seeds adaptable to North Carolina, the percentage of a particular variety used may be reduced or increased accordingly. Although diversity is desirable, it is imperative that the primary crop develop and become an effective protective cover. In addition to the native species mix, additional nurse crop species must be included to provide immediate stabilization and an adequate ground cover.

Piedmont Riparian Species

TREES	SMALL TREES/SHRUBS	HERBACEOUS FLOWERING PLANTS	GRAMINOIDS AND FERNS
Acer negundo	*Aesculus pavia*	*Arisaema triphyllum*	*Andropogon gerardii**
box elder	red buckeye	jack-in-the-pulpit	big bluestem
Acer rubrum	*Aesculus sylvatica*	*Asclepias incarnata*	*Arundinaria gigantea*
red maple	painted buckeye	swamp milkweed	river cane
Acer barbatum	*Alnus serrulata*	*Bidens frondosa*	*Athyrium filix-femina* ssp. *asplenioides*
southern sugar maple	tag alder	beggartick	southern lady fern
Betula nigra	*Amelanchier arborea*	*Chelone glabra*	*Carex crinata*
river birch	common serviceberry	turtlehead	fringed sedge
Carya cordiformis	*Amelanchier canadensis*	*Eupatorium fistulosum*	*Carex intumescens*
bitternut hickory	shadbush serviceberry	Joe-pye-weed	bladder sedge
Carya ovata	*Aronia arbutifolia (Photinia pyrifolia)*	*Eupatorium perfoliatum*	*Carex lupulina*
shagbark hickory	red chokeberry	boneset	hop sedge
Celtis laevigata	*Asimina triloba*	*Helenium autumnale*	*Carex lurida*
sugarberry	common pawpaw	common sneezeweed	lurid sedge
Diospyros virginiana	*Callicarpa americana*	*Helenium flexuosum*	*Carex scoparia*
persimmon	beautyberry	purplehead sneezeweed	broom sedge
Fraxinus pennsylvanica	*Calycanthus floridus*	*Helianthus angustifolius*	*Carex stricta*
green ash	sweet-shrub	swamp sunflower	tussock sedge
Halesia caroliniana	*Carpinus caroliniana*	*Impatiens capensis*	*Carex vulpinoidea*
silverbell	ironwood	jewel-weed	fox sedge
Juglans nigra	*Cephalanthus occidentalis*	*Lobelia cardinalis*	*Chasmanthium latifolium*
black walnut	buttonbush	cardinal flower	river oats
Magnolia virginiana	*Cornus alternifolia*	*Lobelia elongata*	*Chasmanthium laxum*
sweetbay	alternate leaf dogwood	longleaf lobelia	slender woodoats

Piedmont Riparian Species

TREES	SMALL TREES/SHRUBS	HERBACEOUS FLOWERING PLANTS	GRAMINOIDS AND FERNS
Nyssa sylvatica	*Cornus amomum*	*Ludwigia alternifolia*	*Cyperus strigosus*
blackgum	silky dogwood	bushy seedbox	umbrella sedge
Platanus occidentalis	*Corylus americana*	*Mimulus ringens*	*Elymus hystrix*
sycamore	hazel-nut	monkeyflower	bottlebrush grass
Populus deltoides	*Fothergilla gardenii*	*Physostegia virginiana*	*Elymus virginicus*
eastern cottonwood	dwarf witch-alder	obedient plant	Virginia wild rye
Prunus serotina	*Hamamelis virginiana*	*Polygonum sagittatum*	*Juncus coriaceus*
black cherry	witch-hazel	tearthumb	leathery rush
Quercus lyrata	*Hibiscus moscheutos*	*Pycnanthemum tenuifolium*	*Juncus tenuis*
overcup oak	marsh mallow	narrowleaf mountainmint	poverty rush
Quercus michauxii	*Ilex decidua*	*Pycnanthemum muticum*	*Juncus effusus*
swamp chestnut oak	deciduous holly	bigleaf mountainmint	soft rush
Quercus nigra	*Ilex verticillata*	*Rhexia mariana*	*Leersia oryzoides*
water oak	winter berry	Maryland meadowbeauty	rice cutgrass
Quercus pagoda	*Itea virginica*	*Rhexia virginica*	*Onoclea sensibilis*
cherrybark oak	Virginia willow	Virginia meadowbeauty	sensitive fern
Quercus phellos	*Lindera benzoin*	*Rudbeckia laciniata*	*Osmunda cinnamomea*
willow oak	spicebush	cutleaf coneflower	cinnamon fern
Quercus shumardii	*Lyonia ligustrina*	*Sparganium americanum*	*Osmunda regalis*
Shumard oak	male-berry	bur-reed	royal fern
Salix nigra	*Lyonia lucida*	*Symphyotrichum novi-belgii*	*Panicum clandestinum (Dichanthelium*
black willow	fetterbush	New York aster	deertongue
	Magnolia tripetala	*Vernonia noveboracensis*	*Panicum rigidulum*
	umbrella tree	ironweed	redtop panicgrass

Piedmont Riparian Species

TREES	SMALL TREES/SHRUBS	HERBACEOUS FLOWERING PLANTS	GRAMINOIDS AND FERNS
	Physocarpus opulifolius ninebark		*Panicum virgatum* switchgrass
	Rhododendron maximum rosebay		*Polystichum acrostichoides* Christmas fern
	Rhododendron periclymenoides wild azalea		*Saccharum giganteum* sugarcane plumegrass
	Rhododendron viscosum swamp azalea		*Schizachyrium scoparium** little bluestem
	Rosa palustris swamp rose		*Scirpus atrovirens* green bulrush
	Salix sericea silky willow		*Scirpus cyperinus* woolgrass
	Salix caroliniana coastal plain willow		*Scirpus validus (Schoenoplectus* soft stem bulrush
	Sambucus nigra ssp. *canadensis* elderberry		*Sorghastrum nutans** indiangrass
	Spiraea tomentosa steeplebush		*Thelypteris palustris* marsh fern
	Staphlea trifolia bladdernut		*Tripsacum dactyloides* eastern gamagrass
	Styrax americanus American snowbell		
	Vaccinium corymbosum highbush blueberry		

Piedmont Riparian Species

TREES	SMALL TREES/SHRUBS	HERBACEOUS FLOWERING PLANTS	GRAMINOIDS AND FERNS
	Viburnum dentatum southern arrowwood		
	Viburnum nudum possumhaw		
	Xanthorhiza simplicissima yellow-root		

*Indicates plants that prefer drier conditions.