FINAL STREAM RESTORATION PLAN

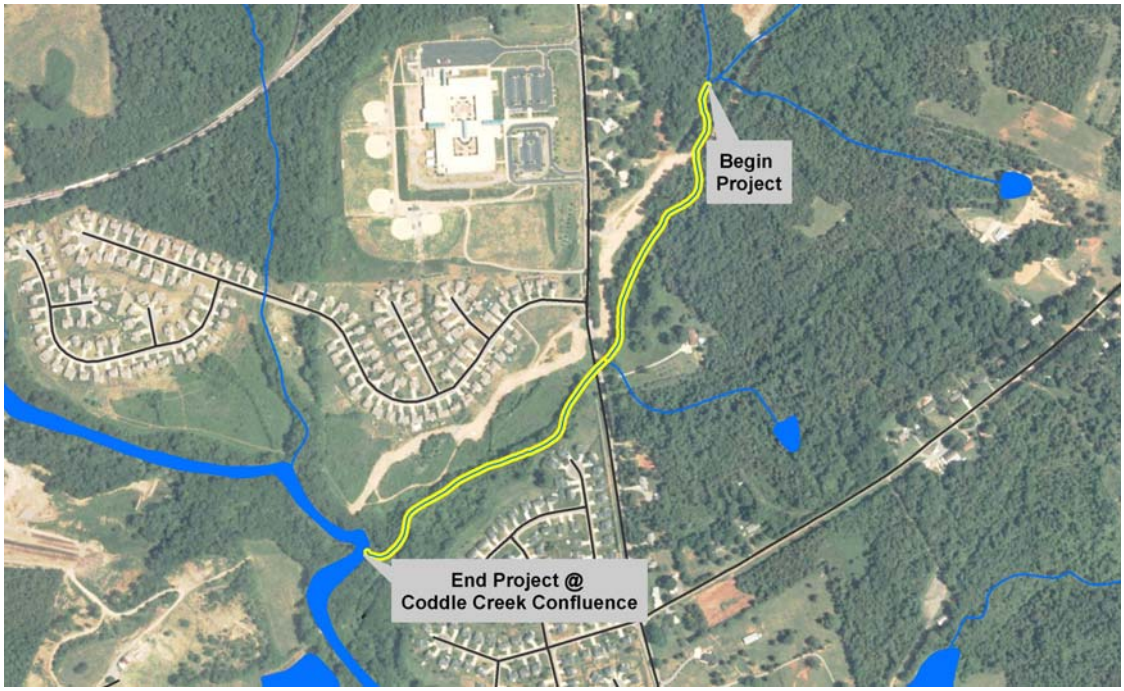
For

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

PROJECT NO: EP4200985

STATE CONSTRUCTION NO: D05004S



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FINAL STREAM RESTORATION PLAN FOR
INDIAN RUN
CABARRUS COUNTY, NC

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The following Stream Restoration Plan was developed by HDR Engineering, Inc of the Carolinas in conjunction with Habitat Assessment and Restoration Program, Inc. (HARP) and utilizing Joyner, Keeney & Associates for the existing reach topographic survey. HARP provided background information and preliminary restoration reach site reviews.

EXECUTIVE SUMMARY

The project reach is located along Indian Run, a second order tributary of Coddle Creek, the latter draining to the Rocky River within the lower North Carolina (NC) portions of the Yadkin-Pee Dee River Basin. The project reach extends from the confluence of Indian Run and Coddle Creek to approximately 3600 linear feet upstream in the NNE direction, across Rocky River Road (Figures 1 and 2).

Coddle Creek, from 0.2 miles upstream of NC Highway 73 (NC-73) to Rocky River, is currently listed on the NC 303(d) List as biologically impaired (NCDENR 2006). The Coddle Creek watershed is one of the targeted high priority restoration areas within the North Carolina Ecosystem Enhancement Program (EEP) plan for the Lower Yadkin River Basin. In addition to the current non-supporting use classification for the lower portions of Coddle Creek, anticipated high rates of development in the watershed pose critical challenges in managing the region's aquatic resources. Land Use / Land Cover analysis indicates that more than 90 percent of the 1.5-square mile Indian Run watershed is currently pervious with a dominance of forested lands, and about 8 to 10 percent is impervious land (Figure 4). It is likely that the majority of the watershed will be built-out within 10 to 20 years. Anticipated impervious cover (as a percentage of the total watershed) is likely to approach 25 to 30 percent at built-out conditions.

The lower 1700 linear feet of the Indian Run catchment, from Rocky River Road to the confluence with Coddle Creek, was previously impacted by channelization. The 1900 foot reach of Indian Run above Rocky River Road has been impacted by both bed incision as well as bank erosion, with over 1200 linear feet of this portion of the reach characterized by unstable banks with moderate to high bank erosion hazard indices (BEHI). Cross-sectional information indicates significant entrenchment, with the bankfull stage approximately three to four feet below current top of bank elevation in the upper section and four to six feet in the lower section.

The goal of this restoration project is to restore approximately 3700 linear feet of a degraded section of Indian Run to a stable channel using natural channel restoration methodologies. The objectives of the Indian Run Stream Restoration Project focus on improving local water quality, enhancing flood attenuation and restoring aquatic and riparian habitat. This will be accomplished by:

- Reestablishing stream stability and capacity to transport watershed flows and sediment load by restoring stable channel morphology, supported with instream habitat and grade/bank stabilization structures;
- Reducing non-point source sedimentation and nutrient inputs into the identified project reaches through the elimination of accelerated bank erosion and reestablishment of native riparian buffer; and
- Enhancing the capacity of the stream to mitigate flood flows by building a bankfull bench.

Below Rocky River Road, approximately 1700 linear feet of the channelized reach will be restored to a natural planform resulting in approximately 1922 linear feet of meandering C-type stream. This Priority II restoration strategy includes building a bankfull bench (ranging from 90 to 120 feet in width) along a meandering channel to the stream's confluence with Coddle Creek.

Above Rocky River Road, the road culvert's elevation will not accommodate Priority I or II restoration, so a bankfull bench is proposed to re-establish some floodprone area and provide relief for future increases in impervious cover within the watershed. This 1900-foot reach of Priority III restoration will attempt to minimize the amount of disturbance on the existing bottomland hardwood forest and riparian canopy by creating a smaller bench than in the lower section and tying in existing elevations to the new bench elevations with 2:1 slopes.

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

The project reach is located along Indian Run, a second order tributary of Coddle Creek, the latter draining to the Rocky River within the lower North Carolina portions of the Yadkin-Pee Dee River Basin. The project reach extends from the confluence of Indian Run and Coddle Creek to approximately 3600 linear feet upstream in the NNE direction, across Rocky River Road (Figures 1 and 2).

1.1 Directions to Project and Reference Reach Sites

To Project Site (Cabarrus County) From I-85 South: Merge onto US-29 S via Exit 58 toward MONROE / CONCORD / BARBER-SCOTIA, go 4.2 miles and turn left onto WARREN C COLEMAN BLVD / US-601 BYP S. Continue to follow US-601 BYP S. for 1.2 miles, then turn right onto OLD CHARLOTTE RD SW. Go 2.1 miles, and turn slightly left onto ROCKY RIVER RD. and travel approximately 0.7 miles south to crossing of Indian Run, a tributary to Coddle Creek. Culvert is between entrances to Autumn Ridge and Boulder Creek Subdivisions.

To Project Site From I-85 North: Merge onto US-29 BYP N via Exit 42 toward NC-49 / US-29, go 1 mile, and stay straight to go onto US-29 N / NC-49 N / N TRYON ST. Continue to follow NC-49 N. for 10.2 miles, then turn right onto OLD CHARLOTTE RD SW, and in 0.5 miles turn sharp to the right onto ROCKY RIVER RD. Travel approximately 0.7 miles south to crossing of Indian Run, a tributary to Coddle Creek. Culvert is between entrances to Autumn Ridge and Boulder Creek Subdivisions.

To Unnamed Tributary (UT) to Reedy Creek Reference Reach Site (Mecklenburg County) From I-85: Take Exit 45 for HARRIS BLVD. / NC-24E, travel east on NC-24 E / W WT HARRIS BLVD for 3.3 miles, turn left onto ROCKY RIVER ROAD for 0.6 miles, then turn right at 2900 ROCKY RIVER ROAD into REEDY CREEK PARK. The stream is located in the park off of the northern segment of the Umbrella Tree Trail.

To Unnamed Tributary (UT) to Reedy Creek Reference Reach Site (Mecklenburg County) From I-485: Take Exit 36 for ROCKY RIVER ROAD, travel east on ROCKY RIVER ROAD toward Charlotte for approximately 3 miles, turn left into REEDY CREEK PARK at 2900 ROCKY RIVER ROAD. The stream is located in the park off of the northern segment of the Umbrella Tree Trail.

To Dixon Branch Reference Reach Site from I-77: Take Exit 18 for HARRIS BLVD. / NC-24, turn west onto HARRIS BLVD for 1.7 miles, turn right onto MT. HOLLY-HUNTERSVILLE ROAD for 0.9 miles, turn right onto ALEXANDERANA ROAD for 0.6 miles. Stream is in the valley west of the pipeline crossing and East Lake Memorial Cemetery. Or Take Exit 18 for HARRIS BLVD. / NC-24, turn east onto HARRIS BLVD for 0.3 miles, turn left onto STATESVILLE ROAD / US-21 for 1.6 miles, then turn left onto ALEXANDERANA ROAD for 0.6 mile. The stream is located west of East Lake Memorial Cemetery and the pipeline crossing.

1.2 USGS Hydrologic Unit Code and NC DWQ River Basin Designations

The project reach is located along Indian Run, a second order tributary of Coddle Creek, the latter draining to the Rocky River within the lower North Carolina portions of the Yadkin-Pee Dee River Basin. The United States Geological Survey (USGS) 14-digit Hydrologic Unit Code (HUC) is 03040105020010 within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-07-11 (upper Rocky River watershed, above confluence with Reedy Creek) (Figure 2). The project reach extends NNE from its confluence with Coddle Creek for a distance of 3580

linear feet, crossing under Rocky River Road. The reach is ungaged, with the closest USGS gaging station within the 14 digit HUC at USGS Gage Station #0212433550 (Latitude 35°19'18", Longitude 80°32'27" NAD83), located on the Rocky River above Irish Buffalo Creek, near Rocky River, North Carolina.

1.3 Project Vicinity Map

Figure 1 shows the location of the site within the southeast Concord metropolitan area and Figure 2 shows the location on the Concord SE quadrangle. Rocky River Road is a narrow two lane road without adequate shoulders for parking. Subdivision streets located north or south of the culvert provide parking for accessing the site.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The drainage area for the Indian Run restoration reach is approximately 1.5 square miles. The delineation from the confluence of Indian Run with Coddle Creek is based on the USGS 7.5 minute topographic quadrangle (Figure 2), using the Cabarrus County two-foot LIDAR contours for verification.

2.2 Surface Water Classification / Water Quality

NCDWQ assigns surface water classifications in order to help protect, maintain, and preserve water quality. Indian Run is unclassified; however, unclassified streams take on the classifications of the streams to which they drain. Coddle Creek, from 0.2 miles upstream of NC-73 to the Rocky River, is Class C waters (EMC 2000).

Coddle Creek is on the 303(d) List as "Impaired" (Biological Integrity – Source Unknown) from a point 0.2 mile upstream of NC-73 to its confluence with the Rocky River, which is a 14-mile section that includes the Indian Run confluence (NCDENR 2006). A map showing the impaired waters, DWQ benthic sampling sites, and ambient water quality monitoring stations within the 03-07-11 basin is shown in Figure 5. The closest monitoring site within the basin is a benthic macroinvertebrate monitoring station along Coddle Creek at the NC-49 crossing, above the Indian Run confluence. NCDWQ sampled the benthic macroinvertebrate community in 2001, with the stream receiving a "Fair" bioclassification due to some available instream habitat (NCDWQ 2003). Sedimentation was noted as a concern during this sampling event.

2.3 Physiography, Geology, and Soils

This watershed is located within the Southern Outer Piedmont ecoregion of the North Carolina Piedmont physiographic province. This ecoregion consists of lower elevations, irregular plains, and less relief than other portions of the Piedmont (Griffith et al 2002). Drainage is relatively mature with a well-developed dendritic network of predominantly C- and E-type streams.

The site lies within the Charlotte belt of the North Carolina Piedmont, which is a geologic province dominated by large areas of variably-metamorphosed plutonic and volcanic rocks. The dominant plutonic rocks are generally characterized as being pre-, syn-, or post-tectonic with respect to the early and middle Paleozoic phases of deformation that imparted new textures and secondary minerals into existing units. The resulting oriented fabrics or foliations represent weaknesses within these rocks that have been worked on by the forces of weathering and erosion, and are often followed by today's surface streams imparting to them a lower than expected sinuosity for the low grades and giving them mixed C and E stream class traits. In the case of the Indian Run tributary to Coddle Creek (see Figure 3), the stream trends for over 3000 linear feet in a relatively straight orientation paralleling measured foliations and parting directions in the underlying metamorphic rocks. The dominant lithology within the watershed, and directly underlying the restoration reach, is a Paleozoic complex of metavolcanic units that in turn form the host rocks to the Concord plutonic suite that is found in the northernmost part of the Indian Run catchment. The metavolcanic rocks are fine-grained and tend to lead to the development of thinner and more clay-rich soils, particularly in hilltop areas. Nickpoints of the metavolcanic rocks are exposed in the bed of Indian Run and are dark grey, dark green, and blackish in appearance.

The restoration reach lies within a low-gradient valley floor underlain predominantly by Chewacla sandy loam that is frequently flooded (Figure 3). Adjacent hill slopes are dominated by Enon sandy loams with 2 to 15 percent slopes. Hilltops are dominated by Cullen clay loams with subordinate Poindexter loam and Pacolet sandy loam (Stephens 1988).

Chewacla loam, classified as thermic Fluvaquentic Dystrochrepts, is a nearly level and somewhat poorly drained soil found within long, narrow floodplains along minor streams and broad, flat floodplains of major streams. The soil is moderately permeable, and available water capacity is high. The seasonal high water table is 0.5 foot to 1.5 feet below the surface and is subject to frequent flooding for brief periods from November to April for most years (Stephens 1988).

2.4 Historical Land Use and Development Trends

Overall, the Yadkin-Pee Dee River 03-07-11 DWQ Subbasin is within the greater metropolitan area of Charlotte, and information related to land cover quickly becomes outdated and tends to underestimate development and impervious land cover. According to DWQ's 2003 Basinwide Plan, "the subbasin land cover information compiled between 1993 and 1995 describe more than 60 percent of the land as forested, nearly 30 percent as pasture or managed herbaceous land, and more than 6 percent as urban (impervious), and the population is projected to increase 53 percent in Cabarrus County between 2000 and 2020" (NCDWQ 2003).

Land cover characteristics for the Indian Run watershed were derived by digital interpretation of the 2006 USDA color orthophotography, which is depicted in Figure 4. The orthophotography analysis indicates that more than 90 percent of the watershed remains pervious with a dominance of forested lands. The individual land cover classes are summarized in Table 3. Aerial photography shows evidence of historical clearing and reforestation activity in portions of the drainage basin, but field inspection of the bottomland hardwoods along the upper portions of the restoration reach (above Rocky River Road) reveals tree species and diameter breast height (DBH) values suggestive of 70 to 80 years of forest succession. The lower channelized reach lies within a cleared area that was last used as pasture and has a narrow fringe of trees along the banks with DBH values suggestive of 40 to 70 years of growth. The Indian Run watershed is currently undergoing significant amounts of residential development. It is likely that the majority of the developable watershed will be built-out within 10 to 20 years. Anticipated impervious cover (as a percentage of the total watershed) is likely to approach 25 to 30 percent at built-out conditions. The extent to which stormwater controls will be introduced in future developments is uncertain, although Cabarrus County and the City of Concord have jurisdiction over stormwater and have been relatively proactive regarding development regulations and enforcement. Restoration design for the Indian Run reach will need to address the potential impact of development on stream hydrology and its attendant adjustments in morphologic regime.

2.5 Endangered / Threatened Species

A review of the North Carolina Natural Heritage Program (NHP) database was conducted to determine the element occurrence records of any federally rare, threatened, or endangered species or critical habitats on or near the site. The NHP and United States Fish and Wildlife Service (USFWS) records show one state and federally-listed endangered species occurring in this portion of Cabarrus County, Schweinitz's Sunflower (*Helianthus schweinitzii*). A survey of the project area indicated that Schweinitz's sunflower does not occur along the roadsides, in the fields, or in the utility rights-of way that exist at the project area.

2.6 Cultural Resources

A review of available records at the North Carolina Department of Cultural Resources - State Historic Preservation Office was conducted to examine known resources located proximal to the project site. A review of available records from the National Register of Historic Places indicates multiple listings within Concord (NPS 2005). The historic resources located within one-mile of the project site include the Leroy McKee-Morrison House, the Joseph Osborne Pharr House, and the Jim Russell House. None of these resources are located on or adjacent to land parcels of the project site or will be affected by construction activities.

2.7 Potential Constraints

2.7.1 Property Boundary and Ownership

No issues regarding boundary location or ownership are anticipated for this project, as the NC State Property Office has secured easements and property for the project. The proposed Indian Run stream restoration construction area covers approximately 4.2 acres between the Coddle Creek confluence and Rocky River Road, and an additional 2 acres from Rocky River Road to a point approximately 1800 feet upstream. Overall, the project falls within six parcels. Two parcels are owned by the Autumn Ridge II Homeowners' Association and total 14.35 acres. Two parcels are owned by the Boulder Creek Homeowners' Association and total 8.86 acres. One 6.79-acre parcel is owned by the State of North Carolina (c/o State Construction Office), and one 8.21-acre parcel is owned by Ms. Chaonn Hoyle.

2.7.2 Site Access

Site access is not an issue as local topography and road infrastructure are adequate to support temporary access for construction from Rocky River Road. It may be advisable to discuss site access with the owners of utility easements in order to provide the best and least-damaging access to the site.

2.7.3 Utilities

There are two utilities in and around the project area that will require coordination, BellSouth and municipal sewer lines. The fiber optic line and right-of-way owned and operated by BellSouth is located on the Hoyle and Autumn Ridge properties. While construction is not anticipated to affect the line, BellSouth should be notified of the construction project. The second utility has two sewer line crossings that will require some coordination. Portions of the lines constructed near the confluence of Indian Run with Coddle Creek may be considered constraints and will dictate the construction and structure that can be used in those areas. The sewer line crossing near the upstream limit of the project is currently causing the stream to pond up behind the abundance of riprap that has been placed at that crossing. This area has been reviewed several times and the utility owner is in the process of removing some of the in-stream rock material causing the backwater problem. Recent visits to the site (July 2007) indicate that the previous gabions along the channel have been removed; however, the large rock in the channel is still causing the water to pond. This location and uncertainty of the utility owner's actions require this area to also be noted as a possible constraint and reviewed during future site visits.

2.7.4 FEMA / Hydrologic Trespass

There are no current FEMA issues with the project site. Indian Run is outside of the regulatory floodplain; please see Section 7.3 for further detail. The project will not incur any hydrologic trespasses.

3.0 PROJECT SITE STREAM

3.1 Channel Classification

Rosgen's Applied River Morphology (1996) techniques on stream morphology and classification were used to evaluate and classify Indian Run. Stream width-to-depth ratio, entrenchment ratio, slope, sinuosity, and channel material are needed to complete this Rosgen-based classification of streams. All these parameters are used to determine the current condition of the channel, classify the stream, and aid in design.

The following definitions are provided for the five criteria:

- Width-to-depth ratio: the ratio of the bankfull width to the mean depth of the bankfull channel. This indicates the channel's ability to dissipate energy and transport sediment.
- Entrenchment ratio: the vertical containment of the stream and the degree to which the channel is incised in the valley floor. This indicates the stream's ability to access its floodplain.
- Slope: the change in water surface elevation per unit of stream length. The slope can be analyzed over the entire reach or over sections (determine the condition of pools/riffles).
- Sinuosity: the ratio of stream length to valley length. Extremely low sinuosity channels in the piedmont of North Carolina typically indicate a straightened channel.
- Channel bed and bank materials indicate the channel's resistance to hydraulic stress and ability to transport sediment (Rosgen 1996).

Typical measurements for the longitudinal profile survey as well as pool and riffle cross-sections included, but were not limited to:

- thalweg
- edge of water
- water surface
- bankfull
- top of low bank
- terrace
- width (bankfull, top of channel, flow)
- depth (mean, bankfull, max)
- bank slope
- width of flood prone area
- belt width
- valley length
- straight length
- pool-to-pool spacing
- bankfull area
- composition of channel materials

Based on collection of the previous criteria and measurements, it was determined that the reach would be classified as a degraded or impaired "C4" channel. "C" streams are located in narrow to wide valleys, have well developed floodplains with slight entrenchment, are relatively sinuous, and generally have a riffle/pool sequence on the average one-half meander wavelength. The slopes on these streams are 2% or less, width/depth ratios are greater than 12, and sinuosity should exceed 1.2. "C" streams can be significantly altered and rapidly de-stabilized when the effects of imposed changes in bank stability, watershed condition, or flow regime are combined and exceed the channel's stability threshold. This appears to be the case for Indian Run, which does not exhibit all of the parameters of a stable C4 reach but rather has been determined to be an impaired reach based on extreme entrenchment and incision, low sinuosity from channelization, and a low width to depth ratio.

3.2 Discharge

The methodology used for the hydrologic analysis required evaluation of the existing bankfull discharge by assessing the onsite bankfull indicators, the North Carolina Rural Piedmont Discharge Curve (Harman et al 1999), and Manning's Equation. The discharge estimate and methods are discussed in detail in Section 3.5 of this document.

3.3 Channel Morphology

3.3.1 Existing Morphology Methodology

In order to demonstrate the current levels of impairment along the targeted reach of Indian Run, the following six steps have been taken:

- Planform maps of the reach were created by field surveys using measuring tapes and compass/transit bearings and by establishing centerline stationing in order to accurately define the length and location of morphologic features.
- Characteristic locations for collection of cross section data were identified and then surveyed using tape, stadia rod, and transit.
- Using a transit and tape, a longitudinal profile focusing on bed features such as riffles, pools, and bedrock nickpoints was completed.
- A BEHI survey of the banks along of the reach was conducted to isolate areas of greatest bank instability and sediment erosion.
- A survey of existing tree species, their diameter and condition was conducted.
- A series of photomosaics were assembled to further document the degree of bank erosion along the reach. These are presented in Appendix B (photo mosaics).

3.3.2 Planform

The planform and morphologic characteristics for the Indian Run restoration reach is shown in Existing Conditions Sheets 1A, 1B, and 1C and summarized in Table 4. The lower section, extending from the confluence with Coddle Creek up to Rocky River Road, is composed of a series of straight ditch-like segments broken up by low-angle bends, or small segments where the channel has undergone aggressive bank erosion and unstable meander development since channelization. The channelized planform does not allow for assessment of meander parameters such as meander wavelength, sinuosity, meander belt width, or meander radius of curvature. The upper reach (upstream of Rocky River Road) follows a natural planform that has evolved over time, allowing a rational assessment of stream morphologic features related to the stream planform.

3.3.3 Cross Sections

Cross sections for Indian Run illustrate that in both the channelized reach below Rocky River Road and the areas above the road, the floodprone stage is below the top of bank. Only 2 of the 8 surveyed sections had a floodprone stage above the elevation of the existing floodplain. There is also considerable variation in the width to depth (W/D) ratios for the reach above Rocky River Road. W/D ratios from 7 to 16 result in problems for stream stability, as extreme fluctuation in W/D ratio promotes sediment transport disequilibrium along the reach.

3.3.4 Longitudinal Profile

Longitudinal profiles are shown in Sheets 1D and 1E, where bed and water surface elevations are plotted with bed structure divided into pools and riffles. The overall slope, riffle and pool slopes, average riffle and pool lengths, and riffle/pool ratios are summarized in Table 4 (Stream Morphologic Parameters). The upper and lower portions of the reach are relatively comparable in their bed structures as well as the average pool lengths and average riffle lengths. These values, when compared to the reference reaches' riffle/pool ratios, riffle lengths, and pool lengths indicate that both the upper and lower portions of Indian Run have less than desirable bed structure to support aquatic habitat.

3.4 Channel Stability Assessment

The stream stability was analyzed using Rosgen Level III methodologies through an examination of parameters such as morphologic data (discussed above), existing trees (species, size, health, and relation to stream), and lateral stability (Bank Erosion Hazard Index (BEHI)). A 50-foot sampling or survey interval was established for conducting the BEHI assessment using the same stationing as used for the morphologic planform and longitudinal survey work. The BEHI values were determined for upper and lower bank areas in order to isolate specific zones of high erosion hazard. The resulting values for the upper reach were initially ranked into four levels of erodibility and these results are presented in Appendix B.

Bank Erosion Hazard Index scores ranged from 22.9 to 38.5 (on an overall scale of 0 to 50), indicating a moderate to high potential for continued bank erosion and channel widening across the entire project reach (Table 5). Additionally, sediment supply is high from severely eroding banks. The existing channel also exhibits long straightened reaches, lack of riffle-pool sequence, lack of pool depth and entrenchment. These factors indicate both vertical and lateral instability through channel incision and widening throughout the project reach.

The major bank areas with erosion and stability problems were photographed for visual documentation and assistance in the development of the conceptual designs. Photo mosaics assembled from the photographs taken from a central vantage point are included in Appendix B.

3.5 Bankfull Verification

The commonly accepted method for natural channel design is based on the ability to select the appropriate bankfull discharge and generate the corresponding bankfull hydraulic geometry from a stable reference reach. Observable bankfull stage indicators can include top of bank, upper breaks in slope, back of the highest depositional feature (i.e. point bars and benches), and the highest scour line. Because bankfull stage can be problematic to determine, especially in a degraded system, any indicator of bankfull was noted in the restoration reach. The field-indicated bankfull stage was then verified using the regional hydraulic geometry relationships (Regional Curves) (Harmon et al 1999). The bankfull cross-sectional areas for the restoration reach were consistent with the cross-sectional area regressed power function lines from the regional curves.

The Regional Curve analysis for rural streams in the North Carolina Piedmont (Harmon et al 1999) generated the following:

Rural Streams (this set is in feet and mi^2):

$$A_{bkf} = 21.43\ A_w^{0.68}$$
$$Q_{bkf} = 89.04\ A_w^{0.72}$$
$$W_{bkf} = 11.89\ A_w^{0.43}$$
$$D_{bkf} = 1.50\ A_w^{0.32}$$

In these equations:

A_w = the drainage basin contributing area; (km^2, mi^2)
A_{bkf} = cross section area of flow at the bankfull stage; (m^2, ft^2)
Q_{bkf} = discharge at the bankfull stage; (m^3/s, ft^3/s)
W_{bkf} = width of the water surface at the bankfull stage; (m, ft)
D_{bkf} = mean depth of flow at the bankfull stage; (m, ft)

Rural regional curves were utilized as opposed to urban curves based on the current land use and strict stormwater BMP guidelines in place. The watershed is currently less than 10% impervious with the remainder being pervious surfaces such as forests and lawns. Cabarrus County in general is developing rapidly. Fortunately, the local government has realized the importance of stormwater BMPs and all future developments will be required to mitigate stormwater flows. Future stormwater discharges are not expected to increase more than 10% due to local guidelines.

3.6 Vegetation

The canopy along the stream corridor above Rocky River Road contains species indicative of a Piedmont/Mountain Bottomland Forest (Schafale and Weakley 1990). The dominant canopy species in this area were black walnut (*Juglans nigra*), hackberry (*Celtis laevigata*), American sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua)*, river birch (*Betula nigra*), green ash (*Fraxinus pennsylvanica*), and water oak (*Quercus nigra*). The small tree / shrub level was fairly open throughout this area with the following species occurring: ironwood (*Carpinus caroliniana*), Chinese privet (*Ligustrum sinense*), trifoliate orange (*Poncirus trifoliata*), and saplings of the canopy tree species. Grape (*Vitus* spp.), greenbrier (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), and Japanese honeysuckle (*Lonicera japonica*) were present throughout.

The existing stream buffer below Rocky River Road is not regarded as a naturally occurring system, but as a result of human-induced disturbance from the adjacent subdivision and former agricultural uses. A narrow fringe of mixed-age trees and scrub brush occur along this portion of Indian Run. The pastured areas bordering the project channels are primarily vegetated with typical field grasses such as fescue (*Festuca* sp.) and other herbs and shrubs. Other herbaceous species include chickweed (*Stellaria media*), curly dock (*Rumex crispus*), white clover (*Trifolium repens*), and dog fennel (*Eupatorium capillifolium*). Scattered individuals or small clumps of shrubs and trees were also noted in these areas, predominantly sweetgum, red maple (*Acer rubrum*), eastern red cedar (*Juniperus virginiana*), and blackberry species (*Rubus* sp.).

4.0 REFERENCE STREAMS

The regional topography, valley slope, and cross sections surveyed along the Indian Run restoration reach indicate that Indian Run occupies a relatively broad level floodplain that would in stable equilibrium conditions be occupied by a C-type transitioning to an E-type (Rosgen 1996, 1997) stream with a bankfull stage at, or very close to, the true top of bank. Stable C- / E-type channels have been difficult to find in the Charlotte area of the North Carolina Piedmont due to the practice of converting level floodplain lands to row crop agriculture in past centuries. For this project it was determined that designing a stable C-type channel would be suitable for the site conditions. Two reference reaches were located for use in designing the plan for Indian Run. The first reference reach was located in Huntersville, NC (Mecklenburg County) and will be referred to as Dixon Branch. The second reference reach site is located in Charlotte, NC (Mecklenburg County) and will be referred to as UT to Reedy Creek. The locations of the reference reaches are shown in Figures 6a and 6b, and directions to the sites can be found in Section 1.1. Other geographic data for the reference reaches are presented in Figures 7 through 10, and summarized in Table 4 (along with the parameters for existing conditions of the degraded segments of Indian Run). Photographs of the reference reaches are included in Appendices C and D.

4.1 Watershed Characterization

4.1.1 Dixon Branch

The Dixon Branch watershed and it hydrologic features are shown in Figure 7a. The watershed is dominated by a mix of wooded and agricultural lands with a subordinate variety of urban land classes, including transportation, low-density residential, and institutional parcels. Interstate 77 bisects the watershed from north to south. Soils within the watershed are shown in Figure 8a, with the reference reach itself lying within a floodplain corridor of Monacan loam soils. As is the case for the Indian Run restoration reach, the reference reach lies within the Charlotte 'Granite' Belt, with a variety of mafic, intermediate, and silicic pluton and metaigneous rock units of variable resistance to chemical and mechanical forces of weathering and erosion.

The reach is located within the outer developing surburban fringe of the Charlotte metropolitan area, and is transitioning from a rural to suburban setting. Over time, this reach could be impacted by future residential and commercial developments due to the proximity to Interstate 77 and newly constructed shopping center.

4.1.2 UT to Reedy Creek

The UT to Reedy Creek watershed and its hydrologic features are shown in Figure 7b. The watershed is dominated by wooded parkland owned by Mecklenburg County as part of the Reedy Creek Nature Preserve. Soils of the watershed are shown in Figure 8b, with the reference reach lying within a stream corridor of Wilkes loam soils. The reference reach lies within the Charlotte 'Granite' Belt, with a variety of mafic, intermediate, and silicic pluton and metaigneous rock units of variable resistance to chemical and mechanical forces of weathering and erosion.

The reach is located within the surburban portions of the Charlotte metropolitan area; however, the majority of the watershed is wooded and protected within the Nature Preserve.

4.2 Channel Classification

4.2.1 Dixon Branch

Based on the data summarized in Table 4, the Dixon Branch reference reach is a Rosgen Type C4 stream. The alluvial floodplain setting, proximity of bankfull to current true top of bank, entrenchment ratios, and low stream slopes support a C channel classification. The reach is located just upstream from the Dixon Branch crossing of Alexanderana Road in Huntersville (Figure 7a). The stream is classified by NCDWQ as a Class C stream. These waters are protected for secondary recreation (wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner), fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. There are no state restrictions on watershed development or types of discharges (NCDWQ 2007).

4.2.2 UT to Reedy Creek

Based on the data summarized in Table 4, the UT to Reedy Creek reference reach is a C4-type stream. The alluvial floodplain setting, proximity of bankfull to current true top of bank, entrenchment ratios, and low stream slopes support a C channel classification. The reach is located within Reedy Creek Nature Preserve, approximately 1500 feet upstream of its confluence with Reedy Creek in Charlotte (Figure 7b). The stream is classified by NCDWQ as a Class C stream. These waters are protected for secondary recreation (wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner), fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. There are no state restrictions on watershed development or types of discharges (NCDWQ 2007).

4.3 Discharge

The observations of bankfull indicators within the reference reaches are summarized in Table 4. The estimated cross sectional areas, wetted perimeters, and channel slopes, combined with estimated Manning's roughness coefficients, provide input parameters for discharge verification using Manning's equation. The bankfull indicators utilized included benches, scour lines, and vegetative indicators just inside the top of bank.

4.4 Channel Morphology

The pattern, dimension and profile of the reference reaches were surveyed using standard morphologic methodology after initial inspection of the stream stability and bankfull indicators. The pattern of the reference stream reaches, derived using meander radius of curvature, meander belt widths, meander wavelengths, and sinuosity, are summarized in Table 4. The dimensions of the reference reaches were surveyed at one riffle and one pool cross-section per reach. A longitudinal profile was collected at each reach as well, measuring over 200 feet at Dixon Branch and over 300 feet at the UT to Reedy Creek. These values are summarized in Table 4.

4.5 Channel Stability Assessment

There are four categories of observations that are used to determine the stability-based appropriateness of a reference reach for restoration design purposes:

- Consistency of channel morphologic parameters with regime-based estimates of channel dimensional parameters and discharge,
- Indications of recent overbank flow and levee aggradation to demonstrate that the channel is hydrologically connected to the surrounding floodplain under current watershed, climate, and hydrologic conditions,
- No significant bed or bank erosion areas, and
- Reasonable riffle and pool habitat present for riffle and meander bend areas, respectively, without signs of aggradation within the channel from the formation or migration of lateral or medial sediment bars (point bars excluded).

Photographs included in Appendices C and D and morphologic surveys shown in Table 4 demonstrate the stability of the selected reaches. Quantitative assessments of sediment export/erosion using a BEHI approach was completed along more than 200 linear feet of each reference reach and can be found in Table 6. The average BEHI values along the left and right banks of the Dixon Branch reach were 17.97 and 14.85, respectively. The average BEHI values along the left and right banks of the UT to Reedy Creek reach were 18.31 and 19.45, respectively. This equates to a low hazard or risk rating for the stream banks.

4.6 Bankfull Verification

The commonly accepted method for natural channel design is based on the ability to select the appropriate bankfull discharge and generate the corresponding bankfull hydraulic geometry. Observable bankfull stage indicators can include top of bank, upper breaks in slope, back of the highest depositional feature (i.e. point bars and benches), and the highest scour line. The most commonly noted bankfull indicator for the Dixon Branch reference reach was top of bank. The field-indicated bankfull stage was then verified using the regional hydraulic geometry relationships (Regional Curves, as discussed above in Section 3.5) (Harmon et al 1999). The bankfull cross-sectional areas for the restoration reach were consistent with the cross-sectional area regressed power function lines from the regional curves.

4.7 Vegetation

4.7.1 Dixon Branch

The canopy along Dixon Branch contains species indicative of a Piedmont/Mountain Bottomland Forest grading to a basic mesic forest upslope of the stream floodplain (Schafale and Weakley 1990). The dominant species in this area were hackberry, American sycamore, sweetgum, ironwood, box elder (*Acer negundo*), river birch, and autumn olive (*Elaeagnus umbellata*). The small tree / shrub level was fairly dense throughout the reach with autumn olive (*Elaeagnus umbellata*) and Chinese privet. Poison ivy was the dominant vine and present throughout the reference reach. The adjacent upland areas contained American beech (*Fagus grandifolia*), flowering dogwoods (*Cornus florida*), and numerous cedars.

4.7.2 UT to Reedy Creek

The riparian corridor for the UT to Reedy Creek contains species indicative of a Piedmont/Mountain Bottomland Forest that quickly grades into a basic mesic forest upslope of the stream floodplain (Schafale and Weakley 1990). The dominant species in this area were umbrella-tree (*Magnolia tripetala*), sweetgum, red maple (*Acer rubrum*), ironwood, and box elder. The small tree / shrub level was fairly dense throughout the

reach with saplings of the aforementioned species. Poison ivy was the dominant vine and herbaceous species throughout the reach. The adjacent upland slopes contained American beech, flowering dogwood, and several species of oaks.

5.0 PROJECT SITE WETLANDS - Not Relevant to this Restoration Plan

6.0 REFERENCE WETLANDS - Not Relevant to this Restoration Plan

7.0 PROJECT SITE RESTORATION PLAN

7.1 Restoration Project Goals and Objectives

The Coddle Creek watershed is one of the targeted high priority restoration areas within the EEP plan for the Lower Yadkin River Basin. In addition to the current non-supporting use classification for the lower portions of Coddle Creek, anticipated high rates of development in the watershed pose critical challenges in managing the region's aquatic resources. Indian Run, with a drainage area of approximately 1.5-square miles, was previously ditched in the lower 1700 linear feet above the confluence with Coddle Creek. The 1900-linear foot reach of Indian Run above Rocky River Road has been impacted by both bed incision as well as bank erosion. Over 1200 linear feet of this portion of the reach is characterized by unstable banks with moderate to high BEHI. Cross-sectional information for the upper and lower reaches (when compared to reference reach and regime data) indicate entrenchment with the bankfull stage approximately three to six feet below current top of bank elevation. Specific morphologic conditions are presented in Table 4, and were summarized in Section 3. Representative bank erosion photo mosaics are shown in Appendix B. This restoration project aims to restore a degraded section of Indian Run to a stable channel using natural channel restoration methodologies. Below Rocky River Road, approximately 1700 linear feet of the channelized reach will be restored to a natural planform resulting in approximately 1922 linear feet of meandering C-type steam. Above Rocky River Road, on-site restrictions will not accommodate raising the channel bed, which would allow the stream to access its historic floodplain. Therefore, a bankfull bench is proposed to recover some of the floodprone area and provide relief for larger storm flows.

The goals and objectives of the Indian Run Stream Restoration Project focus on improving local water quality, enhancing flood attenuation and restoring aquatic and riparian habitat. This will be accomplished by:

- Reestablishing stream stability and capacity to transport watershed flows and sediment load by restoring stable channel morphology, supported by instream habitat and grade/bank stabilization structures;
- Reducing non-point source sedimentation and nutrient inputs into the identified project reaches through the elimination of accelerated bank erosion and reestablishment of native riparian buffer; and
- Enhancing the capacity of the stream to mitigate flood flows by building a bankfull bench.

7.1.1 Designed Channel Classification

The stream restoration concepts proposed herein have been developed following the NC inter-regulatory guidelines for stream restoration in North Carolina (NCDWQ 2001). These concepts consider existing conditions and causes of impairment, and are sensitive to site constraints and future changes in the contributing drainage area. The analysis of conditions within both the impaired and reference reaches follows standard applied fluvial morphologic principles and practices such as those exposited by Rosgen (1994, 1996, 1997) and Newbury and Gaboury (1993). The ultimate goal of this restoration project is to restore approximately 3700 linear feet of a degraded section of Indian Run to a stable channel using natural channel restoration methodologies.

7.1.1.a Indian Run, Rocky River Road to Confluence with Coddle Creek (1922')

This reach was channelized prior to the last 50-70 years of tree growth along its banks, and with the exception of a few trees and shrubs is located within a cleared floodplain that now forms open green space common areas for two residential subdivisions located north and south of the reach (Autumn Ridge and Boulder Creek communities). By agreement with local interests, a corridor of open land has been set aside to construct a new stream channel to the north of the existing channel using a natural Rosgen C-type stream as a design goal. Backwater and flooding constraints for the Rocky River Road crossing of Indian Run will not likely permit complete recovery of the bankfull elevation to the existing floodplain along the reach, but sufficient land has been set aside in the restoration in order to cut a floodplain bench adjacent to the banks of the new stream channel and achieve morphologic design benchmarks, as documented with the reference reaches. The proposed new alignment for Indian Run and some of the proposed restoration implementations to be incorporated into the new channel are presented in Design Sheets 2B-2D.

The restoration in this segment is proposed to have a downstream tie-in at the confluence with Coddle Creek and an upper tie-in at the culvert under Rocky River Road. The proposed restoration is approximately 1922 feet in length with a sinuosity of approximately 1.24. A conservation buffer of approximately 170 feet in width is provided along the stream corridor, which will include both the proposed stream alignment and portions of the filled-in existing channel. As the stream meanders within this conservation corridor, the buffer widths to each side increase and decrease in a balanced or compensating manner to keep the total buffer width approximately constant.

The proposed Priority II restoration along this segment of Indian Run will result in three primary benefits. The restoration will result in the removal of approximately 1700 linear feet of unstable banks, which have generated and transported sediment downstream to a biologically-impaired Coddle Creek, due in part to elevated sediment. Second, the creation of a stable C-type channel in this area will allow attenuation of higher storm flows, which will lessen stress and potential bank erosion in downstream areas. Third, restoration of improved riffle and pool bed structure within the reach should enhance aquatic habitat in the reach, and have secondary ecological benefits for up- and down-stream areas.

The restoration of the longitudinal profile and channel dimension of this lower portion of Indian Run is shown in Design Sheet 3B (longitudinal profile) and Design Sheet 2A (Typical Sections). These elements were designed utilizing the data from the reference reach and aimed toward restoring natural functions to the reach.

7.1.1.b Indian Run, Rocky River Road to confluence with unnamed trib (1808')

The restoration in this upper reach extends 1808 linear feet upstream from the Rocky River Road culvert. A 100-ft conservation buffer is proposed for the entire reach (shown in Design Sheets 2B – 2D) that is offset 50-ft on each side from the proposed centerline. The conservation buffer will be replanted in any areas disturbed by restoration activities with a mix of species appropriate to the setting and surrounding bottomland forest community and habitat.

The enlargement of the stream bed that has occurred in the last 70 years (judging by the age of trees with undercut tree root balls) can be partially recovered through the creation of a bankfull bench and laying back of the sideslopes. These improvements are portrayed in the design typical sections of Design Sheet 2A. A proposed vertical alignment will also help reestablish riffle-pool sequences and increase lateral and vertical stability. The installation of cross vanes and artificial sills will be placed in areas where the channel will be filled to provide grade control.

A bankfull bench is recommended on both sides of the channel in order for establishment of vegetation to protect the banks and add shade to the stream. In the upper reach a minimum 5-foot bankfull bench was incorporated as a balance between floodprone area and impacts to existing trees. Above the upper sewer crossing on Ms. Hoyles' property, where tree preservation is of more concern, the bankfull bench was reduced to 3-feet on each side.

The side slopes, which tie the bankfull bench to natural ground, on the upper reach were steepened to 2:1 (horizontal to vertical). While a 3:1 side slope would be more desirable, the impacts to existing trees would be greater.

The banks will also be protected through the use of single and double armed cross vanes to direct maximum velocity vectors away from the bank areas. Log sills and cross vanes will also be utilized as grade control to insure that the stream bed will not become further incised.

7.1.2 Target Buffer Communities

Restoration for the Indian Run site involves planting of buffers adjacent to the stream. Species proposed for use in the restoration were chosen to represent an Alluvial Forest grading to a Bottomland Forest Community as defined in the *Classification of the Natural Communities of North Carolina, Third Approximation*, by M.P. Schafale and A.S. Weakley (1990). The buffer area adjacent to the stream reach was divided up into four different zones (Stream Bank, Lower Floodplain Bench, Upland Slope, and Pocket Depressions). Refer to Section 7.7 for more detailed information on the buffer communities and planting zones.

7.2 Stability and Sediment Transport Analysis

7.2.1 Methodology

The stream's ability to transport the sediment load without aggrading or degrading is the threshold of the stream's stability. Stability is evaluated through an evaluation of channel competency. Competency is the channel's ability to move particles of a certain size, expressed as units of lbs/ft^2.

Shear stress is the force required to initiate the general movement of particles in a streambed. This entrainment of particles must have the ability to move the largest particle from the bar sample (D_i) to prevent aggradation of particles. In order to move the D_i particle, the stream design must meet a critical depth and slope. The shear stress analysis indicates whether a stream has the ability to move its bedload.

To validate this theory-based explanation, shear stress was calculated for the design riffle cross-sections in both the upper and lower project reaches using the equation:

$$\tau = \gamma Rs$$

Where: τ = shear stress (lbs/ft^2)
γ = specific gravity of water (62.4 lbs/ft^3)
R = hydraulic radius (ft)
s = average water slope (ft/ft)

7.2.2 Calculations and Discussion

Entrainment calculations were performed on the existing and proposed reach. The summary can be found in Table 4.

The required critical depths and slopes were calculated for both the existing and proposed reaches. The existing bankfull channel mean depth was higher than the required bankfull mean depth indicating that the channel was degrading. The existing bankfull water surface slope was higher than the required bankfull water surface slope also indicating a degrading channel. This result was verified through field observations.

Entrainment values were calculated for the proposed channel. Both the bankfull mean depth and bankfull water surface slope matched the required values indicating the proposed reach should be a stable reach and transport the required amount of sediment.

7.3 HEC-RAS Analysis

7.3.1 No-rise, LOMR, CLOMR

According to the FEMA detailed study for Cabarrus County (Flood Insurance Rate Map (FIRM) Number 37025C0120 D - November 2, 1994, See Appendix E), the portion of Indian Run that comprises this project is not in an area of detailed study. Indian Run does flow into Coddle Creek which is a FEMA-regulated stream with determined base flood (100-year water surface) elevations (Zone AE). The construction on Indian Run will not affect the base flood elevations for Coddle Creek.

Cabarrus County is currently in the 90-day review of the current FEMA restudy project. At this time there is no FEMA involvement, but the unapproved DFIRM shows Indian Run being part of a detailed study. Once the new maps have been approved we anticipate a Letter of Map Revison / Conditional Letter of Map Revision (LOMR/CLOMR) will be required if construction has not already started. If construction has not begun, at a minimum a LOMR will be necessary due to the change in stream alignment on the downstream portion of the project.

A HEC-RAS model was developed to determine the effects of the proposed channel geometry on the existing channel. The HEC-RAS Summary Table can be found in Appendix E. The HEC-RAS results for the stream restoration project indicate an overall reduction in water surface elevation in the 100-year storm.

A HEC-RAS model was also developed to verify the bankfull discharge as well as the bankfull channel dimensions. When the model was compiled, the water surface elevation rose just to the top of bank in the pool sections as well as the riffle sections. The model consisted of cross sections cut at every top of riffle, bottom of riffle, and the center of pool for the entire reach.

7.3.2 Hydrologic Trespass

This project does not include Priority I stream restoration or wetland restoration/creation, so hydrologic trespass is not an issue.

7.4 Stormwater Best Management Practices

7.4.1. Narrative of Site-Specific Stormwater Concerns

Currently storm runoff collected from developed parcels adjacent to the reach enters in ephemeral and intermittent channels. These channels' confluences with Indian Run will be assessed for stability and, where necessary, additional energy dissipation and bed/bank protection measures are incorporated to prevent hydraulic impacts in the discharge areas.

7.4.2 Device Description and Application

The restoration plan utilizes in-stream structures such as log sills, rock vanes, log vanes, root wads, and constructed riffles in combination with vegetation to protect the stream channel in stormwater sensitive areas such as confluences with direct outfalls, tributaries, and the floodplain.

7.5 Hydrologic Modifications – not relevant to this restoration plan

7.6 Soil Restoration

Soils on the site currently support vegetation that is typical of the plant restoration community and thus appears adequate to achieve restoration goals. No wetlands are created within this restoration plan, and thus hydric soils are not required. Grading activities will stockpile top soils for reuse in areas of the new floodplain bench cuts, and where needed the final soils will be amended to provide adequate fertility. In addition, some select material will be used inside the channel for portions of the Priority III restoration sections.

7.7 Natural Plant Community Restoration

Re-establishing a riparian buffer composed of native woody and herbaceous species is critical to the success of a stream restoration design. The riparian buffer design consists of 1) acquisition of available plant species, 2) implementation of proposed site preparation including eradicating exotic species, and 3) planting the selected species. Restoration for the Indian Run site involves plant selection reflecting hydrology, shade, and slope. Species used in the restoration have been chosen to represent an Alluvial grading to a Bottomland Forest Community as defined in the *Classification of the Natural Communities of North Carolina, Third Approximation*, by M.P. Schafale and A.S. Weakley, 1990. The buffer area adjacent to the stream reach was divided up into four (4) different zones as follows:

1. Stream Bank
2. Lower Floodplain Bench
3. Upland Slope, and
4. Pocket Depressions

Table 7A provides an alphabetical list of the species, with columns noting the potential habitats for each species. Table 7B provides proposed plant spacing for the four zones with assumption of average distance between plants, in feet on center (ft o.c. – avg). Species selected for planting will be dependent upon availability of local seedling sources. Advance notification/coordination with local nurseries will facilitate availability of various non-commercial elements.

7.7.1 Narrative and Plant Community Restoration

Throughout the site, the target natural community will be an Alluvial Forest on the bankfull/floodplain bench that will grade into a Bottomland Forest as you move away from the stream. In the upper reach, remnants of the target natural communities currently exist with mature individuals of the desired species. As much as possible in these areas, the zone of construction activity will be limited to lessen damage to individual existing trees. In order to develop preliminary restoration concepts, a detailed tree survey was conducted in a 20-foot riparian fringe on both sides of the existing stream.

Where opportunities exist to transplant existing stems for re-vegetation, those individuals will be moved to new positions along the constructed stream section. Individuals considered candidates for transplanting should not be larger than 1.5 inches in diameter at breast height (dbh) for successful transplanting.

Bare-root seedlings will be planted within the specified areas at a density of 436 stems per acre (based on an average 10’ x 10’ spacing) to achieve a mature survivability of 320 trees per acre in the riparian zone (NCDWQ 2001). To provide structural diversity, native shrubs will also be incorporated in the buffers on 4’ x 4’ spacing in small groupings of 2 to 3 individuals sufficient to provide for 2,700 shrubs per acre. Plant placement and groupings will be randomized during installation in order to develop a more naturalized appearance in the buffer zones. Woody vegetation planting will be conducted during dormancy. Plant placement will be further defined during the design process.

Herbaceous vegetation within the buffer shall consist of a native grass mix that may include: big bluestem (*Andropogon gerardii*), purple love grass (*Eragrostis spectabilis*), deertongue (*Panicum clandestinum*), Eastern gama grass (*Tripsacum dactyloides*), river oats (*Chasmanthium latifolium*), and Virginia wildrye (*Elymus virginicus*). In addition, rye grain (*Secale cereale*) or pearl millet (*Pennisetum glaucum*) will be used for temporary stabilization, depending upon the construction season and schedule.

In the streamside zone, live stakes and/or bare root seedlings (plugs) will be used in conjunction with the native herbaceous seed mix to provide natural stabilization. Appropriate species identified for live staking include elderberry (*Sambucus canadensis)*, silky willow (*Salix sericea*), silky dogwood (*Cornus amomum*), and black willow (*Salix nigra*). The plugs include Coralberry (*Symphoricarpos orbiculatus*), elderberry, Virginia willow (*Itea virginica*), and tag alder (*Alnus serrulata*). Live stakes or seedlings will be placed on the outside of meander bends at a density of 2-4 stakes per square yard and in random fashion to give a natural appearance.

The diversity of the bench will be enhanced with the addition of plugs of pawpaw (*Asimina triloba*), spicebush (*Lindera benzoin*), beautyberry (*Callicarpa americana*) and painted buckeye (*Aesculus sylvatica)* to the list of stream bank species. Selection of these species for these two habitats will provide a diverse, shrub dominated community with the stability needed for protection from erosion. By massing some of the species, such as coralberry, pawpaw, spicebush, beautyberry and buttonbush (*Cephalanthus occidentalis*) into groupings along the bench, the different characteristics of the species can become more evident in this suburban setting.

The Upland Slope riparian buffer will be planted with bare root and containerized trees and shrubs, reflecting a mixture of species, such as river birch, sycamore, tulip poplar (*Liriodendron tulipifera*), and green ash (*Fraxinus pennsylvanica*), with the addition of willow oak (*Quercus phellos*), red maple (*Acer rubrum*), persimmon (*Diospyros virginiana*), black walnut, red mulberry (*Morus rubra*), water oak (*Quercus nigra*), and black gum (*Nyssa sylvatica*). Shrubs, as plugs or containerized, include pawpaw, sweetshrub (*Calycanthus floridus*), and bladdernut (*Staphylea trifolia*) to provide increased diversity.

Excavating shallow pools in the floodplain as well as using the existing ditches/drainages and areas of the relic channel after the new channel is constructed will be used to create Pocket Depressions. Benefits of pocket depressions include providing added water quality benefits by treating stormwater runoff from the agricultural fields and subdivisions, floodwater retention, and provide more diversity of habitat for insects, amphibians, and birds along the project reach.

7.7.2 Onsite Invasive Species

Invasive species in the site are relatively limited; however, previously undetected invasive species may occur following the disturbance of construction and the exposure of a remixed seed bank. Three invasive species have been observed, but none exist in large numbers or dense stands. These include Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), and trifoliate orange (*Poncirus trifoliate*).

7.7.3 Invasive Species Control

Invasive species eradication and management will begin during the site preparation stage and continue through the 5-year monitoring period at a minimum. Management procedures described below are based upon recommendations taken from the Southeast Exotic Pest Plant Council Invasive Plant Manual (2003).

Personnel performing herbicide application will have a commercial license as required by the North Carolina Pesticide Board and all work will comply with the North Carolina Pesticide Law of 1971 and applicable federal laws. Environmental conditions including weather, wind, temperature and period of the growing season will be evaluated prior to initiation of management efforts. The sequence of removal procedures will be coordinated with planned seeding and planting tasks.

The first step in removal will consist of an application of Rodeo® or equal herbicide (glyphosate – aquatic label) designated as suitable for extermination of trees and shrubs in riparian and wetland areas. The herbicide will be applied at the maximum recommended rate and in accordance with label instructions. The herbicide will be

applied by spraying on all identified invasive plants and will be conducted in such a way as to prevent drift into adjacent areas.

Two weeks after spraying, all woody vegetation will be removed by cutting stems and stumps to a maximum height of two inches above ground. A 25% glyphosate herbicide solution shall subsequently be applied to completely cover the cut surface of each individual stem or stump.

The site shall be scrutinized throughout the monitoring period to evaluate invasive management effectiveness. If required, additional control steps will be implemented.

8.0 STREAM PERFORMANCE CRITERIA AND MONITORING PLAN

Post-construction monitoring will consist of collection and analysis of geomorphic stability and riparian/streambank vegetation data to evaluate the project's restoration objectives. Additionally, instream structures should remain secure and stable during the monitoring period. The plant species should appear healthy within the four zones identified for revegetation (see Section 7.7).

8.1 Streams

Four monitoring strategies are to be utilized to demonstrate the stability and restoration goals of the stream restoration work: dimension, pattern, profile, and bed material. The monitoring survey protocol should follow that used in the As-built Mitigation Plan. Data collected over the monitoring period should be plotted over that of the previous year(s) for comparison.

A series of benchmarked cross sections are to be established for the monitoring of channel dimensional stability, and these sections should extend to within 5 feet of margins of the conservation buffer to both sides of the channel. These cross sections are to be re-surveyed at the frequency and calendar cycle set by EEP's monitoring protocol utilizing standard stream surveying techniques. The spacing of cross sections shall not exceed 500 feet, should include typical meander and inflection areas, and should include at least one cross section for each reach segment of 20 bankfull width-lengths (in this case approximately one section for every 400 feet). Six monitoring sections should be established for the restoration reach below Rocky River Road, and six sections above Rocky River Road.

Stream pattern is to be assessed, based on valley type and stream type, using measurements of sinuosity such as radius of curvature, wavelength, and belt width.

A longitudinal profile starting and ending at benchmarked station points at the upstream and downstream ends of each of the restoration reaches is also to be resurveyed during each monitoring event.

Finally, a Modified Wolman Pebble Count (Rosgen 1996) is to provide a quantitative characterization of streambed material. Pebble count data can be used to interpret the movement of materials in the stream channels. Established D50 and D84 sizes should increase in coarseness in riffles and increase in fineness in pools. Over time, established D50 and D84 should be compared.

It is expected that there will be some minimal changes in the cross sections, profile, and/or substrate composition. Changes that may occur during the monitoring period will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down cutting, deposition, and/or erosion) or if they are minor changes that represent an increase in stability (e.g., settling, changes in vegetation, and/or decrease in width-to-depth ratio). Unstable conditions that require remediation will indicate failure of restoration activities that need to be addressed prior to continued monitoring.

In addition, a series of photo stations is to be set in the field with benchmarks and documented by azimuths and photos acquired during each of the monitoring events. Such photographs shall provide documentation of the stability of the channel's bed and banks at typical tie-in points, in-stream structures, meander and riffle areas.

8.2 Stormwater Management Devices – not relevant to this restoration plan

8.3 Wetlands - not relevant to this restoration plan

8.4 Vegetation

Native vegetation will be planted using species determined by local knowledge and a local Piedmont reference site. Survival of vegetation within the riparian buffer will be evaluated using the CVS/EEP Vegetation Monitoring Protocol. We currently anticipate monitoring to Level 1 of the Protocol, based on correspondence with Steve Roberts of EEP. This would include survival of planted woody stems. Woody vegetation will be monitored for five years, or for two bankfull events. Plants should be replaced per the contract documents. Permanent sampling plots will be established at random locations within the restoration site per the Protocol. Expected desired species will be monitored and records of sampling locations will be maintained. Non-native, exotic, and undesirable species will be noted during the sample collection. If EEP requests a different level of monitoring at a later date, this will be reflected in the Mitigation Plan.

8.5 Schedule / Reporting

The monitoring and reporting schedule shall occur annually following completion of the re-vegetation within the restoration areas. The first annual cycle should include the first full growing season following re-vegetation. Monitoring reports are to be completed and submitted within 90 days of the end of each annual monitoring cycle. All monitoring data and reporting shall be conducted in accordance with the most current version of the EEP document entitled *Content, Format, and Data Requirements for EEP Monitoring Reports*. As-built and subsequent monitoring reports must include all background, morphologic, sediment, and vegetative elements outlined in the most current version of guidance documents.

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TABLE 1 Project Restoration Structure and Objectives

Restoration Segment / Reach ID	Location	Priority Approach	Existing Linear Footage	Designed Linear Footage	Comments
Reach 1 (Upper)	Above Rocky River Road	Priority III Restoration	1,900	1,808	Restores bankfull dimension within the existing channel, utilizes a partial floodplain bench to partially restore floodprone conditions, and enhances existing pattern and profile.
Reach 2 (Lower)	Below Rocky River Road	Priority II Restoration	1,700	1,922	Fully restores pattern, dimension and profile, excavates a new channel with an adjoining floodplain bench to partially restore floodprone conditions.

TABLE 2 Drainage Areas and Other Parameters

Parameter	Indian Run (Upper Reach)	Indian Run (Lower Reach)	Dixon Branch	UT to Reedy Creek
Drainage Area (mi^2)	1.5	1.5	0.5	0.4
Drainage Area (Ac)	960	960	350	256
Bankfull Width (ft)	20.0	16.0	9.2	8.0
Mean Bankfull Depth (ft)	3.1	3.7	1.2	1.5
Max Bankfull Depth (ft)	3.3	4.6	1.3	1.9
Width / Depth Ratio	6.5	4.3	7.5	5.3
Width Floodprone Area (ft)	53.7	75.0	92	20
Bankfull Area (ft^2)	61.3	74.5	11.3	12.3
Entrenchment Ratio	2.7	4.7	10.0	2.5
Average Slope (ft/ft)	0.0051	0.0052	0.0061	0.0130
Sinuosity (K)	1.3	1.0	1.3	1.3
Rosgen Stream Type	Impaired C4	Impaired Ditch	C4	C4

TABLE 3 Project Watershed Land Use

Land Use	Acreage	Percent
Pervious/Semi-Pervious Classes		
Forest	492	52.4
Open Fields/Lawn/Low-Density Residential	318	33.9
Medium-Density Residential	103	11.0
Subtotal	**913**	**97.2**
Impervious Classes		
Roads/Railroad	14	1.5
Commercial/Institutional Buildings	12	1.3
Subtotal	**26**	**2.8**
Total	**939**	**100.0**

TABLE 4 Stream Morphologic Parameters

SITE NAME	UNITS	Indian Run (Upper)	Indian Run (Lower)	Indian Run Upper	Indian Run Lower	Dixon Branch	UT to Reedy Creek
WATERSHED		Yadkin-Pee Dee	Yadkin-Pee Dee	Yadkin - Pee Dee	Yadkin - Pee Dee	Yadkin - Pee Dee	Yadkin - Pee Dee
REACH DESCRIPTION		Above Rocky River Rd.	Below Rocky River Rd.	Above Rocky River Rd.	Below Rocky River Rd.	Off Alexanderana Rd.	Reedy Creek City Park
STREAM TYPE		Impaired C4	Impaired Ditch	C4	C4	C4	C4
DRAINAGE AREA (DA)	Ac	960.0	960.0	960.00	960.00	350.1	256.0
BANKFULL WIDTH (W_{bkf})	ft	20.0	20.0	20.00	20.00	9.2	8.0
BANKFULL MEAN DEPTH (d_{bkf})	ft	3.1	3.7	1.67	1.67	1.2	1.5
LOWEST BANK HEIGHT RATIO		1.0	1.0	1.07	1.07	1.7	1.6
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})		6.5	5.4	12.00	12.00	7.5	5.3
BANKFULL X-SECTION AREA (A_{bkf})	ft^2	61.3	74.5	29.26	29.26	11.3	12.3
BANKFULL MEAN VELOCITY, ft/s	f/s	5.4	5.9	3.49	3.49	3.1	3.5
BANKFULL DISCHARGE, cfs	ft^3/s	328.4	442.9	102.00	102.00	35.0	43.0
BANKFULL MAX DEPTH (d_{max})	ft	4.6	5.1	1.78	1.78	1.3	1.9
WIDTH Flood-Prone Area (W_{fpa})	ft	53.7	75.0	35.00	100.00	92	20
ENTRENCHMENT RATIO (ER)		2.7	3.8	1.75	5.00	10.0	2.5
MEANDER LENGTH (Lm)	ft	115	-	104 - 213	104 - 213	48 - 77	71 - 85
RATIO OF Lm TO W_{bkf}		5.8	-	5.2 - 10.6	5.2 - 10.6	5.2 - 8.4	8.9 - 10.6
RADIUS OF CURVATURE	ft	25.0	-	20 - 60	35 - 56	6.0 - 22.0	8.0 - 37.0
RATIO OF Rc TO W_{bkf}		1.3	-	0.7 - 4.6	0.7 - 4.6	0.7 - 2.4	1.0 - 4.6
BELT WIDTH	ft	130.0	-	50 - 173	50 - 173	25 - 33	20 - 69
MEANDER WIDTH RATIO		6.0	-	2.5 - 8.6	2.5 - 8.6	2.7 - 3.6	2.5 - 8.6
SINUOSITY (K)		1.16	1.00	1.16	1.24	1.30	1.30
VALLEY SLOPE	ft/ft	0.0066	0.0052	0.0063	0.0061	0.0080	0.0170
AVERAGE SLOPE (S)	ft/ft	0.0051	0.0052	0.0047	0.0035	0.0061	0.0130
RIFFLE SLOPE	ft/ft	0.0270	0.0348	0.0117	0.0114	0.0170	0.0330
POOL SLOPE	ft/ft	0.0005	0.0002	0.0001	0.0001	0.0040	0.0040
RATIO OF POOL SLOPE TO AVERAGE SLOPE	ft/ft	0.4	0.4	0.52	0.52	0.7	0.3
MAX POOL DEPTH	ft	4.79	5.83	2.85	2.85	2.00	2.72
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH		1.56	1.58	1.71	1.71	1.63	1.79
POOL WIDTH	ft	20.00	20.00	29.24	29.24	10.80	14.00
RATIO OF POOL WIDTH TO BANKFULL WIDTH		1.00	1.00	1.46	1.46	1.17	1.75
POOL TO POOL SPACING	ft	10.00	7.50	52 - 101	52 - 101	8.2 - 46.6	4.4 - 47.2
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH		0.50	0.38	2.6 - 5.1	2.6 - 5.1	0.9 - 5.1	0.6 - 5.9

TABLE 5a Bank Erosion Hazard Index Survey and Rank
Indian Run Lower Reach – Confluence to Rocky River Road

Downstream Station	Upstream Station	BEHI Value Right Bank	Right Bank Adjective Rank	BEHI Value Left Bank	Left Bank Adjective Rank
20.5	50	32.7	High	34.0	High
50	100	31.6	High	31.6	High
100	125	31.9	High	33.1	High
125	150	34.1	High	29.5	Moderate
150	175	34.1	High	27.9	Moderate
175	200	33.0	High	27.8	Moderate
200	250	28.9	Moderate	32.4	High
250	300	23.1	Moderate	31.6	High
300	350	29.2	Moderate	25.5	Moderate
350	375	23.5	Moderate	26.2	Moderate
375	400	34.3	High	27.0	Moderate
400	450	30.8	High	24.8	Moderate
450	500	29.3	Moderate	26.4	Moderate
500	550	25.1	Moderate	30.9	High
550	600	34.1	High	23.7	Moderate
600	650	26.1	Moderate	30.4	High
650	700	28.2	Moderate	29.2	Moderate
700	750	25.7	Moderate	28.7	Moderate
750	800	27.0	Moderate	29.7	Moderate
800	850	29.6	Moderate	29.2	Moderate
850	900	25.9	Moderate	28.6	Moderate
900	950	28.1	Moderate	29.3	Moderate
950	1000	29.3	Moderate	28.0	Moderate
1000	1050	27.7	Moderate	30.4	High
1050	1100	29.6	Moderate	29.5	Moderate
1100	1150	28.0	Moderate	32.8	High
1150	1200	28.8	Moderate	32.7	High
1200	1225	30.8	High	29.1	Moderate
1225	1250	31.1	High	29.5	Moderate
1250	1300	29.3	Moderate	28.5	Moderate
1300	1325	31.0	High	28.5	Moderate
1325	1350	28.4	Moderate	27.1	Moderate
1350	1400	31.3	High	26.1	Moderate
1400	1450	29.7	Moderate	31.0	High
1450	1500	30.3	High	30.8	High
1500	1550	31.1	High	31.4	High
1550	1600	29.8	Moderate	29.9	Moderate
1600	1650	30.0	High	31.6	High
1650	1700	28.2	Moderate	29.2	Moderate
1700	1750	28.9	Moderate	28.3	Moderate
1750	1778	29.0	Moderate	29.2	Moderate

TABLE 5b Bank Erosion Hazard Index Survey and Rank
Indian Run Upper Reach – Rocky River Road to Station 2192

Downstream Station	Upstream Station	BEHI Value Right Bank	Right Bank Adjective Rank	BEHI Value Left Bank	Left Bank Adjective Rank
0	50	26.7	Moderate	26.8	Moderate
50	100	30.4	High	24.3	Moderate
100	150	26.9	Moderate	25.2	Moderate
150	200	31.0	High	22.9	Moderate
200	250	26.9	Moderate	37.1	High
250	300	24.9	Moderate	34.2	High
300	350	33.1	High	36.4	High
350	400	26.5	Moderate	24.2	Moderate
400	450	35.3	High	25.9	Moderate
450	500	28.3	Moderate	38.1	High
500	550	29.6	Moderate	38.5	High
550	600	28.6	Moderate	28.6	Moderate
600	650	23.7	Moderate	25.8	Moderate
650	700	30.6	High	32.3	High
700	750	29.6	Moderate	30.9	High
750	800	24.8	Moderate	26.3	Moderate
800	850	27.6	Moderate	37.9	High
850	900	25.7	Moderate	29.8	Moderate
900	950	33.7	High	28.0	Moderate
950	1000	31.0	High	30.4	High
1000	1050	29.7	Moderate	27.3	Moderate
1050	1100	27.5	Moderate	25.7	Moderate
1100	1150	23.6	Moderate	32.1	High
1150	1200	25.8	Moderate	28.9	Moderate
1200	1250	30.0	High	27.6	Moderate
1250	1300	28.2	Moderate	29.2	Moderate
1300	1350	27.7	Moderate	29.2	Moderate
1350	1400	24.8	Moderate	27.0	Moderate
1400	1450	29.1	Moderate	30.2	High
1450	1500	28.4	Moderate	27.7	Moderate
1500	1550	27.9	Moderate	30.5	High
1550	1600	31.4	High	27.3	Moderate
1600	1650	31.0	High	25.6	Moderate
1650	1700	26.9	Moderate	32.7	High
1700	1750	28.7	Moderate	33.5	High
1750	1800	26.3	Moderate	24.3	Moderate
1800	1850	37.7	High	28.3	Moderate
1850	1900	38.1	High	28.7	Moderate
1900	1950	36.9	High	24.8	Moderate
1950	2000	26.9	Moderate	34.0	High
2000	2050	27.2	Moderate	30.3	High
2050	2100	29.7	Moderate	30.0	High
2100	2150	28.0	Moderate	24.6	Moderate
2150	2192	25.6	Moderate	33.5	High

TABLE 6a Bank Erosion Hazard Index Survey and Rank
Reference Reach 1 – Dixon Branch

Downstream Station	Upstream Station	BEHI Value Right Bank	Right Bank Adjective Rank	BEHI Value Left Bank	Left Bank Adjective Rank
0	14	16.5	Low	17.0	Low
14	25	19.5	Low	15.0	Low
25	41	18.0	Low	16.5	Low
41	68	25.5	Moderate	0.0	Depositional
68	83	19.5	Low	21.0	Moderate
83	92	18.0	Low	22.0	Moderate
92	99	0.0	Depositional	23.0	Moderate
99	109	18.5	Low	17.5	Low
109	120	17.5	Low	25.0	Moderate
120	141	16.5	Low	18.5	Low
141	153	24.5	Moderate	0.0	Depositional
153	170	29.5	Moderate	0.0	Depositional
170	189	21.0	Moderate	16.5	Low
189	203	22.0	Moderate	26.0	Moderate
203	211	17.5	Low	16.5	Low
211	220	21.5	Moderate	18.0	Low

TABLE 6b Bank Erosion Hazard Index Survey and Rank
Reference Reach 2 – UT to Reedy Creek

Downstream Station	Upstream Station	BEHI Value Right Bank	Right Bank Adjective Rank	BEHI Value Left Bank	Left Bank Adjective Rank
0	18	16.0	Low	16.5	Low
18	32	23.4	Moderate	18.5	Low
32	46	26.0	Moderate	17.5	Low
46	60	27.5	Moderate	9.5	Very Low
60	71	21.5	Moderate	9.0	Very Low
71	96	17.5	Low	16.5	Low
96	122	15.5	Low	18.0	Low
122	141	16.0	Low	24.0	Moderate
141	149	15.0	Low	31.5	High
149	165	23.0	Moderate	18.5	Low
165	181	17.0	Low	16.5	Low
181	193	26.0	Moderate	14.5	Low
193	216	21.5	Moderate	18.0	Low
216	232	17.0	Low	22.0	Moderate
232	240	0.0	Depositional	34.0	High
240	251	12.0	Low	18.5	Low
251	265	28.5	Moderate	17.0	Low
265	280	33.0	High	15.0	Low
280	289	17.5	Low	16.0	Low
289	300	18.0	Low	16.5	Low
300	322	16.5	Low	17.0	Low

TABLE 7a Designated Vegetative Community

Latin Name	Stream Banks (Riparian Areas)	Levee/Floodplain Bench (Riparian Areas)	Upper Slope/Riparian (50' Conservation) Buffer	Common Name	Form	Size	Spacing (on center–O.C.)
Acer rubrum			*x*	Red maple	Bare-root, containerized	24", 60"	8'
Aesculus sylvatica		*x*		Painted Buckeye	Containerized		4'-6'
Alnus serrulata	*x*	*x*		Tag alder	Bare-root, containerized		8'
Asimina triloba		*x*	*x*	Pawpaw	Containerized		8'
Betula nigra			*x*	River birch	Containerized		8'
Callicarpa americana	*x*	*x*		Beautyberry	Containerized		6'
Calycanthus floridus			*x*	Sweet-shrub	Containerized		4-6'
Celtis laevigata			*x*	Sugarberry	Bare-root	24"	8'
Cephalanthus occidentalis	*x*	*x*		Button bush	Live stake		4'
Cornus amomum	*x*	*x*		Silky dogwood	Bare-root, live stake	24", 18-24"	8', 18"
Diospyros virginiana			*x*	Persimmon	Bare-root, containerized	24"	8'
Fraxinus pennsylvanica			*x*	Green ash	Bare-root, containerized		8'
Itea virginica	*x*	*x*		Virginia willow	Live stake, plug		4'
Juglans nigra			*x*	Black walnut	Bare-root, containerized		10'
Lindera benzoin		*x*		Spicebush	Containerized, plug		4-6'
Liriodendron tulipifera			*x*	Yellow poplar	Containerized		8'
Morus rubra			*x*	Red mulberry	Containerized		8'
Nyssa sylvatica			*x*	Black gum	Bare-root, Containerized	24"	8'
Platanus occidentalis			*x*	Sycamore	Bare-root, containerized	24"	8'
Populus deltoides			*x*	Cottonwood	Live stake, containerized		8'
Quercus nigra			*x*	Water oak	Bare-root, containerized	24"	8'
Quercus phellos			*x*	Willow oak	Bare-root, containerized	24", 60"	8', 8'
Salix sericea	*x*	*x*		Silky willow	Live stake	18-24"	18"
Sambucus canadensis	*x*	*x*	*x*	Elderberry	Containerized, plug, live stake		18"-2'
Staphylea trifolia			*x*	Bladddernut	Containerized, plug		4-6'
Symphoricarpos orbiculatus	*x*	*x*	*x*	Coral-berry	Live stake, plug	18-24"	18"

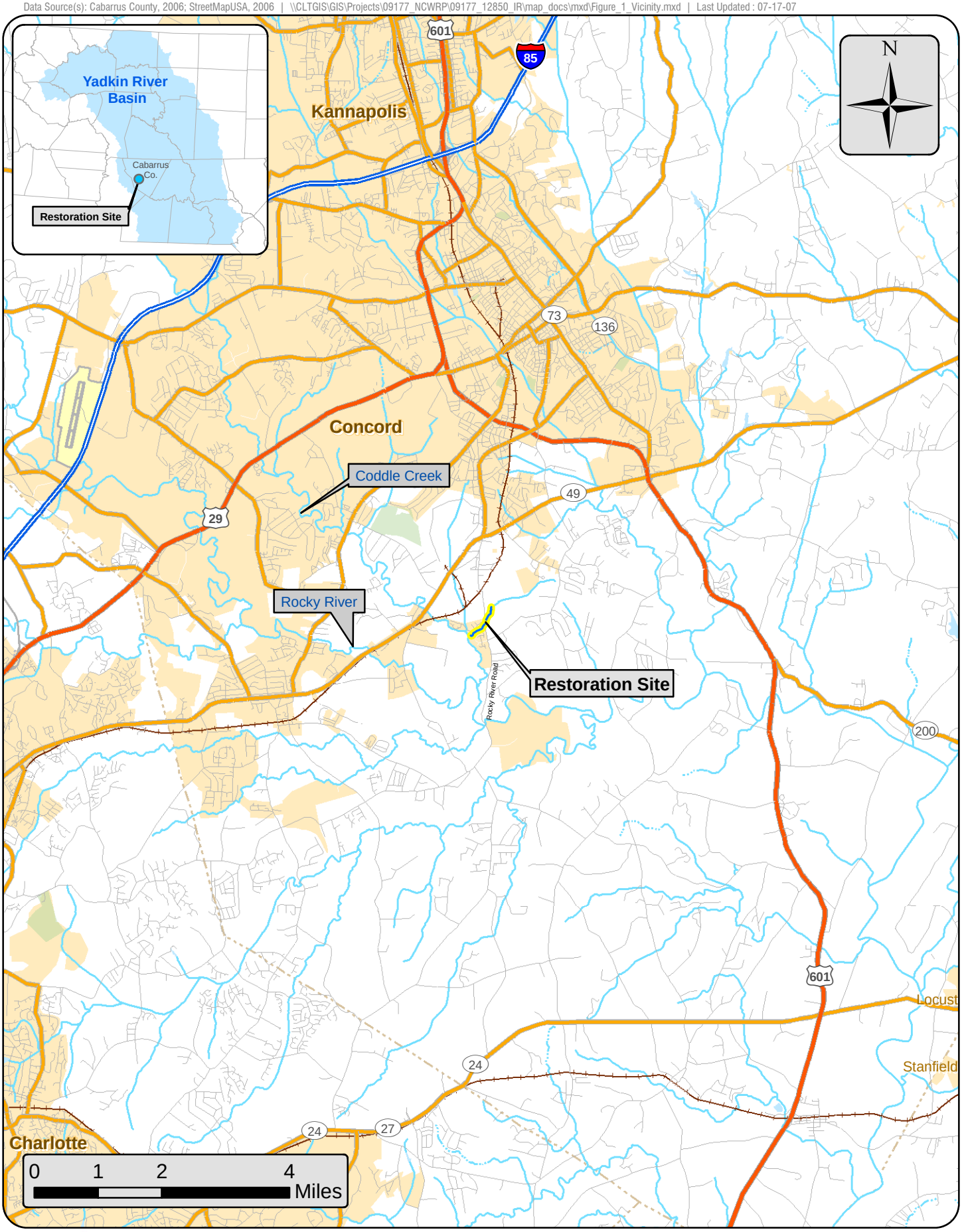
TABLE 7b Planting Zones and Spacing

Upper Reach, Above Rocky River Road

	Size (acres)	Proposed Plant Spacing
Lower Floodplain Bench	0.38	4 ft o.c. avg.
Upland Slope (Buffer)	0.8	10 ft o.c. avg.
Stream Bank	0.83	2 ft o.c. avg.

Lower Reach, Rocky River Road to Confluence with Coddle Creek

	Size (acres)	Proposed Plant Spacing
Lower Floodplain Bench	2.21	4 ft o.c. avg.
Upland Slope (Buffer)	0.9	10 ft o.c. avg.
Stream Bank	0.86	2 ft o.c. avg.

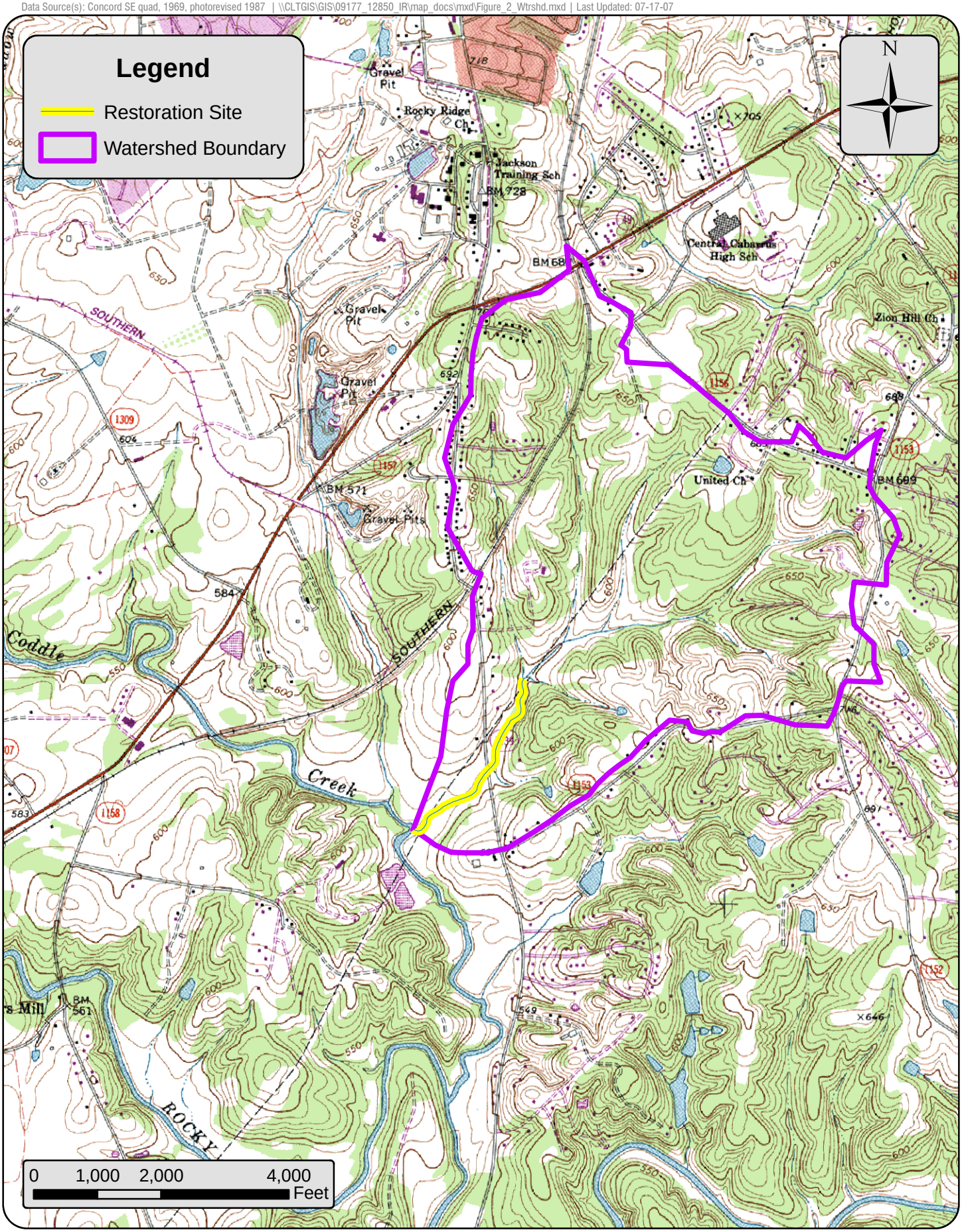


Restoration Site Vicinity

Figure 1

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Data Source(s): Concord SE quad, 1969, photorevised 1987 | \\CLTGIS\GIS\09177_12850_IR\map_docs\mxd\Figure_2_Wtrshd.mxd | Last Updated: 07-17-07



Ecosystem Enhancement PROGRAM

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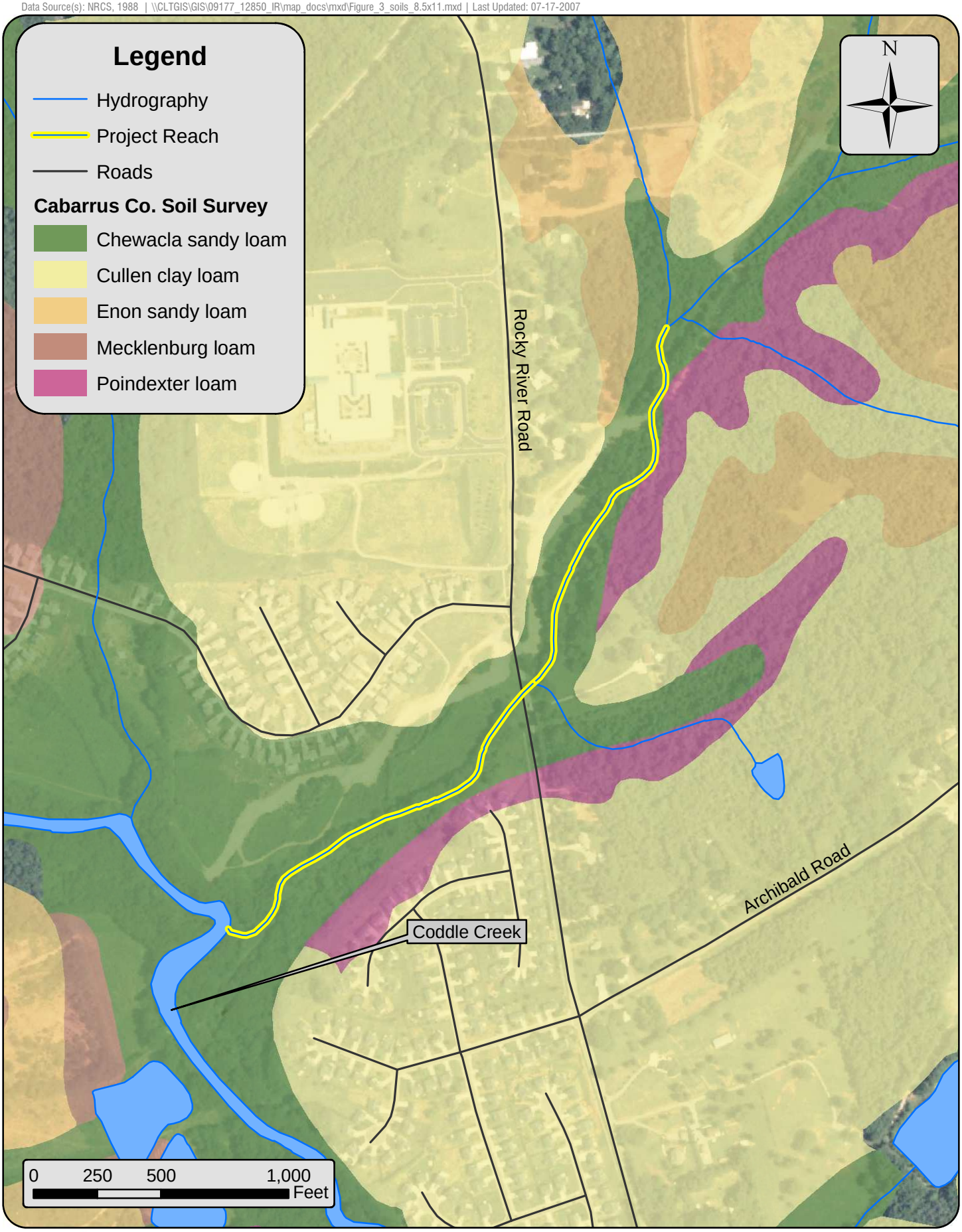
Restoration Site Watershed

Figure 2

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S



Ecosystem Enhancement PROGRAM

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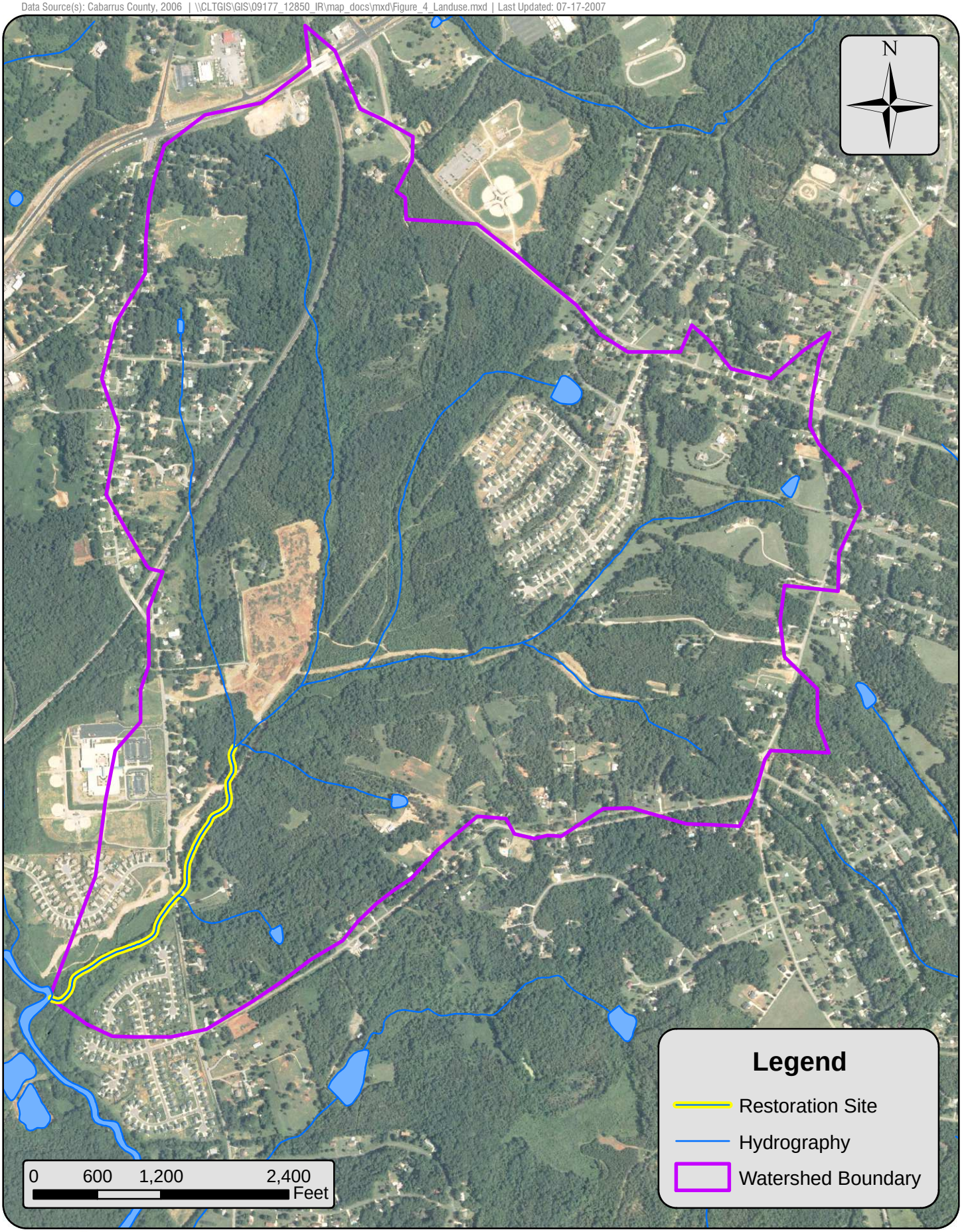
Restoration Site Soils

Figure 3

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Data Source(s): Cabarrus County, 2006 | \\CLTGIS\GIS\09177_12850_IR\map_docs\mxd\Figure_4_Landuse.mxd | Last Updated: 07-17-2007



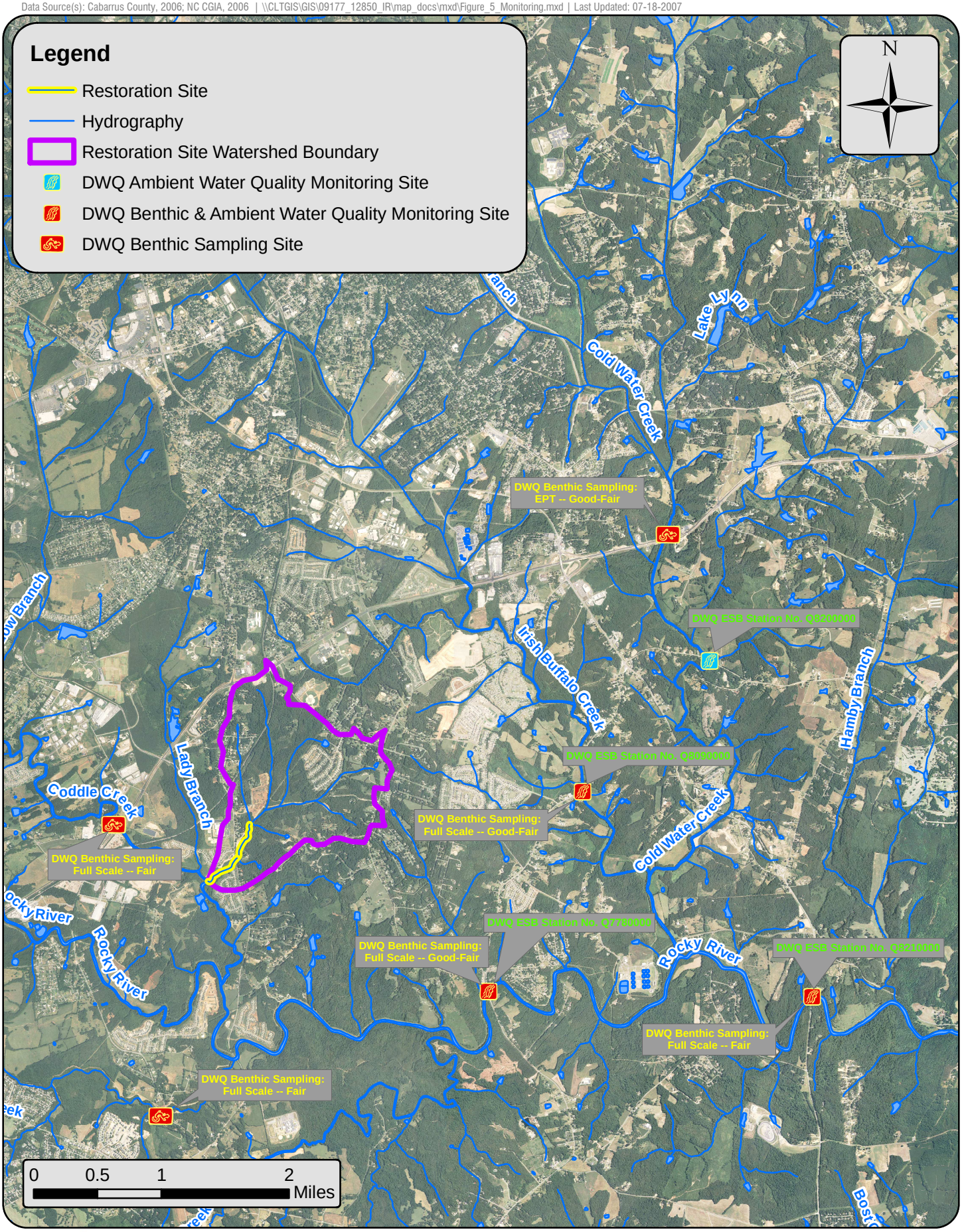
Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠

Restoration Site Watershed Land Use

Figure 4

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S



Local DWQ Monitoring Sites

Figure 5

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

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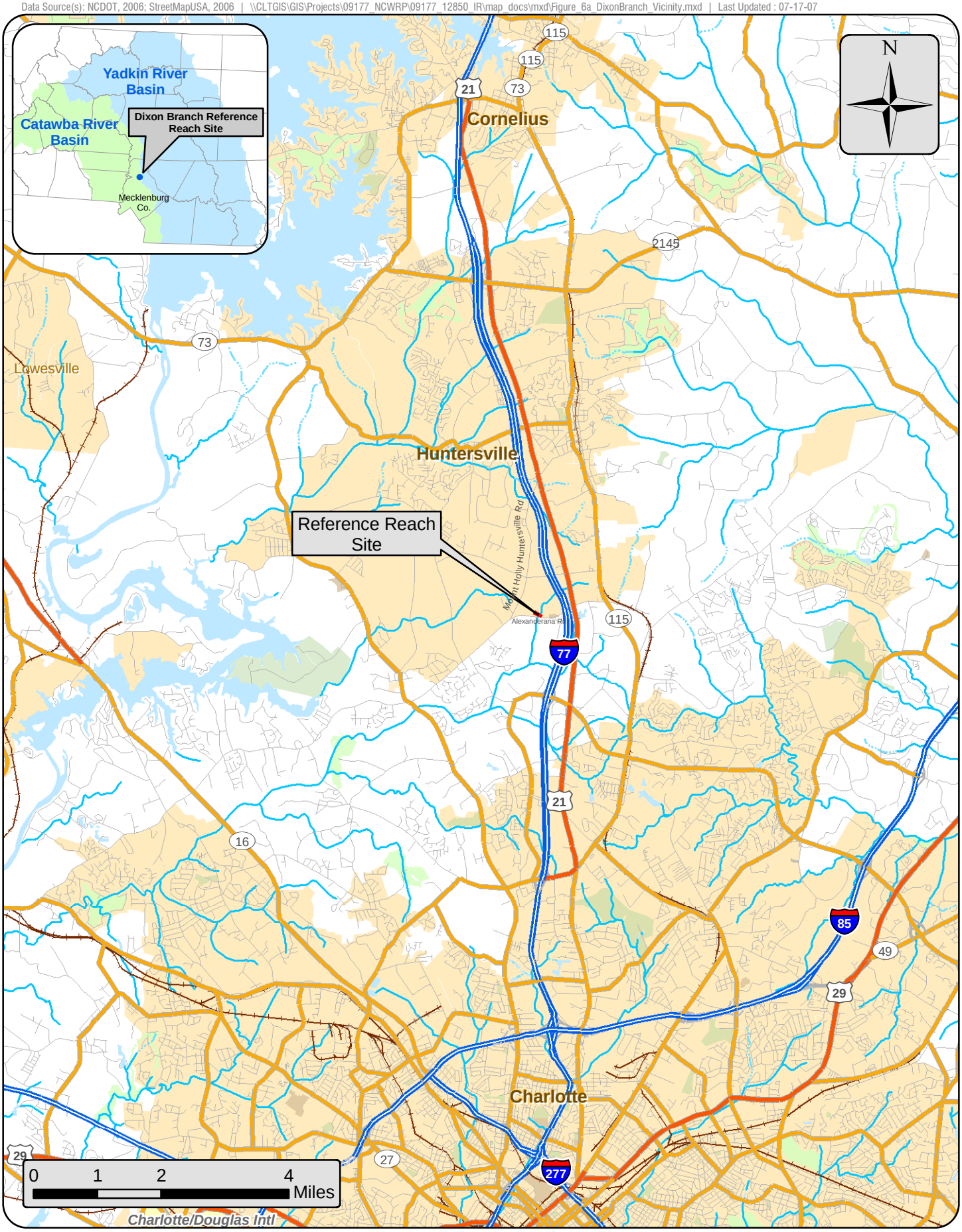


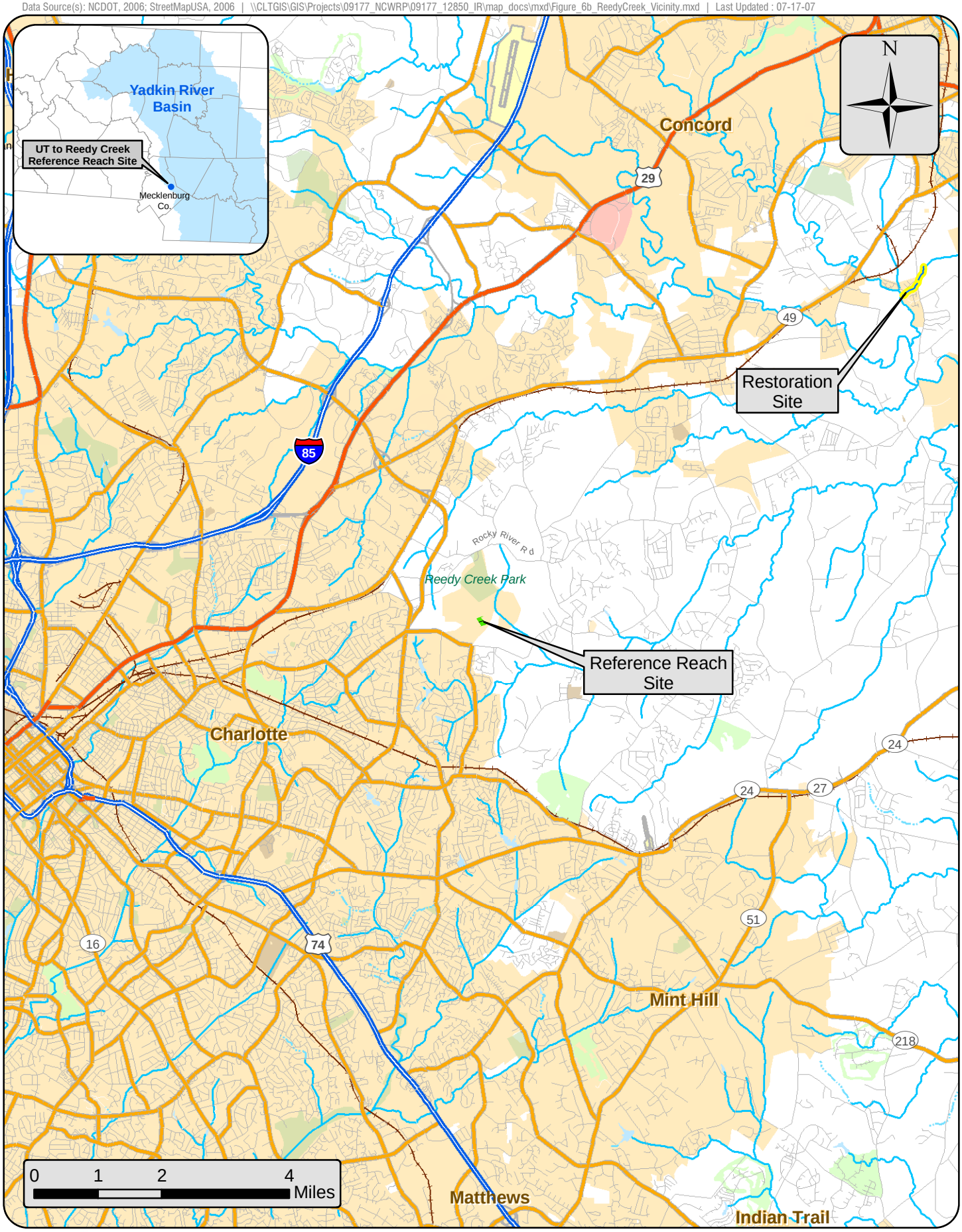
Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠

Dixon Branch Reference Reach Site

Figure 6a

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S



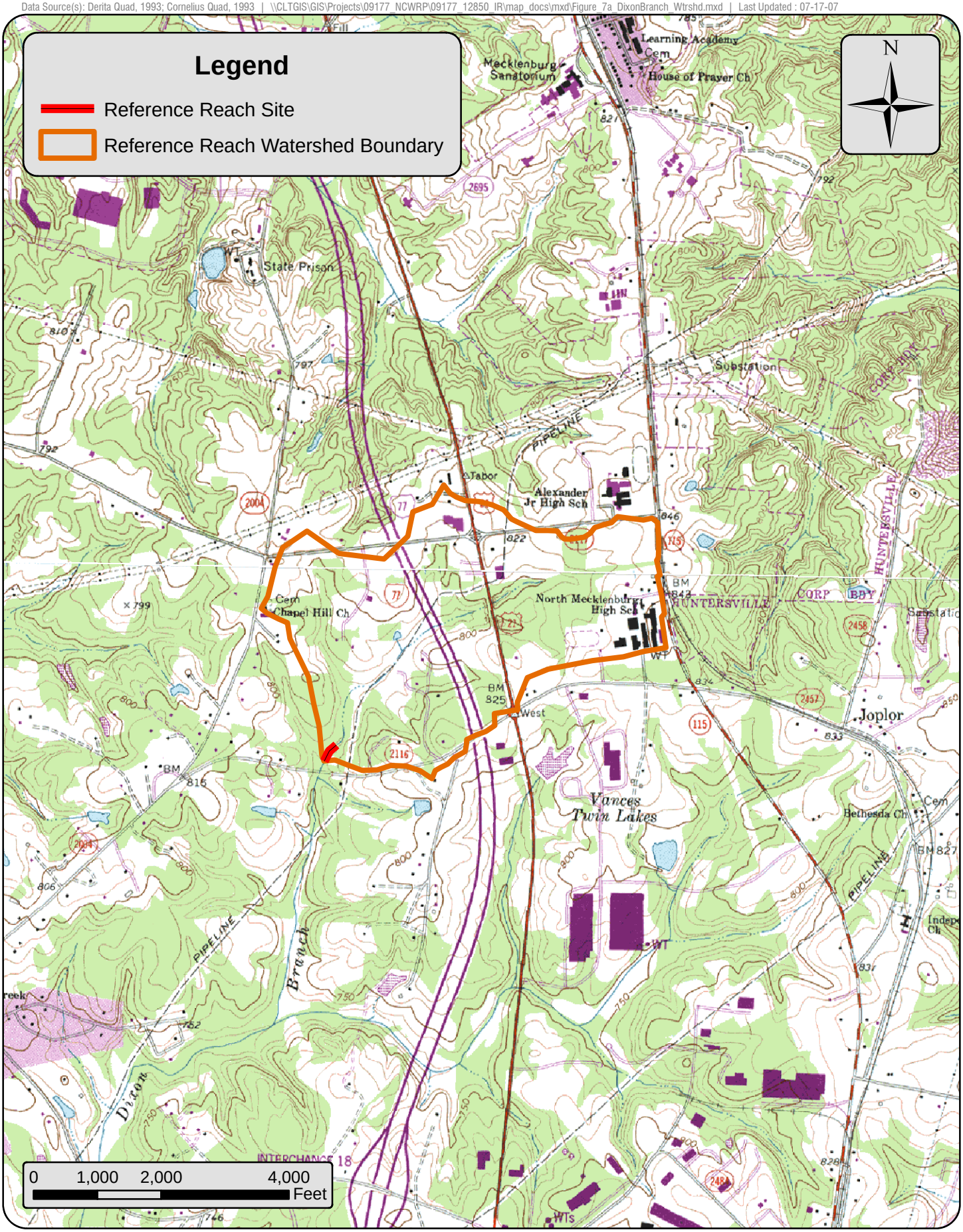
Ecosystem Enhancement PROGRAM

HDR ONE COMPANY | *Many Solutions*℠

UT to Reedy Creek Reference Reach Site

Figure 6b

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S



Dixon Branch Reference Reach Watershed

Figure 7a

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

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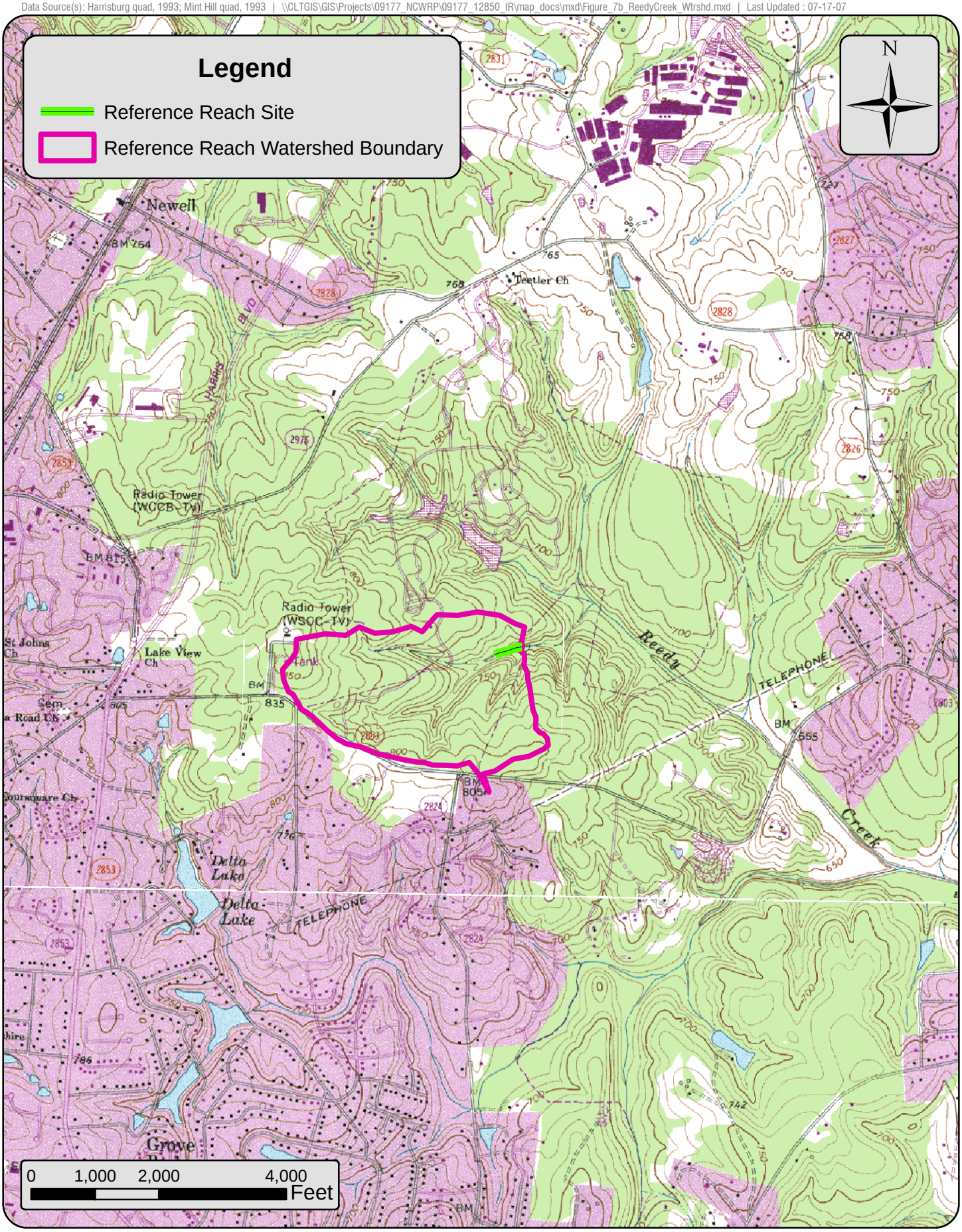

UT to Reedy Creek Reference Reach Watershed

Figure 7b

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

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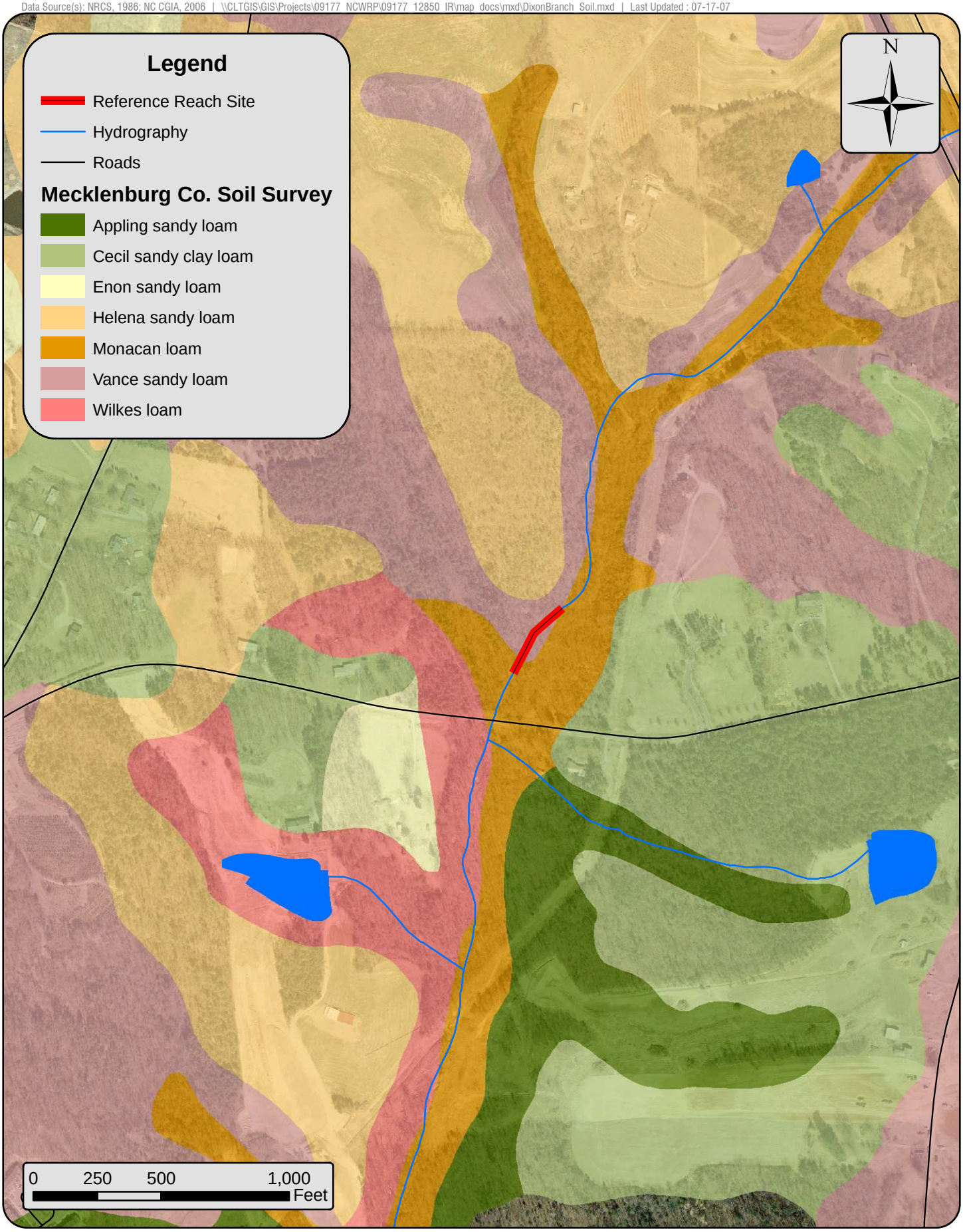


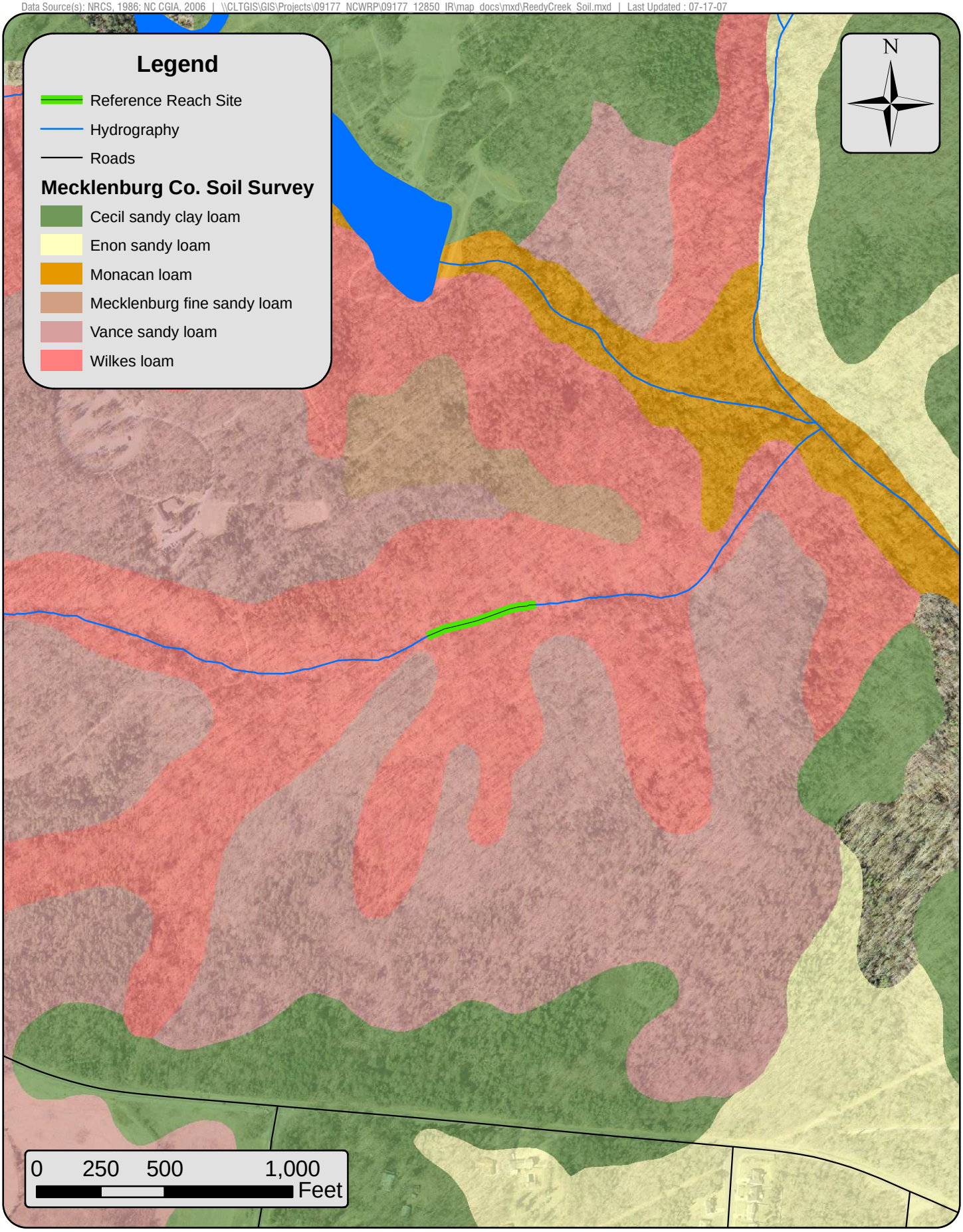
Dixon Branch Reference Reach Soils

Figure 8a

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠



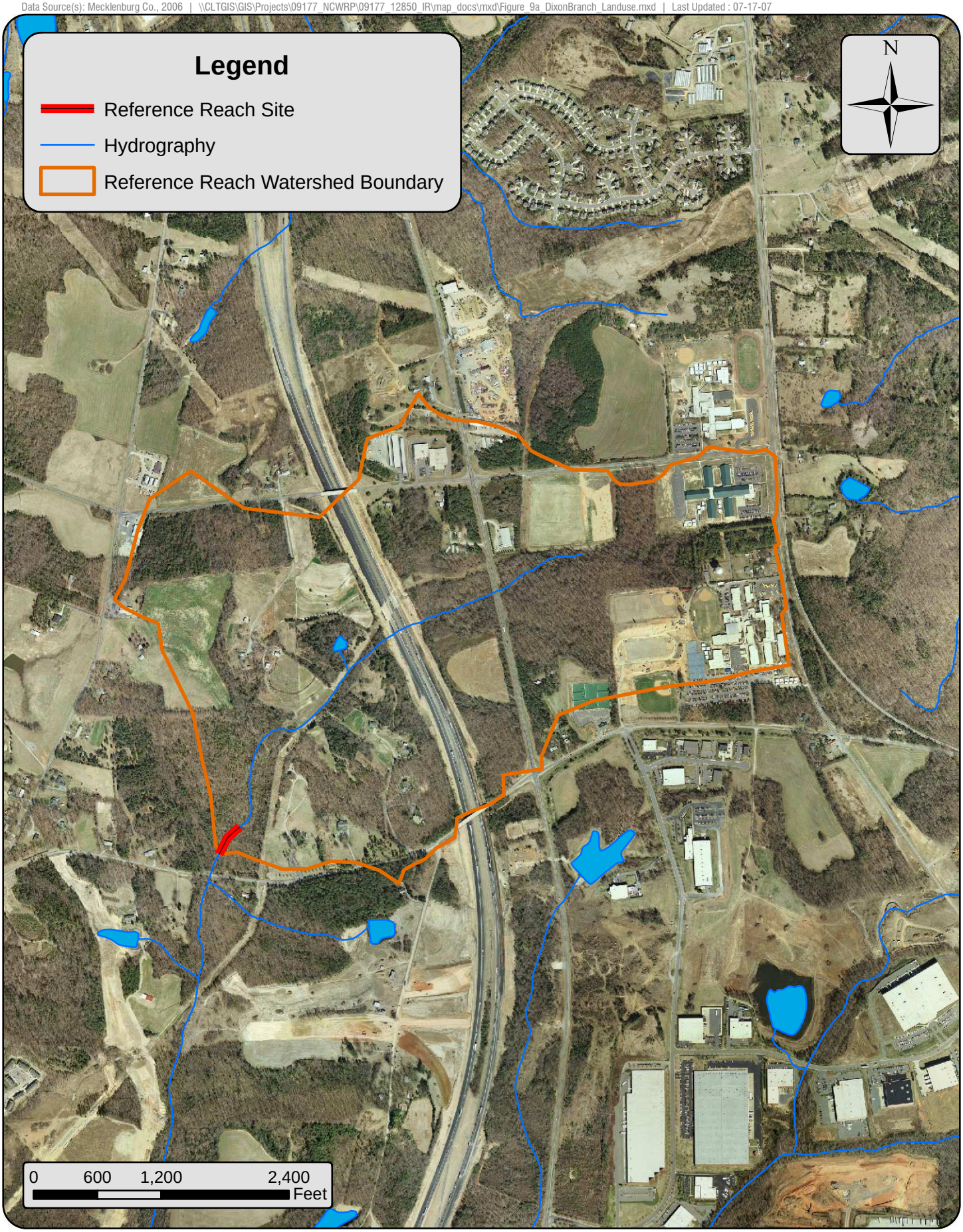
UT to Reedy Creek Reference Reach Soils

Figure 8b

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠



Dixon Branch Reference Reach Watershed Landuse

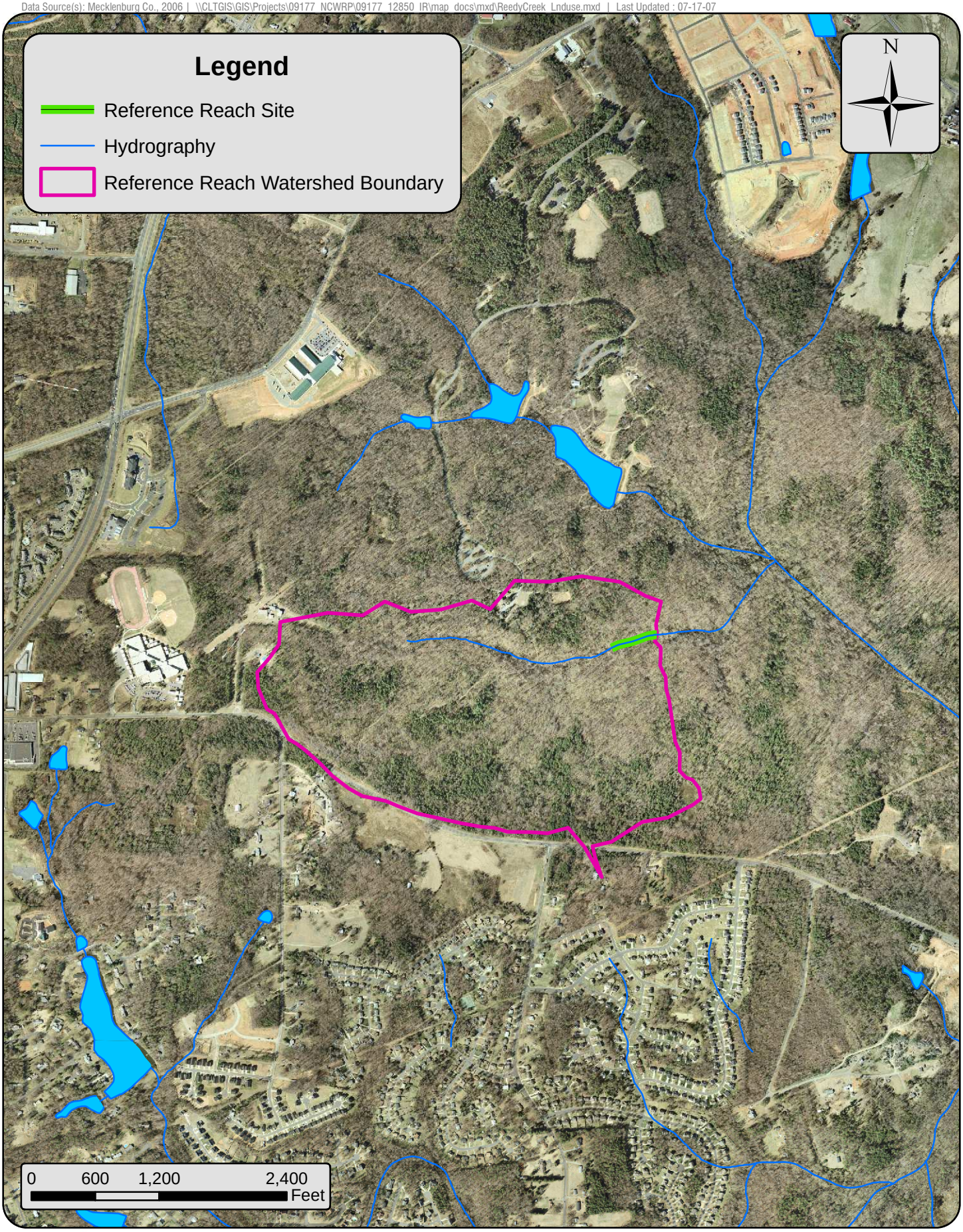
Figure 9a

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠

Data Source(s): Mecklenburg Co., 2006 | \\CLTGIS\GIS\Projects\09177_NCWRP\09177_12850_IR\map_docs\mxd\ReedyCreek_Lnduse.mxd | Last Updated : 07-17-07



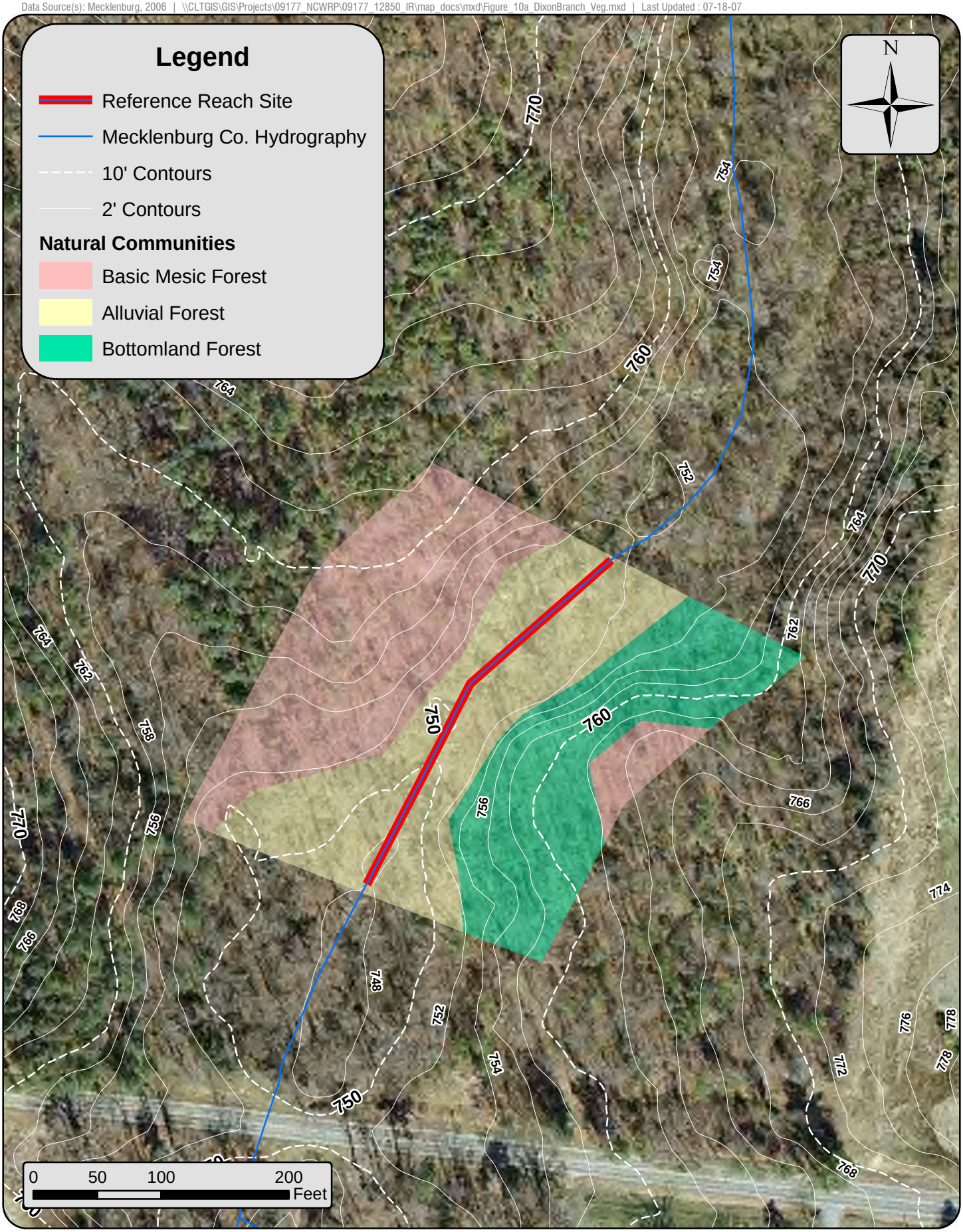
UT to Reedy Creek Reference Reach Watershed Landuse

Figure 9b

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠



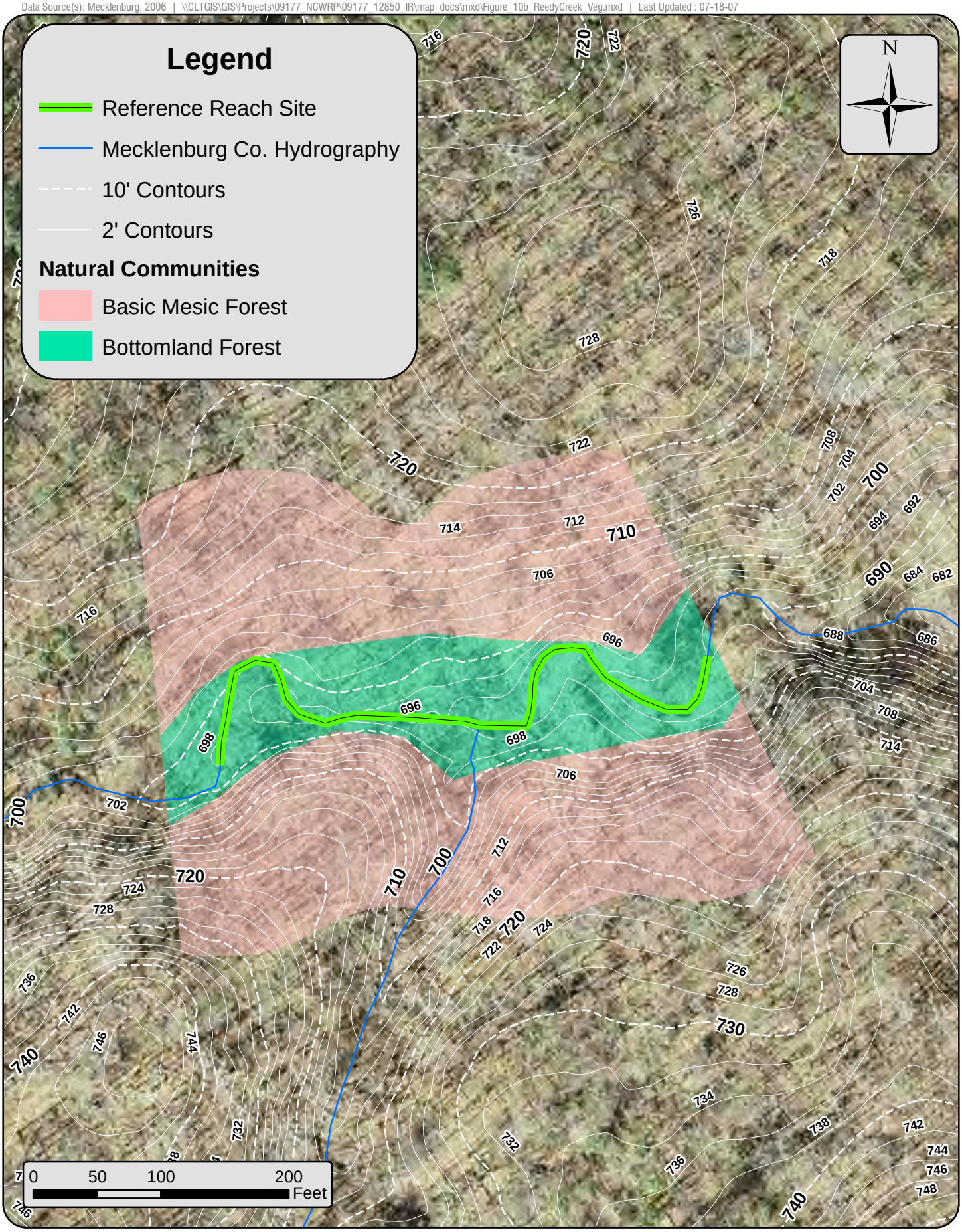
Dixon Branch Reference Reach Vegetative Communities

Figure 10a

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠



UT to Reedy Creek Reference Reach Vegetative Communities

Figure 10b

Indian Run (Tributary to Coddle Creek) | 60% Restoration Plan | Cabarrus County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4200985 | State Constr. No. D05004S

Ecosystem Enhancement Program

HDR ONE COMPANY | *Many Solutions*℠

Sheet I

Existing Channel or Site Conditions

REVISIONS

BEGIN UPPER REACH
INDIAN RUN
STA. 10+00.00

PROPERTY LINE

EXISTING STREAM CENTERLINE

EDWARD F. KIRGAN
PIN: 5528425597
DB 578 PG 272

STATE OF NORTH CAROLINA
PIN: 5528435540
DB 578 PG 274

FOOTBRIDGE

BELLSOUTH PHONE LINE

EXISTING SANITARY SEWER WITH 30' RW

CHAONN K. HOYLE
PIN: 5528435540
DB 578 PG 274

ROCKY RIVER ROAD

MATCH LINE, SEE EXISTING CONDITIONS SHEET 1B

50 0 100
SCALE

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

EXISTING CONDITIONS SHEET 1A

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

PROJECT ENGINEER

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_EX_psh_04.dgn
mwiles

REVISIONS

END UPPER REACH
INDIAN RUN
STA. 28+07.64

BEGIN LOWER REACH
INDIAN RUN
STA. 10+00.00

EXISTING STREAM CENTERLINE

PROPERTY LINE

10X12 BOX CULVERT

BOULDER CREEK
HOMEOWNERS ASSOC.
PIN: 5528410953
DB 2641 PG 104

ROCKY RIVER ROAD

BELLSOUTH PHONE LINE

SANITARY SEWER LINE WITH 30' R/W

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

MATCH LINE, SEE EXISTING CONDITIONS SHEET 1A

MATCH LINE, SEE EXISTING CONDITIONS SHEET 1C

50 0 100
SCALE

8/30/2007
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mmiles

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

EXISTING CONDITIONS SHEET 1B

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

PROJECT ENGINEER

REVISIONS

MATCH LINE, SEE EXISTING CONDITIONS SHEET 1B

PROPERTY LINE

BOULDER CREEK HOMEOWNERS ASSOC.
D.B. 2641 PG. 104
C.O.S. M.B. 32 PG. 70
TAX PARCEL #5528314328

EXISTING STREAM CENTERLINE

BELLSOUTH PHONE LINE

RIM - 540.96
IN - 525.59
OUT - 525.54

END LOWER REACH
INDIAN RUN
STA. 29+22.14

EXISTING SANITARY SEWER WITH 30' RW

EXIST. Ø 36" SS

RIM - 538.51
IN - 525.81
OUT - 525.81

EXISTING CENTERLINE OF CODDLE CREEK

AUTUMN RIDGE II HOMEOWNERS ASSOC.
C.O.S. M.B. 32 PG. 8
TAX PARCEL #5528310585

50 0 100
SCALE

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_EX_psh_06.dgn
mwren

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

EXISTING CONDITIONS SHEET 1C

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
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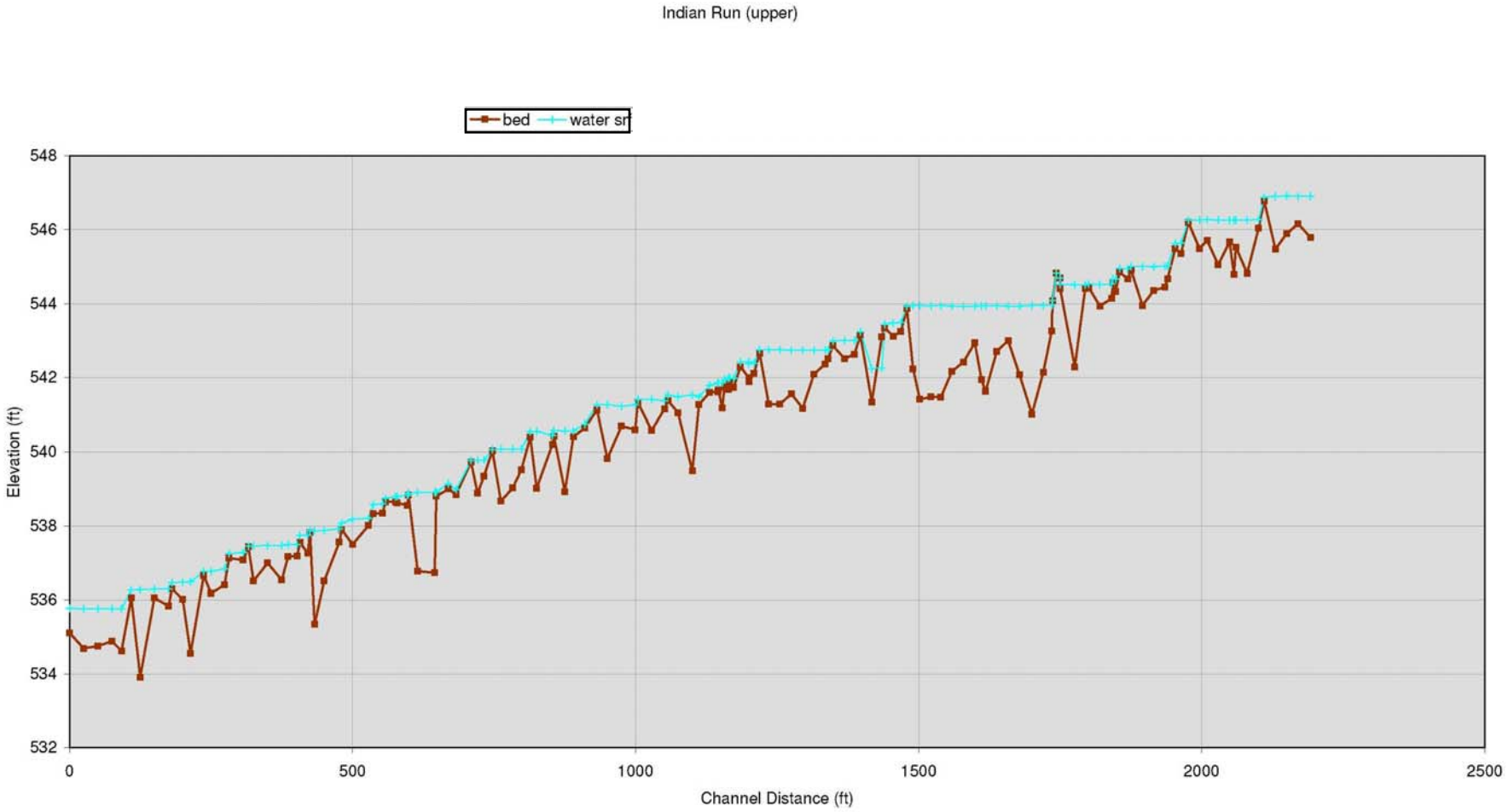
PROJECT ENGINEER



INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

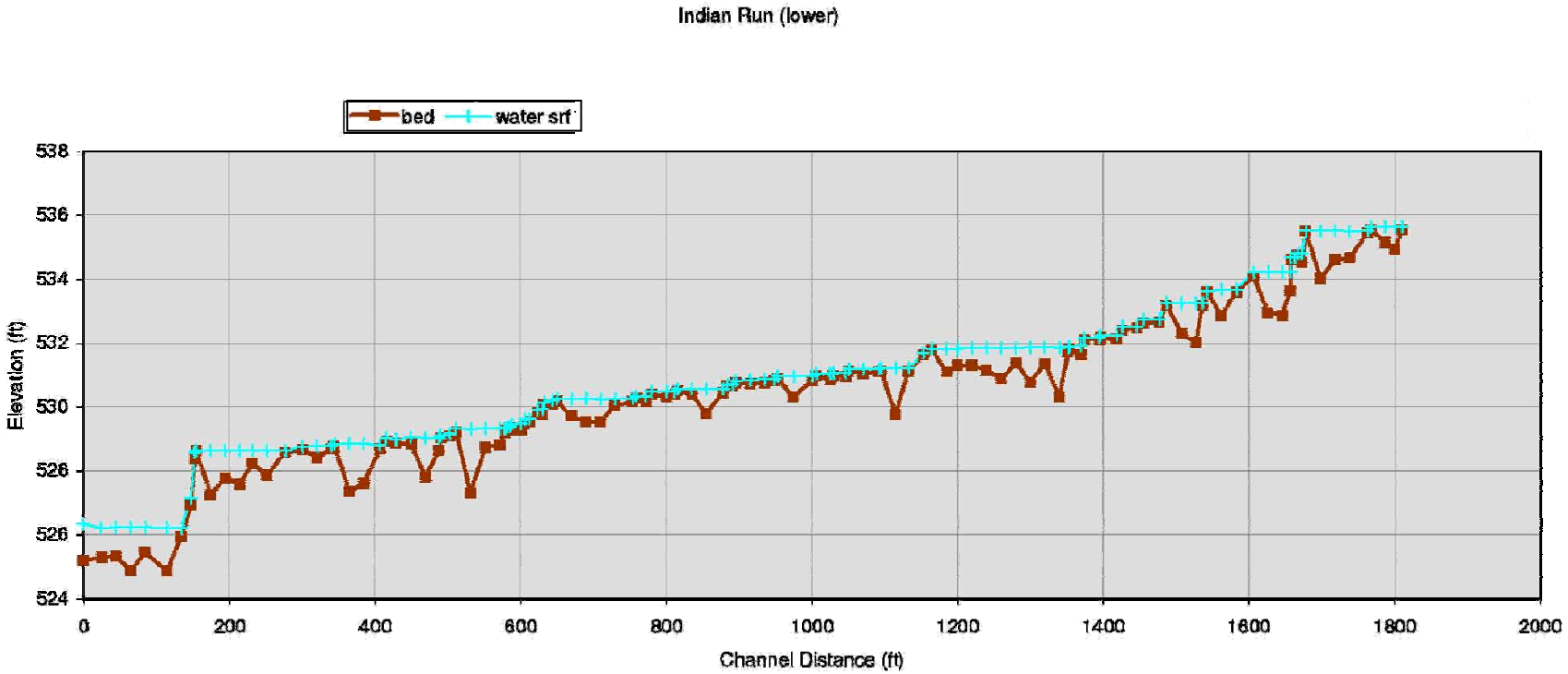
CABARRIS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

SHEET 1D
INDIAN RUN LONGITUDINAL PROFILE

Ecosystem Enhancement PROGRAM

HDR



INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRIS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

SHEET 1E
INDIAN RUN LONGITUDINAL PROFILE

Ecosystem Enhancement PROGRAM

HDR

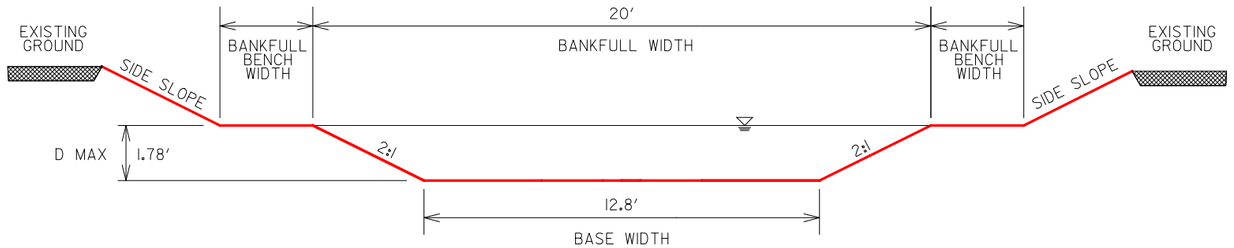
Sheet 2

Design Channel Alignment

REVISIONS

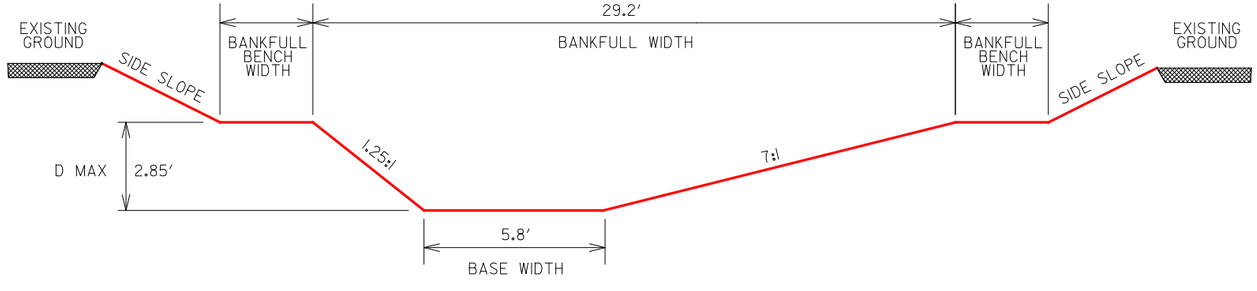
TYPICAL SECTIONS

RIFFLE



	STATION RANGE	BANKFULL BENCH WIDTH	SIDE SLOPE
UPPER REACH	STA. 10+00 TO STA. 14+89 STA 14+89 TO STA. 28+07	3' ON EACH SIDE 5' ON EACH SIDE	2:1 2:1
LOWER REACH	STA. 10+00 TO STA. 29+22	80-100' TOTAL	3:1

POOL



INDIAN RUN (TRIBUTARY TO CODDLE CREEK)
CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

DESIGN SHEET 2A

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

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R:\EEP-WRP\Indian Run\Plansheets\indianrun_typicals.dgn
mwren

REVISIONS

BEGIN UPPER REACH
INDIAN RUN
STA. 10+00.00
LAT: 37.841873
LONG: 83.902224

CONSERVATION CORRIDOR
CONSTRUCTION LIMIT
PROPERTY LINE
BANKFULL BENCH

EDWARD F. KIRGAN
PIN: 5528425597
DB 578 PG 272

STATE OF NORTH CAROLINA
PIN: 5528435540
DB 578 PG 274

CHAONN K. HOYLE
PIN: 5528435540
DB 578 PG 274

10
15
20

EXISTING CENTERLINE OF STREAM

48" OAK TO BE RETAINED

FOOTBRIDGE

BELLSOUTH PHONE LINE

EXISTING SANITARY SEWER WITH 30' RW

ROCKY RIVER ROAD

MATCH LINE, SEE DESIGN SHEET 2C

50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

DESIGN SHEET 2B

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
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R:\EEP-WRP\Indian Run\Plansheets\indianrun_psh_04.dgn
mwren

REVISIONS

END UPPER REACH
INDIAN RUN
STA. 28+07.64
LAT: 37.840170
LONG:83.907076

BEGIN LOWER REACH
INDIAN RUN
STA. 10+00.00
LAT: 37.840016
LONG: 83.907341

CONSERVATION CORRIDOR

CONSTRUCTION LIMIT

PROPERTY LINE

25

10

15

BOULDER CREEK
HOMEOWNERS ASSOC.
PIN: 5528410953
DB 2641 PG 104

BANKFULL BENCH

EXISTING CENTERLINE OF STREAM

ROCKY RIVER ROAD

BELLSOUTH PHONE LINE

SANITARY SEWER LINE WITH 30' R/W

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

CONSERVATION CORRIDOR

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

MATCH LINE, SEE DESIGN SHEET 2B

MATCH LINE, SEE DESIGN SHEET 2D

50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

DESIGN SHEET 2C

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

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3733 National Drive, Suite 207 Raleigh, N.C. 27612

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R:\EEP-WRP\Indian Run\Plansheets\indianrun_psh_05.dgn

REVISIONS

MATCH LINE, SEE DESIGN SHEET 2C

PROPERTY LINE

BANKFULL BENCH

BOULDER CREEK HOMEOWNERS ASSOC.
D.B. 2641 PG. 104
C.O.S. M.B. 32 PG. 70
TAX PARCEL #5528314328

CONSTRUCTION LIMITS

CONSERVATION CORRIDOR

BELLSOUTH PHONE LINE

SMALL TRIBUTARY

EXISTING CENTERLINE OF STREAM

RIM - 540.96
IN - 525.59
OUT - 525.54

END LOWER REACH
INDIAN RUN
STA. 29+22.14
LAT: 37.836766
LONG: 83.910350

EXISTING SANITARY SEWER WITH 30' RW

EXIST. 36" SS

RIM - 538.51
IN - 525.81
OUT - 525.81

AUTUMN RIDGE II HOMEOWNERS ASSOC.
C.O.S. M.B. 32 PG. 8
TAX PARCEL #5528310585

EXISTING CENTERLINE OF CODDLE CREEK

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_psh_06.dgn
mwest

50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

DESIGN SHEET 2D

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

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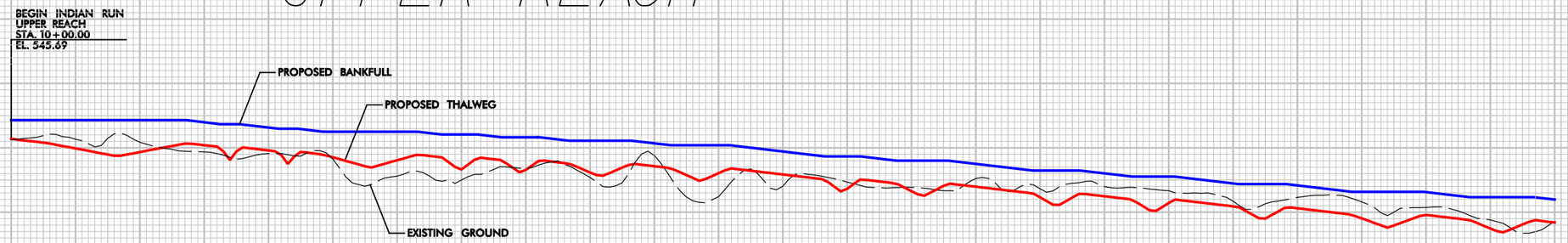
Sheet 3

Design Longitudinal Profile

5/28/99

UPPER REACH



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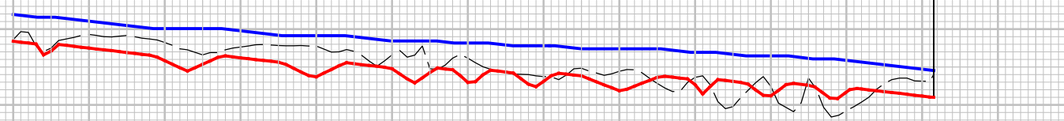
10 11 12 13 14 15 16 17 18 19 20 21 22

UPPER REACH



550 545 540 535 530

22 23 24 25 26 27 28

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)
CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

PROPOSED LONGITUDINAL PROFILE

DESIGN SHEET 3A

Ecosystem Enhancement Program

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8/30/2007
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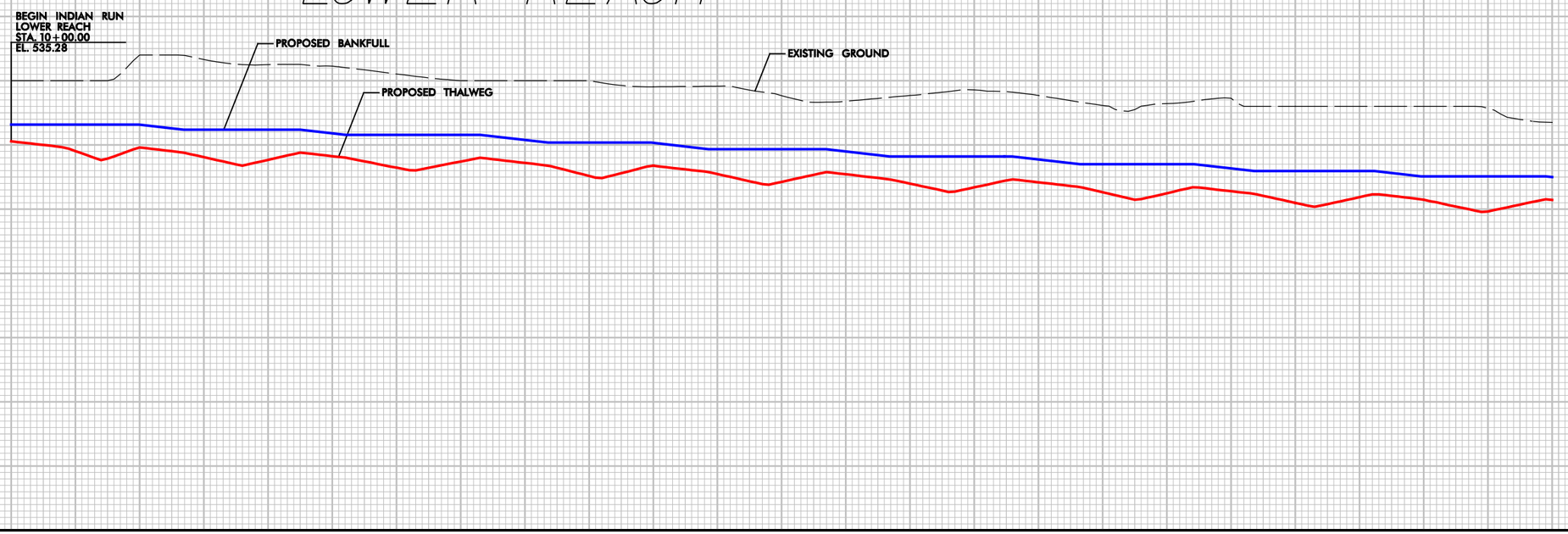
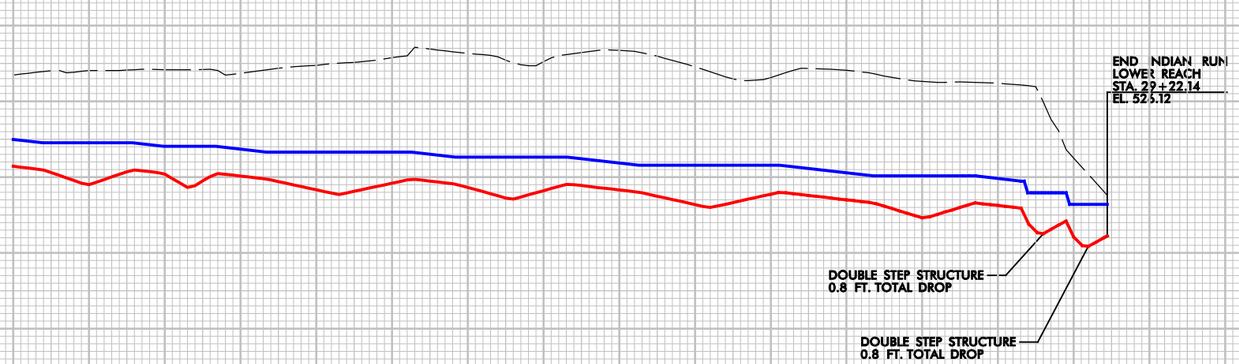
5/28/99

LOWER REACH



LOWER REACH



INDIAN RUN (TRIBUTARY TO CODDLE CREEK)
CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

PROPOSED LONGITUDINAL PROFILE

DESIGN SHEET 3B

Ecosystem Enhancement Program

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8/30/2007
K:\EEP\NRP\Indian Run\Plansheets\indianrun_profiles.dgn

Sheet 4

Designed Vegetative Communities Map by Zone

REVISIONS

BEGIN UPPER REACH
INDIAN RUN
STA. 10+00.00
LAT: 37.841873
LONG: 83.902224

CONSERVATION CORRIDOR
CONSTRUCTION LIMIT
PROPERTY LINE
BANKFULL BENCH
FOOTBRIDGE
EXISTING CENTERLINE OF STREAM
48" OAK TO BE RETAINED
BELLSOUTH PHONE LINE
EXISTING SANITARY SEWER WITH 30' RW
ROCKY RIVER ROAD

EDWARD F. KIRGAN
PIN: 5528425597
DB 578 PG 272

STATE OF NORTH CAROLINA
PIN: 5528435540
DB 578 PG 274

CHAONN K. HOYLE
PIN: 5528435540
DB 578 PG 274

15
20
10

MATCH LINE, SEE PROPOSED PLANTING ZONE 4B

50 0 100
SCALE

LEGEND

PLANTING ZONE 3
PLANTING ZONE 2
PLANTING ZONE 1

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

PROPOSED PLANTING ZONE 4A

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
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PROJECT ENGINEER

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_Plant_psh_04.dgn

REVISIONS

END UPPER REACH
INDIAN RUN
STA. 28+07.64
LAT: 37.840170
LONG:83.907076

BEGIN LOWER REACH
INDIAN RUN
STA. 10+00.00
LAT: 37.840016
LONG: 83.907341

CONSERVATION CORRIDOR

CONSTRUCTION LIMIT

PROPERTY LINE

25

10X12 BOX CULVERT

10

BANKFULL BENCH

15

BOULDER CREEK
HOMEOWNERS ASSOC.
PIN: 5528410953
DB 2641 PG 104

ROCKY RIVER ROAD

BELLSOUTH PHONE LINE

SANITARY SEWER LINE WITH 30' R/W

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

CONSERVATION CORRIDOR

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

MATCH LINE, SEE PROPOSED PLANTING ZONE 4A

MATCH LINE, SEE PROPOSED PLANTING ZONE 4C

50 0 100
SCALE

LEGEND

PLANTING ZONE 3

PLANTING ZONE 2

PLANTING ZONE 1

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

PROPOSED PLANTING ZONE 4B

Ecosystem Enhancement PROGRAM

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PROJECT ENGINEER

8/30/2007
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dmyers

REVISIONS

MATCH LINE, SEE PROPOSED PLANTING ZONE 4B

PROPERTY LINE

BANKFULL BENCH

BOULDER CREEK HOMEOWNERS ASSOC.
D.B. 2641 PG. 104
C.O.S. M.B. 32 PG. 70
TAX PARCEL #5528314328

CONSTRUCTION LIMITS

CONSERVATION CORRIDOR

BELLSOUTH PHONE LINE

SMALL TRIBUTARY

20

25

END LOWER REACH
INDIAN RUN
STA. 29+22.14
LAT: 37.836766
LONG: 83.910350

EXISTING SANITARY SEWER WITH 30' RW

EXIST. 36" SS
RIM - 538.51
IN - 525.81
OUT - 525.81

EXISTING CENTERLINE OF CODDLE CREEK

AUTUMN RIDGE II HOMEOWNERS ASSOC.
C.O.S. M.B. 32 PG. 8
TAX PARCEL #5528310585

50 0 100
SCALE

LEGEND

- PLANTING ZONE 3
- PLANTING ZONE 2
- PLANTING ZONE 1

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

PROPOSED PLANTING ZONE 4C

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_Plant_psh_06.dgn
dmyers

Appendix A

Restoration Site Photographs (Indian Run)

Appendix A – Indian Run Photographs

Photo 1- Confluence with Coddle Creek

Photo 5 - Scour just downstream of sewer crossing

Photo 2 - Lower reach sewer crossing

Photo 6 - Lower Reach

Photo 3 - Culvert replacement on Rocky River Rd.

Photo 7 - Lower Reach

Photo 4 - Lower Reach

Photo 8 - Lower Reach

Appendix A – Indian Run Photographs

Photo 9 - Lower Reach just downstream from culvert

Photo 13 - Culvert Replacement in progress

Photo 10 - Trib directly upstream of culvert.

Photo 14 - Sour upstream of Culvert

Photo 11 - Upper Reach

Photo 15 - Upper Reach

Photo 12 - Upper Reach

Photo 16 - Upper Reach

Appendix A – Indian Run Photographs

Photo 17 - Upper Reach

Photo 21 - Upper Reach

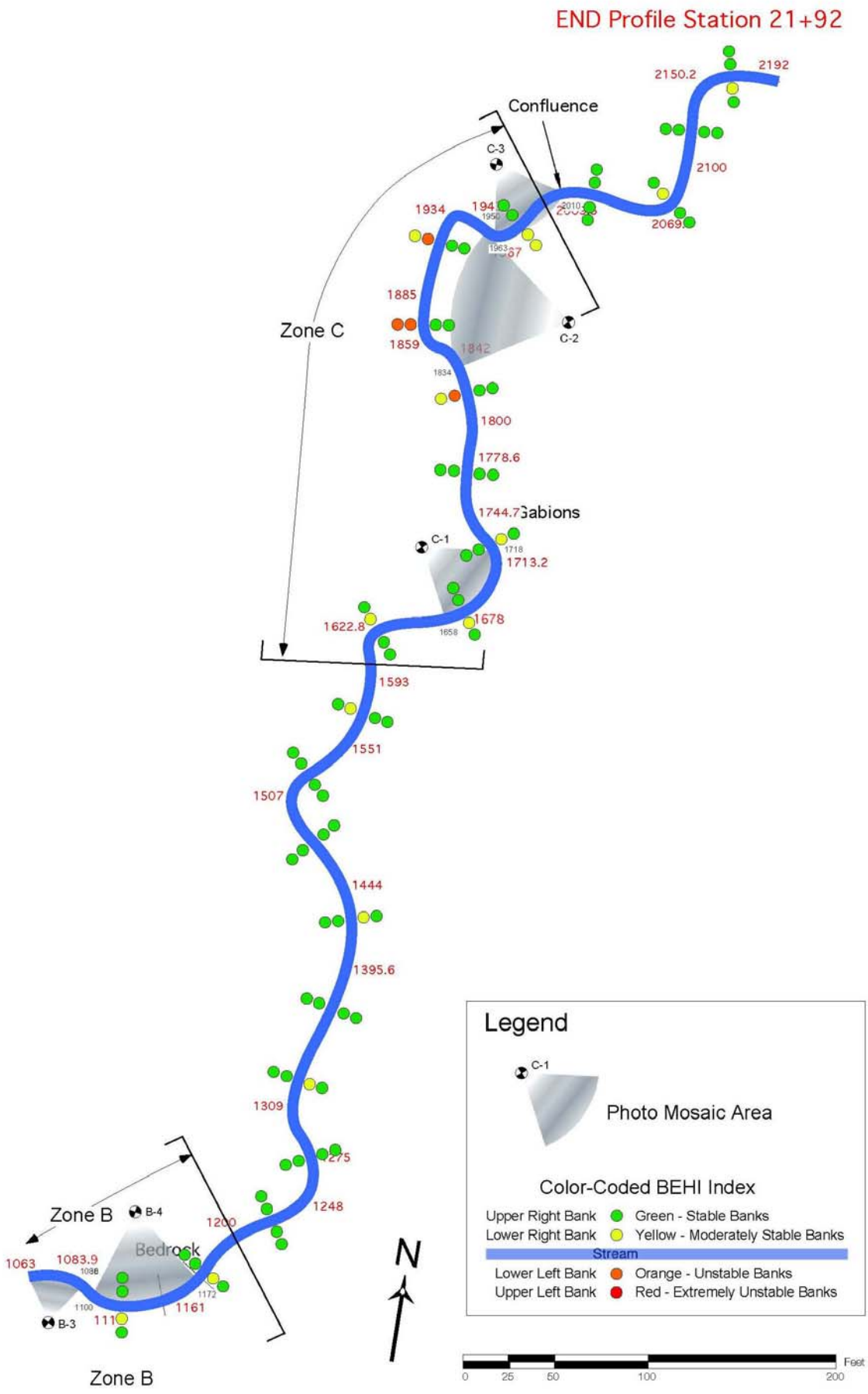
Photo 18 - Upper Reach

Photo 19 - Upper Reach Sewer Crossing

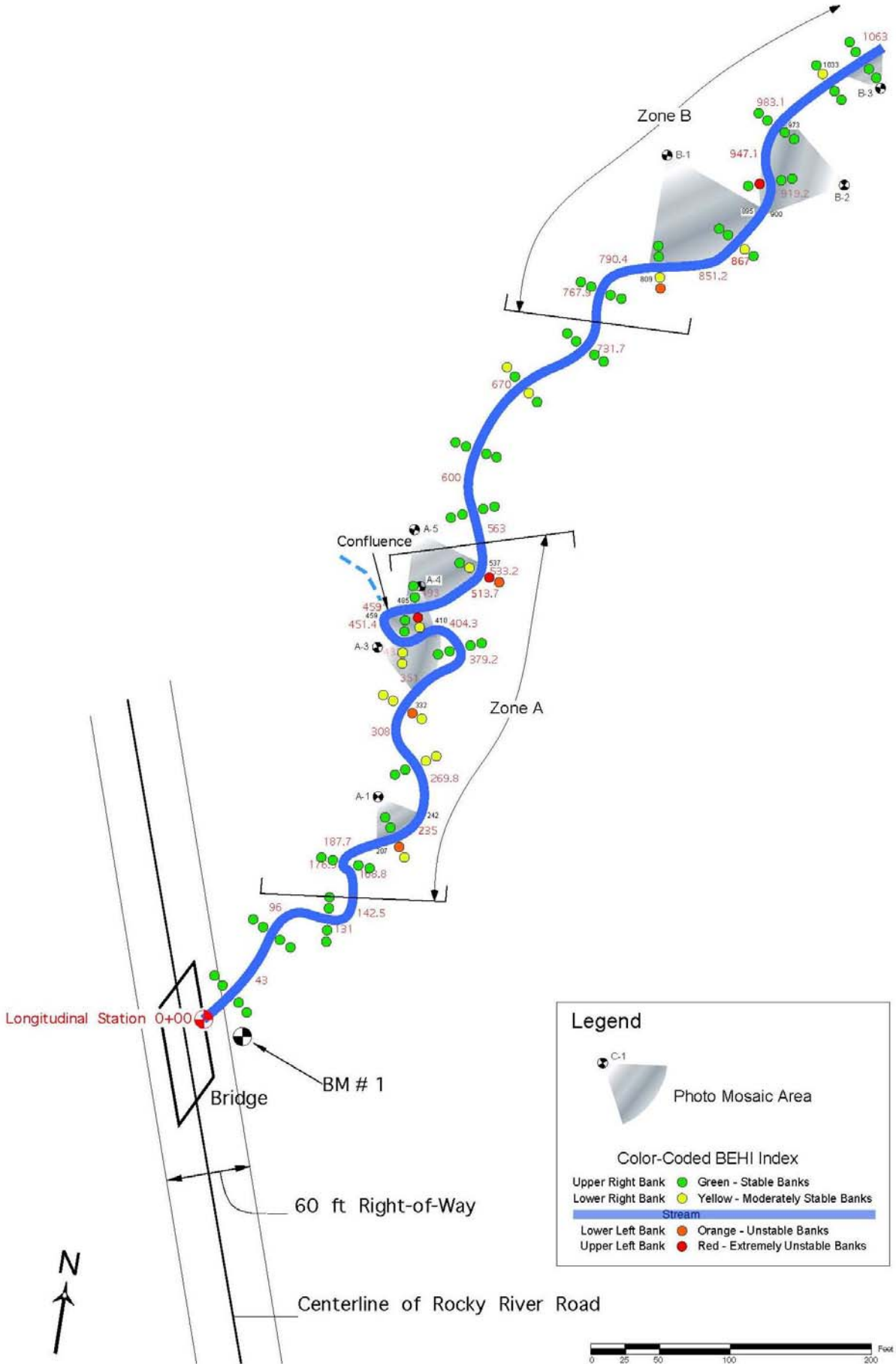
Photo 20 - BMP Outlet

Appendix B

Photo Mosaics and BEHI Assessment

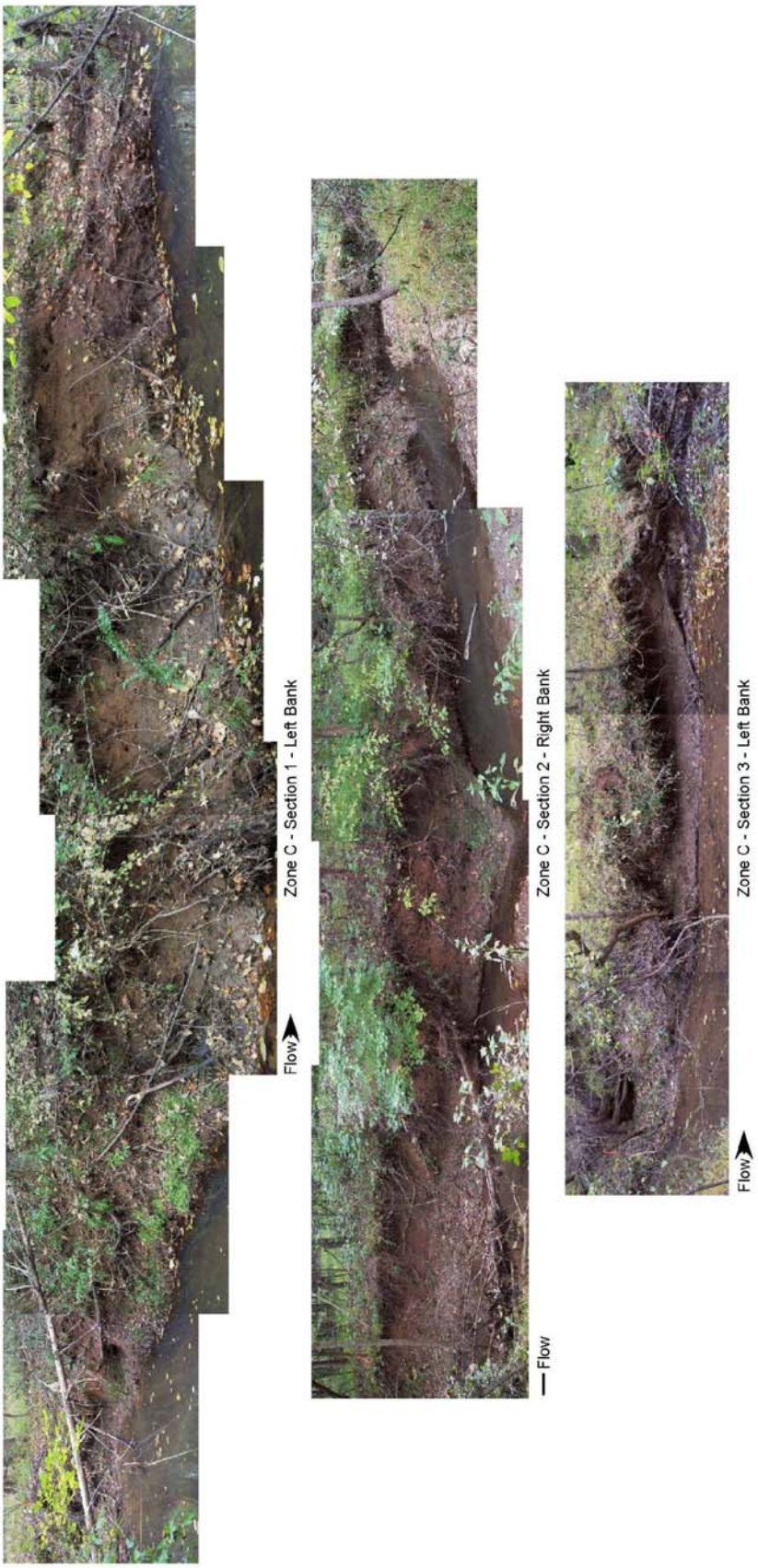

END Profile Station 21+92
2192
2150.2
Confluence
C-3
2100
2069
1934
1885
Zone C
1859
C-2
1842
1800
1778.6
Gabions
C-1
1713.2
1678
1622.8
1593
1551
1507
1444
1395.6
1309
1248
1200
Zone B
B-4
Bedrock
1083.9
1063
B-3
1161
Zone B
N
Legend
C-1
Photo Mosaic Area
Color-Coded BEHI Index
Upper Right Bank
Green - Stable Banks
Lower Right Bank
Yellow - Moderately Stable Banks
Stream
Lower Left Bank
Orange - Unstable Banks
Upper Left Bank
Red - Extremely Unstable Banks
0
25
50
100
200
Feet

Appendix B – Photo Mosaics and BEHI Assessment (Existing Reach)




Zone A - Section 1 - Left Bank
Flow
Zone A - Section 3 - Left Bank
Flow
Zone A - Section 4 - Right Bank
Flow
Zone A - Section 5 - Left Bank
Flow


Zone B - Section 1 - Left Bank
Flow
Zone B - Section 2 - Right Bank
Flow
Zone B - Section 3 - Right Bank
Flow
Zone B - Section 4 - Left Bank
Flow


Zone C - Section 1 - Left Bank
Flow
Zone C - Section 2 - Right Bank
Flow
Zone C - Section 3 - Left Bank
Flow

Appendix C

Reference Site Photographs (Dixon Branch)

Appendix C – Dixon Branch Photographs

Photo 1- Riffle and Pool sequence (looking downstream)

Photo 3 – Riffle Cross Section (looking upstream)

Photo 2 – Channel bar (looking upstream)

Photo 4 – Pool and Riffle sequence

Appendix C – Dixon Branch Photographs

Photo 5 – Pool Cross Section (looking downstream)

Photo 6 – Riffle Cross Section (looking upstream)

Appendix D

Reference Site Photographs (UT to Reedy Creek)

Appendix D – UT to Reedy Creek Photographs

Photo 1- UT to Reedy Creek meander

Photo 5 – Natural step structure

Photo 2 – Pool in meander bend

Photo 6 – Natural step structure

Photo 3 – Bed material in riffle

Photo 7 – Large bed material

Photo 4 – Footbridge crossing

Photo 8 – Longitudinal drop in stream elevation

Appendix D – UT to Reedy Creek Photographs

Photo 9 – Looking downstream

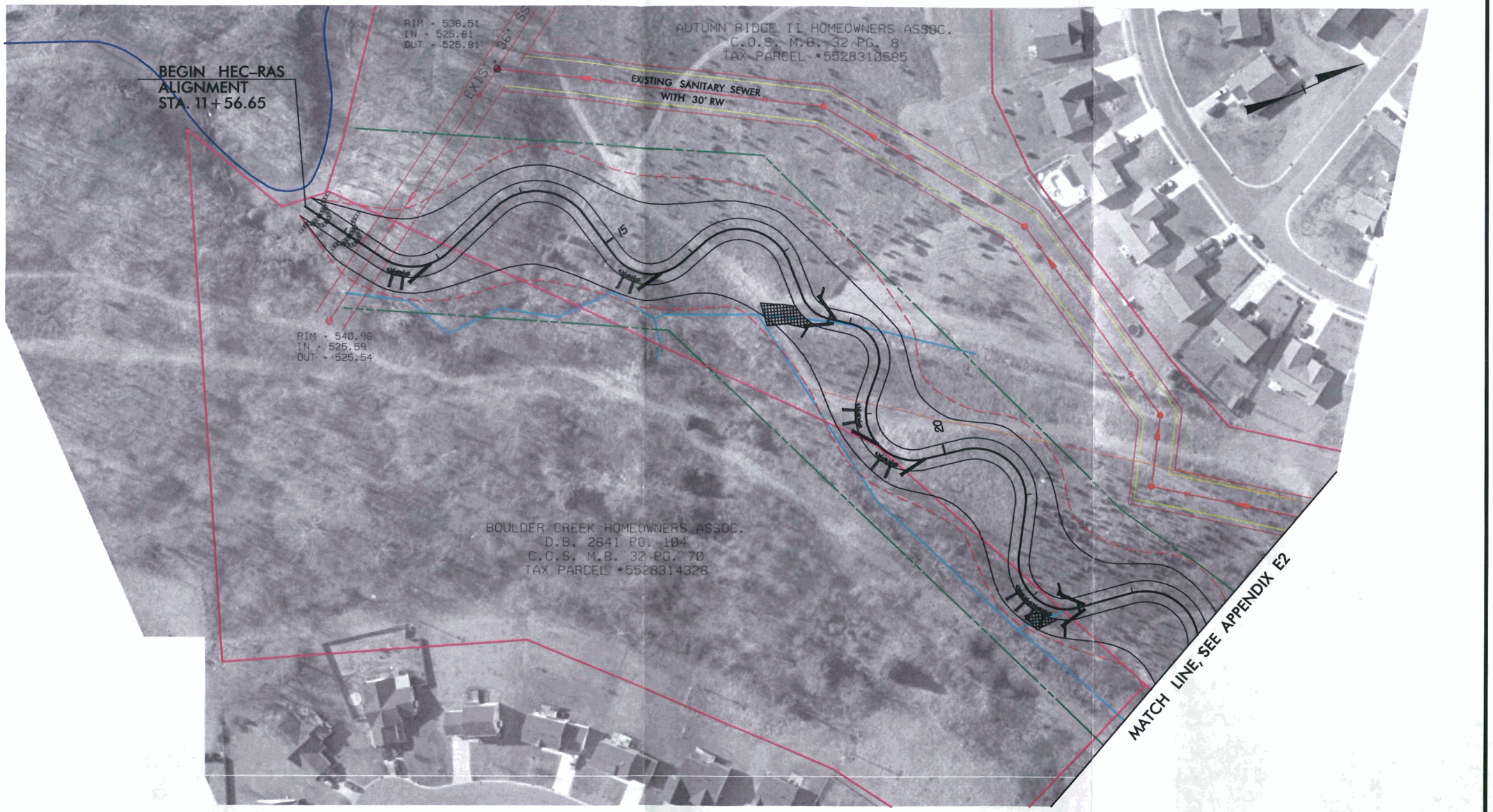
Photo 10 – Looking downstream

Photo 11 – Drop in elevation off large natural rock

Appendix E

HEC-RAS

REVISIONS



50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

HEC-RAS ALIGNMENT APPENDIX E1

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_HR_psh_04.dgn
mmoore

REVISIONS

MATCH LINE, SEE APPENDIX E1

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

AUTUMN RIDGE II
HOMEOWNERS ASSOC.
PIN: 5528310585
MB 32 PG 8

SANITARY SEWER LINE WITH 30' R/W

25

30

10X12 BOX CULVERT

35

MATCH LINE, SEE APPENDIX E3

BOULDER CREEK
HOMEOWNERS ASSOC.
PIN: 5528410953
DB 2641 PG 104

50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

HEC-RAS ALIGNMENT APPENDIX E2

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

PROJECT ENGINEER

8/30/2007
R:\EEP-WRP\Indian Run\Plansheets\indianrun_HR_psh_05.dgn
mmoss

REVISIONS

MATCH LINE, SEE APPENDIX E2

CHADNN K. HOYLE
PIN: 5528435640
DB 578 PG 274

END HEC-RAS
ALIGNMENT
STA. 49+81.38

STATE OF NORTH CAROLINA
PIN: 5528435540
DB 578 PG 274

EDWARD F. KIRGAN
PIN: 5528425597
DB 578 PG 272

50 0 100
SCALE

LEGEND

- LOG CROSS VANE
- LOG VANE OR LOG SILL
- ROCK CROSS VANE
- ROOTWAD
- ROCK CROSS VANE WITH DOUBLE STEP
- CHANNEL PLUG

INDIAN RUN (TRIBUTARY TO CODDLE CREEK)

CABARRUS COUNTY, NC

EEP PROJECT NO. EP4200985
STATE CONST. NO. D05004S

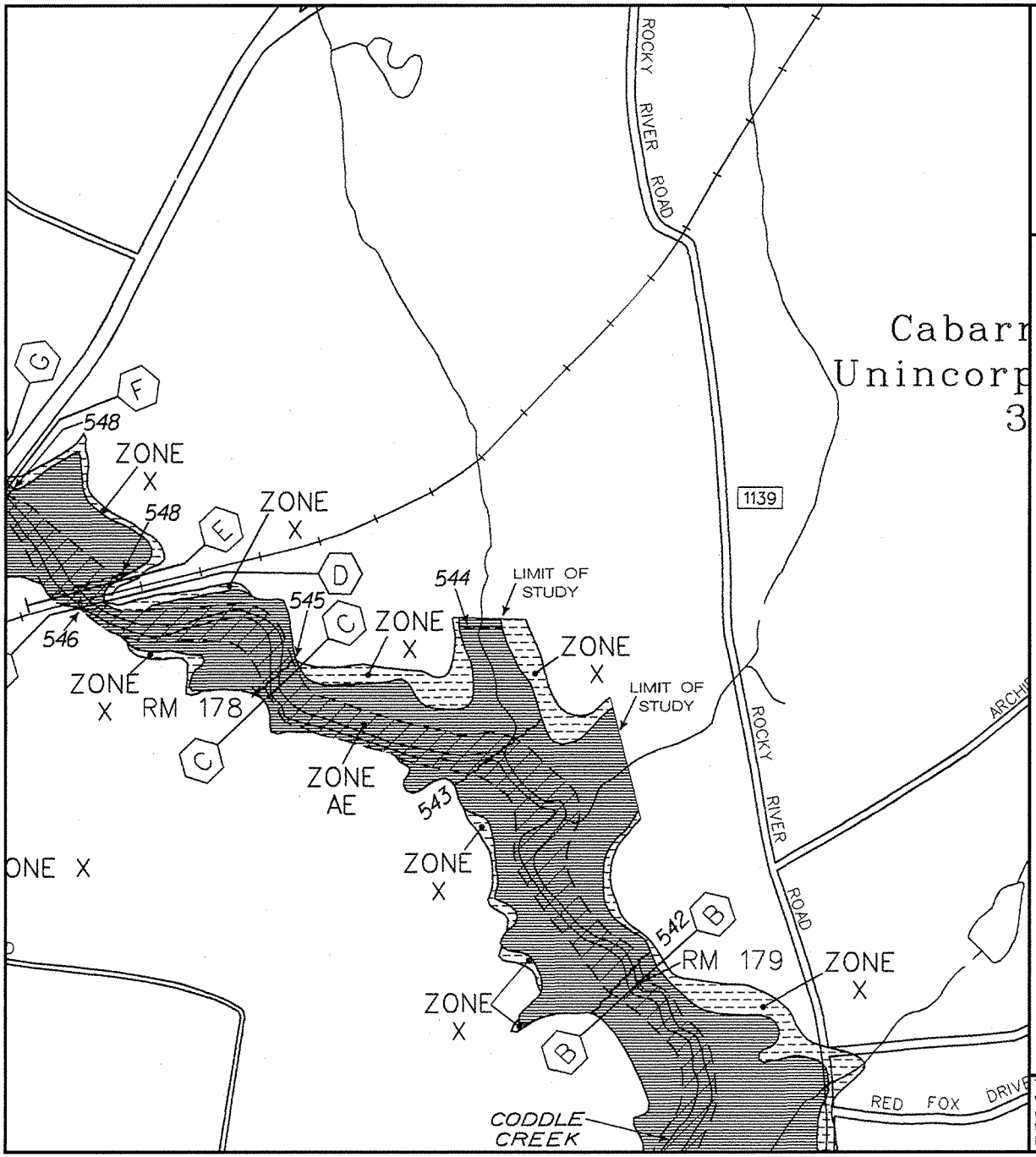
HEC-RAS ALIGNMENT APPENDIX E3

PROJECT ENGINEER

Ecosystem Enhancement PROGRAM

HDR Engineering, Inc. of the Carolinas
3733 National Drive, Suite 207 Raleigh, N.C. 27612

8/30/2007
K:\EEP\Indian Run\Plansheets\indianrun_HR_psh_06.dgn



APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

CABARRUS COUNTY, NORTH CAROLINA AND INCORPORATED AREAS

PANEL 120 OF 180

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CONCORD, CITY OF	370037	0120	D
UNINCORPORATED AREAS	370036	0120	D

Notice to User: The MAP NUMBER shown below should be used when placing map orders; the COMMUNITY NUMBER shown above should be used on insurance applications for the subject community.

MAP NUMBER
37025C0120 D

EFFECTIVE DATE:
NOVEMBER 2, 1994

Federal Emergency Management Agency

River Sta	Profile	Plan	Q Total	W.S. Elev
4899.0	BKF	prop	102	546.38
4899.0	BKF	exist	102	545.31
4899.0	2X BKF	prop	204	547.15
4899.0	2X BKF	exist	204	545.97
4899.0	3X BKF	prop	306	547.62
4899.0	3X BKF	exist	306	546.50
4899.0	10-YR	prop	440	548.11
4899.0	10-YR	exist	440	547.44
4899.0	50-YR	prop	780	549.16
4899.0	50-YR	exist	780	549.33
4899.0	100-YR	prop	960	549.60
4899.0	100-YR	exist	960	550.00
4443.7	BKF	prop	102	544.66
4443.7	BKF	exist	102	543.83
4443.7	2X BKF	prop	204	545.40
4443.7	2X BKF	exist	204	544.95
4443.7	3X BKF	prop	306	545.83
4443.7	3X BKF	exist	306	545.83
4443.7	10-YR	prop	440	546.35
4443.7	10-YR	exist	440	546.75
4443.7	50-YR	prop	780	547.07
4443.7	50-YR	exist	780	548.53
4443.7	100-YR	prop	960	547.54
4443.7	100-YR	exist	960	549.15
3990.0	BKF	prop	102	541.50
3990.0	BKF	exist	102	542.63
3990.0	2X BKF	prop	204	542.11
3990.0	2X BKF	exist	204	543.23
3990.0	3X BKF	prop	306	542.63
3990.0	3X BKF	exist	306	543.59
3990.0	10-YR	prop	440	543.08
3990.0	10-YR	exist	440	544.21
3990.0	50-YR	prop	780	544.89
3990.0	50-YR	exist	780	545.50
3990.0	100-YR	prop	960	546.09
3990.0	100-YR	exist	960	546.46
3666.3	BKF	prop	102	539.71
3666.3	BKF	exist	102	540.14
3666.3	2X BKF	prop	204	540.49
3666.3	2X BKF	exist	204	541.04
3666.3	3X BKF	prop	306	541.21
3666.3	3X BKF	exist	306	541.83
3666.3	10-YR	prop	440	542.22
3666.3	10-YR	exist	440	542.82
3666.3	50-YR	prop	780	544.74
3666.3	50-YR	exist	780	545.27
3666.3	100-YR	prop	960	545.98
3666.3	100-YR	exist	960	546.18

River Sta	Profile	Plan	Q Total	W.S. Elev
3459.7	BKF	prop	102	539.15
3459.7	BKF	exist	102	539.18
3459.7	2X BKF	prop	204	539.95
3459.7	2X BKF	exist	204	540.14
3459.7	3X BKF	prop	306	540.82
3459.7	3X BKF	exist	306	541.03
3459.7	10-YR	prop	440	541.95
3459.7	10-YR	exist	440	542.14
3459.7	50-YR	prop	780	544.61
3459.7	50-YR	exist	780	544.81
3459.7	100-YR	prop	960	545.87
3459.7	100-YR	exist	960	546.03
3203.5	BKF	prop	102	537.15
3203.5	BKF	exist	102	537.23
3203.5	2X BKF	prop	204	538.49
3203.5	2X BKF	exist	204	538.51
3203.5	3X BKF	prop	306	539.51
3203.5	3X BKF	exist	306	539.53
3203.5	10-YR	prop	440	540.67
3203.5	10-YR	exist	440	540.69
3203.5	50-YR	prop	780	543.15
3203.5	50-YR	exist	780	543.16
3203.5	100-YR	prop	960	544.25
3203.5	100-YR	exist	960	544.26
3125.0	Culvert			
3052.8	BKF	prop	102	536.69
3052.8	BKF	exist	102	536.48
3052.8	2X BKF	prop	204	537.44
3052.8	2X BKF	exist	204	537.06
3052.8	3X BKF	prop	306	537.90
3052.8	3X BKF	exist	306	537.71
3052.8	10-YR	prop	440	538.45
3052.8	10-YR	exist	440	538.45
3052.8	50-YR	prop	780	540.07
3052.8	50-YR	exist	780	540.06
3052.8	100-YR	prop	960	540.82
3052.8	100-YR	exist	960	540.82
2620.6	BKF	prop	102	534.54
2620.6	BKF	exist	102	533.51
2620.6	2X BKF	prop	204	535.30
2620.6	2X BKF	exist	204	534.22
2620.6	3X BKF	prop	306	535.72
2620.6	3X BKF	exist	306	534.83
2620.6	10-YR	prop	440	536.10
2620.6	10-YR	exist	440	535.55
2620.6	50-YR	prop	780	536.82
2620.6	50-YR	exist	780	537.04
2620.6	100-YR	prop	960	537.15
2620.6	100-YR	exist	960	537.67

River Sta	Profile	Plan	Q Total	W.S. Elev
2063.9	BKF	prop	102	532.49
2063.9	BKF	exist	102	531.85
2063.9	2X BKF	prop	204	533.24
2063.9	2X BKF	exist	204	532.74
2063.9	3X BKF	prop	306	533.63
2063.9	3X BKF	exist	306	533.45
2063.9	10-YR	prop	440	534.02
2063.9	10-YR	exist	440	534.24
2063.9	50-YR	prop	780	534.80
2063.9	50-YR	exist	780	535.83
2063.9	100-YR	prop	960	535.15
2063.9	100-YR	exist	960	536.49
1664.1	BKF	prop	102	531.14
1664.1	BKF	exist	102	530.47
1664.1	2X BKF	prop	204	531.90
1664.1	2X BKF	exist	204	531.16
1664.1	3X BKF	prop	306	532.34
1664.1	3X BKF	exist	306	531.71
1664.1	10-YR	prop	440	532.72
1664.1	10-YR	exist	440	532.31
1664.1	50-YR	prop	780	533.44
1664.1	50-YR	exist	780	533.53
1664.1	100-YR	prop	960	533.75
1664.1	100-YR	exist	960	534.09
1419.1	BKF	prop	102	530.08
1419.1	BKF	exist	102	529.22
1419.1	2X BKF	prop	204	530.83
1419.1	2X BKF	exist	204	529.87
1419.1	3X BKF	prop	306	531.25
1419.1	3X BKF	exist	306	530.39
1419.1	10-YR	prop	440	531.61
1419.1	10-YR	exist	440	531.00
1419.1	50-YR	prop	780	532.30
1419.1	50-YR	exist	780	532.27
1419.1	100-YR	prop	960	532.59
1419.1	100-YR	exist	960	532.86

Appendix F

NCDWQ Stream Classification Forms for Indian Run, Dixon Branch and UT to Reedy Creek

North Carolina Division of Water Quality – Stream Identification Form Version 3.1

Date: 5/31/07	Project: EEP - Indian Run	Latitude: 35° 20.4'
Evaluator: Jamison	Site: Indian Run	Longitude: 80° 35.7'
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 36.5	County: Cabarrus	Other *e.g. Quad Name:* Project Site

A. Geomorphology (Subtotal = 17.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	(1)	2	3
3. In-channel structure: riffle-pool sequence	0	1	(2)	3
4. Soil texture or stream substrate sorting	0	1	(2)	3
5. Active/relic floodplain	0	1	2	(3)
6. Depositional bars or benches	0	(1)	2	3
7. Braided channel	(0)	1	2	3
8. Recent alluvial deposits	(0)	1	2	3
9[a] Natural levees	0	(1)	2	3
10. Headcuts	(0)	1	2	3
11. Grade controls	0	(0.5)	1	1.5
12. Natural valley or drainageway	0	0.5	(1)	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		(Yes = 3)	

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

B. Hydrology (Subtotal = 9.5)				
14. Groundwater flow/discharge	0	1	(2)	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	0	1	2	(3)
16. Leaflitter	1.5	(1)	0.5	0
17. Sediment on plants or debris	0	0.5	(1)	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	(1)	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 9.5)				
20[b]. Fibrous roots in channel	(3)	2	1	0
21[b]. Rooted plants in channel	(3)	2	1	0
22. Crayfish	0	0.5	(1)	1.5
23. Bivalves	(0)	1	2	3
24. Fish	0	0.5	(1)	1.5
25. Amphibians	0	(0.5)	1	1.5
26. Macrobenthos (note diversity and abundance)	0	(0.5)	1	1.5
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	0	(0.5)	1	1.5
29[b]. Wetland plants in streambed N/A	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

North Carolina Division of Water Quality – Stream Identification Form Version 3.1

Date: 6/26/07	Project: EEP - Indian Run	Latitude: 35° 15.64'
Evaluator: Jamison	Site: UT to Reedy Creek	Longitude: 80° 42.91'
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 44	County: Mecklenburg	Other e.g. Quad Name: Reference Reach

A. Geomorphology (Subtotal = 23.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	1	2	(3)
3. In-channel structure: riffle-pool sequence	0	1	2	←(3)
4. Soil texture or stream substrate sorting	0	1	2	(3)
5. Active/relic floodplain	0	1	←(2)	3
6. Depositional bars or benches	0	1	2	(3)
7. Braided channel	(0)	1	2	3
8. Recent alluvial deposits	0	(1)	2	3
9[a] Natural levees	(0)	1	2	3
10. Headcuts	(0)	1	2	3
11. Grade controls	0	0.5	(1)	1.5
12. Natural valley or drainageway	0	0.5	1	(1.5)
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		(Yes = 3)	

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

B. Hydrology (Subtotal = 9)				
14. Groundwater flow/discharge	0	1	(2)	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	0	1	2	(3)
16. Leaflitter	1.5	(1)	0.5	0
17. Sediment on plants or debris	0	(0.5)	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	(1)	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 11.5)				
20[b]. Fibrous roots in channel	(3)	2	1	0
21[b]. Rooted plants in channel	(3)	2	1	0
22. Crayfish	0	0.5	(1)	1.5
23. Bivalves	(0)	1	2	3
24. Fish	0	0.5	(1)	1.5
25. Amphibians	0	0.5	1	(1.5)
26. Macrobenthos (note diversity and abundance)	0	0.5	1	(1.5)
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	0	(0.5)	1	1.5
29[b]. Wetland plants in streambed N/A	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

North Carolina Division of Water Quality – Stream Identification Form Version 3.1

Date: 6/27/07	Project: EEP - Indian Run	Latitude: 35° 22.03'
Evaluator: Janison	Site: Dixon Branch	Longitude: 80° 51.03'
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 50	County: Mecklenburg	Other *e.g. Quad Name:* Reference Reach

A. Geomorphology (Subtotal = 27.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	1	2	(3)
3. In-channel structure: riffle-pool sequence	0	1	2	(3)
4. Soil texture or stream substrate sorting	0	1	2	(3)
5. Active/relic floodplain	0	1	2	(3)
6. Depositional bars or benches	0	1	2	(3)
7. Braided channel	(0)	1	2	3
8. Recent alluvial deposits	0	1	2	(3)
9[a] Natural levees	0	(1) →	2	3
10. Headcuts	(0)	1	2	3
11. Grade controls	0	0.5	(1)	1.5
12. Natural valley or drainageway	0	0.5	1	(1.5)
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		(Yes = 3)	

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

B. Hydrology (Subtotal = 9.5)				
14. Groundwater flow/discharge	0	1	(2)	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	0	1	2	(3)
16. Leaflitter	(1.5)	1	0.5	0
17. Sediment on plants or debris	0	(0.5)	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	(1)	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 13)				
20[b]. Fibrous roots in channel	(3)	2	1	0
21[b]. Rooted plants in channel	(3)	2	1	0
22. Crayfish	0	0.5	1	(1.5)
23. Bivalves	0	(1)	2	3
24. Fish	0	0.5	1	(1.5)
25. Amphibians	0	0.5	1	(1.5)
26. Macrobenthos (note diversity and abundance)	0	0.5	1	(1.5)
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	(0)	0.5	1	1.5
29[b]. Wetland plants in streambed N/A	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch: