FINAL STREAM & WETLAND

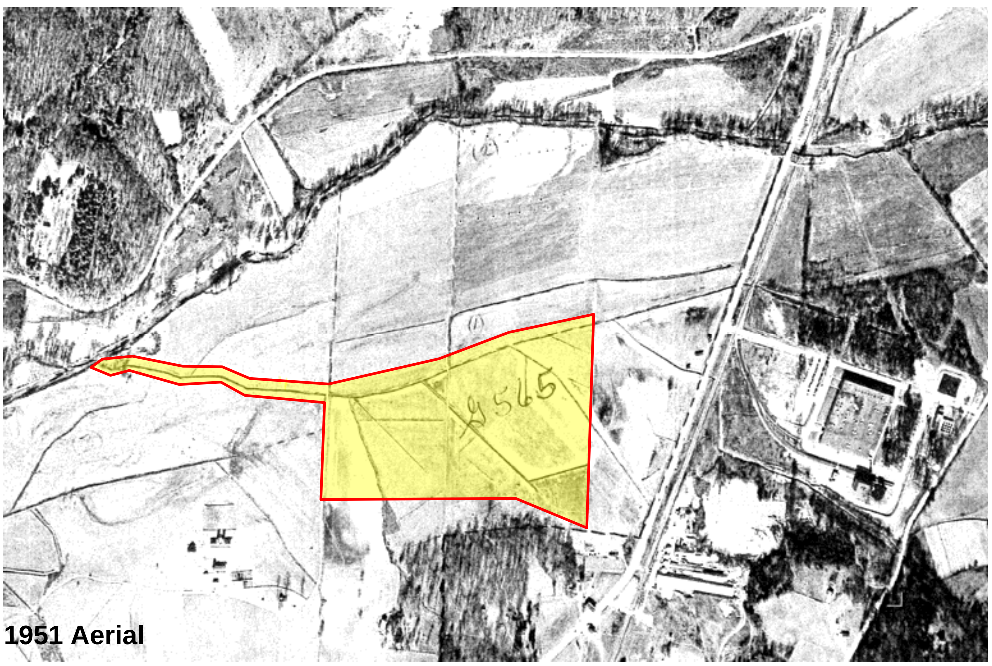
RESTORATION PLAN

For The

FLETCHER-MERITOR SITE
(UT TO CANE CREEK)

FLETCHER, HENDERSON COUNTY, NC

STATE CONSTRUCTION NO: D05039S
PROJECT NO: EP4260721



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FINAL STREAM AND WETLAND RESTORATION PLAN FOR THE FLETCHER – MERITOR SITE (UT TO CANE CREEK) HENDERSON COUNTY, NC

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The following Restoration Plan was developed by HDR Engineering, Inc of the Carolinas and utilized Joel Johnson Land Surveying, Inc. for the existing reach topographic survey.

EXECUTIVE SUMMARY

The project site is located in the northern extents of Henderson County, near the Town of Fletcher, North Carolina (Figure 1). The 93-acre restoration property tract is owned by the Town of Fletcher and is located approximately 500 feet to the west of US 25 and along the north side of Rockwell Drive within the 100-year floodplain of Cane Creek, which drains to the French Broad River (Figure 2). The site can be reached by taking US 25 north from Hendersonville or south from Asheville and turning west on Rockwell Drive. A gravel road provides access into the tract along the southwest perimeter of the site and crosses the Unnamed Tributary (UT) to Cane Creek at a culvert crossing (see Figure 3).

Cane Creek is a North Carolina Class C stream that is listed upstream of US 25 as impaired on the 303(d) list for North Carolina (NCDWQ 2005). In addition, the smaller 1st and 2nd order tributaries to Cane Creek targeted for restoration work in this report drain lands with significant non-point source impacts to water quality from agriculture, industrial/commercial development, and historical clay strip mining. The tract borders approximately 3,500 feet of Cane Creek, contains approximately 3,400 linear feet of unnamed jurisdictional tributaries to Cane Creek, and includes approximately 5,000 linear feet of agricultural drainage ditches. The unnamed jurisdictional tributaries are all channelized and represent the primary targets for restoration work (the 2nd order tributary running east-west is referred to as the Main Stem, the 1st order tributary running north-south into the Main Stem is called the Tributary). In addition, the restoration will promote and enhance floodplain detention with the restoration of approximately 6.34 acres of bottomland forest wetland habitat (no jurisdictional wetlands currently exist onsite).

In the upper portion of the Main Stem of UT to Cane Creek, approximately 1,520 linear feet of the channelized reach will be restored to a natural planform resulting in an increased length of approximately 1,894 linear feet of meandering C/E-type stream. This Priority II restoration strategy includes building a bankfull bench (ranging from 12 to 15 feet in width) along each side of a meandering channel to the stream's confluence with the Tributary. The bankfull bench will slope up at an 8:1 slope in order to reduce the amount of cut for the entire project. A Priority II restoration approach will also be employed to build a floodplain bench ranging from 13 to 17 feet in width along the Main Stem from the confluence with the Tributary to the confluence with Cane Creek (currently approximately 1,320 linear feet). This 1,802 linear foot designed reach will also be a meandering C/E-type channel that must tie into the current elevation of Cane Creek. The various tributaries to the UT will be approached in two ways: two ditches will be plugged or rerouted to help restore the hydrology of two onsite, currently non-jurisdictional wetlands (approximately 6.34 acres), and the Tributary (a small, 1st order, perennial channelized reach approximately 550 linear feet) will be restored to create approximately 648 linear feet of meandering channel using a Priority II approach (see Table 1).

The goal of this restoration project is to improve local water quality and restore aquatic and riparian habitat. The objectives of the Restoration Project focus on restoring approximately 2,840 linear feet of a degraded section of UT to Cane Creek and 550 linear feet of an associated tributary to stable 3,700 and 648 linear foot channels using natural channel restoration methodologies as well as reestablishing hydrology and hydrophytic vegetation to 6.34 acres of historical wetlands. 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;
- Enhancing the capacity of the stream system, by building a bankfull bench and restoring wetlands for attenuation and water quality benefits; and
- Reestablishing the floodplain connectivity by creating the floodplain bench at existing elevations.

The proposed benefits from the stream and floodplain restoration include water quality improvement, habitat enhancement and restoration, stream stability, and opportunities for education. These benefits are individually discussed below:

- **Water Quality –** The primary water quality improvement goal of this restoration effort will be to restore natural stream morphologies that will promote long-term stability and thus potentially improve downstream water quality and biological conditions. Secondly, the restoration plan is proposed to restore floodplain and bottomland wetland habitat areas adjacent to the streams. The proposed improvements in the floodplain will promote water quality goals by three means: a) enhance groundwater storage that augments baseflow and interstorm stream water quality, b) intercept and treat overland storm runoff from the adjacent farm and industrial properties, and c) receive overbank flow from the existing stream channels and drainage ditches, which provides additional stormwater treatment.
- **Aquatic and Wetland Habitat –** The proposed restoration plan will restore up to 6.34 acres of bottomland hardwood and approximately 3,390 linear feet of 1st and 2nd order perennial stream aquatic habitat. The combined stream and wetland restoration will provide an integrated multifunctional stream corridor that supports a robust matrix of natural habitats. Currently, 90 percent or more of the land is under row-crop agriculture with only a few feet of scrub/shrub lining the banks of the stream channels.
- **Stream Stability –** Approximately 3,400 linear feet of existing, previously-channelized 1st and 2nd order streams are available for restoration by returning them to natural Rosgen C/E-type channels to promote long-term channel stability. This restoration will attempt to reverse the impacts of the drainage ditches that currently exist on the property, decreasing downstream peak discharges, and associated bank and sediment erosion problems.
- **Education –** The Town of Fletcher has proposed to develop a recreational facility on-site, including a greenway and park with a conservation/educational component. No time table has been set for this development.

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

The project site is located in the northern extents of Henderson County, near the Town of Fletcher, North Carolina (Figure 1). The 93-acre restoration property tract is owned by the Town of Fletcher and is located approximately 500 feet to the west of US 25 and along the north side of Rockwell Drive (Figure 2). The tract lies within the 100-year floodplain of Cane Creek. The site can be reached by taking US 25 north from Hendersonville or south from Asheville and turning west on Rockwell Drive. A gravel/dirt road allows access to the tract along its southwest perimeter and crosses the Unnamed Tributary to Cane Creek Main Stem at a culvert (see Figure 3).

1.1 Directions to Project and Reference Reach Sites

To Project Site (Henderson County) From I-26: Merge onto US-25 N (US-25 Business) via Exit 44 toward FLETCHER/ MOUNTAIN HOME, go 1.3 miles and turn left onto ROCKWELL DRIVE toward the industrial park. Continue on ROCKWELL DRIVE approximately 0.4 miles, then right onto a dirt/gravel road into the farm fields.

To Orton Branch Reference Reach Site (Buncombe County) From I-26: Take Exit 37 for NC-146 (LONG SHOALS ROAD) toward SKYLAND, travel west on NC-146 for 0.5 miles, turn right onto CLAYTON ROAD for 1.3 miles, and then turn right onto NC-191 for approximately 0.2 miles. Orton Branch crosses under NC-191 and the reference reach is located to the east of the road crossing. There is a gravel pull off to park on the right side of the road.

To Unnamed Tributary (UT) to Little River Reference Reach Site (Transylvania County) From US-64/US-276 in Brevard: Continue on US-276 to the east for approximately 11 miles and then turn left onto CASCADE LAKES ROAD for 350 feet. Turn right onto REASONOVER ROAD. Continue on REASONOVER ROAD 2.8 miles to a parking area adjacent to DUPONT STATE FOREST. Once at the State Forest, take the CONSERVATION ROAD TRAIL approximately 2 miles to the BRIDAL VEIL FALLS ROAD TRAIL for approximately 0.5 miles (These trails are gated and locked; contact DuPont State Forest for vehicular access). The stream is located four hundred feet north of the parking area for Bridal Veil Falls.

1.2 USGS Hydrologic Unit Code and NC DWQ River Basin Designations

Cane Creek and its tributaries lie within the French Broad River Basin of the North Carolina Mountains Physiographic Province. This basin's 8-digit United States Geological Survey (USGS) Hydrologic Unit number is 06010105 within the North Carolina Division of Water Quality (NCDWQ) subbasin 04-03-02. The reach is ungaged, with the closest USGS gage station within the HUC at USGS Gage Station #03447687 (35°25.73' N, 82°33.17'), located on the French Broad River just upstream of the Cane Creek confluence, near Fletcher, North Carolina.

1.3 Project Vicinity Map

Figure 1 shows the location of the site, southwest of Asheville near the Town of Fletcher, and Figure 2 shows the site's location on the Skyland quadrangle. Rockwell Drive is a two lane road to access an industrial complex just to the south of the project site. A dirt/gravel road on the right provides access to the site and parking.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The watershed area for the unnamed tributaries to Cane Creek (Main Stem and Tributary) is shown in Figure 4. The Main Stem, above the confluence with the Tributary, drains an approximate 0.75-square mile watershed to the southeast and the Tributary drains approximately 0.32 square miles to the south.

2.2 Surface Water Classification / Water Quality

NCDWQ assigns surface water classifications in order to help protect, maintain, and preserve water quality. The water quality of unnamed tributaries to Cane Creek on the restoration tract is not rated in the *Draft* French Broad River Basinwide Water Quality Plan (Basinwide Plan) (NCDWQ 2005). However, east (upstream) of the project area, Cane Creek is currently rated as impaired from Ashworth Creek to Cushion Branch (9.6 miles), which is based on a “Fair” bioclassification and indication of declining trends macroinvertibrate data collected just upstream from the SR1006 crossing, at macroinvertibrate sampling point B-6. From Cushion Branch to the French Broad River (2.4 miles), the stream is rated as supporting due to a “Good” bioclassification at fish sampling point F-3. The tributaries to Cane Creek contribute to the area that is classified as supporting at this time. As outlined in the Basinwide Plan, Cane Creek has been identified by NCEEP as one of 28 local watersheds in the basin with the greatest need and opportunity for stream and wetland restoration efforts. The restoration work proposed herein follows this identified set of needs and opportunities.

2.3 Physiography, Geology, and Soils

The site lies within the Brevard Fault Zone of the North Carolina Mountains Physiography Province. Geologic maps are available at the 1:24,000 scale for both the Skyland and Fruitland USGS 6.5 min. quadrangles that bracket the restoration site (Lemmons and Dunn 1973; Dabbagh and McDaniel 1981). There are three aspects of the geology of the area that are relevant to the restoration effort. First, the entirety of the restoration tract is located within unconsolidated Quaternary Alluvium (poorly to well sorted stream deposits of gravel, sand, silt, and clay) that are highly erodible, with little to no cohesive strengths. Second, the maps indicate that most of the watershed areas are located within the Brevard Fault Zone, a zone of highly sheared and recrystallized rocks that are more erodible than the surrounding protolith metamorphic assemblages and which generally produce clay rich soils upon weathering. The broad lowlands within the central-northeast trending corridor of Cane Creek trace out these more erodible units within the fault zone. Thus, in some respects, the streams within the lower elevation areas are comparable to streams within the North Carolina Piedmont Province. Third, within the lower portions of the Skyland quadrangle, between Fletcher and Hendersonville, there is a historical area of clay strip mining that lies within the catchment areas for the two unnamed tributaries included in this restoration project.

According to the Soil Survey of Henderson County (King 1980), the predominant soil groups found within the contributing watershed include Comus, Kinkora, and Codorus (see Figure 3). Kinkora is listed as a hydric soil for the county, and Codorus is listed as having hydric inclusions of Toxaway and Hatboro soils (Gregory 2004).

Comus soils (Coarse-loamy, mixed, active, mesic Fluventic Dystrudepts) consist of very deep, well drained soils on floodplains. They formed in recent alluvium and are high in mica. These soils are well drained and permeability is moderate in the solum and moderate to moderately rapid in the 2C horizon. Slopes range from 0 to 8 percent.

Kinkora soils (Fine, mixed, semiactive, mesic Typic Endoaquults) consist of very deep, poorly drained soils that formed in old fine-textured alluvium. These soils are on nearly level to gently sloping stream terraces within the northern Piedmont Plateau and in parts of the Blue Ridge Mountains. Kinkora soils are poorly drained and permeability is slow in the solum and moderate or moderately rapid in the underlying material.

Codorus soils (Fine-loamy, mixed, active, mesic Fluvaquentic Dystrudepts) consist of very deep, moderately well drained and somewhat poorly drained soils. These soils formed in recently deposited alluvial materials derived from upland soil materials weathered from mostly metamorphic and crystalline rocks. They are on floodplains with smooth, nearly level slopes of 0 to 3 percent. These soils range from moderately well drained to somewhat poorly drained with moderate permeability (USDA 2007).

Although, no detailed geotechnical investigations have been performed, encounters with bedrock during construction are not anticipated due the channel's location on the large floodplain. No bedrock is present in the existing channel. Only small amounts of gravel and cobble from historic fluvial events were revealed when soil borings were taken during the assessment phase.

2.4 Historical Land Use and Development Trends

The land use/land cover within the overall Cane Creek watershed has been outlined within the NCDWQ Basinwide Plan for the French Broad River Basin, and is largely undeveloped (>70 percent forest land) with subordinate farm and urban lands mostly found within the lower valley floor environs. A 2006 high altitude aerial photograph (Figure 4) was interpreted to classify the land cover types in order to understand the hydrologic and stream morphologic impacts of land use and land cover changes. The results from the land cover analysis are included in Table 3. Approximately 20 percent of the Project Site watershed is undeveloped (forested) land, and the remainder is roughly an equal mix of impervious cover (roads and rooftops) and cleared pervious lands under tillage or representing pasture and lawns. Within the pervious land cover lie cleared lands with little vegetation along the southwest perimeter of the catchment area.

According to the Basinwide Plan, the French Broad River Subbasin is expected to experience the largest increase in population growth within Buncombe and Henderson Counties. Population growth in these counties is anticipated to occur around Asheville and Hendersonville. The project site is centrally located between Asheville and Hendersonville, and thus land use trends are expected to lead to additional development and further increases in impervious cover and storm water impacts within the individual watersheds.

One distinction of the tributaries located in this project is that approximately 60 percent of the watershed areas for the unnamed tributaries lie in the more developed low-lying central corridor of the Cane Creek watershed, and thus are more impacted by development than most watersheds of similar size in the region. A second distinction between these unnamed tributaries and most others of comparable watershed area in the Mountain physiographic province of North Carolina is that they fall within Rosgen E-type morphologic settings. This is due to a combination of two factors. First, these are small 1st and 2nd order streams traversing the floodplain of a much higher order stream (Cane Creek, with an 80-square mile drainage area), and second, their watersheds lie within an unusual 1- to 1.5-mile wide northeast-trending geologic belt known as the Brevard Fault Zone. The intensely deformed rocks found within this belt are less resistant to the forces of erosion, and thus on geologic time scales have produced lower elevation and more gentle topography with streams that have more of a North Carolina Piedmont character.

The project site has been under continuous agricultural production for more than 50 years. A 1951 NRCS aerial photograph was reviewed as a historical reference. At that time, the reaches were channelized in essentially the same positions they are at present. There appeared to be little or no riparian vegetation along the channels. Most of the drainage ditches that are currently present on site were also present in 1951.

2.5 Endangered / Threatened Species

A review of the North Carolina Natural Heritage Program (NHP) database was conducted to determine the presence of any 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 seven federally-listed threatened or endangered species and two species listed as Candidate (a taxon under consideration for official listing for which there is sufficient information to support listing) occurring in Henderson County, which are shown in the Table 5.

Due to the project site being significantly altered from the adjacent agricultural uses, suitable habitat is not available for the listed species. However, the restoration of this stream system could increase or create suitable habitat for some of these species in the distant future.

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 only one listing within Fletcher (NPS 2005). This historic resource (The Meadows) is located north of Fletcher on SR 1547 well outside of the project area.

2.7 Potential Constraints

2.7.1 Property Boundary and Ownership

No issues regarding boundary location or ownership are anticipated for this project. The 93-acre project tract lies within the 100-year floodplain of Cane Creek. It is located on a parcel owned by the Town of Fletcher, which has plans to use the land in the future as a greenway/park.

2.7.2 Site Access

Site access is not an issue as road infrastructure is adequate to support temporary access for construction from Rockwell Road.

2.7.3 Utilities

A NPDES-permitted wastewater discharge outfall from Fletcher Warehousing (formerly Cranston Print Works) runs along the Main Stem within the tract. The location of this line is shown on Existing Conditions Sheet 1. The majority of the stream restoration moves the channel laterally away from the existing line, with sufficient offset to allow for a 30-foot wide conservation buffer. In addition, the existing line is a 24” clay pipe which has numerous holes in it across the field and, according to our conversations with EEP and Town staff, is no longer actively producing treated wastewater from the permitted facility.

The preferred alternative for this restoration would be to take the outfall pipe out of service at the upper reaches of the project and discharge it into a created wetland; however, this alternative is not feasible as this permitted discharge may be required in the future. The current plan addresses the need to improve the pipe at a new stream crossing location, which will require replacing an 80-120 foot section of clay pipe with ductile iron pipe and necessary footings.

2.7.4 FEMA / Hydrologic Trespass

The stream restoration site is located within the 100-year floodplain of Cane Creek, as determined by the Flood Emergency Management Agency (FEMA) Detailed Study and shown on Flood Insurance Rate Map (FIRM) effective March 1, 1982 (Appendix D). No development, including stream restoration, within the regulated floodplain may impact the 100-year flood levels, and the proposed design shall follow this requirement. The "No Rise" Certificate will be prepared as required to demonstrate that the proposed stream restoration does not affect the 100-year flood levels.

The Flood Insurance Study (FIS) and FIRM were obtained in the data preparation phase. The HEC 2 model used to determine the FIS water surface elevations was requested from the FEMA's Project Library (Library). The Library provided only the hard copy of the output data (containing flows and velocities for modeled storm frequency events, see Appendix D) and does not include any physical data, such as model cross sections, structures (bridges and culverts), stream characteristics (roughness coefficients), etc.

No action with FEMA will be required for this project. A HEC-RAS analysis will be performed to ensure no increase in water surface elevations on site. The stream is not in a detailed study and the construction plans will maintain a cut-fill balance within the regulated floodplain.

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 the restoration reaches. Stream width-to-depth ratio, entrenchment ratio, slope, sinuosity, and channel material are needed to complete this Rosgen-based classification of streams. All of 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 include, but are 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

Because of artificial digging and modification of channels and ditches on site, there were few morphological characteristics to be drawn from a natural channel design standpoint. In addition to those modifications, an active population of beavers on the stream have caused ponding allowing for sediment deposition and decreased habitat.

Based on collection of the previous criteria and measurements, it was determined that the reach would be classified as a degraded or impaired G channel. G streams are single thread channels that are deeply entrenched, typically have low to moderate sinuosity, and low width to depth ratios. In stable conditions the UT to Cane Creek would most likely be a C/E stream-type which are often located in 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 near 12, and sinuosity should exceed 1.2. C/E 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 UT to Cane Creek which shows signs of past human alteration including channelization to allow for agricultural practices.

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 project reach, the following steps have been taken:

- Planform maps of the reach were created by field surveys using a total station.
- Characteristic locations for collection of cross section data were identified and then surveyed using tape, stadia rod, and transit.
- A profile of the thalweg was measured.
- A BEHI survey of the banks along of the reach was conducted to isolate areas of greatest bank instability and sediment erosion.
- A series of photographs were assembled to further document the degree of impairment along the reach. These are presented in Appendix A.

The pattern, dimensions, and profile characteristics of channels on the property were surveyed and the planform data are shown in Existing Conditions Sheets 1A, 1B, and 1C. Longitudinal profile data are shown in Existing Conditions Sheets 1D and 1E. The survey data does not yield morphologic characteristics which can be used for natural channel design purposes as the unnamed tributaries are all artificially dug or modified channels.

3.3.2 Planform

The planform and morphologic characteristics for the UT to Cane Creek restoration reach are shown in Existing Conditions Sheets 1A, 1B, and 1C and summarized in Table 4. The project reaches for the entire site are 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. Sinuosities on the unnamed tributaries on the property tract are essentially 1.0 with a few areas of minor migration off of the channelized alignments.

3.3.3 Cross Sections

All unnamed tributaries to Cane Creek are altered channels with topographic cross sections indicative of dredge operations (see Figure 4). Asymmetric spoil or dredge material build-up and V-shaped and asymmetric V/U-shaped cross sections are both indicative of track hoe or backhoe operations that have cut and maintained these channels over time.

Cross sections were derived from the survey data for all tributaries and ditches on the property tract. The bankfull dimensions for the two unnamed tributaries were used to determine the existing cross section areas for flow and to provide information to estimate existing bankfull parameters and bankfull discharges using Manning's Equation (Tables 2a, 2b, and 4). The disparities seen along the channel from one section to another, as well as disparities seen between these values and the regime estimates, indicate that channels are not in equilibrium, and for the most part are oversized for any reasonable estimates of bankfull discharges and cross section areas based on either Mountain or Piedmont regime relationships. The Tributary, for example, has dimensions approximately ten times the regime estimates, and currently operates essentially as a storm drain (Rosgen G-type) for the commercial and industrial properties on the south side of Rockwell Drive. Overall, from a dimensional perspective, the channels are not in their proper hydrologic relationship to the existing floodplain, and have inconsistent dimensions to promote sediment transport continuity or channel stability.

3.3.4 Longitudinal Profile

Longitudinal profiles are shown in Existing Conditions Sheets 1D and 1E. Longitudinal profiles were composed using the surveyed data along the Main Stem and its Tributary. The Main Stem Reach has an overall stream grade of only approximately 0.003 ft/ft (or 0.3%), and the Tributary has a grade of approximately 0.015 ft/ft (or 1.5%). The profiles have an artificial stepped character, with most of the stream bed running at grades less than 0.001 ft/ft. The longitudinal profile of the Main Stem indicates that it steps down approximately 10 feet over a run of approximately 3,000 feet. The channel is dominated by runs of sand and silt with infrequent debris-related riffle and pool areas. Lateral bars shift in an unstable pattern along the reach with no indication of perennial vegetation. Thus, the reaches have little riffle or pool habitat of any significance.

The beds of all channelized reaches were not specifically surveyed for riffle and pool areas. However, inspection at numerous points along the existing channels revealed the dominance of runs of sand and silt due to beaver dams. The dominance of sand and silt as the primary bed materials, along with the artificial nature of the channels, did not justify additional quantitative grain size research work within the reach, particularly as design constraints could not be derived from the data.

3.4 Channel Stability Assessment

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)). Approximately 3,000 linear feet of stream was assessed. BEHI ratings were recorded after a change in stream variables, near bank stress, or bank height. These streambank variables included: bank height ratio (stream bank height/maximum bankfull depth), ratio of rooting depth/bank height, rooting density, percent surface area of bank protected, bank angle, number and location of various soil composition layers in the bank, and bank material composition. (Rosgen 1999). The resulting values for the restoration reach were initially ranked into eight levels of erodibility and these results are presented in Appendix B.

Bank Erosion Hazard Index scores ranged from 10 to 40 (on an overall scale of 0 to 50), indicating a low to very high potential for continued bank erosion and channel widening across the entire project reach (Table 6). Additionally, sediment supply is high from severely eroding banks. These areas were mostly located where the channel is constricted and outside of meander bends. 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.

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 degraded reach had many obstacles resulting in potentially inaccurate bankfull identification, thus the bankfull discharges were based on the best available analysis, including Regional Curves and Manning's Equation.

3.5.1 USGS Gage Data

When available, USGS gage data can be used to estimate the discharges based on flow data for certain storm recurrence intervals for a particular stream. However, no USGS gage stations are located along Cane Creek or any of its tributaries; the closest gage station is located on the French Broad River, which is a much larger watershed system. No USGS gage stations exist in the region for comparable waters to the unnamed tributaries that are the focus of the proposed restoration efforts. Thus, the use of USGS gage data for this project is not appropriate.

3.5.2 North Carolina Regime Analysis

A second method of determining the likely dominant (channel forming) discharges in a given setting of North Carolina requires use of "regime" relationships determined by analysis of streams that have good bankfull morphologic indicators as well as USGS gage data. This analysis has been performed for both the North Carolina Mountains and Piedmont physiographic provinces (Harmon et al. 1999). Both sets of relationships appear to be relevant to the proposed restoration. While climatic factors at the project site are clearly linked most closely to the Mountain Province; land use, geology and topography of the site have significant parallels with the North Carolina Piedmont Province. Thus, both sets of regime equations are useful to gain a perspective on bankfull discharge and dimension characteristics. Harmon and others (1999) have generated the following set of relationships:

Piedmont Rural Streams (feet and mi^2)

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

Mountain Rural Streams (feet and mi^2)

$A_{bkf} = 21.61 A_w^{0.68}$
$Q_{bkf} = 100.64 A_w^{0.76}$
$W_{bkf} = 19.05 A_w^{0.37}$
$D_{bkf} = 1.1 A_w^{0.31}$

In these equations,

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

The stream drainage areas pertaining to this project are shown in Figure 3 and tabulated in Table 2a. Both the Piedmont and Mountain province estimates for A_{bkf}, Q_{bkf}, W_{bkf}, and D_{bkf} are listed in Table 2c. In addition, data for two Rosgen E-type reference reaches (found to be comparable to the unnamed tributaries to be restored) is also listed in Table 2a for comparison purposes. The regime data indicates that bankfull discharges are somewhat higher for the Mountain province in comparison to the Piedmont. This is primarily a function of the steeper topography and the tendency in the Mountains for small watersheds to be Rosgen A- to B-type streams, whereas in the Piedmont they would more typically be C with subordinate B- and E-types. In the case of the tributaries to Cane Creek on the restoration tract, the streams are in E-type settings, with limited upper catchment areas of steeper topography (that could substantially shift rainfall-runoff relationship to more mountain-like conditions). Thus, Piedmont regime results appear more appropriate to the project site. As an example, stream gradients along the Main Stem tributary are only 0.003 ft/ft, and thus more typical of Piedmont valley conditions. Table 2c illustrates that our design compared to the Piedmont Regional Curves are within 11% on the Upper Reach, 6% on the Lower Reach, and 4% on the Tributary.

3.5.3 Manning's Equation-Based Estimation of Bankfull Discharge

Detailed topographic mapping has been performed on the project site with careful attention to channel geometry. From this data a series of cross sections were prepared to represent the range of expected design hydrologic conditions. As all channels are modified, no natural significance can be ascribed to the top of bank. Bankfull estimates derived from the existing survey data only represent maximum channel discharge capacities and have little to no bearing on what a natural or equilibrium discharge would likely be in a comparable natural channel setting. However, the estimated cross-sectional areas, wetted perimeters, and channel slope, combined with estimates of the Manning's roughness coefficients, provide input parameters for discharge calculation at each cross section using the Manning's equation. The input parameters and calculated results are presented in Tables 2a and 2b. The estimate of Manning's roughness coefficients is subjective and brings some ambiguity into these calculations. To reflect reasonable variation of these parameters within the studied stream reaches, two values of roughness coefficient (0.03 and 0.04) were used to calculate a range of discharge values. The resulting range of discharges for each stream is shown in Table 2b wherein values determined using the regime relationships are also shown for comparison. The disparities in the regime and Manning-based estimates underscore the artificial nature of the existing channels at the site. They also underscore the extent to which these channels have been basically converted to storm discharge channels with flows largely contained within the channels and out of a natural balance with normal floodplain function.

3.6 Vegetation

The project site is predominantly agricultural land with a limited riparian buffer along the streams. The riparian areas ranged from relatively disturbed to very disturbed. The floodplain buffer along the stream has canopy species consisting of black walnut (*Juglans nigra*), box elder (*Acer negundo*), black willow (*Salix nigra*), sycamore (*Platanus occidentalis*), river birch (*Betula nigra*) and hickories (*Carya* spp.). Sub-canopy and shrub layers consisted of box elder, black willow, elderberry (*Sambucus canadensis*), viburnums (*Viburnum* spp.), multi-flora rose (*Rosa multiflora*), blackberry (*Rubus* spp.), and privet (*Ligustrum sinese*). Herbaceous and vines species included poison ivy (*Toxicodendron radicans*), Japanese honeysuckle (*Lonicera japonica*), pokeweed (*Phytolacca americana*), asters (*Aster* spp.), cockleburs (*Xanthium* spp.), wingstem (*Verbesina alternifolia*), golden rods (*Solidago* spp.), foxtail (*Setaria* spp.), Johnson grass (*Sorghum halepense*), barnyard grass (*Echinochloa muricata*), fescue (*Festuca* spp.) and other grasses.

4.0 REFERENCE STREAMS

The regional topography, valley slope, and cross sections surveyed along the UT to Cane Creek restoration reach indicate that the reach 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 general 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 C/E-type channel would be suitable for the site conditions with width/depth ratio between 10 and 12 and sinuosity between 1.2 and 1.5.

Two reference reaches were located for use in designing the plan for UT to Cane Creek. The first reference reach was located southwest of Asheville, NC (Buncombe County) and will be referred to as Orton Branch. The second reference reach site is located east of Brevard, NC (Transylvania County) and will be referred to as UT to Little River. 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 UT to Cane Creek). Photographs of the reference reaches are included in Appendices C and D.

4.1 Watershed Characterization

4.1.1 Orton Branch

The Orton 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 and low-density residential. The Blue Ridge Parkway and NC-191 are within the Orton Branch watershed. Soils within the watershed are shown in Figure 8a, with the reference reach itself lying within a floodplain corridor of Iotla loam soils. Iotla loams (Coarse-loamy, mixed, active, mesic Fluvaquentic Dystrudepts) consist of very deep, somewhat poorly drained, moderately permeable soils on nearly level floodplains of the Southern Blue Ridge Mountains (USDA 2007). The Orton Branch restoration reach lies within the Muscovite-Biotite Gneiss geologic formation, described as locally sulfidic, interlayered and gradational with mica schist, minor amphibolite, and horneblende gneiss (Sedimentary & Metamorphic Rock in the Blue Ridge Belt).

4.1.2 UT to Little River

The UT to Little River watershed and its hydrologic features are shown in Figure 7b. The watershed is dominated (over 90% forested) by wooded parkland owned by the State as part of DuPont State Forest. The human disturbances to the watershed include trails associated with the State Forest, power lines, and a landing strip. Soils of the watershed are shown in Figure 8b, with the reference reach lying within a stream corridor of Roanoke silt loam soils. Roanoke silt loams (Fine, mixed, semiactive, thermic Typic Endoaquults) consist of very deep, poorly drained, slowly permeable soils formed from fluvial sediments (USDA 2007). The reference reach lies within the Caesars Head Granite Gneiss geologic formation, described as Equigranular to porphyritic, massive to well foliated, and containing biotite and muscovite (Intrusive Rock in the Inner Piedmont).

4.2 Channel Classification

4.2.1 Orton Branch

Based on the data summarized in Table 4, the Orton Branch reference reach is a Rosgen Type C/E4 stream. This reach was very close to the stream type proposed for UT to Cane creek with the appropriate width/depth ratio but lacking the sinuosity. The alluvial floodplain setting, proximity of bankfull to current true top of bank, entrenchment ratios, and low stream slopes support a C/E channel classification. The reach is located just downstream from the Orton Branch crossing of NC-191 (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 Little River

Based on the data summarized in Table 4, the UT to Little River reference reach is an E4-type stream. The alluvial floodplain setting, proximity of bankfull at top of bank, entrenchment ratios, sinuosity, and low stream slopes support an E channel classification for this stream. The reach is located within DuPont State Forest, approximately 400 feet upstream of its confluence with the Little River and Bridal Veil Falls (Figure 7b). The stream is not classified by NCDWQ; however, the Little River is classified 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 backs of benches, scour lines, and vegetative indicators just inside the top of bank for Orton Branch and top of bank for UT to Little River.

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, measuring over 300 feet at Orton Branch and over 250 feet at the UT to Little River. Values derived from the profiles 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 B and C 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 300 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 Orton Branch reach ranged from low to moderate (Table 7). The average BEHI values along the left and right banks of the UT to Little River reach were very low to moderate with the majority of the reach being low (Table 8). Overall the reference stream reaches have 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 Orton Branch and UT to Little River reference reaches 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 Orton Branch

The floodplain forest along Orton Branch contains species indicative of a Piedmont/Mountain Bottomland Forest or a Piedmont/Mountain Alluvial Forest (Schafale and Weakley 1990). The dominant species in the project area have canopy and sub-canopy woody species consisting of sycamore, red maple (*Acer rubrum*), ironwood (*Carpinus caroliniana*), spice bush (*Lindera benzoin*), and privet. Herbaceous and vine species consisted of poison ivy, jewelweed (*Impatiens capensis*), false nettle (*Boehmeria cylindrica*), asters, smartweeds (*Polygonum* spp.), microstegium (*Microstegium vimineum*), New York fern (*Thelypteris noveboracensis*) and wood ferns (*Dryopteris* spp.).

4.7.2 UT to Little River

The riparian corridor for the UT to Little River reference reach contains species indicative of a Swamp Forest/Bog Complex that grades into a Montane Alluvial Forest upslope of the stream (Schafale and Weakley 1990). The floodplain forest has plant species consisting of red maple, alders (*Alnus* spp.), American holly (*Ilex opaca*), viburnums, rhododendrons (*Rhododendron* spp.), fetterbush (*Leucothoe fontanesiana*), royal fern (*Osmunda regalis*), wood ferns, cinnamon fern (*Osmunda cinnamomea*), ladyfern (*Athyrium filix-femina ssp. Asplenioides*), rushes, false nettle, and slender spike grass.

The wetlands along the UT to Little River were located in the floodplain. Vegetation of the bog wetlands consists of boneset (*Eupatorium perfoliatum*), tearthumb (*Polygonum sagittatum*), smartweeds, asters, sphagnum moss (*Sphagnum* spp.), sedges (*Carex* spp.), arrowhead (*Sagittaria* spp.), bur reed (*Sparganium* spp.), royal fern, and Virginia chain fern (*Woodwardia virginica*).

5.0 PROJECT SITE WETLANDS

5.1 Jurisdictional Wetlands

Currently there are no jurisdictional wetlands within the project site. The area is and has been farmed for over 50 years. Ditches across the site have effectively drained the areas which have shown indications of being hydric in the past, based on information from the County Soil Survey and aerial photographs.

5.2 Hydrological Characterization

Monitoring wells were installed on site on September 9, 2007. The data collected from those wells are included in Appendix F (AW - automated gauged wells; MW – manually gauged wells). The information noted in the areas presumed to have been hydric in the past indicates that the water table ranges from approximately 0.7 to 37 inches below the surface. It should be noted that this has been a severe drought year; the rainfall for the area is approximately 0.09 inches above average for the month of September, but is 9.11 inches below average for the 2007 calendar year (State Climate Office of North Carolina 2007). Also, during field investigation, ponding was observed on the surface of the site and around the monitoring wells during and after rain events. The data in Appendix F shows that across the site the groundwater has increased overall and, during and after rain events, there are spikes of high levels of groundwater in shallow soils.

5.3 Soil Characterization

Soils on the project site show indications of being hydric prior to conversion. Kinkora is listed as a hydric soil for the county, and Codorus is listed as having hydric inclusions of Toxaway and Hatboro soils (See Figure 3). However, these soils currently do not support hydrophytic vegetation or show signs of being saturated in the upper 12 inches. While installing the wells and augering additional soil borings across the site, it was noted that hydric characteristics are present at most locations immediately below the plow zone (>12 inches below the surface), except adjacent to the existing ditches where drawdown occurs.

5.4 Plant Community Characterization

The plant community for the areas proposed for wetland restoration is currently farmed in row crops, most recently corn. Due to the conversion to farmlands, a native plant community characterization for the area can not be developed. In Spring 2007, some rushes were present in portions of the field, before the drought conditions worsened and the corn crop began to flourish.

6.0 REFERENCE WETLANDS

Reference wetlands are natural wetland systems that can be used as design templates for the proposed wetland creation practices. These sites should fall in the same ecological and physiographic region as the project site. Topography, hydrological and soil characteristics along with vegetative community descriptions collected from the reference wetland sites provide essential information that can be used in the wetland design.

Two potential reference wetlands were located within a mile of the project site. These wetlands are floodplain depressions and were classified using the jurisdictional definition detailed in the United States Army Corps of Engineers (USACE) Wetland Delineation Manual (USACE 1987). The sites met the soil, vegetative, hydrologic criteria used to identify wetlands. These criteria are described in the sections that follow.

6.1 Hydrologic Characterization

The hydrology of the reference wetland sites is typical of those located in alluvial systems. These floodplain depressions are hydrologically controlled by groundwater water levels, runoff from adjacent uplands, and overbank flooding. Field hydrologic indicators consisted of drainage patterns in wetlands, oxidized root channels, and water marks on woody vegetation. No standing water was present during our site visit. This is most likely due to extreme drought conditions this region has been experiencing.

6.2 Soil Characterization

To determine the extent of hydric soils at the reference sites, soil types and profiles were researched using on-site evaluations along with Natural Resources Conservation Service (NRCS) soil survey data for Henderson County. On-site soil samples within the reference wetlands exhibited hydric soil field indicators, particularly a depleted matrix with a chroma of two or less with many distinct redox concentrations. Soil textures ranged from silt clay loam to clay loam. According to the Henderson County Soil Survey, there are three general soil types found within the reference wetland boundaries. These include Codorus loam, Comus fine loam, and Kinkora loam. Codorus and Kinkora series are listed on the NRCS National Hydric Soils List. A description of each soil type was presented in Section 2.3.

6.3 Plant Community Characterization

Reference wetland plant communities were dominated by various bottomland species. General descriptions of the wetland plant communities are below including the wetlands adjacent to the UT to Little River Reference Reach.

<u>Reference Wetland #1</u>

This wetland is located southwest of the Fletcher restoration project and consisted of few tree species, but included green ash (*Fraxinus pennsylvanica*), black willow (*Salix nigra*) and box elder (*Acer negundo*). Herbaceous species included jewelweed (*Impatiens capensis*), hop sedge (*Carex lupulina*), wool grass (*Scirpus cyperinus*), tearthumb (*Polygonum sagittatum*), soft rush (*Juncus effusus*), microstegium, and slender spike grass (*Chasmanthium laxum*).

Reference Wetland #2

This forested wetland is located in the floodplain north of Cane Creek. Canopy and sub-canopy species consisted of box elder, river birch (*Betula nigra*), elderberry (*Sambucus canadensis*), viburnums (*Viburnum* spp.), and multi-flora rose (*Rosa multiflora*). Few herbaceous and vine species included poison ivy (*Toxicodendron radicans*) and smartweeds (*Polygonum* spp.).

7.0 PROJECT SITE RESTORATION PLAN

7.1 Restoration Project Goals and Objectives

Upstream from US 25, Cane Creek is categorized as a North Carolina Class C stream that is listed as impaired on the USEPA CWA 303(d) list for North Carolina (NCDWQ 2005). UT to Cane Creek as well as its smaller 1st and 2nd order tributaries drain lands with significant impact to water quality from agriculture, industrial/commercial development, and historic clay strip mining. These unnamed jurisdictional tributaries are all channelized and represent primary targets for restoration work within the Cane Creek Watershed. The drainage area for UT to Cane Creek and its tributaries is approximately 1.07 square miles with the Main Stem of draining approximately 0.75 square miles to the southeast and the Tributary to the Main Stem draining approximately 0.32 square miles to the south (See Figure 5). In addition to the approximate 3,400 linear feet of the Main Stem and Tributary, there are approximately 5,000 linear feet of agricultural drainage ditches on the project site.

This restoration project aims to restore a ditched and degraded section of UT to Cane Creek, as well as its Tributary, to a stable channel using natural channel restoration methodologies. This natural channel restoration will consist of a Priority II restoration that will include a bankfull bench to allow for flood attenuation before reconnecting to the natural floodplain. Approximately 3700 linear feet of meandering C/E-type is proposed for the UT to Cane Creek restoration plus 650 linear feet of the Tributary to the Main Stem. A Priority I restoration reconnecting the existing channel to its natural floodplain was preferred for this restoration. However, given the moderately high incised banks at the downstream confluence with Cane Creek and the general low-gradient of the existing channel, this preferred alternative could not be achieved.

The goals and objectives of the UT to Cane Creek 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;
- Enhancing the capacity of the stream system, by building a bankfull bench and restoring wetlands for attenuation and water quality benefits; and
- Reestablishing the floodplain connectivity by creating the floodplain bench at existing elevations.

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 3,400 linear feet of a degraded section of UT to Cane Creek to a stable channel using natural channel restoration methodologies.

7.1.1.a Main Stem, from eastern project boundary to Confluence with Cane Creek

The proposed upper reach of the Main Stem will extend 1,894 linear feet from the eastern project boundary downstream to where the Tributary ties into the Main Stem. From the Tributary tie-in extending downstream to Cane Creek, the lower portion of the Main Stem will encompass a proposed 1,802 linear feet of restored stream.

The existing reach in this section is located among agricultural land-use has been channelized and used primarily as an agricultural drainage ditch. Because of its historic use, the reach contains very few natural channel morphological characteristics. The Town of Fletcher owns the adjacent agricultural fields and has set aside the land to construct the Main Stem south of the existing channel in the upper reach and north of the existing channel in the lower reach. The restored stream will contain an 8:1 slope extending from the bankfull elevation to an elevation and distance that will achieve a floodprone width sufficient for an entrenchment ratio of 3. In some areas, mainly on the upper reach, the 8:1 low inclined slope is able to reach and connect with the natural floodplain. In other areas, primarily the lower reach and the bottom portion of the upper reach, the correct floodprone width is achieved and a side slope of 3:1 is used to connect to the natural floodplain. The design typical sections are shown in Design Sheet 2a.

The proposed C/E-type stream along the Main Stem will provide a meandering pattern with sinuosities of 1.21 and 1.24 in the upper and lower reaches, respectively. Given the natural low gradient of the existing stream, efforts to keep the average slope low restricted the achievement of greater proposed sinuosity. A minimum conservation buffer of 30 feet off the bankfull stage on each side of the stream corridor is provided. This buffer includes 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 conservation buffer will be replanted in any areas disturbed by restoration activities with a mix of appropriate species.

The proposed new alignment for UT to Cane Creek and some of the proposed restoration implementations to be incorporated into the new channel are presented in Design Sheets 2B, 2C, and 2D. In-stream structures will be used to protect banks by directing water away from the banks. The use of cross vanes and single arm vanes will provide grade control as well as direct maximum velocity vectors away from bank areas.

The Priority II restoration along this segment of UT to Cane Creek will result in three primary benefits. The restoration will result in the removal of approximately 2,840 linear feet of ditched stream and unstable banks. Next, the creation of a stable C/E-type channel in this area will allow attenuation of higher storm flows, which will lessen stress and potential bank erosion. Last, restoration of improved riffle and pool bed structure within the reach should enhance aquatic habitat in the reach, and have secondary ecological benefits for upstream and downstream areas.

The restoration of the longitudinal profile and channel dimension of upper and lower reaches of UT to Cane Creek is shown in Design Sheets 3A-3C (longitudinal profiles) and Design Sheet 2A (typical sections). These elements were designed utilizing the data from the reference reaches and aimed toward restoring natural functions to the reach.

7.1.1.b Tributary, from Rockwell Road to Confluence with Main Stem

Much like the Main Stem of UT to Cane Creek, the Tributary has been historically ditched and straightened for agricultural use. The restored Tributary will be a C/E-type stream with appropriate channel dimensions and channel sinuosity. The proposed stream will extend approximately 648 linear feet from the culvert under Rockwell Road to the confluence with the Main Stem of UT to Cane Creek. It will have a sinuosity of approximately 1.22. Also, as shown in Design Sheet 2A (typical sections), the Tributary will contain an upward sloping bench on a low incline connecting the bankfull elevation to the natural floodplain where possible.

The Tributary will also contain in-stream structures such as cross vanes and single arm vanes that will provide grade control as well as protecting bank areas. Step drop structures will be incorporated to provide an acceptable average slope while meeting elevations set by the upstream culvert under Rockwell Road and downstream tie-in with the Main Stem. The resulting Priority II restoration in this segment will have the same benefits of the Main Stem in that the new channel will provide flood attenuation and improved riffle and pool sequence to enhance habitat.

7.1.1.c Wetland Areas along UT to Cane Creek and its Tributary

Three wetland areas totaling 6.34 acres are proposed along the UT to Cane Creek Main Stem. Two wetland areas will be approximately 5.5 acres of bottomland hardwood forest to the south of the Main Stem Reach. This area is to help aid in floodplain detention and restore an area that shows indications of having effectively drained wetlands. In addition, the restoration will restore approximately 0.84 acres of bottomland forest to the north of the downstream portion of the Main Stem. The intention of this wetland is to assist with the flows of the ditch across the field by reducing stormwater velocities and nutrient loading that may discharge into the stream from the previous agricultural activities.

7.1.2 Target Buffer Communities

Restoration for the UT to Cane Creek 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 three different zones (Stream Bank, Floodplain, and Bottomland Wetlands). 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:

$$\tau = \gamma R s$$

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 Appendix G.

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 Henderson County (Preliminary Flood Insurance Rate Map (FIRM) Number 3700965200J – May 21, 2007, See Appendix E), the portion of UT to Cane Creek that comprises this project is not a detailed studied stream. The UT to Cane Creek project lies within the Cane Creek floodplain which is a FEMA-regulated stream with determined base flood (100-year water surface) elevations (Zone AE). The construction on UT to Cane Creek and its Tributary will not affect the base flood elevations for Cane Creek.

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 D. 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 Priority II stream restoration and wetland restoration/creation project does not require raising the current water surface elevation but may require elevating groundwater for success of the wetlands. However, the project is located entirely on lands owned by the Town of Fletcher and should not create any hydrologic trespass beyond the boundaries of the property.

7.4 Stormwater Best Management Practices – not relevant to this restoration plan

7.5 Hydrologic Modifications

This year, 2007, has been a difficult year to assess normal groundwater elevations, as the drought that has persisted (and worsened significantly) through the Summer and Fall has caused groundwater levels to fall severely. The monitoring well data has shown that the clayey subsoils on-site temporarily store rainfall and floodwaters near the surface, and allow for very slow infiltration rates. Based on the existing soil and groundwater data, it is anticipated that normal groundwater elevations occur within 18 to 24 inches of the ground surface. By filling portions of the affected agricultural ditches and grading the areas to create shallow depressional wetlands, we anticipate modifying the hydrologic conditions on-site to restore wetlands to the aforementioned areas. The bottomland wetland south of the Main Stem would be dominated by saturated conditions, with short periods of inundation due to overbank flooding or heavy rainfall with slow infiltration. The bottomland wetland north of the Main Stem will likely be saturated, but this will be somewhat dependent on the flows produced from the ditch flowing off of the agricultural field. A small berm (approximately 1 foot higher than the proposed wetland elevation) will be created to help store surface water within the wetlands and direct high flows to floodplain interceptors, where the flows can safely pass into the restored stream channel.

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. Wetlands proposed onsite are planned for areas in which the soils show indications of being hydric prior to conversion to farmlands and are mapped on the soil surveys as hydric soils or soils with hydric inclusions. Grading activities will stockpile topsoil for reuse in areas where necessary to assist with plantings, provide the proper permeability, and if excess soil is available it will be used for backfill of the existing channel. Where needed, the final soils will be amended to provide adequate fertility. In addition, some select material will be used as needed inside the channel for channel plugs.

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 UT to Cane Creek 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 three (3) different zones as follows:

1. Stream Bank
2. Floodplain Bench (Alluvial Forest)
3. Wetland (Bottomland Forest)

Table 9A provides an alphabetical list of the species, with columns noting the potential habitats for each species. Table 9B provides proposed plant spacing for the three communities 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. The target communities were based off of what is known to typically exist is this geographic location as well as what was found adjacent to Cane Creek and the reference wetlands.

Although few opportunities exist to transplant existing stems for re-vegetation, those suitable as transplants 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 and herb mix that may include: bushy beard grass (*Andropogon glomeratus*), broomsedge (*Andropogon virginicus*), Carex sp. (*Carex lupulina*), soft rush (*Juncus effusus*), switchgrass (*Panicum virgatum*), woolgrass (*Scirpus cyperinus*), rice cutgrass (*Leersia oryzoides*), cardinal flower (*Lobelia cardinalis*), boneset (*Eupatorium perfoliatum*), swamp milkweed (*Asclepias incarnate*), and ironweed (*Vernonia noveboracensis*). 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 dogwood (*Cornus amomum*), ninebark (*Physocarpus opulifolius*), and black willow (*Salix nigra*). 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 floodplain bench will be enhanced with the addition of plugs, bare root seedlings, or containerized plants consisting of boxelder (*Acer negundo*), red maple (*Acer rubrum*), tag alder (*Alnus serrulata*), green ash (*Fraxinus pensylvanica*), pawpaw (*Asimina triloba*), spicebush (*Lindera benzoin*), etc. to the list of stream bank species (See Table 9a for the full species listing). 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 pawpaw, spicebush, and sweet-shrub (*Calycanthus floridus*) into groupings along the bench, the different characteristics of the species can become more evident.

The Bottomland Wetland will be planted with bare root and container trees and shrubs, reflecting a mixture of species, such as red maple, ironwood, bitternut hickory, alternate leaf dogwood, witch hazel, sweetgum, tulip poplar, and black walnut. Shrubs, as plugs or containerized, include pawpaw, sweet-shrub, Virginia willow (*Itea virginica*) and strawberry bush (*Euonymus americana*) to provide increased diversity.

The benefits of these wetlands adjacent to the stream channel 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 are scattered along the project site in the narrow riparian corridor. Multiflora rose (*Rosa multiflora*) is found throughout the project corridor and Chinese privet (*Ligustrum sinense*) is located most abundantly in the lower section of the Main Stem reach. Although these are currently the two invasives noted along the site, previously undetected invasive species may occur following the disturbance from construction and the exposure of a remixed seed bank. An example of this may be microstegium, which is often found in dense populations along riparian corridors.

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 320 feet of Main Stem and 180 feet of Tributary). Six monitoring sections should be established for the Main Stem above the confluence and six sections below the confluence. Three monitoring sections should be established for the Tributary.

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 subsequent 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

Wetland monitoring will include vegetation, soils and groundwater observations. Groundwater monitoring wells are currently in place (3 automated wells and 3 manual wells). Depending on final wetland elevations and proposed grading activities, these wells are likely to be removed prior to construction and replaced after construction is completed. Wetland hydrology will be monitored to demonstrate improvements in the number of days of saturated soil conditions in the upper 12 inches during the growing season and/or the frequency of overbank flooding. A rain gauge will be installed if needed; however, two State Climate Center weather stations are located within 3 miles of the project site that both provide hourly data retrieval. In addition, anaerobic wetland soil conditions may be demonstrated by monitoring soil redox values within the wetland restoration areas. Vegetation monitoring is detailed in Section 8.4 below.

8.4 Vegetation

Native vegetation will be planted using species determined by local knowledge and a local reference site. Survival of vegetation within the wetlands and riparian buffers will be evaluated using the CVS/EEP Vegetation Monitoring Protocol. We currently anticipate monitoring to Level 1 of the Protocol. 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 Condition	Designed Condition	Comments
Main Stem Upper Reach	From the Northeast property line to the confluence with the Tributary	Priority II Restoration	1,520 LF	1,894 LF	Fully restores pattern, dimension and profile by excavating a new channel with an adjoining floodplain bench that grades to the existing ground elevation in order to partially restore flood prone conditions.
Main Stem Lower Reach	From the confluence with the Tributary to the confluence with Cane Creek	Priority II Restoration	1,320 LF	1,802 LF	Fully restores pattern, dimension and profile by excavating a new channel with an adjoining floodplain bench that grades to the existing ground elevation in order to partially restore flood prone conditions.
Tributary	From Rockwell Road to the confluence with the Main Stem	Priority II Restoration	550 LF	648 LF	Fully restores pattern, dimension and profile by excavating a new channel with an adjoining floodplain bench that grades to the existing ground elevation in order to partially restore flood prone conditions.
Bottomland Hardwood Forest	To the southeast and southwest of the confluence of the Main Stem with the Tributary; to the north of the Main Stem Lower Reach along the agricultural ditch	Wetland Restoration	0 acres	6.34 acres	Restores topography, hydrology, and habitats of a natural wetland system by excavating new floodplains and filling agricultural ditches to promote an increase in ground water elevation.

TABLE 2a Drainage Areas and Other Parameters

Parameter	UT to Cane Creek (Upper Main Stem)	UT to Cane Creek (Lower Main Stem)	Tributary	Orton Branch	UT to Little River
Drainage Area (mi^2)	0.75	1.1	0.32	0.54	0.51
Drainage Area (Ac)	480	704	205	345	326
Bankfull Width (ft)	11.0	20.2	16.2	13.5	9.4
Mean Bankfull Depth (ft)	2.8	2.7	2.8	1.5	1.6
Max Bankfull Depth (ft)	4.0	6.0	2.1	2.3	2.0
Width / Depth Ratio	3.9	7.5	5.8	9	5.88
Width Floodprone Area (ft)	11.0	20.2	16.2	125	200
Bankfull Area (ft^2)	30.4	55.1	45.4	20.6	15.2
Entrenchment Ratio	1.0	1.0	1.0	9.26	21.28
Average Slope (ft/ft)	0.0031	0.0031	0.0150	0.0046	0.0021
Sinuosity (K)	1.0	1.0	1.0	1.17	1.5
Rosgen Stream Type	Impaired Ditch	Impaired Ditch	Impaired Ditch	C/E4	E4

TABLE 2b Bankfull Discharges

Location	Existing Top of Bank Discharge* (cfs)	Proposed Top of Bank (Bankfull) Discharge (cfs)
UT to Cane Creek (Upper Main Stem)	90	65
UT to Cane Creek (Lower Main Stem)	235	90
UT to Cane Creek (Tributary)	385	25

*Existing discharge is calculated at top of bank of the existing incised channel.

TABLE 2c Regional Curve Comparison

Location	Design	Piedmont Regional Curve	Mountain Regional Curve
Upper Reach			
Bankfull Mean Depth (ft)	1.5	1.4	1.0
Bankfull Width (ft)	15.0	10.5	17.1
Bankfull Cross-Sectional Area (ft 2)	21.1	17.6	17.8
Bankfull Discharge (cfs)	65.0	72.4	80.9
Lower Reach			
Bankfull Mean Depth	1.7	1.5	1.1
Bankfull Width	17.0	12.4	19.7
Bankfull Cross-Sectional Area	27.1	22.9	23.1
Bankfull Discharge	90.0	95.4	108.2
Tributary			
Bankfull Mean Depth	0.9	1.0	0.8
Bankfull Width	9.0	7.3	12.5
Bankfull Cross-Sectional Area	7.6	9.9	10.0
Bankfull Discharge	25.0	24.1	42.3

TABLE 2d Stream Power and Unit Stream Power

Reach	Bankfull Width	Bankfull Discharge	Average Slope	Stream Power	Unit Stream Power
Lower - Existing	15	90	0.0032	17.97	1.20
Upper - Existing	10	65	0.0030	12.17	1.22
Tributary - Existing	12	25	0.0117	18.25	1.52
Lower - Proposed	17	90	0.0021	11.79	0.69
Upper - Proposed	15	65	0.0021	8.52	0.57
Tributary - Proposed	9	25	0.0039	6.08	0.68
Reference Reaches					
UT to Little River	9.4	52.8	0.0021	6.92	0.74
Orton Branch	13.5	64	0.0045	17.97	1.33

TABLE 3 Project Watershed Land Use

Land Use	Acreage	Percent
Pervious/Semi-Pervious Classes		
Forest	140	19.9
Open Fields/Lawn/Low-Density Residential	201	28.6
Medium-Density Residential	95	13.5
Subtotal	**436**	**62.1**
Impervious Classes		
Commercial/Institutional Buildings/Roads	266	37.9
Subtotal	**266**	**37.9**
Total	**702**	**100.0**

TABLE 4 Stream Morphologic Parameters

SITE NAME	UNITS	Existing UT #1 Lower	Existing UT #1 Upper	Existing UT #2	Proposed UT #1 Lower	Proposed UT #1 Upper	Proposed UT #2	UT to Little River	Orton Branch
WATERSHED		French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad
REACH DESCRIPTION		Below Culvert Crossing	Above Culvert Crossing	Trib 2	Below Culvert Crossing	Above Culvert Crossing	Trib 2	Trib to Little River	Trib to French Broad
STREAM TYPE		G4	G4	G4	C/E4	C/E4	C/E4	E4	C/E4
DRAINAGE AREA (DA)	Ac	704.0	480.0	204.8	704.00	480.00	204.80	326.4	345.6
BANKFULL WIDTH (W_{bkf})	ft	20.2	11.0	16.2	17.00	15.00	9.00	9.4	13.5
BANKFULL MEAN DEPTH (d_{bkf})	ft	2.7	2.8	2.8	1.70	1.50	0.90	1.6	1.5
LOWEST BANK HEIGHT RATIO		2.5	2.5	2.5	1.0	1.0	1.0	1.1	1.2
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})		7.5	3.9	5.8	10.00	10.00	10.00	5.9	9.0
BANKFULL X-SECTION AREA (A_{bkf})	ft^2	55.1	30.4	45.4	27.13	21.13	7.61	15.2	20.6
BANKFULL MEAN VELOCITY, ft/s	f/s	4.3	3.0	2.2	3.32	3.08	3.29	3.6	3.1
BANKFULL DISCHARGE, cfs	ft^3/s	235.0	90.0	100.0	90.00	65.00	25.00	55.0	64.0
BANKFULL MAX DEPTH (d_{max})	ft	6.0	4.0	2.1	2.13	1.88	1.13	2.0	2.3
WIDTH Flood-Prone Area (W_{fpa})	ft	20.2	11.0	16.2	51.00	45.00	27.00	200	125
ENTRENCHMENT RATIO (ER)		1.0	1.0	1.0	3.00	3.00	3.00	21.3	9.3
MEANDER LENGTH (Lm)	ft	-	-	-	63 - 229	56 - 202	34 - 121	35 - 43	62 - 182
RATIO OF Lm TO W_{bkf}		-	-	-	3.7 - 13.5	3.7 - 13.5	3.7 - 13.5	3.7 - 4.6	4.6 - 13.5
RADIUS OF CURVATURE	ft	-	-	-	34 - 51	20 - 60	18 - 27	9.0 - 19.0	10.0 - 54.0
RATIO OF Rc TO W_{bkf}		-	-	-	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	1.0 - 2.0	0.7 - 4.0
BELT WIDTH	ft	-	-	-	34 - 92	30 - 81	18 - 49	19 - 51	0 - 0
MEANDER WIDTH RATIO		-	-	-	2.0 - 5.4	2.0 - 5.4	2.0 - 5.4	2.0 - 5.4	0.0 - 0.0
SINUOSITY (K)		1.00	1.00	1.00	1.24	1.18	1.22	1.50	1.17
VALLEY SLOPE	ft/ft	0.0031	0.0031	0.0150	0.0033	0.0030	0.0134	0.0031	0.0054
AVERAGE SLOPE (S)	ft/ft	0.0031	0.0031	0.0150	0.0021	0.0021	0.0090	0.0021	0.0046
RIFFLE SLOPE	ft/ft	0.0270	0.0348	0.0234	0.0080	0.0082	0.0150	0.0110	0.0150
POOL SLOPE	ft/ft	0.0005	0.0002	0.0002	0.0001	0.0001	0.0001	0.0040	0.0075
RATIO OF POOL SLOPE TO AVERAGE SLOPE	ft/ft	0.4	0.6	1.3	1.66	1.66	1.66	1.9	1.6
MAX POOL DEPTH	ft	6.10	5.83	5.00	3.32	2.93	1.76	3.12	2.90
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH		2.26	2.08	1.79	1.95	1.95	1.95	1.95	1.93
POOL WIDTH	ft	26.70	20.00	20.00	23.77	20.98	12.59	10.80	20.00
RATIO OF POOL WIDTH TO BANKFULL WIDTH		1.32	1.82	1.23	1.40	1.40	1.40	1.15	1.48
POOL TO POOL SPACING	ft	-	-	-	17 - 76	15 - 67	9 - 40	7.0 - 42.0	7.0 - 25.0
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH		-	-	-	1.0 - 4.5	1.0 - 4.5	1.0 - 4.5	0.7 - 4.5	0.5 - 1.9

TABLE 5 Federally Listed Species for Henderson County (5/10/07)

Scientific Name	Common Name	State Status	Federal Status	County Status
Glyptemys muhlenbergii	Bog turtle	T	T(S/A)	Current
Alasmidonta raveneliana	Appalachian elktoe	E	E	Current
Epioblasma capsaeformis	Oyster mussel	EX	E	Historic/Obscure
Helonias bullata	Swamp pink	T-SC	T	Current
Isotria medeoloides	Small whorled pogonia	E	T	Current
Narthecium americanum	Bog asphodel	E	C	Historic
Platanthera integrilabia	White fringeless orchid	E	C	Historic
Sagittaria fasciculata	Bunched arrowhead	E	E	Current
Sarracenia jonesii	Mountain sweet pitcher plant	E-SC	E	Current
Sisyrinchium dichotomum	White irisette	E	E	Current

State Status Codes: E – Endangered, T – Threatened, SC – Special Concern, EX – Extirpated
Federal Status Codes: E – Endangered, T – Threatened, C – Candidate,
T(S/A) – Threatened due to Similarity of Appearance

TABLE 6 Bank Erosion Hazard Index Survey and Rank UT to Cane Creek Restoration Site

Downstream Station	Upstream Station	BEHI Rank Left Bank	Near Bank Stress Left Bank	Left Bank Total FT^3/yr	BEHI Rank Right Bank	Near Bank Stress Right Bank	Right Bank Total FT^3/yr
0	35	Moderate	Low	12.6	Moderate	Moderate	25.2
35	48	High	High	29.3	Moderate	Low	4.7
48	57	Low	Moderate	2.4	Moderate	Low	3.2
57	78	High	Moderate	25.2	Low	Low	2.9
78	100	Moderate	Moderate	15.8	Mod-High	Low	13.2
100	122	Moderate	Low	7.9	Moderate	Low	7.9
122	140	High	Low	11.3	High	Moderate	18.9
140	155	Moderate	High	22.8	High	Low	8.1
155	174	Low-Moderate	Low	3.1	Low-Moderate	High	14.3
174	207	Low-Moderate	Low	7.3	Moderate	Moderate	23.8
207	300	Low	Low	12.6	Low	Low	12.6
300	324	Low-Moderate	High	24.0	Low	Low	3.3
324	350	Moderate	Low	8.2	Moderate	Low	9.4
350	367	Low-Moderate	Low	2.8	Moderate	Moderate	12.2
367	427	Moderate	Moderate	32.4	Mod-High	Low	36.0
427	452	Moderate	Moderate	13.5	Moderate	Low	6.8
452	486	Low-Moderate	Low	7.5	Low	Low	4.6
486	508	Low	Low	3.0	Low	Low	3.0
508	527	Low	Low	2.6	Low	High	10.6
527	556	Moderate	Low	10.4	Moderate	High	44.1
556	575	High	High	47.5	Low-Moderate	Low	5.2
575	600	Low	Moderate	7.7	Low	Low	3.8
600	619	Moderate	Low	6.8	Low	High	10.6
619	651	Moderate	Moderate	28.8	Moderate	Low	11.5
651	673	Moderate	Low	7.9	Moderate	Moderate	15.8
673	700	Mod-High	High	43.2	Moderate	Low	7.3
700	738	Low-Moderate	Low	10.5	High	High	95.0
738	756	Moderate	High	34.2	Low	Low	2.4
756	786	Low	Moderate	4.1	Low	Low	1.8
786	788	Low	Low	3.4	Low	Low	2.7
788	830	Moderate	Low	20.8	High	High	84.0
830	853	Low	Low	4.3	Moderate	Moderate	20.7
853	867	Moderate	Low	5.0	Low-Moderate	Moderate	5.6
867	879	High	High	24.0	Low	Low	1.6
879	900	Moderate	Low	9.5	Low	High	14.7
900	926	Low	Low	4.4	Low	Moderate	8.8
926	941	Low	Low	2.6	Low-Moderate	Moderate	7.5
941	961	Low-Moderate	Moderate	10.0	Moderate	Moderate	18.0
961	1025	Low-Moderate	Low	17.6	Low-Moderate	Low	15.8
1025	1048	Low	Low	3.1	Low	Low	3.1
1048	1076	Low-Moderate	Moderate	14.0	Low	Low	3.8
1076	1114	Low-Moderate	Moderate	19.0	Low-Moderate	Low	10.5
1114	1140	Low	Low	4.4	Low-Moderate	High	39.0
1140	1167	Moderate	Low	12.2	Moderate	Low	12.2
1167	1189	Low-Moderate	High	27.5	Low-Moderate	Low	6.1
1189	1200	Low-Moderate	Moderate	5.5	Moderate	Low	5.0
1200	1221	Low	Low	3.6	Moderate	High	31.9
1221	1253	Moderate	High	60.8	Low-Moderate	Low	7.0
1253	1274	Low	Low	3.6	Moderate	Moderate	15.1
1274	1310	Low-Moderate	Moderate	18.0	Low-Moderate	Low	9.9
1310	1348	Low-Moderate	Low	10.5	Low-Moderate	Low	10.5
1348	1375	Low-Moderate	High	33.8	Low	Low	4.6
1375	1392	Low-Moderate	Moderate	8.5	Low	Low	2.9

TABLE 6 (Cont.) Bank Erosion Hazard Index Survey and Rank
UT to Cane Creek Restoration Site

Downstream Station	Upstream Station	BEHI Rank Left Bank	Near Bank Stress Left Bank	Left Bank Total FT^3/yr	BEHI Rank Right Bank	Near Bank Stress Right Bank	Right Bank Total FT^3/yr
1392	1421	Low	Low	6.0	Moderate	Low	15.8
1421	1448	High	High	60.0	Low	Low	4.1
1448	1467	Low-Moderate	Low	5.2	Moderate	High	43.3
1467	1485	Low	Low	3.1	High	High	45.0
1485	1500	Low-Moderate	Moderate	7.5	Low	Low	2.6
1500	1575	Low-Moderate	Moderate	37.5	Low	Low	12.8
1575	1625	Moderate	High	114.0	Moderate	High	114.0
1625	1639	High	Very High	78.4	Low	Low	2.9
1639	1651	Low	Low	2.0	High	High	42.0
1651	1675	Low	Low	4.1	Mod-High	High	76.8
1675	1695	Moderate	High	45.6	Low	Low	4.1
1695	1719	High	High	72.0	Low	Low	4.9
1719	1741	Moderate	Low	11.9	Moderate	High	50.2
1741	1750	Low	Low	1.8	Moderate	High	17.8
1750	1774	Low	Moderate	9.8	Moderate	Low	13.0
01774	1798	Moderate	High	63.8	Moderate	Low	13.0
1798	1831	Low-Moderate	Low	12.7	Moderate	High	75.2
1831	1848	Low	Moderate	8.1	Moderate	High	45.2
1848	1865	High	High	59.5	Low	Moderate	8.1
1865	1877	Low-Moderate	Low	4.6	Low	Low	2.9
1877	1900	High	Very High	128.8	Low-Moderate	Moderate	16.1
1900	1927	Low	Moderate	12.9	Low-Moderate	Low	8.9
1927	1946	Low-Moderate	High	33.3	Low	Low	3.9
1946	1974	Low-Moderate	Low	9.2	Low	Low	5.7
1974	1989	Low	Moderate	6.1	Low	High	12.6
1989	2017	Low	Moderate	11.4	Low	Low	5.7
2017	2039	Mod-High	High	52.8	Low	Moderate	9.0
2039	2059	High	High	60.0	Low	Low	4.1
2059	2088	Moderate	Moderate	31.3	Low	Low	5.9
2088	2130	Moderate	High	111.7	Low	Low	8.6
2130	2163	Moderate	Low	17.8	Low	Moderate	13.5
2163	2180	High	Moderate	30.6	Moderate	High	38.8
2180	2200	Low-Moderate	Low	7.7	Low-Moderate	Moderate	14.0
2200	2222	High	High	88.0	High	High	66.0
2222	2244	Low-Moderate	Low	8.5	Moderate	High	50.2
2244	2261	Low	Low	3.5	Low-Moderate	Moderate	10.2
2261	2279	Low	Low	3.7	Very High	Very High	86.4
2279	2311	Low-Moderate	High	48.0	Low	Low	6.5
2311	2340	Low	Low	5.9	Moderate	High	66.1
2340	2366	Low	Low	5.3	High	High	78.0
2366	2392	Low	Moderate	10.6	Low	Low	5.3
2392	2425	Low	Low	6.7	Low-Moderate	High	49.5
2425	2470	High	High	101.5	High	High	101.5
2470	2500	Low-Moderate	Low	11.6	Low-Moderate	High	60.0
2500	2523	Mod-High	Low	27.6	Mod-High	Moderate	46.0
2523	2539	High	Low	23.0	Moderate	High	42.6
2539	2572	High	Low	47.5	Low-Moderate	Moderate	23.1
2572	2599	High	Low	38.9	High	High	94.5
2599	2644	High	Moderate	94.5	High	High	180.0
2644	2670	Moderate	Moderate	37.4	Moderate	Moderate	32.8
2670	2689	Very High	Very High	121.6	Low	Low	4.5
2689	2714	High	High	100.0	Low	Moderate	11.9
2714	2751	Moderate	Low	23.3	Moderate	Moderate	46.6

TABLE 6 (Cont.) Bank Erosion Hazard Index Survey and Rank
UT to Cane Creek Restoration Site

Downstream Station	Upstream Station	BEHI Rank Left Bank	Near Bank Stress Left Bank	Left Bank Total FT^3/yr	BEHI Rank Right Bank	Near Bank Stress Right Bank	Right Bank Total FT^3/yr
2751	2783	Low	Low	7.6	Moderate	High	85.1
2783	2800	High	High	59.5	Low	Moderate	6.9
2800	2848	Moderate	High	127.7	Low	Low	9.8
2848	2861	Low	Low	3.1	Low-Moderate	Moderate	9.1
2861	2898	Moderate	High	98.4	Low	Low	7.5
		Left Bank Total FT^3/YR		3040.9	Right Bank Total FT^3/YR		2689.0
		Left Bank Total Tons/YR		146.4	Right Bank Total Tons/YR		129.5
		TOTAL TONS		**275.9**			
		FT^3/FT		**1.98**			

TABLE 7 Bank Erosion Hazard Index Survey and Rank
Orton Branch Reference Reach Site

Downstream Station	Upstream Station	BEHI Rank Left Bank	Near Bank Stress Left Bank	Left Bank Total FT^3/yr	BEHI Rank Right Bank	Near Bank Stress Right Bank	Right Bank Total FT^3/yr
0	29	Low	Low	2.0	Low	Moderate	4.9
29	48	Low	Low	1.9	Low-Moderate	High	14.3
48	62	Low	Moderate	2.9	Low	Low	1.4
62	80	Moderate	High	20.5	Low	Low	1.8
80	96	Low	Low	1.6	Low	Moderate	3.3
96	113	Low	Low	1.7	Low	Moderate	3.5
113	126	Moderate	High	14.8	Low	Low	1.3
126	144	Mod-High	High	21.6	Deposition	Deposition	0.0
144	156	Low	Moderate	2.4	Moderate	Moderate	5.4
156	172	Low	Low	1.4	Mod-High	High	19.5
172	192	Low	Moderate	3.4	Low	Low	2.0
192	206	Low	Low	1.2	Low	High	5.9
206	223	Moderate	Moderate	9.2	Low	Low	1.4
223	237	Moderate	High	21.3	Low	Low	1.4
237	253	Low-Moderate	Low	2.6	Moderate	High	24.3
253	275	Low	Low	2.2	Low	Low	2.2
275	290	Low	Low	1.5	Low-Moderate	High	11.3
290	300	Low-Moderate	Low	1.7	Low-Moderate	High	7.5
300	313	Low	Low	1.3	Low	Moderate	2.7
313	329	Low	Low	1.6	Low-Moderate	High	12.0
329	338	Low-Moderate	High	6.8	Low-Moderate	Low	1.5
		Left Bank Total FT^3/YR		123.7	Right Bank Total FT^3/YR		127.3
		Left Bank Total Tons/YR		6.0	Right Bank Total Tons/YR		6.1
		TOTAL TONS		**12.1**			
		FT^3/FT		**0.048**			

TABLE 8 Bank Erosion Hazard Index Survey and Rank
UT to Little River Reference Reach Site

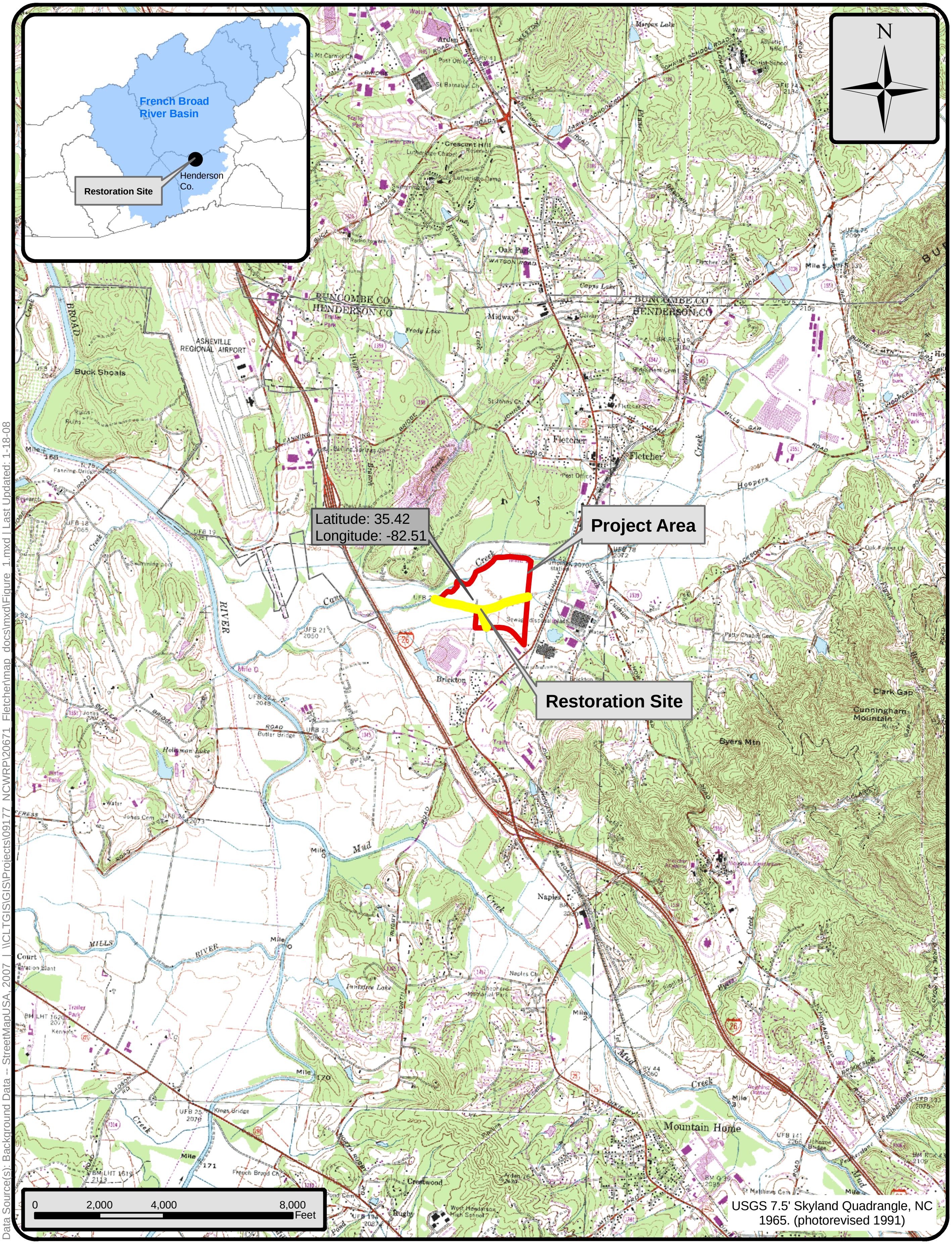
Downstream Station	Upstream Station	BEHI Rank Left Bank	Near Bank Stress Left Bank	Left Bank Total FT^3/yr	BEHI Rank Right Bank	Near Bank Stress Right Bank	Right Bank Total FT^3/yr
0	11	Low	Moderate	1.5	Low	Low	0.7
11	26	Low	High	4.2	Low	Low	1.0
26	39	Low	High	3.6	Low	Low	0.9
39	74	Low	Moderate	6.0	Low	Low	2.4
74	96	Low	Moderate	3.0	Very Low	Low	0.9
96	108	Low	Low	0.8	Low	Moderate	1.6
108	118	Low-Moderate	Low	1.1	Low	High	2.8
118	131	Low	Moderate	1.8	Low	Low	0.9
131	143	Low	Low	0.8	Low	Low	0.6
143	157	Low-Moderate	Moderate	2.8	Low	Low	0.7
157	167	Low	Low	0.3	Low	High	2.8
167	186	Low	Low	1.3	Low	Low	1.3
186	202	Low-Moderate	High	8.0	Low	Low	1.1
202	218	Low	Moderate	2.2	Low	Low	0.8
218	231	Low	Low	0.9	Low	High	3.6
231	256	Very Low	Low	0.8	Low	Low	1.7
256	271	Low	High	6.3	Very Low	Low	0.6
271	290	Low	High	8.0	Low	Low	1.3
290	300	Low	Moderate	2.0	Low	Low	0.7
			Left Bank Total FT^3/YR	55.3		Right Bank Total FT^3/YR	26.5
			Left Bank Total Tons/YR	2.7		Right Bank Total Tons/YR	1.3
			TOTAL TONS	**3.9**			
			FT^3/FT	**0.27**			

TABLE 9a Designated Vegetative Community

Latin Name	Stream Banks (Riparian Areas)	Floodplain Bench (Alluvial Forest)	Bottomland Hardwood	Common Name	Form	Spacing (on center–O.C.)
Acer negundo		*x*		Boxelder	Bare-root, containerized	8’
Acer rubrum		*x*	*x*	Red maple	Bare-root, containerized	8’
Alnus serrulata		*x*		Tag alder	Bare-root, containerized	8'
Asimina triloba		*x*	*x*	Pawpaw	Containerized	8'
Betula nigra		*x*		River birch	Containerized	8'
Calycanthus floridus		*x*		Sweet-shrub	Containerized	4-6'
Carpinus caroliniana		*x*	*x*	Ironwood	Bare-root, containerized	8’
Carya cordiformis		*x*	*x*	Bitternut hickory	Bare-root, containerized	8’
Cornus amomum	*x*	*x*		Silky dogwood	Bare-root, live stake	3’, 8’
Cornus alternifolia			*x*	Alternate leaf dogwood	Bare-root, containerized	4-6’
Euonymus americana			*x*	Strawberry bush	Bare-root, containerized	4-6’
Fraxinus pennsylvanica		*x*	*x*	Green ash	Bare-root, containerized	8'
Hamamelis virginiana			*x*	Witch hazel	Bare-root, containerized	4-6’
Itea virginica		*x*	*x*	Virginia willow	Plug, bare-root, containerized	4'
Juglans nigra		*x*	*x*	Black walnut	Bare-root, containerized	10'
Lindera benzoin		*x*		Spicebush	Containerized, plug	4-6'
Liquidambar styraciflua			*x*	Sweetgum	Bare-root, containerized	8’
Liriodendron tulipifera			*x*	Yellow poplar	Containerized	8’
Leucothoe recurva		*x*		Doghobble	Bare-root, containerized	4-6’
Physocarpus opulifolius	*x*	*x*		Ninebark	Bare-root, live stake	3’, 8’
Platanus occidentalis		*x*		Sycamore	Bare-root, containerized	8’
Rosa palustris		*x*		Swamp rose	Bare-root, containerized	4-6’
Salix nigra	*x*	*x*		Black willow	Live stake	3’
Salix sericea		*x*		Silky willow	Plugs, bare-root	3’
Sambucus canadensis	*x*	*x*		Elderberry	Containerized, plug, live stake	3’

TABLE 9b Planting Zones and Spacing

Zone	Size (acres)	Proposed Plant Spacing
Stream Bank	0.6	3 ft o.c. avg.
Floodplain Bench	2.7	4 ft o.c. avg.
Bottomland Hardwood (buffers and wetlands)	13.6	8 ft o.c. avg



Data Source(s): Background Data -- StreetMapUSA, 2007 | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_FletcherAmap_docs\mxd\Figure_1.mxd | Last Updated: 1-18-08

Ecosystem Enhancement PROGRAM

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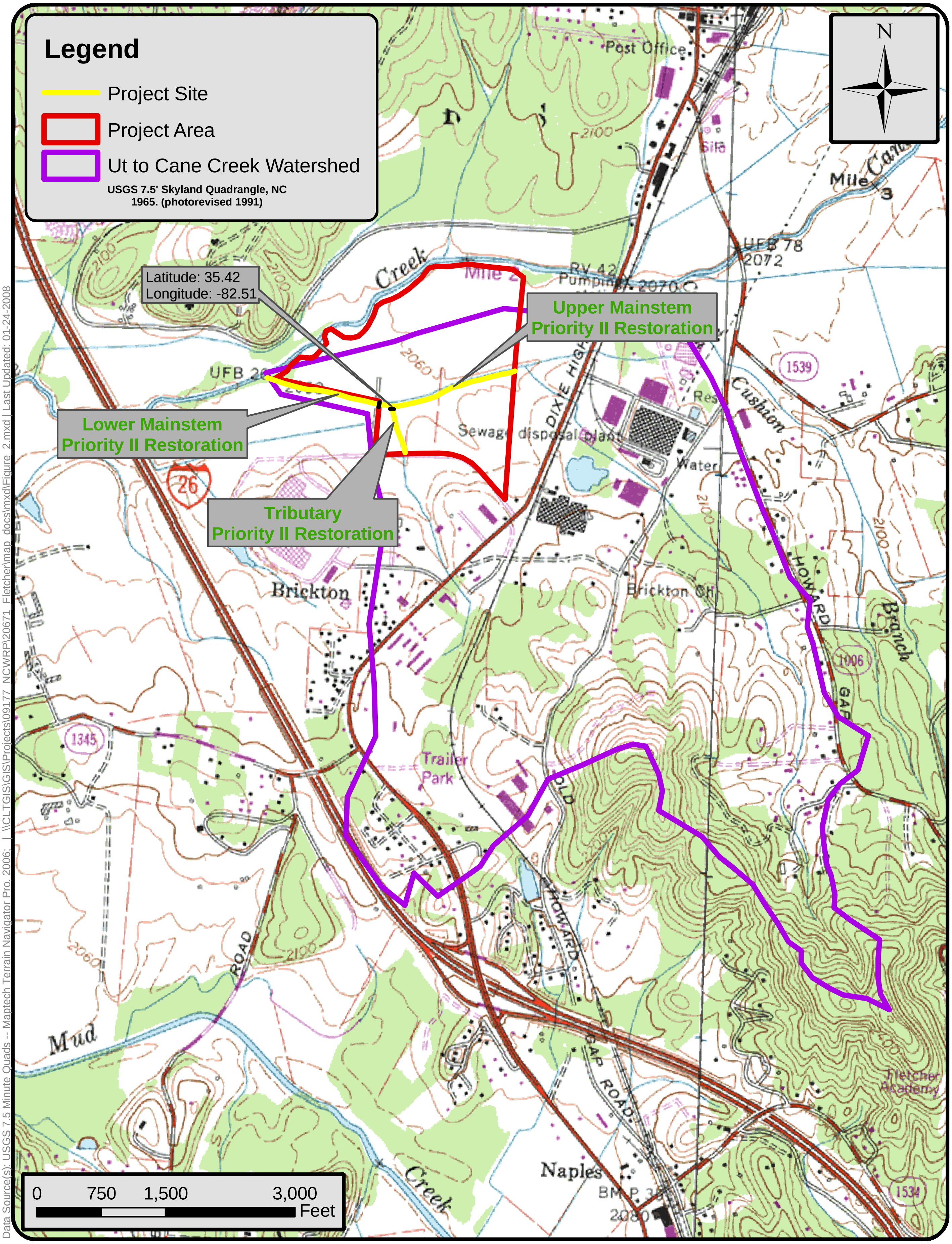
Project Site Vicinity

Figure 1

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Data Source(s): USGS 7.5 Minute Quads -- Maptech Terrain Navigator Pro, 2006; | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_2.mxd | Last Updated: 01-24-2008

Restoration Site Watershed

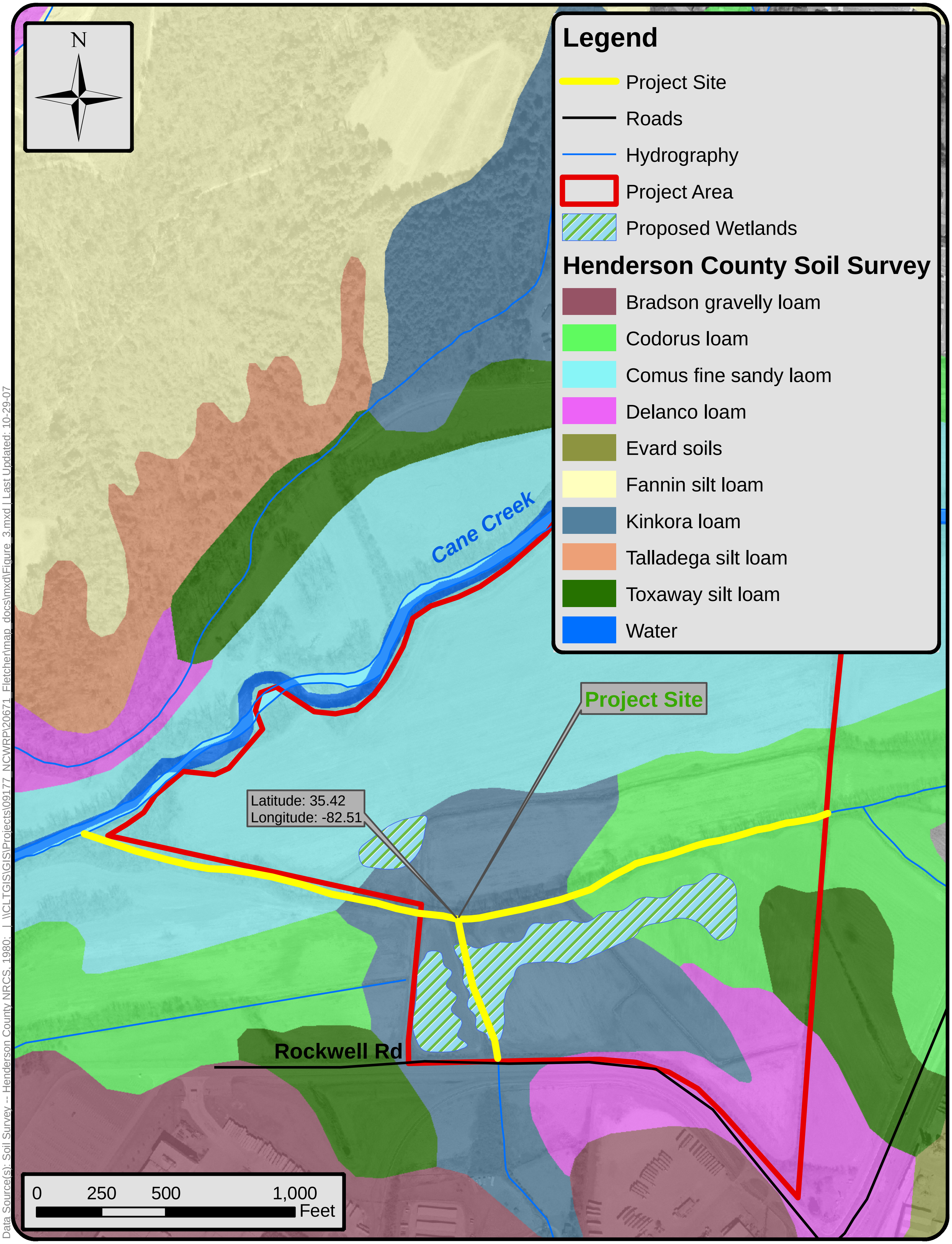
Figure 2

Ecosystem Enhancement Program

HDR ONE COMPANY | Many Solutions

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC

NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Data Source(s): Soil Survey -- Henderson County NRCS, 1980; | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_3.mxd | Last Updated: 10-29-07

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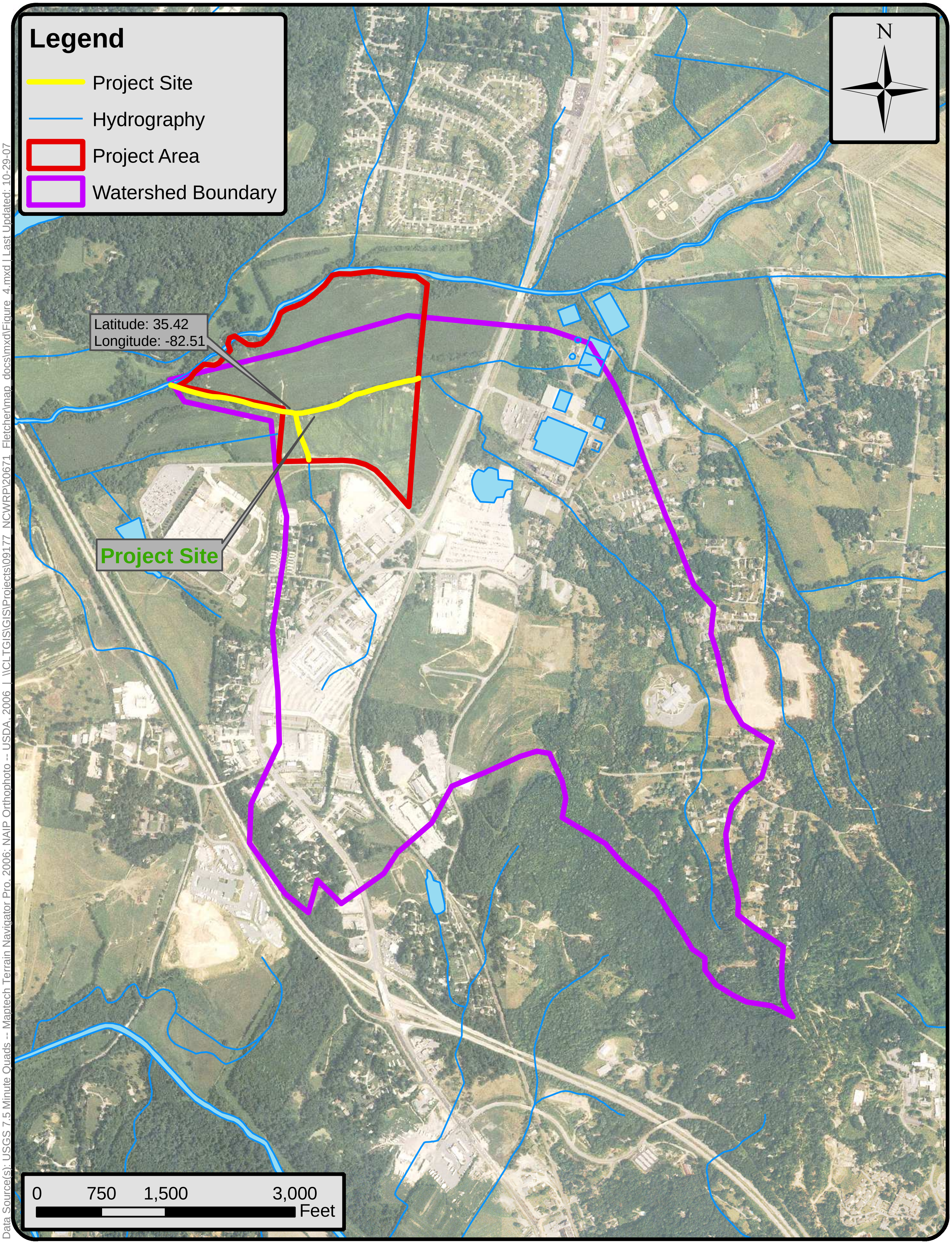
Restoration Site Soils

Figure 3

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Data Source(s): USGS 7.5 Minute Quads -- Maptech Terrain Navigator Pro, 2006; NAIP Orthophoto -- USDA, 2006 | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_4.mxd | Last Updated: 10-29-07

Ecosystem Enhancement PROGRAM

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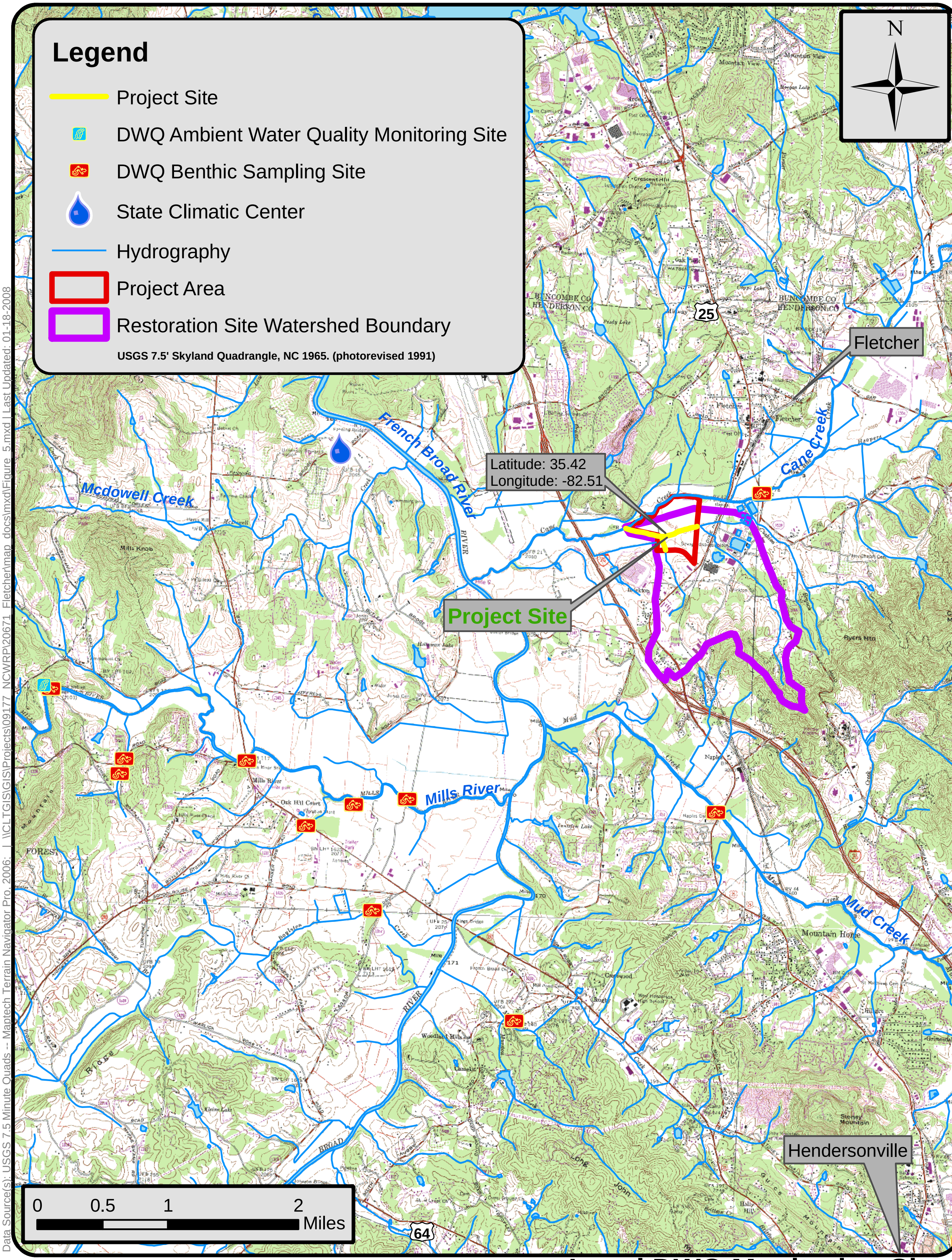
Restoration Site Watershed Land Use

Figure 4

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S

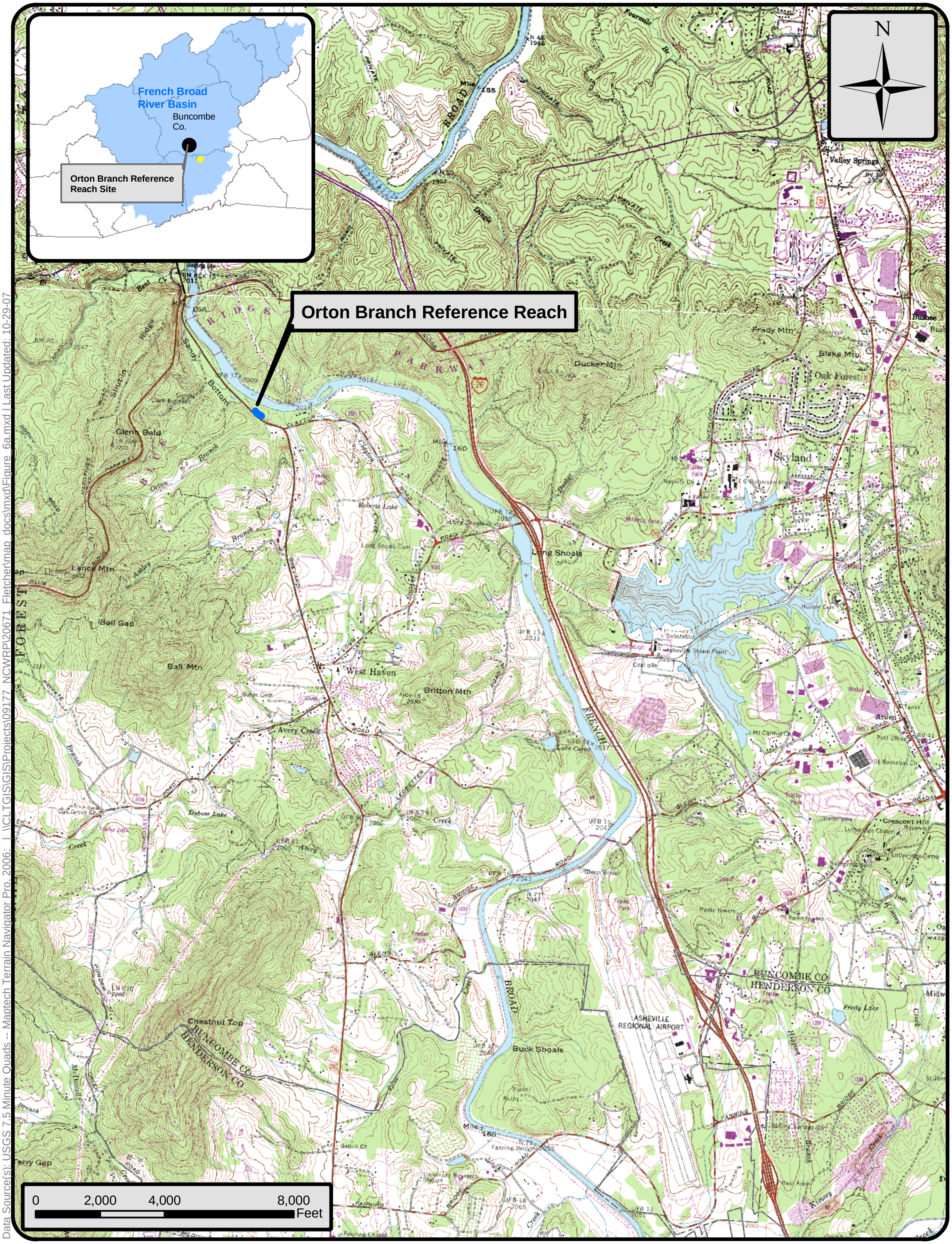


Data Source(s): USGS 7.5 Minute Quads -- Maptech Terrain Navigator Pro, 2006; | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_5.mxd | Last Updated: 01-18-2008

Local DWQ Monitoring Sites

Figure 5

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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Ecosystem Enhancement PROGRAM

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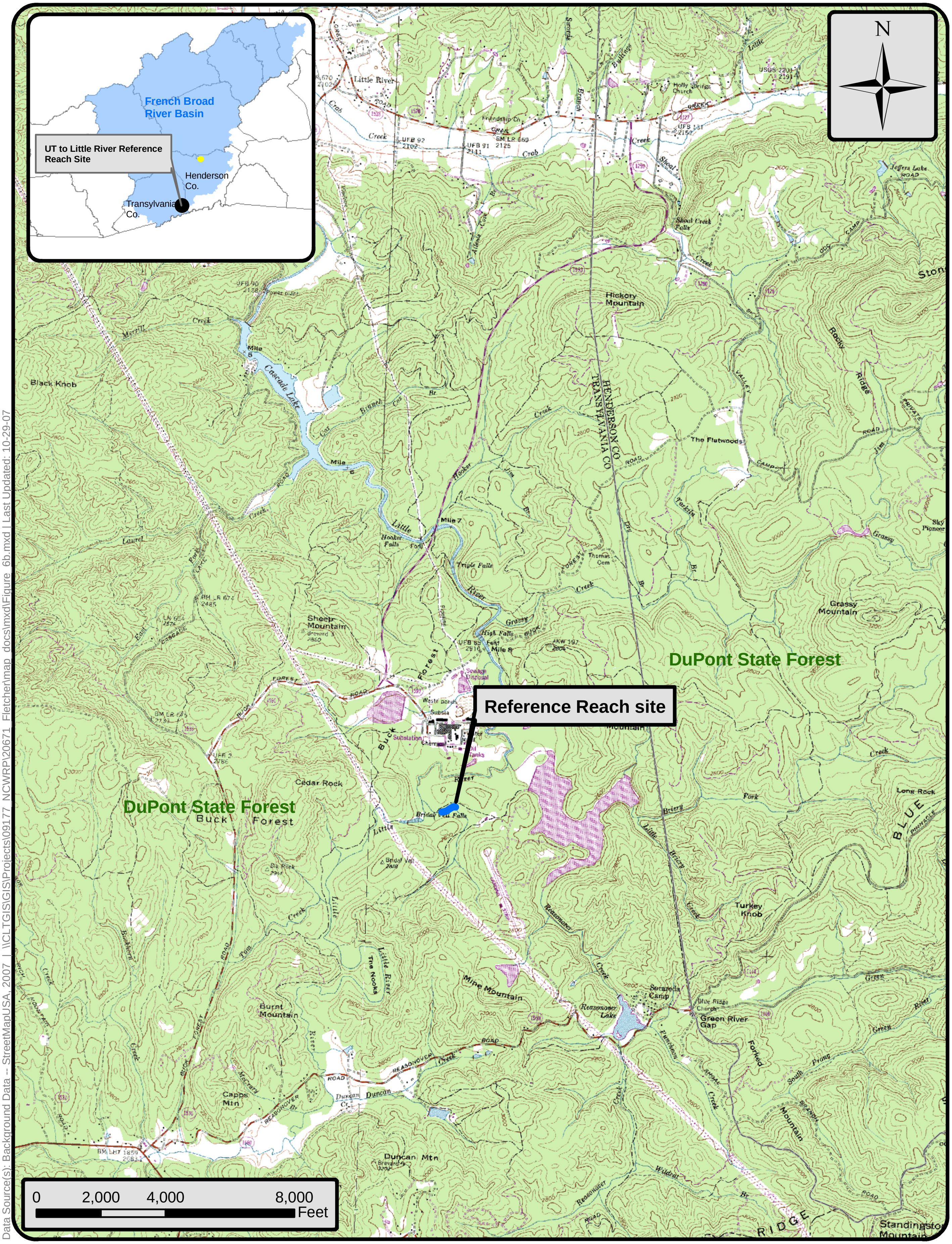
Orton Branch Reference Reach Site

Figure 6a

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Data Source(s): Background Data -- StreetMapUSA, 2007 | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_6b.mxd | Last Updated: 10-29-07

UT to Little River Reference Reach Site

Figure 6b

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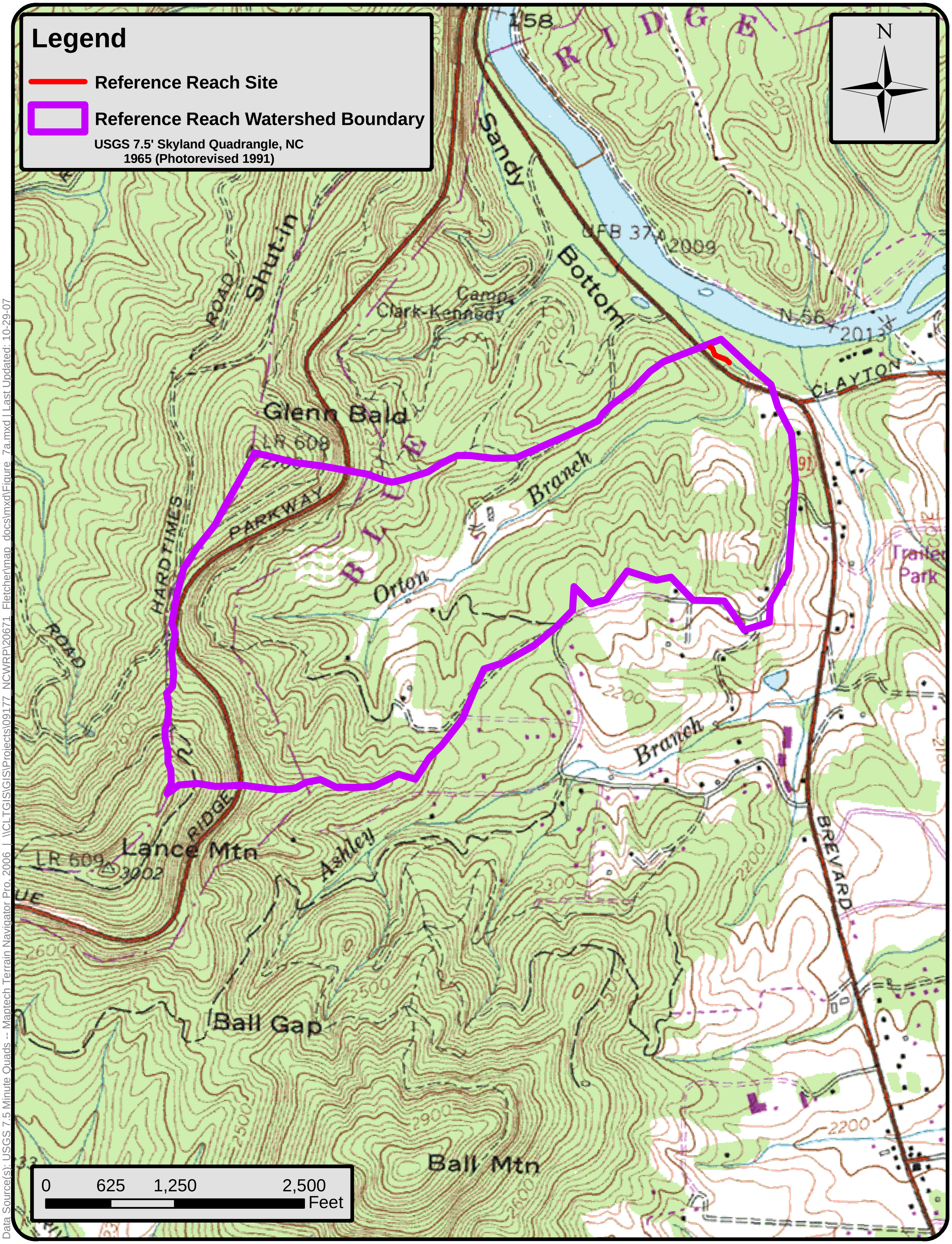
Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC

NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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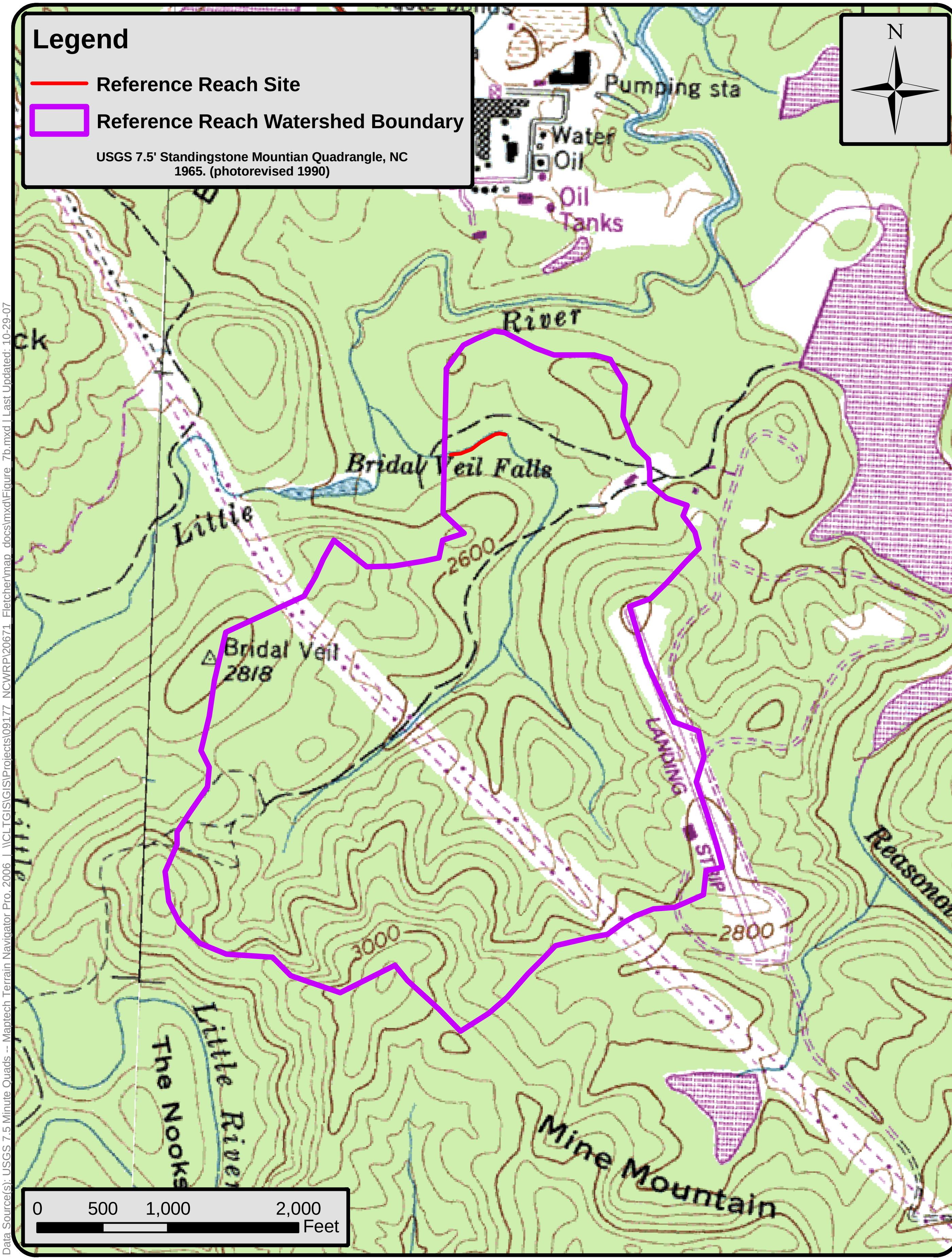
Orton Branch Watershed

Figure 7a

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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Ecosystem Enhancement PROGRAM

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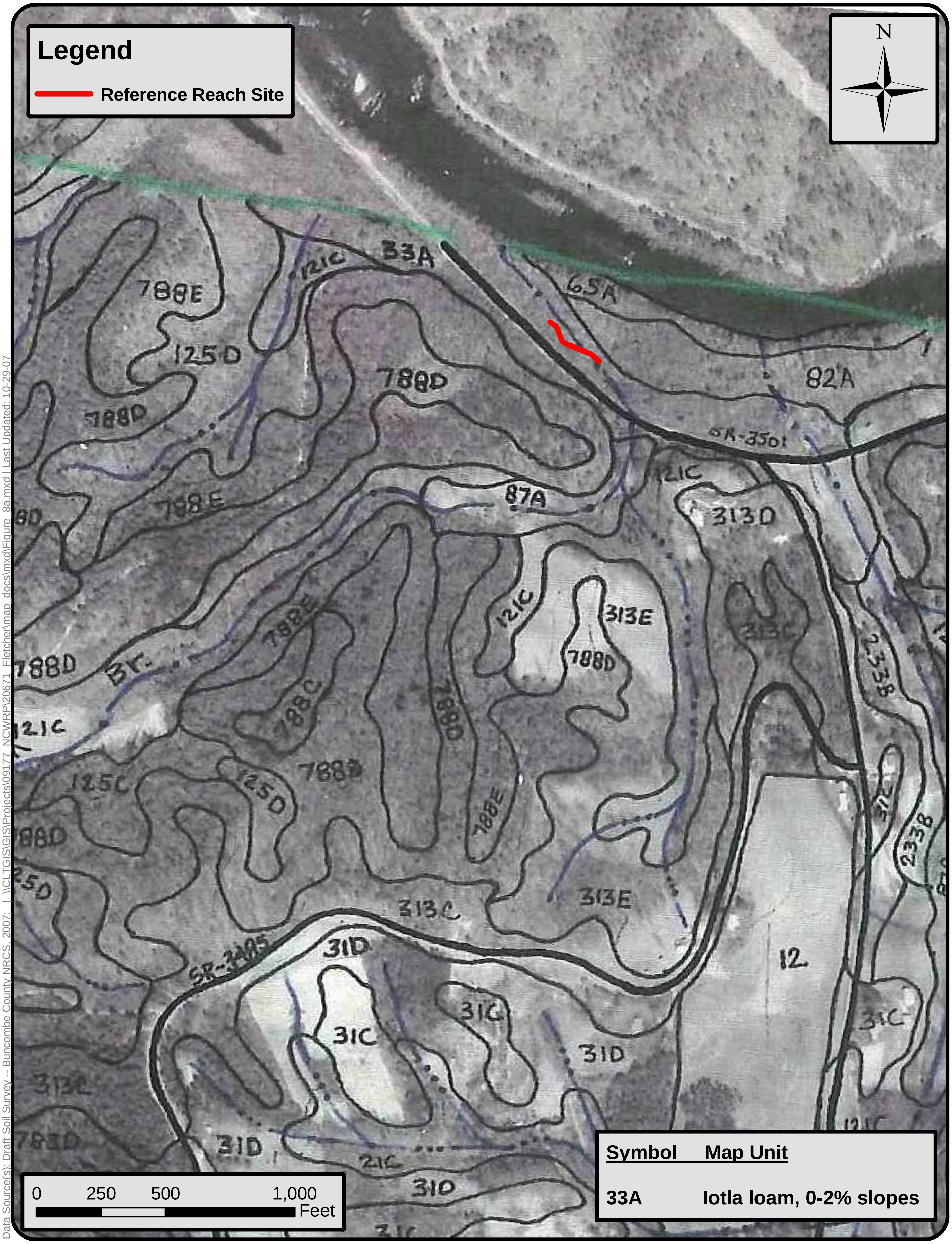
UT to Little River Watershed

Figure 7b

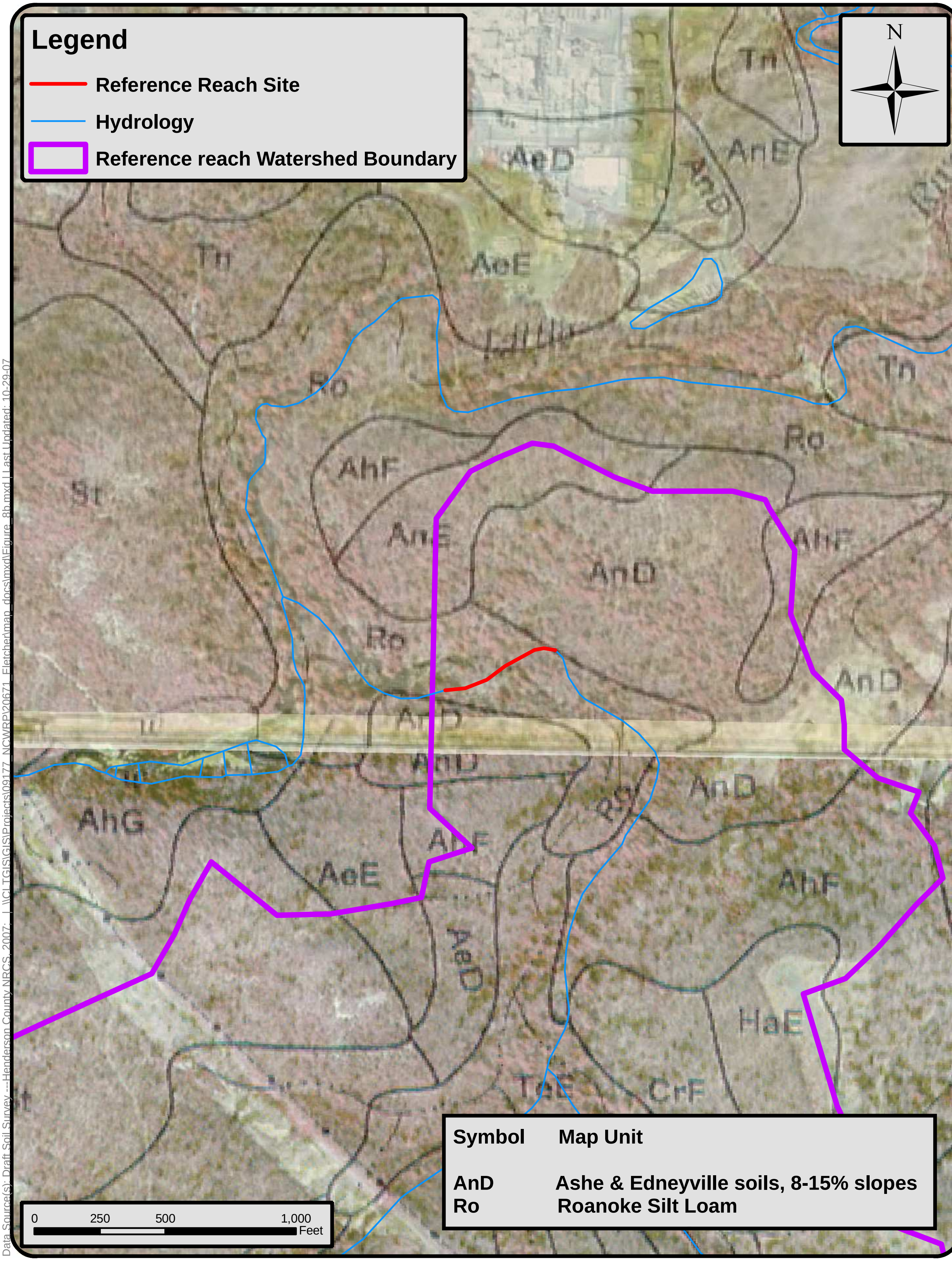
Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Data Source(s): Draft Soil Survey -- Buncombe County NRCS, 2007; | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Figure_8a.mxd | Last Updated: 10-29-07

Orton Branch Soils

Figure 8a



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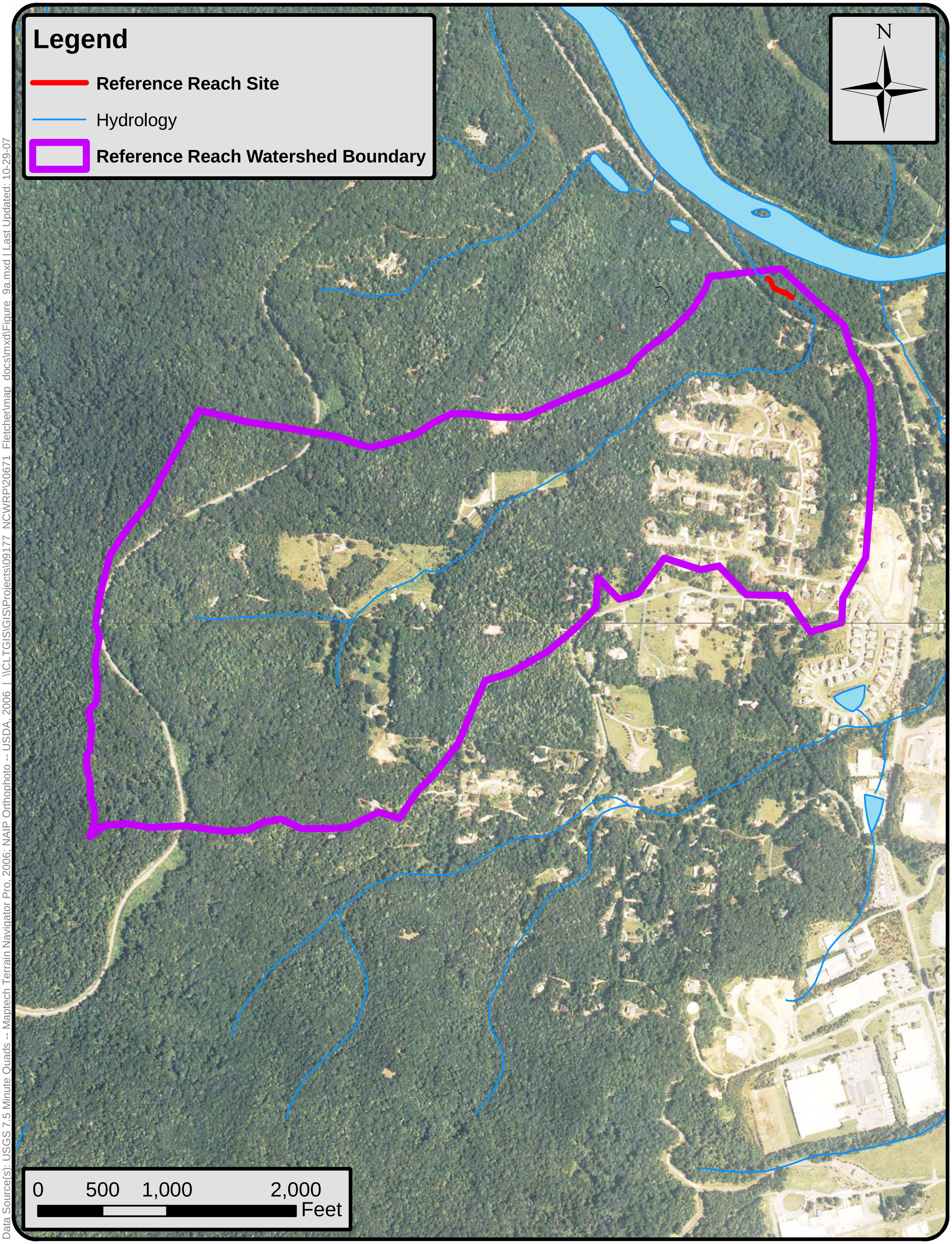
UT to Little River Soils

Figure 8b

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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Ecosystem Enhancement PROGRAM

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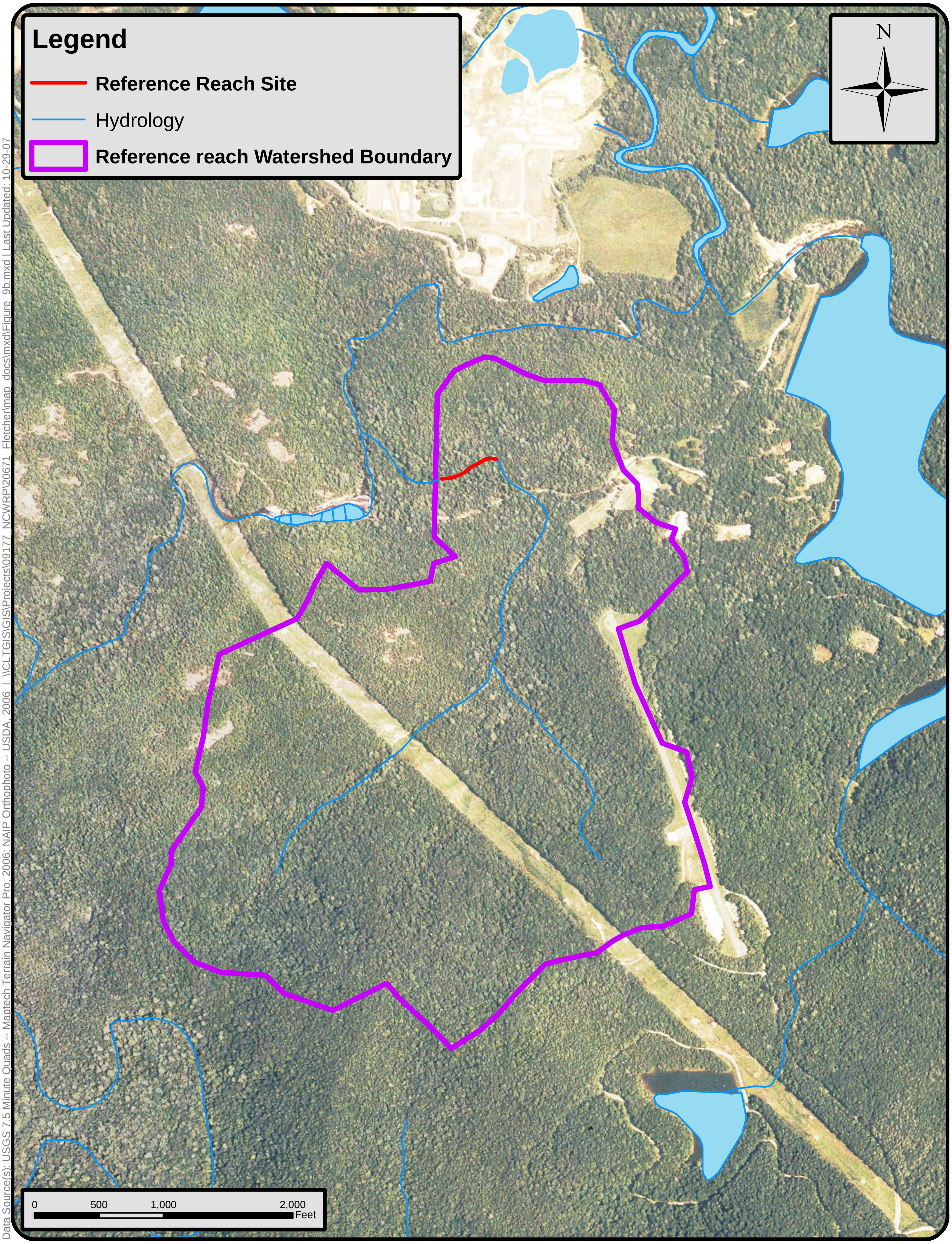
Orton Branch Watershed Land Use

Figure 9a

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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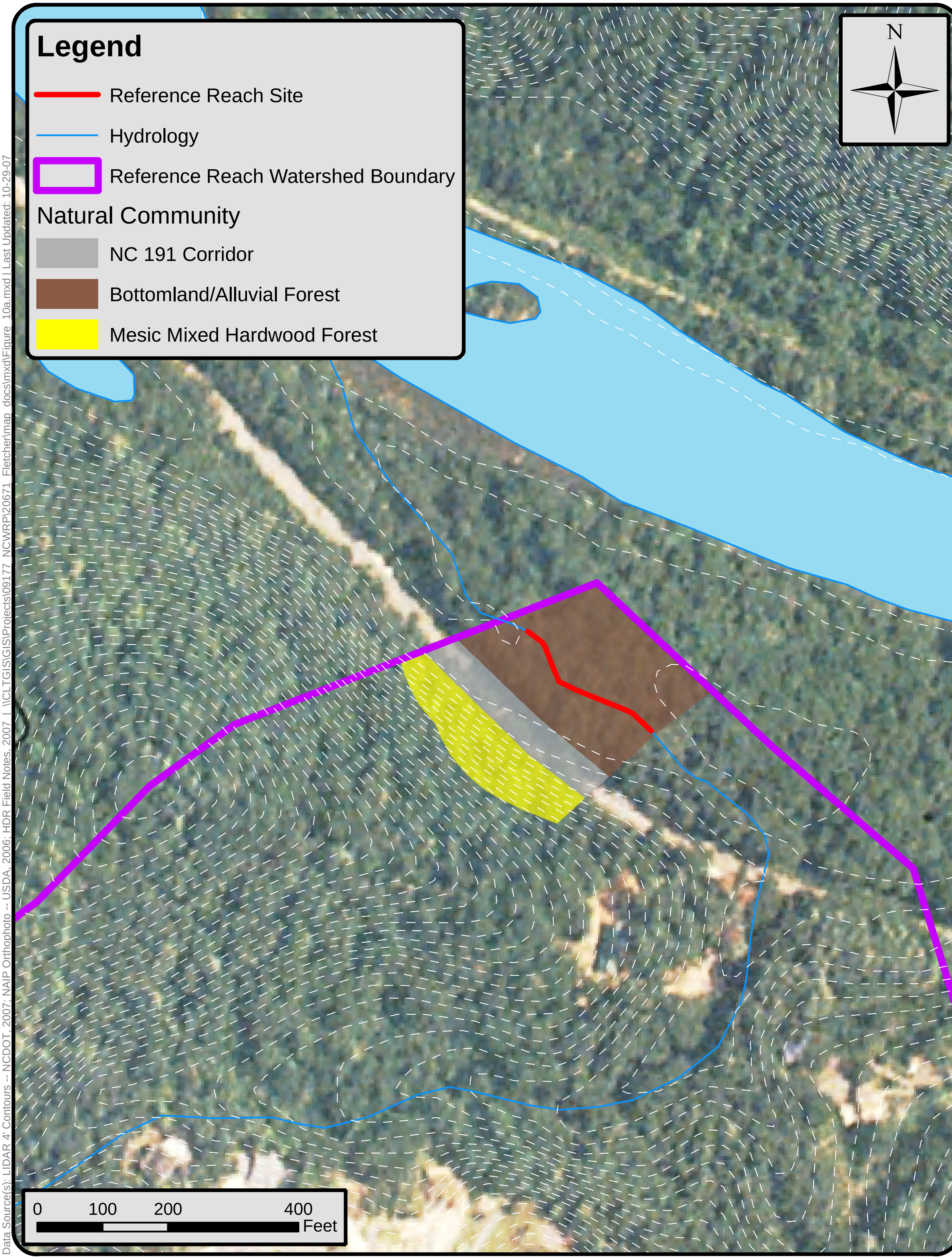
UT to Little River Watershed Landuse

Figure 9b

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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Ecosystem Enhancement PROGRAM

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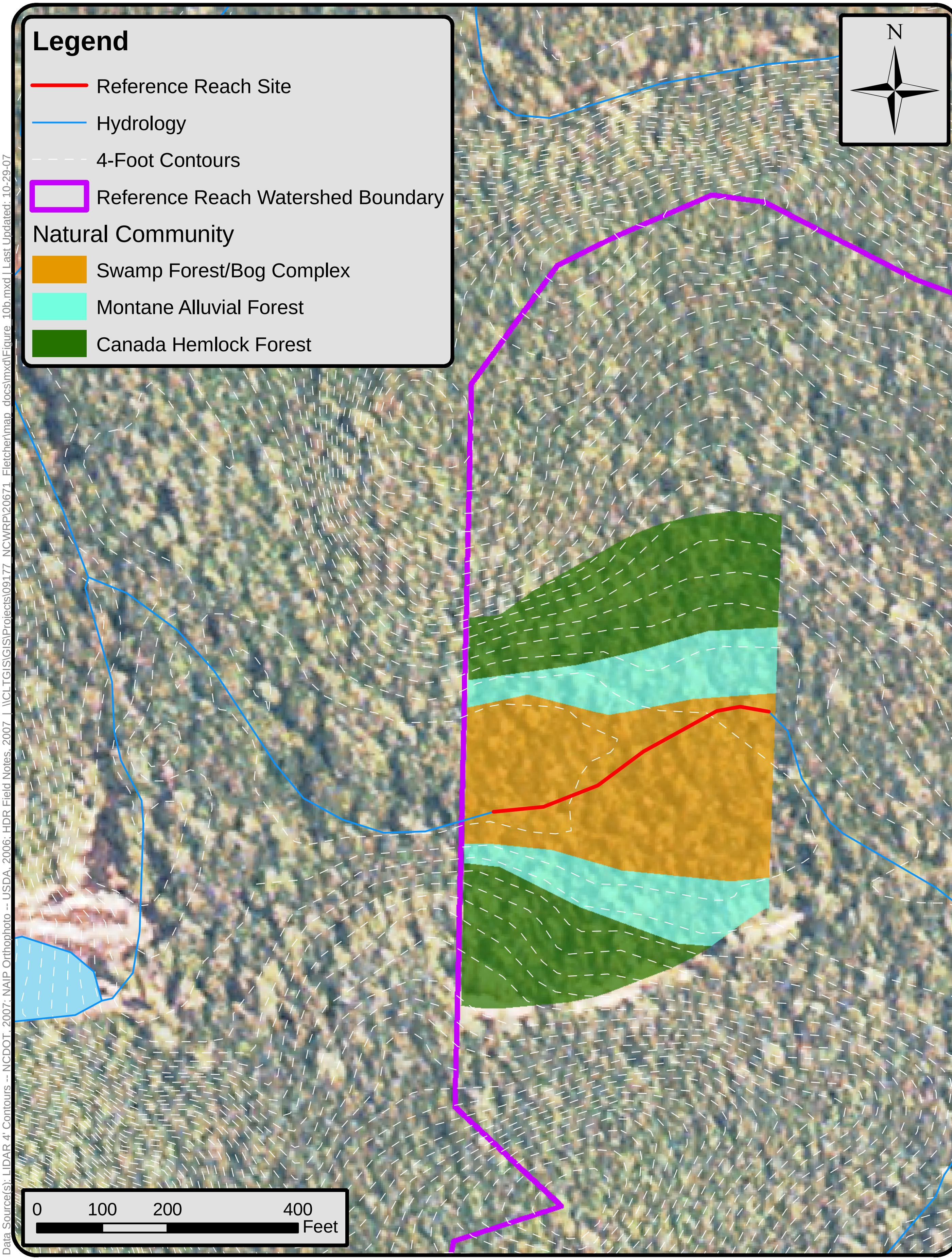
Orton Branch Vegative Communities

Figure 10a

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



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Ecosystem Enhancement PROGRAM

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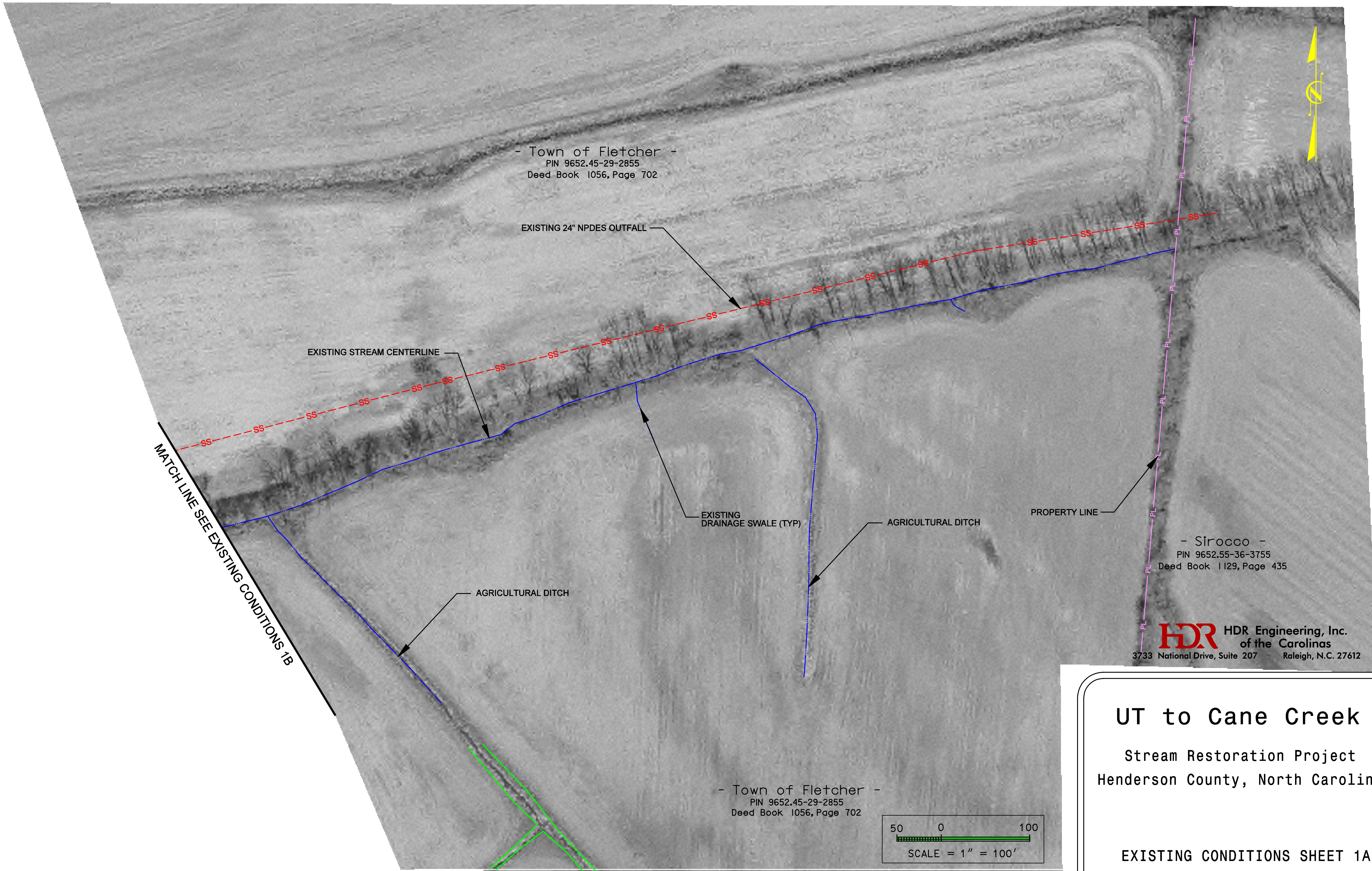
UT to Little River Vegetative Communities

Figure 10b

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC
NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S

Sheet 1

Existing Channel or Site Conditions



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UT to Cane Creek

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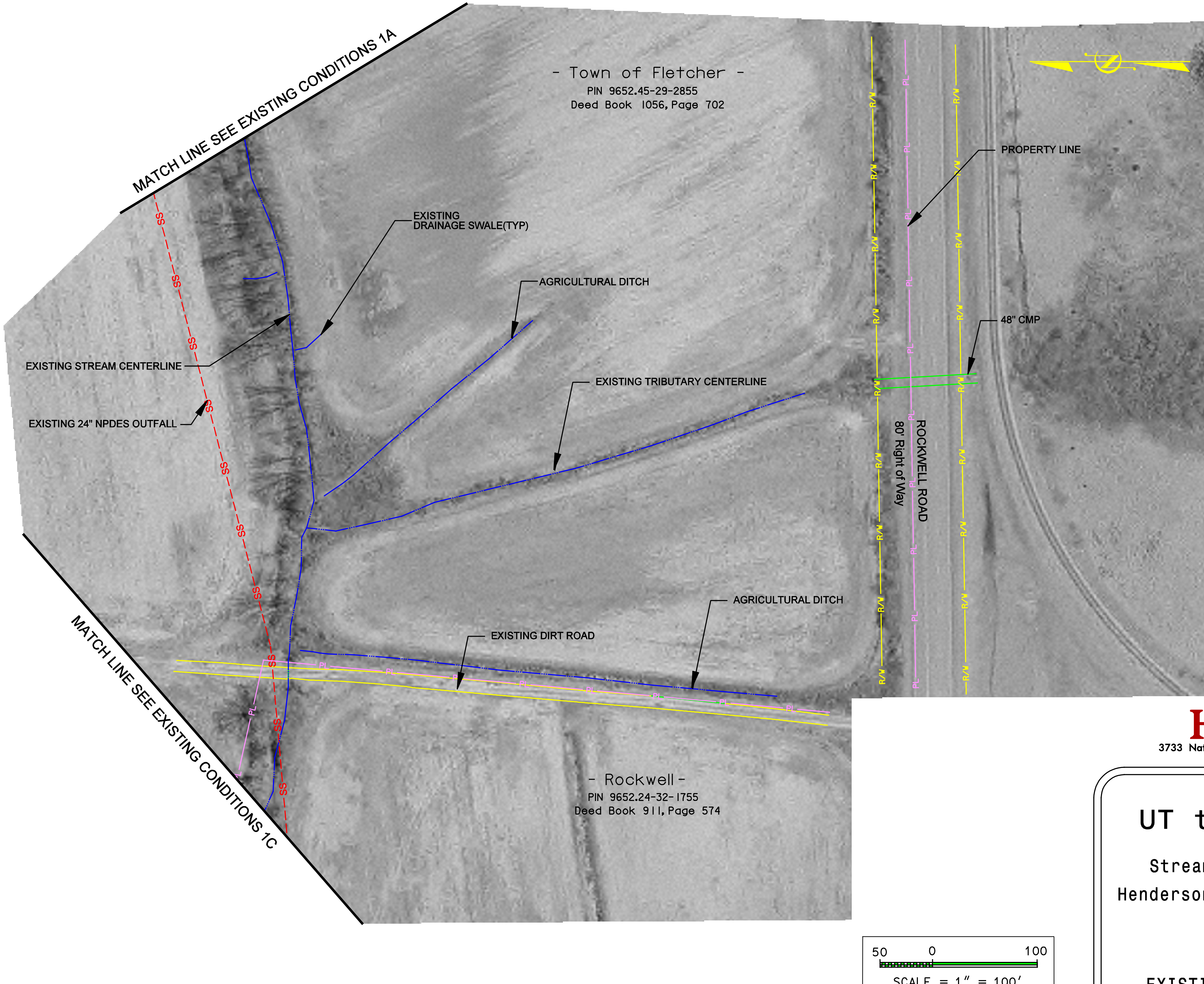
Henderson County, North Carolina

EXISTING CONDITIONS SHEET 1A



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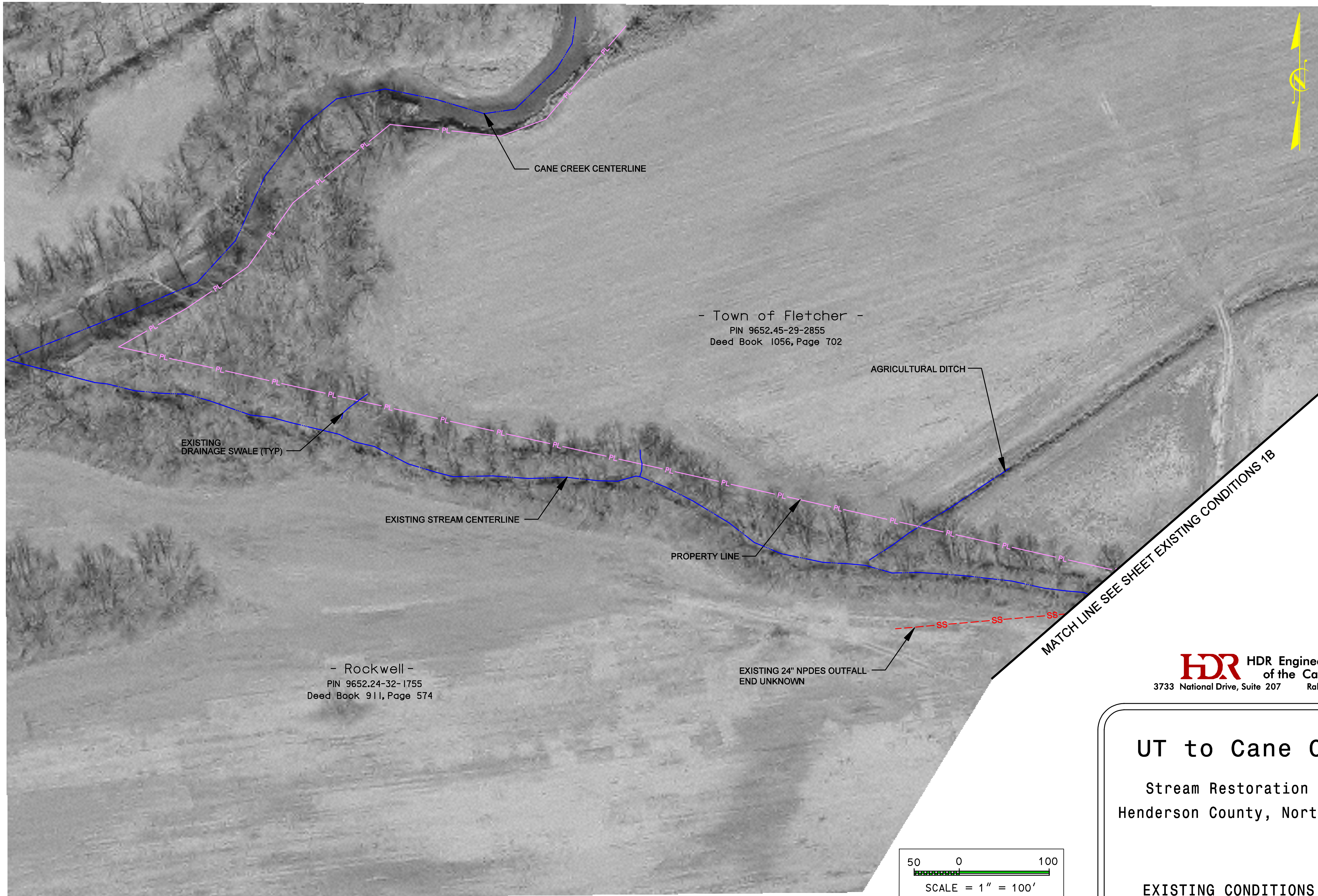
EXISTING CONDITIONS SHEET 1B



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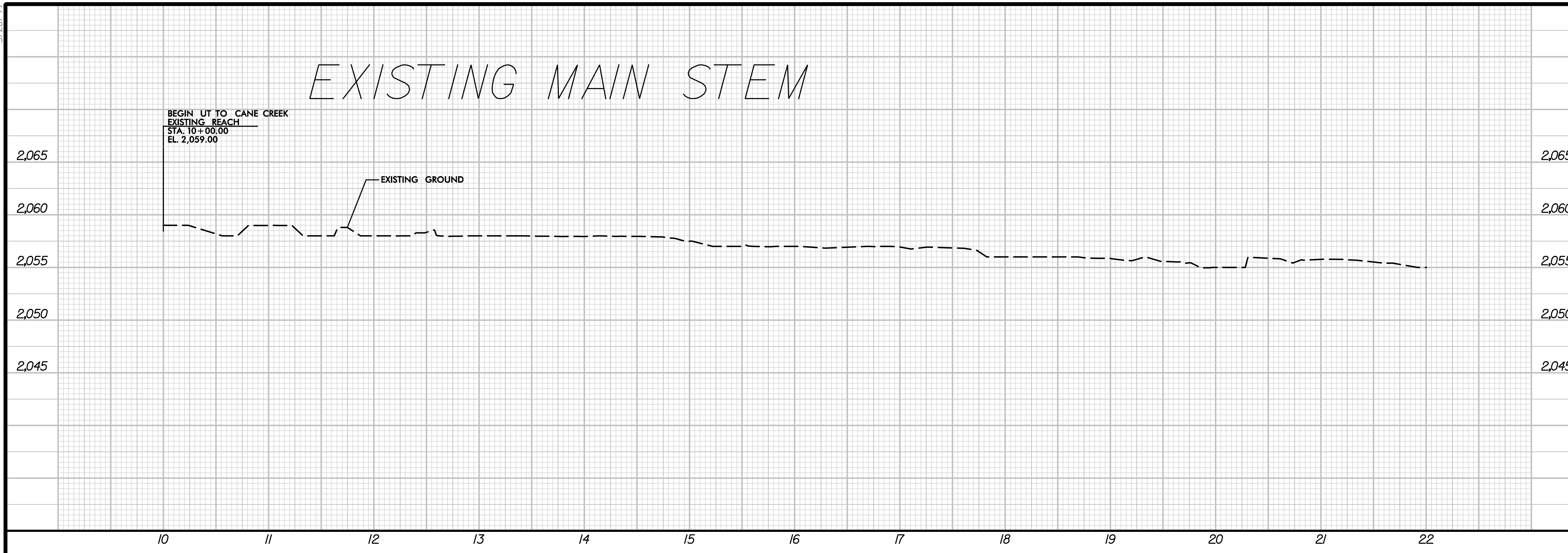
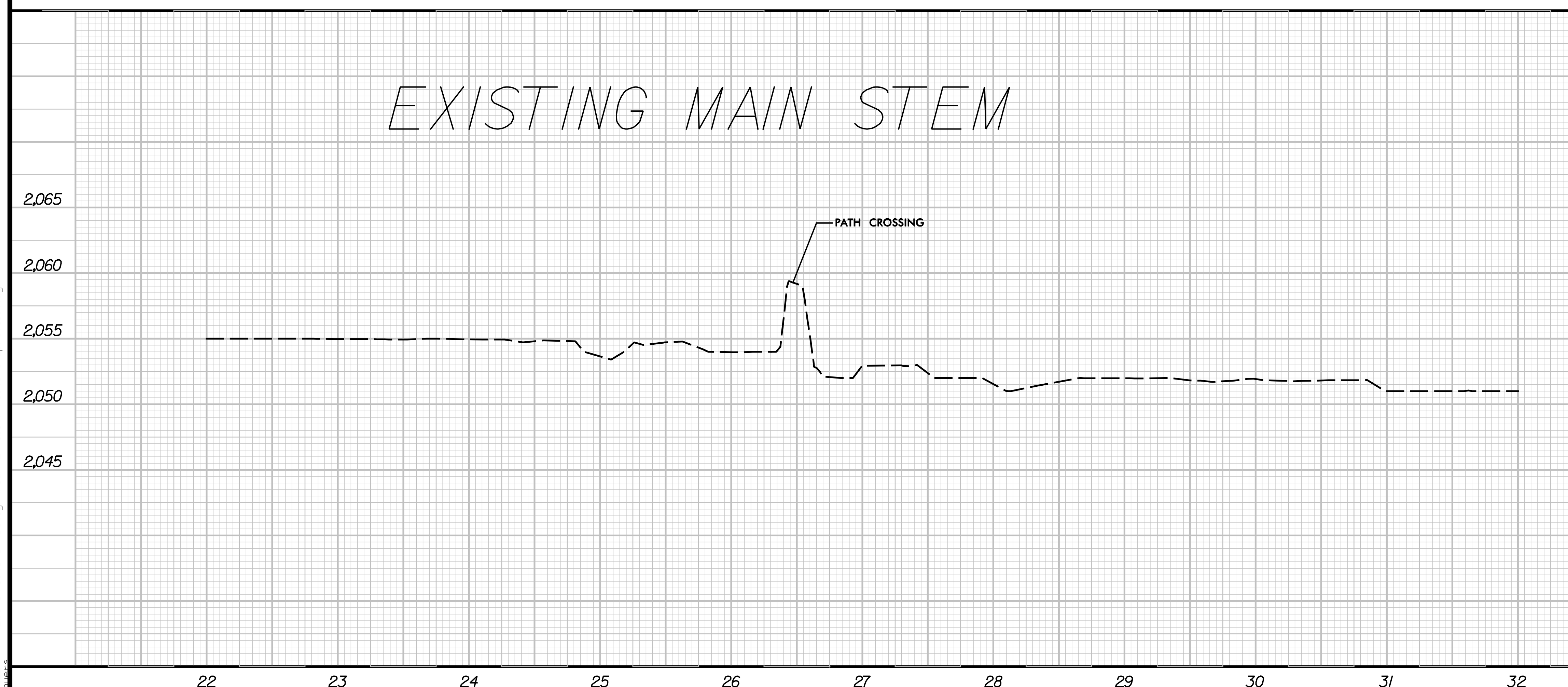
Stream Restoration Project
Henderson County, North Carolina

EXISTING CONDITIONS SHEET 1C





UNNAMED TRIBUTARY TO CANE CREEK

FLETCHER, NC

EXISTING LONGITUDINAL PROFILE

DESIGN SHEET 1D

Ecosystem Enhancement PROGRAM

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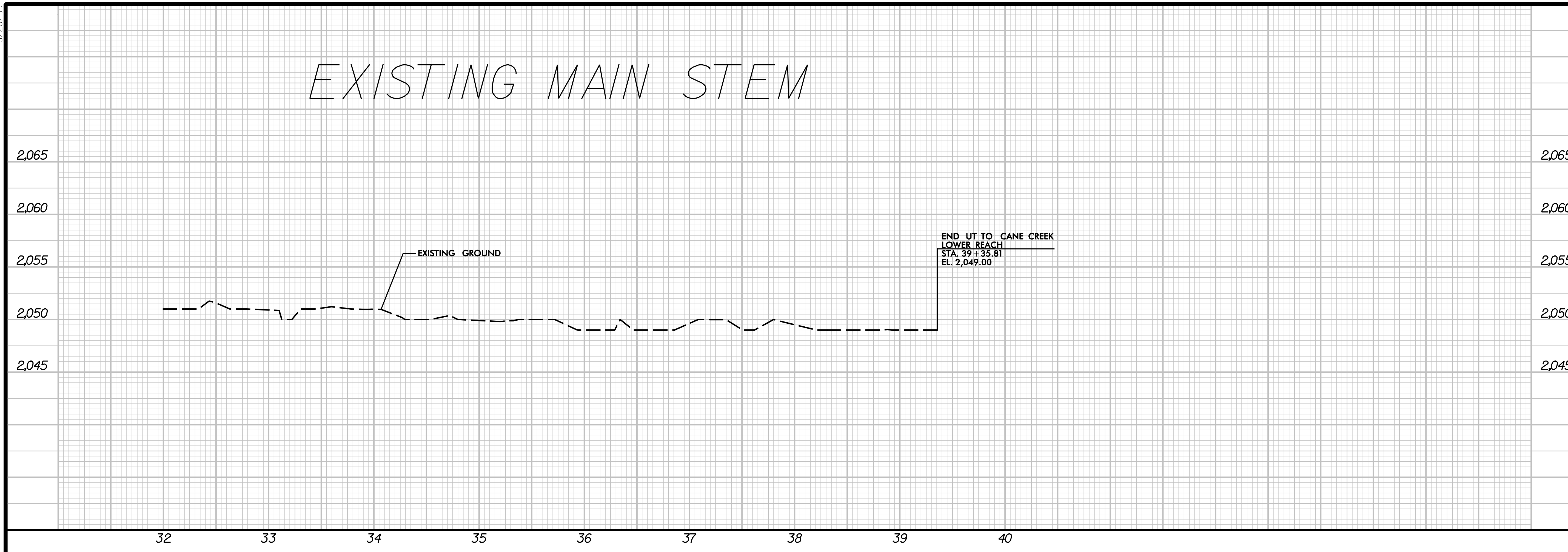

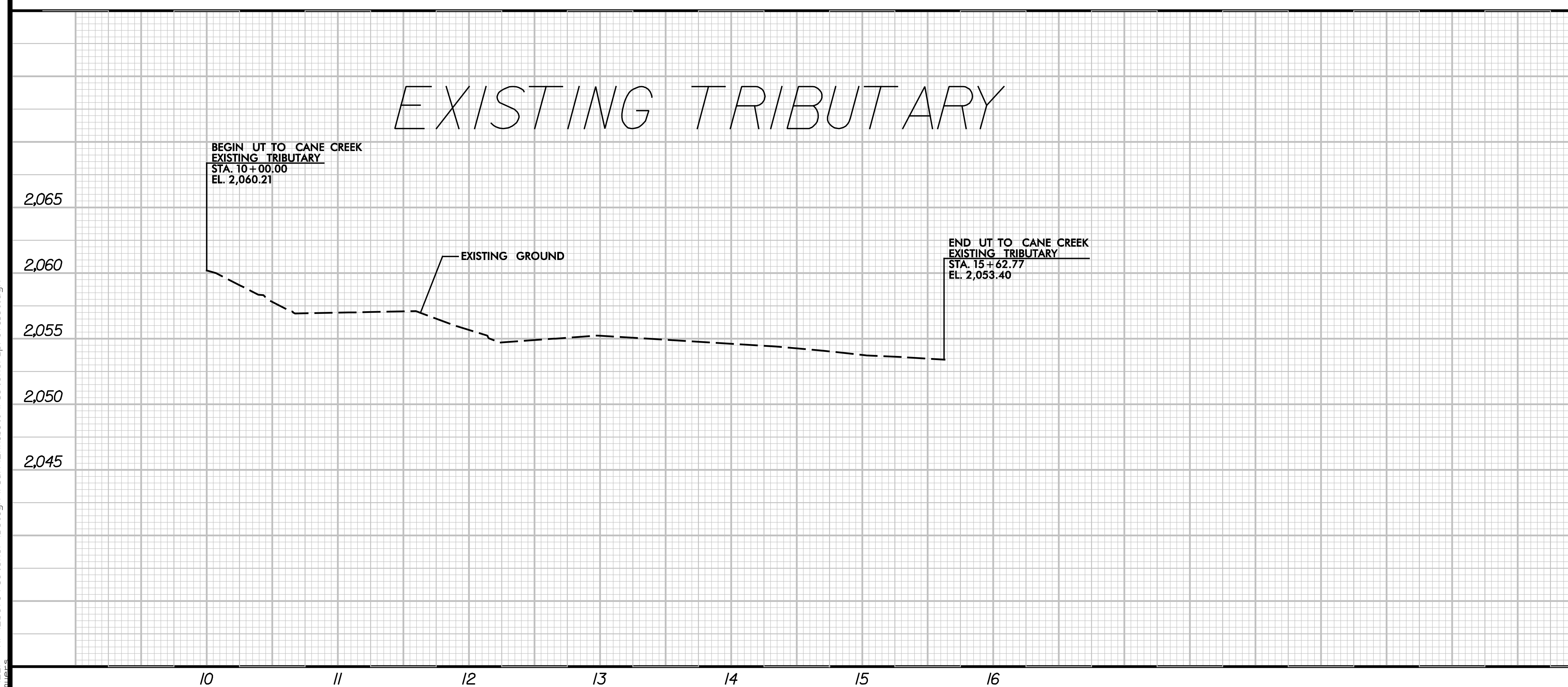

UT TO CANE CREEK

FLETCHER, NC

EXISTING LONGITUDINAL PROFILE

DESIGN SHEET 1E

Ecosystem Enhancement PROGRAM

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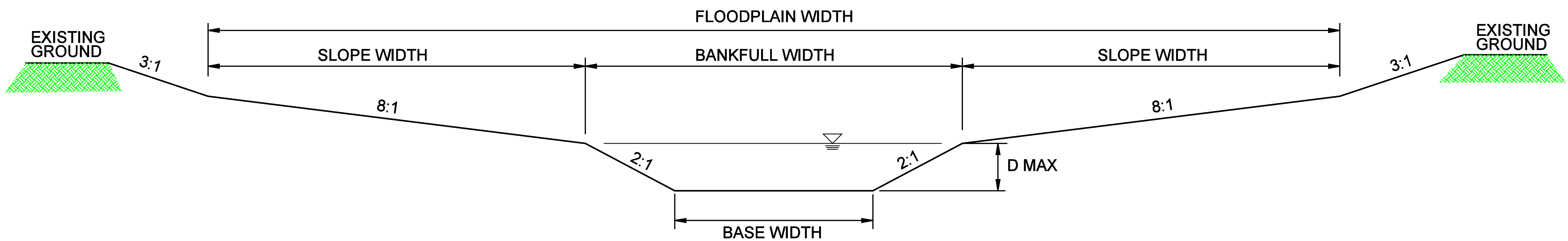
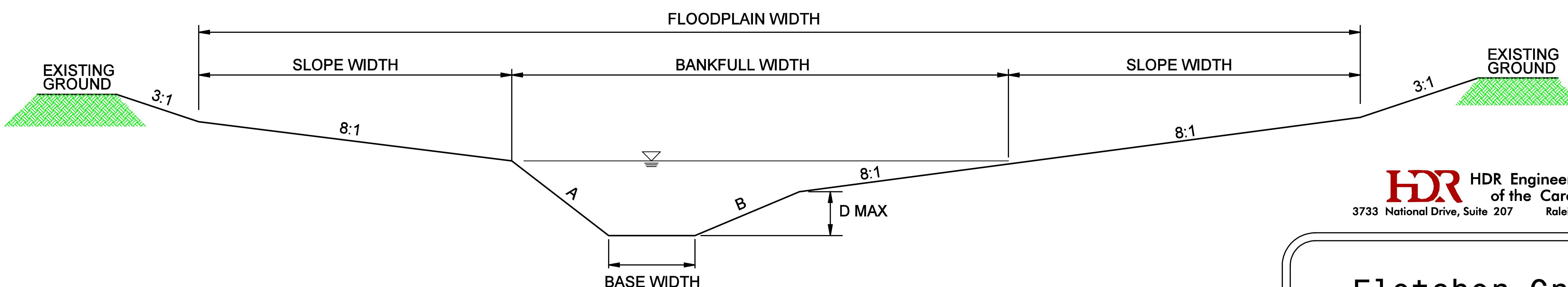
Sheet 2

Design Channel Alignment

TYPICAL SECTIONS

RIFFLE	FLOODPLAIN WIDTH	BANKFULL WIDTH	BASE WIDTH	D MAX	SLOPE WIDTH
UPPER REACH	45′	15′	7.4′	2.1′	15′
LOWER REACH	51′	17′	8.4′	2.1′	17′
TRIB	27′	9′	4.6′	1.1′	9′





POOL	FLOODPLAIN WIDTH	BANKFULL WIDTH	BASE WIDTH	D MAX	SIDE SLOPES A	SIDE SLOPES B	SLOPE WIDTH
UPPER REACH	45′	21′	3.3′	2.9′	1.3:1	2.5:1	12′
LOWER REACH	51′	23.8′	3.8′	3.32′	1.3:1	2.5:1	13.6′
TRIB	27′	12.6′	2.1′	1.1′	1.25:1	2.7:1	7.2′

50 0 100
SCALE = 1″ = 100′

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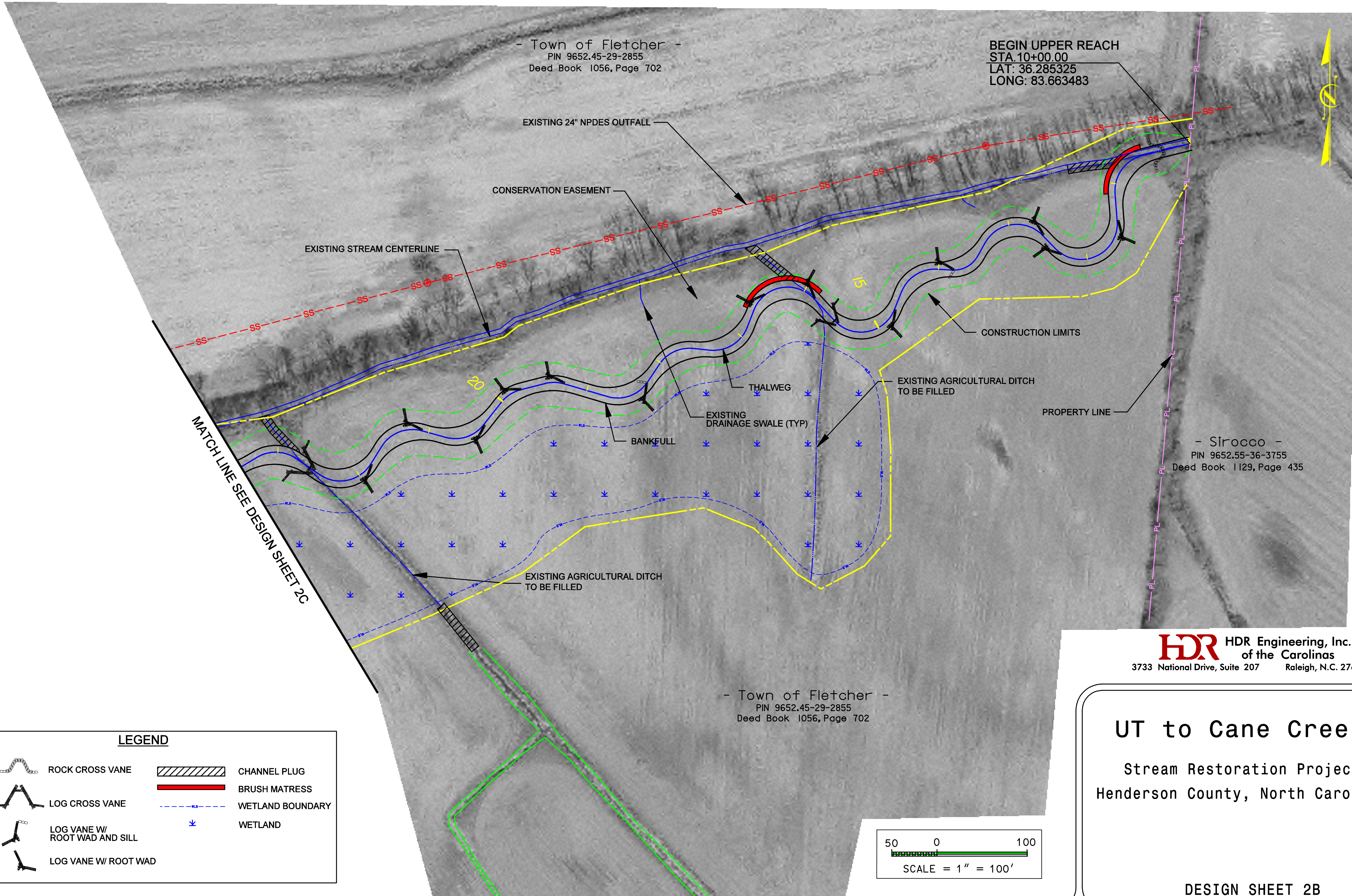
DESIGN SHEET 2A



LEGEND

ROCK CROSS VANE	CHANNEL PLUG
LOG CROSS VANE	BRUSH MATRESS
LOG VANE W/ ROOT WAD AND SILL	WETLAND BOUNDARY
LOG VANE W/ ROOT WAD	WETLAND

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UT to Cane Creek

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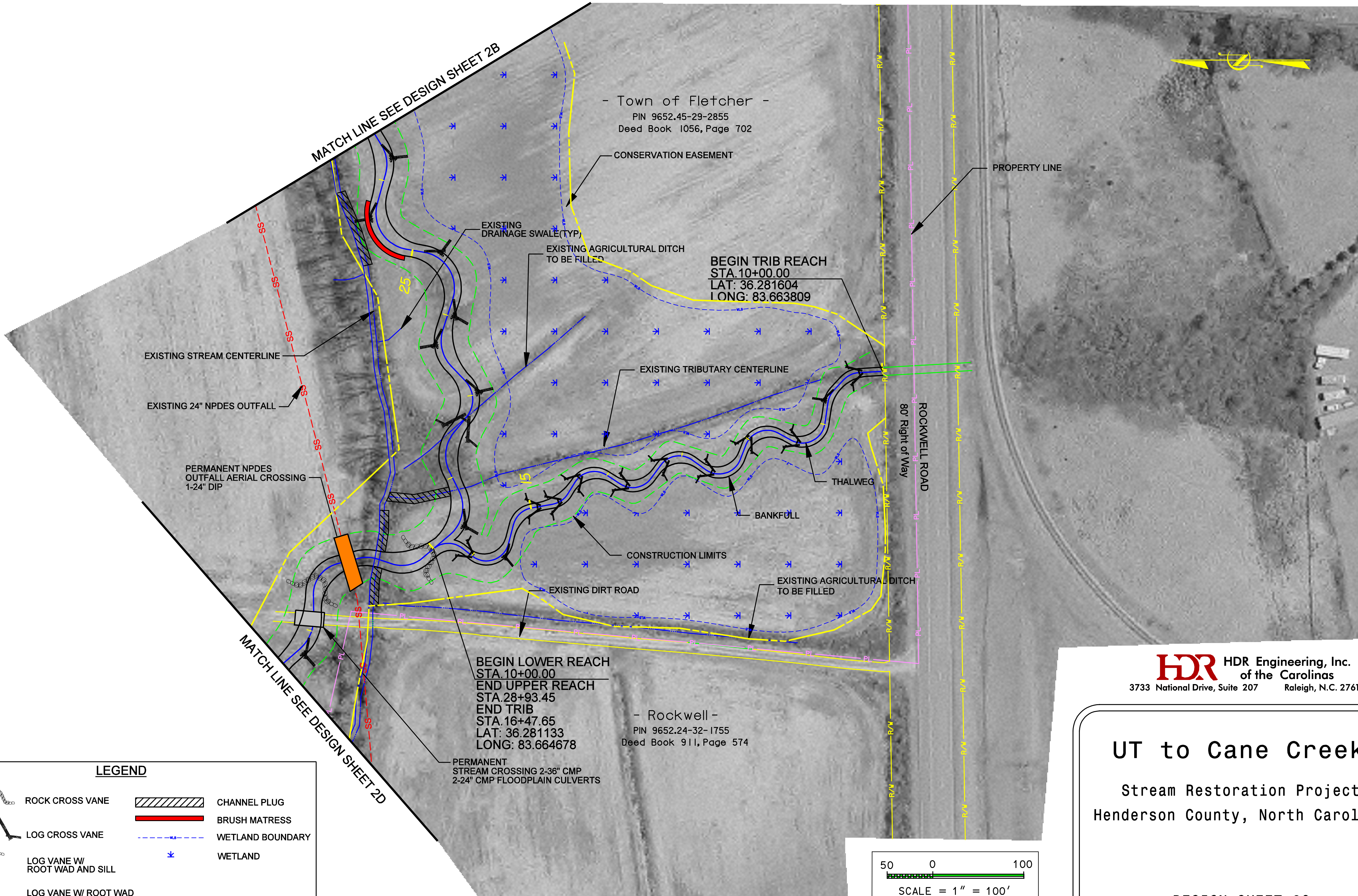
DESIGN SHEET 2B



LEGEND

- ROCK CROSS VANE
- LOG CROSS VANE
- LOG VANE W/ ROOT WAD AND SILL
- LOG VANE W/ ROOT WAD
- CHANNEL PLUG
- BRUSH MATRESS
- WETLAND BOUNDARY
- WETLAND

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SCALE = 1" = 100'

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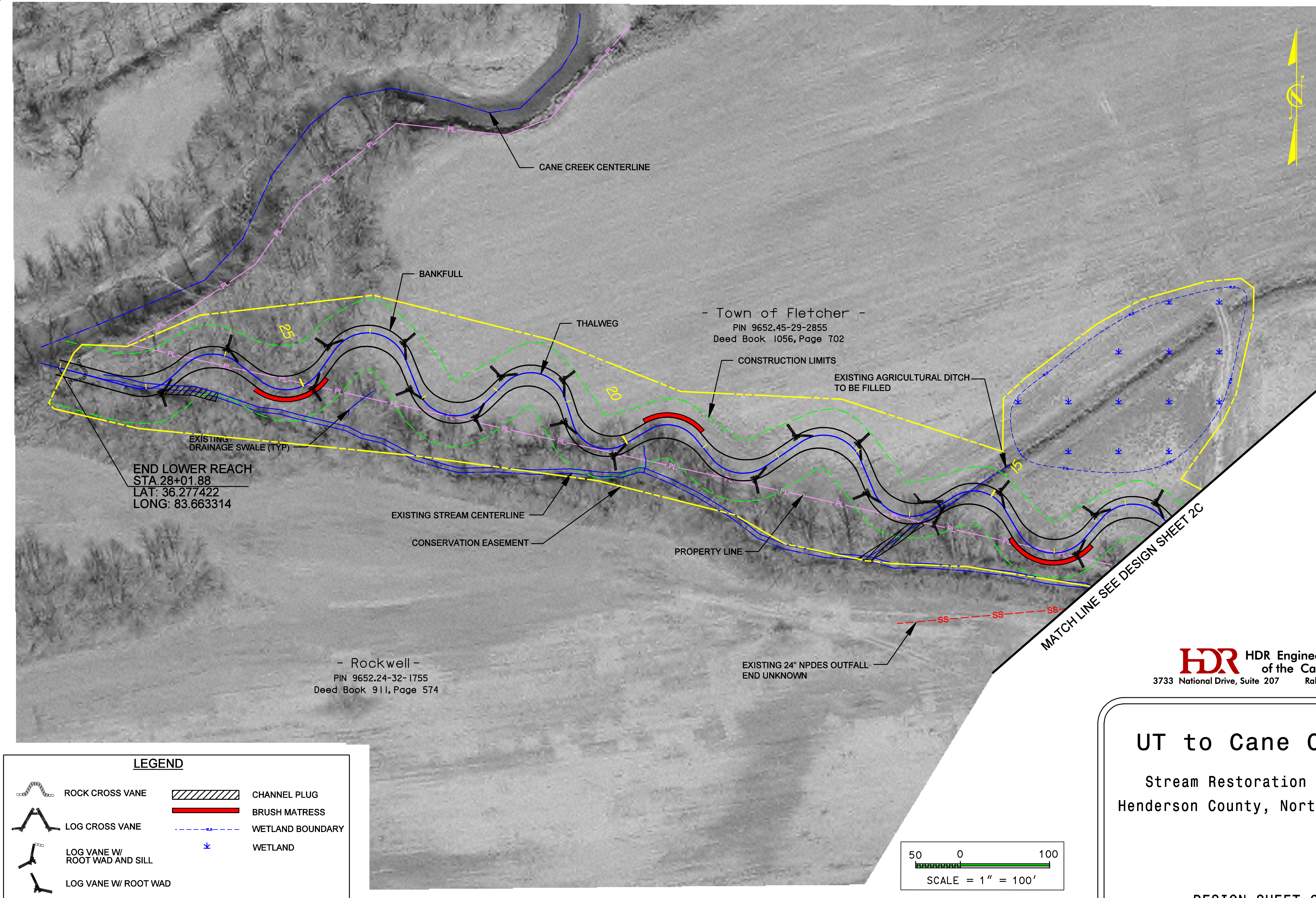
UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

DESIGN SHEET 2C



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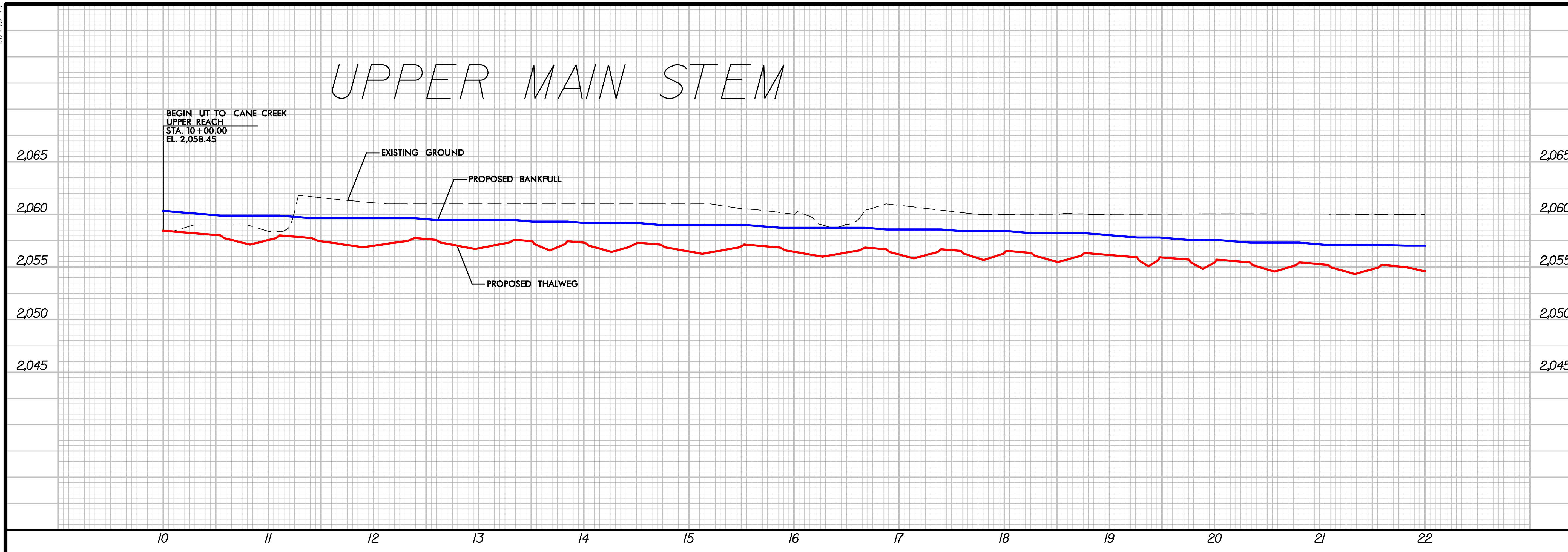
UT to Cane Creek

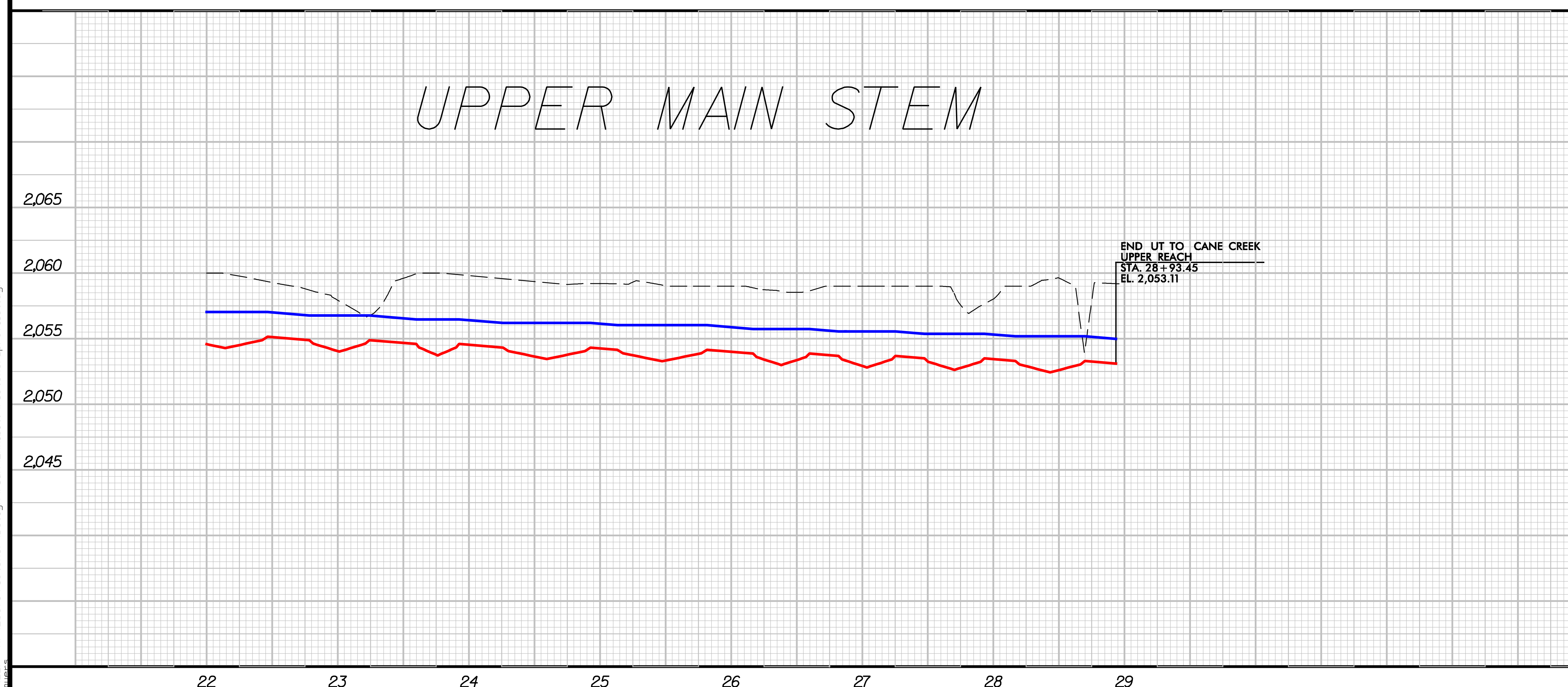
Stream Restoration Project
Henderson County, North Carolina

DESIGN SHEET 2D

Sheet 3

Design Longitudinal Profile





UT TO CANE CREEK

FLETCHER, NC

PROPOSED LONGITUDINAL PROFILE

DESIGN SHEET 3A

Ecosystem Enhancement PROGRAM

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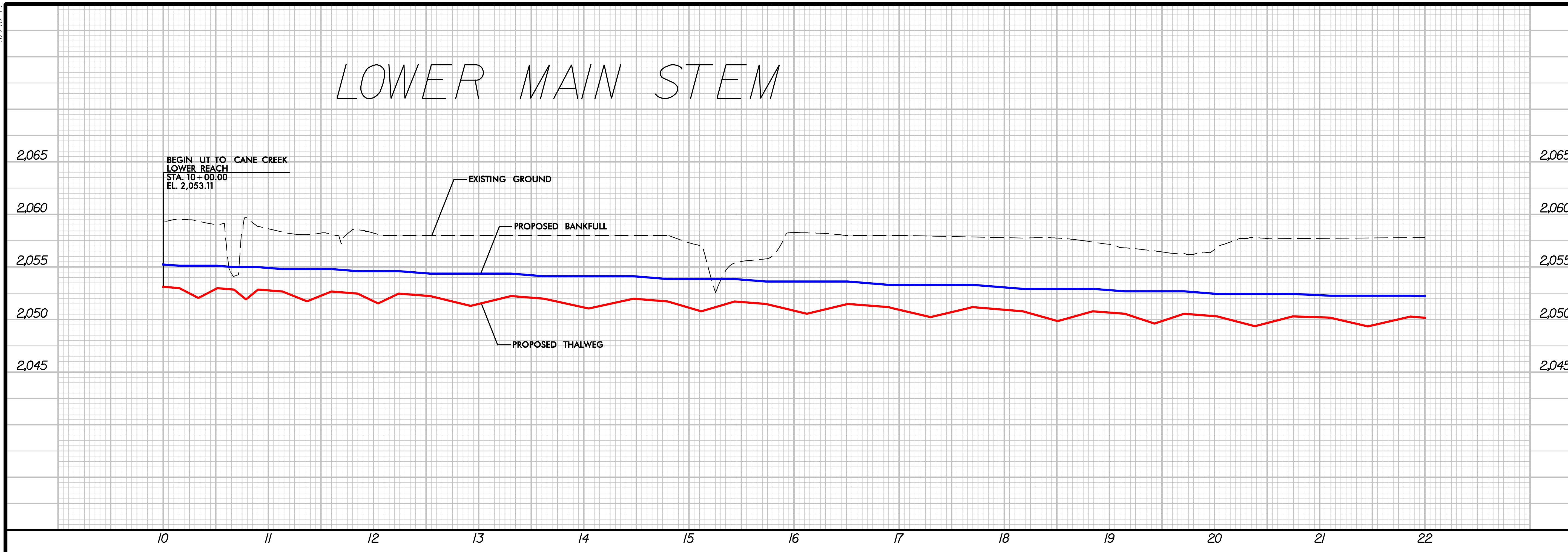

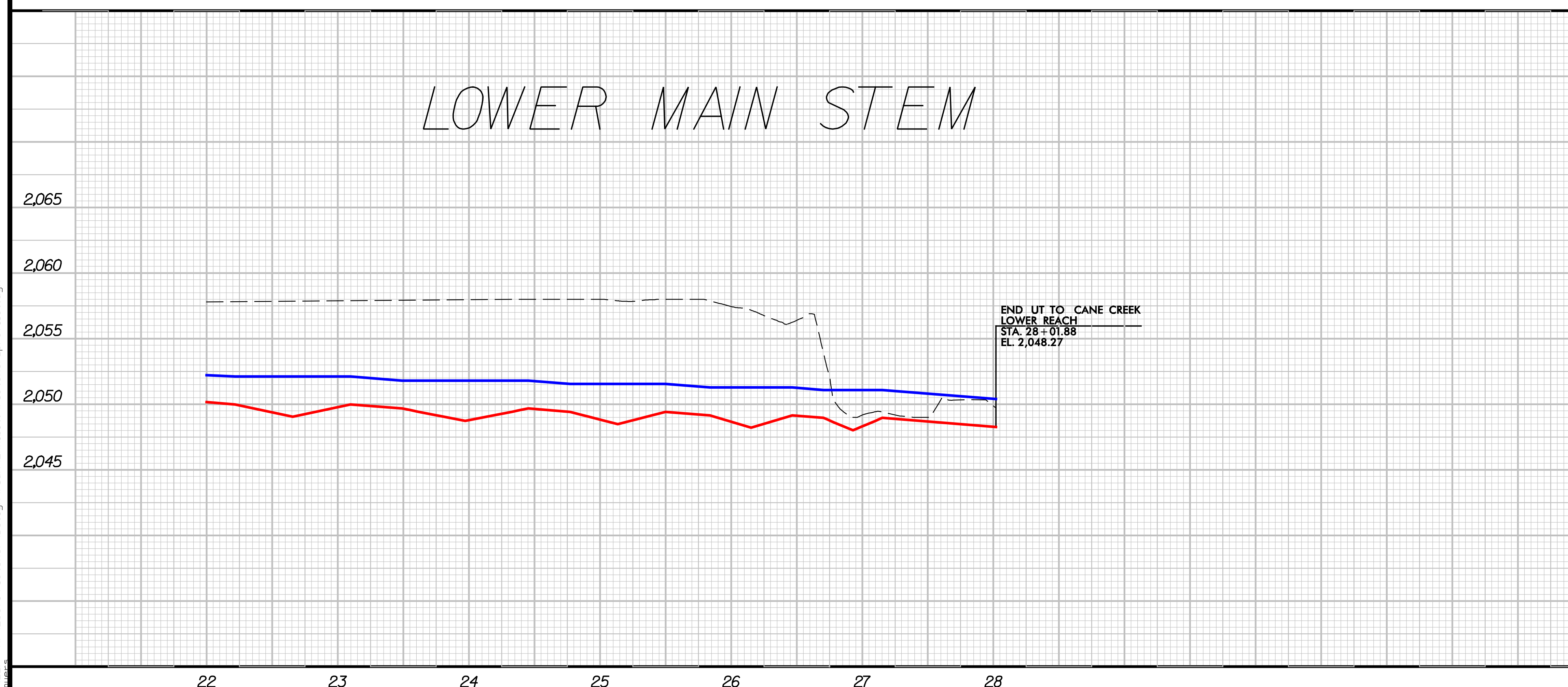

UNNAMED TRIBUTARY TO CANE CREEK

FLETCHER, NC

PROPOSED LONGITUDINAL PROFILE

DESIGN SHEET 3B

Ecosystem Enhancement PROGRAM

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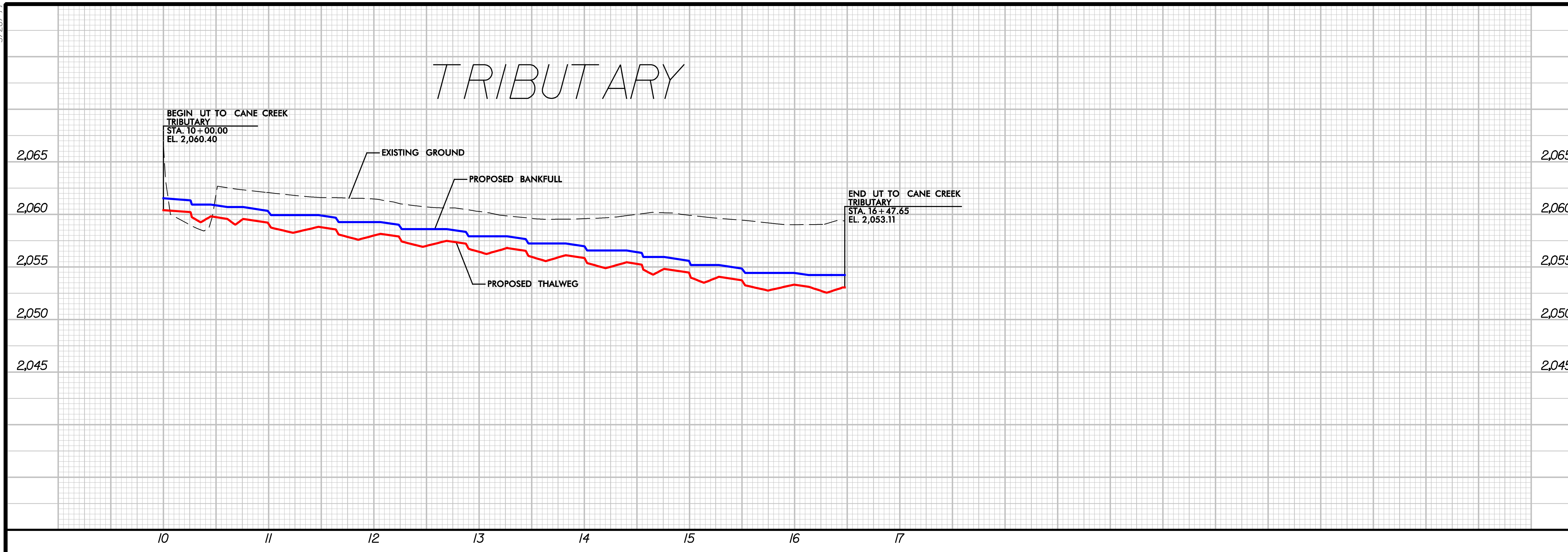

UT TO CANE CREEK

FLETCHER, NC

PROPOSED LONGITUDINAL PROFILE

DESIGN SHEET 3C

Ecosystem Enhancement PROGRAM

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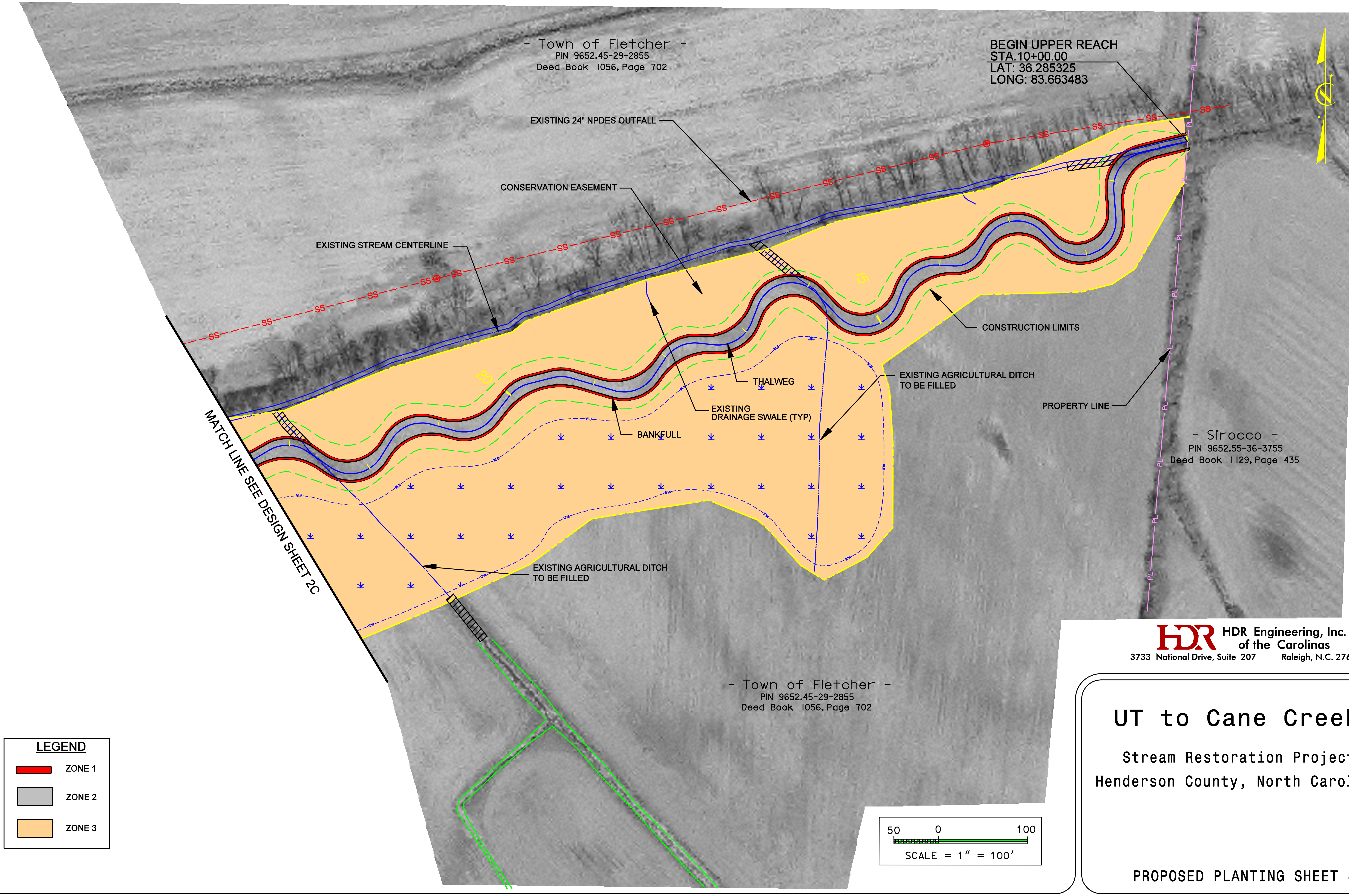
Sheet 4

Designed Vegetative Communities Map by Zone



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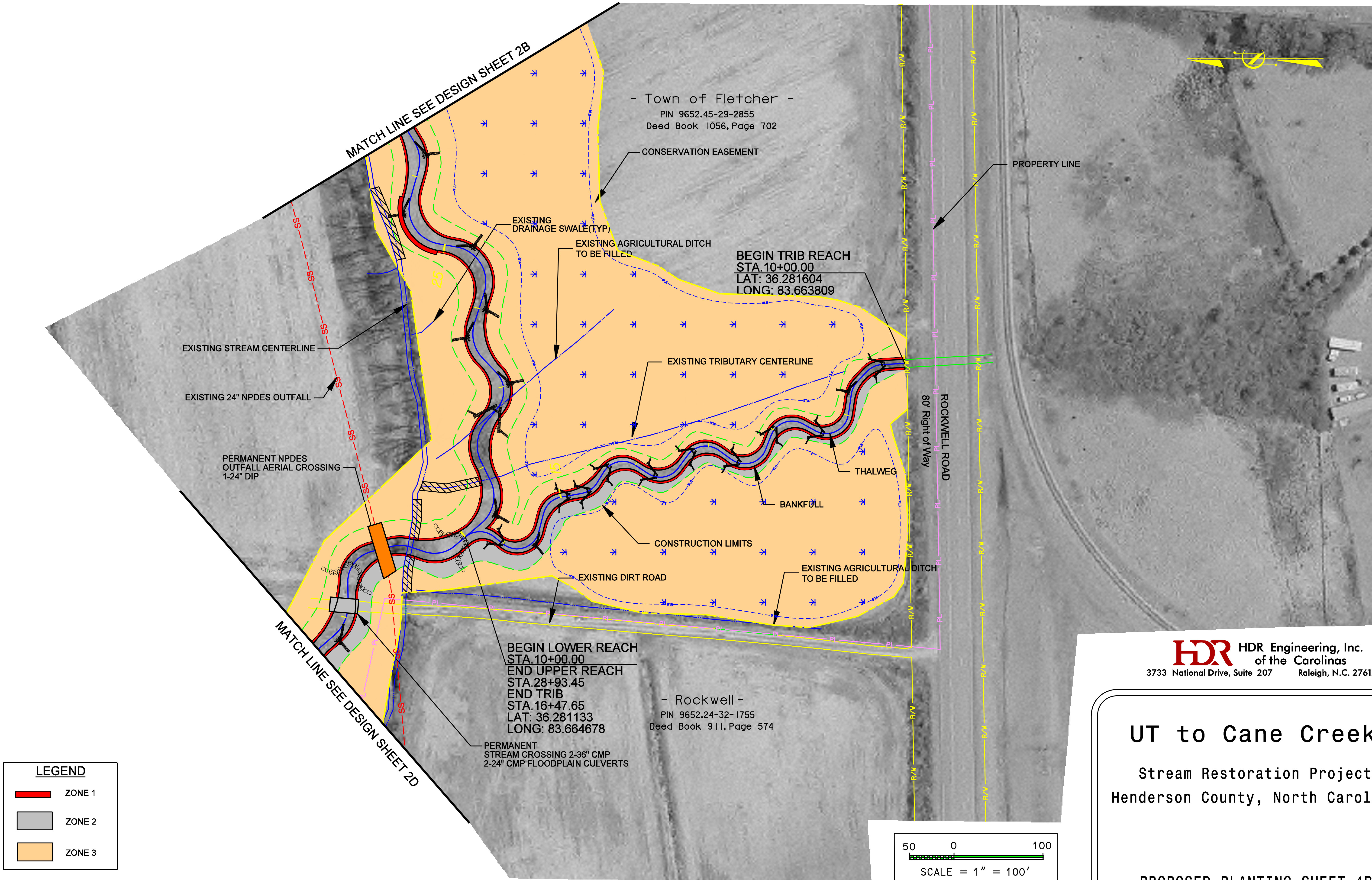
UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

PROPOSED PLANTING SHEET 4A



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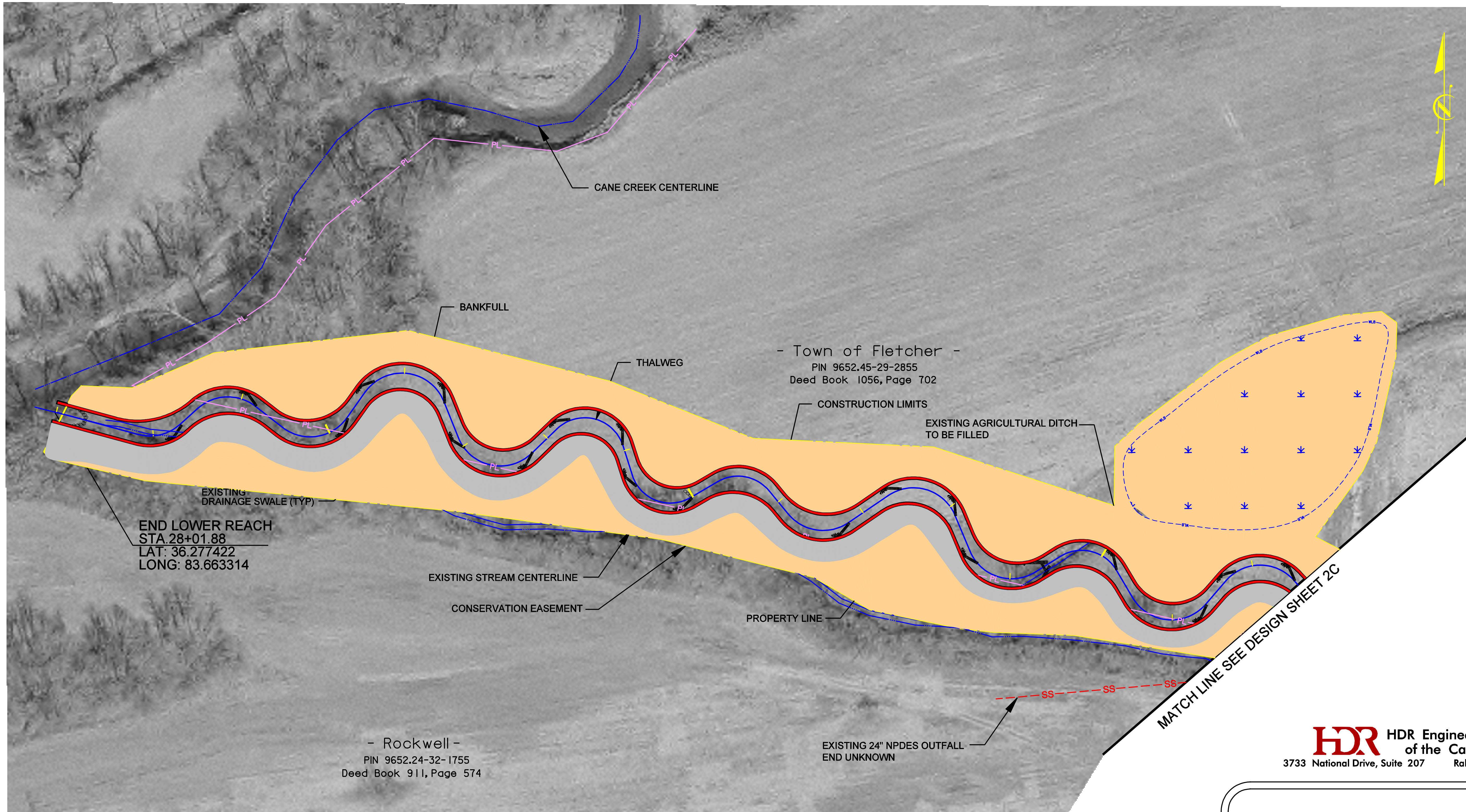
UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

PROPOSED PLANTING SHEET 4B



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LEGEND

ZONE 1

ZONE 2

ZONE 3

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SCALE = 1" = 100'

UT to Cane Creek

Stream Restoration Project

Henderson County, North Carolina

PROPOSED PLANTING SHEET 4C

Appendix A

Restoration Site Photographs (UT to Cane Creek)

Appendix A – UT to Cane Creek Photographs

Photo 1 – Cane Creek adjacent to site, looking downstream

Photo 2 – Looking down the wastewater discharge outfall, with hole in the clay pipe in the foreground

Photo 3 – Confluence of ditch and UT at the top of the project reach; backwater conditions due to beaver activity

Photo 4 – Upper section of project reach, looking south; backwater conditions due to beaver activity

Photo 5 – Depth of backwater (~4 feet) shown in Photo 4

Photo 6 – Upper project reach, looking downstream

Appendix A – UT to Cane Creek Photographs

Photo 7 – Beaver dam in upper project reach

Photo 10 – Lower project reach, looking upstream

Photo 8 – Former beaver dam location, after removal by farmer

Photo 11 – Ditch entering project reach

Photo 9 – Project reach, showing lack of channel structure or pattern

Photo 12 – Lower project reach with unstable banks and bars

Appendix A – UT to Cane Creek Photographs


Photo 13 – Failed wastewater discharge outfall pipe in streambank, just downstream of the farm road crossing


Photo 14 – Lower project reach, showing significant bank instability and channel incision

Appendix B

Reference Site Photographs (Orton Branch)

Appendix B – Orton Branch Photographs


Photo 1 – Meander bend with a small debris jam in the foreground


Photo 2 – View of a riffle and adjacent bedrock, with gravel bar just upstream


Photo 3 – Riffle-pool sequence


Photo 4 – Gravel bar on the inside of a meander bend


Photo 5 – Riffles and pools, looking upstream near the top of the reach

Appendix B – Orton Branch Photographs

Photo 6 – Riffle-pool sequence with a natural log blow-down

Photo 8 – Looking upstream near bottom of the reach

Photo 7 – Riffle in the foreground with some pattern looking downstream

Appendix C

Reference Site Photographs (UT to Little River)

Appendix C – UT to Little River Photographs

Photo 1 – Stable meander with slightly undercut bank habitat, looking upstream

Photo 2 – Looking upstream from outside of a meander bend, with bank vegetation in foreground and natural log structure in the streambed

Photo 3 – Relatively deep pool with sand-dominated substrate

Photo 4 – Channel with typical riparian vegetation shown

Photo 5 – Overhanging vegetation and log habitat in the channel

Appendix C – UT to Little River Photographs

Photo 6 – Log habitat and grade control in-channel

Photo 7 – Riparian zone of reach (two farthest ponchos are in the streambed)

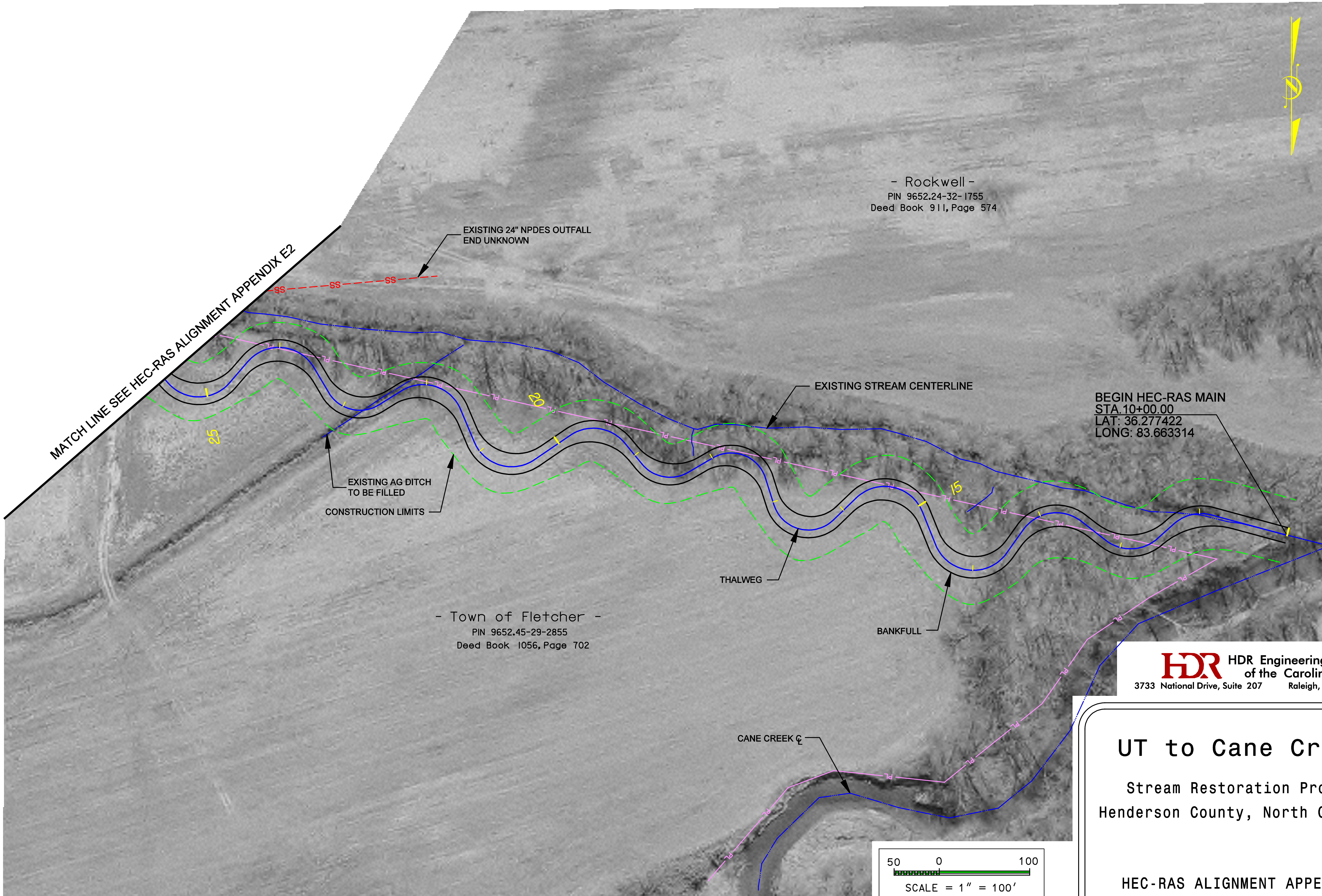
Photo 8 – Riparian wetland, dominated by herbaceous vegetation

Photo 9 – Straight-length section of the reach

Photo 10 – Bottomland hardwood riparian zone, dominated by red maple, ironwood, and interspersed with mountain laurel

Appendix D

HEC-RAS



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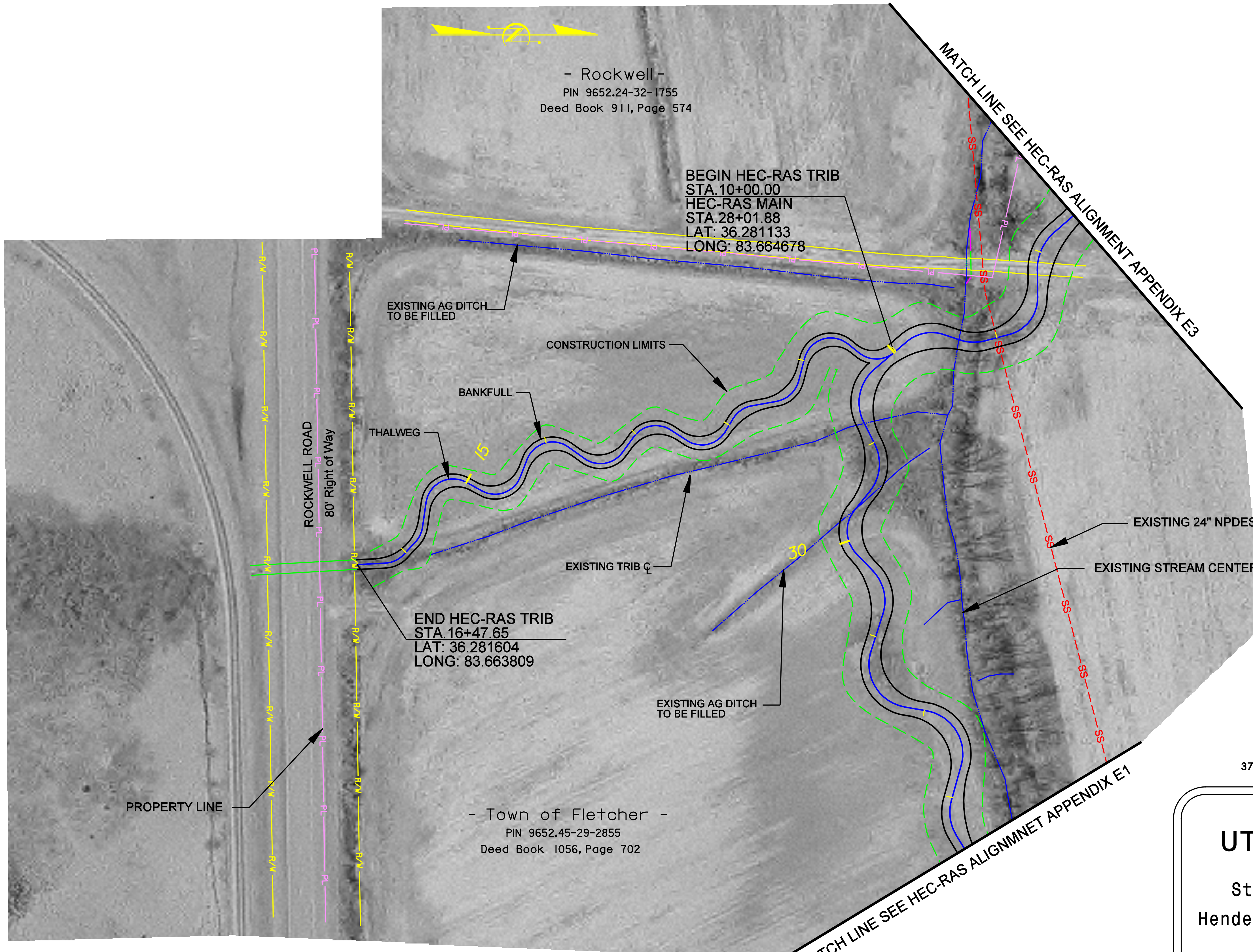
UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

HEC-RAS ALIGNMENT APPENDIX D1



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SCALE = 1" = 100'

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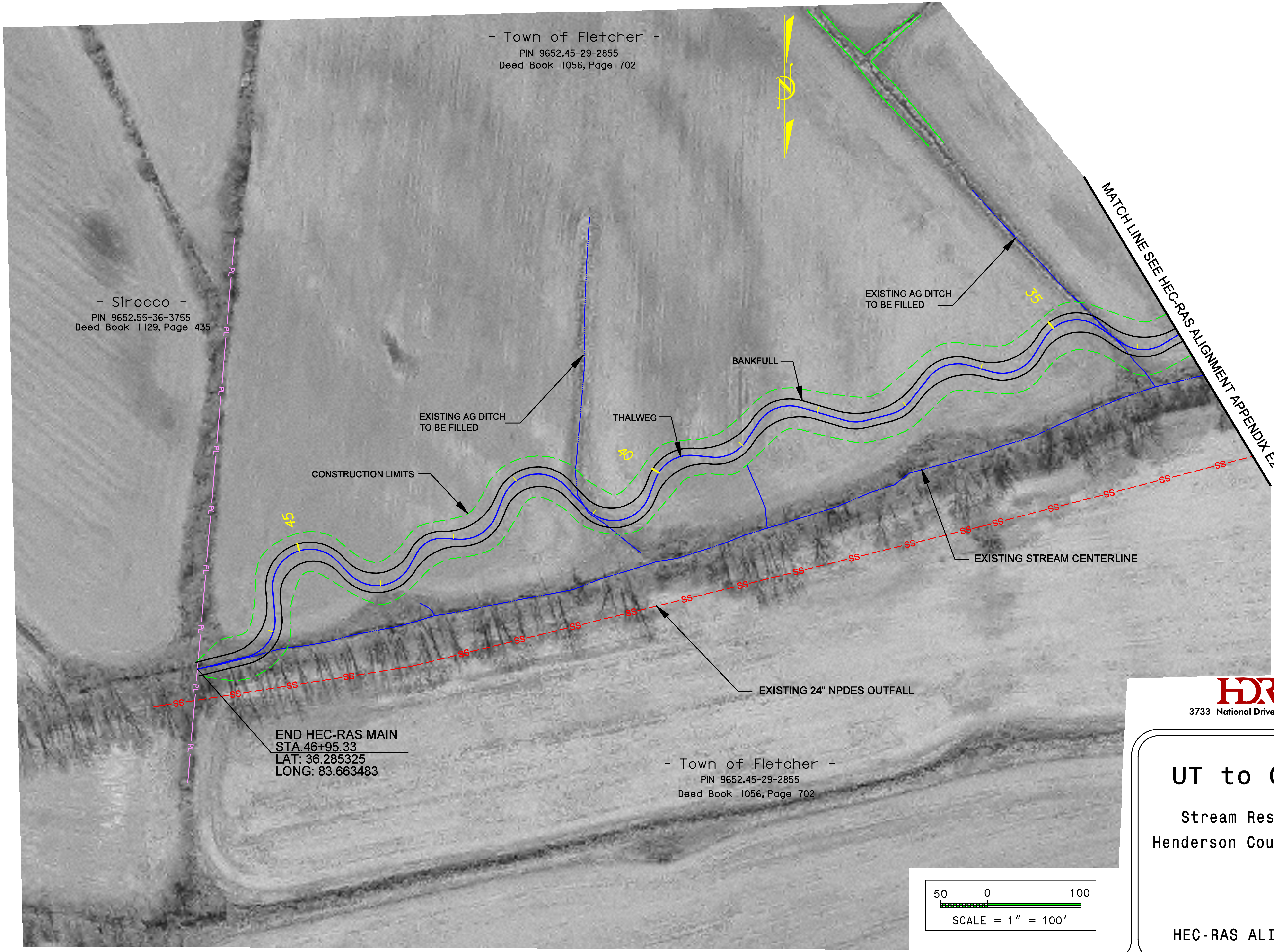
UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

HEC-RAS ALIGNMENT APPENDIX D2



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UT to Cane Creek

Stream Restoration Project
Henderson County, North Carolina

HEC-RAS ALIGNMENT APPENDIX D3

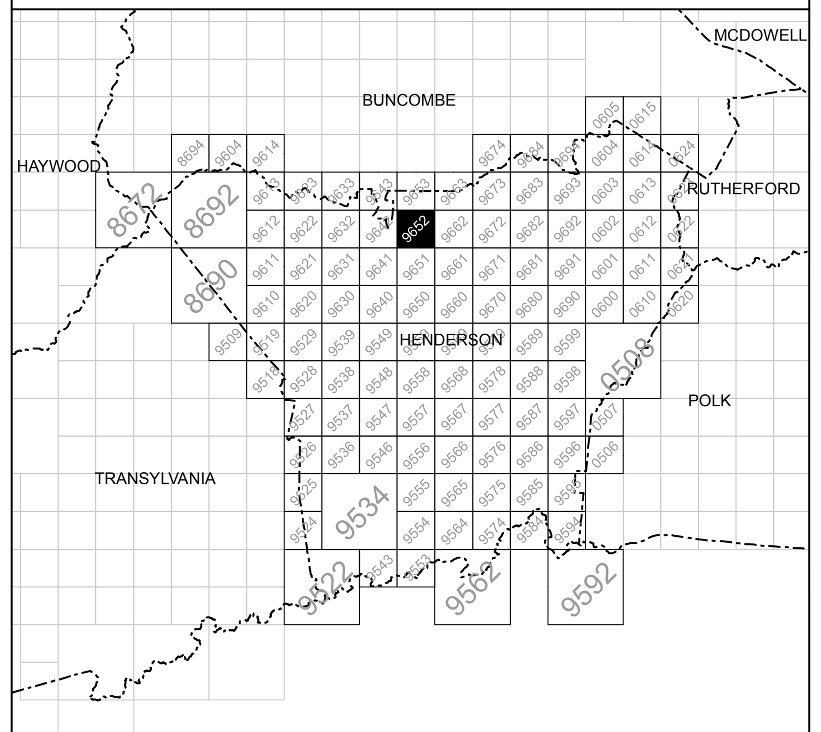
River Sta	Profile	Plan	Q Total	W.S. Elev
3950	Bankfull	proposed	65	2060.02
3950	Bankfull	existing	65	2061.71
3950	2X Bankfull	proposed	130	2060.72
3950	2X Bankfull	existing	130	2061.98
3950	3X Bankfull	proposed	195	2061.23
3950	3X Bankfull	existing	195	2062.13
3950	10-yr	proposed	276	2061.5
3950	10-yr	existing	276	2062.29
3950	50-yr	proposed	501	2061.97
3950	50-yr	existing	501	2062.6
3950	100-yr	proposed	622	2062.21
3950	100-yr	existing	622	2062.75
3750	Bankfull	proposed	65	2059.37
3750	Bankfull	existing	65	2061.41
3750	2X Bankfull	proposed	130	2060.07
3750	2X Bankfull	existing	130	2061.83
3750	3X Bankfull	proposed	195	2060.57
3750	3X Bankfull	existing	195	2061.75
3750	10-yr	proposed	276	2061.04
3750	10-yr	existing	276	2061.82
3750	50-yr	proposed	501	2061.74
3750	50-yr	existing	501	2062.06
3750	100-yr	proposed	622	2062.03
3750	100-yr	existing	622	2062.07
3500	Bankfull	proposed	65	2058.79
3500	Bankfull	existing	65	2060.2
3500	2X Bankfull	proposed	130	2059.43
3500	2X Bankfull	existing	130	2060.62
3500	3X Bankfull	proposed	195	2059.89
3500	3X Bankfull	existing	195	2060.93
3500	10-yr	proposed	276	2060.36
3500	10-yr	existing	276	2060.78
3500	50-yr	proposed	501	2060.69
3500	50-yr	existing	501	2060.93
3500	100-yr	proposed	622	2060.67
3500	100-yr	existing	622	2061.06
3250	Bankfull	proposed	65	2058.48
3250	Bankfull	existing	65	2059.26
3250	2X Bankfull	proposed	130	2058.97
3250	2X Bankfull	existing	130	2059.95
3250	3X Bankfull	proposed	195	2059.34
3250	3X Bankfull	existing	195	2060.23
3250	10-yr	proposed	276	2059.73
3250	10-yr	existing	276	2060.55
3250	50-yr	proposed	501	2060.34
3250	50-yr	existing	501	2060.66
3250	100-yr	proposed	622	2060.51
3250	100-yr	existing	622	2060.72

River Sta	Profile	Plan	Q Total	W.S. Elev
3000	Bankfull	proposed	65	2058.38
3000	Bankfull	existing	65	2059.08
3000	2X Bankfull	proposed	130	2058.73
3000	2X Bankfull	existing	130	2059.5
3000	3X Bankfull	proposed	195	2058.94
3000	3X Bankfull	existing	195	2059.63
3000	10-yr	proposed	276	2059.17
3000	10-yr	existing	276	2059.7
3000	50-yr	proposed	501	2059.81
3000	50-yr	existing	501	2060.59
3000	100-yr	proposed	622	2059.87
3000	100-yr	existing	622	2060.29
2750	Bankfull	proposed	65	2058.37
2750	Bankfull	existing	65	2058.96
2750	2X Bankfull	proposed	130	2058.7
2750	2X Bankfull	existing	130	2059.43
2750	3X Bankfull	proposed	195	2058.88
2750	3X Bankfull	existing	195	2059.57
2750	10-yr	proposed	276	2059.04
2750	10-yr	existing	276	2059.67
2750	50-yr	proposed	501	2059.45
2750	50-yr	existing	501	2060.55
2750	100-yr	proposed	622	2059.69
2750	100-yr	existing	622	2060.05
2515	Bankfull	proposed	65	2058.36
2515	Bankfull	existing	65	2058.77
2515	2X Bankfull	proposed	130	2058.67
2515	2X Bankfull	existing	130	2059.37
2515	3X Bankfull	proposed	195	2058.83
2515	3X Bankfull	existing	195	2059.48
2515	10-yr	proposed	276	2058.96
2515	10-yr	existing	276	2059.55
2515	50-yr	proposed	501	2059.34
2515	50-yr	existing	501	2060.52
2515	100-yr	proposed	622	2059.53
2515	100-yr	existing	622	2059.86
2450	Bankfull	proposed	90	2058.35
2450	Bankfull	existing	90	2058.73
2450	2X Bankfull	proposed	180	2058.65
2450	2X Bankfull	existing	180	2059.35
2450	3X Bankfull	proposed	270	2058.79
2450	3X Bankfull	existing	270	2059.45
2450	10-yr	proposed	356	2058.9
2450	10-yr	existing	356	2059.51
2450	50-yr	proposed	640	2059.13
2450	50-yr	existing	640	2060.51
2450	100-yr	proposed	791	2059.22
2450	100-yr	existing	791	2059.74

River Sta	Profile	Plan	Q Total	W.S. Elev
2370	Bankfull	proposed	90	2058.35
2370	Bankfull	existing	90	2058.71
2370	2X Bankfull	proposed	180	2058.64
2370	2X Bankfull	existing	180	2059.23
2370	3X Bankfull	proposed	270	2058.78
2370	3X Bankfull	existing	270	2059.17
2370	10-yr	proposed	356	2058.88
2370	10-yr	existing	356	2058.97
2370	50-yr	proposed	640	2059.09
2370	50-yr	existing	640	2058.9
2370	100-yr	proposed	791	2059.18
2370	100-yr	existing	791	2059.62
2335			Culvert	
2320	Bankfull	proposed	90	2054.47
2320	Bankfull	existing	90	2055.76
2320	2X Bankfull	proposed	180	2055.27
2320	2X Bankfull	existing	180	2057.12
2320	3X Bankfull	proposed	270	2055.84
2320	3X Bankfull	existing	270	2058.12
2320	10-yr	proposed	356	2056.28
2320	10-yr	existing	356	2058.94
2320	50-yr	proposed	640	2057.38
2320	50-yr	existing	640	2059.39
2320	100-yr	proposed	791	2057.85
2320	100-yr	existing	791	2059.63
2250	Bankfull	proposed	90	2054.28
2250	Bankfull	existing	90	2055.4
2250	2X Bankfull	proposed	180	2055.07
2250	2X Bankfull	existing	180	2056.65
2250	3X Bankfull	proposed	270	2055.66
2250	3X Bankfull	existing	270	2057.58
2250	10-yr	proposed	356	2056.1
2250	10-yr	existing	356	2058.43
2250	50-yr	proposed	640	2057.2
2250	50-yr	existing	640	2059.32
2250	100-yr	proposed	791	2057.67
2250	100-yr	existing	791	2059.59
2000	Bankfull	proposed	90	2053.6
2000	Bankfull	existing	90	2054.5
2000	2X Bankfull	proposed	180	2054.4
2000	2X Bankfull	existing	180	2055.63
2000	3X Bankfull	proposed	270	2054.98
2000	3X Bankfull	existing	270	2056.49
2000	10-yr	proposed	356	2055.42
2000	10-yr	existing	356	2057.17
2000	50-yr	proposed	640	2056.48
2000	50-yr	existing	640	2058.89
2000	100-yr	proposed	791	2056.94
2000	100-yr	existing	791	2059.34

River Sta	Profile	Plan	Q Total	W.S. Elev
1750	Bankfull	proposed	90	2052.83
1750	Bankfull	existing	90	2053.34
1750	2X Bankfull	proposed	180	2053.62
1750	2X Bankfull	existing	180	2054.41
1750	3X Bankfull	proposed	270	2054.18
1750	3X Bankfull	existing	270	2055.24
1750	10-yr	proposed	356	2054.62
1750	10-yr	existing	356	2055.9
1750	50-yr	proposed	640	2055.68
1750	50-yr	existing	640	2057.47
1750	100-yr	proposed	791	2056.12
1750	100-yr	existing	791	2057.69
1500	Bankfull	proposed	90	2052.17
1500	Bankfull	existing	90	2052.54
1500	2X Bankfull	proposed	180	2052.97
1500	2X Bankfull	existing	180	2053.57
1500	3X Bankfull	proposed	270	2053.54
1500	3X Bankfull	existing	270	2054.37
1500	10-yr	proposed	356	2053.97
1500	10-yr	existing	356	2055.01
1500	50-yr	proposed	640	2055.02
1500	50-yr	existing	640	2056.75
1500	100-yr	proposed	791	2055.46
1500	100-yr	existing	791	2057.61
1250	Bankfull	proposed	90	2051.45
1250	Bankfull	existing	90	2051.9
1250	2X Bankfull	proposed	180	2052.22
1250	2X Bankfull	existing	180	2052.87
1250	3X Bankfull	proposed	270	2052.76
1250	3X Bankfull	existing	270	2053.64
1250	10-yr	proposed	356	2053.18
1250	10-yr	existing	356	2054.28
1250	50-yr	proposed	640	2054.26
1250	50-yr	existing	640	2055.99
1250	100-yr	proposed	791	2054.72
1250	100-yr	existing	791	2056.71
1100	Bankfull	proposed	90	2050.91
1100	Bankfull	existing	90	2051.46
1100	2X Bankfull	proposed	180	2051.67
1100	2X Bankfull	existing	180	2052.42
1100	3X Bankfull	proposed	270	2052.21
1100	3X Bankfull	existing	270	2053.19
1100	10-yr	proposed	356	2052.63
1100	10-yr	existing	356	2053.83
1100	50-yr	proposed	640	2053.66
1100	50-yr	existing	640	2055.54
1100	100-yr	proposed	791	2054.11
1100	100-yr	existing	791	2056.26

STATE OF NORTH CAROLINA FIRM PANEL LOCATOR DIAGRAM



DATUM INFORMATION

The **projection** used in the preparation of this map was the North Carolina State Plane (FIPSZONE 3200). The **horizontal datum** was the North American Datum of 1983, GRS80 ellipsoid. Differences in datum, ellipsoid, projection, or Universal Transverse Mercator zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdictional boundaries. These differences do not affect the accuracy of this FIRM. All coordinates on this map are in U.S. Survey Feet, where 1 U.S. Survey Foot = 1200/3937 Meters.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988 (NAVD 88). These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. An average offset between NAVD 88 and the National Geodetic Vertical Datum of 1929 (NGVD 29) has been computed for each North Carolina county. This offset was then applied to the NGVD 29 flood elevations that were not revised during the creation of this statewide format FIRM. The offsets for each county shown on this FIRM panel are shown in the vertical datum offset table below. Where a county boundary and a flooding source with unrevised NGVD 29 flood elevations are coincident, an individual offset has been calculated and applied during the creation of this statewide format FIRM. See Section 6.1 of the accompanying Flood Insurance Study report to obtain further information on the conversion of elevations between NAVD 88 and NGVD 29. To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the North Carolina Geodetic Survey at the address shown below. You may also contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

North Carolina Geodetic Survey
121 West Jones Street
Raleigh, NC 27601
(919) 733-3836
http://www.ncgs.state.nc.us

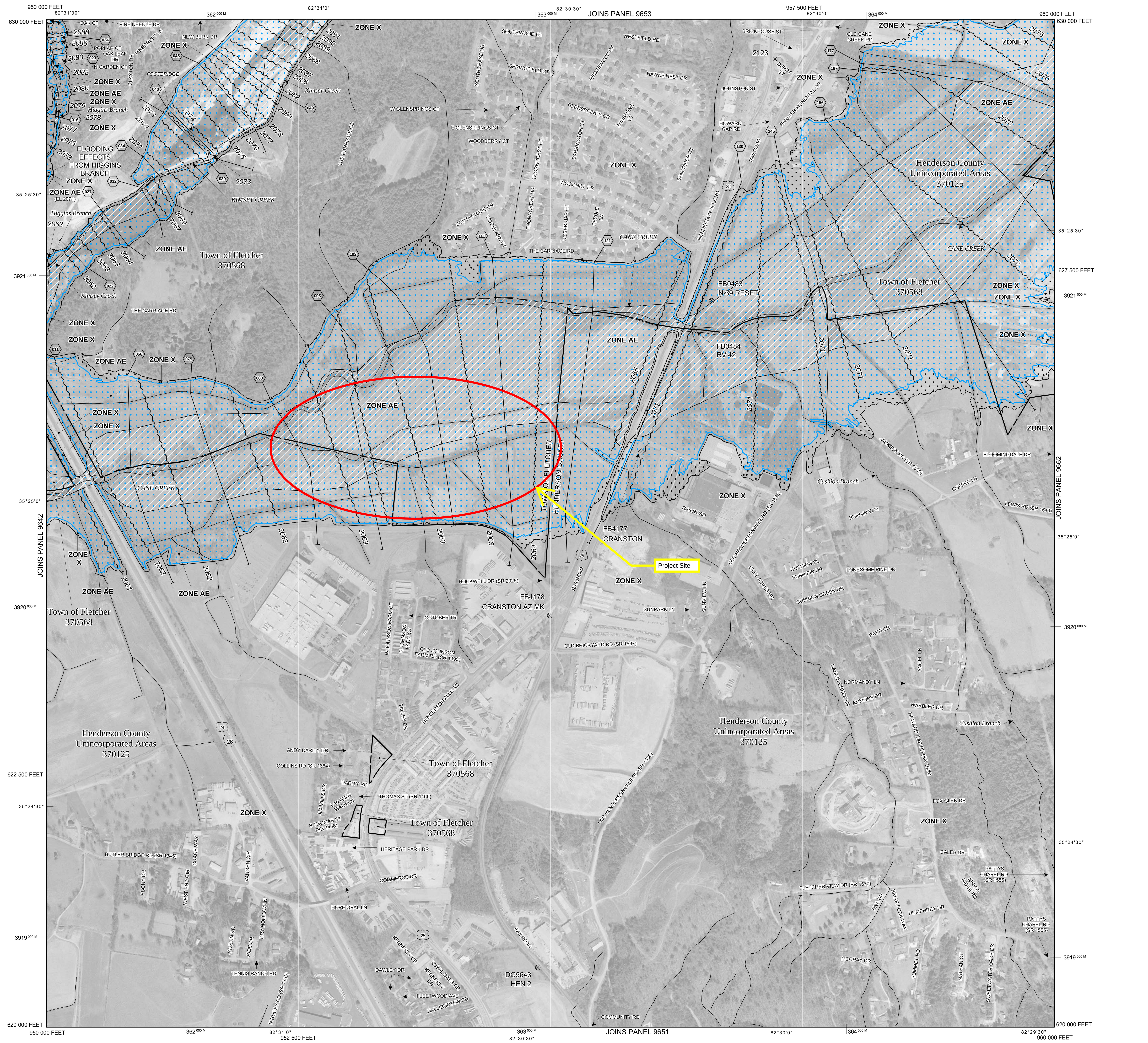
County Average Vertical Datum Offset Table

County	Vertical Datum Offset (ft)
Henderson	-0.15
Example: NAVD 88 = NGVD 29 + (-0.15)	

All streams listed in the **Flood Hazard Data Table** below were studied by detailed methods using field survey. Other flood hazard data shown on this map may have been derived using either a coastal analysis or limited detailed riverine analysis. More information on the flooding sources studied by these analyses is contained in the Flood Insurance Study report.

FLOOD HAZARD DATA TABLE				Floodway Width (feet)
Cross Section	Stream Station[1]	Flood Discharge (cfs)	1% Annual Chance (100-year) Water-Surface Elevation (feet NAVD 88)	Left/Right Distance From The Center of Stream to Encroachment Boundary (Looking Downstream) or Total Floodway Width
CANE CREEK				
066	6,642	11,600	2,062.0	445 / 395
075	7,459	11,600	2,062.1	457 / 443
083	8,270	11,480	2,062.4	719 / 131
093	9,313	11,480	2,062.6	926 / 149
102	10,197	11,480	2,062.8	1,098 / 32
111	11,079	11,480	2,063.2	1,245 / 33
121	12,053	11,480	2,064.1	1,117 / 38
130	12,981	11,400	2,069.1	1,354 / 116
145	14,471	11,340	2,070.9	586 / 614
156	15,589	11,340	2,071.9	695 / 755
167	16,741	11,340	2,072.6	178 / 867
177	17,715	11,340	2,074.1	199 / 1,111
HIGGINS BRANCH				
016	1,611	930	2,078.0	16 / 16
023	2,262	930	2,085.4	16 / 19
024	2,437	930	2,087.9	35 / 23
KIMSEY CREEK				
011	1,078	1,860	2,061.5	78 / 84
022	2,185	1,420	2,061.9	64 / 21
027	2,705	1,420	2,064.5	165 / 9
032	3,156	1,420	2,065.3	237 / 10
034	3,379	1,420	2,070.3	15 / 15
039	3,899	1,420	2,073.1	20 / 30
040	3,977	1,420	2,073.1	17 / 70
045	4,475	1,420	2,076.3	16 / 18
049	4,918	1,420	2,080.9	11 / 194

[1] Feet above mouth



NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles, Floodway Data, Limited Detailed Flood Hazard Data, and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of **regulatory floodways** shown on the FIRM for flooding sources studied by detailed methods were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data for flooding sources studied by detailed methods as well as **non-encroachment widths** for flooding sources studied by limited detailed methods are provided in the FIS report for this jurisdiction. The FIS report also provides instructions for determining a floodway using non-encroachment widths for flooding sources studied by limited detailed methods.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 4.4 "Flood Protection Measures" of the Flood Insurance Study report for information on the flood control structures in this jurisdiction.

Base map information and geospatial data used to develop this FIRM were obtained from various organizations, including the participating local community(ies), state and federal agencies, and/or other sources. The primary base for this FIRM is aerial imagery acquired by Henderson County. The time period of collection for the Henderson imagery is 2001. Information and geospatial data supplied by the local community(ies) that met FEMA base map specifications were considered the preferred source for development of the base map. See geospatial metadata for the associated digital FIRM for additional information about base map preparation.

Base map features shown on this map, such as **corporate limits**, are based on the most up-to-date data available at the time of publication. **Changes in the corporate limits may have occurred since this map was published**. Map users should consult the appropriate community official or website to verify current conditions of jurisdictional boundaries and base map features. This map may contain roads that were not considered in the hydraulic analysis of streams where no new hydraulic model was created during the production of this statewide format FIRM.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

If you have **questions about this map**, or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov.

An accompanying Flood Insurance Study report, Letter of Map Revision (LOMR) or Letter of Map Amendment (LOMA) revising portions of this panel, and digital versions of this FIRM may be available. Visit the **North Carolina Floodplain Mapping Program** website at http://www.ncfloodmaps.com, or contact the **FEMA Map Service Center** at 1-800-358-9616 for information on all related products associated with this FIRM. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov.

MAP REPOSITORY

Refer to listing of Map Repositories on Map Index or visit http://www.ncfloodmaps.com.

EFFECTIVE DATE OF FLOOD INSURANCE RATE MAP PANEL

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to statewide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent, the North Carolina Division of Emergency Management or the National Flood Insurance Program at the following phone numbers or websites:

NC Division of Emergency Management
(919) 715-8000 http://www.nccrimecontrol.org/nfip

National Flood Insurance Program
1-800-638-6620 http://www.fema.gov/business/nfip

NORTH CAROLINA Cooperating Technical State
FEMA'S COOPERATING TECHNICAL PARTNER

This digital Flood Insurance Rate Map (FIRM) was produced through a unique cooperative partnership between the State of North Carolina and the Federal Emergency Agency (FEMA). The State of North Carolina has implemented a long term approach of floodplain management to decrease the costs associated with flooding. This is demonstrated by the State's commitment to map floodplain areas at the local level. As a part of this effort, the State of North Carolina has joined in a Cooperating Technical State agreement with FEMA to produce and maintain this digital FIRM.

www.ncfloodmaps.com

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

012	Cross section line
23 – – – 23	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4276 000 M	1000-meter Universal Transverse Mercator grid ticks, zone 17
1 477 500 FEET	2500-foot grid values: North Carolina State Plane coordinate system (FIPSZONE 3200, State Plane NAD 83 feet)
BM5510 ×	North Carolina Geodetic Survey bench mark (for more information Visit http://www.ncgs.state.nc.us).
BM5510 ⊗	National Geodetic Survey bench mark (for more information visit http://www.ngs.noaa.gov).
BM5510 ◈	NGS-58 GPS 2-5 cm Vertical Control Marks or Contractor-Established NCFMP Bench Marks (for more information visit http://www.ncgs.state.nc.us)
● M1.5	River Mile

GRID NORTH

MAP SCALE 1" = 500' (1 : 6,000)

250 0 500 1000 FEET

150 0 150 300 METERS

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

PANEL 9652J

FIRM
FLOOD INSURANCE RATE MAP
NORTH CAROLINA

PANEL 9652

(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	CID No.	PANEL	SUFFIX
FLETCHER, TOWN OF	370568	9652	J
HENDERSON COUNTY	370125	9652	J

PRELIMINARY
MAY 21 2007

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.

EFFECTIVE DATE

MAP NUMBER
3700965200J

State of North Carolina
Federal Emergency Management Agency

Appendix E

NCDWQ Stream Classification Forms for UT to Cane Creek, Orton Branch, and UT to Little River

NCDWQ Stream Classification Form

Project Name: FLETCHER DESERTION River Basin: FRENCH BROAD County: HENDERSON Evaluator: ERIC MULARSKI
DWQ Project Number: Nearest Named Stream: CANE CREEK Latitude: 35.4186944 Signature: Eric Mul
Date: 10/3/07 USGS QUAD: SKYLAND Longitude: -82.509718 Location/Directions: SEE ATTACHED MAP

PLEASE NOTE: ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used****

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3
****NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0****				
10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present?		***Yes=3***	***No=0***	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 19

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 7

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 2.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel ***And*** >48 Hrs Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		***Yes=1.5***	***No=0***	

SECONDARY HYDROLOGY INDICATOR POINTS: 6.0

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(* ***NOTE:*** *If Total Absence Of All Plants In Streambed As Noted Above Skip This Step* ***UNLESS*** *SAV Present*)*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 4.5

TOTAL POINTS (Primary + Secondary) = 40
(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

USACE AID#________ DWQ #________ Site #____ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: NCEEP
2. Evaluator's name: ERIC MULARSKI
3. Date of evaluation: 10/3/07
4. Time of evaluation: 12:30
5. Name of stream: UT TO CANE CREEK
6. River basin: FRENCH BROAD
7. Approximate drainage area:
8. Stream order: 2ND
9. Length of reach evaluated: ≈2000'
10. County: HENDERSON
11. Site coordinates (if known): prefer in decimal degrees
12. Subdivision name (if any):

Latitude (ex 34.872312): 35.4186944 Longitude (ex –77.556611): -82.509718

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): FROM I-26 TAKE US25 FLETCHER EXIT PROCEED NORTH TAKE LEFT ON ROCKWELL SITE ON NORTH SIDE OF ROAD
14. Proposed channel work (if any): RESTORATION
15. Recent weather conditions: CLOUDY 70'S
16. Site conditions at time of visit: CLOUDY 70'S
17. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: ____% Residential ____% Commercial ____% Industrial 85% Agricultural 15% Forested ____% Cleared / Logged ____% Other (____)
22. Bankfull width: 20'
23. Bank height (from bed to top of bank): 6'
24. Channel slope down center of stream: ✓ Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
25. Channel sinuosity: ✓ Straight ____Occasional bends ____Frequent meander ____Very sinuous ____Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 42 **Comments:** EXTREME DROUGHT CONDITIONS

Evaluator's Signature [signature] **Date** 10/3/07

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE Coastal	Piedmont	Mountain	SCORE
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	5
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	1
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	1
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	1
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	1
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	2
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	2
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	2
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	2
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	3
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				42

* These characteristics are not assessed in coastal streams.

UT to UT

NCDWQ Stream Classification Form

Project Name: FLETCHER RESTORATION River Basin: FRENCH BROAD County: HENDERSON Evaluator: ERIC [signature]
DWQ Project Number: Nearest Named Stream: CANE CREEK Latitude: 35. Signature: [signature]
Date: 10/3/07 USGS QUAD: SKYLAND Longitude: -82. Location/Directions: SEE MAP

PLEASE NOTE: ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used****

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3

****NOTE**: *If Bed & Bank Caused By Ditching And **WITHOUT** Sinuosity Then Score=0**)

10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present? ***Yes***=3 ***No***=0

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 12

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 2

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 6

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 3.0

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		***Yes***=*1.5*		***No***=0

SECONDARY HYDROLOGY INDICATOR POINTS: 4.5

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(* ***NOTE:*** *If Total Absence Of All Plants In Streambed As Noted Above Skip This Step **UNLESS** SAV Present*)*	2	1	75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 2.5

TOTAL POINTS (Primary + Secondary) = 30

(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

USACE AID#________	DWQ #________	Site #____ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: NCEEP
2. Evaluator's name: ERIC MULARSKI
3. Date of evaluation: 10/3/07
4. Time of evaluation: 2:00 PM
5. Name of stream: UT TO UT CANE CREEK
6. River basin: FRENCH BROAD
7. Approximate drainage area:________
8. Stream order: 1ST
9. Length of reach evaluated: 300'
10. County: HENDERSON
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any):________

Latitude (ex. 34.872312): 35.______ Longitude (ex. –77.556611):________

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): SEE ATTACHED MAP

14. Proposed channel work (if any): RESTORATION
15. Recent weather conditions: CLOUDY 70'S
16. Site conditions at time of visit: CLOUDY 70'S
17. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:________
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: ____% Residential ____% Commercial ____% Industrial 90 % Agricultural 10 % Forested ____% Cleared / Logged ____% Other (________)
22. Bankfull width: 6'
23. Bank height (from bed to top of bank): 5'
24. Channel slope down center of stream: ✓ Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
25. Channel sinuosity: ✓ Straight ____Occasional bends ____Frequent meander ____Very sinuous ____Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 36 **Comments:**________

Evaluator's Signature________ **Date** 10/3/07

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	1
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	1
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	2
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	0
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	0
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	3
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	1
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	2
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	2
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	2
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	2
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				36

* These characteristics are not assessed in coastal streams.

NCDWQ Stream Classification Form

Project Name: FLETCHER RESTORATION River Basin: FRENCH BROAD County: BUNCOMBE Evaluator: ERIC MULARSKI
DWQ Project Number: Nearest Named Stream: ORTON BRANCH Latitude: 35.49049762 Signature: [signature]
Date: 10/3/07 USGS QUAD: SKYLAND Longitude: -82.5845503 Location/Directions: SEE ATTACHED MAP

PLEASE NOTE: ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used****

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3
NOTE: If Bed & Bank Caused By Ditching And **WITHOUT Sinuosity Then Score=0**				
10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present?		*Yes*=3	*No*=0	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 20

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 7

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 2.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes*=1.5	*No*=0	

SECONDARY HYDROLOGY INDICATOR POINTS: 6

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(**NOTE:** If Total Absence Of All Plants In Streambed As Noted Above Skip This Step **UNLESS** SAV Present*)*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 5

TOTAL POINTS (Primary + Secondary) = 41.5

(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

USACE AID#__________ DWQ #__________ Site #____ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: NC EEP
2. Evaluator's name: ERIC MULARSKI
3. Date of evaluation: 10/3/07
4. Time of evaluation: 4:30 PM
5. Name of stream: ORTON BRANCH
6. River basin: FRENCH BROAD
7. Approximate drainage area: 341 ACRES
8. Stream order: 2ND
9. Length of reach evaluated: 500'
10. County: BUNCOMBE
11. Site coordinates (if known): prefer in decimal degrees
12. Subdivision name (if any):__________

Latitude (ex. 34.872312): 35.49049762 Longitude (ex. –77.556611): -82.58455035

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other__________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): SEE ATTACHED MAP. FROM I-26 TAKE SR. 146 PROCEED WEST MAKE RIGHT ON CLAYTON MAKE RIGHT S.R. 191
14. Proposed channel work (if any):__________
15. Recent weather conditions: CLOUDY 70'S
16. Site conditions at time of visit: CLOUDY 70'S
17. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:__________
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: 10 % Residential ____% Commercial ____% Industrial ____% Agricultural 90 % Forested ____% Cleared / Logged ____% Other (__________)
22. Bankfull width: 8
23. Bank height (from bed to top of bank): 3
24. Channel slope down center of stream: ____Flat (0 to 2%) ✓ Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
25. Channel sinuosity: ____Straight ____Occasional bends ✓ Frequent meander ____Very sinuous ____Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 77 **Comments:** EXTREME DROUGHT CONDITIONS

Evaluator's Signature [signature] **Date** 10/3/07

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	3
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	4
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	3
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	4
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	4
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	4
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	4
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	5
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	5
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	4
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	4
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				77

* These characteristics are not assessed in coastal streams.

NCDWQ Stream Classification Form

Project Name: FLETCHER RESTORATION River Basin: FRENCH BROAD County: TRANSYLVANIA Evaluator: ERIC MALARSCH
DWQ Project Number: Nearest Named Stream: LITTLE RIVER Latitude: 35.17853197 Signature: [signature]
Date: 10/3/07 USGS QUAD: STANDING STONE MT. Longitude: -82.6193308 Location/Directions: SEE ATTACHED MAP

PLEASE NOTE: ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used****

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3

*(*NOTE: If Bed & Bank Caused By Ditching And **WITHOUT** Sinuosity Then Score=0*)*

10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present? ***Yes=3*** ***No=0***

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 20

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 7

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 2.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5

6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)? ***Yes=1.5*** ***No=0***

SECONDARY HYDROLOGY INDICATOR POINTS: 6.5

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(**NOTE:** If Total Absence Of All Plants In Streambed As Noted Above Skip This Step **UNLESS** SAV Present*)*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 4

TOTAL POINTS (Primary + Secondary) = 41

(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

USACE AID#____________ DWQ #____________ Site #____ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: NCEEP
2. Evaluator's name: Eric Mularski
3. Date of evaluation: 10/4/07
4. Time of evaluation: 10:00 AM
5. Name of stream: UT to Little River
6. River basin: French Broad
7. Approximate drainage area: 382 Acres
8. Stream order: 2nd
9. Length of reach evaluated: 300'
10. County: Transylvania
11. Site coordinates (if known): prefer in decimal degrees
12. Subdivision name (if any): ____

Latitude (ex. 34.872312): 35.17853197 Longitude (ex. –77.556611): -82.61933128

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other____

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): See attached map
Dupont State Forest access off of Reasonover Road Downstream of Bridal Veil Falls

14. Proposed channel work (if any): ____
15. Recent weather conditions: Cloudy 70's
16. Site conditions at time of visit: Light Rain 70's
17. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:____
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: ____% Residential ____% Commercial ____% Industrial ____% Agricultural 100% Forested ____% Cleared / Logged ____% Other (____)
22. Bankfull width: 6 to 8'
23. Bank height (from bed to top of bank): 2-3'
24. Channel slope down center of stream: ✓ Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
25. Channel sinuosity: ____Straight ____Occasional bends ____Frequent meander ✓ Very sinuous ____Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality

Total Score (from reverse): 86 **Comments:**____

Evaluator's Signature [signature] Date 10/4/07

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03 To Comment, please call 919-876-8441 x 26.

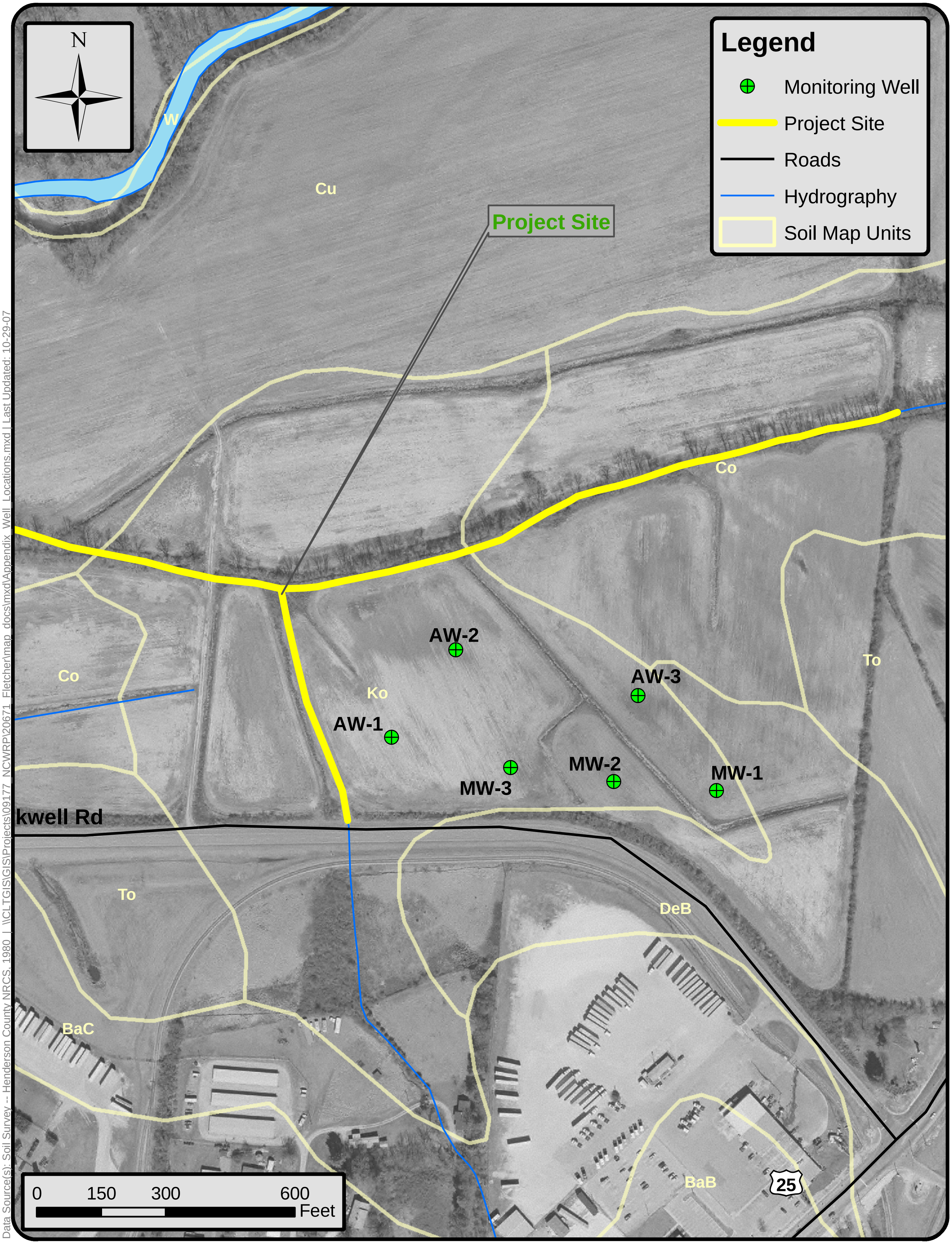
STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	5
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	5
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	4
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	2
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	2
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	3
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	3
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	4
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	5
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	4
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	5
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	5
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	5
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	5
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	4
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	4
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				86

* These characteristics are not assessed in coastal streams

Appendix F

Monitoring Well Data



Data Source(s): Soil Survey -- Henderson County NRCS, 1980 | \\CLTGIS\GIS\Projects\09177_NCWRP\20671_Fletcher\map_docs\mxd\Appendix_Well_Locations.mxd | Last Updated: 10-29-07

Monitoring Well Locations

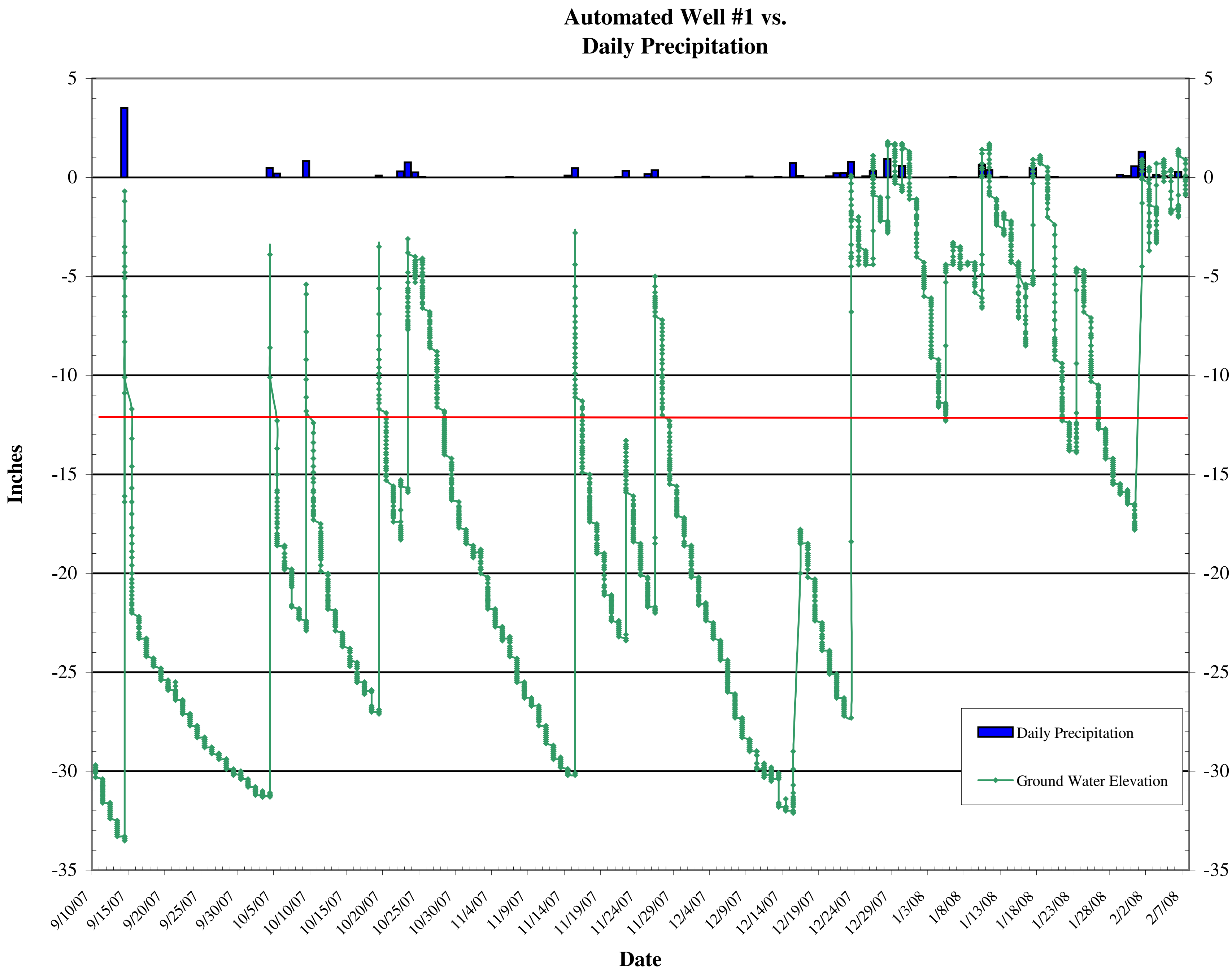
Appendix F

Ecosystem Enhancement Program

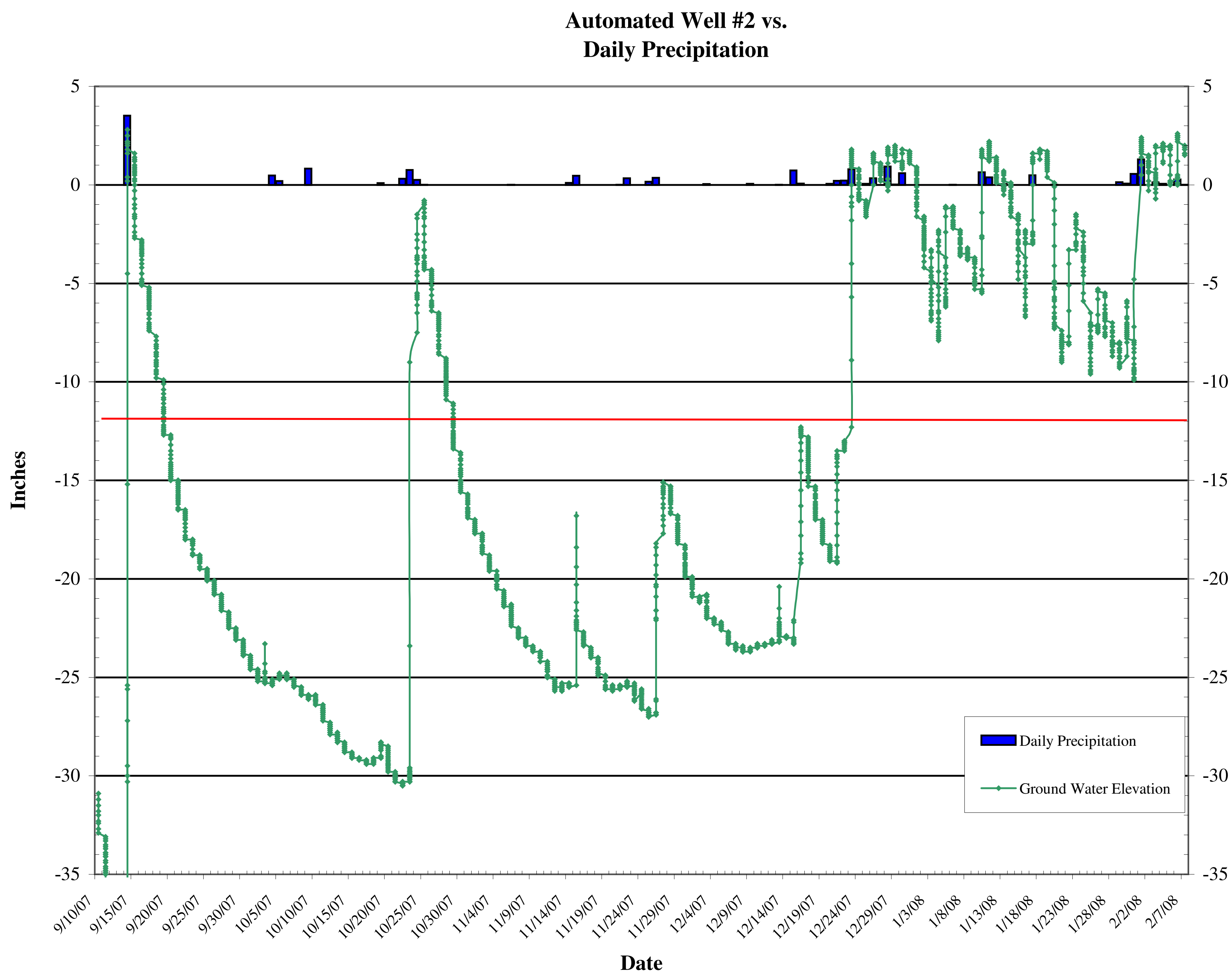
HDR ONE COMPANY | Many Solutions℠

Fletcher-Meritor Stream & Wetland Restoration Plan | Henderson County, NC

NC Ecosystem Enhancement Program | EEP Project No. EP4260721 | State Constr. Project No. D05039S



Automated Well #1 vs.
Daily Precipitation
Inches
Date
5
0
-5
-10
-15
-20
-25
-30
-35
9/10/07
9/15/07
9/20/07
9/25/07
9/30/07
10/5/07
10/10/07
10/15/07
10/20/07
10/25/07
10/30/07
11/4/07
11/9/07
11/14/07
11/19/07
11/24/07
11/29/07
12/4/07
12/9/07
12/14/07
12/19/07
12/24/07
12/29/07
1/3/08
1/8/08
1/13/08
1/18/08
1/23/08
1/28/08
2/2/08
2/7/08
Daily Precipitation
Ground Water Elevation



Automated Well #2 vs.
Daily Precipitation
Inches
Date
Daily Precipitation
Ground Water Elevation
5
0
-5
-10
-15
-20
-25
-30
-35
9/10/07
9/15/07
9/20/07
9/25/07
9/30/07
10/5/07
10/10/07
10/15/07
10/20/07
10/25/07
10/30/07
11/4/07
11/9/07
11/14/07
11/19/07
11/24/07
11/29/07
12/4/07
12/9/07
12/14/07
12/19/07
12/24/07
12/29/07
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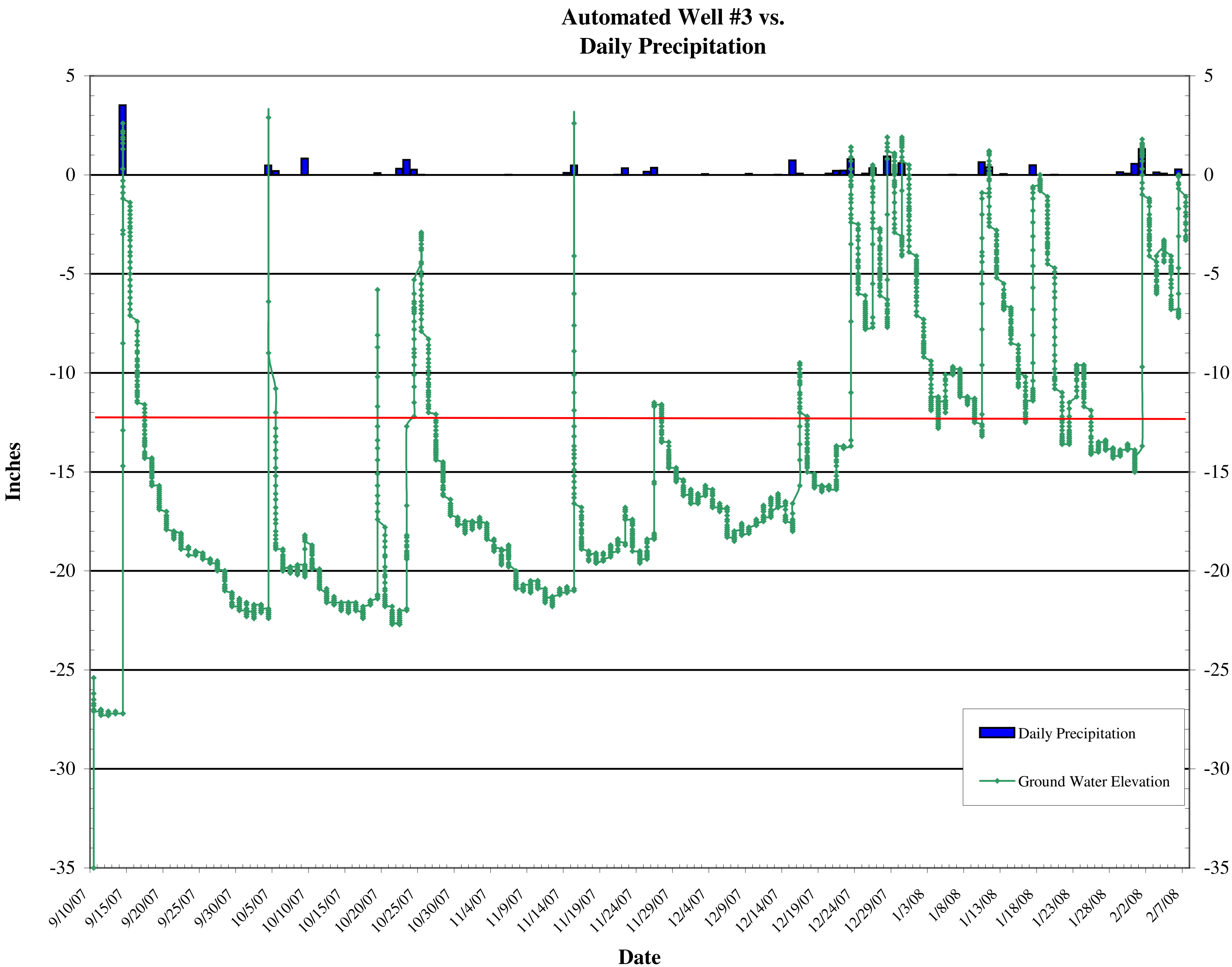
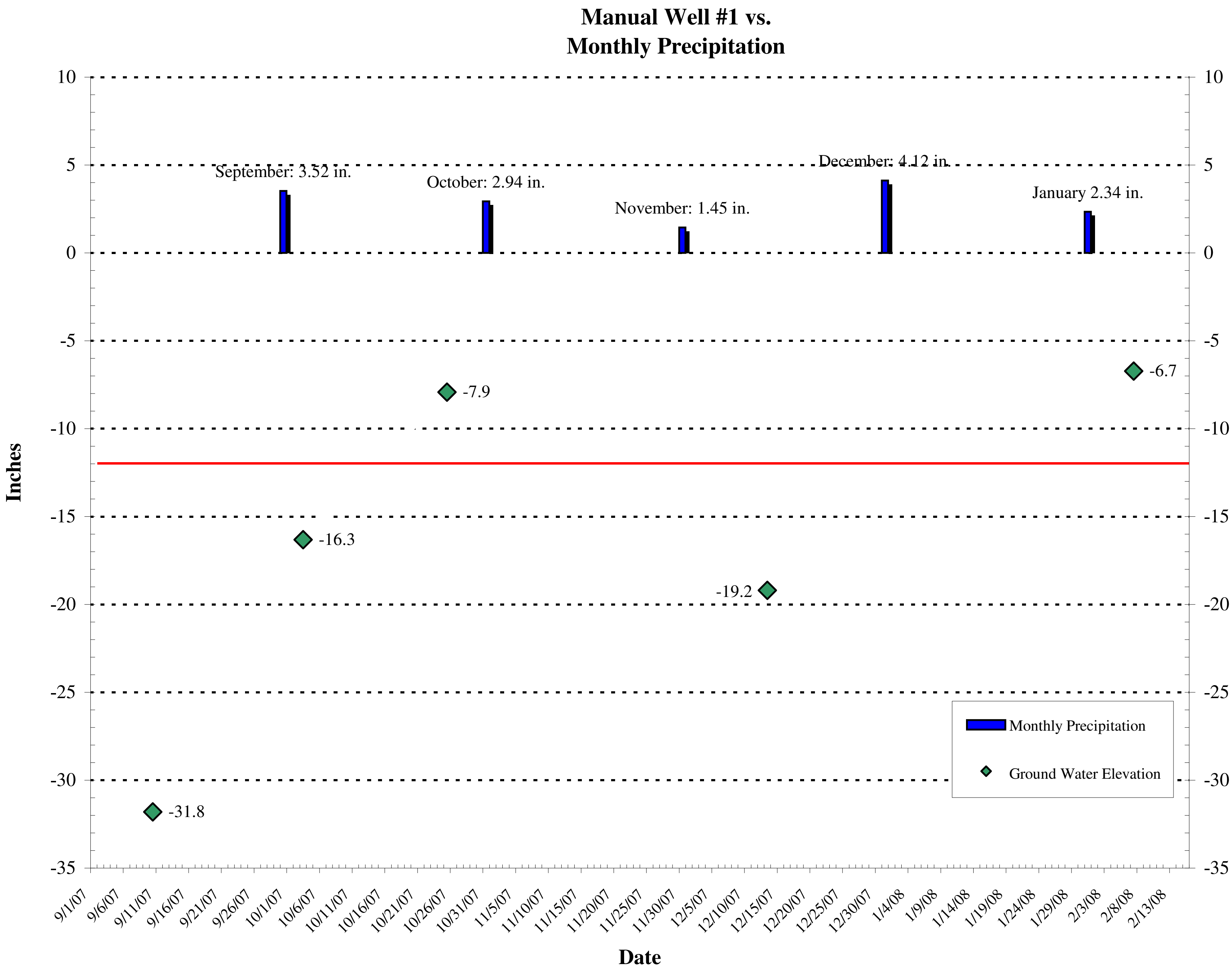
1/28/08
2/2/08
2/7/08



Automated Well #3 vs.
Daily Precipitation
Inches
Date
5
0
-5
-10
-15
-20
-25
-30
-35
9/10/07
9/15/07
9/20/07
9/25/07
9/30/07
10/5/07
10/10/07
10/15/07
10/20/07
10/25/07
10/30/07
11/4/07
11/9/07
11/14/07
11/19/07
11/24/07
11/29/07
12/4/07
12/9/07
12/14/07
12/19/07
12/24/07
12/29/07
1/3/08
1/8/08
1/13/08
1/18/08
1/23/08
1/28/08
2/2/08
2/7/08
Daily Precipitation
Ground Water Elevation



Manual Well #1 vs.
Monthly Precipitation
Inches
Date
September: 3.52 in.
October: 2.94 in.
November: 1.45 in.
December: 4.12 in.
January 2.34 in.
-31.8
-16.3
-7.9
-19.2
-6.7
Monthly Precipitation
Ground Water Elevation
10
5
0
-5
-10
-15
-20
-25
-30
-35
9/1/07
9/6/07
9/11/07
9/16/07
9/21/07
9/26/07
10/1/07
10/6/07
10/11/07
10/16/07
10/21/07
10/26/07
10/31/07
11/5/07
11/10/07
11/15/07
11/20/07
11/25/07
11/30/07
12/5/07
12/10/07
12/15/07
12/20/07
12/25/07
12/30/07
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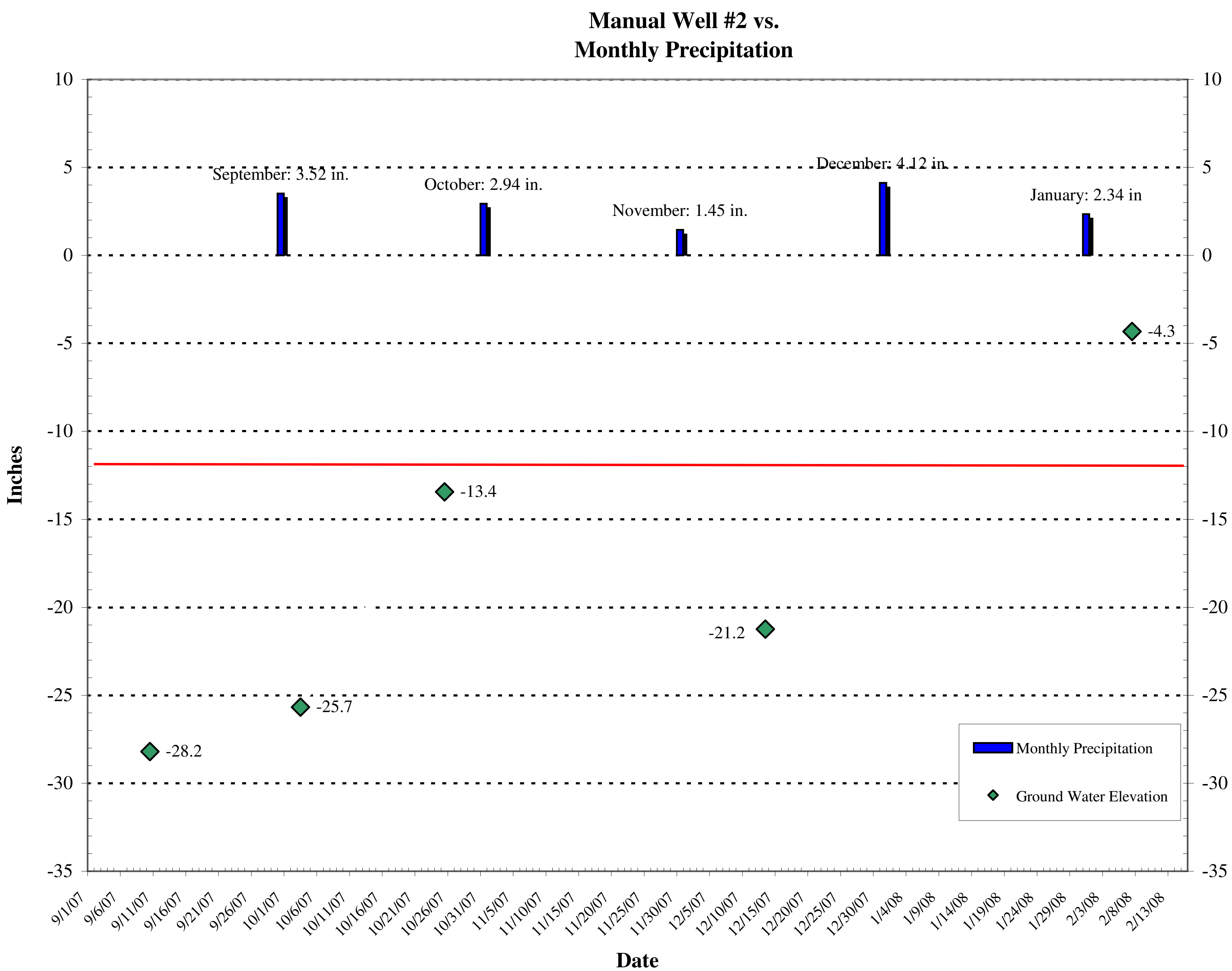
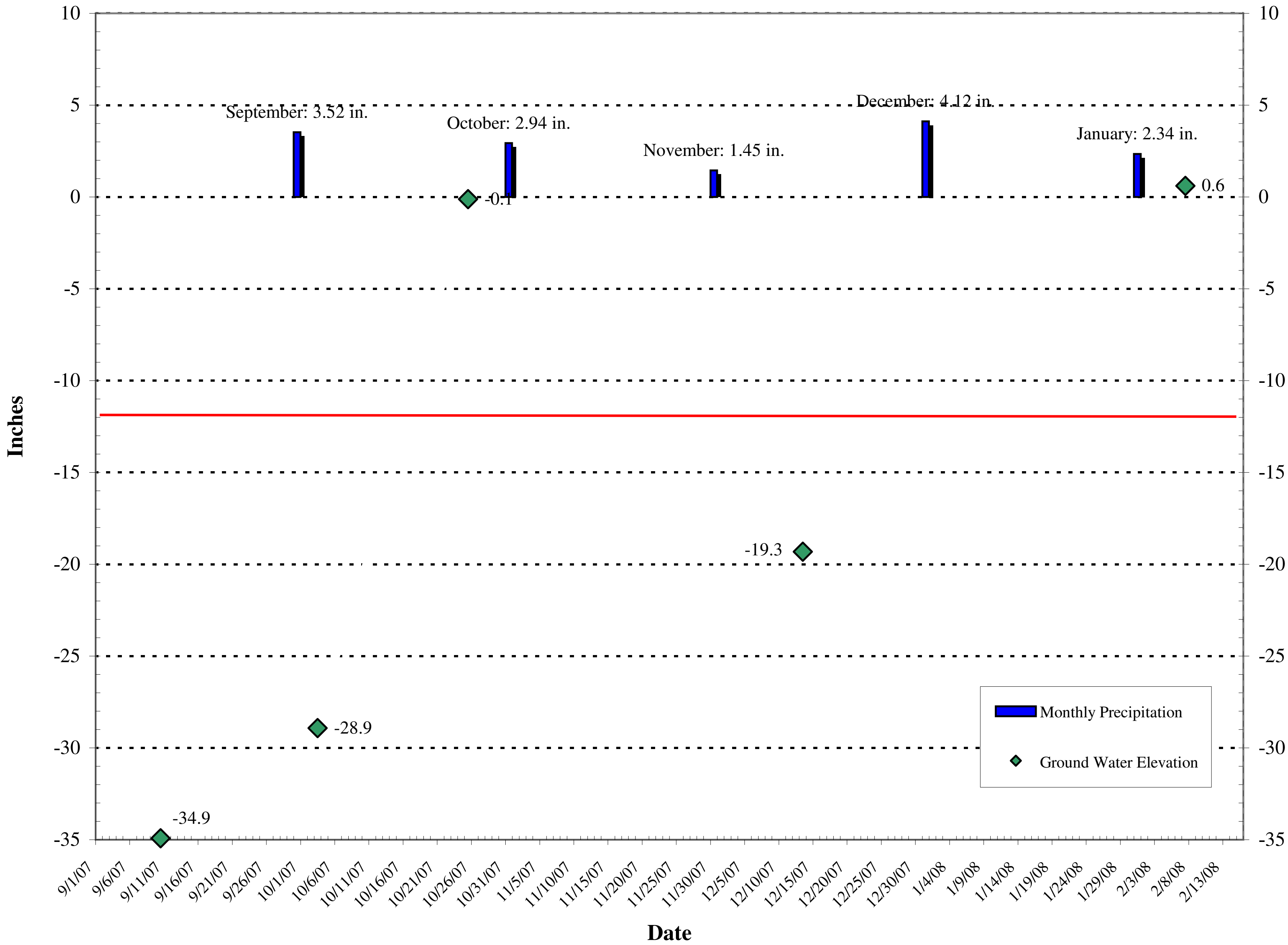
2/8/08
2/13/08



Manual Well #2 vs.
Monthly Precipitation
Inches
Date
September: 3.52 in.
October: 2.94 in.
November: 1.45 in.
December: 4.12 in.
January: 2.34 in
-28.2
-25.7
-13.4
-21.2
-4.3
Monthly Precipitation
Ground Water Elevation
10
5
0
-5
-10
-15
-20
-25
-30
-35
9/1/07
9/6/07
9/11/07
9/16/07
9/21/07
9/26/07
10/1/07
10/6/07
10/11/07
10/16/07
10/21/07
10/26/07
10/31/07
11/5/07
11/10/07
11/15/07
11/20/07
11/25/07
11/30/07
12/5/07
12/10/07
12/15/07
12/20/07
12/25/07
12/30/07
1/4/08
1/9/08
1/14/08
1/19/08
1/24/08
1/29/08
2/3/08
2/8/08
2/13/08

Manual Well #3 vs.
Monthly Precipitation



Appendix G

Entrainment Calculations

ENTRAINMENT CALCULATION FORM

Stream:	Fletcher	Reach:	Existing	
Team:	JRR / WDY	Date:	12/27/2007	

Information Input Area

9.0	D_{50}	Riffle bed material D50 (mm)			
2.0	$D^{\wedge}_{50}$	Bar sample D50 (mm)			
32.00	D_i	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0032	S_e	Existing bankfull water surface slope (ft/ft)			
2.80	d_e	Existing bankfull mean depth (ft)			
1.80	R	Hydraulic Radius of Riffle Cross Section (ft)			
1.65	g_s	Submerged specific weight of sediment			

Calculation of Critical Dimensionless Shear Stress

4.50	$D_{50}/D^{\wedge}_{50}$	If value is between 3-7	**Equation 1** will be used: $t^*_{ci} = 0.0834(D_{50}/D^{\wedge}_{50})^{-0.872}$
3.56	D_i/D_{50}	If value is between 1.3-3.0	**Equation 2** will be used: $t^*_{ci} = 0.0384(D_i/D_{50})^{-0.887}$
0.0225	t^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:** 1

Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

1.22	d_r	Required bankfull mean depth (ft/ft)	$d_r = \frac{t^*_{ci} g_s D_i}{S_e}$
2.80	d_e	Existing bankfull mean depth (ft)	
2.29	d_e/d_r	**Existing Stream Condition:**	**Degrading**

Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

0.0014	S_r	Required bankfull water surface slope (ft)	$S_r = \frac{t^*_{ci} g_s D_i}{d_e}$
0.0032	S_e	Existing bankfull water surface slope (ft)	
2.29	S_e/S_r	**Existing Stream Condition:**	**Degrading**

Sediment Transport Validation

0.36	Bankfull Shear Stress $t_c = gRS$ (lb/ft2) g = Specific Weight of water = 62.4 lbs/ft^3
71	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002)
0.12	Predicted shear stress required to initiate movement of D_i (mm) (see Revised Shields Diagram, Rosgen, 2002)
	Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists.

ENTRAINMENT CALCULATION FORM

Stream:	Fletcher	Reach:	Proposed
Designer:	JRR / WDY	Date:	12/27/2007

Information Input Area

9.00	D_{50}	Riffle bed material D50 (mm)			
2.00	$D^{\wedge}_{50}$	Bar sample D50 (mm)			
32.00	D_i	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0021	S_e	Proposed bankfull water surface slope (ft/ft)			
1.70	d_e	Proposed bankfull mean depth (ft)			
0.66	R	Proposed Hydraulic Radius of Riffle Cross Section (ft)			
1.65	g_s	Submerged specific weight of sediment			

Calculation of Critical Dimensionless Shear Stress

4.50	$D_{50}/D^{\wedge}_{50}$	If value is between 3-7	**Equation 1** will be used:	$t^*_{ci} = 0.0834(D_{50}/D^{\wedge}_{50})^{-0.872}$
3.56	D_i/D_{50}	If value is between 1.3-3.0	**Equation 2** will be used:	$t^*_{ci} = 0.0384(D_i/D_{50})^{-0.887}$
0.0225	t^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:**	1

Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

1.85	d_r	Required bankfull mean depth (ft/ft)	$d_r = \frac{t^*_{ci} g_s D_i}{S_e}$
1.70	d_e	Proposed bankfull mean depth (ft)	
0.9	d_e/d_r	**Proposed Stream Condition:**	**Stable**

Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

0.0023	S_r	Required bankfull water surface slope (ft)	$S_r = \frac{t^*_{ci} g_s D_i}{d_e}$
0.0021	S_e	Existing bankfull water surface slope (ft)	
0.9	S_e/S_r	**Proposed Stream Condition:**	**Stable**

Sediment Transport Validation

0.09	Bankfull Shear Stress t_c =gRS (lb/ft2) g = Specific Weight of water = 62.4 lbs/ft^3
25	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002)
0.12	Predicted shear stress required to initiate movement of D_i (mm) (see Revised Shields Diagram, Rosgen, 2002)
	Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists.