Mill Creek Restoration Plan
Randolph County, North Carolina

Prepared for: NCDENR - Ecosystem Enhancement Program
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FINAL REPORT

Baker Project Number 109664

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Mill Creek Restoration Plan
Randolph County, North Carolina

Prepared for NC Ecosystem Enhancement Program

Design Report Prepared by Baker Engineering

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EXECUTIVE SUMMARY

The North Carolina Ecosystem Enhancement Program (NCEEP) proposes to restore approximately 983 linear feet (LF) of stream, enhance approximately 4,859 LF of stream, and preserve approximately 15,802 LF of stream along four separate reaches of the mainstem of Mill Creek, five unnamed tributaries to Mill Creek, two unnamed tributaries to the Uwharrie River, and one ditch that flows directly into the Uwharrie River that are all located within the project boundaries (Table ES1). In total, approximately 21,644 LF of stream will be permanently protected through a conservation easement within the Mill Creek project boundaries. In addition, the project will also create 1.1 acres of riverine wetlands from prior constructed livestock watering ponds.

The landowners of the Mill Creek site have expressed an interest in protecting the property through multiple conservation measures. All practices proposed in this design report are being funded completely through NCEEP funds. However, additional funding has been provided by a Randolph County Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQUIP) grant and with support from the North Carolina Wildlife Resources Commission (NCWRC) for a native prairiegrass restoration project to occur within formally farmed/grazed portions of the property outside of the NCEEP Mill Creek project boundaries. As a result, ongoing coordination will be necessary between NCEEP, Baker Engineering, the NCWRC, and the landowners as portions of the property are converted from a prior agricultural/livestock farm to actively managed native prairiegrass fields with perpetually protected riparian buffers located along the existing onsite waterways.

The Mill Creek site is located in Randolph County, approximately 11 miles southwest of the City of Asheboro, North Carolina. The site occurs within the eight-digit hydrological unit code (HUC) 03040103, and within the NC Division of Water Quality (NCDWQ) sub-basin 03-07-09 of the Yadkin Valley River Basin (Exhibit 1.1 and 1.2).

Mill Creek is a moderate-sized, perennial stream with a drainage area of approximately 1.3 square miles at its confluence with the Uwharrie River (Exhibit 1.3). Historically, the downstream portion of the site (west of Lassiter Mill Rd – SR 1107) has been used for agriculture and livestock production. Livestock have been removed and the area has become fallow open land, areas used for hay production, or areas recently planted and undergoing active burning by the North Carolina Wildlife Resources Commission (NCWRC) as part of an ecosystem restoration initiative for the entire property. Prior livestock activity has compromised the riparian buffer along many of the project reaches. The upstream portion of the project area (east of Lassiter Mill Rd) is primarily forested. Riparian vegetation in this area is comprised mainly of mature deciduous trees.

In addition to Mill Creek, three unnamed tributaries and one ditch (two tributaries to Mill Creek - UT4 and UT5 and one tributary and one ditch to the Uwharrie River - UT 2 and UT1, respectively) occur within the enhancement/restoration project area (area located west of Lassiter Mill Rd). These tributaries and ditch are small systems with drainage areas of 0.08, 0.06, 0.08, and 0.05 square mile, respectively. These tributaries and ditch (verified during site visit with USACE) originate on the project site and terminate at their confluence with either Mill Creek or the Uwharrie River. These reaches drain pastures and wooded areas. UT2, UT4, and UT5 are considered intermittent in their upper reaches and perennial in the lower reaches, while UT1 is considered ephemeral throughout its length.

Stream preservation encompasses eight stream reaches with existing riparian buffers that will be protected. Seven of the eight reaches lie east of Lassiter Mill Road and are directly upstream of the lower Mill Creek reach (MC1). The eighth reach (UT9) is located in the southern portions of the site. UT9 originates off-site on an adjacent parcel west of Lassiter Mill Rd and drains directly into the Uwharrie River downstream of the Mill Creek-Uwharrie River confluence (Exhibit 1.4). The preservation reaches are currently hydrologically, geomorphically, and geometrically functioning as stable reaches.

Two small, breached ponds located west of Lassiter Mill Road provide an opportunity for wetland creation and with it the associated water quality improvements which will result. Wetland creation consists of grading the breached dams, planting a variety of native wetland plants and trees, and allowing for overbank flooding of the channel that will flow through the created wetlands.

Mill Creek stream activities are shown in Exhibit 1.4. The proposed stream restoration, enhancement, and preservation areas, as well as the wetland creation areas, will provide numerous ecological benefits within the Mill Creek watershed in addition to portions of the Uwharrie River adjacent to and immediately downstream of the property boundaries. While many of the benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality, hydrology, and habitat are outlined below as project goals and objectives.

<u>Goals</u>

- Improve water quality within the UT2 and Mill Creek watersheds by reducing sediment and nutrient inputs, increasing dissolved oxygen concentrations, improve stream stability, and wetland filtering
- Improve water quantity within the UT2 and Mill Creek watersheds by improving ground water recharge, restoring hydrologic connections, and reconnecting channels with floodplains
- Improve aquatic and terrestrial habitat within the UT2 and Mill Creek watersheds by improving substrate and in-stream cover, reducing water temperature by increasing shading, improving terrestrial habitat, and improving overall aesthetics
- Increase animal and vegetation biodiversity within the site by connecting the riparian buffer improvements associated with the NCEEP's Mill Creek project with an NCWRC native piedmont prairiegrass restoration project located outside of the NCEEP's conservation easement boundaries.

<u>Objectives</u>

- Permanently protect 21,644 LF of stream channel through a conservation easement
- Restore 938 LF of perennial stream channel
- Enhance 4,859 LF of perennial and intermittent stream channel
- Preserve 15,802 LF of perennial channel
- Create 1.5 acres of wetland
- Restore UT2 to its original drainage path to the Uwharrie River below the breached dam
- Create a new channel below UT5's breached dam that flows along the fall of the valley to reduce the toe-of-slope erosion on the left bank
- Improve floodplain functionality by matching floodplain elevation with bankfull stage or by creating a bench to open the floodplain in areas where the channel is incised
- Establish native stream bank and floodplain vegetation in the permanent conservation easement
- Improve aquatic and riparian habitat by creating deeper pools and areas of re-aeration, planting a riparian buffer, and reducing bank erosion.

TABLE ES 1.
Restoration Overview

Wetland Type / Project Feature	Existing Size/Length	Proposed Size/Length	Approach
Wetland 1 along UT2	0.9 AC	0.9 AC	Creation – planting native vegetation and enhancing hydrology.
Wetland 2 along UT5	0.2 AC	0.2 AC	Creation – planting native vegetation and enhancing hydrology.
Mill Creek (MC1)	2,214 FT	1,460 FT 754 FT	Enhancement I – benching, sloping banks, installing structures and planting native vegetation along 1,460' of stream Enhancement II – planting native vegetation along 754' of stream.
Stream Reach UT1	1,799 FT	1,799 FT	Filling the upper 600' of the agriculturally dug ditch.
Stream Reach UT2	1,703 FT	875 FT 1,012 FT	Restoration – approx. 875' of new channel above and below breached dam, while restoring original drainage Enhancement II – planting buffer along 1012' of stream.
Stream Reach UT4	2,350 FT	541 FT 1,809 FT	Enhancement II – planting buffer along approx. 541' of stream Preservation of buffer along approx. 1,809' of stream.
Stream Reach UT5	1,289 FT	108 FT 250 FT 842 FT	Restoration – approx. 108' of new channel below breached dam Enhancement I – benching approx. 250' of stream Enhancement II – planting buffer along 842' of stream.
Stream Reach UT6	954 FT	954 FT	Preservation of buffer along approx. 954' of stream.
Stream Reach UT7	2,529 FT	2,529 FT	Preservation of buffer along approx. 2,529' of stream.
Stream Reach UT8	2,003 FT	2,003 FT	Preservation of buffer along approx. 2,003' of stream.
Stream Reach UT9	5,239 FT	5,239 FT	Preservation of buffer along approx. 5,239' of stream.
Stream Reach MC2	998 FT	998 FT	Preservation of buffer along approx. 998' of stream.
Stream Reach MC3	785 FT	785 FT	Preservation of buffer along approx. 785' of stream.
Stream Reach MC4	1,485 FT	1,485 FT	Preservation of buffer along approx. 1,485' of stream.

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1.0 INTRODUCTION AND BACKGROUND

1.1 Location and Project Description

The North Carolina Ecosystem Enhancement Program (NCEEP) proposes to restore approximately 983 linear feet (LF) of stream, enhance approximately 4,859 LF of stream, preserve approximately 15,802 LF of stream, and create 1.1 acres of riverine wetlands within the Yadkin Valley River Basin. The Mill Creek mitigation site (35^0 33' 21" N, 79^0 58' 16" W) is located approximately 11 miles southwest of the City of Asheboro in Randolph County, North Carolina. Exhibits 1.1 and 1.2 provide an overview of the project site. The site occurs within the eight-digit hydrological unit code (HUC) 03040103, and within the NC Division of Water Quality (NCDWQ) sub-basin 03-07-09 of the Yadkin Valley River Basin (Exhibit 1.1 and 1.2).

To get to the project site from Asheboro, NC, one must take Route 49 South (towards Charlotte). After approximately seven miles make a hard left turn onto Mechanic Road. Turn right onto Lassiter Mill Road. Travel approximately 7 miles and turn right onto High Pine Church Road. The entrance to the project is on the left, 900' from the intersection. There is a yellow steel gate at the entrance.

Mill Creek is a moderate-sized, perennial stream with a drainage area of approximately 1.3 square miles at its confluence with the Uwharrie River (Exhibit 1.3). Historically, the downstream portion of the site (west of Lassiter Mill Rd – SR 1107) has been used for agriculture and livestock production. Livestock have been removed and the area has become fallow open land, areas used for hay production, or areas recently planted and undergoing active burning by the North Carolina Wildlife Resources Commission (NCWRC) as part of an ecosystem restoration initiative for the entire property. Prior livestock activity has compromised the riparian buffer along many of the project reaches. The upstream portion of the project area (east of Lassiter Mill Rd) is primarily forested. Riparian vegetation in this area is comprised mainly of mature deciduous trees.

In addition to Mill Creek, three unnamed tributaries and one ditch (two tributaries to Mill Creek - UT4 and UT5 and one tributary and one ditch to the Uwharrie River - UT 2 and UT1, respectively) occur within the enhancement/restoration project area (area located west of Lassiter Mill Rd). These tributaries and the ditch are relatively small stream systems with drainage areas of 0.08, 0.06, 0.08, and 0.05 square mile, respectively. These tributaries and ditch (verified during site visit with USACE) originate on the project site and terminate at their confluence with either Mill Creek or the Uwharrie River. These reaches drain pastures and wooded areas. UT2, UT4, and UT5 are considered intermittent in their upper reaches and perennial in the lower reaches, while UT1 is considered ephemeral throughout its length.

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Two small, breached ponds located west of Lassiter Mill Road provide an opportunity for wetland creation and with it the associated water quality improvements which will result. Wetland creation consists of grading the breached dams, planting a variety of native wetland plants and trees, and allowing for overbank flooding of the channel that will flow through the created wetlands.

1.2 Project Goals and Objectives

Mill Creek mitigation activities are shown in Exhibit 1.4. The proposed stream restoration, enhancement, and preservation areas, as well as the wetland creation areas, will provide numerous ecological benefits within the Mill Creek watershed in addition to portions of the Uwharrie River adjacent to and immediately downstream of the property boundaries. While many of the benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality, hydrology, and habitat are outlined below as project goals and objectives.

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- Improve water quality within the UT2 and Mill Creek watersheds by reducing sediment and nutrient inputs, increasing dissolved oxygen concentrations, improve stream stability, and wetland filtering
- Improve water quantity within the UT2 and Mill Creek watersheds by improving ground water recharge, restoring hydrologic connections, and reconnecting channels with floodplains
- Improve aquatic and terrestrial habitat within the UT2 and Mill Creek watersheds by improving substrate and in-stream cover, reducing water temperature by increasing shading, improving terrestrial habitat, and improving overall aesthetics
- Increase animal and vegetation biodiversity within the site by connecting the riparian buffer improvements associated with the NCEEP's Mill Creek project with an NCWRC native piedmont prairiegrass restoration project located outside of the NCEEP's conservation easement boundaries.

Objectives

- Permanently protect 21,644 LF of stream channel through a conservation easement
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- Improve floodplain functionality by matching floodplain elevation with bankfull stage or by creating a bench to open the floodplain in areas where the channel is incised
- Establish native stream bank and floodplain vegetation in the permanent conservation easement
- Improve aquatic and riparian habitat by creating deeper pools and areas of re-aeration, planting a riparian buffer, and reducing bank erosion
- Increase species habitation throughout the property and the surrounding land.

1.3 Report Overview

This report has been arranged and formatted to maximize its utility. Readers unfamiliar with stream and wetland restoration science and methodology may wish to review the background material in Sections 2 and 3. Those familiar with Baker Engineering's design processes and procedures may wish to focus on Sections 4, 5, 6, 7, and 8 of the report, which are specific to the project site. These sections cover the site assessment findings, selection and application of design criteria, and site design. Section 9 summarizes post-construction monitoring and evaluation procedures. References are provided in Section 10.

1.4 Native Piedmont Prairiegrass Restoration Project.

The Mill Creek stream and wetland restoration project is being coordinated with an ongoing native piedmont prairegrass restoration project which is being conducted within portions of the property located outside of the NCEEP's conservation easement boundaries. The prairegrass conversion is being funded by a Randolph County Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQUIP) grant with additional support being provided by the North Carolina Wildlife Resources Commission (NCWRC).

The prairiegrass restoration project within the Grissom property is a relatively large scale grassland initiative which will convert approximately 100 acres of degraded fescue pasture previously used for agricultural and livestock purposes into a naturally functioning piedmont prairegrass field planted with native and locally grown grasses and wildflowers while removing introduced and exotic species such as Chinese privet (*Ligustrum sinense*), kudzu (*Pueraria montana*), and Japanese honeysuckle (*Lonicera japonica*) which commonly occur throughout the property. Naturally occurring piedmont prairies have been rapidly diminishing across central North Carolina due to continued development and expansion into these native prairiegrass habitats.

While traditional stream and riparian buffer restoration projects typically only protect a targeted waterway(s), the restoration of stream, riparian buffer, and prairiegrass habitats within this project should provide an excellent opportunity to gain valuable experience in establishing and maintaining distinctly different yet adjacent vegetative communities while providing vegetative connectivity and increased ecological stability. Improving habitat quality within the riparian buffers should benefit existing wildlife while restoring the prairiegrass habitat should offer opportunities for the re-introduction of early successional wildlife species found and occurring in prairegrass fields such as indigo bunting (*Passerina cyanea*), grasshopper sparrow (*Ammodramus savannarum*), eastern meadowlark (*Sturnella magna*), loggerhead shrike (*Lanius ludovicianus*), and bobwhite quail (*Colinus virginianus*).

Continued coordination between NCEEP, Baker Engineering, the NCWRC, and the landowners will be necessary prior to construction and during construction to avoid confusion and delays that may occur during the implementation of both projects. Long term management of the prairiegrass fields, requires a fire management plan be developed to determine subsequent burnings and additional maintenance issues. Vegetation within the NCEEP conservation easement boundaries is not subject to burning so long term agreements regarding frequency of burns, fire lanes, etc. will be necessary between the NCWRC and the NCEEP to insure the success of both projects. The concurrent development of a stream/riparian buffer restoration project with a native piedmont prairiegrass restoration project provides an excellent opportunity to explore an ecosystem restoration initiative not usually seen with stream or wetland restoration projects.

2.0 STREAM RESTORATION BACKGROUND SCIENCE AND METHODS

2.1 Application of Fluvial Processes to Stream Restoration

A stream and its floodplain comprise a dynamic environment where the floodplain, channel, and bedform evolve through natural processes. Weather and hydraulic processes erode, transport, sort, and deposit alluvial materials throughout the riparian system. The size and flow of a stream are directly related to its watershed area. Other factors that affect channel size and stream flow are geology, land use, soil types, topography, and climate. The morphology, or size and shape, of the channel reflect all of these factors (Leopold et al., 1992; Knighton, 1998). The result is a dynamic equilibrium where the stream maintains its dimension, pattern, and profile over time, and neither degrades nor aggrades. Land use changes in the watershed, including increases in imperviousness and removal of riparian vegetation, can upset this balance. A new equilibrium may eventually result, but not before large adjustments in channel form can occur, such as extreme bank erosion or incision (Lane, 1955; Schumm, 1960). By understanding and applying natural stream processes to stream restoration projects, a self-sustaining stream can be designed and constructed that maximizes stream and biological potential (Leopold et al., 1992; Leopold, 1994; Rosgen, 1996).

In addition to transporting water and sediment, natural streams provide the habitat for many aquatic organisms including fish, amphibians, insects, mollusks, and plants. Trees and shrubs along the banks provide a food source and regulate water temperatures. Channel features such as pools, riffles, steps, and undercut banks provide diversity of habitat, oxygenation, and cover (Dunne and Leopold, 1978). Stream restoration projects can repair these features in concert with the return of a stable dimension, pattern, and profile. The following sections provide an overview of the primary channel forming process and typical stream morphology.

2.1.1 Channel Forming Discharge

The channel forming discharge, also referred to as bankfull discharge, effective discharge, or dominant discharge, creates a natural and predictable channel size and shape (Leopold et al., 1992; Leopold, 1994). Channel forming discharge theory states that there is a unique flow that over a long period of time would yield the same channel morphology that is shaped by the natural sequence of flows. At this discharge, equilibrium is most closely approached and the tendency to change is minimized (Inglis, 1947). Uses of the channel forming discharge include channel stability assessment, river management using hydraulic geometry relationships, and natural channel design (Soar and Thorne, 2001).

Proper determination of bankfull stage in the field is vital to stream classification and the natural channel design process. The bankfull discharge is the point at which flooding occurs on the floodplain (Leopold, 1994). This flood stage may or may not be the top of the stream bank. On average, bankfull discharge occurs every 1.5 years (Leopold, 1994; Harman et al., 1999; McCandless, 2003). If the stream has incised due to changes in the watershed or streamside vegetation, the bankfull stage may be a small depositional bench or scour line on the stream bank (Harman et al., 1999). In this case, the top of the bank, which was formerly the floodplain, is called a terrace. A stream with terraces at the top of its banks is considered to be incised.

2.1.2 Bedform Diversity and Channel Substrate

The profile of a stream bed and its bed materials are largely dependent on valley slope and geology. In simple terms, steep, straight streams are found in steep, colluvial valleys, while flat, meandering streams are found in flat, alluvial valleys. Colluvial valleys have slopes between two percent and four percent, while alluvial channels have slopes less than two percent. A colluvial valley forms through hillslope processes. Sediment supply in colluvial valleys is controlled by hillslope erosion and mass wasting, i.e., the sediments in the stream bed originated from the hillslopes. Sediments reaching the channel in a colluvial valley are typically poorly sorted mixtures of fine and coarse grained materials ranging in size from sand to boulders. In contrast, an alluvial valley forms through stream and floodplain processes. Sediments in alluvial valleys include some coarse gravel and cobble transported from steeper upland areas, but are predominantly fine-grained particles such as gravel and sand. Grain size generally decreases with valley slope (Leopold et al., 1992).

2.1.2.1 Step/Pool Streams

A step/pool bed profile is characteristic of steep streams formed within colluvial valleys. Steep mountain streams demonstrate step/pool morphology as a result of episodic sediment transport mechanisms. Because of the high energy associated with the steep channel slope, the substrate in step/pool streams contains significantly larger particles than streams in flatter, alluvial valleys. Steps form from accumulations of boulders and cobbles that span the channel, resulting in a backwater pool upstream and plunge pool downstream. Smaller particles collect in the interstices of steps creating stable, interlocking structures (Knighton, 1998).

In contrast to meandering streams that dissipate energy through meander bends, step/pool streams dissipate energy through drops and turbulence. Step/pool streams have relatively low sinuosity. Pattern variations are commonly the result of debris jams, topographic features, and bedrock outcrops.

2.1.2.2 Gravel Bed Streams

Meandering gravel bed streams in alluvial valleys have sequences of riffles and pools that maintain channel slope and bed stability. The riffle is a bed feature composed of gravel or larger size particles. During low flow periods, the water depth at a riffle is relatively shallow and the slope is steeper than the average slope of the channel. At low flows, water moves faster over riffles, and the resulting turbulence provide oxygen to the stream. Riffles control the stream bed elevation and are usually found entering and exiting meander bends. The inside of the meander bend is a depositional feature called a point bar, which also helps maintain channel form (Knighton, 1988). Pools are typically located on the outside bends of meanders between riffles. Pools have a flat slope and are much deeper than the average depth of the channel. At low flows, pools are depositional features and riffles are scour features.

At high flows, the water surface becomes more uniform: the water surface slope at the riffles decreases and the water surface slope at the pools increases. The increase in pool slope coupled with the greater water depth at the pools causes an increase in shear stress at the bed elevation. The opposite is true at riffles. With a relative increase in shear stress, pools scour. The relative decrease in shear stress at riffles causes bed material deposits at these features during the falling limb of the hydrograph.

2.1.2.3 Sand Bed Streams

While gravel bed streams have riffle/pool sequences, with riffles composed of gravel-size particles, sand bed channels are characterized by median bed material sizes less than two millimeters in diameter (Bunte and Abt, 2001). Bed material features called ripples, dunes, planebeds, and antidunes characterize the sand bedform. Although sand bed streams technically do not have riffles, the term is often used to describe the crossover reach between pools. We use "riffle" in this report as equivalent to the crossover section.

The size, stage, and variation of sand bedforms are formed by changes in unit stream power as described below. These bedforms are symptomatic of local variations in the sediment transport rate and cause minor to major variations in aggradation and degradation (Gomez, 1991). Sand bedforms can be divided between low flow regimes and high flow regimes with a transitional zone between the two. Ripples occur at low flows where the unit stream power is just high enough to entrain sand size particles. This entrainment creates small wavelets from random sediment accumulations that are triangular in profile with gentle upstream and steep downstream slopes. The ripple dimensions are independent of flow depth and heights are less than 0.02 meters.

As unit stream power increases, dunes eventually replace ripples. Dunes are the most common type of sand bedform and have a larger height and wavelength than ripples. Unlike ripples, dune height and wavelength are proportional to flow depth. The movement of dunes is the major cause of variability in bed-load transport rates in sand bed streams. Dunes are eventually washed out to leave an upper-flow plane bed characterized by intense bedload transport. This plane bed prevents the patterns of erosion and deposition required for dune development. This stage of bedform development is called the transitional flow regime between the low flow features and the high flow regime features (Knighton, 1998).

As flow continues to increase, standing waves develop at the water surface and the bed develops a train of sediment waves (antidunes), which mirror the surface forms. Antidunes migrate upstream by way of scour on the downstream face and deposition on the upstream face, a process that is opposite of ripples and dunes. Antidunes can also move downstream or remain stationary for short periods (Knighton, 1998).

2.1.3 Stream Classification

The Rosgen stream classification system categorizes essentially all types of channels based on measured morphological features (Rosgen, 1994, 1996). The system presents several stream types based on a hierarchical system. The classification system is illustrated on Exhibit 2.1. The first level of classification distinguishes between single and multiple thread channels. Streams are then separated based on degrees of entrenchment, width/depth ratio, and sinuosity. Slope range and channel materials are also evaluated to subdivide the streams. Stream types are further described according to average riparian vegetation, organic debris, blockages, flow regimes, stream size, depositional features, and meander pattern.

Bankfull stage is the basis for measuring the width/depth and entrenchment ratios, two of the most important delineative criteria. Therefore, it is critical to correctly identify bankfull stage when classifying streams and designing stream restoration measures. A detailed discussion of bankfull stage was provided in Section 2.1.1.

2.1.4 Stream Stability

A naturally stable stream must be able to transport the sediment load supplied by its watershed while maintaining dimension, pattern, and profile over time so that it does not degrade or aggrade (Rosgen, 1994). Stable streams migrate across alluvial landscapes slowly over long periods of time while maintaining their form and function. Instability occurs when scouring causes the channel to incise (degrade) or excessive deposition causes the channel bed to rise (aggrade). A generalized relationship of stream stability proposed by Lane (1955) is shown as a schematic drawing in Exhibit 2.2. The drawing shows that the product of sediment load and sediment size is proportional to the product of stream slope and discharge or stream power. A change in any one of these variables causes a rapid physical adjustment in the stream channel.

2.1.5 Channel Evolution

A common sequence of physical adjustments has been observed in many streams following disturbance. This adjustment process is often referred to as channel evolution. Disturbance can result from channelization, increase in runoff due to build-out in the watershed, removal of streamside vegetation, and other changes that negatively affect stream stability. All of these disturbances occur in both urban and rural environments. Several models have been used to describe this process of physical adjustment for a stream. The Simon (1989) channel evolution model characterizes evolution in six steps, including:

I. sinuous, pre-modified
II. channelized
III. degradation
IV. degradation and widening
V. aggradation and widening
VI. quasi-equilibrium.

Exhibit 2.3 illustrates the six steps of the Simon channel evolution model.

The channel evolution process is initiated once a stable, well-vegetated stream that interacts frequently with its floodplain is disturbed. Disturbance commonly results in an increase in stream power that causes degradation, often referred to as channel incision (Lane, 1955). According to research summarized by the Federal Interagency Stream Restoration Working Group (FISRWG), incision eventually leads to over-steepening of the banks and, when critical bank heights are exceeded, the banks begin to fail and mass wasting of soil and rock leads to channel widening. Incision and widening continue moving upstream in the form of a head-cut. Eventually the mass wasting slows and the stream begins to aggrade. A new low-flow channel begins to form in the sediment deposits. By the end of the evolutionary process, a stable stream with dimension, pattern, and profile similar to those of undisturbed channels forms in the deposited alluvium. The new channel is at a lower elevation than its original form with a new floodplain constructed of alluvial material (FISRWG, 1998).

2.1.6 Priority Levels of Restoring Incised Rivers

Though incised streams can occur naturally in certain landforms, they are often the product of disturbance. High, steep stream banks, poor or absent in-stream or riparian habitat, increased erosion and sedimentation, and low sinuosity are all characteristics of incised streams. Complete restoration of the stream, where the incised channel's grade is raised so that an abandoned floodplain terrace is reclaimed, is ideally the overriding project objective. There may be scenarios, however, where such an objective is impractical due to encroachment into the abandoned floodplain terrace by homes, roadways, utilities, etc. A priority system for the restoration of incised streams, developed and used by Rosgen (1997), considers a range of options to provide the best level of stream restoration possible for the given setting. Exhibit 2.4 illustrates various restoration/stabilization options for incised channels within the framework of the Rosgen's priority system. Generally:

Priority 1 – Re-establishes the channel on a previous floodplain (i.e., raises channel elevation); meanders a new channel to achieve the dimension, pattern, and profile characteristic of a stable stream for the particular valley type; and fills or isolates existing incised channel. This option requires that the upstream start point of the project not be incised.

Priority 2 – Establishes a new floodplain at the existing bankfull elevation (i.e., excavates a new floodplain); meanders channel to achieve the dimension, pattern, and profile characteristic of a stable stream for the particular valley type; and fills or isolates existing incised.

Priority 3 – Converts a straight channel to a different stream type while leaving the existing channel in place by excavating bankfull benches at the existing bankfull elevation. Effectively, the valley for the stream is made more bowl-shaped. This approach uses in-stream structures to dissipate energy through a step/pool channel type.

Priority 4 – Stabilizes the channel in place using in-stream structures and bioengineering to decrease stream bed and stream bank erosion. This approach is typically used in highly constrained environments.

2.2 Natural Channel Design Overview

Restoration design of degraded stream reaches first involves accurately diagnosing their current condition. Understanding valley type, stream type, channel stability, bedform diversity, and potential for restoration is essential to developing adequate restoration measures (Rosgen, 1996). This combination of assessment and design is often referred to as natural channel design.

The first step in a stream restoration design is to assess the reach, its valley, and its watershed to understand the relationship between the stream and its drainage basin and to evaluate the causes of stream impairment. Bankfull discharge is estimated for the watershed. After sources of stream impairment are identified and channel geometry is assessed, a plan for restoration can be formulated.

Design commences at the completion of the assessment stage. A series of iterative calculations are performed using data from reference reaches, pertinent literature, and evaluation of past projects to develop an appropriate stable cross-section, profile, and plan form dimensions for the design reach. A thorough discussion of design parameter selection is provided in Section 2.5. The alignment should avoid an entirely symmetrical layout to mimic natural variability, create a diversity of aquatic habitats, and improve aesthetics.

Once a dimension, pattern, and profile have been developed for the project reach, the design is tested to ensure that the new channel will not aggrade or degrade. A discussion of sediment transport methodology is provided in Section 2.6.

After the sediment transport assessment, additional structural elements are then added to the design to provide grade control, protect stream banks, and enhance habitat. Section 2.7 describes these in-stream structures in detail.

Once the design is finalized, detailed drawings are prepared showing dimension, pattern, profile, and location of additional structures. These drawings are used in the construction of the project.

Following the implementation of the design, a monitoring plan is established to:

- Ensure that stabilization structures are functioning properly

- Monitor channel response in dimension, pattern and profile, channel stability (aggradation/degradation) particle size distribution of channel materials, and sediment transport and stream bank erosion rates
- Determine biological response (food chains, standing crop, species diversity, etc.)
- Determine the extent to which the restoration objectives have been met.

2.3 Geomorphic Characterization Methodology

Geomorphic characterization of stream features includes the bankfull identification, bed material characterization and analysis, and stream classification.

2.3.1 Bankfull Identification

Correct identification of bankfull is important to the determination of geomorphic criteria such as stream type, bank height ratios, width to depth ratios, and entrenchment ratios. Baker Engineering's field techniques for bankfull identification are as follows:

- Identify the most consistent bankfull indicators along the reach that were obviously formed by the stream, such as a point bar or lateral bar. Bankfull is usually the back of this feature, unless sediment supply is high. In that case, the bar may flatten and bankfull will be the front of the feature at the break in slope. The indicator is rarely the top of the bank or lowest scour mark.
- Measure the difference in height between the water surface and the bankfull indicator. For example, the indicator may be 2.2 feet above water surface. Bankfull stage corresponds to a flow depth. It should not vary by more than a few tenths of a foot throughout the reach, unless a tributary enters the reach and increases the size of the watershed.
- Go to a stable riffle. If a bankfull indicator is not present at this riffle, use the height measured in the previous step to establish the indicator. For example, measure 2.2 feet above water surface and place a flag in both the right and left bank.
- Measure the distance from the left bank to the right bank between the indicators. Calculate the cross-sectional area.
- Obtain the appropriate regional curve (e.g., rural Piedmont, urban Piedmont, Mountain, or Coastal Plain) and determine the cross-sectional area associated with the drainage area of the reach.
- Compare the measured cross-sectional area to the regional curve cross-sectional. If the measured cross-sectional area is not a close fit, look for other bankfull indicators and test them. If there are no other indicators, look for reasons to explain the difference between the two cross-sectional areas. For example, if the cross-sectional area of the stable riffle is lower than the regional curve area, look for upstream impoundments, wetlands, or a mature forested watershed. If the cross-sectional area is higher than the regional curve area, look for stormwater drains, parking lots, or signs of channelization.

It is important to perform the bankfull verification at a stable riffle using indicators from depositional features. The cross-sectional area will change with decreasing stability. In some streams, bankfull indicators will not be present due to incision or maintenance. In such cases, it is important to verify bankfull through other means such as a gauge station survey or reference bankfull information that is specific to the geographic location. The gauge information can be used, along with regional curve information, to estimate bankfull elevation in a project reach that lacks bankfull indicators.

2.3.2 Bed Material Characterization

Baker Engineering typically performs bed material characterization using a modified Wolman procedure (Wolman, 1956; Rosgen, 1996). A 100-count pebble count is performed in transects across the streambed, with the number of riffle and pool transects being proportional to the percentage of riffles and pools within the longitudinal distance of a given stream type. As stream type changes, a separate pebble count is performed. The median particle size of the modified Wolman procedure is known as the d_{50}. The d_{50} describes the bed material classification for that reach. The bed material classification is shown on Exhibit 2.1 and ranges from a classification of 1 for a channel d_{50} of bedrock to a classification of 6 for a channel d_{50} in the silt/clay particle size range.

The modified Wolman pebble count is not appropriate for sand bed streams. When working in sandbed systems, a bulk sampling procedure is used to characterize the bed material. Cores (2” - 3” deep) are sampled from the bed along the entire reach. These cores are taken back to a lab and dry sieved to obtain a sediment size distribution. This information is used to classify the stream and to complete the sediment transport analysis.

2.3.3 Stream Classification

Cross-sections are surveyed along stable riffles for the purpose of stream classification. Values for entrenchment ratio and width/depth ratio, along with sinuosity and slope, are used to classify the stream. The entrenchment ratio (ER) is calculated by dividing the flood-prone width (width measured at twice the maximum bankfull depth) by the bankfull width. The width/depth ratio (w/d ratio) is calculated by dividing bankfull width by mean bankfull depth). Exhibit 2.5 shows examples of the channel dimension measurements used in the Rosgen stream classification system.

Finally, the numbers associated with each bed material classification used are used to further classify the stream type. For example, a Rosgen E3 stream type is a narrow and deep cobble-dominated channel with access to a floodplain that is greater than two times its bankfull width.

2.4 Channel Stability Assessment Methodology

Baker Engineering uses a modified version of stream channel stability assessment methodology developed by Rosgen (2001). The Rosgen method is a field assessment of the following stream channel characteristics:

- Stream Channel Condition
- Vertical Stability
- Lateral Stability
- Channel Pattern
- River Profile and Bed Features
- Channel Dimension Relations
- Channel Evolution.

This field exercise is followed by the evaluation of various channel dimension relationships. The evaluation of the above characteristics leads to a determination of a channel’s current state, potential for restoration, and appropriate restoration activities. A description of each category is provided in the following sections.

2.4.1 Stream Channel Condition Observations

Stream channel conditions are observed during initial field inspection (stream walk). Baker Engineering notes the following characteristics:

- Riparian vegetation – concentration, composition, and rooting depth and density
- Sediment depositional patterns – such as mid-channel bars and other depositional features that indicate aggradation and can lead to negative geomorphic channel adjustments
- Debris occurrence – presence or absence of woody debris
- Meander patterns – general observations with regard to the type of adjustments a stream will make to reach equilibrium
- Altered states due to direct disturbance – such as channelization, berm construction, and floodplain alterations.

These qualitative observations are useful in the assessment of channel stability. They provide a consistent method of documenting stream conditions that allows comparison across different sets of conditions. The observations also help explain the quantitative measurements described below.

2.4.2 Vertical Stability – Degradation/Aggradation

The bank height and entrenchment ratios are measured in the field to assess vertical stability. The bank height ratio is measured as the ratio of the lowest bank height divided by a maximum bankfull depth. Table 2.1 shows the relationship between bank height ratio (BHR) and vertical stability developed by Rosgen (2001).

Table 2.1
Conversion of Bank Height Ratio (Degree of Incision) to Adjective Rankings of Stability (Rosgen, 2001)

Adjective Stability Rating	Bank Height Ratio
Stable (low risk of degradation)	1.0 – 1.05
Moderately unstable	1.06 – 1.3
Unstable (high risk of degradation)	1.3 – 1.5
Highly unstable	> 1.5

The entrenchment ratio is measured as the width of the floodplain at twice the maximum bankfull depth. If the entrenchment ratio is less than 1.4 (+/- 0.2), the stream is considered entrenched (Rosgen, 1996).

2.4.3 Lateral Stability

The degree of lateral containment (confinement) and potential lateral erosion are assessed in the field by measuring the meander width ratio (MWR) and the Bank Erosion Hazard Index (BEHI) (Rosgen, 2001). The MWR is the meander belt width divided by the bankfull channel width, and provides insight into lateral channel adjustment processes depending on stream type and degree of confinement. For example, a MWR of 3.0 often corresponds with a sinuosity of 1.2, which is the minimum value for a stream to be classified as meandering. If the MWR is less than 3.0, lateral adjustment is probable. BEHI ratings along with near bank shear stress estimates can be compared to data from monitored sites and used to estimate the annual lateral stream bank erosion rate.

2.4.4 Channel Pattern

Channel pattern is assessed in the field by measuring the stream's plan features including radius of curvature, meander wavelength, meander belt width, stream length, and valley length. Results are used to compute the meander width ratio (described above), ratio of radius of curvature to bankfull width, sinuosity, and meander wavelength ratio (meander wavelength divided by bankfull width). These dimensionless ratios are compared to reference reach data for the same valley and stream type to assess whether channel pattern has been impacted.

2.4.5 River Profile and Bed Features

A longitudinal profile is created by measuring and plotting elevations of the channel bed, water surface, bankfull, and low bank height. Profile points are surveyed at prescribed intervals and at significant breaks in slope such as the head of a riffle or the head of a pool. This profile can be used to assess changes in river slope compared to valley slope, which affect sediment transport, stream competence, and the balance of energy. For example, the removal of large woody debris may increase the step/pool spacing and result in excess energy and subsequent channel degradation. Facet (e.g., riffle, run, pool) slopes of each individual feature are important for stability assessment and design.

2.4.6 Channel Dimension Relations

The bankfull width/depth ratio provides an indication of departure from reference reach conditions and relates to channel instability. A greater width/depth ratio compared to reference conditions may indicate accelerated stream bank erosion, excessive sediment deposition, stream flow changes, and alteration of channel shape (e.g., from channelization). A smaller width/depth ratio compared to reference conditions may indicate channel incision and downcutting. Both increases and decreases in width/depth ratio can indicate evolutionary shifts in stream type (i.e., transition of one stream type to another). Table 2.2 shows the relationship between the degree of width/depth ratio increase and channel stability developed by Rosgen (2001).

Table 2.2
Conversion of Width/Depth Ratios to Adjective Ranking of Stability (Rosgen, 2001a)

Stability Rating	Ratio of Project to Reference Width/Depth
Very stable	1.0
Stable	1.0 – 1.2
Moderately unstable	1.21 – 1.4
Unstable	> 1.4

While an *increase* in width/depth ratio is associated with channel *widening*, a *decrease* in width/depth ratio is associated with channel *incision*. For incised channels, the ratio of channel width/depth ratio to reference reach width/depth ratio will be less than 1.0. The reduction in width/depth ratio indicates excess shear stress and movement of the channel toward an unstable condition.

2.4.7 Channel Evolution

Simon's channel evolution model (introduced in Section 2.1.5) relies on a qualitative, visual assessment of the existing stream channel characteristics (bank height, evidence of degradation/aggradation, presence of bank slumping, direction of bed and bank movement, etc.). Establishing the evolutionary stage of the channel helps ascertain whether the system is moving towards greater stability or instability. The model also provides a better understanding of the cause and effect of channel change. This information, combined with Rosgen's (1994) priority levels of restoration aids in determining the restoration potential of unstable reaches.

2.5 Design Parameter Selection Methodology

Baker Engineering uses a combination of approaches to develop design criteria for channel dimension, pattern, and profile. These approaches are described in the following sections. A flow chart for selecting design criteria is shown in Exhibit 2.6.

2.5.1 Upstream Reference Reaches

The best option for developing design criteria is to locate a reference reach upstream of the project site. A reference reach is a channel segment that is stable—neither aggrading nor degrading— and is of the same morphological type as the channel under consideration for restoration. The reference reach should also have a similar valley slope as the project reach. The reference reach is then used as the blueprint for the channel design (Rosgen, 1998). To account for differences in drainage area and discharge between a reference site and a project site, data on channel characteristics (dimension, pattern, and profile), in the form of dimensionless ratios, are developed for the reference reach. If the reach upstream of the project does not have sufficient pattern, but does have a stable riffle cross-section, only dimension ratios are calculated. It is ideal to measure a reference bankfull dimension that was formed under the same environmental influences as the project reach.

2.5.2 Reference Reach Searches

If a reference reach cannot be located upstream of the project reach, a review of a reference reach database is performed. A database search is conducted to locate known reference reaches in close proximity to the project site. The search includes streams with the same valley as the project reach and stream type as the design. If references are found meeting these criteria, the reference reach is field-surveyed for validation and comparison with the database values which may have been originally collected and provided by a third party. If a search of the database reveals no references which meet the appropriate criteria, a field search is performed locally to identify a reference reach which has not yet been surveyed.

Potential reference reaches are identified by first evaluating U.S. Geological Survey (USGS) topographic quadrangles and aerial photography for an area. In general, the search is limited to subwatersheds within or adjacent to the project watershed. In certain cases, a reference reach may be identified farther away that matches the same valley and stream type as the proposed design of the project site. In such a case, care is taken to ensure that the potential reference reach lies within the same physiographic region as the project reach. Potential reference sites identified on maps are then field-evaluated to determine if they are stable systems of the appropriate stream and valley type. If appropriate, reference reach surveys are conducted. When potential sites are located on private property, landowner permission is acquired prior to any survey work being conducted.

2.5.3 Reference Reach Databases

If a reference reach is not found in close proximity to the project site, a reference reach database is consulted and summary ratios are acquired for all streams with the same valley and stream type within the project's physiographic region. These ratios are then compared to literature values and regime equations along with ratios developed through the evaluation of successful projects.

2.5.4 Regime Equations

Baker Engineering uses a variety of published journals, books, and design manuals to cross-reference North Carolina database values with peer-reviewed regime equations. Examples include *Fluvial Forms and Processes* by David Knighton (1998), *Mountain Rivers* by Ellen Wohl (2000), and the *Hydraulic Design of Stream Restoration Projects* (Copeland et al., 2001) by the US Army Corps of Engineers (USACE). The most common regime equations used in our designs are for pattern. For example, most reference reach surveys in the eastern United States show radius of curvature divided by bankfull width ratios much less than 1.5. However, the USACE manual recommends a ratio greater than 2.0 to maintain stability in free-forming systems. Since most stream restoration projects are constructed on floodplains denude of woody vegetation, we often use the USACE-recommended value rather than reference reach data. Meander wavelength and pool-to-pool spacing ratios are examples of other parameters that are sometimes designed with higher ratios than those observed on reference reaches, for similar reasons as described for radius of curvature.

2.5.5 Comparison to Past Projects

All of the above techniques for developing ratios and/or regime equations are compared to past projects built with similar conditions. Ultimately, these sites provide the best pattern and profile ratios because they reflect post-construction site conditions. While most reference reaches are in mature forests, restoration sites are in floodplains with little or no mature woody vegetation. This lack of mature woody vegetation severely alters floodplain processes and stream bank conditions. If past ratios did not provide adequate stability or bedform diversity, they are not used. Conversely, if past project ratios created stable channels with optimal bedform diversity; they will be incorporated into the design.

Ultimately, the design criteria are selections of ratios and equations made upon a thorough evaluation of the above tasks. Combinations of approaches may be used to optimize the design. The final selection of design criteria for the restoration site is discussed in Section 7.0.

2.6 Sediment Transport Competency and Capacity Methodology

Stream restoration designs must be tested to ensure that the new channel dimensions (in particular, the design bankfull mean depth) create a stream that has the ability to move its sediment load without aggrading or degrading over long periods of time. The ability of the stream to transport its total sediment load is quantified through two measures: sediment transport competency and sediment transport capacity. Competency is a stream's ability to move particles of a given size and is a measurement of force, often expressed as units of pounds per square foot (lbs/ft^2). Sediment transport capacity is a stream's ability to move a quantity of sediment and is a measurement of stream power, often expressed as units of watts/square meter. Sediment transport capacity is also calculated as a sediment transport rating curve, which provides an estimate of the quantity of total sediment load transported through a cross-section per unit time. The curve is provided as a sediment transport rate in pounds per second (lbs/sec) versus discharge or stream power.

The total volume of sediment transported through a cross-section consists of bedload plus suspended load fractions. Suspended load is normally composed of fine sand, silt, and clay particles transported in the water column. Bedload is generally composed of larger particles, such as course sand, gravels, and cobbles, which are transported by rolling, sliding, or hopping (saltating) along the bed.

2.6.1 Competency Analysis

Median substrate size has an important influence on the mobility of particles in stream beds. Critical dimensionless shear stress (τ*ci) is the measure of force required to initiate general movement of particles in a bed of a given composition. At shear stresses exceeding this critical value, essentially all grain sizes are transported at rates in proportion to their presence in the bed (Wohl, 2000). τ*ci can be calculated for gravel-bed stream reaches using surface and subsurface particle samples from a stable, representative riffle in the reach (Andrews, 1983). Critical dimensionless shear stress is calculated as follows (Rosgen, 2001):

1. Using the following equations, determine the critical dimensionless shear stress required to mobilize and transport the largest particle from the bar sample (or subpavement sample).

a) Calculate the ratio d50/d^50

Where: d50 = median diameter of the riffle bed (from 100 count in the riffle or pavement sample)

d^50 = median diameter of the bar sample (or subpavement)

If the ratio d50/d^50 is between the values of 3.0 and 7.0, then calculate the critical dimensionless shear stress using Equation 1.

$$\tau \text{*ci} = 0.0834\ (\text{d50/d\^{}50})^{-0.872} \qquad \text{(Equation 1)}$$

b) If the ratio d50/D^50 is not between the values of 3.0 and 7.0, then calculate the ratio of di/d50.

Where: di = Largest particle from the bar sample (or subpavement)

d50 = median diameter of the riffle bed (from 100 count in the riffle or the pavement sample)

If the ratio di/d50 is between the values of 1.3 and 3.0, then calculate the critical dimensionless shear stress using Equation 2.

$$\tau \text{*ci} = 0.0384\ (\text{di/d50})^{-0.887} \qquad \text{(Equation 2)}$$

2.6.2 Aggradational Analysis

The aggradation analysis is based on calculations of the required depth and slope needed to transport large sediment particles, in this case defined as the largest particle of the riffle subpavement sample. Required depth can be compared with the existing/design mean riffle depth and required slope can be compared to the existing/design slope to verify that the stream has sufficient competency to move large particles and thus prevent thalweg aggradation. The required depth and slope are calculated by:

$$d_r = \frac{1.65\tau^*_{ci} d_i}{S_e} \qquad \text{(Equation 3)}$$

$$s_r = \frac{1.65\tau^*_{ci} d_i}{d_e} \qquad \text{(Equation 4)}$$

Where: dr (ft) = Required bankfull mean depth

de (ft)= Design bankfull mean depth

1.65 = Sediment density (submerged specific weight)

= density of sediment (2.65) – density of water (1.0)

τ *ci = Critical dimensionless shear stress

di (ft) = Largest particle from bar sample (or subpavement)

sr (ft/ft) = Required bankfull water surface slope

se (ft/ft) = Design bankfull water surface slope

The aggradation analysis is used to assess both existing and design conditions. For example, if the calculated value for the existing critical depth is significantly larger than the measured maximum bankfull depth, this indicates that the stream is aggrading. Alternately, if the proposed design depth significantly differs from the calculated critical depth and the analysis is deemed appropriate for the site conditions, the design dimensions should be revised accordingly.

2.6.3 Competency Analysis using a Modified Shield's Curve

As a complement to the required depth and slope calculations, boundary shear stresses for a design riffle cross-section can be compared with a modified Shield's curve to predict sediment transport competency. The shear stress placed on the sediment particles is the force that entrains and moves the particles, given by:

$$\tau = \gamma R s \qquad \text{(Equation 5)}$$

Where, τ = shear stress (lb/ft^2)

γ = specific gravity of water (62.4 lb/ft^3)

R = hydraulic radius (ft)

s = average channel slope (ft/ft)

The boundary shear stress can be estimated for the design cross-section and plotted on a modified Shield's curve, as shown in Exhibit 2.7. The particle size that Shield's curve predicts will be moved is compared to the D_i of the site subpavement. Shield's curve predicts whether the design conditions will have enough shear stress to move a particle larger than the largest subpavement particle found in the creek and prevent aggradation.

2.6.4 Sediment Transport Capacity

For sand bed streams, sediment transport capacity is much more important than competency. Sediment transport capacity refers to the stream's ability to move a mass of sediment past a cross-section per unit time in pounds/second or tons/year. Sediment transport capacity can be assessed directly using actual monitored data from bankfull events if a sediment transport rating curve has been developed for the project site. Since this curve development is extremely difficult, other empirical relationships are used to assess sediment transport capacity. The most common capacity equation is stream power. Stream power can be calculated a number of ways, but the most common is:

$$w = \gamma QS/W_{bkf}, \text{ where} \qquad \text{(Equation 6)}$$

w = mean stream power in W/m^2

γ = specific weight of water (9810 N/m3). $\gamma = \rho\, g$ where ρ is the density of the water-sediment mixture (1,000 kg/m^3) and g is the acceleration due to gravity (9.81 m/s^2)

Q = bankfull discharge in m^3/s

S = Design channel slope (meters per meter)

W_{bkf} = Bankfull channel width in meters

Note: 1 ft-lb/sec/ft^2 = 14.56 W/m^2

Equation 6 does not provide a sediment transport rating curve; however, it does describe the stream's ability to accomplish work, i.e., move sediment. Calculated stream power values are compared to reference and published values. If deviations from known stable values for similar stream types and slopes are observed, the design should be reassessed to confirm that sediment will be adequately transported through the system without containing excess energy in the channel.

2.7 In-stream Structures

There are a variety of in-stream structural elements used in restoration. Exhibit 2.8 illustrates a few typical structures. These elements are comprised of natural materials such as stone, wood, and live vegetation. Their shape and location works with the flow dynamics to reinforce, stabilize, and enhance the function of the stream channel. In-stream structures provide three primary functions: grade control, stream bank protection, and habitat enhancement.

2.7.1 Grade Control

Grade control pertains mainly to the design bed profile. A newly excavated gravel stream bed with a slope greater than 0.5 percent is seldom able to maintain the desired slopes and bed features (riffles, runs, pools and glides) until a pavement/subpavement layer has been established. Stone and/or log structures installed at the bed elevation and at critical locations in the plan view help to set up the new stream bed for long-term vertical stability. Over time, as the new channel adjusts to its sediment transport regime and vegetative root mass establishes on the banks, the need for grade control diminishes.

2.7.2 Bank Protection

Bank protection is critical during and after construction as bank and floodplain vegetation is establishing a reinforcing root mass. This vegetation establishment lasts for several years, but vegetation is typically providing meaningful bank protection after two to four growing seasons. Bank protection structures generally provide both reinforcement to the stream banks and re-direction of flow away from the banks and toward the center of the channel.

2.7.3 Habitat Enhancement

Habitat enhancement can take several forms and is often a secondary function of grade control and bank protection structures. The flow of water over vanes and wing deflectors creates scour pools, which provide diversity of in-stream habitat. Boulder clusters form eddies that provide resting places for aquatic species. Constructed riffles and vane structures encourage oxygenation of the water. Root wads provide cover and shade, and encourage the formation of deep pools at the outside of meander bends.

2.7.4 Selection of Structure Types

Table 2.3 summarizes the names and functions of several in-stream structures.

Table 2.3
Functions of In-stream Structures

Structure	Function (Primary = 1, Secondary = 2)		
	Grade Control	Bank Protection	Habitat Enhancement
Cross Vane	1	1	2
Single Arm Vane		1	2
J-Hook Vane		1	2
Constructed Riffle	1	1	2
Log Weir	1		2
Wing Deflector	2	1	1
Step Pool	1	1	2
Boulder Cluster			1
Root Wad		1	1
Brush Mattress		1	2
Cover Log			1

The selection of structure types and locations typically follows dimension, pattern, and profile design. In some situations, structure installation comprises the main, or possibly only, effort required to restore a stream. More often, structures are used in conjunction with grading, realignment, and planting in an effort to improve channel stability and aquatic habitat.

2.8 Vegetation

The planting of additional and/or more desirable vegetation is an important aspect of the restoration plan. Vegetation helps stabilize stream banks, creates habitat and a food source for wildlife, lowers water temperature by stream shading, improves water quality by filtering overland flows, and improves the aesthetics of the site.

The reforestation component of a restoration project typically includes live dormant staking of the stream banks, riparian buffer plantings, invasive species removal, and seeding for erosion control. The stream banks and the riparian area are typically planted with both woody and herbaceous vegetation to establish a diverse streamside buffer. Establishing vegetation along the stream banks is a very desirable means of erosion control because of the dynamic, adaptive, and self-repairing qualities of vegetation. Vegetative root systems stabilize channel banks by holding soil together, increasing porosity and infiltration, and reducing soil saturation through transpiration. During high flows, plants lie flat and stems and leaves shield and protect the soil surface from erosion. In most settings, vegetation is more aesthetically appropriate than engineered stabilization structures.

Stream banks are delineated into four zones when considering a planting scheme:

1. Channel bottom - extending up to the low flow stage. Emergent, aquatic plants dominate bank range, extending from the low flow stage to the bankfull stage.
2. Lower bank - frequently flooded, extending from the low flow stage to the bankfull stage. A mix of herbaceous and woody plants including sedges, grasses, shrubs and trees.
3. Upper bank – occasionally flooded, but most often above water. Dominated by shrubs and small trees.
4. Riparian area – infrequently flooded, terrestrial, and naturally forested with canopy-forming trees.

The most appropriate source of plant material for any project is the site itself. Desirable plants that need to be removed in the course of construction should be salvaged and transplanted as part of the restoration plan. The next best alternative is to obtain permission to collect and transplant native plants from areas nearby. This transplant process ensures that the plants are native and adapted to the locale. Finally, plants may need to be purchased. They should be obtained from a nearby reputable nursery that guarantees that the plants are native and appropriate for the locale and climate of the project site.

2.8.1 Live Staking

Live staking is a method of revegetation that utilizes live, dormant cuttings from appropriate species to cheaply, and effectively establish vegetation. The installation of live stakes on stream banks serves to protect the banks from erosion and at the same time provide habitat, shade and improved aesthetics. Live staking must take place during the dormant season (November to March in the southeast US). Live stakes can be gathered locally or purchased from a reputable commercial supplier. Stakes should be at least ½ inches in diameter and no more than 2 inches in diameter, between 2 and 3 feet in length, and living based on the presence of young buds and green bark. Stakes are cut at an angle on the bottom end and driven into the ground with a rubber mallet.

2.8.2 Riparian Buffer Re-Vegetation

Riparian buffers are areas of perennial vegetation adjacent to rivers and streams and are associated with a number of benefits. Buffers are important in nutrient and pollutant removal in overland flow and may provide for additional subsurface water quality improvement in the shallow groundwater flow. Buffers provide habitat and travel corridors for wildlife populations and are an important recreational resource. It is also important to note that riparian buffer areas help to moderate the quantity and timing of runoff from the upland landscape and contribute to the groundwater recharge process.

Buffers are most valuable and effective when comprised of a combination of trees, shrubs, and herbaceous plants. Although width generally increases the capacity of riparian buffers to improve water quality and provide greater habitat value, even buffers less than 85 feet wide have been shown to improve water quality and habitat (Budd et al., 1987). An estimated minimum width of 30 feet is required for creating beneficial forest structure and riparian habitat.

In stream and wetland restoration, where buffer width is often limited, the following design principles apply:

- Design for sheet flow into and across the riparian buffer area
- If possible, the width of the riparian buffer area should be proportional to the watershed area, the slope of the terrain, and the velocity of the flow through the buffer
- Forest structure should include understory and canopy species. Canopy species are particularly important adjacent to waterways to moderate stream temperatures and to create habitat
- Use native plants that are adapted to the site conditions (e.g., climate, soils, and hydrology). In suburban and urban settings riparian forested buffers do not need to resemble natural ecosystems to improve water quality and habitat.

2.9 Risk Recognition

It is important to recognize the risks inherent in the assessment, design, and construction of environmental restoration projects. Such endeavors involve the interpretation of existing conditions to deduce appropriate design criteria, the application of those criteria to design, and, most importantly, the execution of the construction phase. There are many factors that ultimately determine the success of these projects and many of the factors are beyond the influence of a designer. To compile all of the factors is beyond the scope of this report. Further, it is impossible to consider and to design for all of them. However, it is important to acknowledge those factors such as daily temperatures, the amount and frequency of rainfall during and following construction, subsurface conditions, and changes in watershed characteristics, that are beyond the control of the designer.

Many restoration sites will require some post-construction maintenance, primarily because newly planted vegetation plays a large role in channel and floodplain stability. Stream restoration projects are most vulnerable to adjustment and erosion immediately after construction, before vegetation has had a chance to become fully established. Risk of instability diminishes with each growing season. Streams and floodplains usually become self-maintaining after the second year of growth. However, unusually heavy floods often cause erosion, deposition and/or loss of vegetation in even the most stable channels and forested floodplains.

Maintenance issues and recommended remediation measures will be detailed and documented in the as-built and monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed.

3.0 WETLAND RESTORATION BACKGROUND SCIENCE AND METHODS

3.1 The Importance of Wetlands

Wetlands are unique landscape features that can provide numerous benefits to ecosystems. They are usually delineated based on three components: hydric soils, wetland hydrology, and hydrophytic vegetation. Natural wetlands are generally formed when the geology and hydrology of an area allow for surface or groundwater to accumulate near the soil surface. Wetlands offer unique habitats for flora and fauna, remove nutrients and other contaminants, allow for surface water storage, and recharge groundwater aquifers. Wetlands help to reduce the impacts of floods, improve water quality, and provide aesthetic and recreational benefits (Mitsch and Gosselink, 2000; King, 2000). The functions performed by wetlands are site-specific, depending on the location in the ecosystem and environmental conditions.

Many natural processes or anthropogenic activities can impact wetlands. Wetland restoration seeks to restore wetland functions to areas that currently possess hydric soils but no longer support wetland hydrology or vegetation. Wetland restoration design must take into consideration each of the three components of wetlands (soils, hydrology, and vegetation). The following sections will provide an overview of the restoration process used by Baker Engineering.

3.2 Hydric soils

Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper horizons (Federal Register, July 13, 1994). Soil development is directly affected by the hydrology of an area, as well as by its climate, parent material, time, soil organisms, and topography. Anaerobic conditions result in specific soil biogeochemical processes, such as the retention of organic matter, the chemical reduction of nitrogen (NO_3), iron (Fe), manganese (Mn), sulfur (S), and carbon (C). When a soil is saturated, aerobic microorganisms deplete the remaining oxygen in the system. As oxygen becomes more and more limiting, anaerobic organisms begin to utilize oxidized soil components that are further reduced (Mausbach and Richardson, 1994). The first reaction that occurs under anaerobic conditions is the reduction of nitrate. As the oxidation-reduction (redox) potential continues to decrease, manganese is reduced, then iron, and finally, sulfur and carbon. The soil pH, temperature, and mineral content are all important factors in the rates of transformation (Mitsch and Gosselink, 2000). These reduction processes result in characteristic hydric soil indicators, such as the retention of organic matter, gleyed soils, soils with low-matrix chromas, sulfur odor, etc.

There are two main types of hydric soils: organic soils and mineral soils. Organic soils, or Histosols, are soils that have more than 30% organic matter to a depth of 40 centimeters and that develop under nearly continuous saturation or inundation (Buol et al, 1989). These soils are also called peat or mucks. All organic soils are considered to be hydric except for Folists, which occur on dry slopes.

Hydric soils with less than 30% organic matter are classified as mineral soils. When saturated or inundated for extended periods of time, mineral soils develop characteristic indicators, which are a result of depletion of oxygen within the soil (Mitsch and Gosselink, 2000; US Department of Agriculture (USDA), 1996). The reduction of nitrogen, iron, and manganese forms hydric soil indicators that are referred to as redoximorphic features (Vepraskas, 1996). Redoximorphic features include, but are not limited to: gleyed soils, soils with low-matrix chroma, redox concentrations, oxidized rhyzospheres, and iron and manganese concretions.

Wetlands are commonly referred to as the kidneys of the landscape (Mitsch and Gosselink, 2000). The analogy is applicable because wetlands filter the water that flows through them, trapping sediment and sequestering nutrients, including carbon, nitrogen, and phosphorous (Craft and Casey, 2000). Wetland soils may be factors in changing the global cycles of nitrogen, sulfur, methane, and carbon dioxide. Wetland soils help to return excess nitrogen to the atmosphere through denitrification. The use of fossil fuels has greatly increased the amount of atmospheric sulfate. When these sulfates are washed out of the atmosphere into wetlands, they can be reduced and even removed permanently from the sulfur cycle (Mitsch and Gosselink, 2000). Carbon can be sequestered into wetland soils, helping to reduce carbon dioxide concentrations.

When hydric soils are converted to agriculture, changes to the soils' chemistry and structure often occur. Once drained, wetland areas are typically graded smooth to improve surface drainage, a process that removes much of the sites' natural topographic variability. The organic content of the soils often decreases due to the oxidation caused by aeration. Concentrations of major and micro-nutrients are often increased due to the application of fertilizers. "Loose" soil structures of many wetland soils are typically converted to more blocky and massive structures, due to years of mechanized equipment traffic. Plow pans, or layers of highly compacted soil, are often present approximately 12 to 18 inches below the surface.

Assessment of on-site hydric soils begins with collected soil survey data from the Natural Resources Conservation Service (NRCS). Since soil survey data are collected on a regional scale, on-site investigations begin by evaluating the accuracy of NRCS mapping. Soil borings are conducted across the restoration site to confirm the presence of hydric soil series and the boundaries. Soil profiles are recorded for each location. For hydrologic analysis purposes, measurements of in-situ saturated hydraulic conductivity are also conducted. Under high water table conditions, the auger hole method, as described by van Beers (1970), is used. Under lower water table conditions, a constant head permeameter (amoozemeter) is used. Measurements are made at representative locations across the site to determine the variability in hydraulic conductivity across the site.

3.3 Wetland Vegetation

Wetland hydrology and hydric soils create what can be considered a harsh environment for many biotic organisms. Since many wetlands are only periodically inundated or saturated, water levels may not be consistently high or low. Many aquatic plants are not able to flourish when wetlands temporarily dry, and many xeric species are not able to adapt to conditions that are periodically wet. Wetland plants have adapted to life in this unpredictable environment.

Wetland plants, also referred to as hydrophytic vegetation, possess a range of adaptations that enable them to tolerate or avoid water stress. The three major types of adaptations are morphological, physiological, and reproductive. Morphological adaptations enable plants to increase the oxygen supply, either by growing into aerobic environments or by allowing oxygen to penetrate the anoxic zone (Mitsch and Gosselink, 2000). Various morphological adaptations that vascular plants may exhibit are buttressed tree trunks, adventitious roots, shallow root systems, floating leaves, hypertrophied lenticels, and/or multi-trunks.

Physiological adaptations to wetland environments include oxidized rhizospheres, changes in water uptake, nutrient absorption, and respiration. Some species are capable of transferring oxygen from the root system into the adjacent soil, producing oxidized rhizospheres surrounding the root. Under saturated conditions, many hydric plants have no change in their nutrient uptake, whereas flood-intolerant species lose the ability to control nutrient absorption (Mitsch and Gosselink, 2000).

Reproductive adaptations allow wetland vegetation to establish and grow within inundated soil conditions. Some of these adaptations include prolonged seed viability (including production of a large seed bank), timing of seed production in the non-saturated season, production of buoyant seeds, flood-tolerant species, and germination of seeds while fruit is attached to the tree. These reproductive, morphological, and hydrophytic adaptations allow wetland plants to flourish in relatively harsh environments and create communities of plants adapted to wetland conditions.

Plant communities generally exist along a topographic gradient. Hill tops or southwest-facing slopes tend to have the most xeric vegetation, whereas bottomlands tend to have the most mesic species. These topographic gradients tend to have plant communities directly associated with them. It should be noted that some species will be found in both xeric and mesic community types. Plant communities are based on species assemblages and not on individual species. Hydrophytic vegetation is defined by the USACE Wetland Delineation Manual as "the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present" (USACE, 1987). According to the manual, species that have an indicator status of Obligate Wetland Plants (OBL), Facultative Wetland Plants (FACW), or Facultative Plants (FAC) are considered to be typically adapted for life in wetlands or anaerobic soil conditions. Typically, a wetland plant community contains more than 50 percent of the dominant species as OBL, FACW, or FAC species.

When restoring wetlands, Baker Engineering utilizes native plants to approximate the community that would naturally live within that physiographic community type. Species selection is based on reference wetland vegetation analyses, professional knowledge of availability and viability of specific plants, and expected post-restoration hydrologic conditions. Special emphasis is placed on re-creating a community type that is adapted to the conditions of the restoration site. The re-creation is accomplished by planting hard mast tress, lightly-seeded trees, and various understory or midcanopy, woody species. The utilization of hard mast species creates additional wildlife food sources and allows for late, successional species to become established. The utilization of lightly-seeding species allows for the faster development of wildlife cover and habitat. The planting of understory species helps to ensure a more diverse plant community that will provide long-term benefits to wildlife.

3.4 Wetland Hydrology

Wetland hydrology is often sited as the primary driving force influencing wetland development, function, and persistence (Gosselink and Turner, 1978; Sharitz et al., 1990) and also one of the hardest variables to assess and predict accurately. Hydrology drives the development of hydric soil characteristics, water and soil chemistry, and hydrophytic plant communities. Most functions commonly attributed to wetlands (water filtering, nutrient cycling, sediment trapping, ecosystem diversity, etc.) are a direct result of the hydrologic characteristics of wetland systems. For these reasons, Baker Engineering places significant emphasis on the correct assessment of wetland hydrologic conditions, under both pre- and post-restoration conditions.

Assessment of wetland hydrology begins by touring the project site to observe hydrologic conditions. When possible, site tours are conducted during dry times (several weeks following the last rainfall event) and wet times (immediately following large rainfall events). Evaluation of site conditions during dry periods provides valuable evidence about existing site function and indicates the hydrologic variability across the site. Wetland hydrology assessments during dry periods focus on the following key questions:

1. *Are there areas that are currently exhibiting wetland hydrology?* These areas require special attention and will likely be subject to regulatory permit conditions.
2. *Where are the areas of the site that appear especially dry?* These areas will likely require the greatest attention to restore wetland hydrology.
3. *What are the sources of water on the site that can be manipulated during restoration?* Sources may include groundwater discharge, run-off, surface water flows, and stream flows. Various design techniques are available for storing more water within the restoration site to

increase wetness. The primary source of water available will directly affect the type of design that will be most effective at restoring wetland hydrology.

Evaluation during wet periods allows for observations regarding runoff patterns, areas of ponding and water storage, flow routing, and surface flow interactions. Wetland hydrology assessments during wet periods focus on the following key questions:

1. *How is runoff currently being routed across the site?* Most degraded sites have been topographically manipulated to direct runoff to a drainage outlet as quickly as possible. Restoration must reduce the loss of water from the site and restore water storage functions of natural wetland sites.
2. *Are there any surface water sources that could be used in the restoration design?* Sources may include ephemeral and intermittent ditches, drainage swales, and overland flow.
3. *If stream flow or overbank flow is believed to have once contributed to wetland hydrology, can these sources be restored?* Evaluation of stream channels primarily involves the evaluation of bankfull stage in relation to existing bank heights, whether streambed elevations can be altered, and hydrologic trespass.

When necessary for accurate assessment of existing hydrologic conditions, monitoring wells are installed to document local water table conditions. Wells are installed to a depth of approximately 40 inches, following the procedures outlined under USACE's Wetland Research Program (WRP) Technical Note ERDC TN-WRAP-00-02 (July, 2000). Monitoring wells are typically installed as combinations of automated and manually-read wells. Automated wells are installed in areas where precise measurement of hydrologic conditions is necessary. Such areas may include areas near drainage features, where the prediction of the drainage effect is needed, areas where the hydrologic functioning is difficult to predict through visual assessments, and areas where the hydrologic status of an area is questionable (i.e., does wetland hydrology exist?). Manually-read wells are typically read on a monthly basis and are used to supplement the data collected with automated wells. Manual wells are typically installed in areas where the hydrologic status is predictable based on visual assessments, but measured data will allow for more conclusive evaluation of pre- and post-restoration conditions. Manual wells, installed as piezometers, can also be installed in nests to determine the direction of groundwater movement.

Accurate site mapping is essential to the evaluation of site hydrology and restoration design. Topographic maps of the site are produced using either ground or aerial survey methods. Digital elevation models (DEMs) are developed that include topographic contours (typically 1.0 foot contours or less), locations of all drainage features and outlets, structures, existing wetland areas, and monitoring well locations. DEMs are used to visually depict the hydrologic features of the site, develop hydrologic model inputs, and evaluate proposed restoration practices.

3.5 Wetland Hydrologic Analyses

Hydrology data collected at the proposed restoration site is essential for documenting the hydrologic conditions of the site at the time of collection; however, data collected over several months to a year are limited for evaluating the site's long-term performance under varying rainfall and climatic conditions. Existing condition data alone also provides little insight into how the site will perform once restoration activities are completed. For these reasons, hydrologic modeling is often used to further evaluate the potential restoration site.

The most common hydrologic model used by Baker Engineering to evaluate wetland hydrology is DRAINMOD (version 5.1). DRAINMOD has been identified as an approved hydrologic tool for assessing wetland hydrology by the NRCS. DRAINMOD was developed by NC State University for the study and design of water management systems on poorly-drained, shallow water table soils. A combination of methods is used in the model to simulate infiltration, drainage, surface runoff, evapotranspiration, and seepage processes on an hour-by-hour, day-by-day basis. DRAINMOD was modified by Skaggs et al., (1991) for application to wetland determinations by the addition of a counter that calculates the number of times the water table rises above a specified depth and remains there for a given period during the growing season. For more information on DRAINMOD and its application to high water table soils, see Skaggs (1980).

DRAINMOD is used to develop hydrologic simulation models to represent conditions at a variety of locations across the proposed restoration area. Model parameters are selected based on field measurements and professional judgment about site conditions. Rainfall and air temperature information are collected from the nearest automated weather station. If automated weather stations are too far away, automated rain gauges may be installed on site. Soil parameters are determined from on-site evaluations of soil stratification and in-situ-measured hydraulic conductivity.

Measured field parameters are entered into the model, and initial model simulations are compared with observed data collected from monitoring wells. To calibrate the model, parameters not measured in the field are adjusted within the limits typically encountered under similar soil and geomorphic conditions, until model simulations most closely match observed well data.

It is important to note that DRAINMOD uses simplifying assumptions to estimate water table depths. When applied to a site with complex hydrologic processes, the model can be used to assess overall trends and relationships but is unlikely to offer exact predictions of water table hydrology. Calibration of the model is aimed at matching the relative response of water table drawdown and the overall depth that the water table reaches at different times during the year. Once these objectives are met, the model is assumed to adequately reflect the hydrologic response of the site to varying precipitation and climatic events.

Once model simulations are developed that reflect the existing conditions of the site, other simulations may be developed to represent the hydrology of the site after restoration practices have been implemented. Inputs that describe the drainage features of the site are altered to represent the restoration conditions. Inputs typically include: drainage feature spacing (increased due to the removal of ditches), drainage feature depth (typically decreased when restoring an associated stream and raising the streambed or filling and plugging drainage ditches), surface storage (increased through scarification practices), and crop inputs (conversion to trees instead of row crops). Model simulations are used to predict the changes in water table hydrology as a result of the proposed restoration practices.

DRAINMOD computes daily water balance information and develops summaries that describe the loss pathways for rainfall over the model simulation period. To compare long-term results, the amounts of rainfall, infiltration, drainage, runoff, and evapotranspiration estimated for the existing condition can be compared with simulations run for the proposed restoration practices. Infiltration represents the amount of water that percolates into the soil and is lost via drainage or runoff. Drainage is the loss of infiltrated water that travels through the soil profile and is discharged to the drainage ditches or to underlying aquifers. Runoff is water that flows overland and reaches the drainage ditches before infiltration. Evapotranspiration is water that is lost by the direct evaporation of water from the soil or through the transpiration of plants. Comparisons may include average annual amounts, annual maximums and minimums, and even day-to-day comparisons of hourly water table hydrographs.

3.6 Assessment of Existing Wetland Areas

Conditions across a potential restoration site will often vary dramatically. While much of the site may be targeted for restoration due to lack of wetland hydrology and functions, there may be areas of the site that still support wetland hydrology and wetland functions to some degree. These areas require special consideration as part of a proposed restoration design.

The proposed project area is reviewed for the presence of wetlands and waters of the United States in accordance with the provisions of Executive Order 11990, the Clean Water Act, and subsequent federal regulations. Wetlands have been defined by the USACE as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas” [33 CFR 328.3(b) and 40 CFR 230.3 (t)]. Within the project area, locations that display one or more wetland components are reviewed to determine the presence of wetlands using hydrophytic vegetation, permanent or periodic inundation or saturation, and hydric soils.

Following an in-office review of the National Wetland Inventory (NWI) maps, NRCS Soil Surveys, and USGS Quadrangle maps, a pedestrian survey of the project area is made to investigate suspect areas and to delineate all wetlands and waters of the U.S. The project area is examined utilizing the jurisdictional definition detailed in the USACE Wetlands Delineation Manual. Supplementary information to further support wetland determinations is found in the *National List of Plant Species that Occur in Wetlands: Southeast (Region 2)* (Reed, 1988).

Baker Engineering collects data on the three wetland components and completes USACE wetland determination field sheets for each identified wetland area. These sheets document the wetland conditions that were observed on-site, including the presence of hydrophytic (wetland) vegetation, hydric soils, and wetland hydrology. The wetland systems are also classified using the *Classification of the Natural Communities of North Carolina, Third Approximation,* by Schafale and Weakley (1990). This classification system includes descriptions of all the natural community types in North Carolina (112 types and subtypes), including vegetation, soils, physical environment, dynamics, distinguishing features, examples, and associated rare plants. Wetlands are also classified using the *Hydrogeomorphic Classification of Wetlands* (HGM) by Brinson (1993). Since HGM subtypes are still being developed for North Carolina, HGM principles are used to describe the geomorphic setting, water sources, hydrodynamics, and functioning of identified wetland systems.

Where jurisdictional wetlands are identified, the wetland boundary is flagged with marking tape, at intervals of 25 to 50 feet. Baker Engineering follows the USACE Wilmington District procedures for survey and recordation of wetland boundaries. Surveys of wetland boundaries are conducted with either sub-meter accuracy Global Positioning System (GPS) equipment or total station survey equipment. A professional land surveyor (PLS) oversees any detailed land surveys. Wetland drawings are prepared using Geographic Information Systems (GIS) and/or computer aided design and drafting (CADD) applications and submitted to USACE and the NCDWQ for jurisdictional determination and verification when required.

3.7 Reference Wetlands

Reference wetlands are natural wetland systems that are similar in function and geomorphic setting to the proposed restoration site. Reference wetlands can be used as templates for the proposed restoration design. Data collected from reference wetland sites, including vegetation communities, hydrologic characteristics, and topographic features, can provide valuable information for the evaluation of proposed restoration practices. Analysis of the vegetation communities within the reference site is used as a tool for developing the planting plan for the restoration site. Reference wetlands can also be used for comparison purposes to determine whether the restored wetland site is on a trajectory for success during the required monitoring period.

The reference wetland site should be located as close to the proposed restoration site as possible. The reference wetland should be of the same hydrogeomorphic classification as the proposed restoration site, and generally located within the same climatic, physiographic, and ecological region. Soil characteristics should closely match those of the proposed restoration site. Fully functioning wetland systems appropriate for reference sites may be difficult to locate in some areas; as a result, reference sites are often located some distance from the restoration site.

Once a potential reference site is located, Baker Engineering secures landowner permission to further evaluate the area as a potential reference site. On-site evaluations are similar to those previously described for jurisdictional wetland areas on restoration sites and include the documentation of vegetation communities, soil series, and visual observations regarding wetland hydrology. USACE wetland determination field sheets are completed for the reference wetland.

If the reference site is found to be appropriate for the restoration project, several groundwater wells are installed across the reference site to capture the range of hydrologic conditions. Automated and manual wells are generally installed in combination, with automated wells installed at the wettest and driest extremes of conditions and manual wells installed in more average conditions. This approach allows for accurate documentation of the hydrologic range of conditions across the site. Well data are downloaded monthly throughout the required monitoring period.

3.8 Wetland Restoration Techniques

Restoration techniques will vary by the type of wetland to be restored and the goals of the restoration. The purpose of this section is to describe some of the techniques that Baker Engineering commonly uses to restore lost functions and values on wetland restoration sites.

3.8.1 Restoration Techniques for Wetland Hydrology

The restoration of appropriate hydrology is the cornerstone of any wetland restoration project. Without the appropriate hydrology, all other wetland functions will be compromised. Several commonly used techniques are described below.

<u>Restoration of Stream Channels</u> – Many wetland restoration sites will contain stream channels that have been channelized and straightened. Channelization of streams lowers the baseflow water elevation in the channel, lowers the adjacent water table, increases the loss of water from the site through both increased surface and subsurface drainage, and decreases the frequency and severity of flooding events on adjacent lands.

The restoration of stream channels to restore wetland hydrology involves raising the streambed elevation such that the stream is reconnected to the abandoned hydric floodplain (i.e., agricultural fields). This process raises the local water table by raising the elevation of the drainage outlet, and restores a natural flooding regime to the site. For more information on stream restoration practices, see Sections 2.1, 2.2, and 2.5.

<u>Filling and Blocking of Drainage Features</u> – Drainage features may include ditches, channels, swales, and subsurface drains. Ditches are the most common drainage feature encountered on agricultural sites. Ditches are generally constructed on parallel spacings that are based on the drainage characteristics of the soils. Ditches and subsurface drains provide an outlet for subsurface drainage that is often several feet lower than the surrounding ground elevation. The effect is that groundwater moves toward the ditches where it is discharged, thus lowering the water table elevation.

Filling and blocking of drainage features removes the drainage effect they provide. The choice between partially blocking and completely filling the drainage features is primarily driven by the amount of soil that must be disposed of during construction. When there is an excess of soil to be disposed of, ditches and swales are completely filled. When the quantity of soil for disposal is limited, ditches and swales are blocked by partially filling, or plugging, the features at specific locations. Plugs are at least 50 to 100 feet in length, and soil material placed for the plugs is compacted with heavy equipment, used on site during construction. The actual length of the plugs will be based on the predicted hydraulic conductivity of the compacted fill material. The spacing between plugs will vary, depending on the slope of the site and the amount of soil for disposal.

Once ditches have been filled in or plugged, additional fill material will be piled over the filled ditch to a height of no more than 6 inches, to allow for subsidence and settling of the fill over time. Without additional material, settling of the fill could cause the drainage feature to partially reform over time and affect the hydrology of the site.

Subsurface drains, such as tiles and plastic pipe, are located and excavated so that they no longer function. Once drains have been removed, excavated soil material is placed back in the excavated trench and compacted.

Run-off Diversions – In some areas, it is beneficial to construct shallow diversions and swales to direct surface water run-off into the site. This practice is commonly used when restoration areas are adjacent to long hill slopes, where significant amounts of run-off may be produced during large rain events. The diversions are used to direct the run-off to areas of the restoration site where the additional water inputs are most needed.

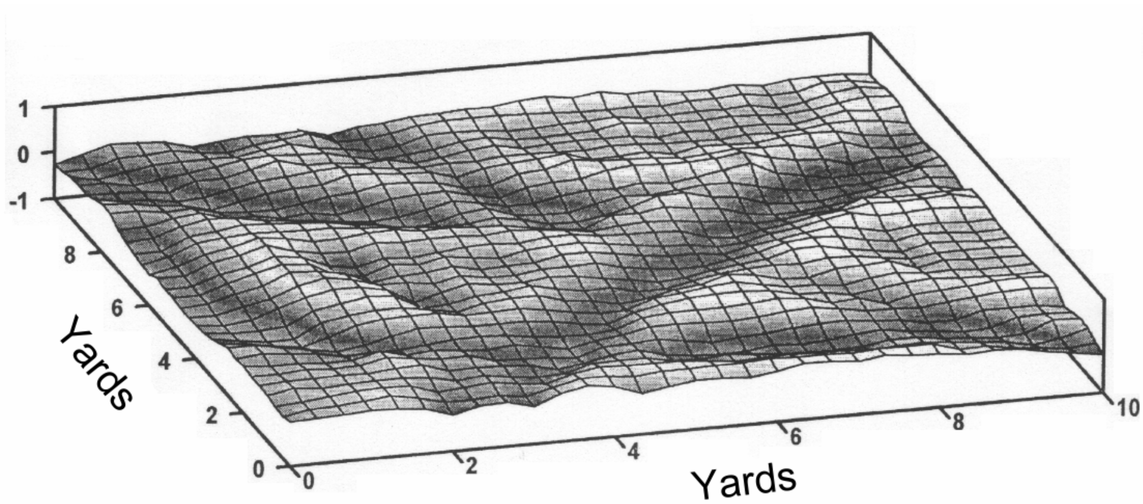
Shallow Depressions and Floodplain Pools – To increase the diversity of hydrologic conditions across the site, shallow depressions and floodplain pools can be excavated or created by leaving sections of ditches only partially filled in certain areas. The depressions are constructed to mimic the function of natural sloughs and pools commonly found across many wetland ecosystems. These areas provide increased surface storage of precipitation and floodwaters, improve biotic diversity, and provide breeding areas for a number of amphibian and reptile species.

Depressions and pools are generally constructed to be less than 1 foot deep. The size of depressions can vary, depending on the site; however, depressions 200 feet by 100 feet are typical of many sites. The depressions are designed to hold water for extended periods, ranging from several weeks to many months. For many amphibian species, it is crucial that the pools dry up completely during the late summer months. These ephemeral pools are typically constructed in higher elevation areas away from the active stream channel. For other species, pools that retain some degree of ponded water throughout the year are most beneficial. These features, which represent backwater sloughs, oxbow ponds, and floodplain pools, are typically constructed near the active stream channel, where the high water table conditions and frequent flooding will maintain water levels in the pools.

Restoration of Microtopography – In order to improve drainage and increase agricultural production, farmed wetland soils are often graded to a smooth surface and crowned to enhance run-off. Microtopography contributes to the properties of forest soils and to the diversity and patterns of plant communities (Lutz, 1940; Stephens, 1956; Bratton, 1976; Ehrnfeld, 1995). The introduction of microtopography also increases surface storage on the site, reducing run-off and erosion and enhancing infiltration.

Microtopography is established on the restored site after design grades have been achieved, using the procedures described by Scherrer (2000). The equipment should leave a furrow approximately 7 feet wide and 6 inches deep, and a corresponding mound approximately 7 feet wide and 6 inches high. The equipment should be run in parallel lines approximately 25 feet apart, and then over the same area in "figure 8" patterns to create a random pattern of interconnected and isolated furrows and ridges, as shown in Figure 3.1. The actual distance between furrows and mounds and the height of the mounds can be adjusted depending on the targeted amount of surface storage to be restored.

Figure 3.1
Typical Pattern of Restored Wetland Microtopography (Scherrer, 2000)



3.8.2 Restoration Techniques for Wetland Soils

Soil Scarification and Tillage – Disking and tillage practices commonly used in agriculture can be used to break the plow pan and reduce compaction of the soil caused by years of agricultural production. Tillage practices will also be used to remove any field crowns, restoring a more natural topography to the site. When necessary, rippers will be used to till to depths of 12 to 18 inches to break any compacted pan layers.

Soil Amendments – Samples of top soil from the site can be collected and tested to determine soil fertility and chemical properties. If necessary, soil amendments (fertilizer, lime, etc.) will be applied at rates appropriate for the target vegetation. For land which has been in agricultural production for a number of years, it is likely that soil fertility will be high and amendments will not be necessary.

3.8.3 Restoration Techniques for Wetland Vegetation

Tree Planting Techniques – Under typical conditions, bare-root tree species will be planted within all areas of the site conservation easement. Bare-root vegetation is typically planted at a target density of 680 stems per acre, or an 8 by 8 foot grid. Experience has shown this density to be favorable for overall survival of at least 320 planted stems at the end of 5 years, which is a common success criterion for mitigation sites. Planting of bare-root trees is conducted during the dormant season, which lasts from late November to early March for most of the state.

Species selection is based on reference wetland vegetation analyses, professional knowledge of availability and viability of specific plants, and expected post-restoration hydrologic conditions. Species selection for revegetation of the site will generally follow those suggested by Schafale and Weakley (1990) and tolerances cited in the USACE Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997). Tree species selected for restoration will generally range from weakly tolerant to tolerant of flooding. Weakly tolerant species are able to survive and grow in areas where the soil is saturated or flooded for relatively short periods of time. Moderately tolerant species are able to survive on soils that are saturated or flooded for several months during the growing season. Flood tolerant species are able to survive on sites in which the soil is saturated or flooded for extended periods during the growing season (WRP, 1997).

Observations are made during construction of the site regarding the relative wetness of areas to be planted. Planting zones are determined based on these assessments, and planted species will be matched according to their wetness tolerance and the anticipated wetness of the planting area.

When feasible, trees are transported to the site from the nursery and stored on-site in a refrigerated cooler prior to planting. If on-site refrigeration is not available, trees are planted within two days of being transported to the site. Soils across the site are sufficiently disked and loosened prior to planting. Trees are planted by manual labor, using a dibble bar, mattock, planting bar, or other similar method. Planting holes for the trees are made sufficiently deep to allow the roots to spread out and down without "J-rooting." Soil is loosely compacted around trees once they have been planted to prevent them from drying out.

Permanent Seed Mixtures – Permanent seed mixtures are applied to all disturbed areas of the project site. Different mixtures may be specified for different areas of the site, depending on the wetness and degree of stabilization required at the site. Mixtures will also include temporary seeding to allow for application with mechanical broadcast spreaders and rapid ground cover following application. Temporary seeding is applied to all disturbed areas of the site that are susceptible to erosion, including constructed streambanks, access roads, side-slopes, spoil piles, etc.

3.9 Application of Fluvial Processes to Stream and Wetland Restoration

A stream and its wetland floodplain (referred to here as the riparian area) comprise a dynamic environment where the floodplain, wetland areas, channel, and bedform evolve through natural processes. Weather and hydraulic processes erode, transport, sort, and deposit alluvial materials throughout the riparian system. The size and flow of a stream are directly related to its watershed area. Other factors that affect channel size and stream flow are geology, land use, soil types, topography, and climate. The morphology, or size and shape, of the channel reflects all of these factors (Leopold et al., 1992; Knighton, 1998). The size and flow of the stream channel also influence the size and functioning of wetland areas adjacent to the channel. The result is a dynamic equilibrium in which the stream maintains its dimension, pattern, and profile over time, and adjacent wetland areas evolve with the meandering of the stream across its floodplain. Land use changes in the watershed, including increases in imperviousness, removal of riparian vegetation, and drainage of adjacent wetlands can upset this balance. A new equilibrium may eventually result, but not before large adjustments in channel form can occur, such as extreme bank erosion or incision (Lane, 1955; Schumm, 1960). These adjustments in channel form often have negative effects on associated wetland areas, as processes of channel incision increase drainage of adjacent areas. By understanding and applying the processes of riparian form and function to stream and wetland restoration projects, a self-sustaining riparian system can be designed and constructed that maximizes ecosystem function and potential.

In riparian systems, wetland functions cannot be restored without also addressing the restoration of stream functions; therefore, it is crucial that the degraded stream system be restored to the appropriate dimension, pattern, and profile while allowing the stream access to the abandoned floodplain and associated wetland areas. In this way, the stream becomes one of the primary sources of water and nutrient inputs to the wetland system. As such, the development of stream and wetland design components becomes an iterative process.

4.0 WATERSHED ASSESSMENT RESULTS

4.1 Watershed Delineation

Watershed boundaries for the targeted project reaches were determined by delineating the existing watersheds on the USGS 7.5 minute topographic quadrangle (Eleazer quad). The site occurs within the eight-digit hydrological unit code (HUC) 03040103, and within the NC Division of Water Quality (NCDWQ) sub-basin 03-07-09 of the Yadkin Valley River Basin (Exhibit 1.1 and 1.2). The total drainage area of all project reaches at the outlet of the project area is estimated to be approximately 1.95 square miles. Exhibit 1.3 shows the watershed boundaries for the project.

4.2 Surface Water Classification

The NCDWQ designates surface water classifications for water bodies such as streams, rivers, and lakes, which define the best uses to be protected within these waters (e.g., swimming, fishing, and drinking water supply). These classifications carry with them an associated set of water quality standards to protect those uses. All surface waters in North Carolina must at least meet the standards for Class C (fishable/swimmable) waters. The other primary classifications provide additional levels of protection for primary water contact recreation (Class B) and drinking water supplies (WS). Class C waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. Classifications and their associated protection rules may also be designed to protect the free flowing nature of a stream or other special characteristics.

The project will involve Mill Creek, five unnamed tributaries to Mill Creek (UT4, UT5, UT6, UT7 and UT8), and three unnamed tributaries to the Uwharrie River (UT1, UT2 and UT9). Mill Creek flows through the entire site and is a tributary to the Uwharrie River. Mill Creek and the Uwharrie River in this area are classified as “C” waters, indicating that the systems are considered to support aquatic life and secondary recreational uses (NCDWQ, 2000). The stream and wetland approaches described in this plan will reduce the amount of sediment and nutrients being discharged directly to Mill Creek, thus improving the overall water quality in the Uwharrie River along the property boundaries and directly downstream of the project.

4.3 Geology

The Mill Creek site is located in southwestern Randolph County in the Piedmont physiographic region of North Carolina. The underlying geology of the project area is within the Carolina Slate Belt, Cid, and Uwharrie formations that consists of Cambrian age felsic metavolcanic rock, specifically metamorphosed dacitic to rhyolitic flows and tuffs, which are interbedded with mafic metavolcanics as well as metamudstone (Geologic Map of North Carolina, NC Geological Survey, 1998). Outcrops found within the project area likely belong to the Uwharrie Formation. The vicinity topography is characterized by gently rolling hills and alluvial valleys. Local relief within the project site to be constructed is 78 feet.

The Cid formation consists of thin to thick bedded metamudstone and meta-argillite interbedded with metasandstone, metaconglomerate, and metavolcanic rock. The Uwharrie formation consists of metamorphosed dacitic to rhyolitic flows and tuffs.

4.4 Soils

Soils types at the site were determined using Natural Resource Conservation Service (NRCS) Soil Survey data for Randolph County (USDA, 1995), along with on-site evaluations to identify areas of hydric soils. A map depicting the boundaries of each soil type is presented in Exhibit 4.1 and the major soil types are shown in Table 4.1. The majority of the site is mapped as the Badin-Tarrus complex. The Badin-Tarrus complex consists of well drained with moderately permeable soils. Slopes range from 8 to 15 percent and are moderately erodable. Badin-Tarrus soils are typically found in ridges and hillslopes and in the western part of the county. Flooding is infrequent on these soils.

The Dogue, Georgeville, and Mecklenburg series are mapped on small areas of the site. Dogue soil is found on the northwestern corner of the project. These soils are moderately well drained and have a moderately slow permeability. They are typically found in low terraces. Georgeville soils are found in a small area in the northwest section of the project area and in a large area in the eastern section of the project. This is a well drained soil with moderate permeability. They are typically found in ridges and hillslopes. Mecklenburg soils area mapped in a small area in the northwestern section of the project area. This is a well drained soil with slow permeability. They are typically found in broad ridges. No areas of hydric soil were identified in the project area.

Table 4.1
Project Soil Types and Descriptions (from Randolph County Soil Survey, USDA-NRCS, 1995)

Soil Name	Location	Hydric List	Description
Badin-Tarrus	Ridges and hillslopes	-	Well drained and moderately permeable with slopes from 8 to 15 percent
Dogue	Low terraces	-	Moderately well drained soils and moderately slow permeability with slopes from 2 to 6 percent
Georgeville	Ridges and hillslopes	-	Well drained soil with moderate permeability with slopes from 8 to 15 percent
Mecklenburg	Broad ridges	-	Well drained soil with slow permeability with slopes from 8 to 15 percent

4.5 Land Use and Boundaries

Land use within the project area consists of historic cattle pastures, agricultural fields, forested areas, and fallow fields being converted to native prairiegrass fields by the NCWRC. The Mill Creek watershed is rural with adjacent land uses that include crop land, open land, forested areas, and some residential property. High Pine Church Rd (SR 1143) bounds the project site on the northern portion of the property. The western portion of the site is bounded by the Uwharrie River. The eastern portion of the site is bounded by forested land and the Uwharrie National Forest bounds the project area to the south. Lassiter Mill Rd (SR 1107) which runs north to south through the site, crosses through the project area and passes over Mill Creek and UT4. An unpaved farm road crosses UT1 through a culvert.

4.6 Endangered/Threatened Species

Some populations of plants and animals are declining either as a result of natural forces or their difficulty competing with humans for resources. Plants and animals with a federal classification of Endangered (E), Threatened (T), Proposed Endangered (PE), and Proposed Threatened (PT) are protected under the provisions of Section 7 and Section 9 of the Endangered Species Act of 1973. Federally classified species listed for Randolph County, and any likely impacts to these species as a result of the proposed project construction, are discussed in the following sections.

Species that the U.S. Fish and Wildlife Service (USFWS) list under federal protection for Randolph County as of August 11, 2006 are listed in Table 4.2. A brief description of the characteristics and habitat requirements of these species follow the table, along with a conclusion regarding potential project impact.

Letters were sent to USFWS and NCWRC in October of 2006, requesting each agency comment on the proposed project. No comments were received from the USFWS. NCWRC responded that they "do not anticipate the project to result in significant adverse impacts to aquatic and terrestrial wildlife resources." Correspondence regarding Endangered/Threatened species is provided in Appendix B.

Table 4.2
Species Under Federal Protection in Randolph County

Family	Scientific Name	Common Name	Federal Status	Date Listed	State Status	Habitat Present / Biological Conclusion
Vertebrate						
Cyprinidae	*Notropis mekistocholas*	Cape Fear Shiner	E	9-15-1987	E	No /No effect
Vascular Plants						
Asteraceae	*Helianthus schweinitzii*	Schweinitz's Sunflower	E	5-7-1991	E	No/No Effect

Notes:

E An Endangered species is one whose continued existence as a viable component of the state's flora or fauna is determined to be in jeopardy.

T Threatened

4.6.1 Federally Protected Species

4.6.1.1 Vertebrates

Cape Fear Shiner

The Cape Fear shiner is a small minnow, rarely exceeding 2.4 inches in length. It is a pale silvery yellow with a black stripe along each side. The fins are yellow and pointed, the upper lip is black, and the lower lip has a thin black bar along its edge.

Water willow (*Justicia americana*) beds in flowing areas of creeks and rivers appear to be an essential element of the species' habitat. The Cape Fear shiner is found in clean, rocky streams over gravel, cobble, and boulder substrate, and is known to inhabit pools, riffles, and slow runs. Juveniles are often found in slack water, among mid-stream rock outcrops, and in side channels and pools.

Biological Conclusion: No Effect

While the Cape Fear shiner is found in Randolph County, it is found in the Cape Fear, not the Yadkin/Pee-Dee Basin. No suitable habitat exists for the Cape Fear shiner within the proposed restoration area. Based upon the NHP's database, checked on October 24, 2006, no populations of this species have been reported in the project area. Therefore, the proposed project is not anticipated to result in an adverse impact to this species.

4.6.1.2 Vascular Plants

Schweinitz's Sunflower

Schweinitz's sunflower, usually 3 to 6 feet tall, is a perennial herb with one to several fuzzy purple stems growing from a cluster of carrot-like tuberous roots. Leaves are 2 to 7 inches long, 0.4 to 0.8 inch wide, lance-shaped, and usually opposite, with upper leaves alternate. Leaves feel like felt on the underside and rough, like sandpaper, on the upper surface. The edges of the leaves tend to curl under. Flowers are yellow composites, and generally smaller than other sunflowers in North America. Flowering and fruiting occur mid-September to frost. This plant grows in clearings and along the edges of upland woods, thickets and pastures. It is also found along roadsides, powerline clearings, old pastures, and woodland openings. It prefers full sunlight or partial shade, but is intolerant of full shade.

Biological Conclusion: No Effect

Potential habitat for Schweinitz's sunflower occurs along roadsides, power line right-of-ways, and field edges throughout the project area. The project study area was evaluated for potential Schweinitz's sunflower habitat and extensive field surveys were performed on October 3, 2006, during the blooming season for the species. No populations were found within the area of potential impact. No populations of this species have been reported in the project area. Therefore, the proposed project is not anticipated to result in an adverse impact to this species.

4.6.2 Federal Species of Concern and State Status

Federal Species of Concern (FSC) are not legally protected under the Endangered Species Act and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as Threatened or Endangered. Table 4.3 includes FSC species listed for Randolph County and their state classifications. Organisms that are listed as Endangered (E), Threatened (T), or Special Concern (SC) on the NHP list of Rare Plant and Animal Species are afforded state protection under the State Endangered Species Act and the North Carolina Plant Protection and Conservation Act of 1979. However, the level of protection given to state-listed species does not apply to NCDENR EEP activities.

Table 4.3
Federal Species of Concern in Randolph County

Scientific Name	Common Name	Federal Status	State Status

Alasmidonta varicosa	Brook Floater	FSC	E
Fusconaia masoni	Atlantic Pigtoe	FSC	E
Lampsilis cariosa	Yellow Lampmussel	FSC	E
Toxolasma pullus	Savannah Lilliput	FSC	E
Villosa vaughaniana	Carolina Creekshell	FSC	E
Lotus helleri	Carolina Birdfoot-trefoil	FSC	SR-T
Etheostoma collis	Carolina Darter	FSC	SC

4.7 Cultural Resources

Baker Engineering sent a letter on October 4, 2006 requesting that the North Carolina State Historic Preservation Office (HPO) review the potential for cultural resources in the vicinity of the Mill Creek restoration site. A response was received on November 7, 2006 indicating that the HPO had reviewed the proposed project and was not aware of any historic resources which would be affected by the project. A copy of the HPO correspondence is included in Appendix B.

4.8 Potentially Hazardous Environmental Sites

Baker Engineering obtained an Environmental Data Resources (EDR) Transaction Screen Map Report that identifies and maps real or potential hazardous environmental sites within the distance required by the American Society of Testing and Materials (ASTM) Transaction Screen Process (E 1528-00). A copy of the report with an overview map is included in Appendix C. The overall environmental risk for this site was determined to be low. Environmental sites including Superfund (National Priorities List, NPL); hazardous waste treatment, storage, or disposal facilities; the Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS); suspect state hazardous waste, solid waste or landfill facilities were not identified by the report in the proposed project area.

EDR did identify one leaking underground storage tank (LUST) on the Incident Management Database (IMD) on the project site. A Notice of Violation (NOV) was not issued for this incident. However, a Notice of Regulatory Requirements (NORR) was issued for this incident. According to EDR, the removal of a home heating oil underground storage tank (UST) was completed. The EDR report indicates that groundwater contamination was not detected, however soil contamination was confirmed.

Ruth Ann Grissom (the current landowner) confirmed that there were three USTs, located on the property and all were removed in 2004. One UST for heating oil was located on the southwest side of the house. Two USTs, one for gasoline and one for diesel were located north of the outbuilding near the pasture. All contaminated soil was removed from the site.

It is concluded that the Mill Creek restoration project would not be adversely affected by the incident due to the proximity of the soil contamination to the construction limits or the conservation easement.

4.9 Potential Constraints

The Mill Creek project site was accessed in regards to potential fatal flaws and site constraints. No constraints or fatal flaws have been identified during project design development.

4.9.1 Property Ownership and Boundary

NCEEP has entered into an Agreement for the acquisition of a conservation easement with the landowner of the Mill Creek Project: Amy Grissom and Amy Grissom, LLC. The conservation easement (Exhibit 1.2) has been recorded at the Randolph County courthouse in Asheboro, NC. The Agreement allows NCEEP to proceed with the project and to restrict future land-use and development within the project corridors in perpetuity.

4.9.2 Hydrologic Trespass

Based on 2008 Federal Emergency Management Agency (FEMA) mapping, the project area bounded by the Uwharrie River is classified in Zone AE, and designated as a special flood hazard area inundated by the 100-year flood. Base flood elevations have been determined for Zone AE areas. The areas affected by Zone AE are:

- Mill Creek from upstream of Lassiter Mill Road to the confluence with Uwharrie River
- All of UT1
- UT2 from the wetland area to the confluence
- UT5 around the confluence
- UT4 from Lassiter Mill Road to the confluence

The surrounding unnamed tributaries are classified in Zone X, which are designated as areas with minimal flooding.

4.9.3 Site Access

Temporary access during construction for haul roads will need to be coordinated with the NCWRC to avoid areas currently planted with native prairiegrass. Discussions with representatives with the NCWRC indicate additional vegetative plantings will be discontinued until construction activities are completed. Permanent access to the stream corridors for post-restoration monitoring should occur along existing NCDOT road right-of-ways (High Pine Church Rd and Lassiter Mill Rd). Permanent access routes to UT2, UT8, MC3, and MC4 will have to be determined from continuing conversations with the landowner.

4.9.4 Utilities

No known utilities will be affected during construction activities.

4.9.5 Threatened and Endangered Species

Rare, threatened, and endangered species occurrences were examined as part of the existing conditions survey. It is anticipated that no rare, threatened, or endangered species will be affected by this project.

4.9.6 Cultural Resources

No known cultural or archaeological sites are recorded within the property boundary. It is anticipated that this project will have no impact on such sites.

4.9.7 Farm Operations

The Grissom parcels are not currently being used for agricultural purposes.

4.9.8 Soils

Soils have been investigated and no constraints or fatal flaws were identified.

5.0 EXISTING WETLAND CONDITIONS

5.1 Wetlands

The proposed project area was reviewed for the presence of wetlands and waters of the United States in accordance with the provisions of Executive Order 11990, the Clean Water Act, and subsequent federal regulations. Wetlands have been defined by the USACE as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas” (33 CFR 328.3(b) and 40 CFR 230.3 (t)). The project area was reviewed to determine the presence of wetlands by determining if the site exhibited one or more of the following wetland characteristics:

1. Prevalence of hydrophytic vegetation.
2. Permanent or periodic inundation or saturation.
3. Hydric soils.

5.1.1 Jurisdictional Wetland Findings

Following an in-office review of the National Wetland Inventory (NWI) map, Natural Resource Conservation Service (NRCS) Soil Survey, and United States Geological Survey (USGS) Quadrangle map, a field survey of the project area was made to investigate the suspect areas and to delineate all wetlands and waters of the U. S. The project area was examined utilizing the jurisdictional definition further detailed in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987). Supplementary information to further support wetland determinations was found in the *National List of Plant Species that Occur in Wetlands: Southeast (Region 2)* (Reed, 1988).

During initial site investigations, two potential jurisdictional wetlands were located on the project site. On September 20, 2006, Baker Engineering staff delineated the two potential wetland areas. Both areas exhibited hydrological and vegetation characteristics of a wetland; however, the areas did not exhibit characteristics for wetland soils. Primary indicators of wetland hydrology observed included inundation, saturated soils, water marks, and drainage patterns. Secondary indicators noted included oxidized root channels, water-stained leaves, and positive facultative species (FAC)-neutral results. The percentage of hydrophytic vegetation at the site ranged from 60 to 68 percent, indicating a wetland system. Soils at the site were listed by the Soil Survey of Randolph County as Mecklenburg clay loam and Badin –Tarrus complex. Wetland delineation forms (provided in Appendix D) were completed for both areas and were field reviewed by the USACE. The USACE representative found that the two potential areas did not exhibit hydric soils and therefore were not classified as jurisdictional wetlands. The following paragraphs describe the two areas investigated within the project area that will be proposed creation sites, as described in Chapter 8.

Wetland Creation Site 1

Wetland creation site 1 is located within the bottom of a small breached pond in an agricultural field. It is located on UT2, and is drained by a ditch that bypasses the natural drainage of the valley and is connected to Mill Creek above the confluence with the Uwharrie River. Water coming from upstream splays out across the area, resulting in long periods of inundation and soil saturation. Vegetation within the area has been impacted by past cattle grazing. The primary tree species in the area is willow oak (*Quercus phellos*), with herbaceous and understory vegetation including arrow arum (*Peltandra virginica*), golden rod (*Solidago* sp.), sedge (*Carex spp.*), and soft rush (*Juncus effusus*). During field assessments, the percentage of hydrophytic vegetation was 60 percent. The soils were clay loams and were dark brown, with light reddish-brown mottles. There were no hydric soil indicators present within the area.

Wetland Creation Site 2

Wetland creation site 2 is located on UT5 in the bottom of a small breached pond, and therefore is similar to creation site 1. Herbaceous vegetation in the area is dominated by the same species listed for creation site 1; however, there are no tree species within creation site 2. The percentage of hydrophytic vegetation at the site was 68 percent. Soils were very dark brown clay loams, with dark yellowish-brown mottles. There were no hydric soil indicators present within the area.

5.2 Soils

Based on information from the county soil survey, the primary soils found in the proposed wetland creation areas are Badin-Tarrus complex and Mecklenburg clay loam. The Badin-Tarrus complex consists of well drained and moderately permeable soils found on slopes ranging from 8 to 15 percent. Badin-Tarrus soils are typically found on ridges and hillslopes in Randolph County and flooding is rare. Mecklenburg clay loam soils are found on piedmont uplands, along broad ridges. This series is very well drained and has slow permeability. Neither Badin-Tarrus nor Mecklenburg soils are considered hydric soils, and no hydric indicators were noted during on-site assessments.

5.3 Climatic Conditions

The average growing season (defined as the period in which temperatures are maintained above 28 degrees Fahrenheit under average conditions) for Randolph County is 248 days long, beginning on March 16 and ending November 18. Randolph County has an average annual rainfall of 42.62 inches (NRCS, 2007). Rainfall data were collected for the monitoring period from the nearest automated weather station, located in Asheboro (Asheboro 2 W, NC COOP: 310286). Monthly precipitation amounts from January 2006 through June 2007 are compared with Randolph County WETS table average monthly rainfall in Table 5.1. These data indicate that over the monitoring period, rainfall was well below normal except during June and November 2006, when conditions were wetter than average, due to several large storms that passed through the area.

Table 5.1
Comparison of Monthly Rainfall Amounts for Project Site and Long-Term Averages

Month-Year	Observed Monthly Precipitation (in)	WETS Table Average Monthly Precipitation (in)	Deviation of Observed from Average (in)
Jan-06	2.6	4.44	-1.84
Feb-06	1.39	3.71	-2.32
Mar-06	1.76	4.27	-2.51
Apr-06	4.52	3.49	1.03
May-06	2.37	4.25	-1.88
Jun-06	7.85	3.97	3.88
Jul-06	2.38	4.12	-1.74
Aug-06	2.38	4.26	-1.88
Sep-06	2.42	4.31	-1.89

Oct-06	3.33	3.59	-0.26
Nov-06	6.03	3.16	2.87
Dec-06	2.15	3.26	-1.11
Jan-07	0.67	4.44	-3.77
Feb-07	3.36	3.71	-0.35
Mar-07	2.6	4.27	-1.67
Apr-07	3.66	3.49	0.17
May-07	0.71	4.25	-3.54
Jun-07	3.09	3.97	-0.88
Sum	**53.27**	**67.96**	**-17.69**

5.4 Hydrology

The hydrology of sections of UT2 and UT5 has been altered through the prior construction of a dam on each waterway (Exhibit 5.1). The dams were constructed to create ponds to provide drinking water to livestock. Although the dams have been breached, years of standing water has promoted the establishment of hydrophytic vegetation within each former pond.

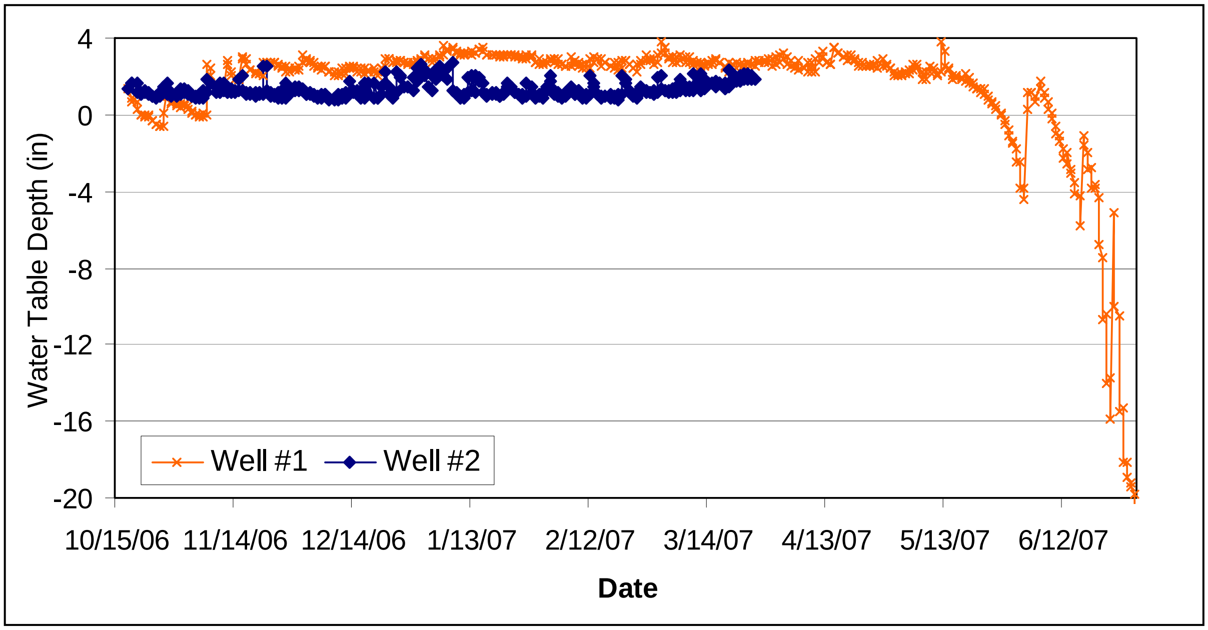
UT2 is located between UT1 (ditch) and UT5 in the northwestern portions of the property. The waterway flows southwesterly across the site, passing through wetland creation site 1. UT2 exits the pond and drains into a manmade constructed ditch through the adjacent floodplain before entering directly into Mill Creek near the Uwharrie River confluence. The UT2 watershed is located entirely within the property. UT5 originates between a former silage storage area and Lassiter Mill Rd. The waterway flows southwest through wetland creation site 2 until its confluence with Mill Creek. The UT5 watershed is also located entirely within the property.

During October 2006, two groundwater monitoring wells were installed to monitor water table depth in the breached pond sites. Well 1 was installed within creation site 1, and Well 2 was installed within creation site 2 (locations are shown in Exhibit 5.1). The wells were located in areas where hydrology appeared to have been affected by water ponded upstream of the breached dams.

Water table data were collected from the wells from October 2006 through June 2007. During March 2007, the well logger for Well 2 malfunctioned and data collected after this period is unreliable. During the period of monitoring, monthly rainfall amounts were well below normal.

During most of the dormant season and early growing season, both well locations exhibited near constant saturation with surface ponding and little fluctuation in water levels. This is due to the depressional nature of the areas, and water which is held back by the breached dams. During May 2007 on creation site 1, low rainfall and increased evapotranspiration losses resulted in increased water table depth and more fluctuation in the local water table in response to rainfall events. Visual observations of conditions at creation site 2 indicate that near constant saturation has continued at this site through June 2007, most likely due to the increased drainage area that drains to creation site 2 relative to creation site 1.

Figure 5.1
Hydrographs of the Groundwater Monitoring Wells on the Mill Creek Site (October 2006 through June 2007).



6.0 STREAM CORRIDOR ASSESSMENT RESULTS

6.1 Brief Reach Description

For analysis and design purposes, Baker Engineering divided the Mill Creek project into twelve reaches. Eleven reaches are located in the northern portions of the site and one reach is located in the southern portion. The reach locations are shown in Exhibit 1.2 and project lengths are provided in Table 6.1. The reaches were numbered sequentially from west to east, with an "UT" designation for "Unnamed Tributary" (to either Mill Creek or the Uwharrie River) or as "MC" for sections of the mainstem of Mill Creek. Livestock had access to UT1, UT2, UT4, UT5, UT6, and wetland creation sites 1 and 2 before their removal.

One ditch (UT1) and two UT's (UT2 & UT9) drain directly into the Uwharrie River. UT1 enters the property from the north along High Pine Church Road, flows southwesterly across the property passing through a culvert before emptying into the Uwharrie River. UT2 begins on the property to the southeast of UT1; it also flows southwesterly across the property, passing through a prior constructed pond. The waterway exits the pond and flows into a constructed ditch that empties into Mill Creek near its confluence with the Uwharrie River. UT9 originates on an adjacent parcel, flows in a general northwesterly direction, passing underneath Lassiter Mill Rd, and drains directly into the Uwharrie River downstream of the Mill Creek-Uwharrie River confluence.

Mill Creek originates east of Lassiter Mill Rd. Mill Creeks' headwaters are located on an adjacent parcel east of the project boundaries. Mill Creek flows in a general westerly direction across the property before passing through a culvert underneath Lassiter Mill Rd. Three UT's enter Mill Creek before it passes underneath Lassiter Mill Rd. UT6 is a headwater stream that flows north to south, passing through a constructed pond before entering Mill Creek. UT7 and UT8 are also headwater streams that originate within the property boundaries. Both waterways flow south to north before their respective confluences with Mill Creek. UT4 originates west of Lassiter Mill Rd, the waterway flows in a general south to north direction, passing underneath Lassiter Mill Rd, before its confluence with Mill Creek. UT5 originates just west of Lassiter Mill Rd, flows southwesterly across the property, and passes through a constructed pond before entering Mill Creek.

Based on the USGS topographic map, Mill Creek throughout the project area is depicted as a perennial blue-line stream. UT4, UT6, UT7, UT8, UT9 and the lower reaches of UT 2 and UT5 below the breached ponds are depicted as intermittent blue-line streams. UT1 and the sections of UT2 and UT5 located above the constructed ponds are not designated on the USGS topographic map. Based on field evaluations of intermittent or perennial status, the stream channels were evaluated to determine if they were perennial streams (based on a minimum score of 30 for perennial streams and the presence of biological indicators), using the NCDWQ *Determination of the Origin of Perennial Streams* guidelines, the results are listed in Table 6.1, with stream forms presented in Appendix D. The total current length of streams to be restored, enhanced and preserved on the project site is 983 LF, 4,859 LF, and 15,802 LF, respectively.

6.2 Geomorphic Characterization and Channel Stability Assessment

Baker Engineering performed general topographic and planimetric surveying of the project site and produced a contour map based on survey data in order to create plan set base mapping. Watershed sizes were calculated at the terminus of each reach and are summarized in Table 6.1. Geomorphic surveys were conducted on preservation stream reaches. Cross-section surveys of the stream reaches were also performed to assess the current condition and overall stability of the channels. Cross-section locations are shown on Exhibit 5.1. The following subsections summarize the survey results for all project reaches that are subject to either stream restoration or stream enhancement activities. Table 6.2 summarizes geomorphic data for project reaches that will be enhanced or restored. Appendix E contains summaries of existing condition parameters, cross-section survey results and bed material distribution graphs for the site.

Table 6.1
Reach Descriptions

Reach	Reach Length (linear feet)	Watershed Size (square miles)	NCDWQ Intermittent/ Perennial Stream Form Score
MC1	2,214	1.32	38.5 – perennial
MC2	998	1.10	41.25 – perennial
MC3	785	0.79	31.25 – perennial
MC4	1,485	0.53	30.25 – perennial
UT1	1,799	0.05	6.75 – ephemeral
UT2	1,012 875	0.08	22.75 – intermittent 32.75 – perennial
UT4	1,809 541	0.08	20 – intermittent 28.5 – intermittent
UT5	580 620	0.06	19.25 – intermittent 30.2 – perennial
UT6	954	0.06	7.75 – ephemeral
UT7	2,529	0.17	25.75 – intermittent
UT8	2,003	0.08	17.25 – ephemeral
UT9	5,239	0.49	30.75 – perennial

6.2.1 MC1 Reach

MC1 is the portion of Mill Creek located between Lassiter Mill Rd and the Uwharrie River (Exhibit 1.2). As Mill Creek emerges from the culvert underneath Lassiter Mill Rd, the waterway surface drops approximately two and a half feet onto bedrock, due to a perched 72-inch concrete culvert. The upper reach of MC1 is mostly a cobble bed stream with a moderately defined riffle pool sequence. However, riffles appear to dominate the upper reach of MC1. A large amount of bedrock is present in this area, which prevents the stream from down cutting. The channel is moderately incised and riparian vegetation is comprised mostly of large to small trees along the banks. Bank erosion throughout upper MC1 is low to moderate. The riparian vegetation zone is narrow on both sides of the stream. Upper MC1 flows through a former cattle pasture with a high, steep bank on the north side of the reach. The south side of upper MC1 is relatively flat and low, the south side serves as the active floodplain for the upper reach of Mill Creek. MC1 is classified as a B3c/1 stream type (Rosgen, 1994). The d50 of the channel bed material is small cobble.

The lower reach of MC1 is mostly a cobble to gravel bed stream, with a finer substrate dominating near the confluence with the Uwharrie River. Lower MC1 has a moderately defined riffle pool sequence. A moderate amount of bedrock is present, preventing the stream from further incision. The lower reach of MC1 also occurs in abandoned cattle pastures. Lower MC1 is moderately incised near UT5 and becomes highly incised as the waterway approaches the Uwharrie River. Stream bank erosion throughout the lower reach of MC1 is moderate. Riparian vegetation is comprised of large to small hardwood tree species and Chinese privet (*Ligustrum sinense*). The riparian buffer on the north side of the stream is narrow (~5 to 15 ft) while the buffer on the southern side of lower MC1 is moderate (~20 to 50 ft).

According to cross-sectional measurements, MC1 is incised with an average bank height of 1.8. This value falls into the highly unstable range in Rosgen's comparison of bank height ratio to vertical stability ranking. Mill Creek is confined within the valley and displays low meander geometry. These conditions generally lead to lateral instability over time; however, a low-flow regime and herbaceous vegetation on the banks have served to maintain some stability along this reach of MC1.

6.2.2 UT1 Reach

UT1 is a short, ephemeral, toe-of-the slope ditch with a relatively small drainage area. UT1 is situated between a low, flat floodplain to the west and a high steep slope immediately east of the channel. UT1 is forested to the east by mature deciduous tree species and by herbaceous vegetated to the west. UT1 lacks distinct riffles and pools and functions primarily as a drainage ditch. Channel hydrology appears to be driven by rainfall and toe-of-the-slope drainage. Increasing side slopes as the waterway approaches the Uwharrie River have led to moderate bank erosion on the lower portion of the tributary. A culvert conveys the flow from the lower portion of UT1 into the Uwharrie River.

6.2.3 UT2 Reach

UT2 is a relatively short reach in a moderately sloped valley with a small drainage area. UT2 is confined within the valley in the upper reach and exhibits a small defined channel below a headcut that widens slightly throughout the reach until the channel enters a wetland area. The channel fans out once it reaches the wetland and evenly flows to a low point where it enters a breach in the old dam. Below the dam, the lower reach was diverted from its natural channel and merged with a man-made drainage ditch that discharges into Mill Creek. The water source appears to be surface and ground water drainage from the surrounding hill slopes. Both reaches of UT2 flow through a grass covered valley with randomly distributed trees on the upper reach of the tributary. The breached pond portion of UT2 is forested to the east and is grass covered to the west. The upper portion of the upper reach is slightly incised, and has poor bedform with undistinguishable riffles and pools. UT2 classifies as a B5/1 stream type (Rosgen, 1994). The d50 of the channel bed material classifies as very coarse sand.

UT2 is incised with an average bank height of 1.7 in the surveyed cross-sections. This value falls into the highly unstable range in Rosgen's comparison of bank height ratio to vertical stability ranking. The stream is confined within the valley and displays low meander geometry. These conditions generally lead to lateral instability over time; however, a low-flow regime and herbaceous vegetation on the banks along the reach have served to maintain some stability along the reach.

6.2.4 UT4 Reach

The enhancement section and lower reach of UT4 is the shortest reach in the project site. It is an intermittent channel and is located in a moderately sloped valley with a small drainage area. UT4 enters the project site through a culvert underneath Lassiter Mill Road. The channel is moderately eroded at the culvert. Erosion decreases with distance from the culvert. The channel follows the natural valley until it enters Mill Creek. Moderate bedform is found below the culvert with moderate riffle and pool sequences. UT4 flows through a grass covered valley with small riparian trees. UT4 classifies as an E4b stream type (Rosgen, 1994). The d50 of the channel bed material classifies as very fine gravel.

UT4 is incised with a bank height of 1.8 in the surveyed cross-section. This value falls into the highly unstable range in Rosgen's comparison of bank height ratio to vertical stability ranking. The stream is confined within the valley and displays low meander geometry.

6.2.5 UT5 Reach

UT5 is an additional relatively short reach in a moderately sloped valley with a small drainage area. The upper reach of UT5 exhibits a small defined intermittent channel below a headcut, which widens slightly throughout the reach until the channel enters a breached pond area. The channel is highly eroded with poor bedform above the breached pond area, as numerous drainage ditches enter UT5 from the hill slopes on both sides of the valley. The upper reach follows the low point of the valley until it enters a breach in the old dam. The channel enters a steep slope below the dam. This change in elevation is halted by the channel contacting with bedrock. The lower reach of UT5 (below the breached dam) is highly eroded and incised below the dam until the channel merges with Mill Creek, at which point the erosion is reduced. Poor bedform is found below the dam with poor riffle and pool sequences. All of UT5 flows through a grass covered valley with a few small trees in the upper reach of the tributary. The breached pond portion and the lower reach are composed of a relatively low number of large and small trees along the channel. UT5 classifies as a B4/1 stream type, however the incised lower reach of UT5 functions as a G channel (Rosgen, 1994). The d50 of the channel bed material classifies as fine gravel.

UT5 is incised with an average bank height of 3.9 in the surveyed cross-sections. This value falls into the highly unstable range in Rosgen's comparison of bank height ratio to vertical stability ranking. The stream displays low meander geometry due to it being confined within the valley.

Table 6.2
Geomorphic Data for Mill Creek and Tributaries[1]

Parameter	Value					Units
	MC1[2]	UT1[3]	UT2	UT4	UT5[2]	
Bankfull Width (W_{bkf})	25.3	N/A	7.15	5.3	5.1	Feet
Bankfull Mean Depth (d_{bkf})	1.28	N/A	0.49	0.84	0.63	Feet
Cross-Sectional Area (A_{bkf})	27.6	N/A	3.49	4.48	3.20	Square feet
Width/Depth Ratio (W/D ratio)	19.8	N/A	14.66	6.34	8.04	
Bankfull Max Depth (d_{mbkf})	1.9	N/A	1.06	1.28	1.16	Feet
Floodprone Area Width (W_{fpa})	36.7	N/A	12.05	21.5	19.65	Feet
Entrenchment Ratio (ER)	1.4	N/A	1.68	4.0	4.0	
Bank Height Ratio (BHR)	1.8	N/A	1.7	1.8	3.91	
Channel Materials (Particle Size Index – d_{50})	Small Cobble		Very coarse sand	Fine gravel	Fine gravel	
d_{16}	9.82	N/A	0.1	0.8	0.7	Millimeters
d_{35}	43.00	N/A	0.6	2.6	1.8	Millimeters
d_{50}	90	N/A	1.0	4.0	7.1	Millimeters
d_{84}	>2048	N/A	5.2	10.3	14.5	Millimeters
d_{95}	>2048	N/A	8.5	18.6	27.4	Millimeters
Water Surface Slope (S)	.0090	N/A	.0251[4]	.0290	.0432[4]	Feet per foot
Channel Sinuosity (K)	1.27	N/A	1.14	1.05	1.17	
Rosgen Stream Type	B3c/1	N/A	B5/1	E4b	B4/1	

Notes:
1. No geomorphic data was obtained for the streams that are recommended for preservation.
2. More than one riffle cross-section was surveyed. Values presented are averages.
3. Limited survey data acquired; ephemeral channel will be filled in with excess material from site.
4. Water surface slopes along the sections to be restored.

6.3 Bankfull Verification

The bankfull stage on Mill Creek and the tributaries were identified in the field; the indicators were a break in slope on a flat depositional feature, a high scour line, and the top of bank. Vegetation trends were used as validation for this stage selection. These indicators are consistent with other North Carolina rural Piedmont streams. Bankfull data for the project reaches are compared with the rural

North Carolina Piedmont Regional Curve in Exhibit 6.1. The project's bankfull cross-sectional areas consistently fall within the 95 percent confidence intervals for the rural Piedmont Regional Curve, indicating that bankfull stage was adequately identified. Regional curve equations developed from the North Carolina rural Piedmont study are provided in Table 6.3.

One active USGS gauge is located near the project site: the Dutchman's Creek gauge (USGS Gauge Number 02123567) is located approximately 10 miles downstream from the project site, as shown in Exhibit 6.2. The watershed size at the gauge is 3.44 square miles. The gauge is located immediately upstream of two 72-inch CMP culverts under River Road which likely cause backwater at the bankfull stage. Due to this condition, the typical straight line projection of bankfull elevation through the gauge was not used. Baker performed a survey at the gauge and prepared a HEC-RAS hydraulic model using the survey data on a previous project for NCEEP (UT to Barnes). A hypothetical flow corresponding to the bankfull elevation upstream of the gauge was routed through the gauge station and related to the gauge plate height. Using the USGS gauge rating table, a discharge of 215 cfs was established for the bankfull stage. The primary bankfull indicators at this site were a break in slope in the bank and a bench feature.

The computer program PEAKFQ was used to perform a log-Pearson Type III flood frequency analysis on the 18 years of peak flow record for the gauge. This flood frequency analysis indicated that a 215-cfs event has a recurrence interval of approximately 1.3 years at this site on Dutchman's Creek. This recurrence interval of 1.3 years is close to the average value of 1.5 years observed for many streams and within the accepted range of one to two years.

The Dutchman's Creek discharge data were plotted on the regional curve along with the bankfull discharges predicted using Manning's equation with the surveyed channel geometry for Mill Creek, the unnamed tributaries, and the reference reaches. As shown in Exhibit 6.1, all of the values fall within the 95% confidence limits of the rural Piedmont regional curve.

Table 6.3
NC Rural Piedmont Regional Curve Equations.

North Carolina Rural Piedmont Regional Curve Equations	
NCSU Data (Harman et al, 1999)	
$Q_{bkf} = 66.57 A_w^{0.89}$	$R^2=0.97$
$A_{bkf} = 21.43 A_w^{0.68}$	$R^2=0.95$
$W_{bkf} = 11.89 A_w^{0.43}$	$R^2=0.81$
$D_{bkf} = 1.5 A_w^{0.32}$	$R^2=0.88$

6.4 Stream Reference Site

The Mickey stream reference site is located in Surry County, approximately thirteen miles northwest of the town of Elkin, North Carolina, and approximately eighty miles northwest of the project site (Exhibit 6.3). The site is near the community of Devotion with a drainage area of 0.45 mi^2 (Exhibit 6.4) and is a past stream restoration project that has been stable for almost five years. This system and the streams to be restored both have steep slopes, small drainage areas, and flow into larger river systems. The Mickey Reach is vertically and horizontally stable, has several points of aeration in the form of riffles and rock and woody debris jams, and shows excellent habitat potential. The upstream section of the Mickey Reach was restored within 20- to 30- year old forest and the downstream section was restored within pastureland, which can be viewed on the reference site soils map (Exhibit 6.5). The vegetation along the entire Mickey reach is flourishing.

Field surveys of the reference site were conducted in early spring, 2002. The site has been surveyed on a yearly basis since the original survey to evaluate any changes on the site. It was determined during a site visit in December of 2006 that the site has had more than 10 bankfull events while remaining stable and is therefore a viable reference site. Survey data were used to evaluate the natural channel parameters describing the dimension, pattern, and profile of the stream. Natural channel design parameters are summarized in Appendix F.

The reference stream is classified as a "B4" channel using the Rosgen Stream Classification System (Rosgen, 1994). Longitudinal profile and cross-sections are presented in Appendix G. "B" type channels are more typical of higher gradient cobble/gravel-bed stream systems that are found in highly dissected fluvial valleys. "B" type streams typically form a series of steps with irregularly spaced pools and do not transport a high amount of sediment. The "4" indicates that the stream is a gravel-bed system. Median particle size of the bed material is approximately 35 mm (see Appendix G for particle size distribution data). The reference reach stream has appropriate bed features for a gravel-bed system, with shallow pools in the meander bends, and deeper pools formed by scour features such as roots and debris jams.

6.4.1 Reference Stream Vegetation

The reference stream is well buffered along both stream banks, with tree species that include sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), willow oak (*Quercus phellos*), water oak (*Quercus nigra*), swamp chestnut oak (*Quercus michauxii*), and green ash (*Fraxinus pennsylvanica*). The small tree/shrub layer is dominated by sweetbay magnolia (*Magnolia virginiana*), American holly (*Ilex opaca*), sugarberry saplings (*Celtis laevigata*), giant cane (*Arundinaria gigantea*), elderberry (*Sambucus canadensis*), coastal doghobble (*Leucothoe axillaris*), sweet pepperbush (*Clethra alnifolia*), beautyberry (*Callicarpa americana*), and blackberry (*Rubus* spp.). The herb and vine strata contain false nettle (*Boehmeria cylindrica*), jewel-weed (*Impatiens capensis*), cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis*), green-briar (*Smilax* spp.), Virginia creeper (*Parthenocissus quinquefolia*), grape (*Vitis* spp.), poison ivy (*Toxicodendron radicans*), and honeysuckle (*Lonicera japonica*).

7.0 STREAM RESTORATION

7.1 Restoration Benefits

The Mill Creek mitigation site provides a unique opportunity for a more comprehensive ecosystem rehabilitation approach than is possible with "typical" stream and wetland restoration projects. In addition to the 124.35 acres being protected by the NCEEP conservation easement, the EQUIP Project will transform and protect approximately 100 additional acres of previously farmed or grazed land which surrounds the NCEEP stream buffer easement boundaries. The inclusion of the EQUIP native Piedmont prairie-grass restoration project will allow for the recreation of an almost extinct North Carolina landscape form while protecting existing headwater streams systems.

The restoration component of the proposed project (the area located west of Lassiter Mill Rd) is composed of approximately 79 percent perennial streams and 21 percent intermittent/ephemeral streams, which is in line with current NCEEP guidelines regarding perennial/intermittent mitigation credits generated from a potential stream site. However, due to, the inclusion of 15,802 linear ft of stream preservation (located primarily east of Lassiter Mill Rd) the total perennial/intermittent ratio for the site falls short of that typically required for mitigation sites (approximately 52/48 perennial/intermittent).

The preservation areas provide substantial linear feet of perennial as well as additional intermittent and ephemeral streams that are not typically protected under current NCEEP guidelines. Besides the acquisition costs for the conservation easement, the preservation areas do not require additional resources be allocated for fencing, cattle crossings, vegetation plantings, stream design, construction, etc. Stream credits generated in the preservation areas are acquired as a result of portions of the property being placed under easement. Failure to take advantage of the opportunities presented by this preservation opportunity to meet a 80/20 perennial/intermittent ratio requirement would miss the opportunity to extend and protect the project limits and prevent future development within the headwater areas of the Mill Creek project. The relatively low costs associated with the easements, in addition to the significance of preserving such a large area, would appear to merit their inclusion in the project no matter their affect on the stream ratios.

The combination of the NCEEP and EQUIP programs allows for more of the watershed to be protected, increasing the habitat restoration opportunities that exist by removing the threat of development within the uplands surrounding the NCEEP conservation easement boundaries. Water quality benefits such as additional water retention, agricultural and nutrient pollutant removal will also be achieved, as will the ecological benefits of increasing habitat diversity in the watershed. This combination of stream restoration/enhancement, restored prairie, and preserved land will provide a large, unfenced natural area with a complex habitat network that will be permanently protected through conservation easements greatly enhancing the Mill Creek project as a NCEEP mitigation site.

7.2 Constraints

Potential obstacles to construction activities may be the location of temporary haul roads needed during construction be located within the projects "limits of disturbance" because the property is also in the process of being converted from fallow agricultural/livestock field to native prairiegrass fields. A power line easement (Randolph EMC) runs along the NCDOT right of way on High Pine Church Road and Lassiter Mill Road. The power line easements contain small feeder lines to individual residential homes. Since the power lines and water lines are close to the road right of way and away from the stream project, vegetation planted should not interfere with the power lines or the water lines. Species planting may have to be modified around wires used to stabilize utility poles along Lassiter Mill Rd and UT4. There are no other known or foreseen constraints at the site associated with structure and/or infrastructure encroachments.

7.3 Design

After examining the assessment data collected at the site and exploring the site's potential for restoration, an approach to the project reaches was developed. First, an appropriate stream type for the valley type was selected. Based on the channel evolution sequence ascribed to the stream after examination of existing conditions survey data and other field observations, as well as conditions observed on reference streams under similar conditions the project design stream types were further refined. Available belt width and channel incision were considered as well. The proposed stream types and approaches for the project are summarized in Table 7.1. The existing conditions and design criteria of the project reaches are provided in Tables 7.2a and 7.2b.

Table 7.1
Project Design Stream Types

Reach	Restored Stream Type	Rationale
MC1	B3c/1	Enhancement I-benching, in-stream structures, and planting vegetation will alleviate some of the stresses upon MC1's dimension; pattern will not change. The profile is bedrock controlled and the pattern is confined within the valley. Benching in areas where bank height ratios are highly unstable will lower the nearbank shear stresses. Enhancement II- planting riparian buffer will alleviate erosion along the upper portion of MC1.
UT1	N/A	Reach is an agriculturally dug ditch at the toe of the slope. The top 600' of the ditch can be filled with excess material from the excess fill generated from UT2 to reduce erosion at the top of the reach.
UT2	B5/1	Wetland Creation - old breached pond remains saturated throughout the year. The breached dam will be excavated such that the wetland remains hydrologically connected. Restoration - downstream of the wetland (~450') will be restored to a B stream type with a functioning floodplain (Rosgen Priority Level 2 approach) and a shallow channel (~425') will be cut through the wetland creation area to allow water to saturate the entire area during the drier months of the year. Enhancement II - a riparian buffer will be planted upstream of the wetland.
UT4	E4b	Enhancement II - a riparian buffer will be planted.
UT5	B4/1	Wetland Creation - old breached pond remains saturated throughout the year. The breached dam will be excavated such that the wetland remains hydrologically connected. Restoration - below the wetland, ~125' of stream will be restored to a B stream type with a functioning floodplain (Rosgen Priority Level 2 approach). Enhancement II-benching (downstream of restoration), and planting vegetation (throughout UT5) will alleviate erosion; and pattern will not change. The profile is bedrock controlled and the pattern is confined within the valley. Benching in areas where bankheight ratios are highly unstable will lower the nearbank shear stresses.
UT6	N/A	Preservation-Approx. 954' of stream will be preserved.
UT7	N/A	Preservation-Approx. 2,529' of stream will be preserved.
UT8	N/A	Preservation-Approx. 2,003' of stream will be preserved.
UT9	N/A	Preservation-Approx. 5,000' of stream will be preserved.

Table 7.1
Project Design Stream Types

Reach	Restored Stream Type	Rationale
MC2	N/A	Preservation-Approx. 998' of stream will be preserved.
MC3	N/A	Preservation-Approx. 687'of stream will be preserved.
MC4	N/A	Preservation-Approx. 1,443' of stream will be preserved.
All Reaches	N/A	Riparian buffers at least 50 feet in width will be established along all stream reaches. All buffer areas will be protected by a perpetual conservation easement.

Table 7.2a
Existing Conditions and Design Parameters for Project Reaches

Mill Creek Project[1,2]	MC1 Enhancement I Existing Stream Values[3]		MC1 Enhancement I Design Stream Values		UT2 Restoration Existing Stream Values[4]		UT2 Restoration Design Stream Values		Rationale
Parameter	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Stream Length (ft)	1,460		1,460		1,703 [5]		875		
Drainage Area, DA (sq mi)	1.33		1.33		0.08		0.08		
Stream Type (Rosgen)	B3c/1		B3c/1		B5/1		B5/1		Note 1
Bankfull Discharge, Qbkf (cfs)	70.42		70.42		8.4		8.4		Note 2
Bankfull Riffle XSEC Area, Abkf (sq ft)	27.6	27.6	27.6	27.6	3.5	3.5	3.8	3.8	
Bankfull Mean Velocity, Vbkf (ft/s)	2.6		2.6		2.4		2.2		V=QA
Bankfull Riffle Width, Wbkf (ft)	25.3		18.2	20.3	7.2		6.8	7.5	
Bankfull Riffle Mean Depth, Dbkf (ft)	1.3		1.4	1.5	0.5		0.5	0.6	D=A/W
Width to Depth Ratio, W/D (ft/ft)	19.8		12.0	15.0	14.7		12.0	15.0	Note 3
Width Floodprone Area, Wfpa (ft)	36.7		25	40	12.1		15	25	
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	1.4		1.4	2.0	1.7		2.2	3.3	Note 4
Riffle Max Depth @ bkf, Dmax (ft)	1.9		1.7	2.1	1.1		0.6	0.8	
Riffle Max Depth Ratio, Dmax/Dbkf	1.5		1.2	1.4	0.5		1.2	1.4	Note 5
Max Depth @ tob, Dmaxtob (ft)	3.4		1.7	2.3	1.8		0.6	0.9	
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.8		1.0	1.1	1.7		1.0	1.1	Note 6
Meander Length, Lm (ft)	---		---		---		---		Note 7
Meander Length Ratio, Lm/Wbkf	---		---		---		---		Note 7
Radius of Curvature, Rc (ft)	---		---		---		---		Note 7
Rc Ratio, Rc/Wbkf	---		---		---		---		Note 7
Belt Width, Wblt (ft)	---		---		---		---		Note 7

Table 7.2a
Existing Conditions and Design Parameters for Project Reaches

Mill Creek Project[1,2]	MC1 Enhancement I Existing Stream Values[3]		MC1 Enhancement I Design Stream Values		UT2 Restoration Existing Stream Values[4]		UT2 Restoration Design Stream Values		Rationale
Parameter	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Meander Width Ratio, Wblt/Wbkf	---		---		---		---		Note 7
Sinuosity, K	1.27		1.27		1.14		1.14		
Valley Slope, Sval (ft/ft)	0.0115		0.0115		0.0251		0.0251		
Channel Slope, Schan (ft/ft)	0.0090		0.0090		0.0140		0.0140		
Slope Riffle, Srif (ft/ft)	---		0.0099	0.0162	---		0.0154	0.0252	
Riffle Slope Ratio, Srif /Schan	---		1.1	1.8	---		1.1	1.8	Note 5
Slope Pool, Spool (ft/ft)	---		0.0001	0.0023	---		0.0001	0.0035	
Pool Slope Ratio, Spool/Schan	---		0.01	0.25	---		0.01	0.25	Note 5
Pool Max Depth, Dmaxpool (ft)	---		2.8	4.5	---		1.0	1.8	
Pool Max Depth Ratio, Dmaxpool/Dbkf	---		2.0	3.0	---		2.0	3.0	Note 5
Pool Width, Wpool (ft)	---		20.0	30.5	---		7.4	11.3	
Pool Width Ratio, Wpool/Wbkf	---		1.1	1.5	---		1.1	1.5	Note 8
Pool-Pool Spacing, Lps (ft)	---		27.3	101.7	---		10.1	37.7	
Pool-Pool Spacing Ratio, Lps/Wbkf	---		1.5	5.0	---		1.5	5.0	Note 5
d16 (mm)	9.82		9.82		0.1		0.1		
d35 (mm)	43.00		43.00		0.6		0.6		
d50 (mm)	90.00		90.00		1.0		1.0		
d84 (mm)	>2048		>2048		5.2		5.2		
d95 (mm)	>2048		>2048		8.5		8.5		

<u>*Footnotes:*</u>
1. Denotes that UT4 only has Enhancement II (541') and Preservation (1,809).
2. Reaches UT6 (954'), UT7 (2,529'), UT8 (2,003'), UT9 (5,239'), MC2 (998'), MC3 (785'), and MC4 (1,485') are all Preservation Reaches.
3. Denotes that MC1 also has an Enhancement II Reach (754') that only consists of buffer planting.
4. Denotes that UT2 also has an Enhancement II Reach (1,012') that only consists of buffer planting.
5. Existing channel is a toe of slope channel that drains into Mill Creek. The design is to restore the original drainage back into Uwharrie River.
6. Denotes that UT5 also has an Enhancement II Reach (842') that only consists of buffer planting.
7. The existing channel is the section that has breached the dam and is cutting into the hillslope. The design is to restore the original drainage pattern with the valley.

<u>Rationale Notes:</u>
1. A B stream type is appropriate for steeply sloped channels (generally greater than 0.02), with steep fluvially dissected valleys.

2. Bankfull discharge was estimated using Manning's equation.
3. A final W/D ratio was selected based on relationships of W/D ratio to slope in NC Piedmont reference reach streams, in-house composite ratios, as well as sediment transport analyses.
4. Required for stream classification.
5. This ratio was based on past project evaluation of similar B type design channels.
6. A bank height ratio near 1.0 ensures that all flows greater than bankfull will spread onto a floodplain. This minimizes shear stress in the channel and maximizes floodplain functionality resulting in lower risk of channel instability.
7. Parameters were not derived since the channels are relatively straight (low sinuosity) and are confined with in the valley.
8. Values were chosen based on reference reach database analysis and past project evaluation. It is more conservative to design a pool wider than the riffle. Over time, the pool width may narrow, which is a positive evolutionary step.

Table 7.2b
Existing Conditions and Design Parameters for Project Reaches

Mill Creek Project[1,2]	UT5 Restoration Existing Stream Values[6]		UT5 Restoration Design Stream Values		Rationale
Parameter	MIN	MAX	MIN	MAX	
Stream Length (ft)	200[7]		125		
Drainage Area, DA (sq mi)	0.06		0.06		
Stream Type (Rosgen)	B4/1		B4/1		Note 1
Bankfull Discharge, Qbkf (cfs)	9.6		9.6		Note 2
Bankfull Riffle XSEC Area, Abkf (sq ft)	3.1	3.1	3.8	3.8	
Bankfull Mean Velocity, Vbkf (ft/s)	2.5		2.5		V=QA
Bankfull Riffle Width, Wbkf (ft)	4.9		6.8	7.5	
Bankfull Riffle Mean Depth, Dbkf (ft)	0.6		0.5	0.6	D=A/W
Width to Depth Ratio, W/D (ft/ft)	7.8		12.0	15.0	Note 3
Width Floodprone Area, Wfpa (ft)	32.5		15	30	
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	4.0		2.2	4.0	Note 4
Riffle Max Depth @ bkf, Dmax (ft)	1.4		0.6	0.8	
Riffle Max Depth Ratio, Dmax/Dbkf	2.3		1.2	1.4	Note 5
Max Depth @ tob, Dmaxtob (ft)	2.2		0.6	0.9	
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.5		1.0	1.1	Note 6
Meander Length, Lm (ft)	---		---		Note 7
Meander Length Ratio, Lm/Wbkf	---		---		Note 7
Radius of Curvature, Rc (ft)	---		---		Note 7
Rc Ratio, Rc/Wbkf	---		---		Note 7
Belt Width, Wblt (ft)	---		---		Note 7
Meander Width Ratio, Wblt/Wbkf	---		---		Note 7
Sinuosity, K	1.17		1.17		
Valley Slope, Sval (ft/ft)	0.0381		0.0381		

Table 7.2b
Existing Conditions and Design Parameters for Project Reaches

Mill Creek Project[1,2] Parameter	UT5 Restoration Existing Stream Values[6] MIN	UT5 Restoration Existing Stream Values[6] MAX	UT5 Restoration Design Stream Values MIN	UT5 Restoration Design Stream Values MAX	Rationale
Channel Slope, Schan (ft/ft)	0.0325		0.0325		
Slope Riffle, Srif (ft/ft)	---		0.0358	0.0585	
Riffle Slope Ratio, Srif/Schan	---		1.1	1.8	Note 5
Slope Pool, Spool (ft/ft)	---		0.0003	0.0081	
Pool Slope Ratio, Spool/Schan	---		0.01	0.25	Note 5
Pool Max Depth, Dmaxpool (ft)	---		1.0	1.8	
Pool Max Depth Ratio, Dmaxpool/Dbkf	---		2.0	3.0	Note 5
Pool Width, Wpool (ft)	---		7.4	11.3	
Pool Width Ratio, Wpool/Wbkf	---		1.1	1.5	Note 8
Pool-Pool Spacing, Lps (ft)	---		10.1	37.7	
Pool-Pool Spacing Ratio, Lps/Wbkf	---		1.5	5.0	Note 5
d16 (mm)	0.7		0.7		
d35 (mm)	1.8		1.8		
d50 (mm)	7.1		7.1		
d84 (mm)	14.5		14.5		
d95 (mm)	27.4		27.4		

Footnotes:
1. Denotes that UT4 only has Enhancement II (541') and Preservation (1,809).
2. Reaches UT6 (954'), UT7 (2,529'), UT8 (2,003'), UT9 (5,239'), MC2 (998'), MC3 (785'), and MC4 (1,485') are all Preservation Reaches.
3. Denotes that MC1 also has an Enhancement II Reach (754') that only consists of buffer planting.
4. Denotes that UT2 also has an Enhancement II Reach (1,012') that only consists of buffer planting.
5. Existing channel is a toe of slope channel that drains into Mill Creek. The design is to restore the original drainage back into Uwharrie River.
6. Denotes that UT5 also has an Enhancement II Reach (842') that only consists of buffer planting.
7. The existing channel is the section that has breached the dam and is cutting into the hillslope. The design is to restore the original drainage pattern with the valley.

Rationale Notes:
1. A B stream type is appropriate for steeply sloped channels (generally greater than 0.02), with steep fluvially dissected valleys.
2. Bankfull discharge was estimated using Manning's equation.
3. A final W/D ratio was selected based on relationships of W/D ratio to slope in NC Piedmont reference reach streams, in-house composite ratios, as well as sediment transport analyses.
4. Required for stream classification.
5. This ratio was based on past project evaluation of similar B type design channels.
6. A bank height ratio near 1.0 ensures that all flows greater than bankfull will spread onto a floodplain. This minimizes shear stress in the channel and maximizes floodplain functionality resulting in lower risk of channel instability.
7. Parameters were not derived since the channels are relatively straight (low sinuosity) and are confined with in the valley.

8. Values were chosen based on reference reach database analysis and past project evaluation. It is more conservative to design a pool wider than the riffle. Over time, the pool width may narrow, which is a positive evolutionary step.

7.4 Design Criteria Selection

Selection of natural channel design criteria is based on a combination of approaches, including review of reference reach databases, regime equations, and evaluation of results from past projects, as discussed in Section 2.5.

Selection of a general restoration approach was the first step in selecting design criteria for the streams on the Mill Creek site. The approach was based on each reach's potential for restoration as determined during the site assessment. After selection of the general restoration approach, specific design criteria were developed so that each reach's plan view layout, cross-section dimensions, and profile could be described for the purpose of developing construction documents.

7.4.1 Reference Reach Survey

As discussed in Section 6.4, a stream reference reach was identified and surveyed approximately 80 miles northeast of the project site. The Mickey Reach site is an example of a reference quality B4 channel under similar geomorphological conditions as the project site. Specific natural channel parameters are provided in Appendix F.

7.4.2 Reference Reach Database

An internal reference reach database has been developed by Baker Engineering for the evaluation of reference reach parameters from multiple sites within a geographic area. The database includes three B type reference reaches, in addition to the Mickey reference reach, that were surveyed in the Piedmont and have been used for design purposes on other projects. Collectively, the data provide valuable information regarding the range of conditions documented for similar stream systems.

7.4.3 Design Criteria Selection Method

Specific design parameters were developed using a combination of reference reach data, past project experiences, and best professional judgment. The design philosophy at the Mill Creek site is to use conservative values for the selected stream types and to allow natural variability in stream dimension, facet slope, and bed features to form over long periods of time under the processes of flooding, re-colonization of vegetation, and watershed influences.

7.5 Sediment Transport

Shear stress and stream power relationships were only generated for reaches that would be restored (lower reaches of UT2 and UT5) within the project. UT2 and UT5 reaches have median particle sizes that result in their classification as small gravel, and coarse sand bed streams, respectively. While these median particle sizes indicate some diversity, the overall composition is fairly similar. Each of the streams has 50% to 60% sand, 30% to 50% gravel, and less than 10% cobble/bedrock as bed substrate. In isolated locations, coarse material and bedrock in riffles appears to control grade. The streams also receive significant quantities of fine materials from both bank erosion and contributions from the upstream catchment. While restoration of the channel will reduce localized bank erosion, the channel will still need to transport the fine materials from upstream sources. In sand bed streams, sediment transport capacity is a critical analysis, whereas in gravel bed streams, sediment transport competency is a critical analysis. Since the design reaches must transport both sand and gravel sized particles, both capacity and competency were analyzed.

Sediment transport capacity, measured as unit stream power (W/m^2) as discussed in Section 2.6, was compared for the existing stream channels and the design conditions. Table 7.2 shows bankfull boundary shear stress and stream power values for existing and design conditions. Stream power values for the existing and design conditions all compare well to values for similar streams and valley types described by Bledsoe et al (2002).

Sediment transport competency is measured in terms of the relationship between critical and actual depth at a given slope and occurs when the critical depth produces enough shear stress to move the largest (d_{100}) subpavement particle. As shown in Table 7.2, UT2 and UT5 have design depths greater than the critical depth which may indicate the tendency to degrade. The concern for degradation will be addressed by grade control structures which will be installed as discussed in Section 7.4. As a second check of sediment transport competency, boundary shear stress was plotted on Shield's Curve (as discussed in Section 2.6.3) to estimate the largest moveable particle. In both streams, as shown in Table 7.3, the Shield's Curve predicts the mobility of particles larger than the d_{100} observed in the subpavement. Both of these sediment transport competency analyses confirm the ability of the design channel to transport the coarse sediment load.

TABLE 7.3
Boundary Shear Stresses and Stream Power for Existing and Proposed Conditions of UT2 and UT5

Parameter	Value			
	UT2 Existing Conditions	UT2 Proposed Conditions	UT5 Existing Conditions	UT5 Proposed Conditions
Bankfull Discharge, Q (cfs)	8.4	8.4	9.6	9.6
Bankfull Area (square feet)	3.5	3.8	3.1	3.8
Mean Bankfull Velocity (cfs)	2.4	2.2	2.5	2.5
Bankfull Width, W (feet)	7.2	7.1	4.9	6.8
Bankfull Mean Depth, D (feet)	0.5	0.5	0.6	0.6
Width to Depth Ratio, w/d (feet/ foot)	14.7	13.4	7.8	12
Wetted Perimeter (feet)	8.3	8.2	8.0	7.9
Hydraulic Radius, R (feet)	0.4	0.5	0.4	0.5
Channel Slope (feet/ foot)	0.0251	0.0251	.0325	.0450
Boundary Shear Stress, τ (lbs/ft^2)	0.37	0.4	0.79	1.35
Subpavement D_{100} (mm)	20	20	25	25
Largest Moveable Particle (mm) per Modified Shield's Curve	60 – 80	60 – 80	100 – 150	150 – 202
Critical Depth (feet)	0.20	0.20	0.13	0.10
Critical Slope (feet/ foot)	.0050	0.0051	.0071	.0076

TABLE 7.3
Boundary Shear Stresses and Stream Power for Existing and Proposed Conditions of UT2 and UT5

Parameter	Value			
	UT2 Existing Conditions	UT2 Proposed Conditions	UT5 Existing Conditions	UT5 Proposed Conditions
Stream Power (W/m^2)	11.1	11.1	58.1	58.4

7.6 In-Stream Structures

A variety of in-stream structures are proposed for the project reaches. Structures such as root wads, constructed riffles, cross vanes, rock vanes, step pools, and wing deflectors will be used to stabilize the newly-restored and enhanced streams. Table 7.4 summarizes the use of in-stream structures at the site.

Table 7.4
In-stream Structure Types and Locations

Structure Type	Location
Root wads	MC1
Constructed riffles	UT2 and UT5
Cross vanes	UT2 and UT5
Rock vanes	MC1
Single wing deflectors	MC1
Double wing deflectors	MC1
Step pools	UT2 and UT5
Cover logs	MC1

7.6.1 Root Wads

Root wads are placed at the toe of the stream bank along the outside of meander bends for the creation of habitat and for stream bank protection. Root wads include the root mass or root ball of a tree plus a portion of the trunk. They are used to armor a stream bank by deflecting stream flows away from the bank. In addition to stream bank protection, they provide structural support to the stream bank and habitat for fish and other aquatic animals. They also serve as a food source for aquatic insects. Root wads will be placed along Mill Creek.

7.6.2 Constructed Riffles

A constructed riffle consists of coarse bed material placed in the stream at the specific riffle locations along the profile. The purpose of this structure is to provide grade control and improve riffle habitat.

7.6.3 Cross Vanes

Cross vanes are used to provide grade control, keep the thalweg in the center of the channel, and protect the stream bank. A cross vane consists of two rock vanes joined by a center structure installed perpendicular to the direction of flow. This center structure sets the invert elevation of the stream bed. Vanes are located just downstream of the point where the stream flow intercepts the bank at acute angles.

7.6.4 Rock Vanes

Rock vanes are used for bank protection, and to keep the thalweg in the center of the channel. A rock vane consists of an arm extending in a gentle downward upstream direction. The upstream end of the structure sets the invert elevation of the stream bed. Vanes are located just downstream of the point where the stream flow intercepts the bank at acute angles.

7.6.5 Single Wing Deflectors

Single wing deflectors are used for bank protection, and to keep the thalweg in the center of an overly wide channel. A single deflector consists of two arms extending out from the bank with another arm connecting the two arms together, which is parallel to the stream flow. The area inside the arms is filling with stream alluvium. During low and normal flows, the wing deflector redirects the flow of the channel away from the bank for which it is protecting. High flows will overtop the structure. The wing deflector deepens and narrows the channel thalweg. Wing deflectors allow an overly wide channel to have narrower base flow geometry (Nyman, 2003).

7.6.6 Double Wing Deflectors

Double wing deflectors are used for bank protection, and to keep the thalweg in the center of an overly wide channel. A double deflector is two single wing deflectors within the same cross-section. During low and normal flows, the wing deflectors redirect the flow of the channel away from the banks for which it is protecting. High flows will overtop the structures. The wing deflectors deepen and narrow the channel thalweg. Wing deflectors allow an overly wide channel to have narrower base flow geometry (Nyman, 2003).

7.6.7 Step Pools

Step pools structures that are used for long term stability in steep gradient streams. Step pools typically have stair-step profiles that are armored with boulder inverts (Knighton, 1998). The steps are separated by plunge pools. Step pools effectively dissipate energy, transport sediment, oxygenate the water, and provide stability within a high gradient system.

7.6.8 Cover Logs

A cover log is placed along the outside of a meander bend to provide habitat in the pool area. It is most often installed in conjunction with rootwads. The log is buried into the outside bank of the meander bend; the opposite end extends through the deepest part of the pool and may be buried in the inside of the meander bend, in the bottom of the point bar. The placement of the cover log near the bottom of the bank slope on the outside of the bend encourages scour in the pool. This increased scour provides a deeper pool for bedform variability. Cover logs will be used on Mill Creek; however, fewer will be placed in the small reaches because the habitat value is not as great.

7.7 Vegetation

The vegetative components of this project include stream bank, floodplain, and headwater area planting. In addition, any areas of the site that lack diversity or are disturbed or adversely impacted by the construction process will be replanted. Bare-root trees, live stakes, and permanent seeding will be planted within designated areas of the conservation easement. A minimum 50-foot buffer will be established along all restored stream reaches. In many areas, the buffer width will be in excess of 50 feet. In general, bare-root vegetation will be planted at a target density of 460 stems per acre. Planting of bare-root trees and live stakes will be conducted during the dormant season, with all trees installed between the last week of November and the third week of March.

Selected species for hardwood re-vegetation are presented in Table 7.4 below. Tree species selected for stream restoration areas will be weakly tolerant to tolerant of flooding. Weakly tolerant species are able to survive and grow in areas where the soil is saturated or flooded for relatively short periods of time. Moderately tolerant species are able to survive in soils that are saturated or flooded for several months during the growing season. Tree species selected for the wetland restoration areas will be tolerant of flooding. Flood tolerant species are able to survive on sites in which the soil is saturated or flooded for extended periods during the growing season (WRP, 1997).

Once trees are transported to the site, they will be planted within two days. Soils across the site will be sufficiently disked and loosened to a depth of 12” prior to planting. Trees will be planted by manual labor using a dibble bar, mattock, planting bar, or other approved method. Planting holes for the trees will be sufficiently deep to allow the roots to spread out and down without “J-rooting.” Soil will be loosely compacted around trees once they have been planted to prevent them from drying out.

Live stakes will be installed randomly two to three feet apart using triangular spacing—or at a density of 968 to 1,452 stem per acre—along the stream banks, between the toe of the stream bank and bankfull elevation. Site variations may require slightly different spacing.

Permanent seed mixtures will be applied to all disturbed areas of the project site. Table 7.5 lists the species, mixtures, and application rates that will be used. A mixture is provided that is suitable for streambank areas, floodplain and wetlands. Mixtures will also include temporary seeding (rye grain or browntop millet) to allow for application with mechanical broadcast spreaders. To provide rapid growth of herbaceous ground cover and biological habitat value, the permanent seed mixture specified will be applied to all disturbed areas outside the banks of the restored stream channel. The species provided are deep-rooted and have been shown to proliferate along restored stream channels, providing long-term stability. Permanent seeding will be applied at a rate of 15 pounds per acre.

Temporary seeding will be applied to all disturbed areas of the site that are susceptible to erosion. These areas include constructed streambanks, access roads, side slopes, and spoil piles. If temporary seeding is applied from November through April, rye grain will be used and applied at a rate of 70 pounds per acre. If applied from May through October, temporary seeding will consist of browntop millet, applied at a rate of 25 pounds per acre.

Bare-root trees and live stake species selected for re-vegetation of the restoration site are listed in Table 7.5. Table 7.6 summarizes the permanent seed mixtures for the restoration site. Species selection may change due to availability at the time of planting.

Through ongoing discussions with the landowner, representatives with the NCEEP, the NCWRC, and Baker Engineering; the landowner has requested that vegetation planting within the NCEEP conservation easement corridors be done in coordination with the NCWRC and the EQUIP program grant. Conversion of the fields surrounding UT4, both east and west of Lassiter Mill Rd has been initiated. Included in the NCWRC planting program are prescribed burns to aid in the growth and establishment of the targeted vegetation species in addition to reducing the potential of invasive species from establishing in the converted prairiegrass fields. Burning is not expected to occur within the NCEEP easement areas.

A list of vegetation species planted to date within the prairiegrass fields has been provided (Table 7.7). To aid in the success of the prairiegrass conversion, the NCWRC has requested that the upper portions (headwaters areas) of UT2, UT5, and along the buffer outer edges of MC1 be planted with selected early successional shrubs and herbaceous species from Table 7.6 to mimic their vegetation species list provided in Table 7.7. Initial discussions indicate that this will be possible. Continued coordination with the NCWRC is anticipated during planting of the easement areas and over the course of the vegetation monitoring period.

Table 7.5

Proposed Bare-root and Live Stake Species

Common Name	Scientific Name	Percent Planted by Species	Planting Density
Stream Restoration Buffer			
River Birch	*Betula nigra*	15%	42 stems per acre
Sugarberry	*Celtis laevigata*	5%	14 stems per acre
Green Ash	*Fraxinus pennsylvanica*	10%	28 stems per acre
Black Walnut	*Juglans nigra*	5%	14 stems per acre
Sycamore	*Platanus occidentalis*	20%	56 stems per acre
Swamp Chestnut Oak	*Quercus michauxii*	10%	28 stems per acre
Willow Oak	*Quercus phellos*	8%	22 stems per acre
Northern Red Oak	*Quercus rubra*	7%	19 stems per acre
Persimmon	*Diospyros virginiana*	10%	28 stems per acre
Black Gum	*Nyssa sylvatica*	10%	28 stems per acre
Early Successional Shrubs and Trees			
Coralberry	*Symphoricarpos orbiculatus*	5%	9 stems per acre
Southern Arrowwood	*Viburnum dentatum*	10%	18 stems per acre
Virginia Sweetspire	*Itea virginica*	5%	9 stems per acre
Elderberry	*Sambucus canadensis*	10%	18 stems per acre
Chicksaw Plum	*Prunus augustifolia*	5%	9 stems per acre
Common Winterberry	*Ilex verticillata*	10%	18 stems per acre
Silky Dogwood	*Cornus amomum*	15%	27 stems per acre
Flowering Dogwood	*Cornus florida*	15%	27 stems per acre
Eastern Redbud	*Cercis canadensis*	10%	18 stems per acre
Swamp Rose	*Rosa palustris*	10%	18 stems per acre
Parsley-leaf Hawthorn	*Crataegus marshallii*	5%	9 stems per acre
Streambanks (Live Stakes)			
Silky Willow	*Salix sericea*	30%	1452 stems per acre
Black Willow	*Salix nigra*	10%	484 stems per acre
Silky Dogwood	*Cornus amomum*	40%	1936 stems per acre
Elderberry	*Sambucus canadensis*	20%	968 stems per acre
Wetland Plantings			
Green Ash	*Fraxinus pennsylvanica*	20%	92 stems per acre
Sycamore	*Platanus occidentalis*	20%	92 stems per acre
Sugarberry	*Celtis laevigata*	10%	46 stems per acre

Cottonwood	*Populus deltoidies*	5%	23 stems per acre
Overcup Oak	*Quercus lyrata*	15%	69 stems per acre
Tag Alder	*Alnus serrulata*	15%	69stems per acre
Silky Dogwood	*Cornus amomum*	15%	69stems per acre

Table 7.6
Proposed Permanent Seed Mixture

Common Name	Scientific Name	Percent of Mixture	Seeding Density (lbs/acre)	Wetness Tolerance
Streambank, Floodplain and Wetland Areas				
Big bluestem	*Andropogon gerardii* – NC Ecotype	5%	0.8	FAC
Tick seed	*Bidens frondosa*	8%	1.3	FACW
Hop sedge	*Carex lupulina*	5%	0.8	OBL
Shallow sedge	*Carex lurida*	5%	0.8	OBL
Tussock sedge	*Carex stricta*	5%	0.8	OBL
Fox sedge	*Carex vulpinoidea*	5%	0.8	OBL
River oats	*Chasmanthium latifolium*	5%	0.8	FAC-
Lance leaf coreopsis	*Coreopsis lanceolata*	5%	0.8	FACU
Virginia wildrye	*Elymus virginicus*	15%	2.4	FAC
Purple lovegrass	*Eragrostis spectabilis*	2%	0.3	FACU
Soft rush	*Juncus effusus*	5%	0.8	FACW+
Pink Muhly grass	*Muhlenbergia capillaris*	2%	0.3	FACU
Switchgrass	*Panicum virgatum*	10%	1.6	FAC+
Pennsylvania Smartweed	*Polygonum pennsylvanicum*	8%	1.3	FACW
Little bluestem	*Schizachyrium scoparium* - NC Ecotype	5%	0.8	FACU
Indian grass	*Sorgastrum nutans* – NC Ecotype	5%	0.8	FACU
Gamma grass	*Tripsicum dactyloides*	5%	0.8	FAC+

Table 7.7
NCWRC Native Grassland Vegetation Species List

Common Name	Scientific Name
Native Prairie Grassland Areas –Currently Planted	
Tick seed	*Bidens frondosa*
Suther Indian grass	*Sorgastrum nutans*
Montgomery Little Bluestem	*Schizachyrium scoparium*
Lance leaf coreopsis	*Coreopsis lanceolata*
Narrow leaved Sunflower	*Helianthus angustifolia*

Plains Coreopsis	*Coreopsis tinctoria*
Large-flower tickseed	*Coreopsis grandiflora*
Blanket Flower	*Gaillardia pulchella*

7.8 Invasive Species Removal

Invasive species including kudzu (*Pueraria montana*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*) and Chinese privet (*Ligustrum sinense*) have been noted in most of the riparian areas of the channels within the project site. Invasive species will be removed by grading operations and by hand cutting and treating with herbicides in areas that are to be planted. If these or other invasive species re-establish and persist for more than three years after the stream restoration has been constructed, hand cutting and herbicide treatment will be required. If any invasive species are determined to pose potential problems within the first three years following restoration, corrective actions may be taken earlier.

8.0 WETLAND CREATION DESIGN

8.1 Potential for Wetland Mitigation

On-site investigations and field reviews with the USACE determined that there are no jurisdictional wetlands or areas of existing hydric soils located within the project area. Therefore, there is no potential for wetland restoration or wetland enhancement practices. Two areas were identified that currently exhibit wetland hydrology and hydrophytic vegetation, but do not contain hydric soils. These areas have developed upstream of two small farm pond dams which have both breached and now only pond shallow water. Well data collected from the two areas indicate that they remain inundated for extended periods during the dormant and early growing seasons, and that water levels during these times fluctuate very little. An USACE representative commented during field reviews that these areas would be appropriate for wetland creation practices for mitigation credit, since the areas are not currently considered jurisdictional wetlands and are not underlain by hydric soils.

The proposed wetland mitigation approaches for the project are summarized in Table 8.1.

Table 8.1
Project Wetland Design Approaches

Site	Mitigation Approach	Rationale
Wetland Site 1	Creation	Site is not appropriate for restoration or enhancement because area is not a jurisdictional wetland and does not contain hydric soils. Site currently supports hydrophytic vegetation. However, the site remains inundated for extended periods and water table depths fluctuate little due to ponded water. Creation practices will seek to grade down the breached dam, construct a more natural topography, and allow for more natural fluctuation of water levels to support a broader diversity of hydrophytic vegetation.
Wetland Site 2	Creation	See discussion above for Site 1

8.2 Wetland Design

The topography of the created sites will be patterned after natural floodplain wetland sites, and will include the creation of minor depressions and tip mounds (microtopography) that promote diversity of hydrologic conditions and habitats common to natural wetland areas. A shallow channel will be constructed through the wetland creation areas to provide a hydrologic connection to upstream and downstream stream channel improvements. The channel will also reduce periods of constant inundation and provide for periodic overbank flooding. These techniques will be instrumental to the improvement of site hydrology by promoting more diverse hydrologic conditions than are currently found on the sites. Grading activities will focus on removing the breached dam structures and providing a stabilized outlet to route wetland flows into the channel downstream.

Wetland creation will include re-vegetating the two sites with woody vegetation. Selected species for wetland areas are presented in Table 7.4, and will be tolerant of flooded conditions. It is estimated that these proposed practices will result in approximately 1.1 acres of wetland creation.

9.0 MONITORING AND EVALUATION

Channel stability, vegetation survival, and wetland hydrology will all be monitored on the project site. Post-restoration monitoring will be conducted for five years following the completion of construction to document project success and will follow the most current NCEEP mitigation guidelines.

9.1 Stream Monitoring

Geomorphic monitoring of restored or enhanced stream reaches will be conducted for five years to evaluate the effectiveness of the restoration practices. Monitored stream parameters include stream dimension (cross-sections), pattern (longitudinal survey), profile (profile survey), and photographic documentation. Specific monitoring requirements will vary according to the work that is performed, as listed in Table 9.1. The methods used and any related success criteria are described below for each parameter.

Table 9.1
Monitoring Procedures for Stream Restoration, Enhancement, and Preservation Reaches

Mitigation Approach	Monitoring Procedures Required *
Restoration	Bankfull events, cross-sections, pattern, longitudinal profile, photo points
Enhancement Level I	Bankfull events, cross-sections, longitudinal profile, photo points
Enhancement Level II	Photo points
Preservation	None

* Monitoring requirements are based on the USACE and NCDWQ *Stream Mitigation Guidelines*, April 2003.

9.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gages and photographs. At least one crest gage will be installed along each monitored stream reach. The crest gages will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

9.1.2 Cross-sections

Two permanent cross-sections will be installed per 1,000 LF of stream restoration and enhancement level I work, with one located at a riffle cross-section and one located at a pool cross-section. Each cross-section will be marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently used to facilitate easy comparison of year-to-year data. The annual cross-section survey will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in as-built cross-sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen Stream Classification System, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

9.1.3 Pattern

Annual measurements taken for the plan view of the restoration site will include sinuosity, meander width ratio, and radius of curvature. The radius of curvature measurements will be taken on newly constructed meanders for the first year of monitoring only.

9.1.4 Longitudinal Profile

A longitudinal profile will be completed in years one, three, and five of the monitoring period. The profile will be conducted for at least 3,000 LF of restored channel. Measurements will include thalweg, water surface, inner berm, bankfull, and top of low bank. Each of these measurements will be taken at the head of each feature (e.g., riffle, run, pool, glide) and the maximum pool depth. The survey will be tied to a permanent benchmark.

The longitudinal profiles should show that the bedform features are remaining stable (i.e., they are not aggrading or degrading). The pools should remain deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed for channels of the design stream type.

9.1.5 Bed Material Analyses

Since the streams through the project site are dominated by sand-size particles, pebble count procedures would not show a significant change in bed material size or distribution over the monitoring period; therefore, bed material analyses are not recommended for this project.

9.1.6 Photo Reference Sites

Photographs will be used to document restoration success visually. Reference stations will be photographed before construction and continued for at least five years following construction. Reference photos will be taken once a year. Photographs will be taken from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) on the site are monitored in each monitoring period. Site photographs are presented in Appendix A.

The stream will be photographed longitudinally beginning at the downstream end of the restoration site and moving upstream to the end of the site. Photographs will be taken looking upstream at delineated locations. Reference photo locations will be marked and described for future reference. Points will be close enough together to provide an overall view of the reach. The angle of the shot will depend on what angle provides the best view and will be noted and continued in future shots. When modifications to photo position must be made due to obstructions or other reasons, the position will be noted along with any landmarks and the same position will used in the future.

Lateral reference photos. Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. The survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will be included in each photo. Photographers should make an effort to consistently maintain the same area in each photo over time.

Structure photos. Photographs will be taken at each grade control structure along the restored stream. Photographers should make every effort to consistently maintain the same area in each photo over time.

9.2 Wetland Monitoring

9.2.1 Wetland Hydrologic Monitoring

Groundwater-monitoring stations will be installed within the wetland creation areas to document hydrologic conditions of the creation sites. Two groundwater monitoring stations will be installed, both being automated groundwater gauges with one gauge located in each creation area. Ground water monitoring stations will follow the USACE standard methods found in WRP Technical Notes ERDC TN-WRAP-00-02 (July 2000).

In order to determine if the rainfall is normal for the given year, rainfall amounts will be tallied using data obtained from the Randolph County WETS Station.

The objective is for the monitoring data to show the site is saturated within 12 inches of the soil surface for at least 12 percent of the growing season. The creation site hydrology will be compared to pre-construction conditions in terms of groundwater, frequency of overbank events, and soil characterization.

9.3 Vegetation Monitoring

Successful restoration of the vegetation on a mitigation site is dependent upon active planting of preferred canopy species and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, thirteen vegetation-monitoring plots will be installed across the restoration site to capture three percent of the total conservation easement. The size of individual quadrants will be 100 square meters for woody tree species. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Individual seedlings will be marked to ensure that they can be found in subsequent monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each succeeding year, until the final success criteria are met, the restored site will be evaluated between June and November. Specific and measurable success criteria for plant density on the project site will be based on the recommendations from NCEEP and past project experience.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year-old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criterion will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. While measuring species density is the current accepted methodology for evaluating vegetation success on restoration projects, species density alone may be inadequate for assessing plant community health. For this reason, the vegetation monitoring plan will incorporate the evaluation of additional plant community indices to assess overall vegetative success.

9.4 Reporting Requirements

A restoration plan and an as-built report documenting both stream restoration and wetland creation will be developed within 60 days of the completion of planting and the installation of wells on the restored site. The report will include all information required by current NCEEP mitigation plan guidelines, including elevations, photographs, well and sampling plot locations, a description of initial species composition by community type, and monitoring stations. The report will include a list of the species planted and the associated densities. The monitoring program will be implemented to document system development and progress toward achieving the success criteria referenced in the previous sections. Stream morphology, as well as wetland hydrology and vegetation, will be assessed to determine the success of the mitigation. The monitoring program will be undertaken for 5 years, or until the final success criteria are achieved, whichever is longer. Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCEEP. The monitoring reports will include:

- A detailed narrative summarizing the condition of the restored site and all regular maintenance activities
- As-built topographic maps showing location of monitoring gauges, vegetation sampling plots, permanent photo points, and location of transacts
- Photographs showing views of the restored site taken from fixed-point stations
- Hydrologic information
- Vegetative data
- Identification of any invasion by undesirable plant species, including quantification of the extent of invasion of undesirable plants by either stem counts, percent cover, or area, whichever is appropriate
- A description of any damage done by animals or vandalism
- Wildlife observations.

9.5 Maintenance Issues

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established woody floodplain vegetation are more susceptible to erosion from floods than those with a mature hardwood forest.
- Projects with sandy non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content.
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels.
- Wet weather during construction can make accurate channel and floodplain excavations difficult.
- Local wildlife can impact the rate at which the native buffer can be established.
- Extreme and/or frequent flooding can cause floodplain and channel erosion.
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed.
- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in the As-Built and Monitoring reports. Factors which may have caused any maintenance needs, including any of the conditions listed above, shall be discussed.

10.0 REFERENCES

Andrews, E. D., 1983. Entrainment of gravel from naturally sorted river bed material, Geological Society of America Bulletin, 94, 1225-1231.

Bledsoe, Brian P., C. C. Watson, and D. S. Biedenharn, 2002. Quantification of Incised Channel Evolution and Equilibrium. JAWRA, vol. 38, No 3, 861-870.

Bratton, S. P. 1976. Resource Division in an Understory Herb Community: Responses to Temporal and Microtopographic Gradients. The American Naturalist 110 (974):679-693.

Brinson, M.M., 1993. A Hydrogeomorphic Classification for Wetlands. U. S. Army Corps of Engineers, Waterways Exp. Stn, Tech. Rep. WRP-DE-4, Washington, D. C. 79 pp. +app.

Buol, S.W., F.D. Hole and R.J. McCracken, 1989. Soil Genesis and Classification. Iowa State University Press, 446 pp.

Budd, W.W, P.L. Cohen, P.R. Saunders and F.R. Steiner, 1987. Stream Corridor Management in the Pacific Northwest: I. Determination of Stream Corridor Widths. Environmental Management.

Bunte, K. and S. Abt, 2001. Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-Bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring. Gen. Tech. Rep. RMRS-GTR-74. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 428 p.

Copeland, R.R, D.N., McComas, C.R. Thorne, P.J. Soar, M.M. Jones, and J.B. Fripp, 2001. United States Army Corps of Engineers. Hydraulic Design of Stream Restoration Projects. Washington, DC.

Craft, C.B., W.P. Casey, 2000. Sediment and Nutrient Accumulation in Floodplain and Depressional Freshwater Wetlands of Georgia, USA. Wetlands, Vol. 20, No. 2, June 2000, pp 323-332.

Dunne, T. and L. B. Leopold, 1978. Water in Environmental Planning. New York: W. H. Freeman and Company.

Ehrnfield, J. G., 1995. Microsite Differences in Surface Substrate Characteristics in Chamaecyparis Swamps of the New Jersey Pinelands. Wetlands 15(2):183-189.

Federal Interagency Stream Restoration Working Group (FISRWG), 1998. Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service, Springfield, VA.

Gomez, B., 1991. Bedload Transport. Earth-Science Reviews 31, 89-132.

Gosselink, J. G., and R. E. Turner, 1978. The Role of Hydrology in Freshwater Wetland Ecosystems. In Freshwater Wetlands, 63-78. R. E. Good, D. F. Whigham, and R. L. Simpson, eds. Burlington, Mass.: Academic Press.

Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith, 1999. Bankfull Hydraulic Geometry Relationships for North Carolina Streams. Wildland Hydrology. AWRA Symposium Proceedings. Edited by: D.S. Olsen and J.P. Potyondy. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

Inglis, C.C. 1947. Meanders and their Bearing on River Training. Institution of Civil Engineers, Maritime and Waterways Engineering Division, Paper No. 7, 54 pp.

King, R. 2000. Effects of Single Burn Events on Degraded Oak Savanna. Ecological Restoration 18:228-233.

Knighton, David, 1998. Fluvial Forms and Processes. Rutledge, Chapman, and Hall, Inc. New York, NY.

Lane, E. W., 1955. Design of stable channels. Transactions of the American Society of Civil Engineers. Paper No. 2776. pp. 1234-1279.

Leopold, L. B., M. G. Wolman and J. P. Miller, 1992. Fluvial Processes in Geomorphology. Dover Publications, Inc. New York, NY.

Leopold, L.B., 1994. A View of the River. Harvard University Press, Cambridge, Mass.

Lutz, H. J., 1940. Disturbance of Forest Soil Resulting from the Uprooting of Trees. Yale University School of Forestry Bulletin No. 45.

Mausbach, M.J., J.L. Richardson, 1994. Biogeochemical Processes in Hydric Soil Formation. Current Topics in Wetland Biogeochemistry, Vol. 1, 1994, pp 68-124.

McCandless, T. L., 2003. Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Allegheny Plateau and the Valley and Ridge Hydrologic Regions. US Fish and Wildlife Service, Annapolis, MD.

Mitsch, W.J., and J.G. Gosselink, 2000. Wetlands. John Wiley & Sons, Inc., 920 pp.

Nyman, D.C., 2003. Aquatic habitat enhancements for Mad River and Beaver Pond Brook in conjunction with reconstruction of I-84, Waterbury, Connecticut. Proceedings of the International Conference on Ecology and Transportation, Lake Placid, New York, August, 2003.

North Carolina Department of Environment, Health and Natural Resources. 2000. Water Quality Stream Classifications for Streams in North Carolina. Water Quality Section, July 2000. Raleigh, NC. NCDENR website cited on April 25, 2007 http://h2o.enr.state.nc.us/csu/swc.html.

North Carolina Geological Survey, 1998. Geologic map of North Carolina. http://www.geology.enr.state.nc.us/maps/ncgs_main_maps_page.html#Geological%20and%20Geophysical%20Maps

Reed, Jr., Porter B. 1988. National List of Plant Species That Occur in Wetlands: National Summary. US Fish & Wildlife Service. Biol. Rep. 88 (24). 244 pp.

Rosgen, D. L. 1994. A Classification of Natural Rivers. Catena 22:169-199.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colo.

Rosgen, D.L., 1997. A Geomorphological Approach to Restoration of Incised Rivers. In: Wang, S.S.Y, E.J. Langendoen, and F.D. Shields, Jr. (Eds.). Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. pp. 12-22.

Rosgen, D.L., 1998. The Reference Reach - a Blueprint for Natural Channel Design. Draft Presented at ASCE Conference on River Restoration in Denver Colorado - March, 1998. ASCE. Reston, VA.

Rosgen, D.L., 2001. A stream channel stability assessment methodology. Proceedings of the Federal Interagency Sediment Conference, Reno, NV, March, 2001.

Schafale, M.P. and A.S. Weakley, 1990. Classification of the Natural Communities of North Carolina, Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, NCDEHNR, Raleigh, North Carolina.

Scherrer, E., 2000. Using Microtopography to Restore Wetland Plant Communities in Eastern North Carolina. MS Thesis, Forestry Department, North Carolina State University.

Schumm, S.A., 1960. The Shape of Alluvial Channels in Relation to Sediment Type. US Geological Survey Professional Paper 352-B. U.S. Geological Survey, Washington, DC.

Sharitz, R. R., R. L. Schneider, and L. C. Lee. 1990. Composition and Regeneration of a Disturbed River Floodplain Forest in South Carolina. In Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems, 195-218. J. G. Gosselink, L. C. Lee, and T. A. Muir, eds. Boca Raton, Fla.: Lewis Publishers.

Simon, A., 1989. A Model of Channel Response in Disturbed Alluvial Channels. Earth Surface Processes and Landforms 14(1):11-26.

Skaggs, R. W. 1980. DRAINMOD Reference Report: Methods for Design and Evaluation of Drainage-Water Management Systems for Soils with High Water Tables. US Department of Agriculture, Soil Conservation Service. 329 pp.

Skaggs, R. W., D. Amatya, R. O. Evans, and J. E. Parsons, 1991. Methods for Evaluating Wetland Hydrology. American Society of Agricultural Engineers, St. Joseph, MI. Paper No. 91-2590.

Soar and Thorne, 2001. Channel Restoration Design for Meandering Rivers. US Army Corps of Engineers, Engineering Research and Development Center. Coastal and Hydraulics Laboratory, ERDC\CHL CR-01-1. September, 2001.

Stephens, E. P., 1956. The Uprooting of Trees: a Forest Process. Soil Science Society of America Proceedings 20:113-116.

US Army Corps of Engineers Wetland Research Program (WRP), 1997. Technical Note VN-RS-4.1.

US Army Corps of Engineers Wetland Research Program (WRP), July 2000. Technical Notes ERDC TN-WRAP-00-02.

US Army Corps of Engineers. Environmental Laboratory, 1987. "Corps of Engineers Wetlands Delineation Manual," Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

US Department of Agriculture, Natural Resources Conservation Service (NRCS), 1996. Field Indicators of Hydric Soils in the United States. G.W. Hurt, Whited, P.M., and Pringle, R.F. (eds,). USDA, NRSCS, Forth Worth, TX.

US Department of Agriculture, Natural Resources Conservation Service (NRCS), 2007. Climate Information for Randolph County North Carolina. National Water & Climate Center. Beltsville, Maryland. Website cited on June 14, 2007, http://www.wcc.nrcs.usda.gov/cgibin/climchoice.pl?state=nc&county=37101.

US Department of Agriculture, Natural Resources Conservation Service (NRCS), 1995. Soil Survey of Randolph County, North Carolina. http://soildatamart.nrcs.usda.gov/Manuscripts/NC151/0/randolph.pdf

US Environmental Protection Agency (USEPA). 2005. Watershed Assessment of River Stability and Sediment Supply, v1.0. Available online at http://www.epa.gov/warsss/. Accessed July 12, 2007.

van Beers, W. F. J., 1970. The Auger-Hole Method: a Field Measurement of Hydraulic Conductivity of Soil Below the Water Table. Rev. ed. ILRI Bulletin 1, Wageningen, 32 pp.

Vepraskas, M.J. 1996. Redoximorphic Features for Identifying Aquic Conditions. North Carolina Agricultural Research Service.

Wohl, E.E. 2000. Mountain Rivers. Am. Geophys. Union Press, 320 pp.

Wolman, M.G. and L.B. Leopold., 1956. River Floodplains: Some Observations on their Formation. USGS Professional Paper 282-C. U.S. Geological Survey, Washington, DC.

Exhibits

Appendix A

Mill Creek Project Photolog

Appendix B

Cultural and Natural Resources Correspondence

Appendix C

EDR Transaction Screen Map Report

Appendix D

Wetland Delineation Data and Stream Forms

Appendix E

Existing Conditions Summaries: Cross-Sections, Longitudinal Profiles, and Bed Material Analyses

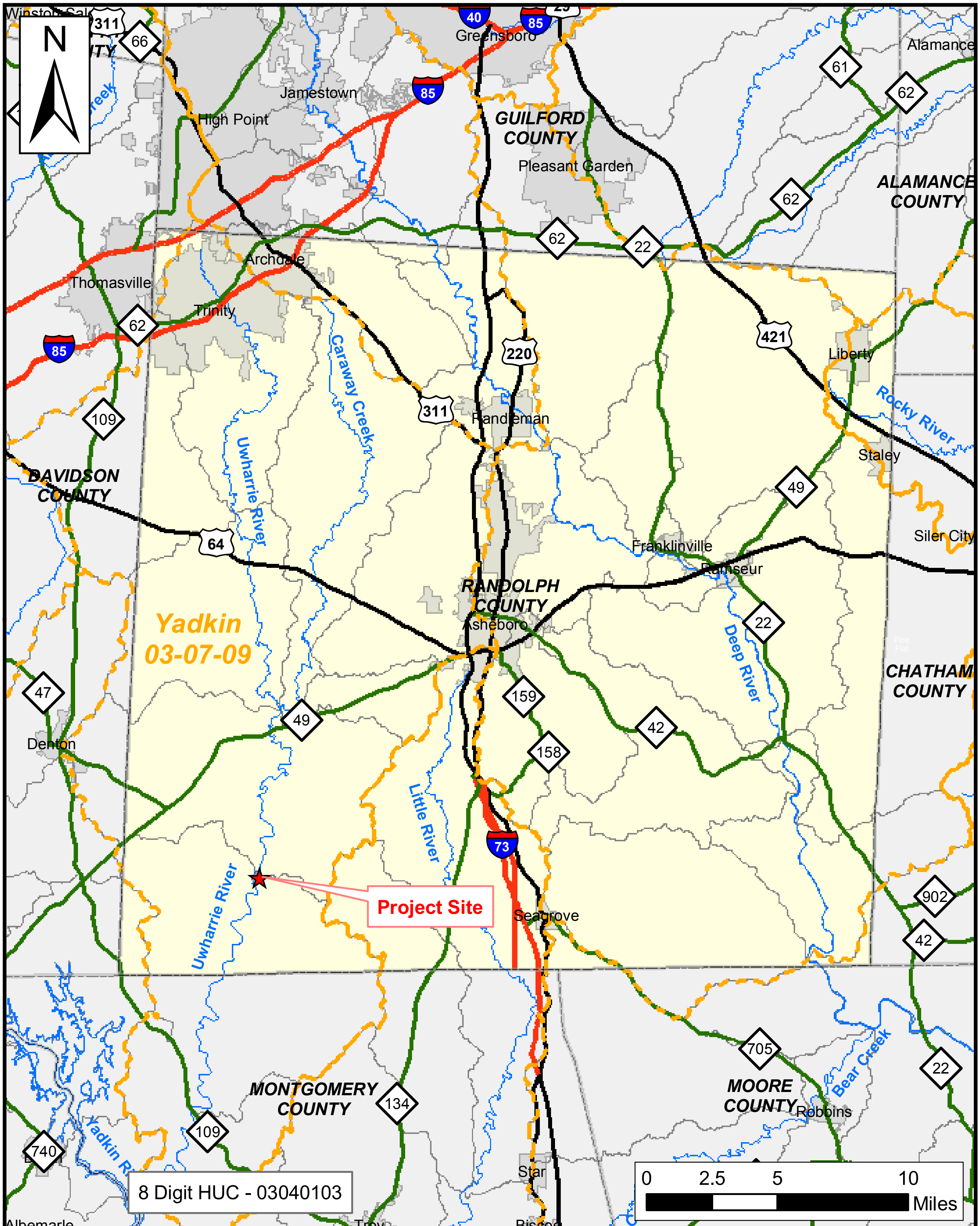
Appendix F

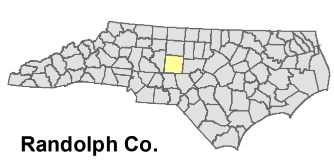
Design Parameters

Appendix G

Reference Reach Conditions Summaries: Cross-Sections, Longitudinal Profiles, Bed Material Analyses, and Photographs

Exhibits





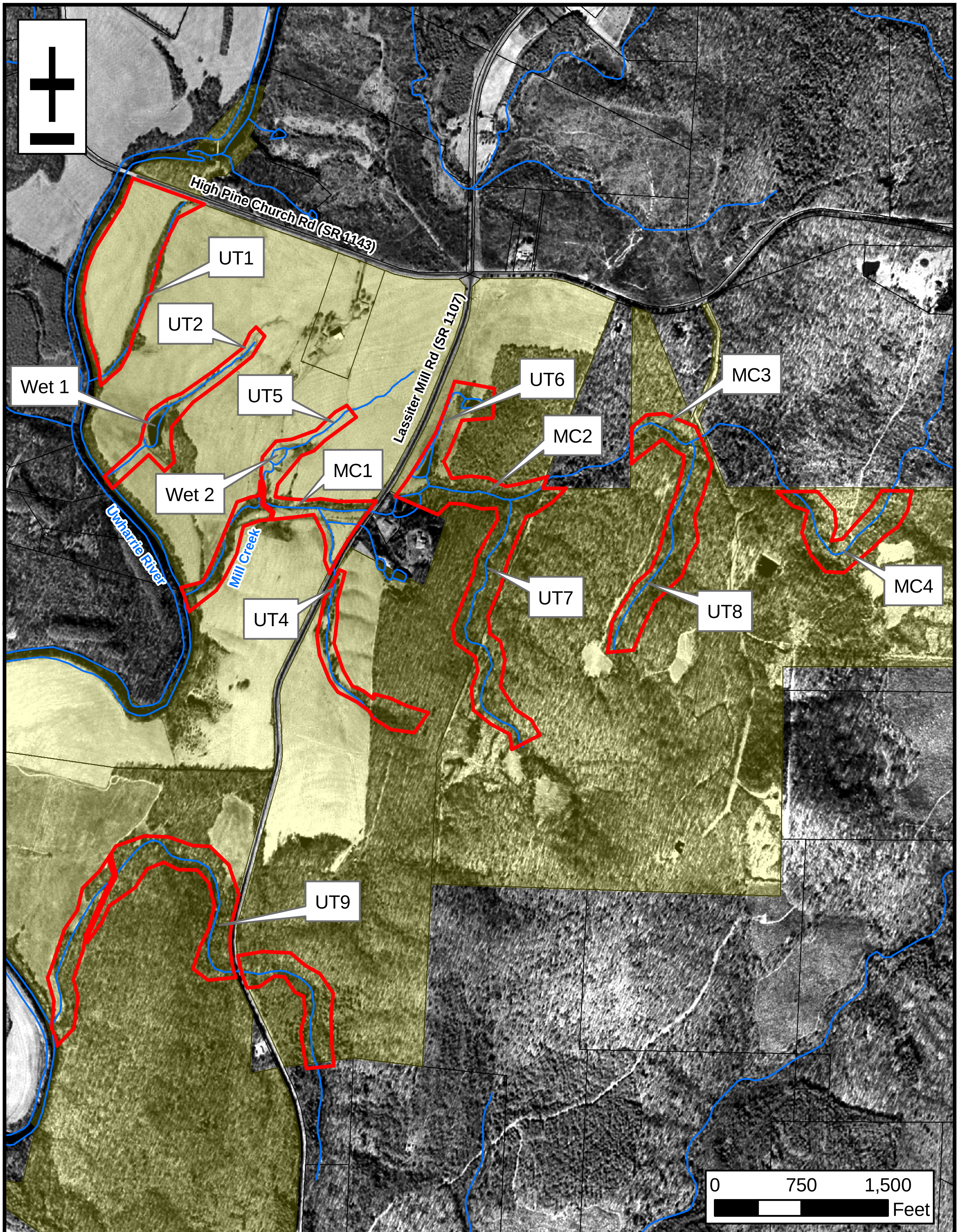
Legend

- County Boundary
- NCDWQ Sub-basin
- USGS Hydrologic Unit

Exhibit 1.1
Project Vicinity Map
Mill Creek Site

Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, North Carolina 27518
Phone: 919.463.5488
Fax: 919.463.5490

Map Prepared: July 23, 2007



Stream Corridor Boundaries/Conservation Easement

Hydro - Rivers/Streams

Project Parcel Boundary

Hydrologic Unit (8 digit) = 03040103

DWQ Sub Basin = 03-07-09

Exhibit 1.2 - Site Location Map
Mill Creek Site

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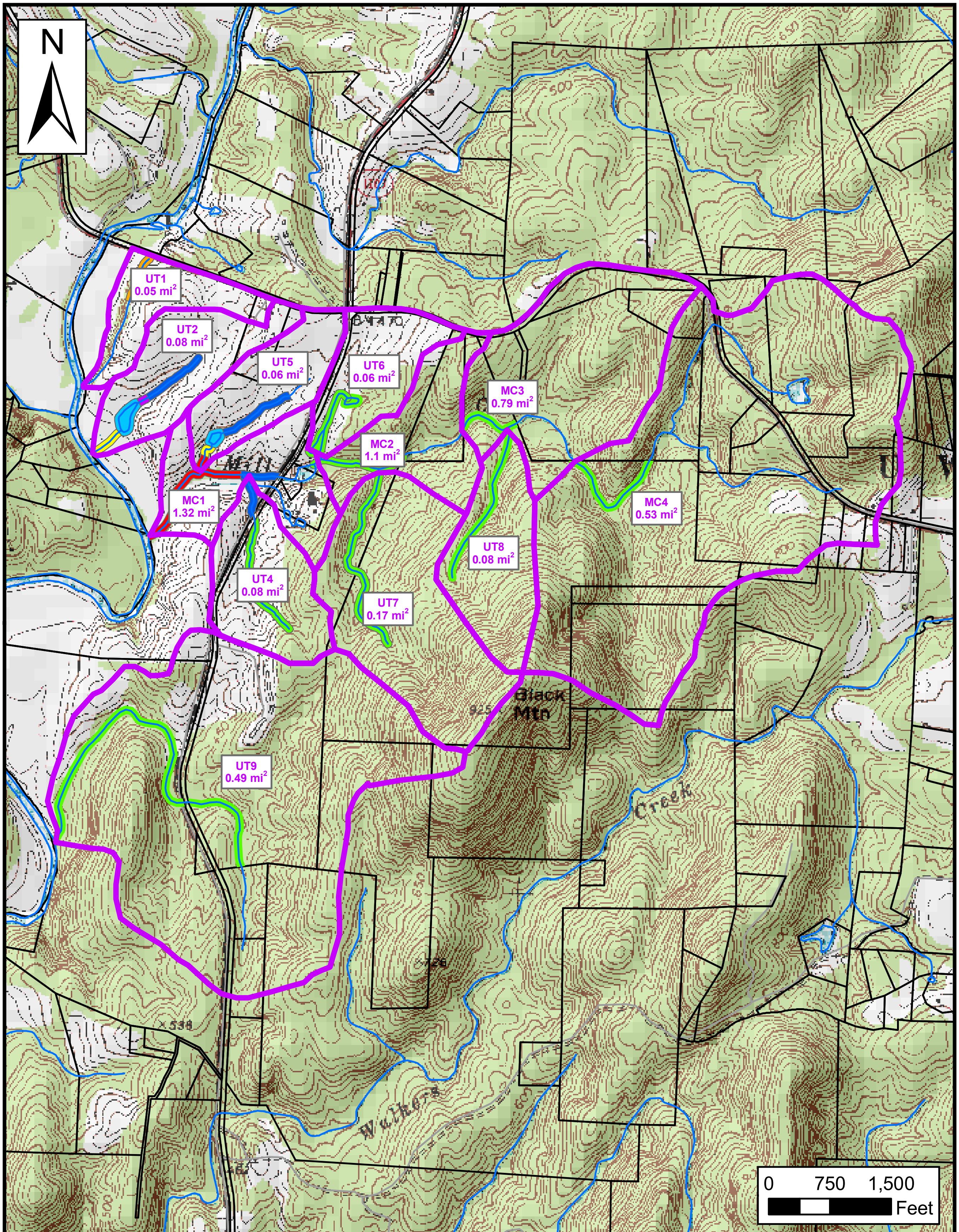
Map Prepared: July 23, 2007; Revised October 17, 2007



Watershed Boundary	Stream Restoration
Riparian Enhancement	Stream Enhancement I
Filling In	Stream Enhancement II
Stream Preservation	Wetland Creation

Ecosystem Enhancement PROGRAM

Exhibit 1.3
Watershed Map
Mill Creek Site

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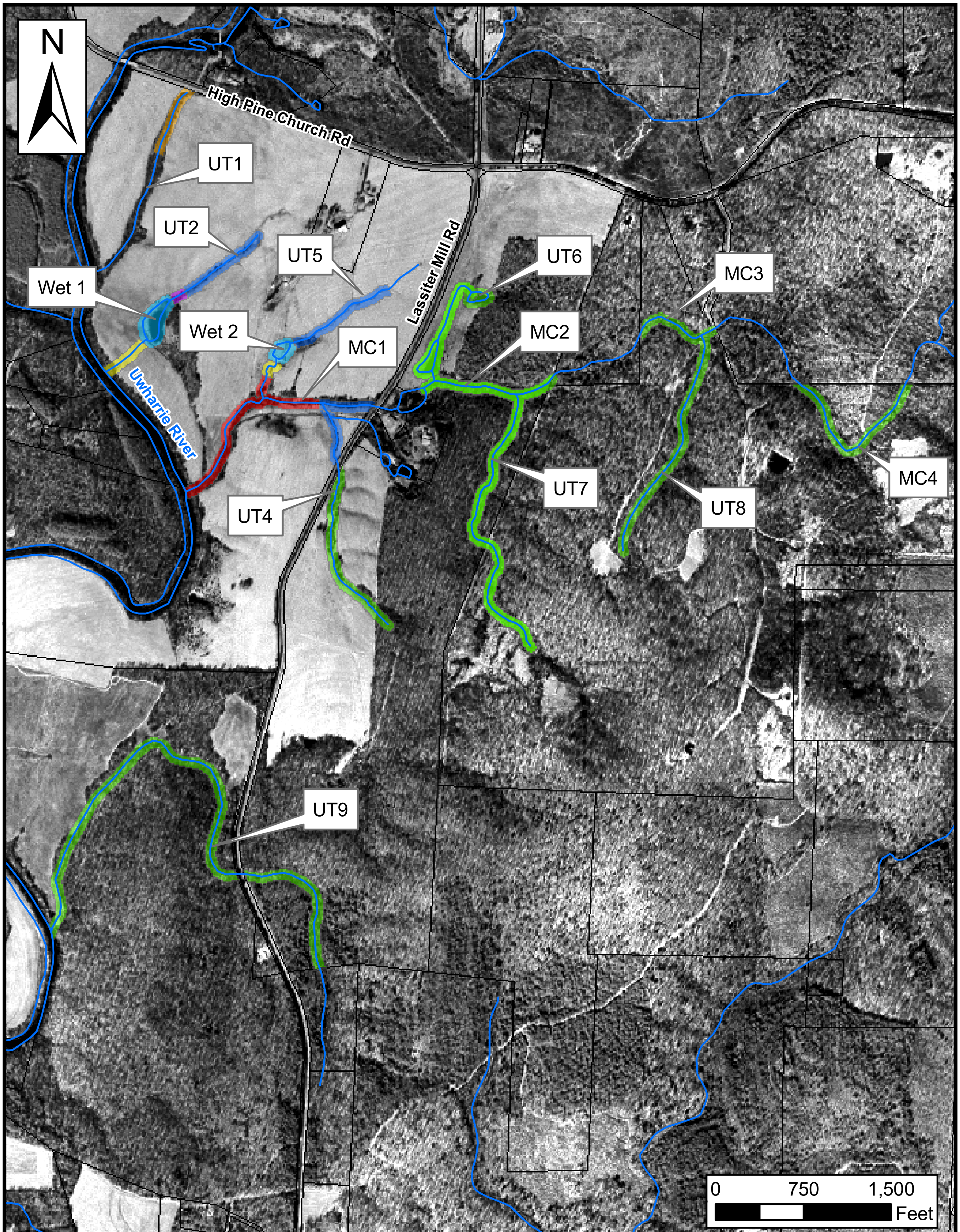
Map Prepared: July 23, 2007



Ecosystem Enhancement PROGRAM

Parcel Boundary	Stream Restoration
Riparian Enhancement	Stream Enhancement I
Filling In	Stream Enhancement II
Stream Preservation	Wetland Creation

Exhibit 1.4 - Proposed Stream and Wetland Approach

Baker

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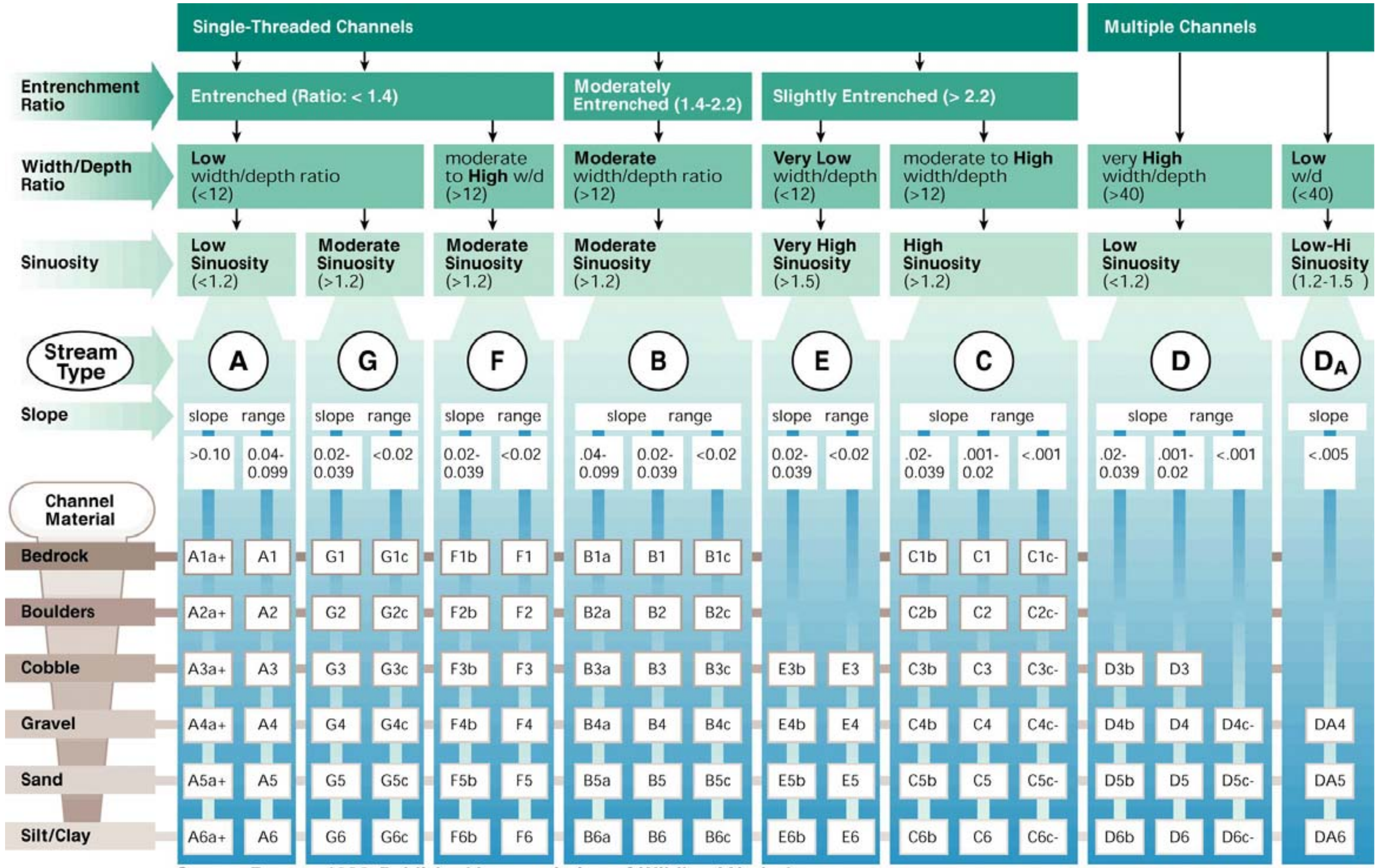
Map Prepared: July 23, 2007

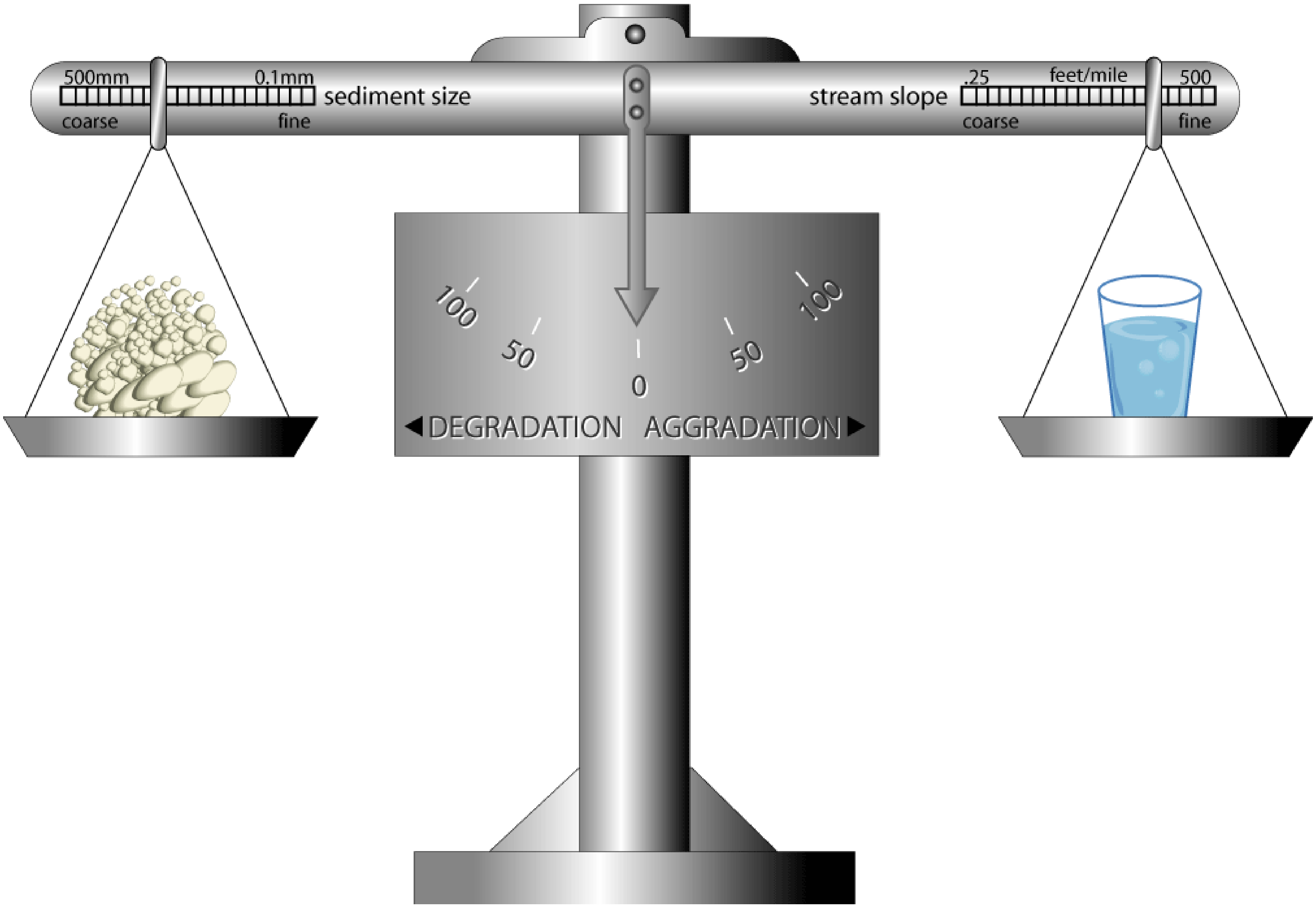


Source: Rosgen 1996. Published by permission of Wildland Hydrology.

Fig. 7.12 -- Rosgen's stream classification system (Level II).
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

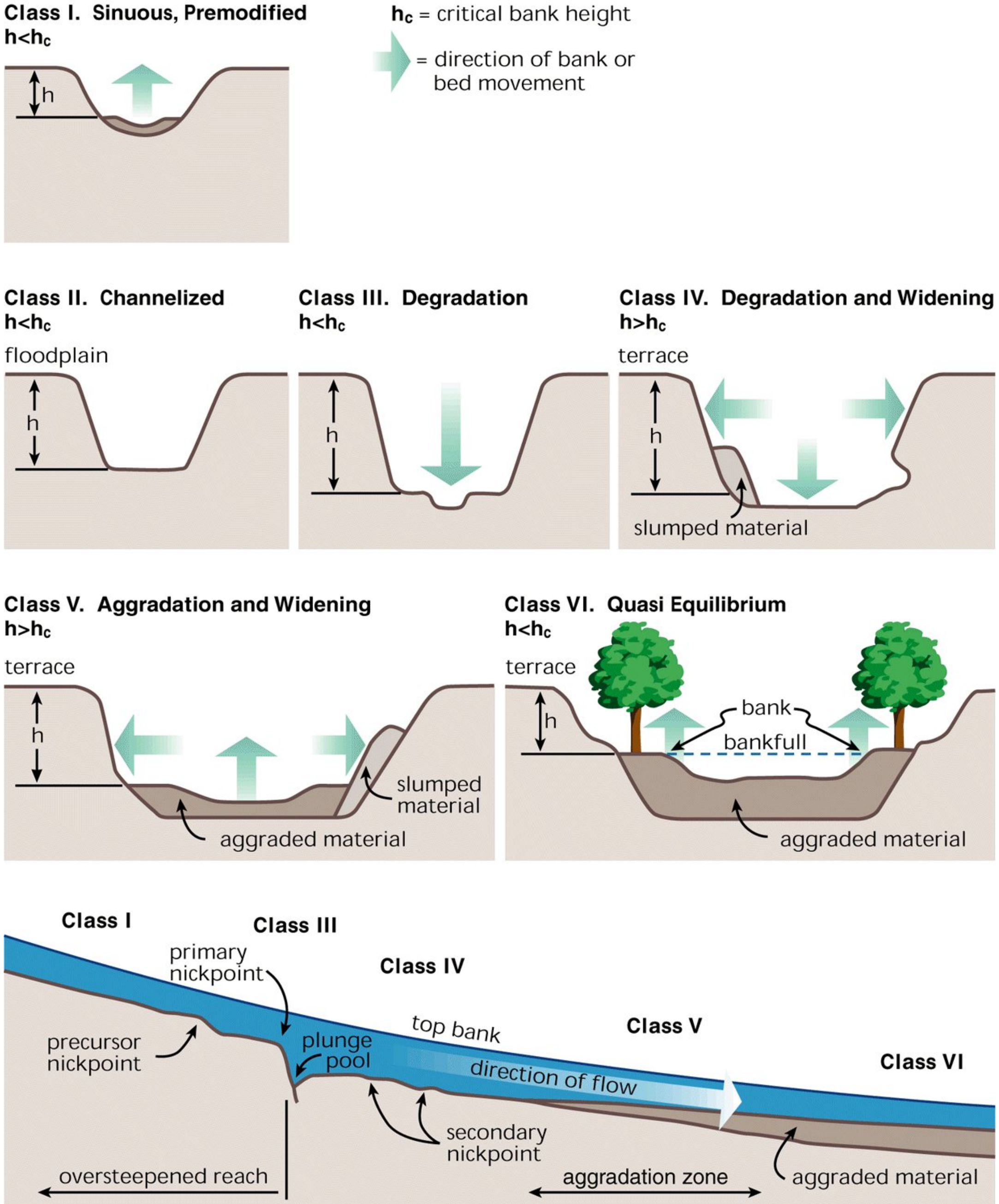
Exhibit 2.1
Rosgen Stream Classification
Mill Creek Restoration Plan

Source: Rosgen, David L., *Applied River Morphology*, Wildland Hydrology, 1996



After: Lane, 1955

Exhibit 2.2
Factors Influencing Stream Stability



Source: Simon, 1989; US Army Corps of Engineers, 1990.
Fig. 7.14 -- Channel evolution model..
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

Exhibit 2.3
Simon Channel Evolution Model

Source: Simon, 1989

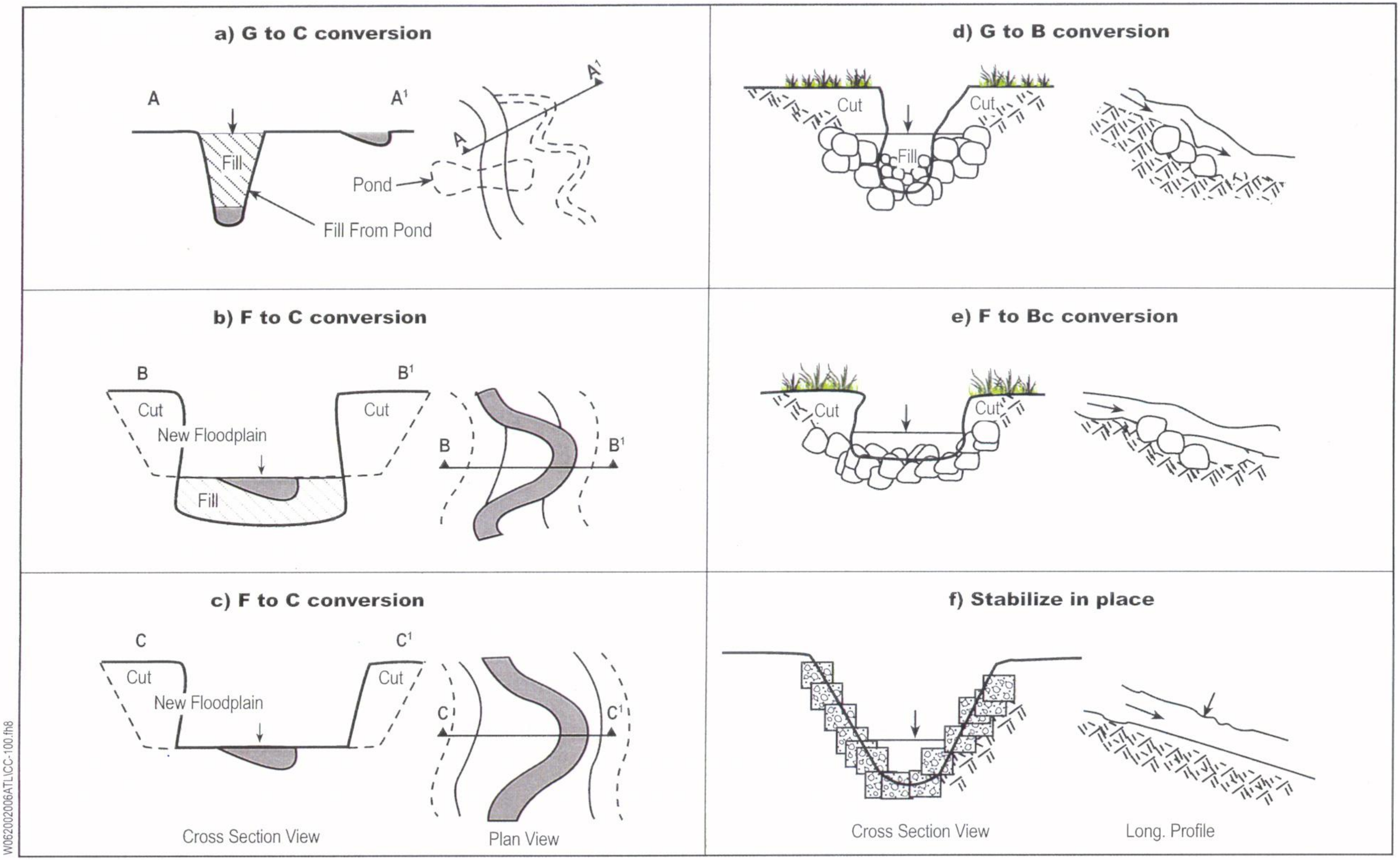
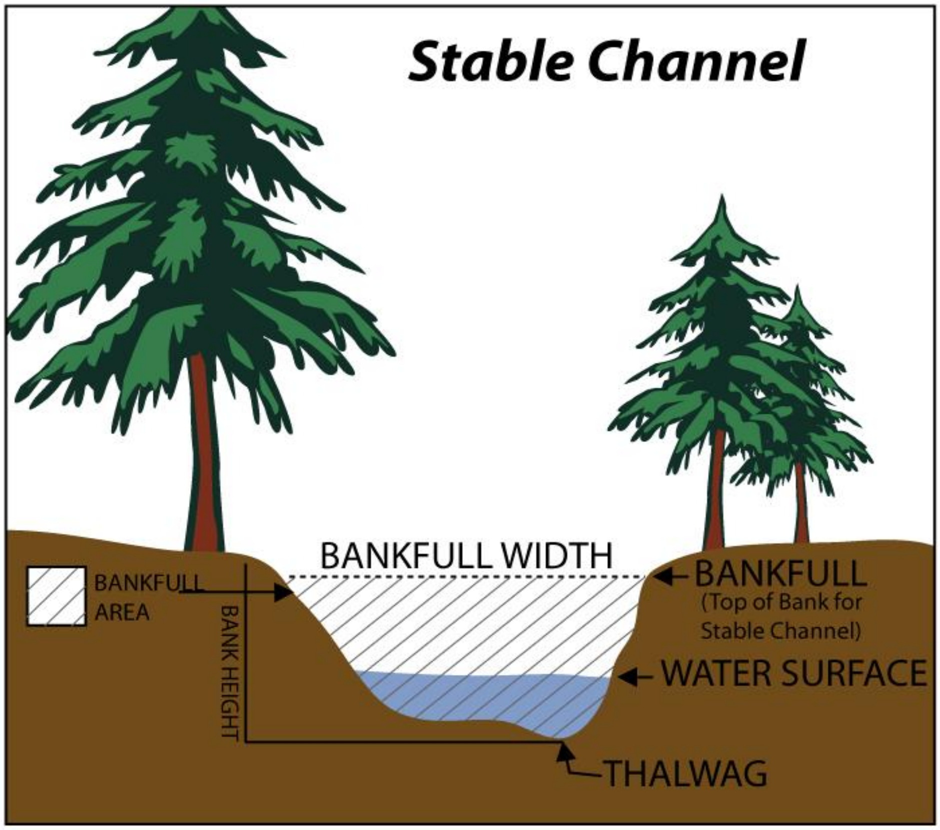
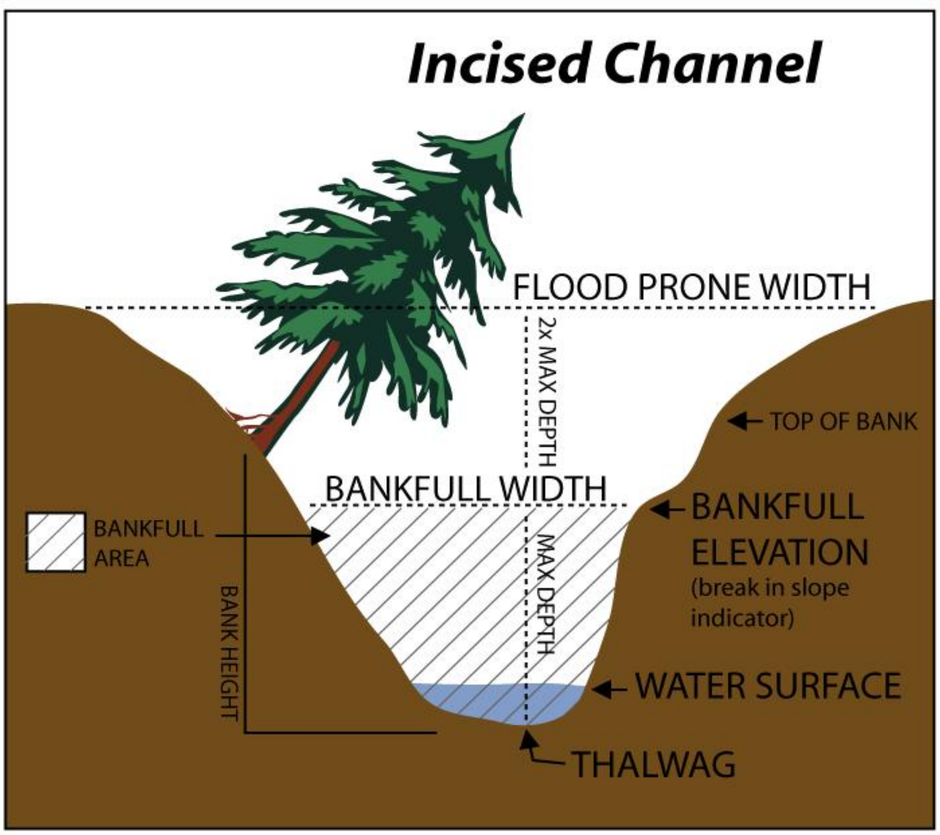


Exhibit 2.4
Restoration Priorities for Incised Channels

Source: Rosgen, David L., "A Geomorphological Approach to Restoration of Incised Rivers," *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*, 1997





Channel Dimension Measurements

Bankfull Elevation is associated with the channel forming discharge. It is the point where channel processes and flood plain processes begin.

Bankfull width: the distance between the left bank bankfull elevation and the right bank bankfull elevation

Bankfull mean depth: the average depth from bankfull elevation to the bottom of the stream channel

Max depth (dmax): the deepest point within the cross-section measured to the bankfull elevation

Width to Depth Ratio: Bankfull width ÷ Bankfull mean depth

Bank Height Ratio: Bank height (measured from top of bank to the bottom of the stream channel) ÷ the max depth of the bankfull elevation (dmax)

Flood Prone Width: Width measured at the elevation of two times (2x) the maximum depth at bankfull (dmax)

Entrenchment Ratio: Floodprone width ÷ bankfull width

Exhibit 2.5
Channel Dimension Measurements

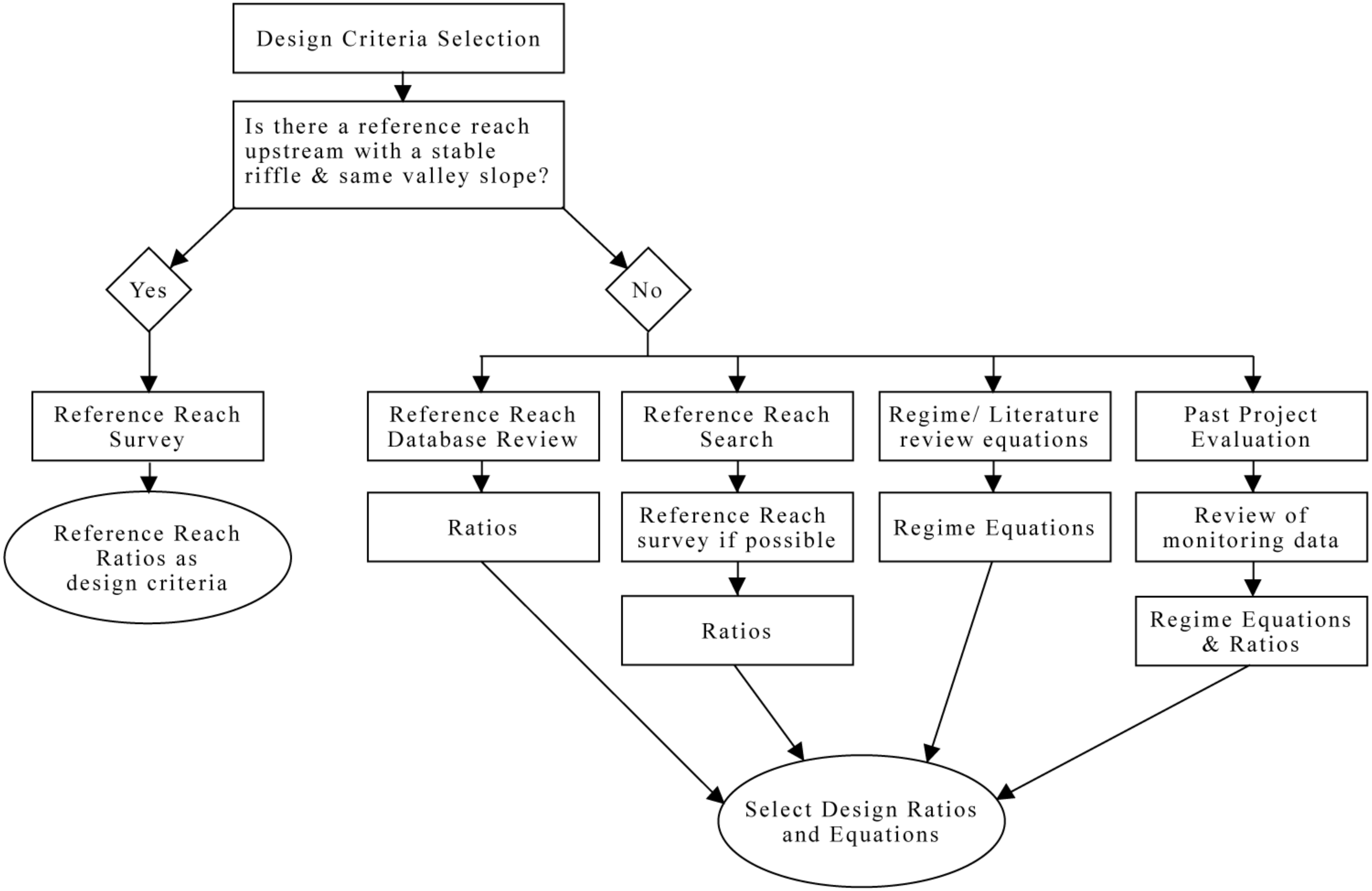
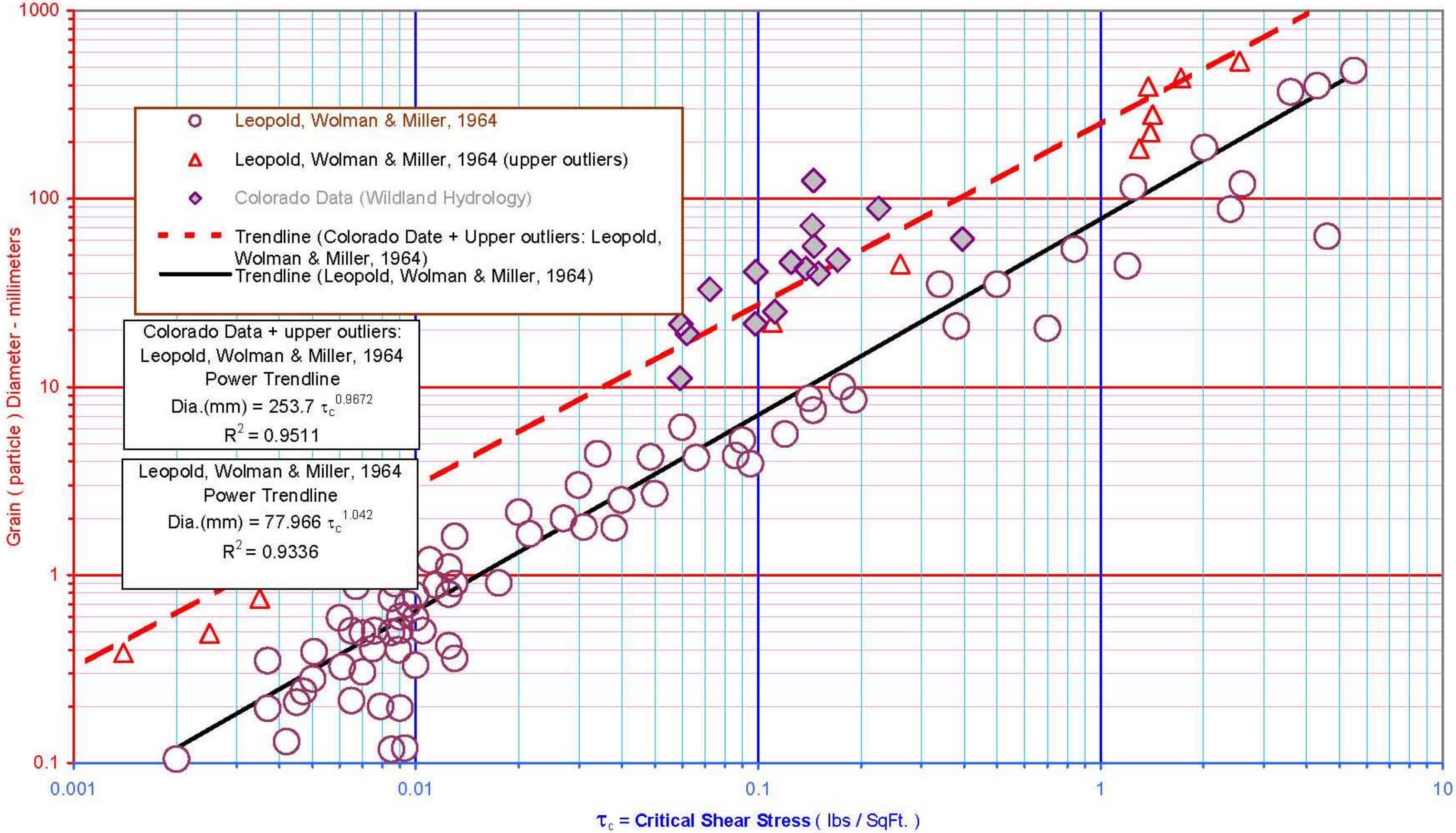


Exhibit 2.6
Design Criteria Selection

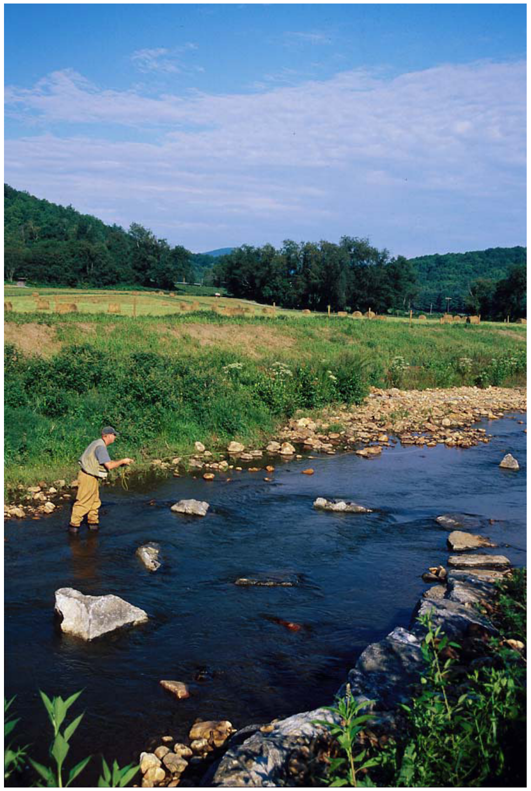


From USEPA Watershed Assessment of River Stability & Sediment Supply (WARSSS) v1.0)

Exhibit 2.7

Modified Shield's Curve

Mill Creek Restoration Plan



J-Hook

Double Wing Deflector

Rock Cross Vane

Rock Vane

Exhibit 2.8
Examples of In-Stream Structures
Mill Creek Restoration Plan

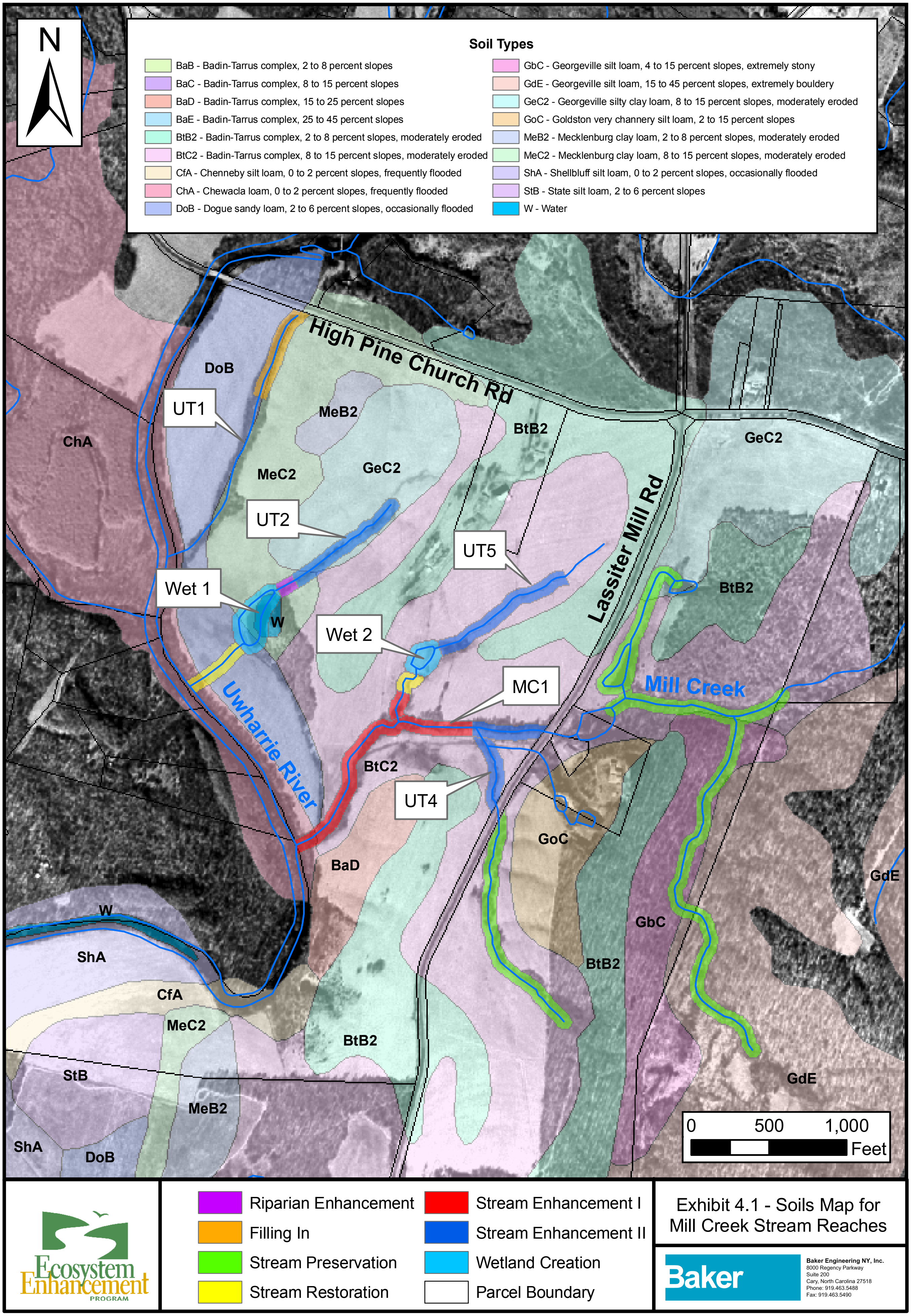
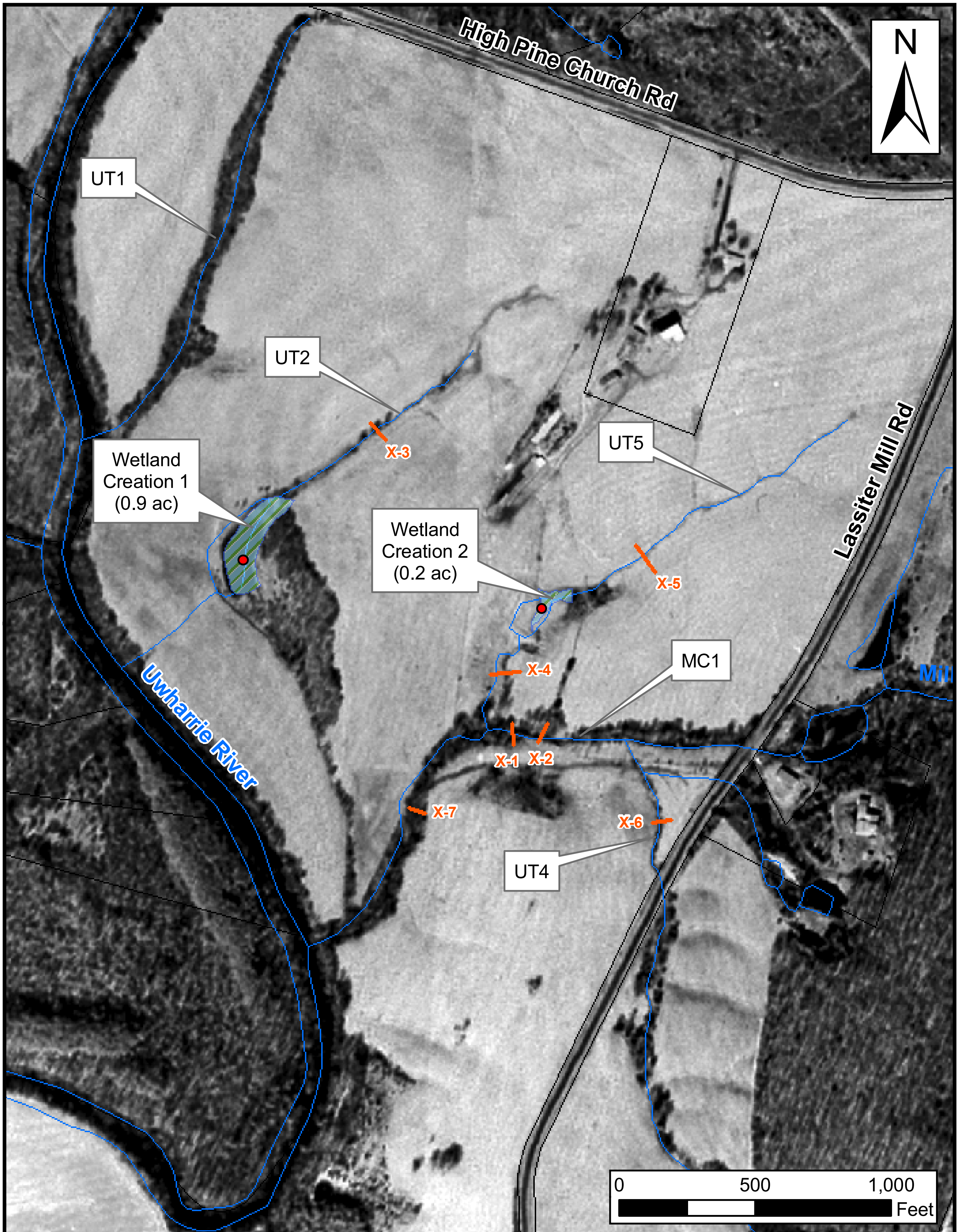


Exhibit 4.1 - Soils Map for Mill Creek Stream Reaches

Map Prepared: July 23, 2007



Parcel Boundary
Wetlands
Hydro - Rivers/Streams
Cross Sections
Monitor Wells

Exhibit 5.1
Site Hydrology & Cross-Sections Map
Mill Creek Site

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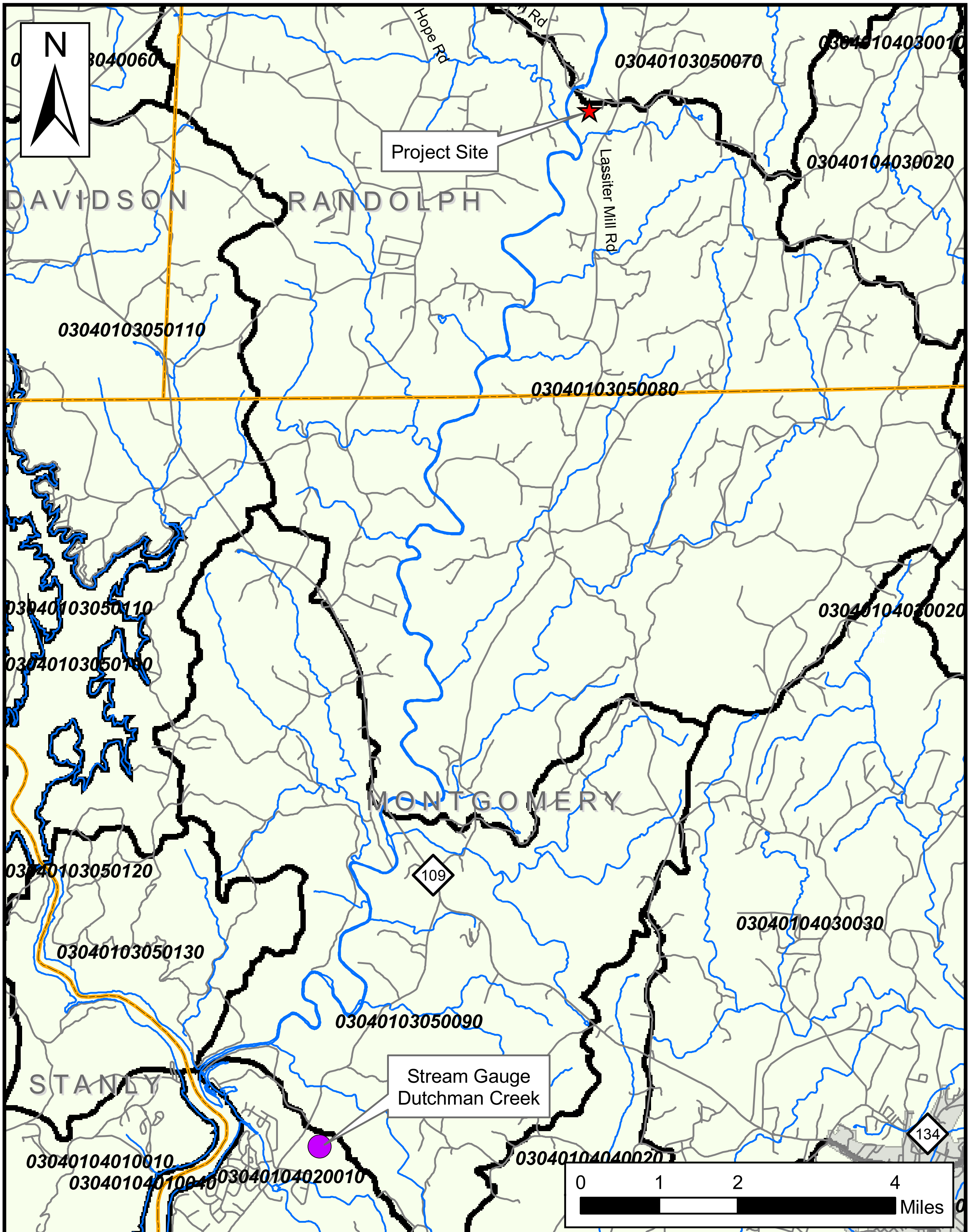
Map Prepared: July 23, 2007



MillCreek Gauge

Mill Creek Location

County Boundary

Hydro - Rivers/Streams (100k)

Road

HUC Boundary (14 digit)

Ecosystem Enhancement PROGRAM

Exhibit 6.2 - USGS Stream Gauge Site
Mill Creek Site

Baker

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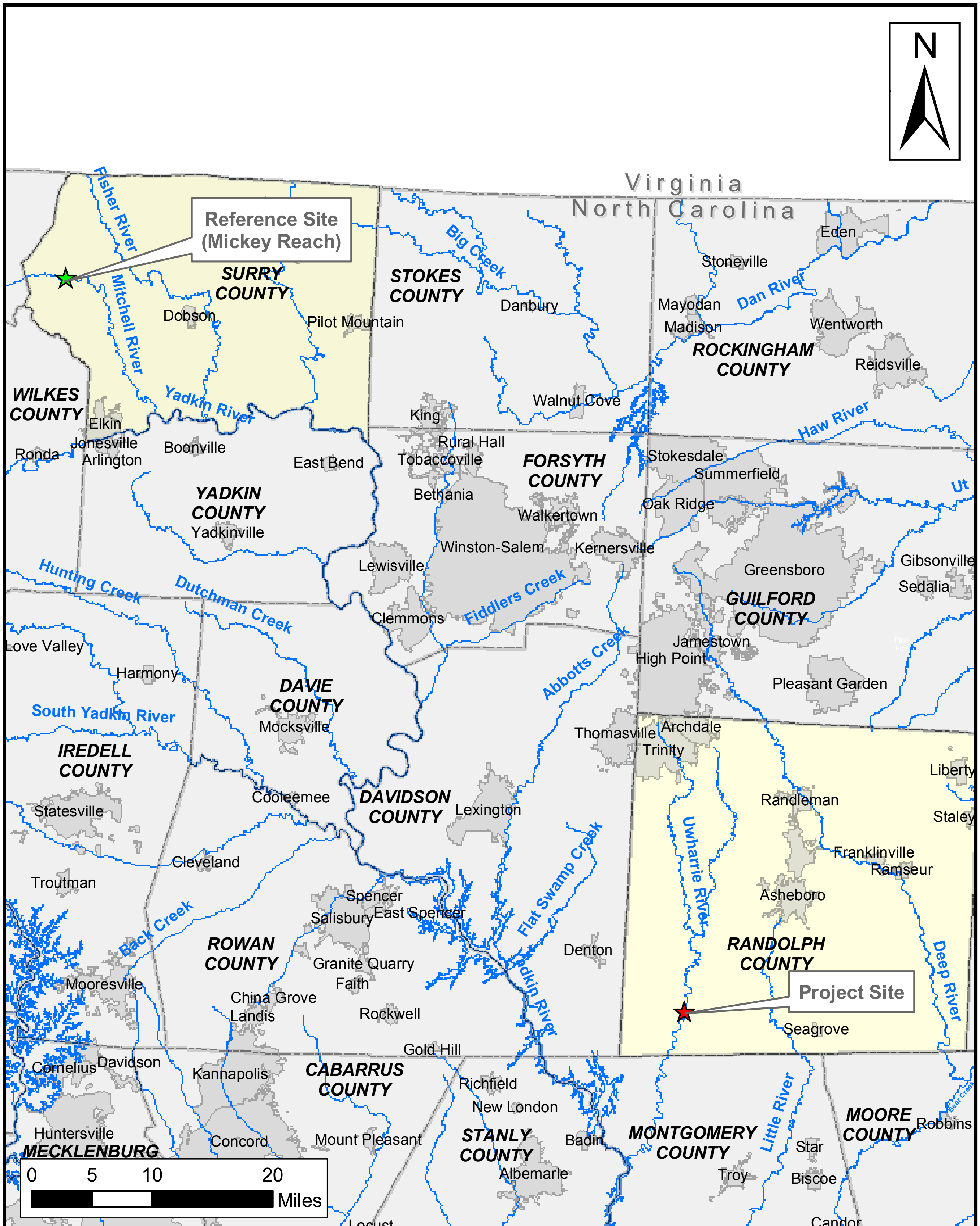
Fax: 919.463.5490

Map Prepared: July 23, 2007



★ Mill Creek Location
★ Reference Site
County Boundary
Major Rivers/Streams
Municipality Boundary

Exhibit 6.3
Stream Reference Site Location
Mill Creek Site

Baker

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Map Prepared: July 23, 2007

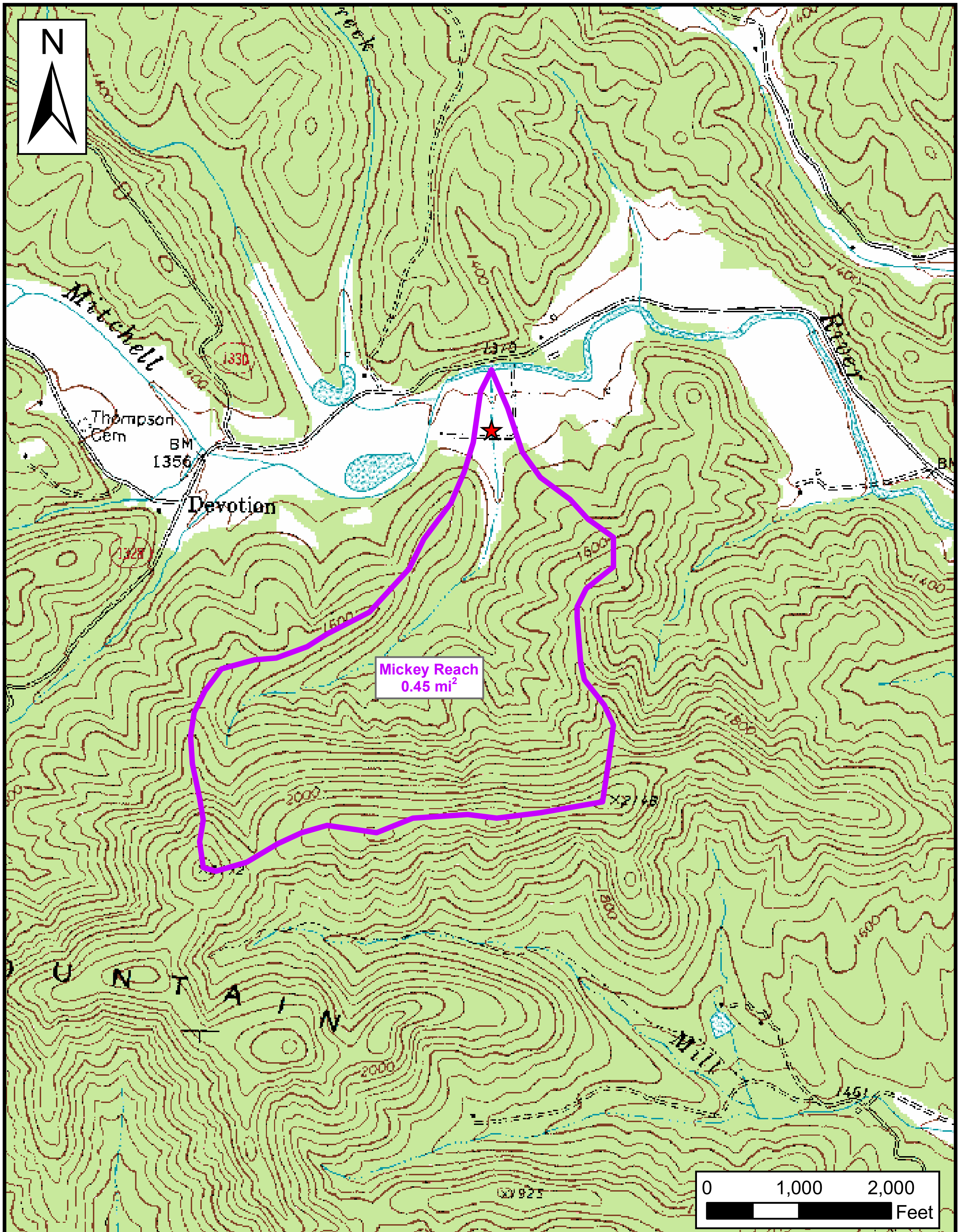

Exhibit 6.4
Reference Site Watershed Map
Mill Creek Site

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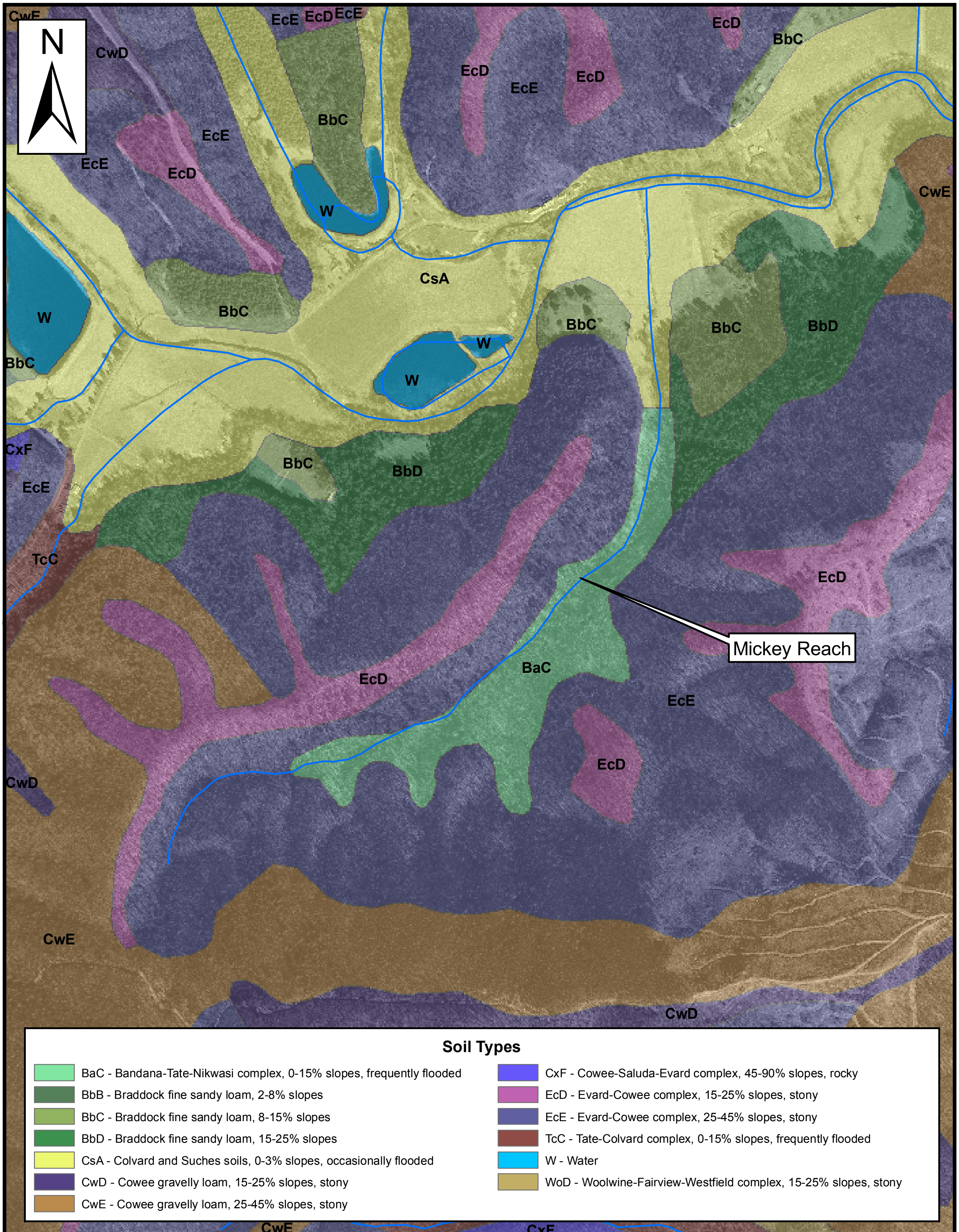
Map Prepared: July 23, 2007



Ecosystem Enhancement PROGRAM

0 1,000 2,000
Feet

Exhibit 6.5
Reference Site Soils Map
Mill Creek Site

Baker
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Map Prepared: July 23, 2007

Appendix A

Mill Creek Photolog

Mill Creek Photo Log

Beginning of the Mill Creek section at Lassiter Mill Road.

Mill Creek downstream of culvert and above UT5 confluence.

Mill Creek at confluence with UT5, view is upstream.

Mill Creek where proposed Ford stream crossing will be located.

Depositional bench forming on Mill Creek.

View upstream of the depositional bench.

Mill Creek, view is upstream.

Mill Creek, view is downstream.

Mill Creek, view is downstream.

View of Mill Creek above confluence with the Uwharrie River, view is downstream.

View of UT1 where the upper 600 feet will be filled in .

Old pond on UT2 that is proposed to be wetland creation.

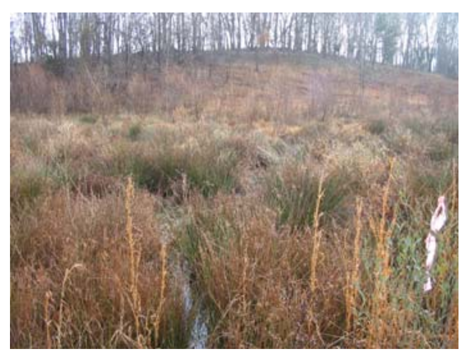
View of area of proposed wetland creation on UT2.

Bank erosion at the breached section of the dam on UT2.

Outflow at the breached section of UT2 , view is upstream.

View of the proposed channel area below the old pond along UT2.

View of the old dam on UT2.



View of the proposed channel area below the old dam.

View of the area where UT2 will tie into the Uwharrie River, view is upstream.

View of the area where UT2 will tie into the Uwharrie River, view is downstream.

Beginning of UT5, view is downstream, proposed preservation.

Proposed wetland creation on UT5, view is dowstream.

Area below the old dam on UT5, view is downstream.

UT5 channel at the old dam below the proposed wetland creation.

Bank erosion below the UT5 dam.

Headcut on UT5 below the old dam, view is downstream.

UT5 channel above the conflunece with Mill Creek, view is upstream.


Outflow at the UT2 wetland dam, view is upstream.


Upper section of UT4, view is downstream.


Middle section of the UT4 channel, view is upstream.


Lower section of the UT4 channel, view is upstream.


Area above UT6 confluence with Mill Creek 2, view is upstream.


Mill Creek 2 channel, view is upstream.


Mill Creek 2 at property boundary, view is upstream.


Mill Creek 3 at driveway culvert, view is upstream.


Mill Creek 3 below culvert, view is downstream.

Mill Creek 3 mid-stream, view is upstream.

Mill Creek 4 upstream of property boundary, view is upstream.

Mill Creek 4 lower end of reach, view is upstream.

Mill Creek 4 at property boundary, view is upstream.

Upper pond at headwaters of UT6, view is east.

UT6 upper pond spillway, view is downstream.

UT6 mid-stream, view is downstream.

Lower pond on UT6, view is downstream.

UT6 lower pond spillway above Mill Creek, view is downstream.

UT7 channel, view is upstream.

UT7 channel mid-stream, view is upstream.

UT7 channel, view is upstream.

UT8 above Mill Creek, view is upstream.

UT8 channel, view is upstream.

UT8 upper end of reach, view is upstream.

UT8 at top of reach, view is upstream.

UT9 east of Lassier Mill Road culvert, view is downstream.

UT9 west of Lassiter Mill Road culvert, view is downstream.

Appendix B

Cultural and Natural Resources Correspondence

gravel, cobble, and boulder substrate, and is known to inhabit pools, riffles, and slow runs. Juveniles are often found in slack water, among mid-stream rock outcrops, and in side channels and pools.

Biological Conclusion: No Effect

While the Cape Fear shiner is found in Randolph County, it is found in the Cape Fear, not the Yadkin/Pee-Dee Basin. No suitable habitat exists for the Cape Fear shiner within the proposed restoration area. Based upon the NHP's database, checked on October 24, 2006, no populations of this species have been reported in the project area. Therefore, the proposed project is not anticipated to result in an adverse impact to this species.

Helianthus schweinitzii **(Schweinitz's sunflower)**
Federal Status: Endangered
Plant Family: Asteraceae
Federally Listed: May 7, 1991

Schweinitz's sunflower, usually 3 to 6 feet tall, is a perennial herb with one to several fuzzy purple stems growing from a cluster of carrot-like tuberous roots. Leaves are 2 to 7 inches long, 0.4 to 0.8 inch wide, lance-shaped, and usually opposite, with upper leaves alternate. Leaves feel like felt on the underside and rough, like sandpaper, on the upper surface. The edges of the leaves tend to curl under. Flowers are yellow composites, and generally smaller than other sunflowers in North America. Flowering and fruiting occur mid-September to frost. This plant grows in clearings and along the edges of upland woods, thickets and pastures. It is also found along roadsides, powerline clearings, old pastures, and woodland openings. It prefers full sunlight or partial shade, but is intolerant of full shade.

Biological Conclusion: No Effect

Potential habitat for Schweinitz's sunflower occurs along roadsides, power line right-of-ways, and field edges throughout the project area. The project study area was evaluated for potential Schweinitz's sunflower habitat and extensive field surveys were performed on October 3, 2006, during the blooming season for the species. No populations were found within the area of potential impact. No populations of this species have been reported in the project area. Therefore, the proposed project is not anticipated to result in an adverse impact to this species.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning this project.

Sincerely,

Ken Gilland

Ken Gilland
Buck Engineering, A Unit of Michael Baker Corporation
8000 Regency Parkway, Suite 200

Baker

Mr. Dale Suiter
US Fish and Wildlife Service
Raleigh Field Office
P.O. Box 33726
Raleigh, NC 27636

11/3/2006

Subject: Effects Concurrence for EEP Wetland and Stream mitigation project in Randolph County.

Dear Mr. Suiter,

The purpose of this letter is to request review and comment on any possible issues that might emerge with respect to threatened and endangered species from a stream restoration project conducted on the subject site. The Mill Creek site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel impacts. Several sections of channel have been identified as significantly degraded. A USGS map showing the approximate property lines and areas of potential ground disturbance is enclosed.

This letter is a follow up to our October 4 correspondence which included a discussion of the endangered species in Randolph County (see Table 1). On October 3, 2006, one of our biologists conducted a site survey for Schweinitz's sunflower. Our biological conclusions and supporting information are summarized below to assist in your evaluation of the site.

Table 1. Federally Protected Species for Randolph

Scientific Name	Common Name	Federal Status	Biological Conclusion
Invertebrates			
Notropis mekistocholas	Cape Fear Shiner	E	No Effect
Vascular Plants			
Helianthus schweinitzii	Schweinitz's Sunflower	E	No Effect

Notes: E – Endangered denotes a species in danger of extinction throughout all or a significant portion of its range.

Notropis mekistocholas (Cape Fear Shiner)
Federal Status: Endangered
Animal Family: Cyprinidae
Federally Listed: September 26, 1987

The Cape Fear shiner is a small minnow, rarely exceeding 2.4 inches in length. It is a pale silvery yellow with a black stripe along each side. The fins are yellow and pointed, the upper lip is black, and the lower lip has a thin black bar along its edge.

Water willow (Justicia americana) beds in flowing areas of creeks and rivers appear to be an essential element of the species' habitat. It is found in clean, rocky streams over

Cary, NC 27511,
Phone: (919) 459-9035,
Email: kgilland@mbakercorp.com

cc:

Kristie Carson
1652 Mail Service Center
Raleigh, NC 27699

Baker

10/4/2006

Ms. Shannon Deaton
North Carolina Wildlife Resource Commission
Division of Inland Fisheries
1721 Mail Service Center
Raleigh, NC 27699

Subject: EEP Wetland and Stream Mitigation Project in Randolph County.

Dear Ms. Deaton,

The purpose of this letter is to request review and comment on any possible issues that might emerge with respect to fish and wildlife issues associated with a potential wetland and stream restoration project on the attached site (USGS site maps with approximate property lines and areas of potential ground disturbance are enclosed).

The Mill Creek site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel and wetland impacts. The project will involve the restoration of Mill Creek and various unnamed tributaries in the Yadkin River Basin, which include sections of channel that are identified as significantly degraded. Project goals include the restoration or enhancement of approximately 6,035 linear feet of stream and enhancement of approximately 1.5 acres of wetlands for the purpose of obtaining stream and wetland mitigation credit in the Yadkin River basin.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland

Ken Gilland
Buck Engineering, A Unit of Michael Baker Corporation
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com

cc:
Kristie Carson
1652 Mail Service Center
Raleigh, NC 27699

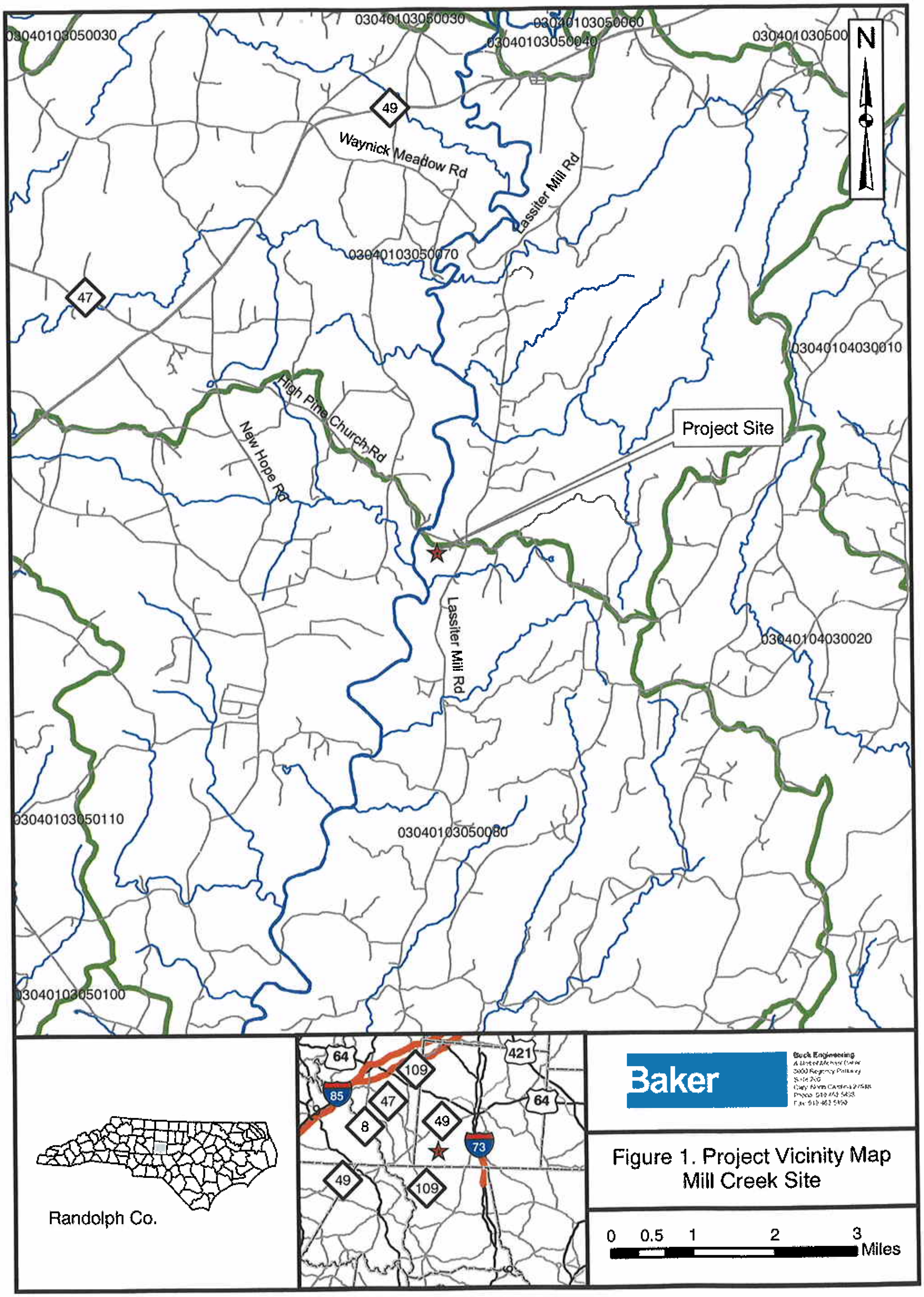
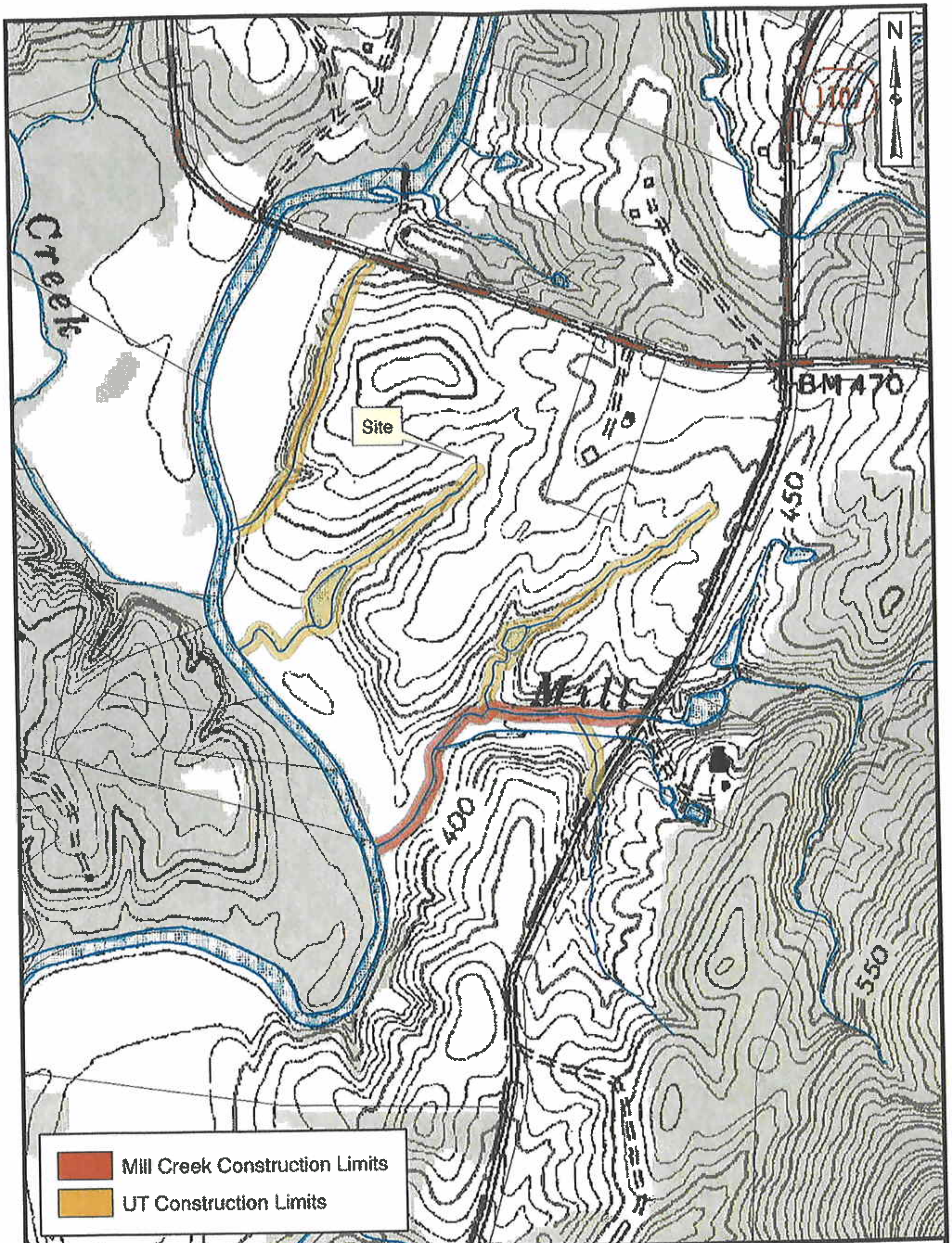


Figure 1. Project Vicinity Map
Mill Creek Site

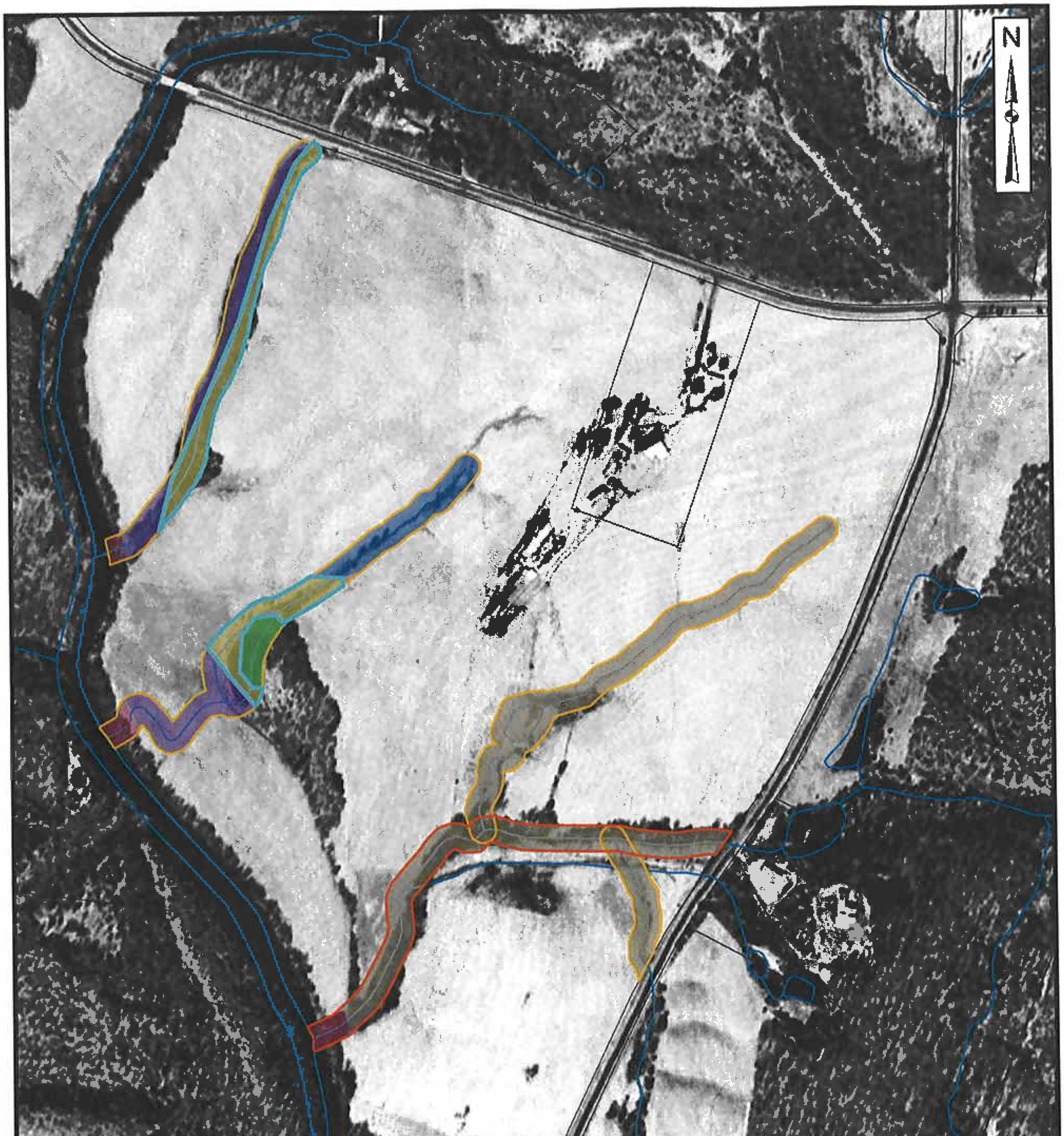


Baker

Buck Engineering

0 250 500 750 1,000 Feet

Construction Limits and Topography Mill Creek Site



Construction Limits Soils

- BtC2 - Badin-Tarrus complex, 8 to 15 percent slopes, moderately eroded (10.31 acres)
- ChA - Chewacla loam, 0 to 2 percent slopes, frequently flooded (.78 acres)
- DoB - Dogue sandy loam, 2 to 6 percent slopes, occasionally flooded (3.75 acres)
- GeC2 - Georgeville silty clay loam, 8 to 15 percent slopes, moderately eroded (1.64 acres)
- MeC2 - Mecklenburg clay loam, 8 to 15 percent slopes, moderately eroded (3.31acres)
- W - Water (0.63 acres)

Baker

Buck Engineering

0 250 500 750 Feet

Construction Limits and Soils
Mill Creek Site

North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

26 October 2006

Mr. Ken Gilland
Buck Engineering, A Unit of Michael Baker Corporation
8000 Regency Parkway, Suite 200
Cary, NC 27511

Subject: Mill Creek Wetland and Stream Mitigation Project, Randolph County, North Carolina.

Dear Mr. Gilland:

Biologists with the North Carolina Wildlife Resources Commission have reviewed the subject information. Our comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) and North Carolina General Statutes (G.S. 113-131 et seq.).

The North Carolina Ecosystem Enhancement Program proposes to restore approximately 6,035 linear feet of Mill Creek and several unnamed tributaries in the Yadkin-Pee Dee River basin and 1.5 acres of wetlands. Several sections of channel have been identified as significantly degraded. Specific details regarding the proposed stream and wetland restoration project were not included.

There are records for the federal species of concern and state endangered Carolina creekshell (*Villosa vaughaniana*) and Atlantic pigtoe (*Fusconaia masoni*); the state threatened Roanoke slabshell (*Elliptio roanokensis*); and state special concern notched rainbow (*Villosa constricta*) in the Uwharrie River downstream of the project site.

Stream and wetland restoration projects often improve water quality and aquatic habitat. We recommend establishing native, forested buffers in riparian areas to protect water quality and aquatic habitat and to improve terrestrial habitat and provide a travel corridor for wildlife species. Provided measures are taken to minimize erosion and sedimentation from construction/restoration activities, we do not anticipate the project to result in significant adverse impacts to aquatic and terrestrial wildlife resources.

Thank you for the opportunity to review this project. If you require further assistance, please contact our office at (336) 449-7625.

Sincerely,

Shari L Bryant

Shari L. Bryant
Piedmont Region Coordinator
Habitat Conservation Program

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

Baker

Renee Gledhill-Earley
State Historic Preservation Office
4617 Mail Service Center
Raleigh, NC 27699-4617

10/4/2006

Subject: EEP Wetland and Stream mitigation project in Randolph County.

Dear Ms. Gledhill-Earley,

The Ecosystem Enhancement Program (EEP) requests review and comment on any possible issues that might emerge with respect to archaeological or cultural resources associated with a potential wetland and stream restoration project on the attached site (USGS site maps with approximate property lines, areas of potential ground disturbance, and locations of and photographs of structures (if applicable) are enclosed).

The Mill Creek site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel and wetland impacts. The project will involve the restoration of Mill Creek and various unnamed tributaries in the Yadkin River Basin, which include sections of channel that are identified as significantly degraded. Project goals include the restoration or enhancement of approximately 6,035 linear feet of stream and enhancement of approximately 1.5 acres of wetlands for the purpose of obtaining stream and wetland mitigation credit in the Yadkin River basin.

No architectural structures or archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. In addition, the majority of the site has historically been disturbed due to agricultural purposes such as tilling. As the enclosed aerial photograph shows, the majority of the area within the construction limits of the site consists of farmland or straightened stream channel.

We ask that you review this site based on the attached information to determine the presence of any historic properties. Thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland
Buck Engineering, A Unit of Michael Baker Corporation
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com
cc:
Kristie Carson
1652 Mail Service Center
Raleigh, NC 27699

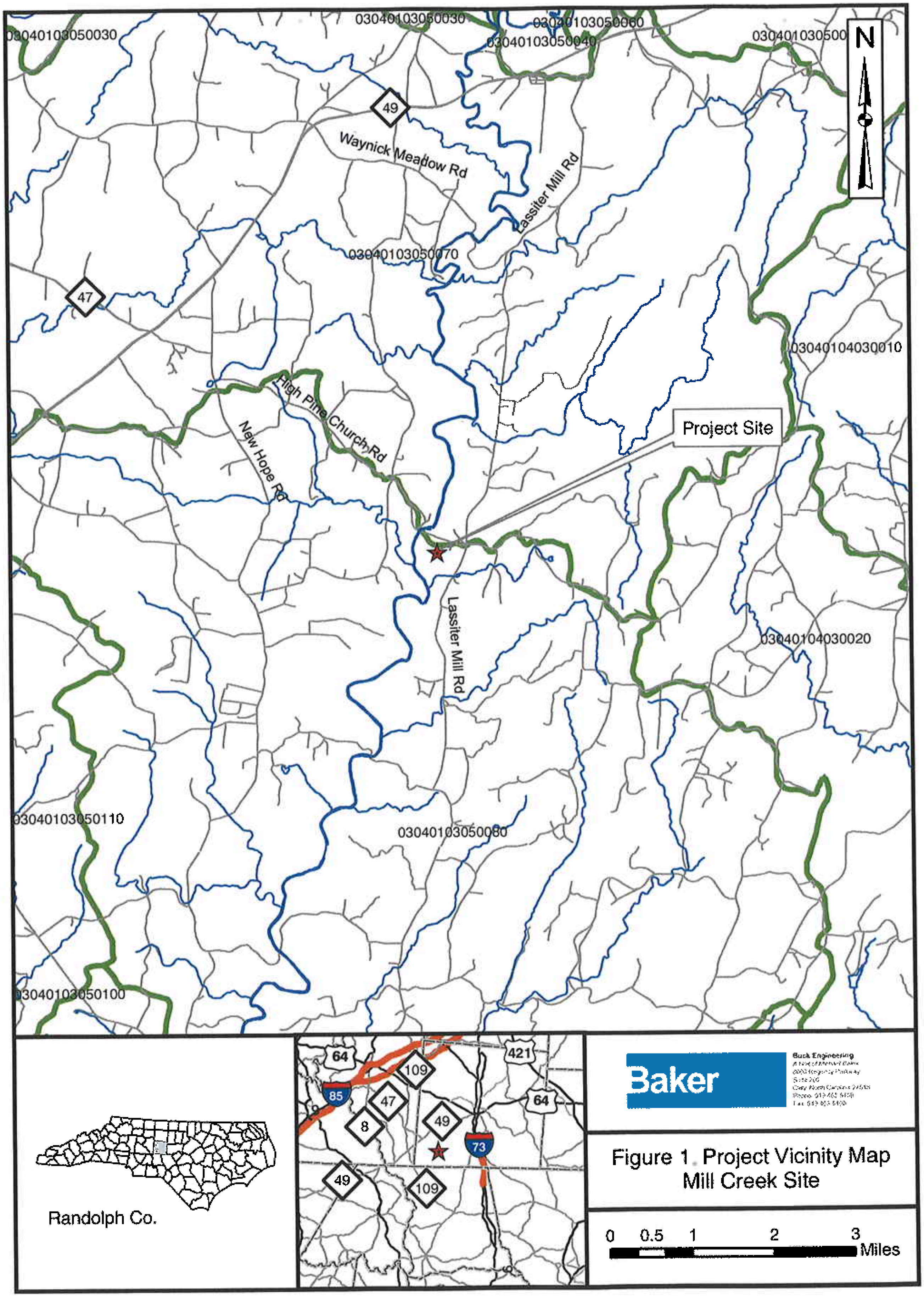
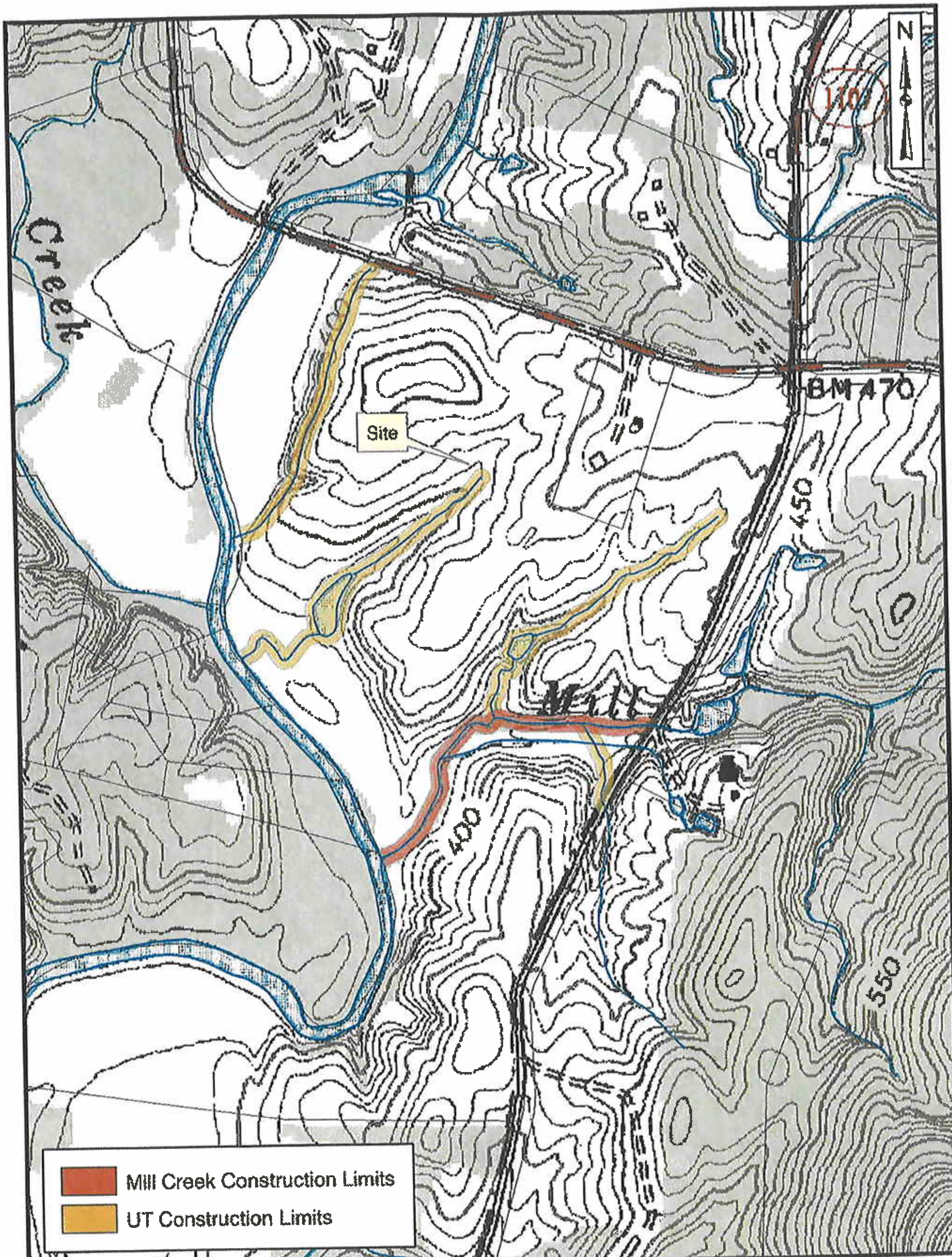


Figure 1. Project Vicinity Map
Mill Creek Site

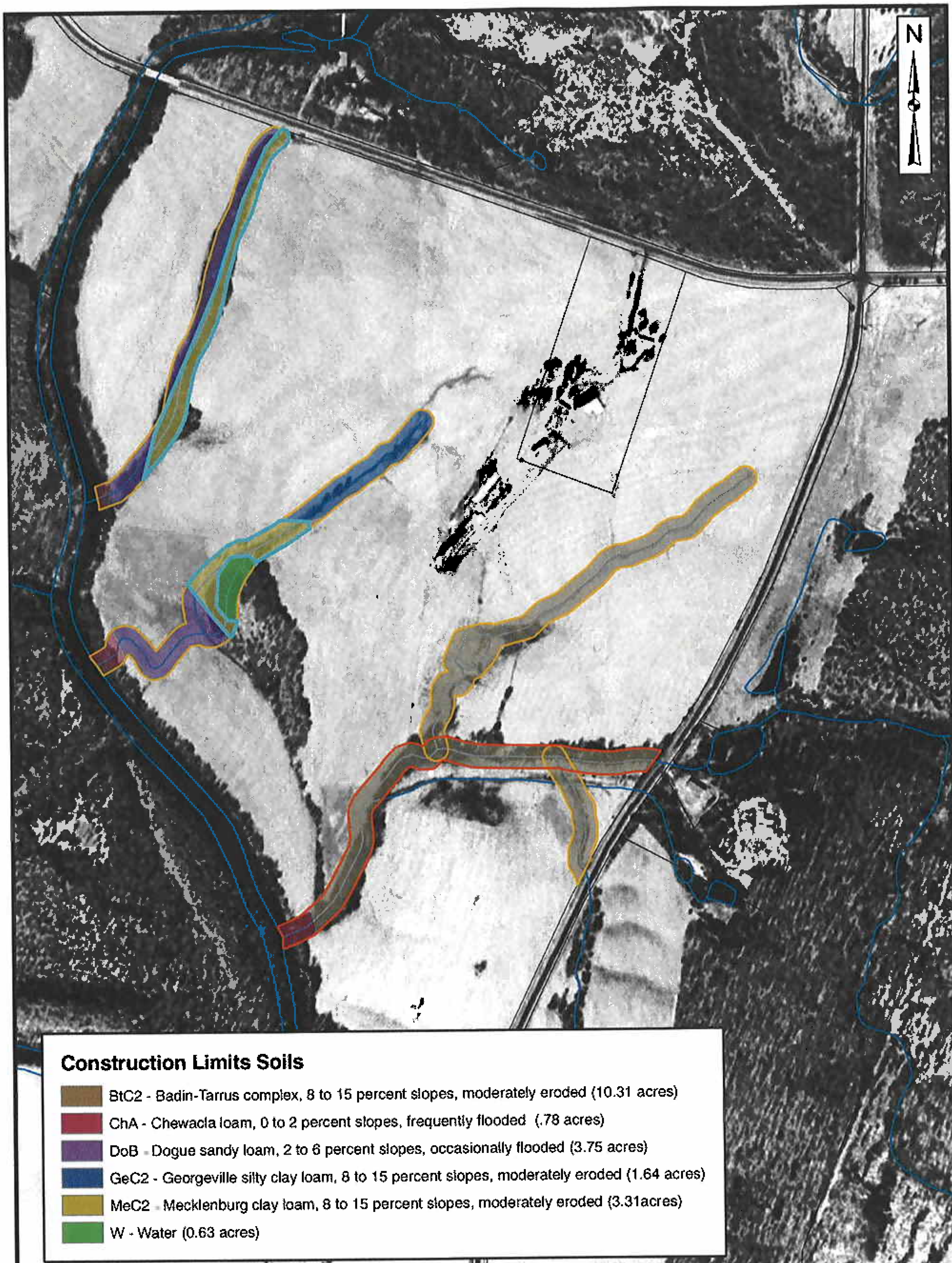


Baker

Buck Engineering

0 250 500 750 1,000 Feet

Construction Limits and Topography
Mill Creek Site



Baker Buck Engineering	0 250 500 750 Feet	Construction Limits and Soils Mill Creek Site

North Carolina Department of Cultural Resources

State Historic Preservation Office

Peter B. Sandbeck, Administrator

Michael F. Easley, Governor
Lisbeth C. Evans, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

November 2, 2006

Ken Gilland
Buck Engineering
8000 Regency Parkway, Suite 200
Cary, NC 27511

Re: EEP, Wetland and Stream Restoration, Mill Creek Site, Randolph County, ER 06-2622

Dear Mr. Gilland:

Thank you for your letter of October 4, 2006, concerning the above project.

We have conducted a review of the proposed undertaking and are aware of no historic resources that would be affected by the project. Therefore, we have no comment on the undertaking as proposed.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, contact Renee Gledhill-Earley, environmental review coordinator, at 919/733-4763, ext. 246. In all future communication concerning this project, please cite the above referenced tracking number.

Sincerely,

Peter B. Sandbeck

Peter Sandbeck by MPM

Categorical Exclusion Form for Ecosystem Enhancement Program Projects

Part 1: General Project Information	
Project Name:	Mill Creek Stream Restoration Project
County Name:	Randolph County
EEP Number:	D07010S
Project Sponsor:	Buck Engineering, A Unit of Michael Baker
Project Contact Name:	Ken Gilland
Project Contact Address:	8000 Regency Parkway, Suite 200
Project Contact E-mail:	kgilland@mbakercorp.com
EEP Project Manager:	Kristie Corson

Project Description

The Mill Creek project site is located approximately 3.6 miles north of the Montgomery County-Randolph County line, within cataloging unit 03040103 and NC Division of Water Quality (NCDWQ) sub-basin 03-07-09 of the Yadkin River Basin.

The site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel and wetland impacts. The project will involve the restoration of Mill Creek and various unnamed tributaries in the Yadkin River Basin, which include sections of channel that are identified as significantly degraded. Project goals include the restoration or enhancement of approximately 6,035 linear feet of stream and enhancement of approximately 1.1 acres of wetlands for the purpose of obtaining stream and wetland mitigation credit in the Yadkin River basin.

For Official Use Only

Reviewed By:

1-5-07 — Kristie F. Corson

Date — **EEP Project Manager**

Conditional Approved By:

Date — **For Division Administrator FHWA**

☐ **Check this box if there are outstanding issues**

Final Approval By:

1-5-07 — Donald [illegible]

Date — **For Division Administrator FHWA**

Part 2: All Projects Regulation Question	Response
Coastal Zone Management Act (CZMA)	
1. Is the project located in a CAMA county?	☐ Yes ☑ No
2. Does the project involve ground-disturbing activities within a CAMA Area of Environmental Concern (AEC)?	☐ Yes ☐ No ☐ N/A
3. Has a CAMA permit been secured?	☐ Yes ☐ No ☐ N/A
4. Has NCDCM agreed that the project is consistent with the NC Coastal Management Program?	☐ Yes ☐ No ☐ N/A
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)	
1. Is this a "full-delivery" project?	☐ Yes ☑ No
2. Has the zoning/land use of the subject property and adjacent properties ever been designated as commercial or industrial?	☐ Yes ☐ No ☐ N/A
3. As a result of a limited Phase I Site Assessment, are there known or potential hazardous waste sites within or adjacent to the project area?	☐ Yes ☐ No ☐ N/A
4. As a result of a Phase I Site Assessment, are there known or potential hazardous waste sites within or adjacent to the project area?	☐ Yes ☐ No ☐ N/A
5. As a result of a Phase II Site Assessment, are there known or potential hazardous waste sites within the project area?	☐ Yes ☐ No ☐ N/A
6. Is there an approved hazardous mitigation plan?	☐ Yes ☐ No ☐ N/A
National Historic Preservation Act (Section 106)	
1. Are there properties listed on, or eligible for listing on, the National Register of Historic Places in the project area?	☐ Yes ☑ No
2. Does the project affect such properties and does the SHPO/THPO concur?	☐ Yes ☐ No ☐ N/A
3. If the effects are adverse, have they been resolved?	☐ Yes ☐ No ☐ N/A
Uniform Relocation Assistance and Real Property Acquisition Policies Act (Uniform Act)	
1. Is this a "full-delivery" project?	☐ Yes ☑ No
2. Does the project require the acquisition of real estate?	☐ Yes ☐ No ☐ N/A
3. Was the property acquisition completed prior to the intent to use federal funds?	☐ Yes ☐ No ☐ N/A
4. Has the owner of the property been informed: * prior to making an offer that the agency does not have condemnation authority; and * what the fair market value is believed to be?	☐ Yes ☐ No ☐ N/A

Part 3: Ground-Disturbing Activities Regulation Question	Response
American Indian Religious Freedom Act (AIRFA)	
1. Is the project located in a county claimed as "territory" by the Eastern Band of Cherokee Indians?	☐ Yes ☑ No
2. Is the site of religious importance to American Indians?	☐ Yes ☐ No ☐ N/A
3. Is the project listed on, or eligible for listing on, the National Register of Historic Places?	☐ Yes ☐ No ☐ N/A
4. Have the effects of the project on this site been considered?	☐ Yes ☐ No ☐ N/A
Antiquities Act (AA)	
1. Is the project located on Federal lands?	☐ Yes ☑ No
2. Will there be loss or destruction of historic or prehistoric ruins, monuments or objects of antiquity?	☐ Yes ☐ No ☐ N/A
3. Will a permit from the appropriate Federal agency be required?	☐ Yes ☐ No ☐ N/A
4. Has a permit been obtained?	☐ Yes ☐ No ☐ N/A
Archaeological Resources Protection Act (ARPA)	
1. Is the project located on federal or Indian lands (reservation)?	☐ Yes ☑ No
2. Will there be a loss or destruction of archaeological resources?	☐ Yes ☐ No ☐ N/A
3. Will a permit from the appropriate Federal agency be required?	☐ Yes ☐ No ☐ N/A
4. Has a permit been obtained?	☐ Yes ☐ No ☐ N/A
Endangered Species Act (ESA)	
1. Are federal Threatened and Endangered species and/or Designated Critical Habitat listed for the county?	☑ Yes ☐ No
2. Is Designated Critical Habitat or suitable habitat present for listed species?	☐ Yes ☑ No ☐ N/A
3. Are T&E species present or is the project being conducted in Designated Critical Habitat?	☐ Yes ☐ No ☐ N/A
4. Is the project "likely to adversely affect" the species and/or "likely to adversely modify" Designated Critical Habitat?	☐ Yes ☐ No ☐ N/A
5. Does the USFWS/NOAA-Fisheries concur in the effects determination?	☐ Yes ☐ No ☐ N/A
6. Has the USFWS/NOAA-Fisheries rendered a "jeopardy" determination?	☐ Yes ☐ No ☐ N/A

Executive Order 13007 (Indian Sacred Sites)	
1. Is the project located on Federal lands that are within a county claimed as "territory" by the EBCI?	☐ Yes ☑ No
2. Has the EBCI indicated that Indian sacred sites may be impacted by the proposed project?	☐ Yes ☐ No ☐ N/A
3. Have accommodations been made for access to and ceremonial use of Indian sacred sites?	☐ Yes ☐ No ☐ N/A
Farmland Protection Policy Act (FPPA)	
1. Will real estate be acquired?	☑ Yes ☐ No
2. Has NRCS determined that the project contains prime, unique, statewide or locally important farmland?	☑ Yes ☐ No ☐ N/A
3. Has the completed Form AD-1006 been submitted to NRCS?	☑ Yes ☐ No ☐ N/A
Fish and Wildlife Coordination Act (FWCA)	
1. Will the project impound, divert, channel deepen, or otherwise control/modify any water body?	☑ Yes ☐ No
2. Have the USFWS and the NCWRC been consulted?	☑ Yes ☐ No ☐ N/A
Land and Water Conservation Fund Act (Section 6(f))	
1. Will the project require the conversion of such property to a use other than public, outdoor recreation?	☐ Yes ☑ No
2. Has the NPS approved of the conversion?	☐ Yes ☐ No ☐ N/A
Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat)	
1. Is the project located in an estuarine system?	☐ Yes ☑ No
2. Is suitable habitat present for EFH-protected species?	☐ Yes ☐ No ☐ N/A
3. Is sufficient design information available to make a determination of the effect of the project on EFH?	☐ Yes ☐ No ☐ N/A
4. Will the project adversely affect EFH?	☐ Yes ☐ No ☐ N/A
5. Has consultation with NOAA-Fisheries occurred?	☐ Yes ☐ No ☐ N/A
Migratory Bird Treaty Act (MBTA)	
1. Does the USFWS have any recommendations with the project relative to the MBTA?	☐ Yes ☑ No
2. Have the USFWS recommendations been incorporated?	☐ Yes ☐ No ☐ N/A
Wilderness Act	
1. Is the project in a Wilderness area?	☐ Yes ☑ No
2. Has a special use permit and/or easement been obtained from the maintaining federal agency?	☐ Yes ☐ No ☐ N/A

Appendix C

EDR Transaction Screen Map Report

EDR LoanCheck®
Basic
with Geocheck®

Mill Creek
7795 High Pine Church Road
Asheboro, NC 27205

Inquiry Number: 1766930.1s

October 02, 2006

EDR® Environmental Data Resources Inc

The Standard in Environmental Risk Management Information

440 Wheelers Farms Road
Milford, Connecticut 06461

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

TABLE OF CONTENTS

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

EXECUTIVE SUMMARY

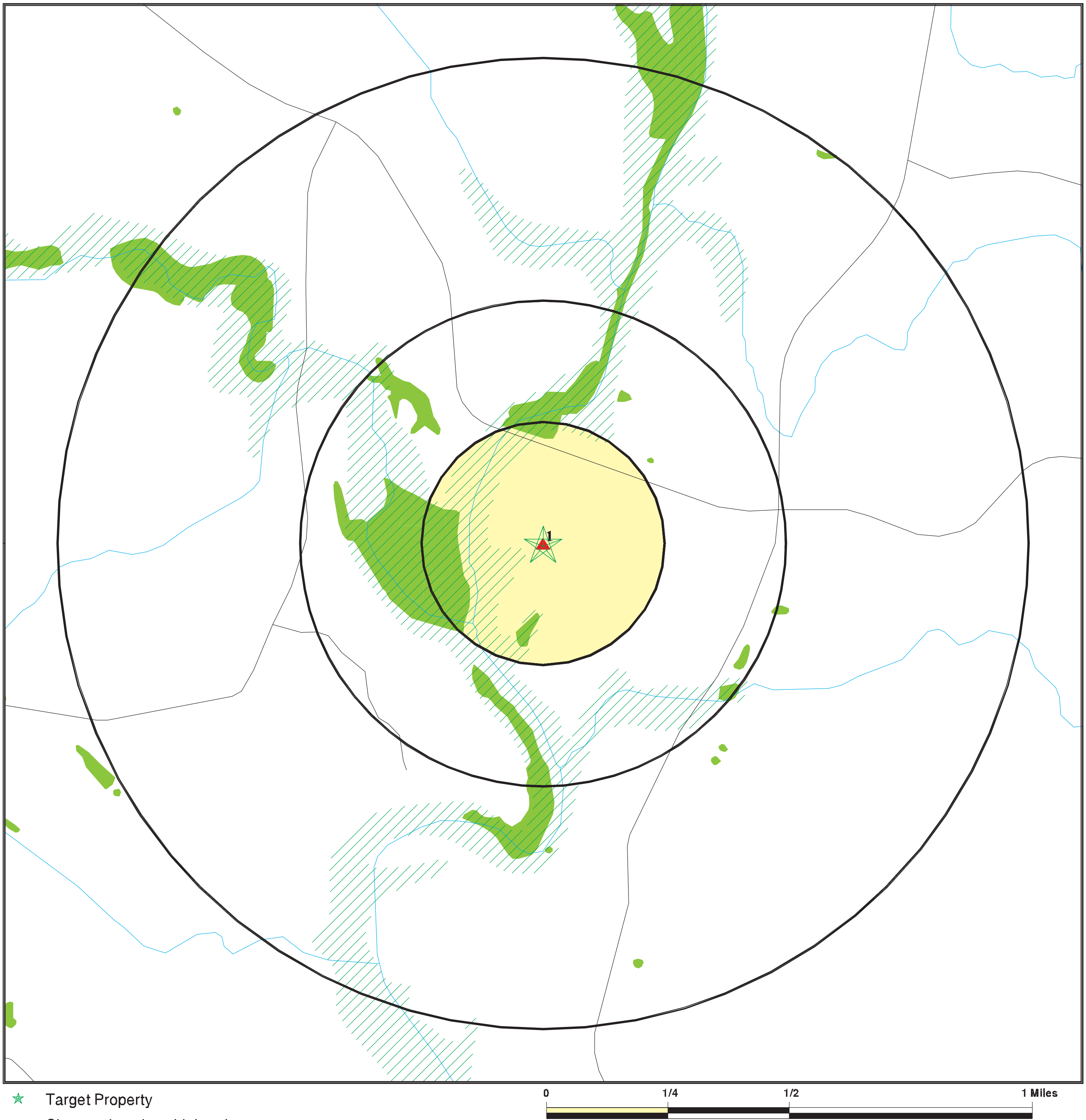
A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR).
The results of this search follow:

TARGET PROPERTY ADDRESS

MILL CREEK
7795 HIGH PINE CHURCH ROAD
ASHEBORO, NC 27205
Elevation: 445 ft.
EDR Inquiry Number: 1766930.1s

TARGET PROPERTY SEARCH RESULTS		FEDERAL RECORDS																															STATE AND LOCAL RECORDS														TRIBAL R ECORDS			EDR PROPRIET ARY RECORDS
Site	Map ID Direction Distance Distance ft. Elevation ft.	NPL	Proposed NPL	Delisted NPL	NPL RECOVERY	CERCLIS	CERC-NFRAP	CORRACTS	RCRA TSD	RCRA Lg. Quan. Gen.	RCRA Sm. Quan. Gen.	ERNS	HMIRS	US ENG CONTROLS	US INST CONTROL	DOD	FUDS	US BROWNFIELDS	CONSENT	ROD	UMTRA	ODI	TRIS	TSCA	FTTS	SSTS	ICIS	PADS	MLTS	MINES	FINDS	RAATS	State Haz. Waste	NC HSDS	IMD	State Landfill	OLI	LUST	LUST TRUST	UST	AST	INST CONTROL	VCP	DRYCLEANERS	BROWNFIELDS	NPDES	INDIAN RESERV	INDIAN LUST	INDIAN UST	EDR MGP
MILLIKAN PROPERTY (DOROTHY) 7795 HIGH PINE CHURCH ROAD ASHEBORO, NC 27205 S106349322	1 TP																																		X			X												

OVERVIEW MAP - 1766930.1s



Target Property

Sites at elevations higher than or equal to the target property

Sites at elevations lower than the target property

Manufactured Gas Plants

National Priority List Sites

Landfill Sites

Dept. Defense Sites

Indian Reservations BIA

Oil & Gas pipelines

100-year flood zone

500-year flood zone

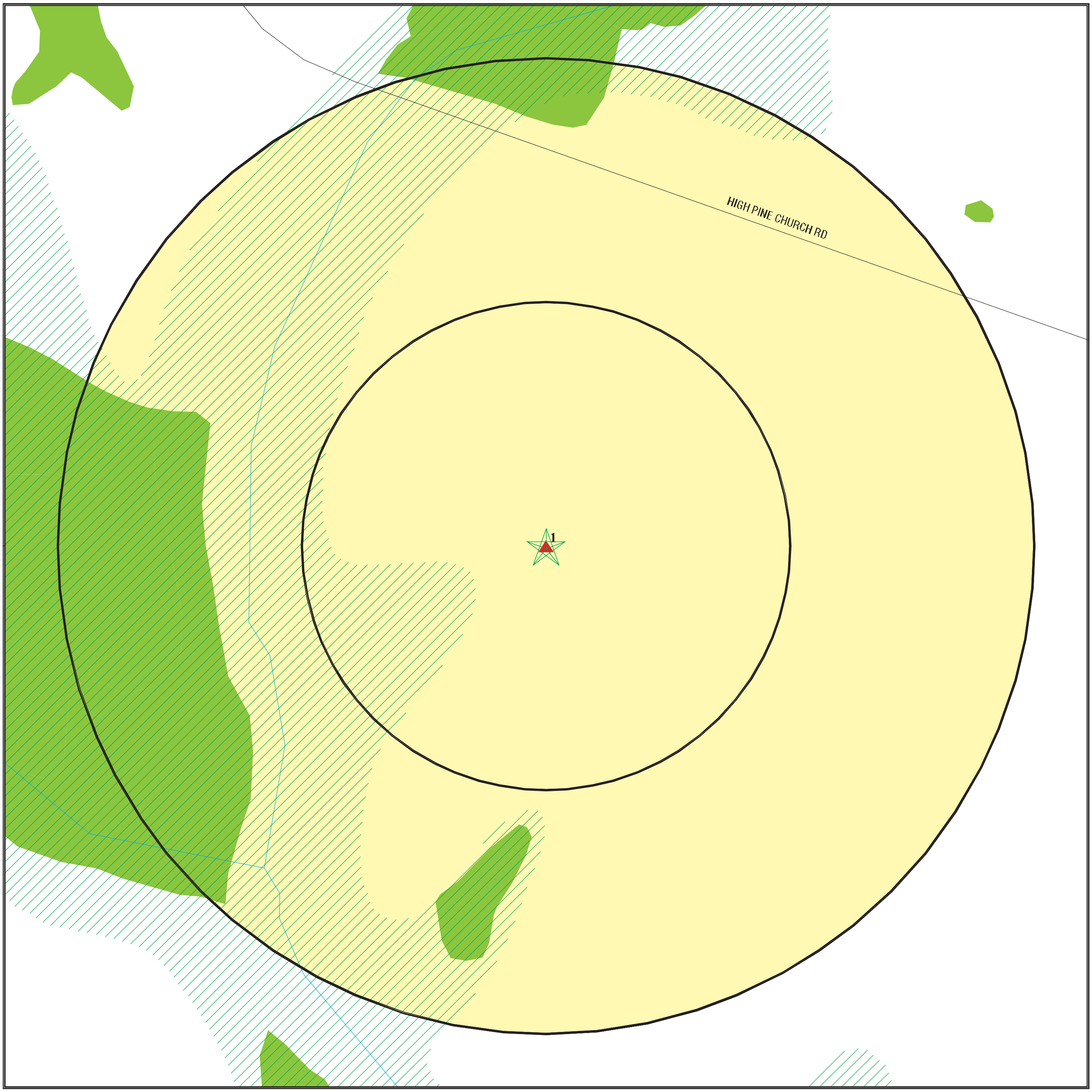
National Wetland Inventory

State Wetlands

Hazardous Substance Disposal Sites

SITE NAME:	Mill Creek	CLIENT:	Buck Engineering
ADDRESS:	7795 High Pine Church Road Asheboro NC 27205	CONTACT:	Ken Gilland
		INQUIRY #:	1766930.1s
LAT/LONG:	35.5604 / 79.9739	DATE:	October 02, 2006 5:33 pm

DETAIL MAP - 1766930.1s



0 1/16 1/8 1/4 Miles

- Target Property
- Sites at elevations higher than or equal to the target property
- Sites at elevations lower than the target property
- Manufactured Gas Plants
- Sensitive Receptors
- National Priority List Sites
- Landfill Sites
- Dept. Defense Sites
- Indian Reservations BIA
- Oil & Gas pipelines
- 100-year flood zone
- 500-year flood zone
- National Wetland Inventory
- State Wetlands
- Hazardous Substance Disposal Sites

SITE NAME:	Mill Creek	CLIENT:	Buck Engineering
ADDRESS:	7795 High Pine Church Road Asheboro NC 27205	CONTACT:	Ken Gilland
		INQUIRY #:	1766930.1s
LAT/LONG:	35.5604 / 79.9739	DATE:	October 02, 2006 5:33 pm

EDR LoanCheck® Basic: Environmental Risk Review

October 2, 2006

Property Name

MILL CREEK
7795 HIGH PINE CHURCH ROAD
ASHEBORO, NC 27205

440 Wheelers Farms Road
Milford, CT 06460
Phone:800-352-0050
Fax:800-231-6802
Web:www.edrnet.com

EDR™ Environmental Data Resources Inc

ENVIRONMENTAL RISK LEVEL

To help evaluate environmental risk, the *EDR LoanCheck®Basic* provides an Environmental Risk Level, based on a search of current government records requested to be searched by Buck Engineering.

X	**ELEVATED RISK**	Based on the records found in this report, the environmental risk level for this property is elevated.
	LOW RISK	Based on the records found in this report, the environmental risk level for this property is minimal.

User Instructions

For more information regarding this Environmental Risk Level, please refer to page 2 and other supporting reports.

User Comments

Reports and Databases

The following reports an/or databases were requested by customer and were included in the Environmental Risk Level where available:

- EDR Radius Map Report

EDR LoanCheck® Basic: Environmental Risk Review

FINDINGS CONTRIBUTING TO THE ENVIRONMENTAL RISK LEVEL

The environmental ELEVATED RISK is based upon the findings listed below. For additional detail, click on the records marked with "Detail" to turn to the corresponding page. To return to this page, press Alt + Left Arrow on your keyboard or click the green arrow at the bottom of the window.

TARGET PROPERTY

Current Govt. Records	*Address*	*Data Source*	*Distance*	
MILLIKAN PROPERTY (DOROTHY)	7795 HIGH PINE CHURCH ROA	LUST IMD	TP	Detail pg.3

SURROUNDING PROPERTIES

Current Govt. Records

No records identified (if any) were determined to be of elevated risk.

Map ID Direction Distance Distance (ft.) Elevation	Site	Database(s)	EDR ID Number EPA ID Number
1 **Target** **Property**	**MILLIKAN PROPERTY (DOROTHY)** **7795 HIGH PINE CHURCH ROAD** **ASHEBORO, NC 27205**	**LUST** **IMD**	**S106349322** **N/A**

Actual:
447 ft.

LUST:

Facility ID:	Not reported		
Incident Number:	30352	UST Number:	WS-6883
Lat/Long:	35 33 38.16 79 58 6.54	Lat/Long Decimal:	35.5606 79.96849
Testlat:	Not reported		

Regional Officer Project Mgr:	sbw
Region:	Winston-Salem
Company:	DOROTHY MILLIKAN
Contact Person:	Not reported
Telephone:	3366253497
RP Address:	7795 HIGH PINE CHURCH ROAD
RP City,St,Zip:	ASHEBORO, NC 27205-
RP County:	Not reported
Comm / Non-comm UST Site:	NON COMMERCIAL
Risk Classification:	U
Risk Class Based On Review:	H
Corrective Action Plan Type:	Not reported
Level Of Soil Cleanup Achieved:	Not reported
Tank Regulated Status:	Non Regulated
Contamination Type:	Soil

Source Type:	Leak-underground	Product Type:	PETROLEUM
Date Reported:	3/12/2004	Date Occur:	3/11/2004
NOV Issue Date:	Not reported	NORR Issue Date:	Not reported
Site Priority:	Not reported	Phase Of LSA Req:	Not reported
Site Risk Reason:	Not reported	Land Use:	Not reported
Closure Request:	Not reported	# Of Supply Wells:	0
Close Out:	Not reported		
MTBE:	No	MTBE1:	Unknown
Flag:	No	Flag1:	No
LUR Filed:	Not reported	Release Detection:	0
GPS Confirmed:	7	Cleanup:	3/11/2004
Current Status:	File Located in House	RBCA GW:	Not reported
PETOPT:	4	RPL:	No
CD Num:	0	Reel Num:	Not reported
RPOW:	Yes	RPOP:	No
Error Flag:	0		
Error Code:	N	Error Type:	Not reported
Submitted:	3/12/2004	Valid:	No
Description:	During removal of home heating oil UST, soil contamination was confirmed.		
Ownership:	Private		
Operation Type:	Residential	Facility Type:	4
Location:	Residence	Site Priority:	Not reported
Priority Update:	Not reported	PIRF/Min Soil:	Not reported
Wells Affected:	Unknown	Wells Affected #:	Not reported
Samples Taken:	Yes	Samples Include:	Not reported
5 Min Quad:	Not reported	7.5 Min Quad:	Not reported

Last Modified:	Not reported
Incident Phase:	**Response**
NOV Issued:	Not reported
NORR Issued:	4/1/2004
45 Day Report:	Not reported
Public Meeting Held:	Not reported
Corrective Action Planned:	Not reported
SOC Sighned:	Not reported
Reclassification Report:	Not reported

MILLIKAN PROPERTY (DOROTHY) (Continued) **S106349322**

RS Designation: Not reported
Closure Request Date: Not reported
Close-out Report: Not reported
Comments: GPS recreational data entered, funding stopped norr issued

IMD:
Region: WS
Facility ID: 30352
Date Occurred: 3/11/2004
Submit Date: 3/12/2004
GW Contam: No Groundwater Contamination detected
Soil Contam: Yes
Incident Desc: During removal of home heating oil UST, soil contamination was confirmed.
Operator: Not reported
Contact Phone: 3366253497
Owner Company: DOROTHY MILLIKAN
Operator Address:7795 HIGH PINE CHURCH ROAD
Operator City: ASHEBORO
Oper City,St,Zip: ASHEBORO, NC 27205-
Ownership: Private
Operation: Residential
Material: Not reported
Qty Lost 1: Not reported
Qty Recovered 1: Not reported
Source: Leak-underground
Type: Gasoline/diesel
Location: Residence
Setting: Not reported
Risk Site: Unknown
Site Priority: Not reported
Priority Code: Not reported
Priority Update: Not reported
Dem Contact: sbw
Wells Affected: Unknown
Num Affected: Not reported
Wells Contam: Not reported
Sampled By: y
Samples Include: Not reported
7.5 Min Quad: Not reported
5 Min Quad: Not reported
Latitude: 35.56055555
Longitude: -79.96833333
Latitude Number: 353338
Longitude Number: 795806
Latitude Decimal: 35.5605555555556
Longitude Decimal: 79.9683333333333
GPS: 7
Agency: DWM
Facility ID: 30352
Last Modified: Not reported
Incident Phase: RE
NOV Issued: Not reported
NORR Issued: 4/1/2004
45 Day Report: Not reported
Public Meeting Held: Not reported
Corrective Action Planned: Not reported
SOC Sighned: Not reported

MILLIKAN PROPERTY (DOROTHY) (Continued) **S106349322**

Reclassification Report:	Not reported
RS Designation:	Not reported
Closure Request Date:	Not reported
Close-out Report:	Not reported

TERMS AND DEFINITIONS

IMD: Incident Management Database
Groundwater and/or soil contamination incidents

Date of Government Version: 07/21/2006
Date Data Arrived at EDR: 08/01/2006
Date Made Active in Reports: 08/23/2006
Number of Days to Update: 22

Source: Department of Environment and Natural Resources
Telephone: 919-733-3221
Last EDR Contact: 08/01/2006
Next Scheduled EDR Contact: 10/23/2006
Data Release Frequency: Quarterly

LUST: Regional UST Database
This database contains information obtained from the Regional Offices. It provides a more detailed explanation of current and historic activity for individual sites, as well as what was previously found in the Incident Management Database. Sites in this database with Incident Numbers are considered LUSTs.

Date of Government Version: 06/02/2006
Date Data Arrived at EDR: 06/07/2006
Date Made Active in Reports: 07/06/2006
Number of Days to Update: 29

Source: Department of Environment and Natural Resources
Telephone: 919-733-1308
Last EDR Contact: 09/07/2006
Next Scheduled EDR Contact: 12/04/2006
Data Release Frequency: Quarterly

Appendix D

Wetland Delineation Data and Stream Forms

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: UTZ Pond wetland 1 (wet) Applicant / Owner: Investigator: D. Honeycutt, John Hutton	Date: 9-20-06 County: Randolph State: NC
Do normal circumstances exist on the site? Yes ___ No ✓ Is the site significantly disturbed (Atypical situation)? Yes ___ No ✓ Is the area a potential problem area? Yes ___ No ___ (explain on reverse if needed)	Community ID: ___ Transect ID: ___ Plot ID: ___

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. willow oak	<15%	FACW-	9.		
2. Peltandra	18%	OBL	10.		
3. Golden rod	<10%	FACU	11.		
4. carex	20%	FAC-OBL	12.		
5. juncus	30%	FACW-OBL	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 68%

Remarks: Wetland Vegetation Present Based Upon Greater than 50% of the Plant Species are/are not Classified as FAC-OBL in the National List of Plant Species that Occur in Wetlands. Sample plot was taken…

HYDROLOGY

___ Recorded Data (Describe In Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: 0 (in.)

Depth to Free Water in Pit: 0 (in.)

Depth to Saturated Soil: 0 (in.)

Wetland Hydrology Indicators

Primary Indicators:
- ✓ Inundated
- ✓ Saturated in Upper 12"
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ✓ Drainage Patterns in Wetlands

Secondary Indicators:
- ✓ Oxidized Roots Channels in Upper 12"
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ✓ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks:

UT2 Pond wet datapoint

SOILS

Map Unit Name
(Series and Phase): Water Drainage Class:

Taxonomy (Subgroup): Confirm Mapped Type? Yes___ No ✓

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-.4	A	7.5YR 4/3	2.5YR 4/6	10% mottle	clay loam
0-.4	-	—	10YR 6/2	10% mottle	"
.4	B	7.5YR 4/3	2.5YR 4/1	10% mottle	"
			10YR 6/2	50% mottle	"
.8					gravel
1.1		no change			.4-1.1 no change

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
___ Aquic Moisture Regime
✓ Reducing Conditions
___ Gleyed or Low-Chroma Colors
___ Concretions
___ High Organic Content in Surface Layer in Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed On Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes ✓ No ___
Wetland Hydrology Present? Yes ✓ No ___
Hydric Soils Present? Yes ___ No ✓

Is the Sampling Point Within a Wetland? Yes ✓ No ___

Remarks: Location (describe) is/is not classified as a wetland based upon the criteria set forth in the 1987 Army Corps of Engineers Wetlands Delineation Manual.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: UT2 Wetland 1 (Up) Applicant / Owner: Investigator:	Date: 9.20.06 County: Randolph State: NC
Do normal circumstances exist on the site? Yes___ No ✓ Is the site significantly disturbed (Atypical situation)? Yes___ No ✓ Is the area a potential problem area? Yes___ No ✓ (explain on reverse if needed)	Community ID: Transect ID: Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. goldenrod (solidago)	<10%	FAC	9.		
2. blackberry (rubus)	<10%	FAC	10.		
3. fescue	>80%	UPL	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 0%

Remarks: Wetland Vegetation Present Based Upon Greater than 50% of the Plant Species are/are not Classified as FAC-OBL in the National List of Plant Species that Occur in Wetlands. Sample plot ~~was~~ taken…

HYDROLOGY

___ Recorded Data (Describe In Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________(in.)

Depth to Free Water in Pit: ________(in.)

Depth to Saturated Soil: ________(in.)

Wetland Hydrology Indicators

Primary Indicators:
- ___ Inundated
- ___ Saturated in Upper 12"
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators:
- ___ Oxidized Roots Channels in Upper 12"
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ✓ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks:

no hydrology indicators noted

UT2 pond upland point

SOILS

Map Unit Name
(Series and Phase): Mecklenburg Clay loam Drainage Class: well drained

Taxonomy (Subgroup): ______ Confirm Mapped Type? Yes ___ No ✓

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	2.5YR 4/8	5YR 6/6	10%	clay

Hydric Soil Indicators:

- ____ Histosol
- ____ Histic Epipedon
- ____ Sulfidic Odor
- ____ Aquic Moisture Regime
- ____ Reducing Conditions
- ____ Gleyed or Low-Chroma Colors
- ____ Concretions
- ____ High Organic Content in Surface Layer in Sandy Soils
- ____ Organic Streaking in Sandy Soils
- ____ Listed On Local Hydric Soils List
- ____ Listed on National Hydric Soils List
- ____ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	Yes ___	No ✓	Is the Sampling Point
Wetland Hydrology Present?	Yes ___	No ✓	Within a Wetland? Yes ___ No ✓
Hydric Soils Present?	Yes ___	No ✓	

Remarks: Location (describe) is/is not classified as a wetland based upon the criteria set forth in the 1987 Army Corps of Engineers Wetlands Delineation Manual.

Mill Creek Wetland 1 (UP)

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: Mill Creek / UT5 wetland 2 (wet) Applicant / Owner: Investigator: D. Huneycutt, J. Hutton	Date: 9-20-06 County: Randolph State: NC
Do normal circumstances exist on the site? Yes___ No ✓ Is the site significantly disturbed (Atypical situation)? Yes___ No ✓ Is the area a potential problem area? Yes ✓ No___ (explain on reverse if needed)	Community ID: Transect ID: Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. carex	20%	FAC	9.		
2. Arrowhead (Sagittaria)	40%	OBL	10.		
3. Goldenrod (Solidago)	<15	FAC	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 60%

Remarks: Wetland Vegetation Present Based Upon Greater than 50% of the Plant Species are/are not Classified as FAC-OBL in the National List of Plant Species that Occur in Wetlands. Sample plot was taken…

HYDROLOGY

___ Recorded Data (Describe In Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: 2-4 (in.)

Depth to Free Water in Pit: 0 (in.)

Depth to Saturated Soil: 0 (in.)

Wetland Hydrology Indicators

Primary Indicators:
- ✓ Inundated
- ✓ Saturated in Upper 12"
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ✓ Drainage Patterns in Wetlands

Secondary Indicators:
- ✓ Oxidized Roots Channels in Upper 12"
- ✓ Water-Stained Leaves
- ___ Local Soil Survey Data
- ✓ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks:

UT5 Pond wet datapoint

SOILS

Map Unit Name
(Series and Phase): Badin-Tarrus

Drainage Class: Well drained

Taxonomy (Subgroup): ____

Confirm Mapped Type? Yes ___ No ✓

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
1-12	A	10YR 4/1	10YR 5/3	50%	clay loam

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ✓ Sulfidic Odor slight
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ✓ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed On Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	Yes ✓	No ___
Wetland Hydrology Present?	Yes ✓	No ___
Hydric Soils Present?	Yes ___	No ✓

Is the Sampling Point Within a Wetland? Yes ✓ No ___

Remarks: Location (describe) is/is not classified as a wetland based upon the criteria set forth in the 1987 Army Corps of Engineers Wetlands Delineation Manual.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: UT 5 Wetland (Up) 2 Applicant / Owner: Investigator: D. Huneycutt, J. Hutton	Date: 9-20-06 County: Randolph State: NC
Do normal circumstances exist on the site? Yes____ No ✓ Is the site significantly disturbed (Atypical situation)? Yes____ No ✓ Is the area a potential problem area? Yes____ No____ (explain on reverse if needed)	Community ID: Transect ID: Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Goldenrod	10%	FAC	9.		
2. Dog Fennel (Chamaemelum)	20%	FACU	10.		
3. Fescue	70%	UPL	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 0%

Remarks: Wetland Vegetation Present Based Upon Greater than 50% of the Plant Species are/are not Classified as FAC-OBL in the National List of Plant Species that Occur in Wetlands. Sample plot ~~was~~ taken…

HYDROLOGY

___ Recorded Data (Describe In Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs ___ Other ✓ No Recorded Data Available Field Observations: Depth of Surface Water: ________(in.) Depth to Free Water in Pit: ________(in.) Depth to Saturated Soil: ________(in.)	Wetland Hydrology Indicators Primary Indicators: ___ Inundated ___ Saturated in Upper 12" ___ Water Marks ___ Drift Lines ___ Sediment Deposits ___ Drainage Patterns in Wetlands Secondary Indicators: ___ Oxidized Roots Channels in Upper 12" ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)

Remarks:
No hydrology indicators noted

UT5 pond upland datapoint

SOILS

Map Unit Name
(Series and Phase): Badin - Tarrus Drainage Class: well-drained

Taxonomy (Subgroup): ______ Confirm Mapped Type? Yes___ No ✓

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	2.5YR 4/8	5YR 6/6	10%	clay

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed On Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes ___ No ✓
Wetland Hydrology Present? Yes ___ No ✓
Hydric Soils Present? Yes ___ No ✓

Is the Sampling Point Within a Wetland? Yes___ No ✓

Remarks: **Location (describe)** is/is not classified as a wetland based upon the criteria set forth in the 1987 Army Corps of Engineers Wetlands Delineation Manual.

Mill Crk wetland 2 (UP)

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

Date: 9/21/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** Mill Creek 1	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 38.5	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 20)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

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

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

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

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

West of Lassiter Mill Road

Sketch:

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

Date: 9/22/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** Mill Creek 2	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 41.25	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 25)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 8)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 8.25)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 10/3/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** Mill Creek 3	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* *31.25*	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 15)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 7.5)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 8.75)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 10/3/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** Mill Creek 4	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 30.25	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 15)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 7.5)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 7.75)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 9/20/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 1	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 6.75	**County:** Randolph	**Other** *e.g. Quad Name*:

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

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

B. Hydrology (Subtotal = 3.5)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **<u>or</u>** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 3.25)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 9/20/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 2	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 22.75	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 10.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 7)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5.25)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 2/19/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 4	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* *20*	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 11.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on <u>existing</u> USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 5)	Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **<u>or</u>** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 3.5)	Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 2/19/07	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 4P	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 28.5	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 16.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 5)	Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 6.75)	Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 9/21/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 5	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 19.25	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 7.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 4)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5.75)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

downstream

Sketch:

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

Date: 7/11/07	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT5 below dam	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* ***36.5***	**County:** Randolph	**Other** *e.g. Quad Name*:

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

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

B. Hydrology (Subtotal = 7.5)				
14. Groundwater flow/discharge	0	1	**2**	3
15. Water in channel and > 48 hrs since rain, **<u>or</u>** Water in channel -- dry or growing season	0	1	2	**3**
16. Leaflitter	1.5	**1**	0.5	0
17. Sediment on plants or debris	0	**0.5**	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	**1**	1.5
19. Hydric soils (redoximorphic features) present?	No = **0**		Yes = 1.5	

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

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

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

- Duck potato
- Caddisfly, beetle, 2 salamanders, left-handed snail
- Point taken on lower portion of UT5 from Mill Creek to toe of slope of dam outfall.

Sketch:

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

Date: 9/21/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 6	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 7.75	**County:** Randolph	**Other** *e.g. Quad Name***:**

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

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

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

C. Biology (Subtotal = 3.25)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Form location was above second pond

Sketch:

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

Date: 9/22/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 7	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 27.75	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 18)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on <u>existing</u> USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

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

C. Biology (Subtotal = 6.75)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 9/28/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 8	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 17.25	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 9.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on <u>existing</u> USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 2.5)	Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **<u>or</u>** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5.25)	Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

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

Sketch:

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

Date: 9/22/06	**Project:** Mill Creek	**Latitude:**
Evaluator: D. Huneycutt	**Site:** UT 9	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 30.75	**County:** Randolph	**Other** *e.g. Quad Name*:

A. Geomorphology (Subtotal = 21)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

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

B. Hydrology (Subtotal = 4)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5.75)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

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

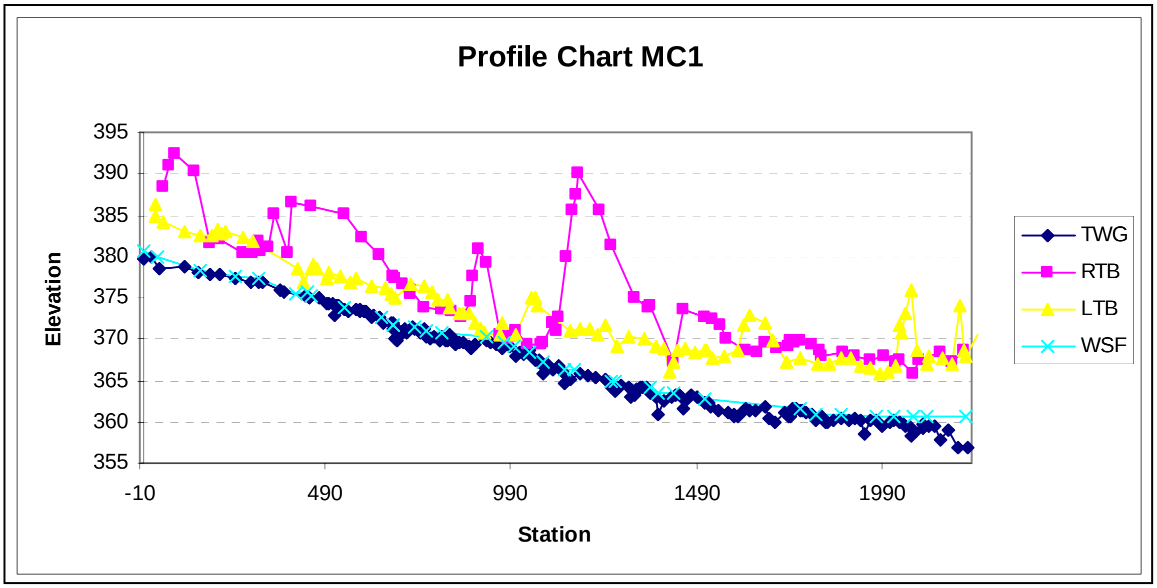
Notes: (use back side of this form for additional notes.)

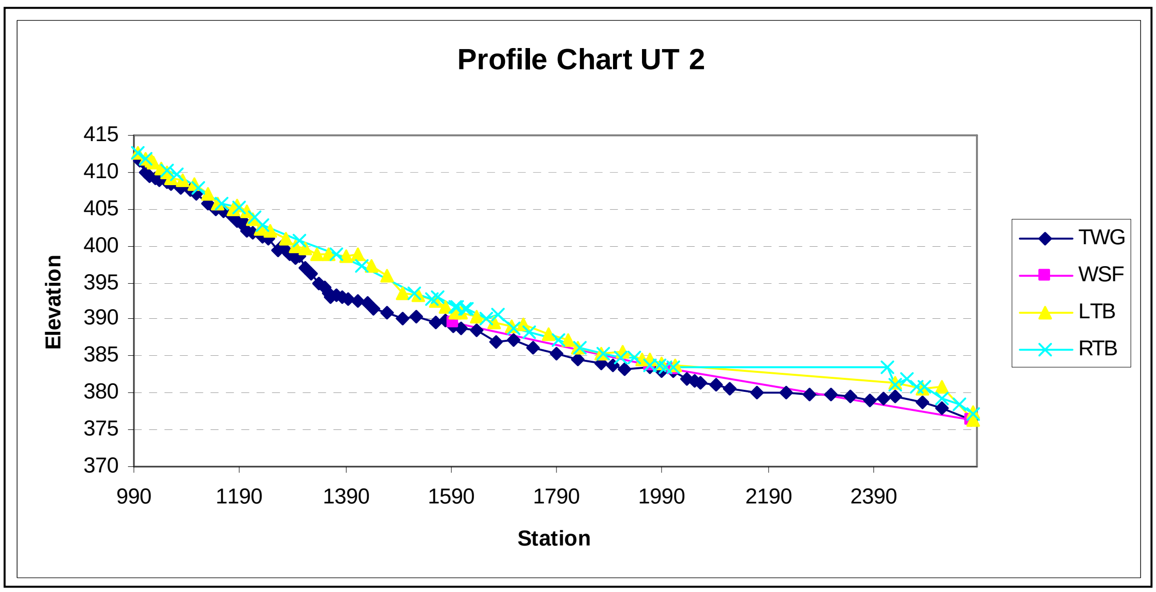
Sketch:

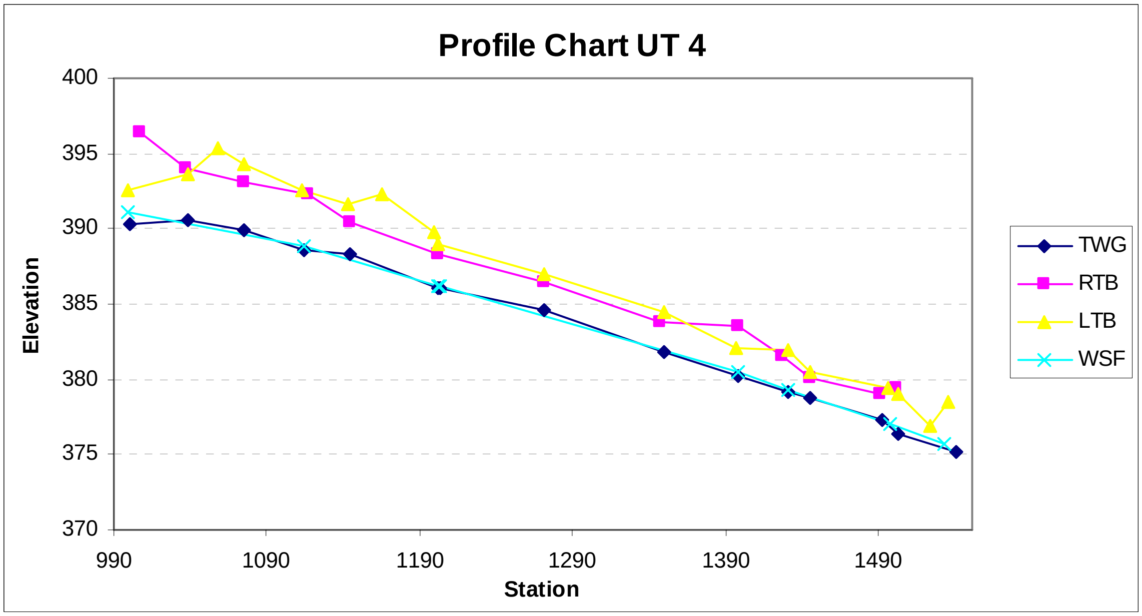
Appendix E

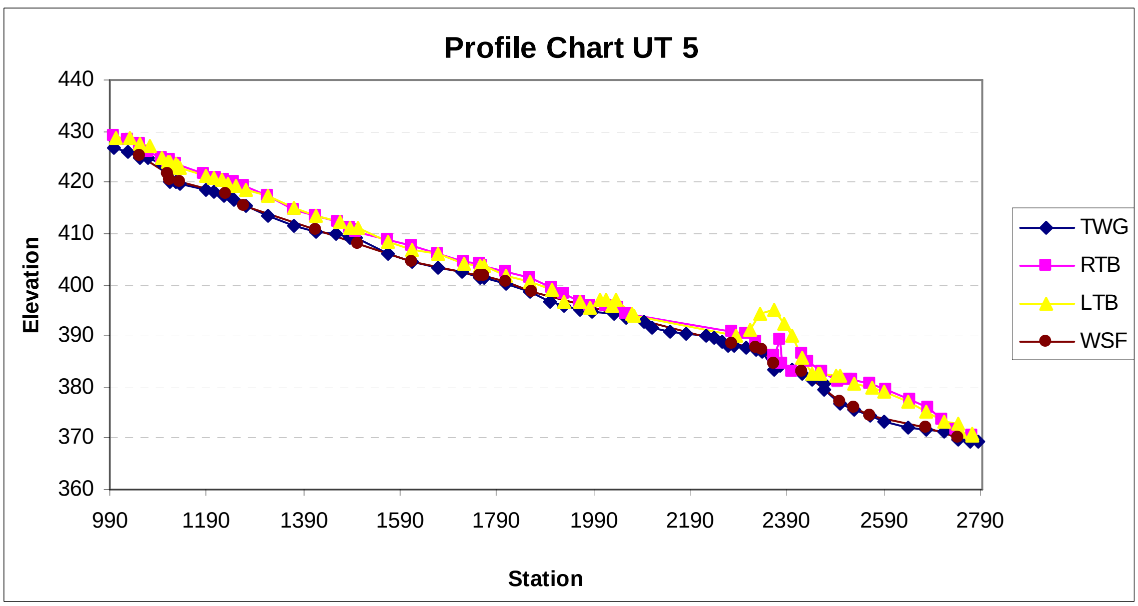
Existing Conditions Summaries: Longitudinal Profiles, Cross-Sections, and Bed Material Analyses

Profile Graphs



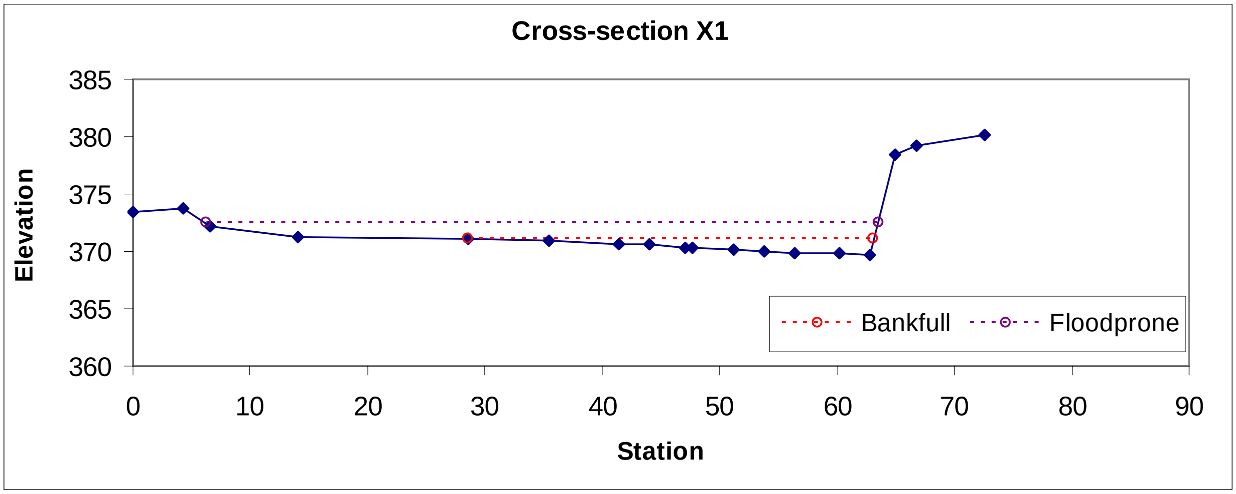



Profile Chart UT 4
400
395
390
385
380
375
370
990
1090
1190
1290
1390
1490
Elevation
Station
TWG
RTB
LTB
WSF

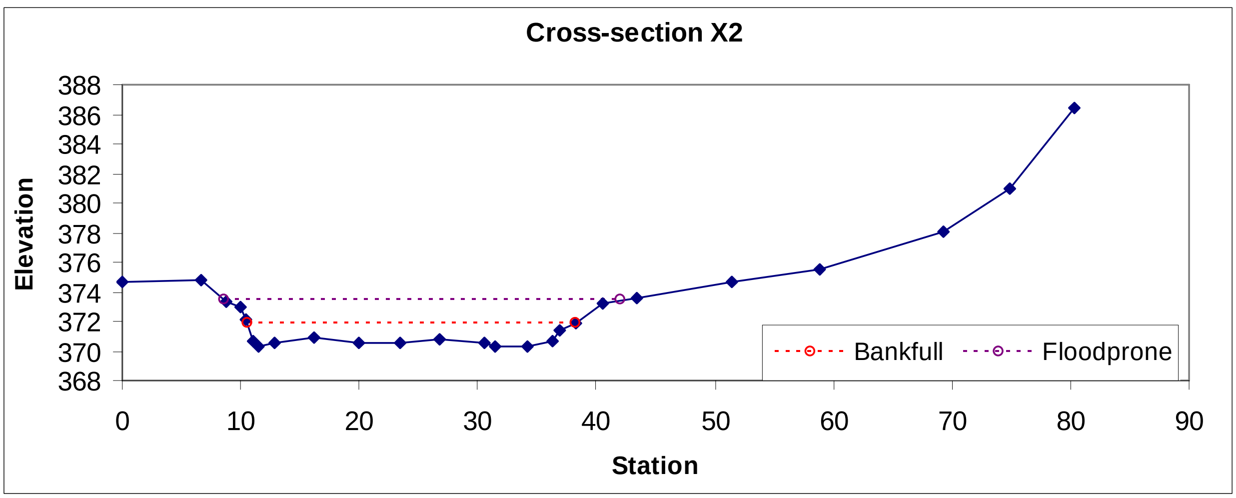

Profile Chart UT 5
440
430
420
410
400
390
380
370
360
990
1190
1390
1590
1790
1990
2190
2390
2590
2790
Elevation
Station
TWG
RTB
LTB
WSF

Cross-sections

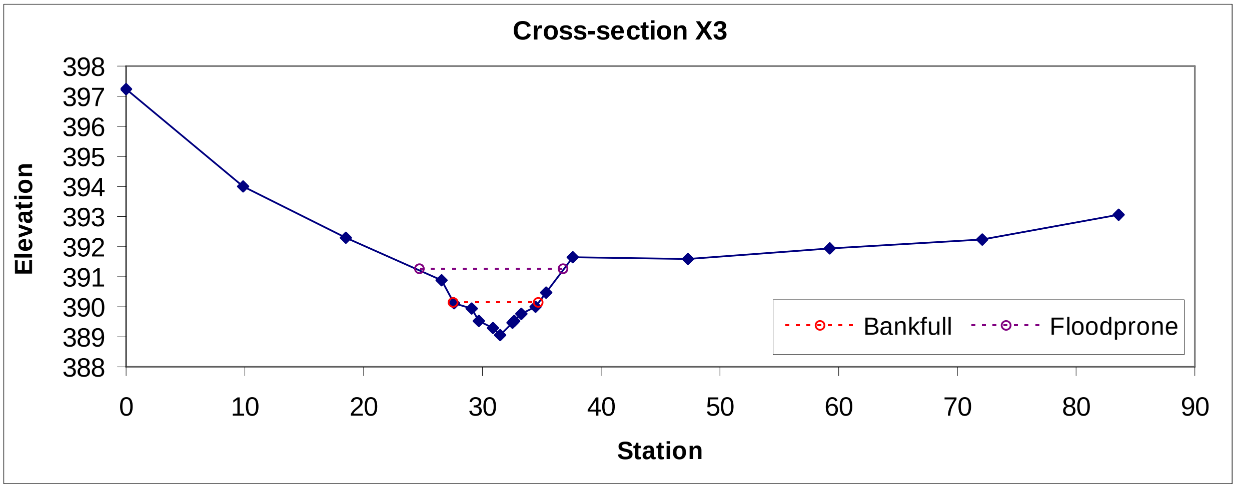
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	Bc	22.9	34.62	0.66	1.42	52.44	1	1.7	371.05	371.05



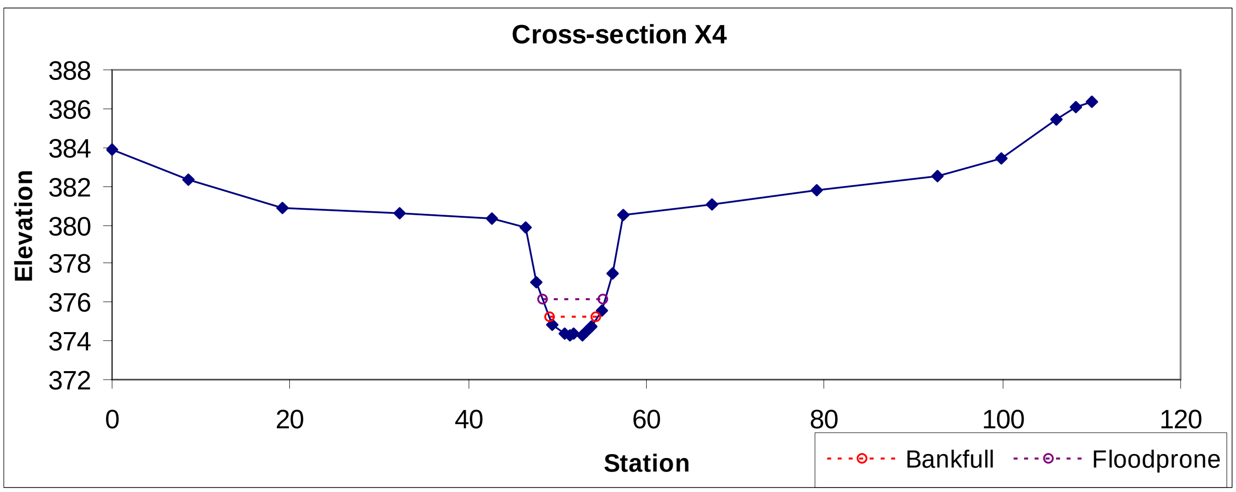
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	F	32.3	27.65	1.17	1.59	23.67	2.1	1.2	371.83	373.63



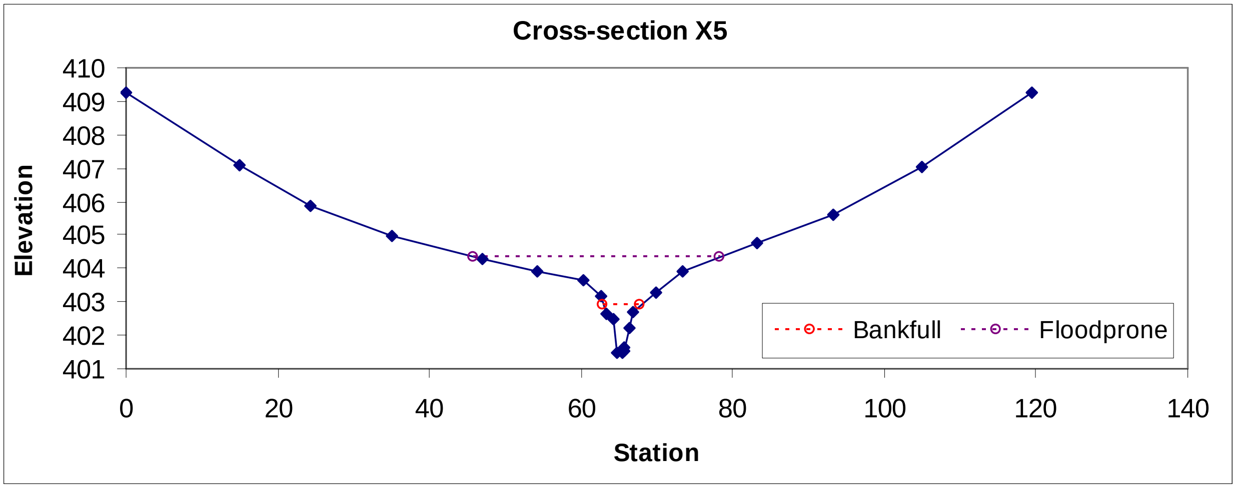
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	Bc	3.5	7.15	0.49	1.06	14.66	1.7	1.7	390.14	390.89



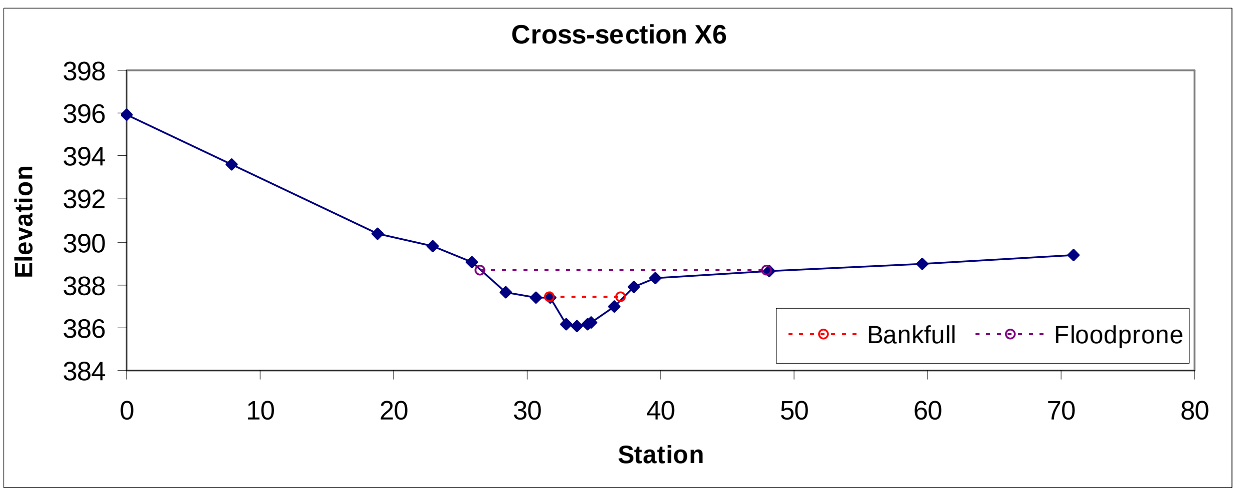
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	G	3.3	5.24	0.63	0.87	8.3	6.3	1.3	375.2	379.83



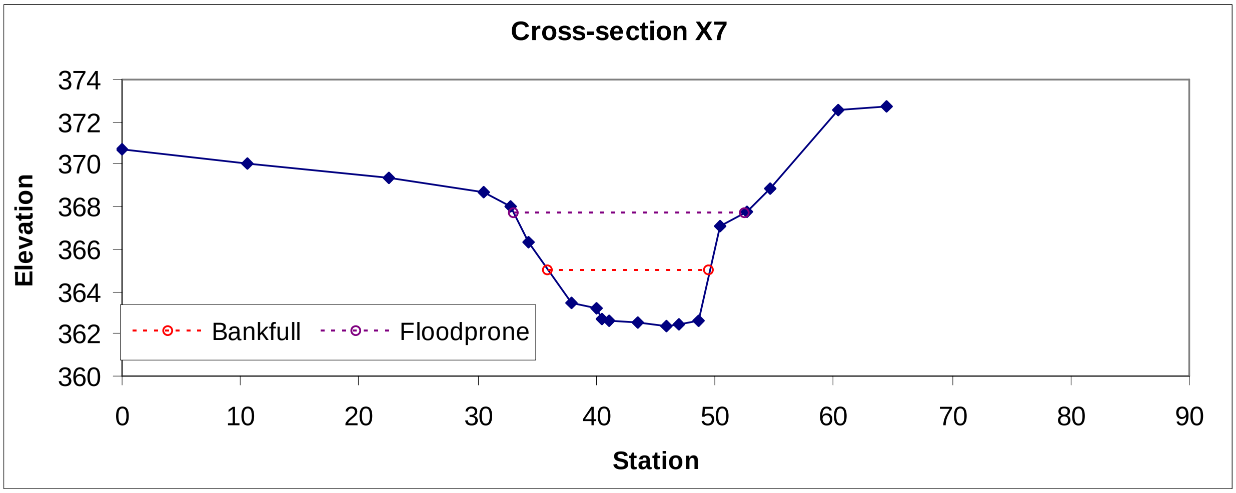
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	Eb	3.1	4.89	0.63	1.44	7.79	1.5	6.6	402.9	403.67

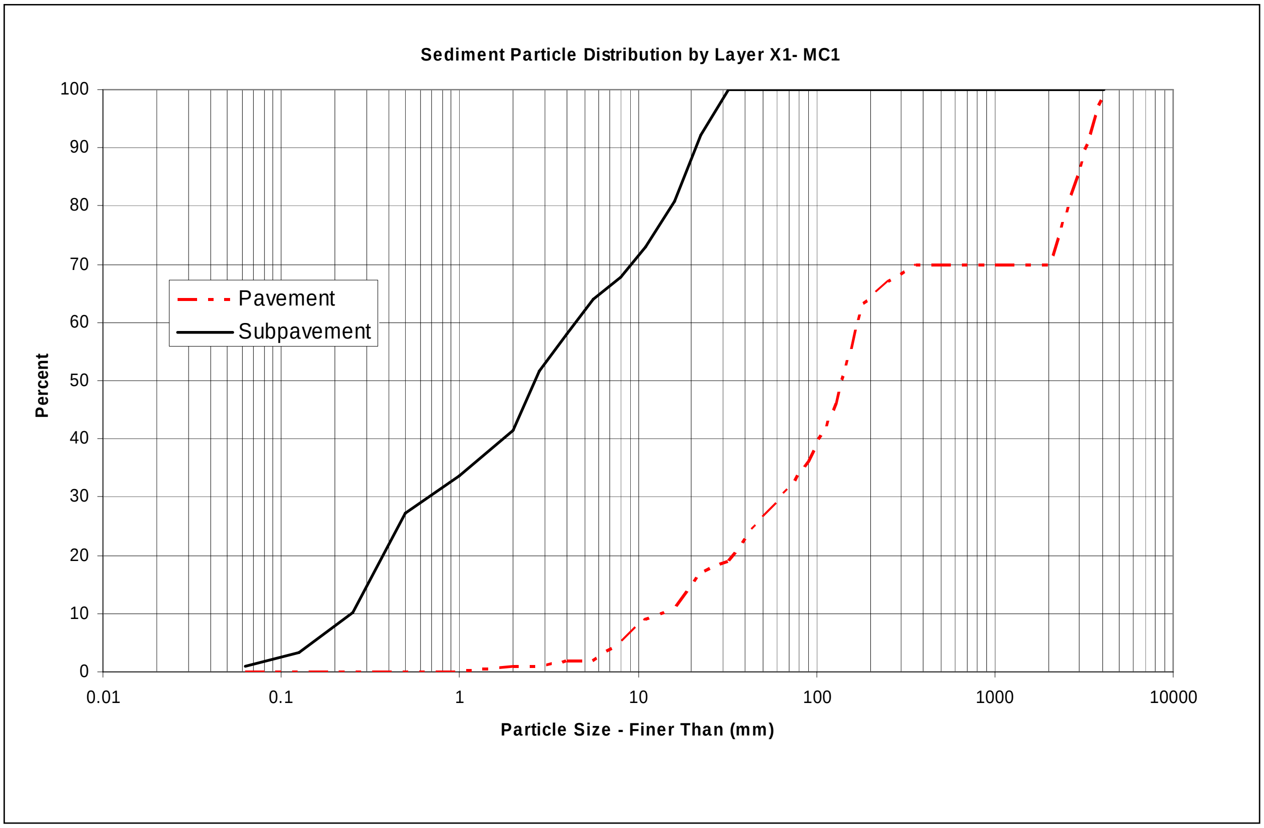


Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	Eb	4.5	5.33	0.84	1.28	6.34	1.8	4	387.36	388.34

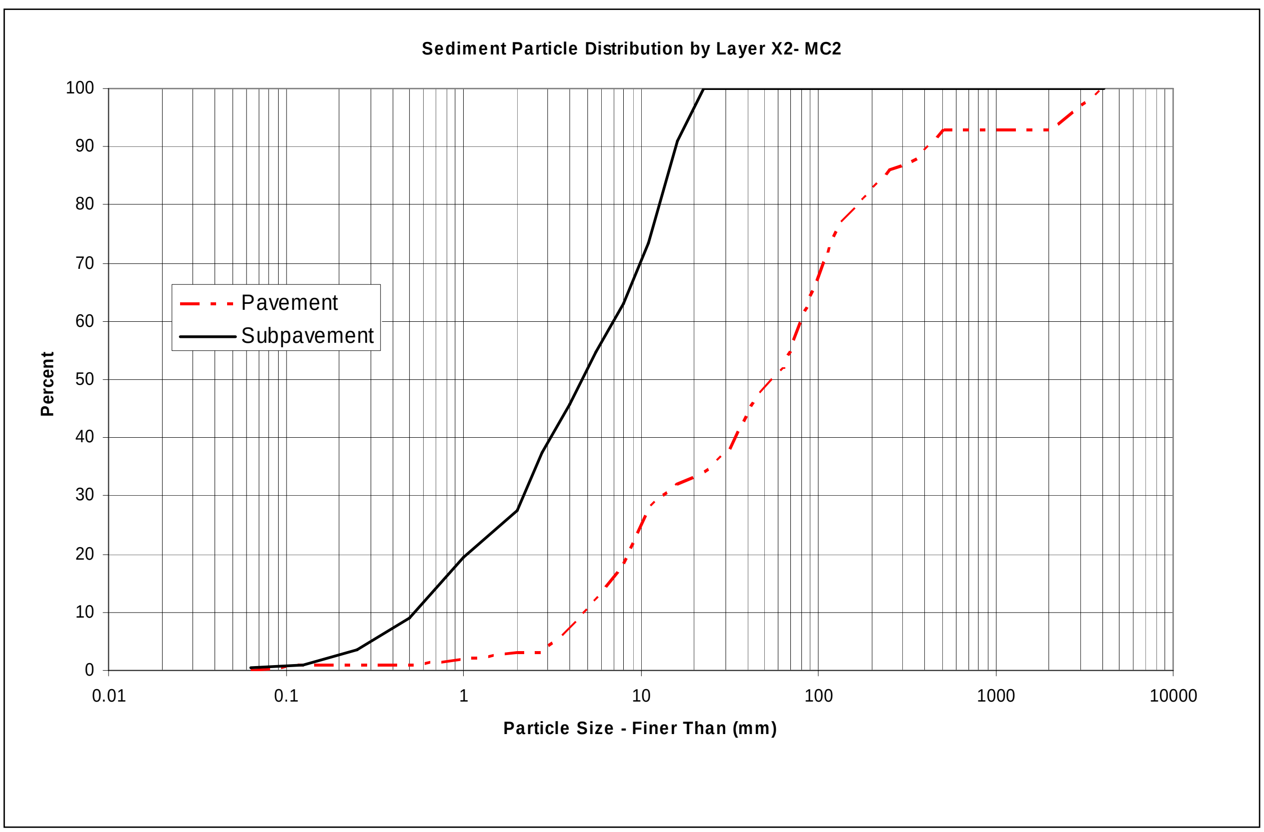


Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
	Bc	27.6	13.7	2.01	2.67	6.81	2.4	1.4	365	368.69

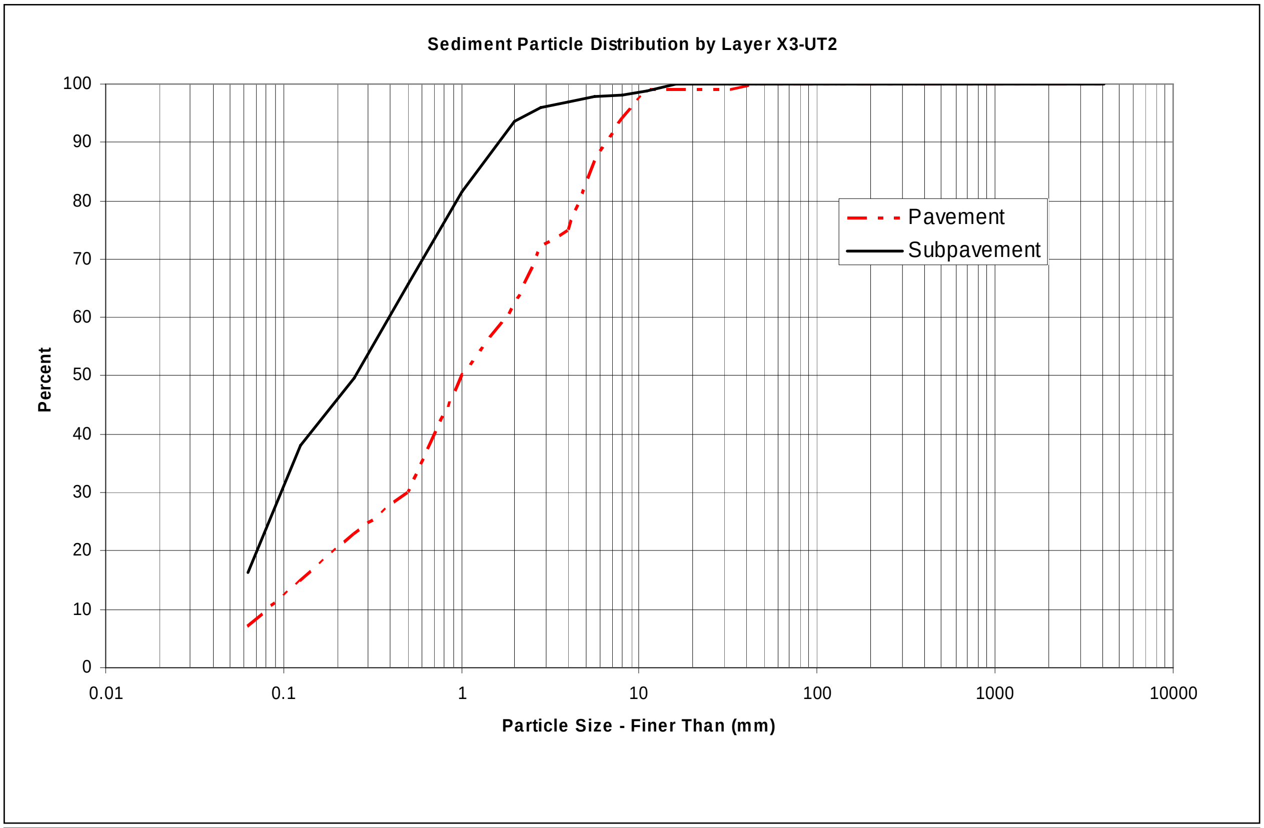


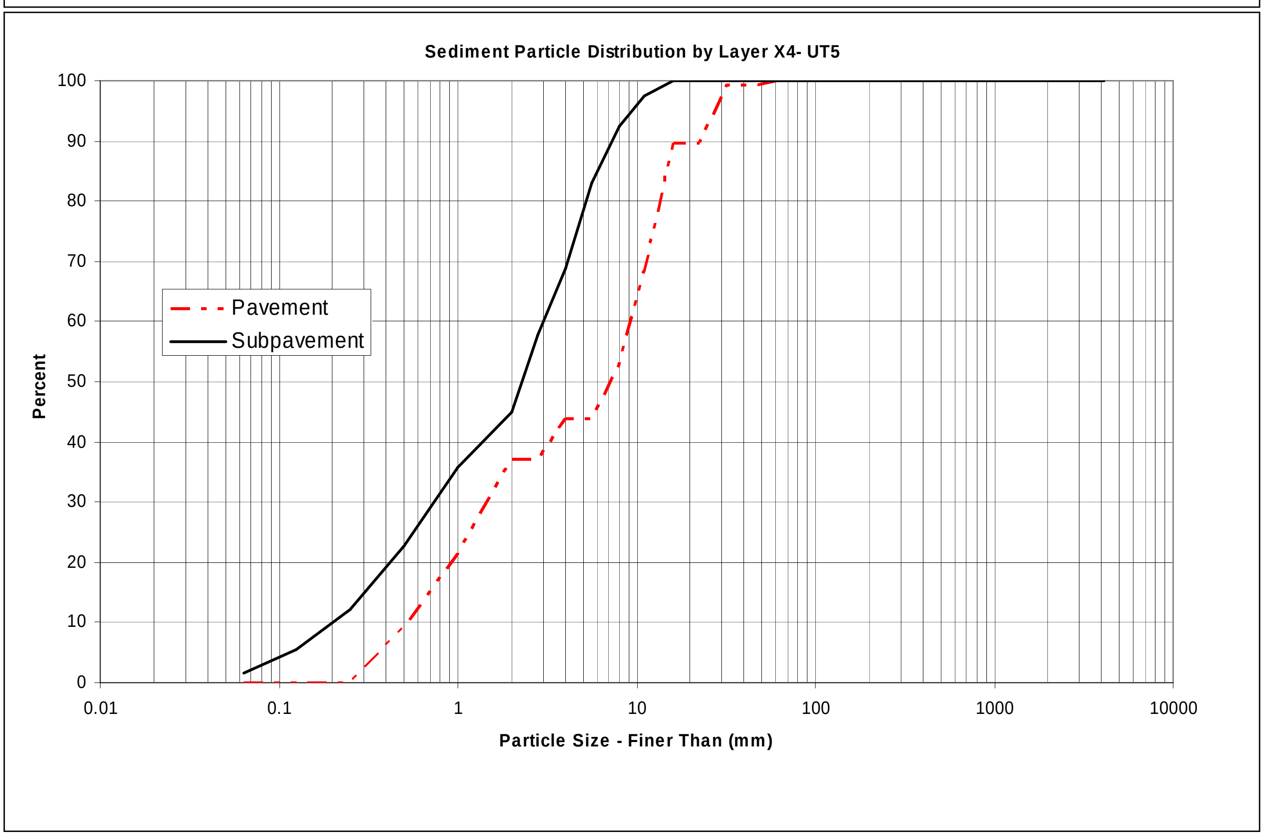


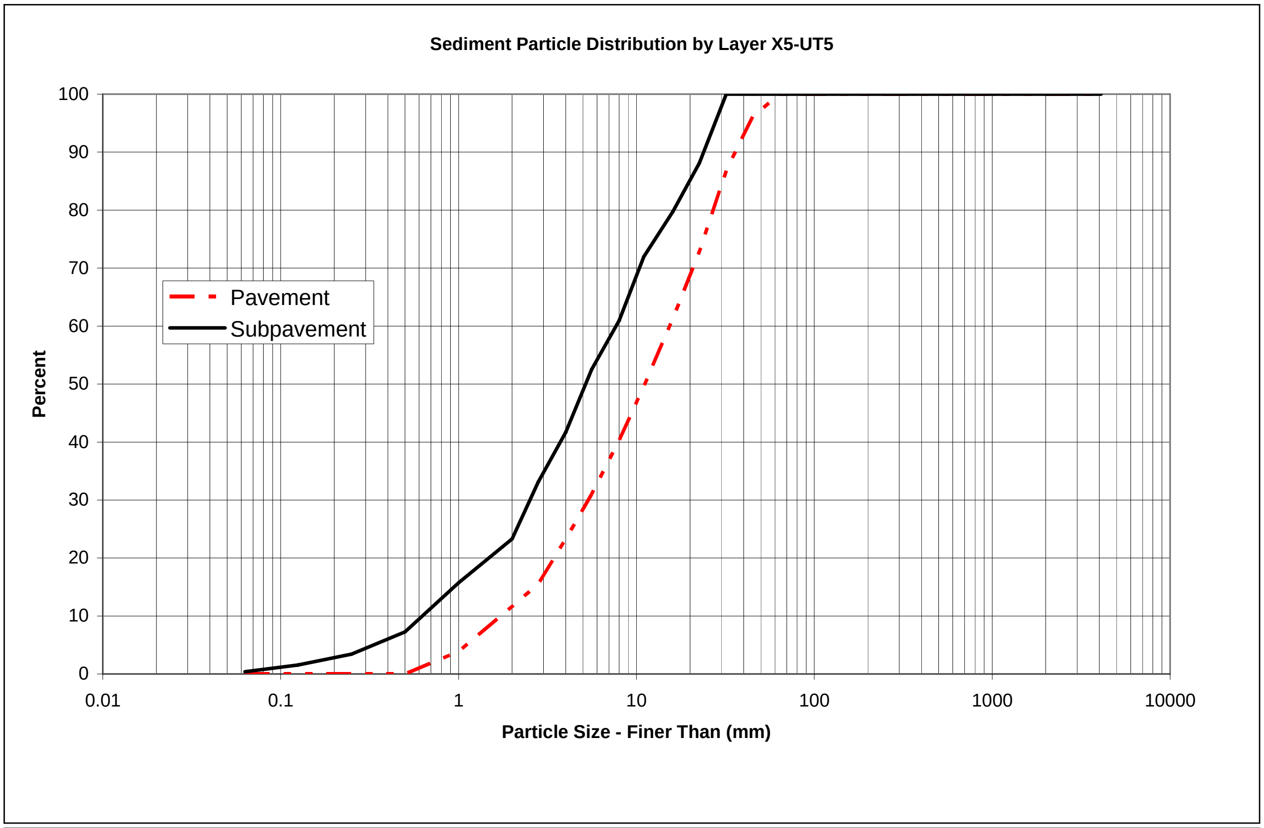
Sediment Particle Distribution by Layer X1- MC1
Percent
Particle Size - Finer Than (mm)
Pavement
Subpavement
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000

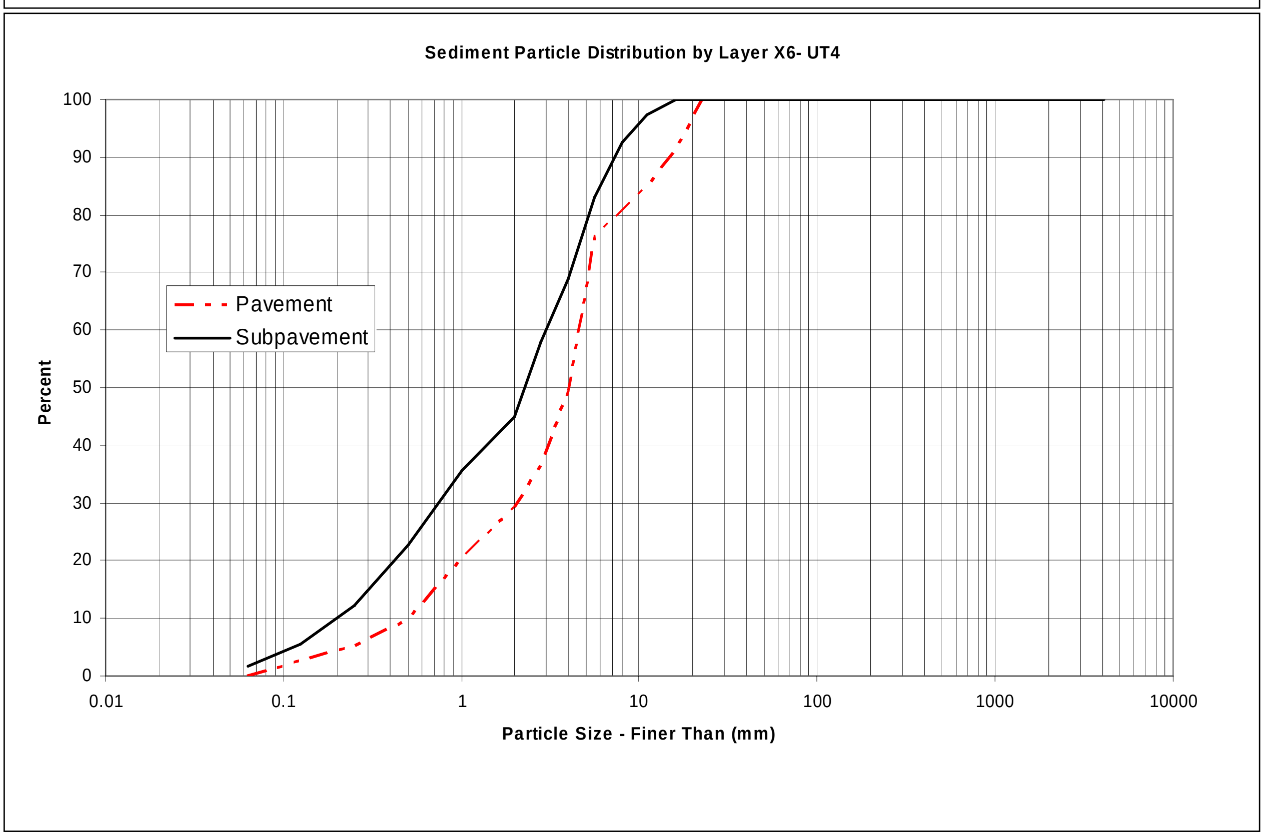


Sediment Particle Distribution by Layer X2- MC2
Percent
Particle Size - Finer Than (mm)
Pavement
Subpavement
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000


Sediment Particle Distribution by Layer X3-UT2
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement


Sediment Particle Distribution by Layer X4- UT5
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement


Sediment Particle Distribution by Layer X5-UT5
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement


Sediment Particle Distribution by Layer X6- UT4
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement

Appendix F

Design Parameters

Reference parameters used to determine design ratios				
Parameter	**Mickey Reach (See Appendix G)**		**Composite Reference Data from past projects**	
	MIN	**MAX**	**MIN**	**MAX**
Drainage Area, DA (sq mi)	0.45	0.45		
Stream Type (Rosgen)	B4	B4		
Bankfull Riffle XSEC Area, Abkf (sq ft)	5.3	11.2		
Bankfull Riffle Width, Wbkf (ft)	10.8	14.9		
Bankfull Riffle Mean Depth, Dbkf (ft)	0.4	1.0		
Width to Depth Ratio, W/D (ft/ft)	10.4	40.1	12	15
Width Floodprone Area, Wfpa (ft)	35	40		
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	2.7	3.2		
Riffle Max Depth @ bkf, Dmax (ft)	0.7	2.1		
Riffle Max Depth Ratio, Dmax/Dbkf	1.0	3.0	1.2	1.4
Max Depth @ tob, Dmaxtob (ft)	1.5	6.2		
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.0	1.0	1.0	1.1
Meander Length, Lm (ft)	70	280		
Meander Length Ratio, Lm/Wbkf *	4	16		
Radius of Curvature, Rc (ft)	28	47		
Rc Ratio, Rc/Wbkf *	2	3		
Belt Width, Wblt (ft)	18	65		
Meander Width Ratio, Wblt/Wbkf *	1	4		
Sinuosity, K	1.13	1.13	1.1	1.2
Valley Slope, Sval (ft/ft)	0.0396	0.0396		
Channel Slope, Schan (ft/ft)	0.0350	0.0350		
Slope Riffle, Srif (ft/ft)	0.0110	0.1220		
Riffle Slope Ratio, Srif/Schan	0.3143	3.4857		
Slope Pool, Spool (ft/ft)	0.0000	0.0570		
Pool Slope Ratio, Spool/Schan	0.0000	1.6286		
Slope Run, Srun (ft/ft)				
Run Slope Ratio, Srun/Schan				
Slope Glide, Sglide (ft/ft)				
Glide Slope Ratio, Sglide/Schan				
Pool Max Depth, Dmaxpool (ft)	4.4	5.3		
Pool Max Depth Ratio, Dmaxpool/Dbkf	3.5	4.2	2	3
Pool Area, Apool (sq ft)	12.7	26.1		
Pool Area Ratio, Apool/Abkf	1.5	3.2		
Pool Width, Wpool (ft)	8.0	13.7		
Pool Width Ratio, Wpool/Wbkf	0.6	1.1	1.1	1.5
Pool Length, Lpool (ft)	3.5	19.1		
Pool Length Ratio, Lpool/Wbkf	0.3	1.3		
Pool-Pool Spacing, Lps (ft)	5.9	114.6		
Pool-Pool Spacing Ratio, Lps/Wbkf	0.5	7.7	1.5	5
d16 (mm)	5.75	5.75		
d35 (mm)	18.15	18.15		
d50 (mm)	40.45	40.45		
d84 (mm)	118.81	118.81		
d95 (mm)	197.44	197.44		

Mill Creek Project	MC1 Existing StreamValues		MC1 Design StreamValues		UT2 Existing StreamValues		UT2 Design StreamValues		UT5 Existing StreamValues		UT5 Design StreamValues		Rationale
Parameter	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	
Drainage Area, DA (sq mi)	1.33		1.33		0.08		0.08		0.06		0.06		
Stream Type (Rosgen)	B3c/1		B3c/1		B5/1		B5/1		B4/1		B4/1		Note 1
Bankfull Discharge, Qbkf (cfs)	70.42		70.42		8.4		8.4		9.6		9.6		Note 2
Bankfull Riffle XSEC Area, Abkf (sq ft)	27.6	27.6	27.6	27.6	3.5	3.5	3.8	3.8	3.1	3.1	3.8	3.8	
Bankfull Mean Velocity, Vbkf (ft/s)	2.6		2.6		2.4		2.2		2.5		2.5		V=QA
Bankfull Riffle Width, Wbkf (ft)	25.3		18.2	20.3	7.2		6.8	7.5	4.9		6.8	7.5	
Bankfull Riffle Mean Depth, Dbkf (ft)	1.3		1.4	1.5	0.5		0.5	0.6	0.6		0.5	0.6	d=A/W
Width to Depth Ratio, W/D (ft/ft)	19.8		12.0	15.0	14.7		12.0	15.0	7.8		12.0	15.0	Note 3
Width Floodprone Area, Wfpa (ft)	36.7		15	25	12.1		15	25	32.5		15	30	
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	1.4		0.8	1.2	1.7		2.2	3.3	6.6		2.2	4.0	Note 4
Riffle Max Depth @ bkf, Dmax (ft)	1.9		1.7	2.1	1.1		0.6	0.8	1.4		0.6	0.8	
Riffle Max Depth Ratio, Dmax/Dbkf	1.5		1.2	1.4	0.5		1.2	1.4	2.3		1.2	1.4	Note 5
Max Depth @ tob, Dmaxtob (ft)	3.4		1.7	2.3	1.8		0.6	0.9	2.2		0.6	0.9	
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.8		1.0	1.1	1.7		1.0	1.1	1.5		1.0	1.1	Note 6
Meander Length, Lm (ft)	---		---		---		---		---		---		Note 7
Meander Length Ratio, Lm/Wbkf *	---		---		---		---		---		---		Note 7
Radius of Curvature, Rc (ft)	---		---		---		---		---		---		Note 7
Rc Ratio, Rc/Wbkf *	---		---		---		---		---		---		Note 7
Belt Width, Wblt (ft)	---		---		---		---		---		---		Note 7
Meander Width Ratio, Wblt/Wbkf *	---		---		---		---		---		---		Note 7
Sinuosity, K	1.27		1.1	1.3	1.14		1.10	1.20	1.17		1.10	1.20	
Valley Slope, Sval (ft/ft)	0.0115		0.0115		0.0251		0.0251		0.0381		0.0381		
Channel Slope, Schan (ft/ft)	0.0090		0.0090		0.0140		0.0140		0.0325		0.0325		
Slope Riffle, Srif (ft/ft)	---		0.0099	0.0162	---		0.0154	0.0252	---		0.0358	0.0585	
Riffle Slope Ratio, Srif/Schan	---		1.1	1.8	---		1.1	1.8	---		1.1	1.8	Note 5
Slope Pool, Spool (ft/ft)	---		0.0001	0.0023	---		0.0001	0.0035	---		0.0003	0.0081	
Pool Slope Ratio, Spool/Schan	---		0.01	0.25	---		0.01	0.25	---		0.01	0.25	Note 5
Pool Max Depth, Dmaxpool (ft)	---		2.8	4.5	---		1.0	1.8	---		1.0	1.8	
Pool Max Depth Ratio, Dmaxpool/Dbkf	---		2.0	3.0	---		2.0	3.0	---		2.0	3.0	Note 5
Pool Width, Wpool (ft)	---		20.0	30.5	---		7.4	11.3	---		7.4	11.3	
Pool Width Ratio, Wpool/Wbkf	---		1.1	1.5	---		1.1	1.5	---		1.1	1.5	Note 8
Pool-Pool Spacing, Lps (ft)	---		27.3	101.7	---		10.1	37.7	---		10.1	37.7	
Pool-Pool Spacing Ratio, Lps/Wbkf	---		1.5	5.0	---		1.5	5.0	---		1.5	5.0	Note 5
d16 (mm)	9.82		9.82		0.1		0.1		0.7		0.7		
d35 (mm)	43.00		43.00		0.6		0.6		1.8		1.8		
d50 (mm)	90.00		90.00		1.0		1.0		7.1		7.1		
d84 (mm)	>2048		>2048		5.2		5.2		14.5		14.5		
d95 (mm)	>2048		>2048		8.5		8.5		27.4		27.4		

***Existing stream values for UT2 and UT5 represent the entire reach and design values represent both reaches below the breached dam that are to be restored.**

Notes:

[1] *A B stream type is appropriate for steeply sloped channels (generally greater than 0.02), with steep fluvially dissected valleys.*
[2] *Bankfull discharge was estimated using Manning's equation.*
[3] *A final W/D ratio was selected based on relationships of W/D ratio to slope in NC Piedmont reference reach streams, as well as sediment transport analyses.*
[4] *Required for stream classification.*
[5] *This ratio was based on past project evaluation of similar B type design channels.*
[6] *A bank height ratio near 1.0 ensures that all flows greater than bankfull will spread onto a floodplain. This minimizes shear stress in the channel and maximizes floodplain functionality resulting in lower risk of channel instability.*
[7] *Parameters were not derived since the channels are relatively straight (low sinuosity) and are confined with in the valley.*
[8] *Values were chosen based on reference reach database analysis and past project evaluation. It is more conservative to design a pool wider than the riffle. Over time, the pool width may narrow, which is a positive evolutionary step.*

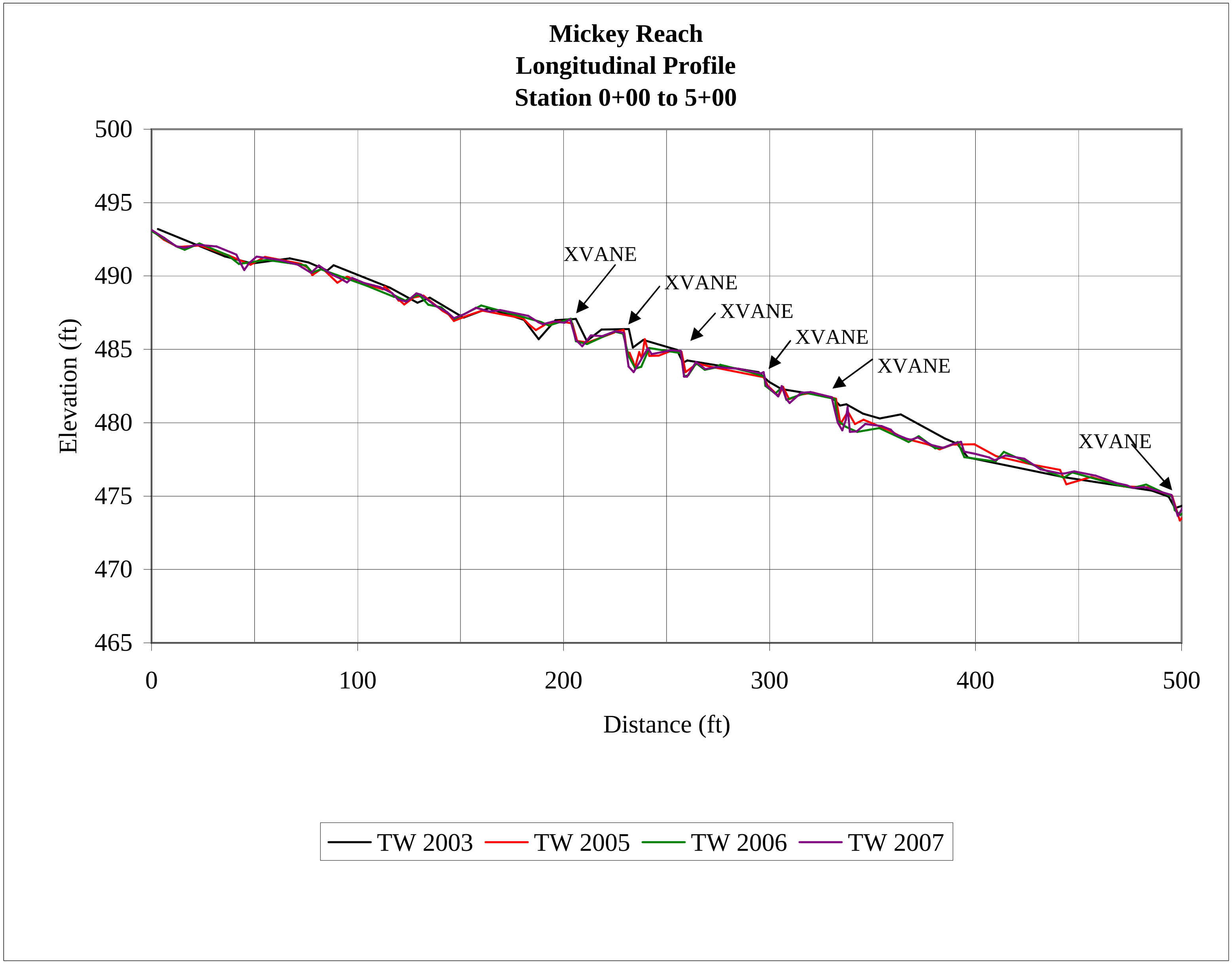
Appendix G

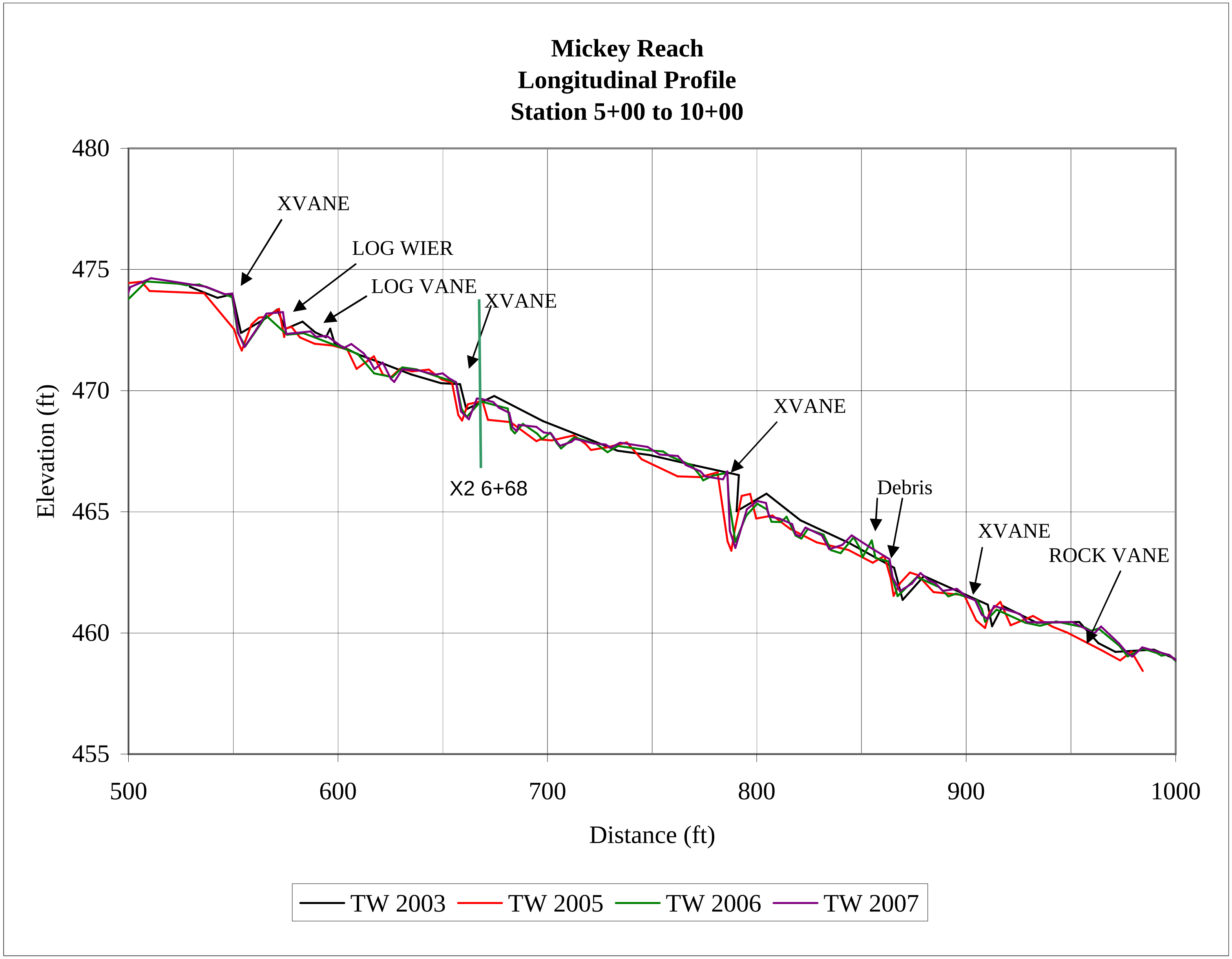
Reference Reach Conditions Summaries: Reach Parameters, Longitudinal Profiles, Cross-Sections, Bed Material Analyses, and Photographs

UT trib to Mitchell River - Mickey Reach

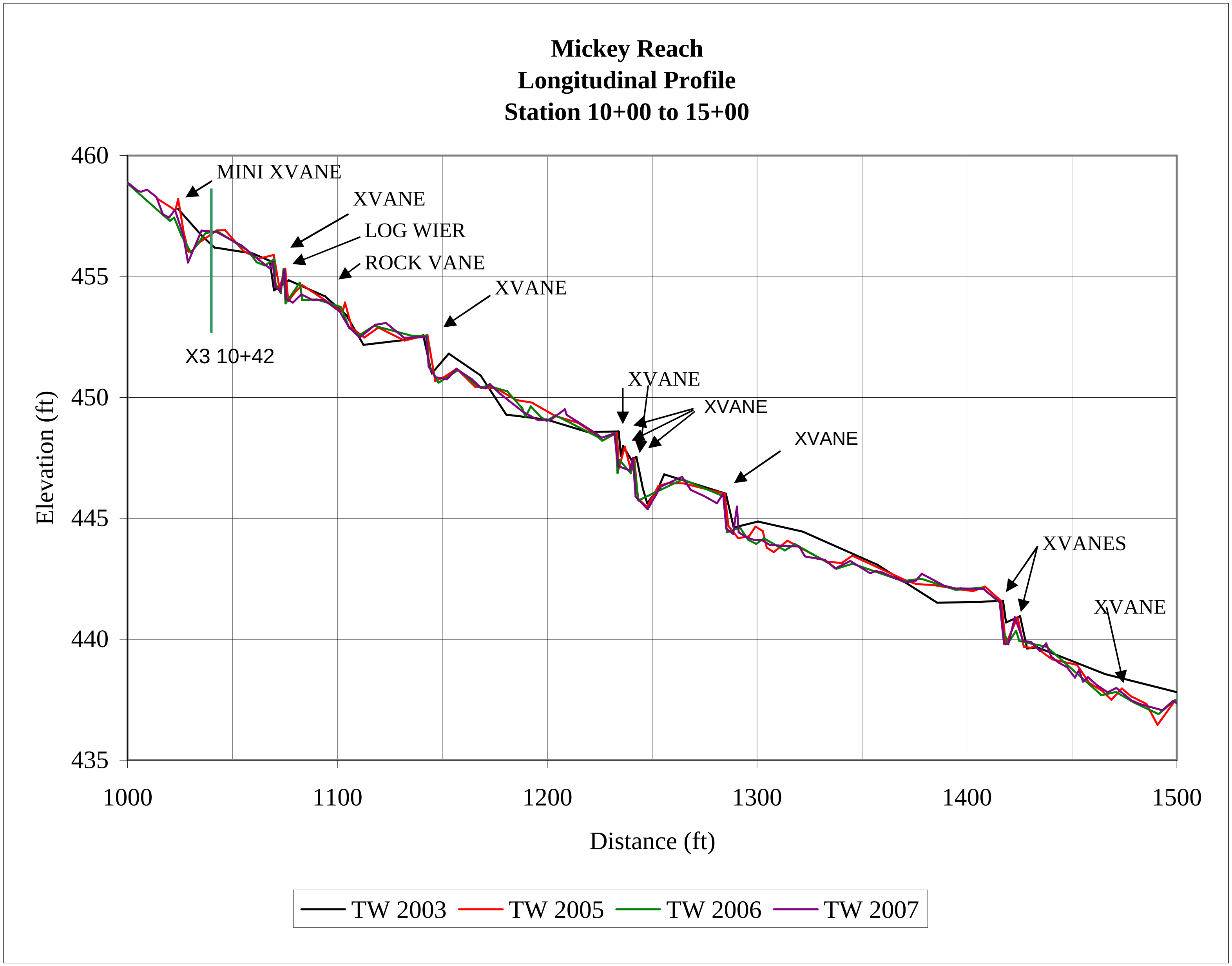
XSEC1 was not measured due to debris

	Existing Stream		Design Stream		Monitoring 2003		Monitoring 2004		Monitoring 2005		Monitoring 2006		Monitoring 2007	
Parameter	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**	**MIN**	**MAX**
Drainage Area, DA (sq mi)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Stream Type (Rosgen)	B4	B4	B4	B4	B4	B4	B4	B4	B4	B4	B4	B4	B4	B4
Bankfull XSEC Area, Abkf (sq ft)	13.1	16.2	13.1	16.2	7.4	13.6	11.6	13.1	7.5	11.7	9.1	12.2	5.3	11.2
Bankfull Width, Wbkf (ft)	11.7	21.7	11.7	21.7	11.5	27.0	10.0	18.0	8.5	23.7	8.8	19.7	10.8	14.9
Bankfull Mean Depth, Dbkf (ft)	0.6	1.3	0.6	1.0	0.5	1.0	0.6	1.3	0.5	0.9	0.5	1.1	0.4	1.0
Width to Depth Ratio, W/D (ft/ft)	10.1	30.4	10.7	17.0	12.3	53.7	7.8	34.2	9.7	48.1	7.7	34.3	10.4	40.1
Width Floodprone Area, Wfpa (ft)	18.0	410.0	20	410	35	410	35	40	35	40	35	40	35	40
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	1.1	32.0	1.7	32.0	2.2	3.7	1.9	3.5	1.7	4.1	2.0	4.0	2.7	3.2
Max Depth @ bkf, Dmax (ft)	0.9	2.5	0.9	2.5	1.1	1.8	1.1	2.3	1.0	1.8	1.1	1.9	0.7	2.1
Max Depth Ratio, Dmax/Dbkf	1.3	1.9	1.1	3.1	1.5	2.4	1.4	2.9	1.4	2.6	1.6	2.7	1.0	3.0
Max Depth @ tob, Dmaxtob (ft)	1.8	9.2	1.0	1.0	1.1	1.8	1.1	2.3	1.7	4.1	1.7	4.1	1.5	6.2
Bank Height Ratio, Dtob/Dmax (ft/ft)	2.0	3.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Meander Length, Lm (ft)	70	280	70	280	70	280	70	280	70	280	70	280	70	280
Meander Length Ratio, Lm/Wbkf	4.4	17.6	4.4	17.6	4	16	4	16	4	16	4	16	4	16
Radius of Curvature, Rc (ft)	19	47	28	47	28	47	28	47	28	47	28	47	28	47
Rc Ratio, Rc/Wbkf	1.1	3.0	2.0	3.0	2	3	2	3	2	3	2	3	2	3
Belt Width, Wblt (ft)	18	65	18	65	18	65	18	65	18	65	18	65	18	65
Meander Width Ratio, Wblt/Wbkf (ft)	1.1	4.1	1.1	4.1	1	4	1	4	1	4	1	4	1	4
Sinuosity, K	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.14	1.14	1.13	1.13	1.13	1.13
Valley Slope, Sval (ft/ft)	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396
Channel Slope, Schan (ft/ft)	0.0333	0.0333	0.0333	0.0333	0.0280	0.0280	0.0280	0.0280	0.0346	0.0346	0.0350	0.0350	0.0350	0.0350
Slope Riffle, Srif (ft/ft)	0.0057	0.0625	0.0057	0.0625	0.0276	0.0613	~	~	0.0248	0.1010	0.0180	0.0720	0.0110	0.1220
Riffle Slope Ratio, Srif/Schan	0.2	1.9	0.2	1.9	1.0	2.2	~	~	0.7	2.9	0.5149	2.0571	0.3143	3.4857
Slope Pool, Spool (ft/ft)	0.0000	0.0050	0.0000	0.0050	~	~	~	~	0.0000	0.0190	0.0000	0.0580	0.0000	0.0570
Pool Slope Ratio, Spool/Schan	0.00	0.15	0.00	0.15	~	~	~	~	0.00	0.55	0.0000	1.6571	0.0000	1.6286
Pool Max Depth, Dmaxpool (ft)	2.2	2.5	2.2	2.5	1.9	2.8	2.6	2.9	1.8	3.2	2.6	3.5	4.4	5.3
Pool Max Depth Ratio, Dmaxpool/Dbkf	2.2	2.5	2.0	4.0	2.7	4.0	3.2	3.6	2.6	4.6	2.1	2.8	3.5	4.2
Pool Area, Apool (sq ft)	14.8	15.9	14.8	15.9	9.5	25.6	12.6	24.5	7.5	23.0	14.5	25.2	12.7	26.1
Pool Area Ratio, Apool/Abkf	1.1	1.2	1.1	1.2	0.9	2.3	1.0	2.0	0.7	2.3	1.4	2.4	1.5	3.2
Pool Width, Wpool (ft)	14.3	14.6	14.3	14.6	6.6	15.1	6.6	15.1	6.9	14.0	6.8	14.3	8.0	13.7
Pool Width Ratio, Wpool/Wbkf	0.7	1.2	0.9	0.9	0.4	0.9	0.4	0.9	0.4	0.8	0.5	1.1	0.6	1.1
Pool Length, Lpool (ft)	13.0	18.0	13.0	18.0	5.0	25.0	~	~	6.1	22.0	5.7	28.1	3.5	19.1
Pool Length Ratio, Lpool/Wbkf	0.8	1.1	0.8	1.1	0.3	1.5	~	~	0.4	1.3	0.6	1.4	0.3	1.3
Pool-Pool Spacing, Lps (ft)	48.0	231.0	48.0	231.0	11.0	128.0	~	~	11.0	105.0	9.0	121.3	5.9	114.6
Pool-Pool Spacing Ratio, Lps/Wbkf	3.0	14.5	3.0	7.0	0.6	7.5	~	~	0.7	6.2	1.0	6.2	0.5	7.7
d16 (mm)	5.6	5.6	5.6	5.6	0.17	0.17	9.60	9.60	9.08	9.08	0.97	0.97	5.75	5.75
d35 (mm)	14.3	14.3	14.3	14.3	13.77	13.77	20.37	20.37	21.53	21.53	26.72	26.72	18.15	18.15
d50 (mm)	30.8	30.8	30.8	30.8	30.43	30.43	31.26	31.26	33.60	33.60	40.56	40.56	40.45	40.45
d84 (mm)	88.4	88.4	88.4	88.4	81.40	81.40	82.06	82.06	74.53	74.53	87.24	87.24	118.81	118.81
d95 (mm)	110.0	110.0	110.0	110.0	145.40	145.40	125.63	125.63	115.98	115.98	127.72	127.72	197.44	197.44

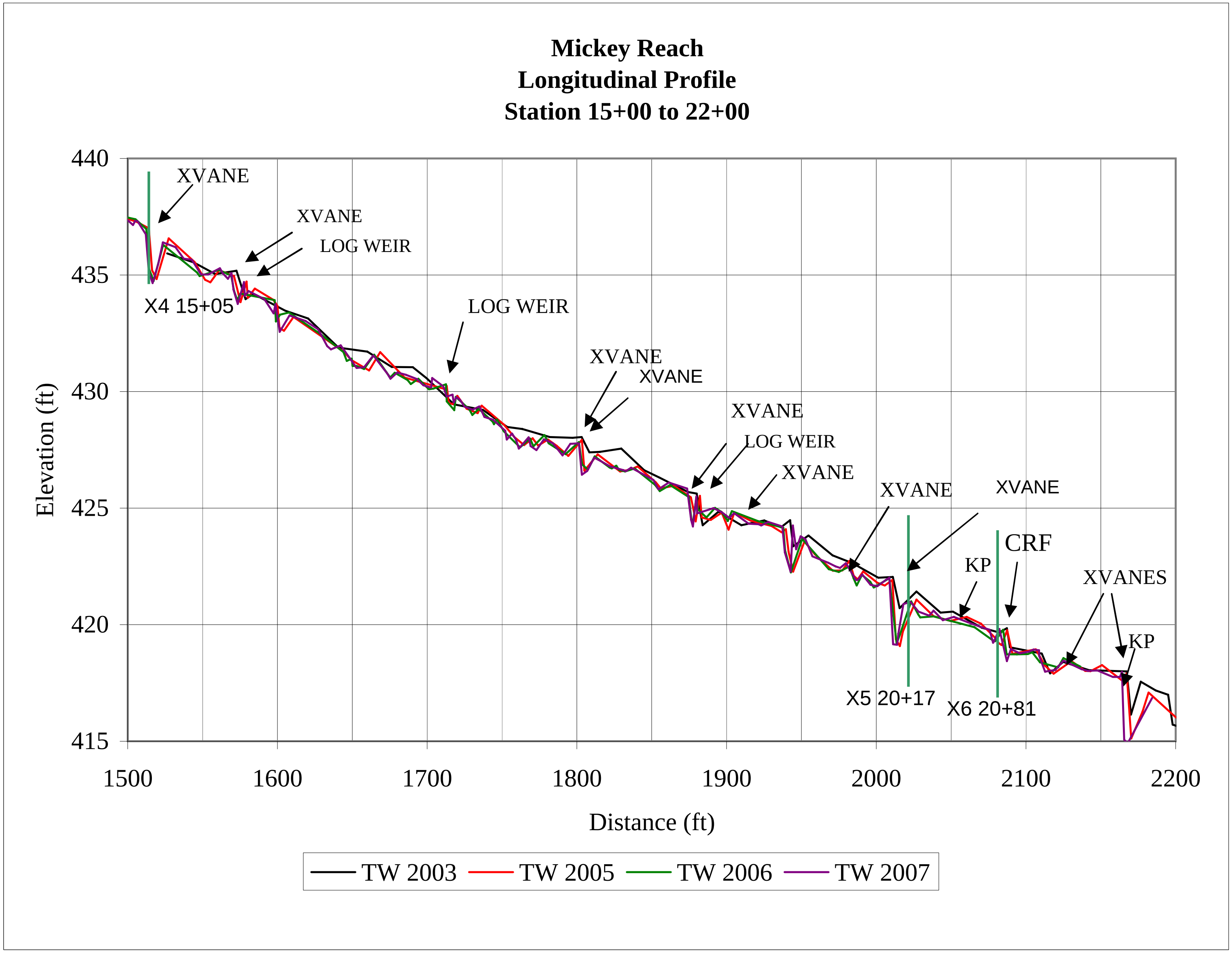

Mickey Reach
Longitudinal Profile
Station 0+00 to 5+00
Elevation (ft)
Distance (ft)
500
495
490
485
480
475
470
465
0
100
200
300
400
500
XVANE
XVANE
XVANE
XVANE
XVANE
XVANE
TW 2003
TW 2005
TW 2006
TW 2007

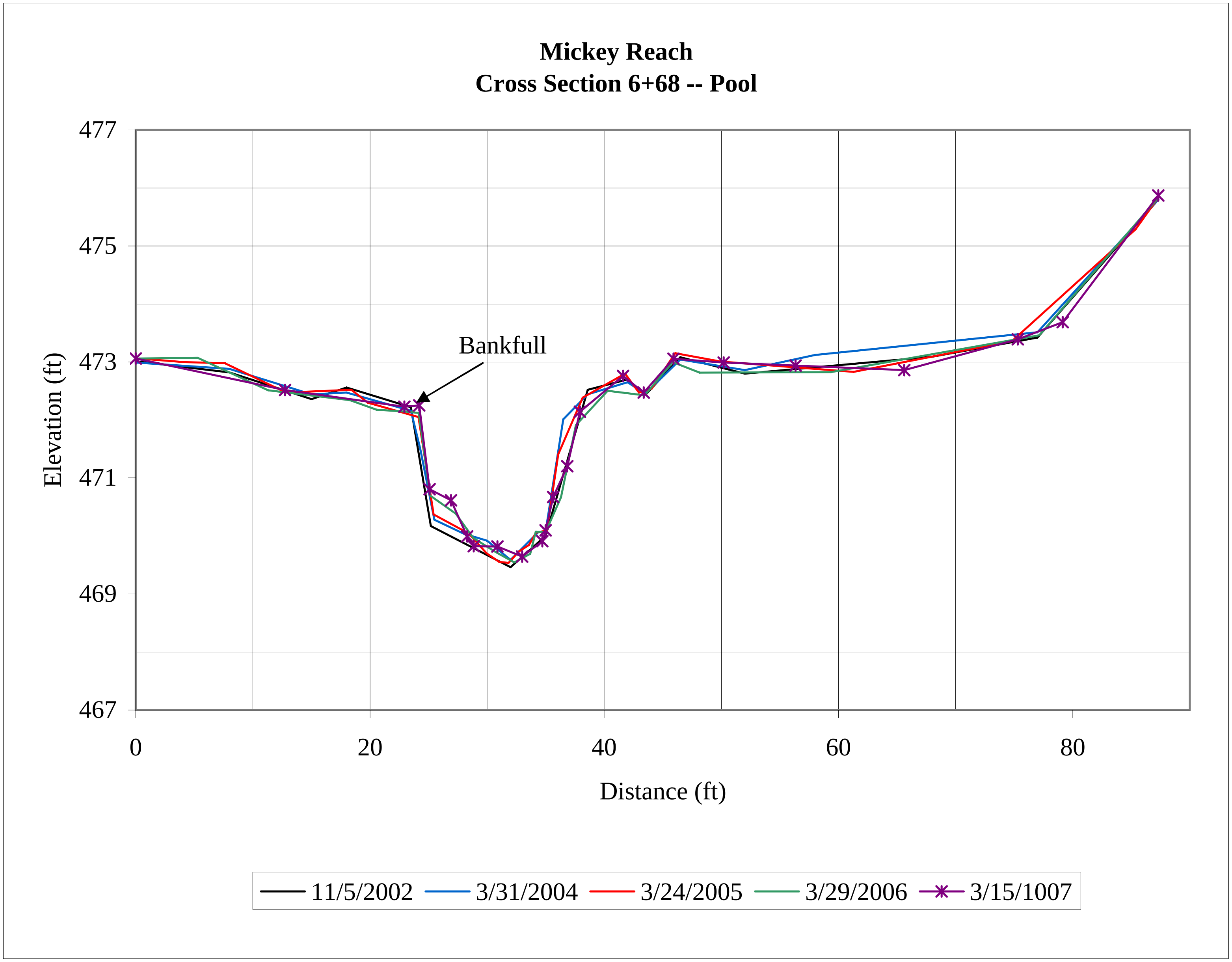


Mickey Reach
Longitudinal Profile
Station 5+00 to 10+00
480
475
470
465
460
455
500
600
700
800
900
1000
Elevation (ft)
Distance (ft)
XVANE
LOG WIER
LOG VANE
XVANE
X2 6+68
XVANE
Debris
XVANE
ROCK VANE
TW 2003
TW 2005
TW 2006
TW 2007

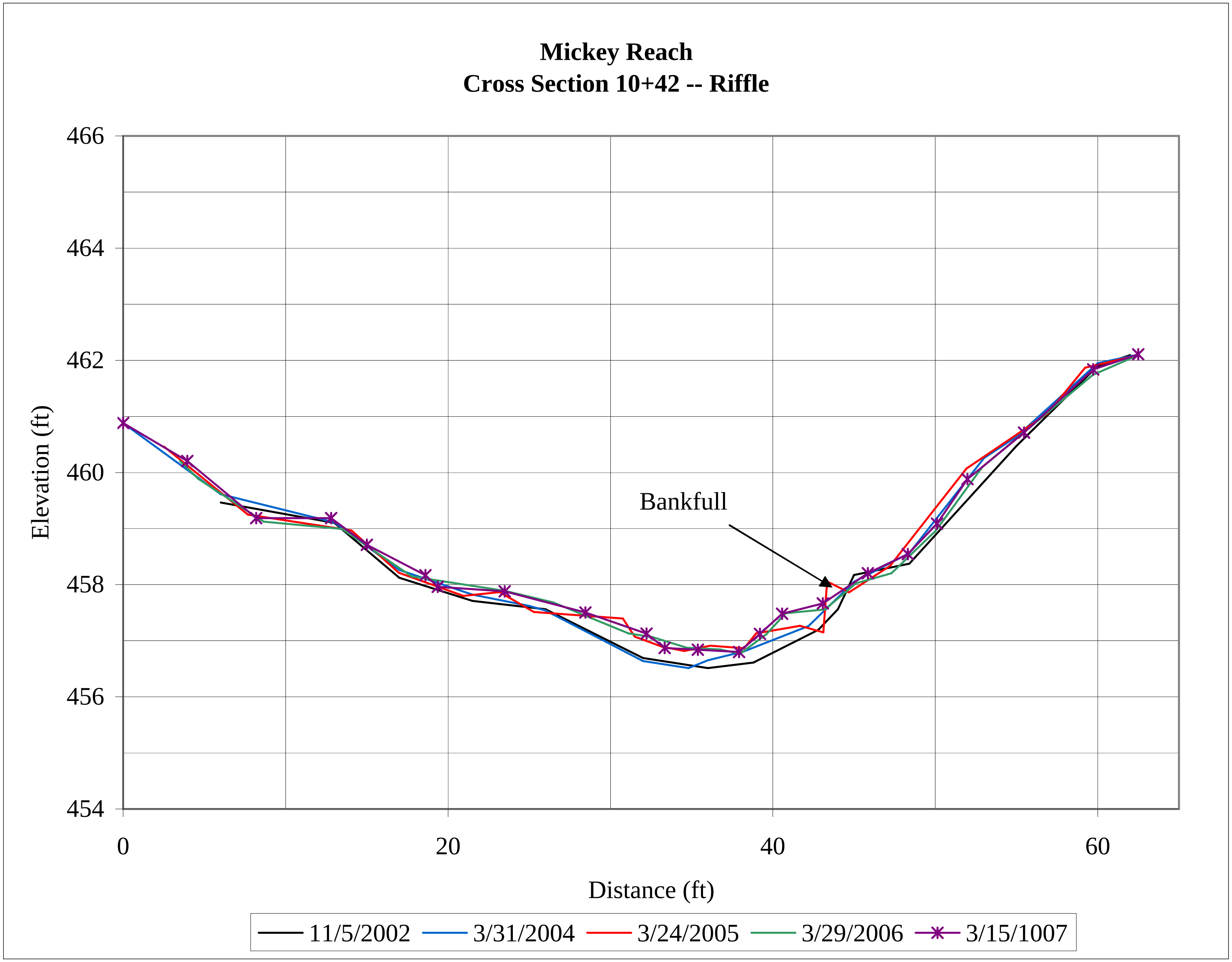


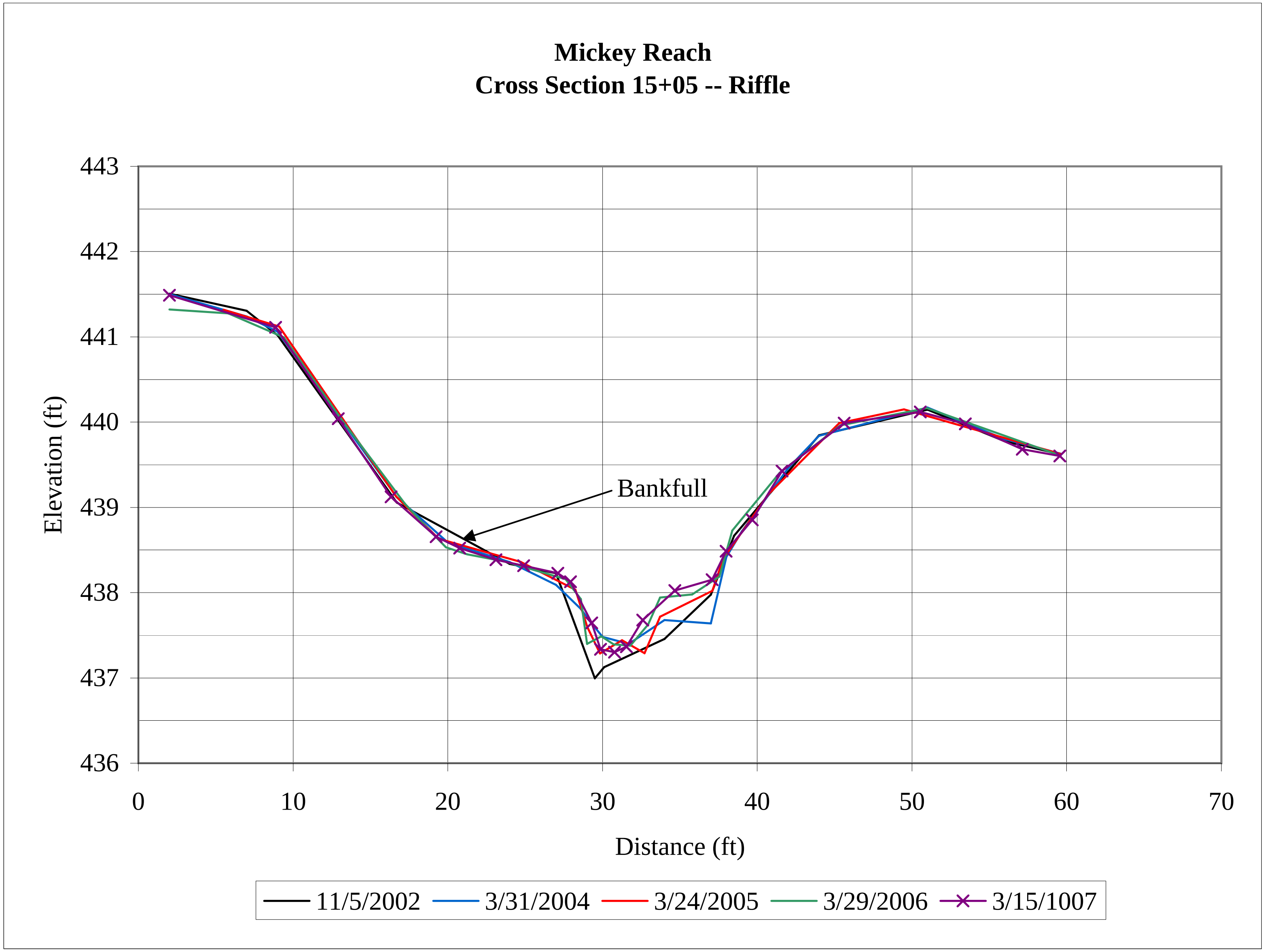
Mickey Reach
Longitudinal Profile
Station 10+00 to 15+00
460
455
450
445
440
435
Elevation (ft)
1000
1100
1200
1300
1400
1500
Distance (ft)
MINI XVANE
XVANE
LOG WIER
ROCK VANE
XVANE
X3 10+42
XVANE
XVANE
XVANE
XVANES
XVANE
TW 2003
TW 2005
TW 2006
TW 2007


Mickey Reach
Longitudinal Profile
Station 15+00 to 22+00
Elevation (ft)
Distance (ft)
440
435
430
425
420
415
1500
1600
1700
1800
1900
2000
2100
2200
XVANE
XVANE
LOG WEIR
X4 15+05
LOG WEIR
XVANE
XVANE
XVANE
LOG WEIR
XVANE
XVANE
XVANE
CRF
KP
XVANES
KP
X5 20+17
X6 20+81
TW 2003
TW 2005
TW 2006
TW 2007



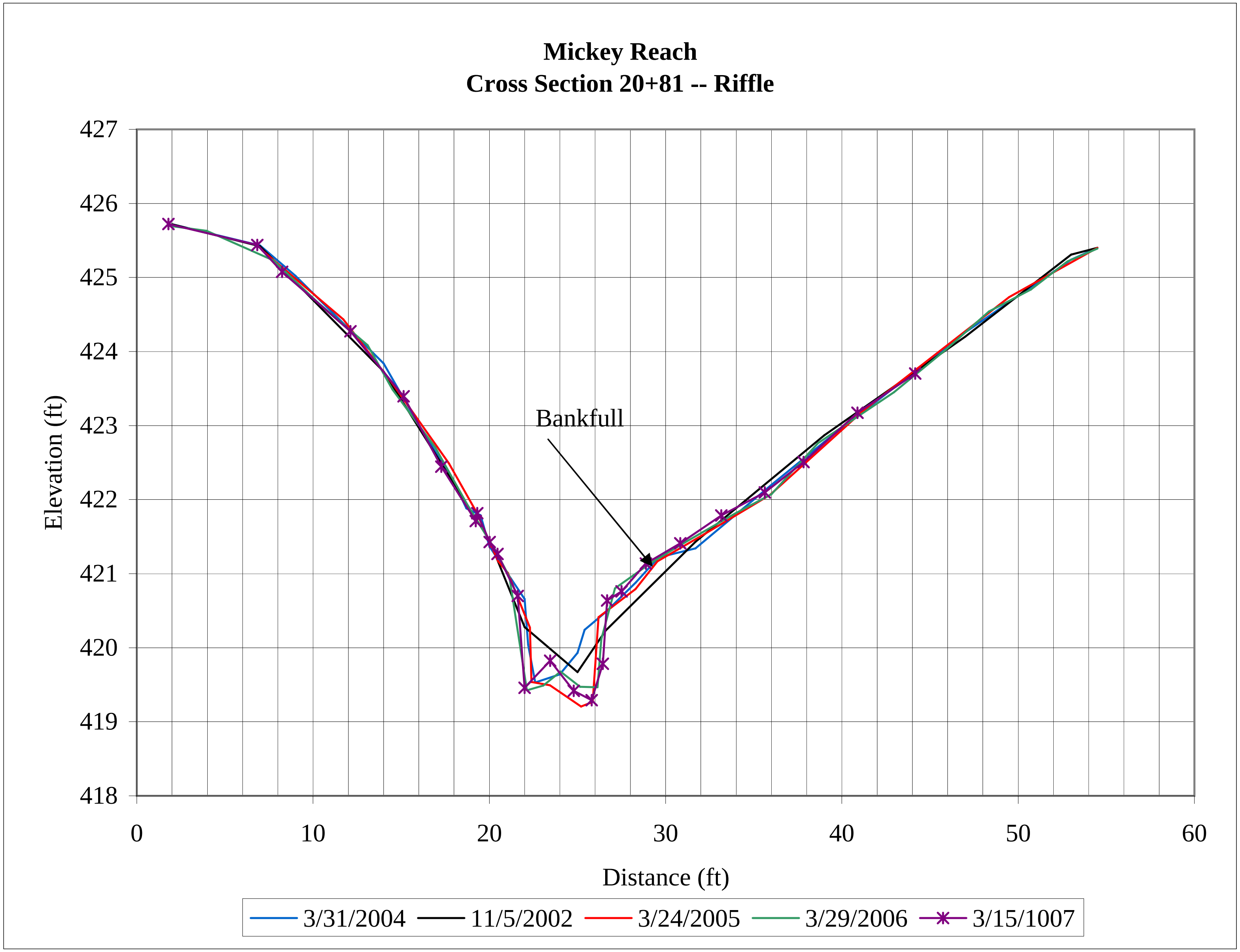
Mickey Reach
Cross Section 6+68 -- Pool
Bankfull
477
475
473
471
469
467
Elevation (ft)
0
20
40
60
80
Distance (ft)
11/5/2002
3/31/2004
3/24/2005
3/29/2006
3/15/1007


Mickey Reach
Cross Section 10+42 -- Riffle
466
464
462
460
458
456
454
Elevation (ft)
0
20
40
60
Distance (ft)
Bankfull
11/5/2002
3/31/2004
3/24/2005
3/29/2006
3/15/1007

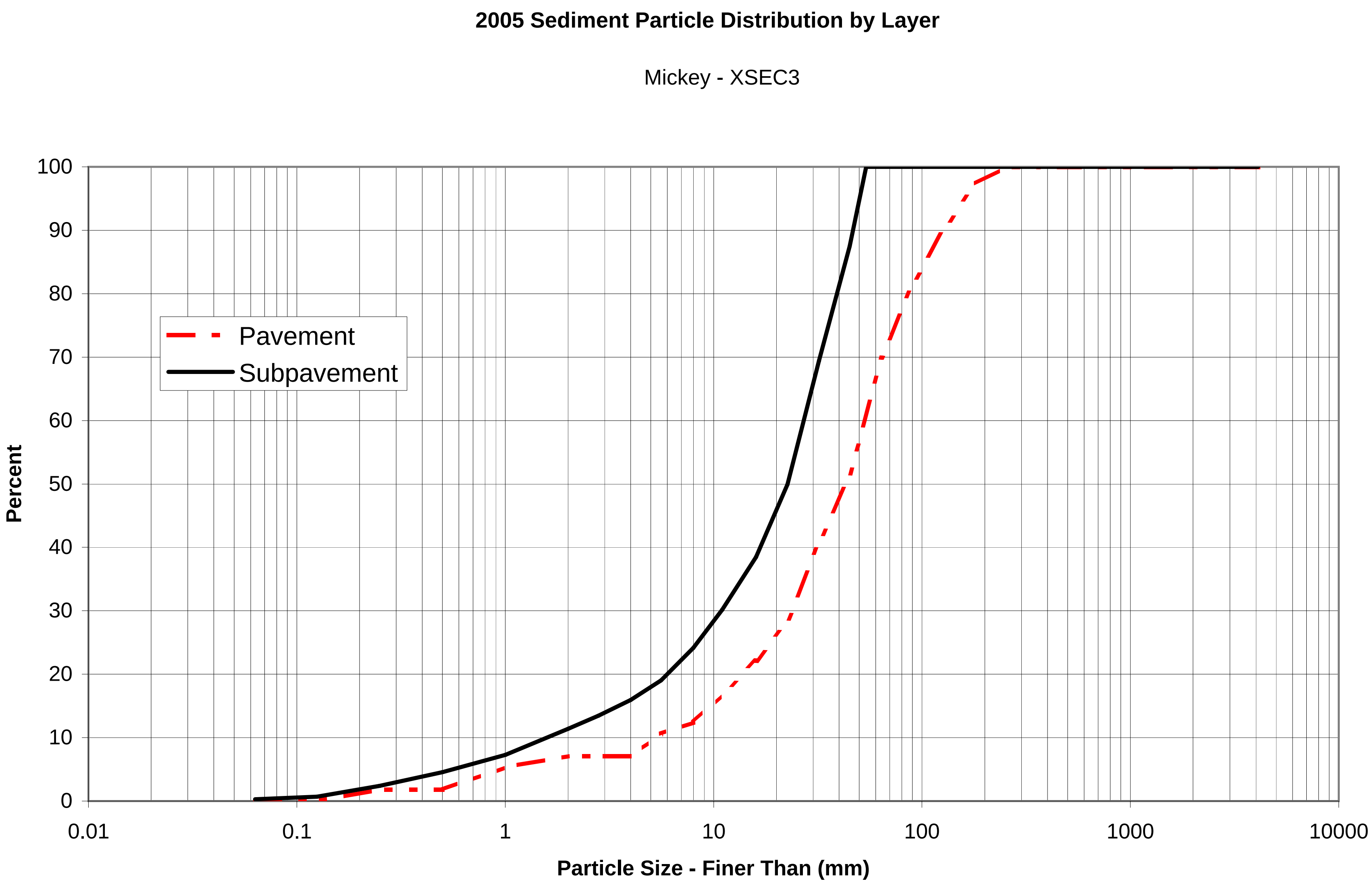


Mickey Reach
Cross Section 15+05 -- Riffle
Elevation (ft)
Distance (ft)
Bankfull
443
442
441
440
439
438
437
436
0
10
20
30
40
50
60
70
11/5/2002
3/31/2004
3/24/2005
3/29/2006
3/15/1007

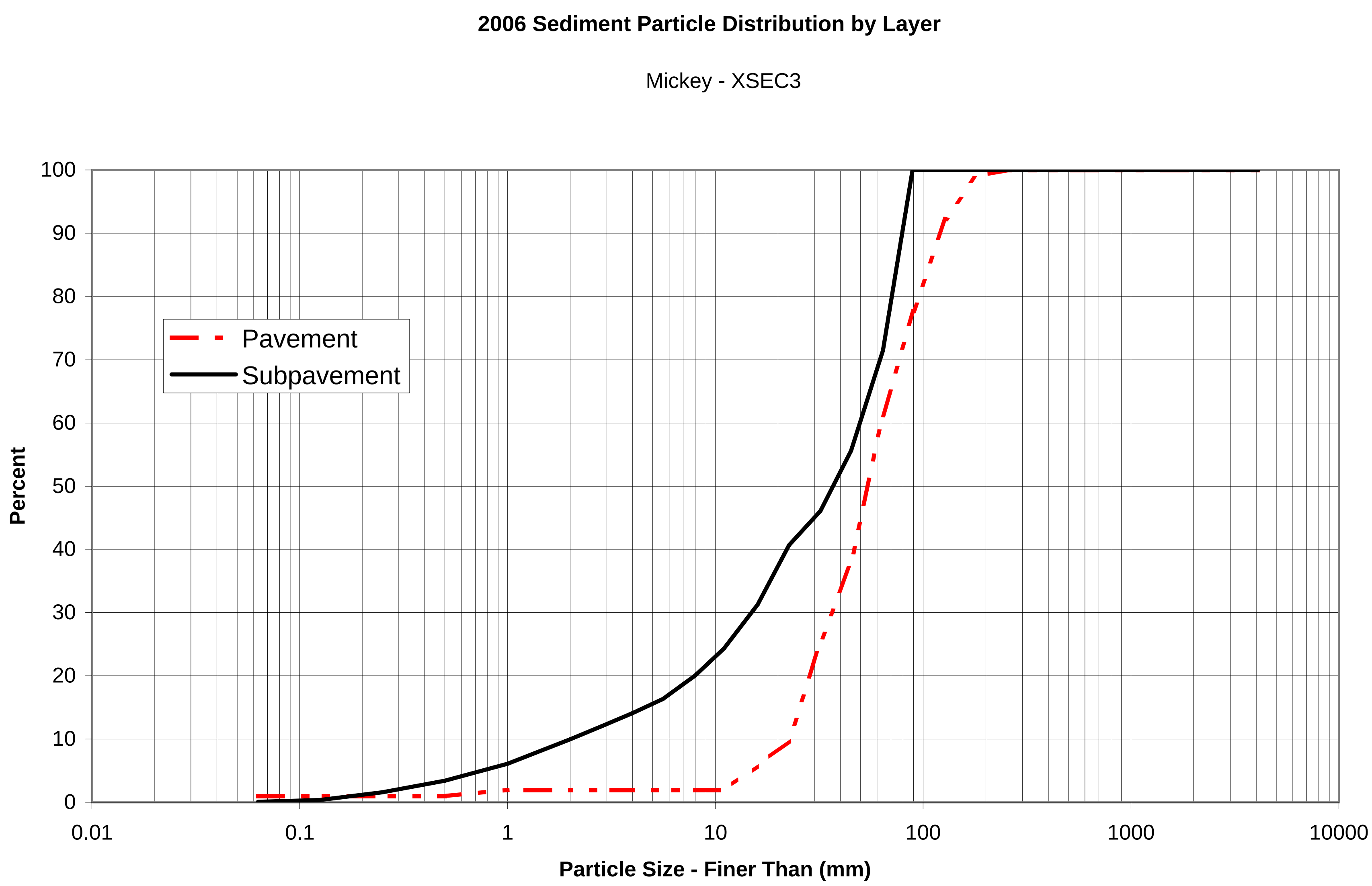
Mickey Reach
Cross Section 20+17 -- Pool
Bankfull
Elevation (ft)
427
426
425
424
423
422
421
420
419
0
10
20
30
40
50
60
Distance (ft)
11/5/2002
3/31/2004
3/24/2005
3/29/2006
3/15/1007



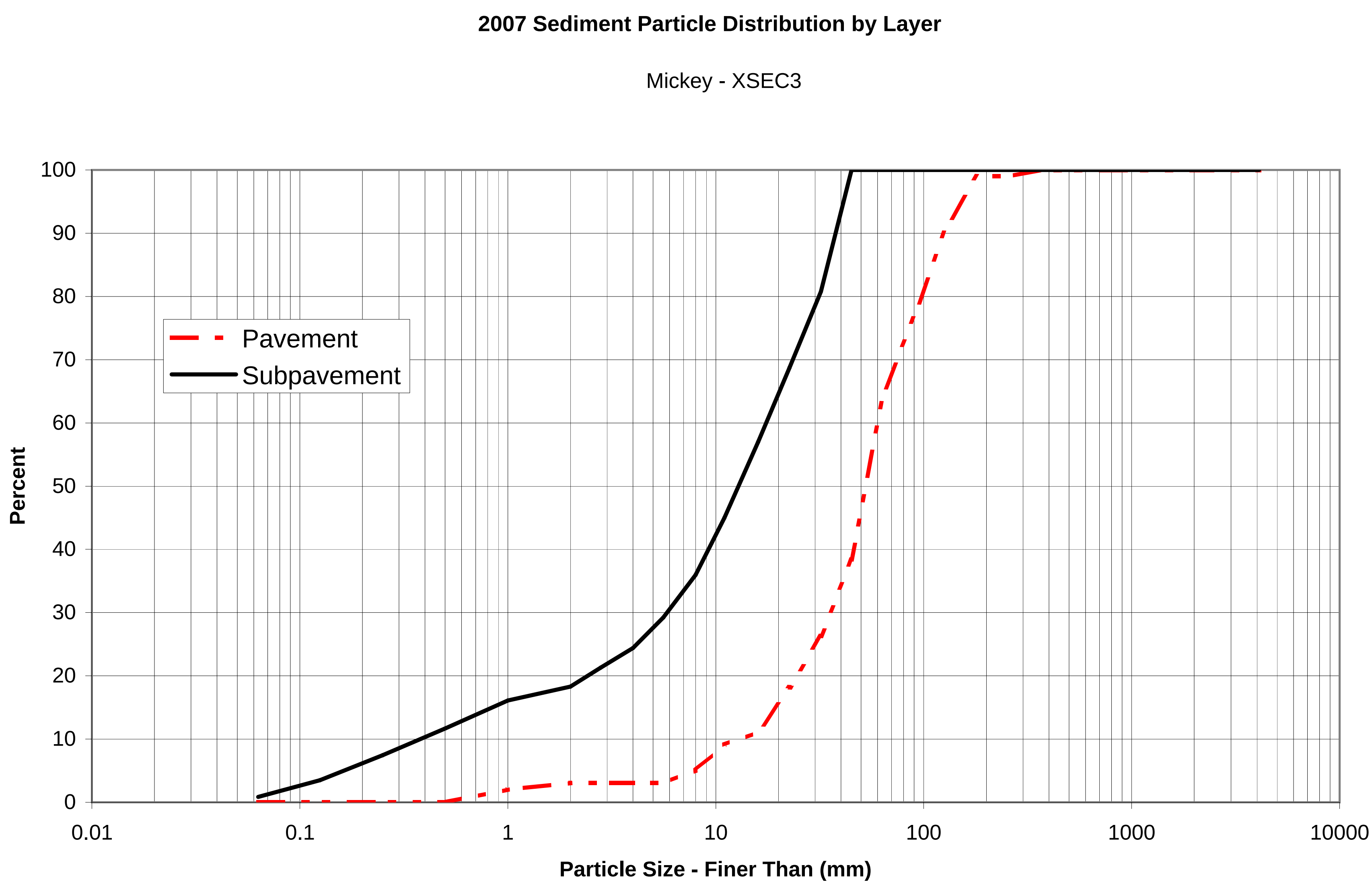
Mickey Reach
Cross Section 20+81 -- Riffle
Elevation (ft)
Distance (ft)
Bankfull
427
426
425
424
423
422
421
420
419
418
0
10
20
30
40
50
60
3/31/2004
11/5/2002
3/24/2005
3/29/2006
3/15/1007

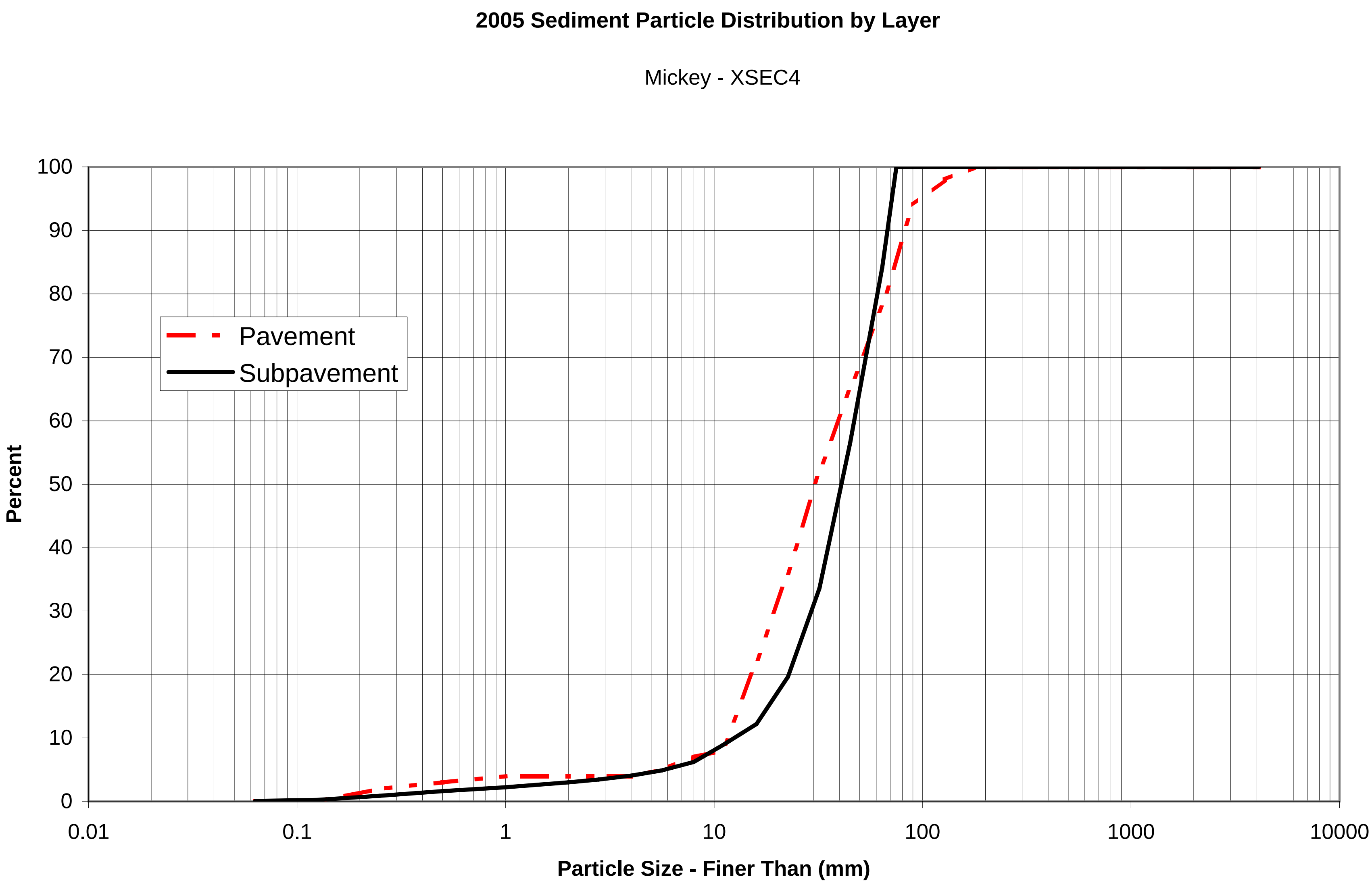


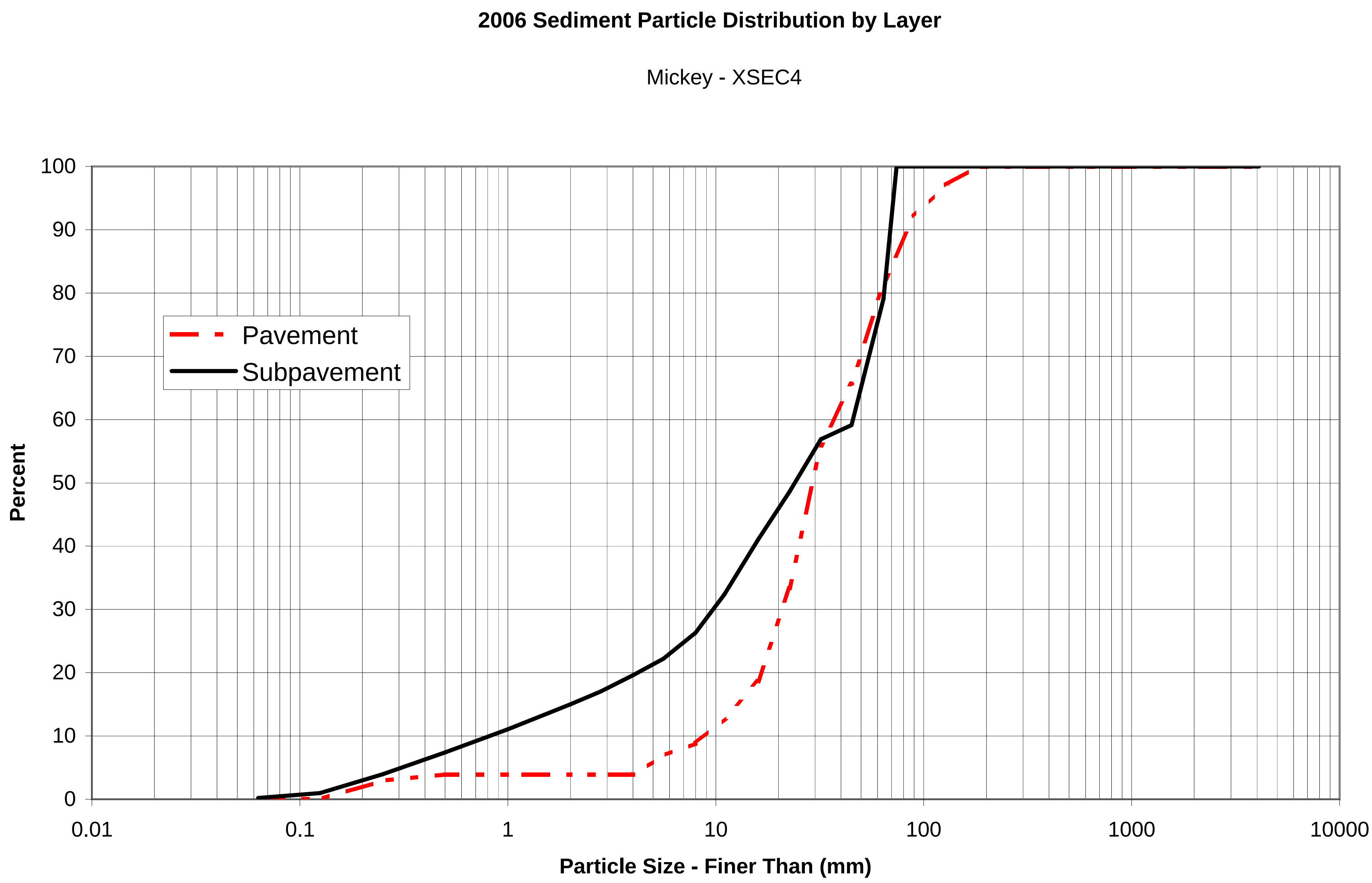
2005 Sediment Particle Distribution by Layer
Mickey - XSEC3
Pavement
Subpavement
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)

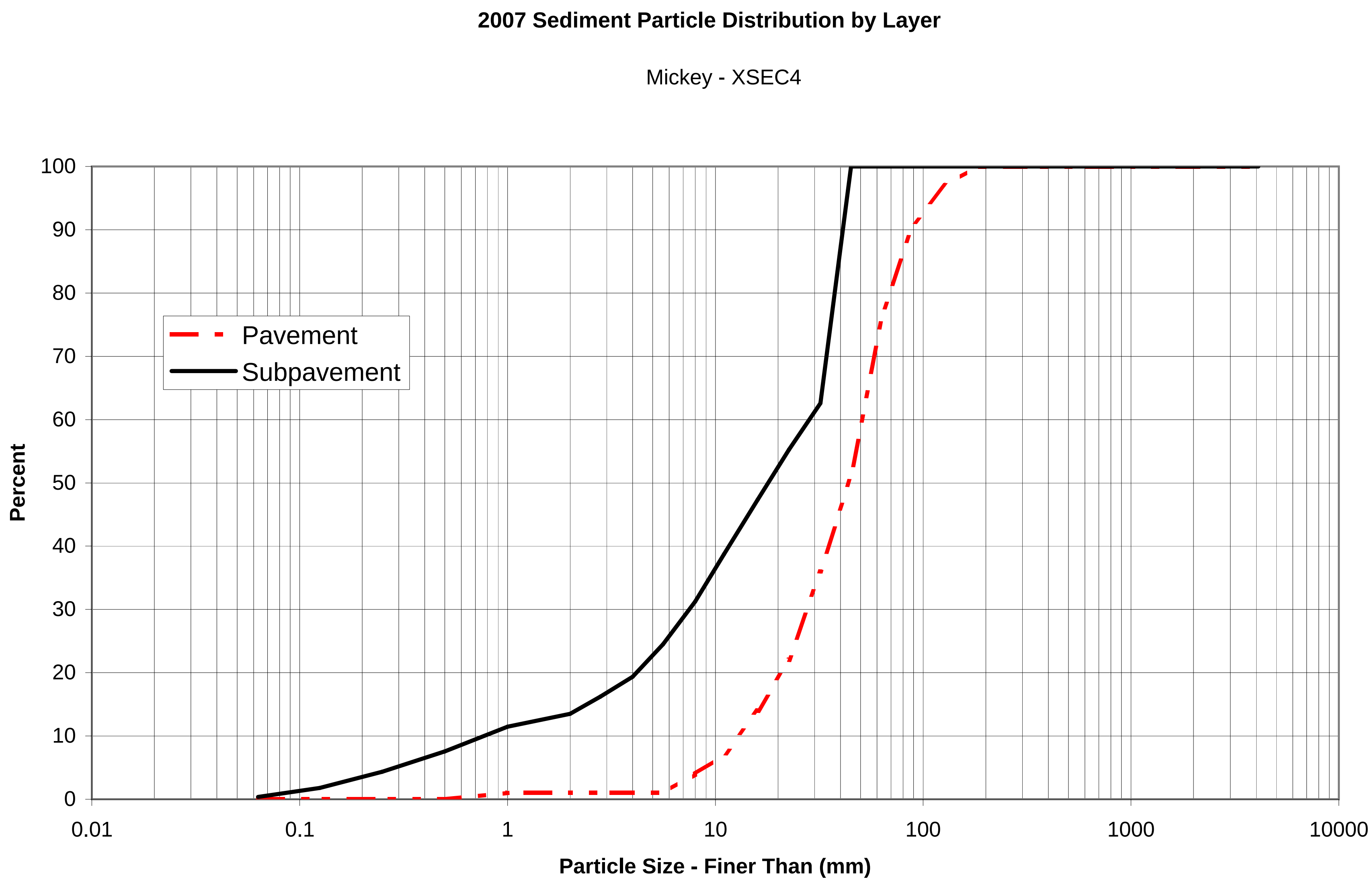


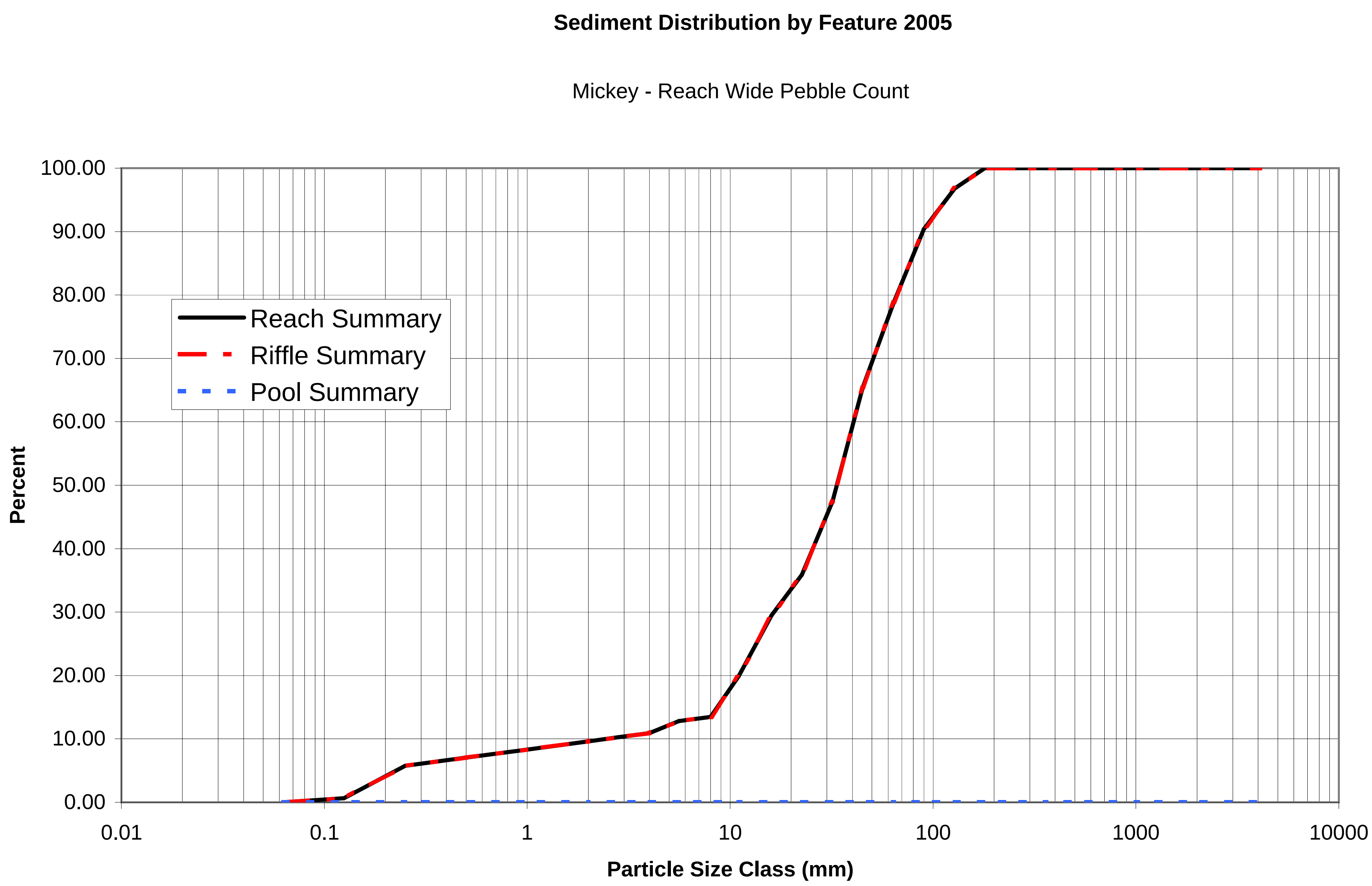
2006 Sediment Particle Distribution by Layer
Mickey - XSEC3
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement

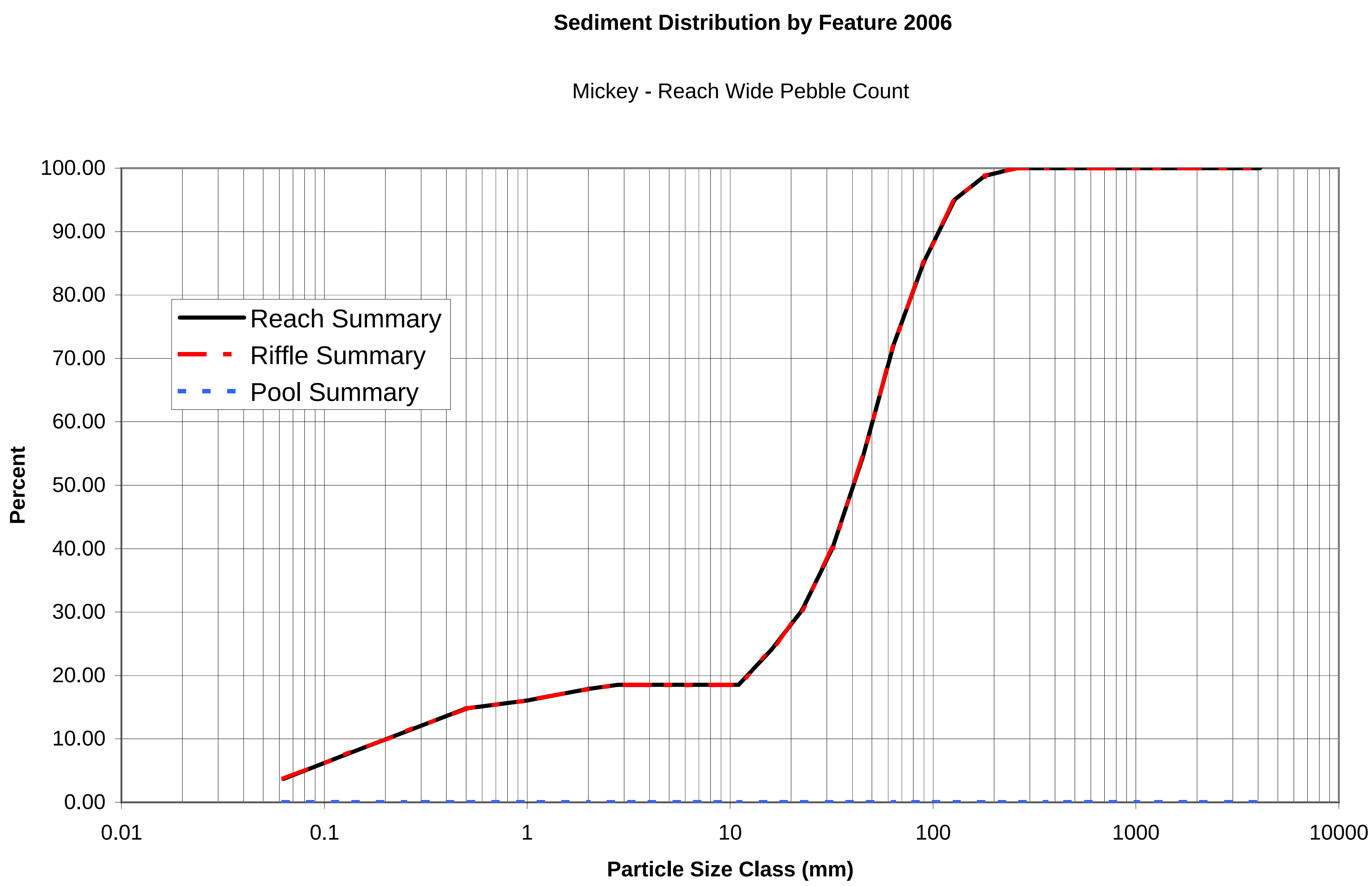

2007 Sediment Particle Distribution by Layer
Mickey - XSEC3
Pavement
Subpavement
Percent
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)


2005 Sediment Particle Distribution by Layer
Mickey - XSEC4
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)
Pavement
Subpavement

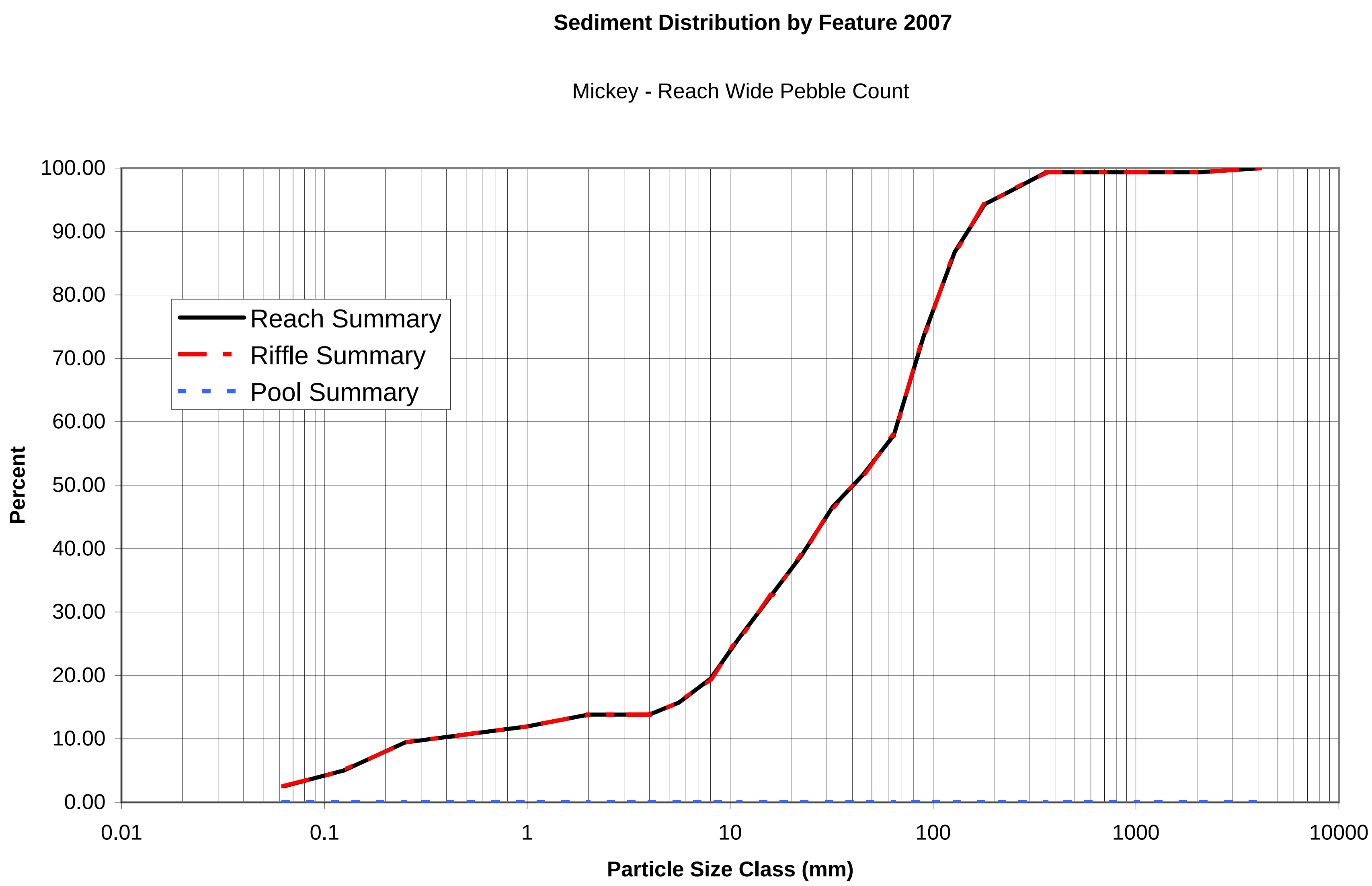

2006 Sediment Particle Distribution by Layer
Mickey - XSEC4
Pavement
Subpavement
Percent
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)


2007 Sediment Particle Distribution by Layer
Mickey - XSEC4
Pavement
Subpavement
Percent
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000
Particle Size - Finer Than (mm)


Sediment Distribution by Feature 2005
Mickey - Reach Wide Pebble Count
Percent
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.01
0.1
1
10
100
1000
10000
Particle Size Class (mm)
Reach Summary
Riffle Summary
Pool Summary



Sediment Distribution by Feature 2006
Mickey - Reach Wide Pebble Count
Percent
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.01
0.1
1
10
100
1000
10000
Particle Size Class (mm)
Reach Summary
Riffle Summary
Pool Summary



Sediment Distribution by Feature 2007
Mickey - Reach Wide Pebble Count
Reach Summary
Riffle Summary
Pool Summary
Percent
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.01
0.1
1
10
100
1000
10000
Particle Size Class (mm)

Mickey Photo Log

001 PP1 200 Dec 02

002 PP1 220 Mar 04

003 PP1 220 Mar 05

004 PP1 220 Mar 06

005 PP1 220 Mar 07

PP2 270 B4 restoration

Mickey Photo Log

PP2 270 Mar 03

PP2 270 Mar 04

PP2 270 Mar 05

PP2 270 Mar 06

PP2 270 Mar 07

PP3 320 Dec 02

Mickey Photo Log

PP3 320 Mar 04

PP3 320 Mar 05

PP3 320 Mar 06

PP3 320 Mar 07

PP4 325 Mar 03

PP4 325 Mar 04

Mickey Photo Log


PP4 325 Mar 05


PP4 325 Mar 06


PP4 325 Mar 07


PP5 350 Jan 03


PP5 350 Mar 03


PP5 350 Mar 04

Mickey Photo Log


PP5 350 Mar 05


PP5 350 Mar 06


PP5 350 Mar 07


PP6 490 Dec 02


PP6 490 Mar 04


PP6 490 Mar 05

Mickey Photo Log

PP7 648 XSEC2 Dec 02

PP7 648 XSEC2 Mar 04

PP7 648 XSEC2 Mar 05

PP7 648 XSEC2 Mar 06

PP7 648 XSEC2 Mar 07c

PP8 675 XSEC2 Mar 04

Mickey Photo Log

PP8 675 XSEC2 Mar 05

PP9 840 Dec 02

PP9 840 Mar 04

PP9 840 Mar 05

PP9 840 Mar 06

PP9 840 Mar 07

Mickey Photo Log

PP10 880 Dec 02_c

PP10 880 Dec 02

PP10 880 Mar 04

PP10 880 Mar 05

PP10 880 Mar 06

PP10 880 Mar 07

Mickey Photo Log

PP11 925 Dec 02

PP11 925 Mar 04

PP11 925 Mar 05

PP11 925 Mar 06

PP11 925 Mar 07

PP12 1025 XSEC3 Mar 04

Mickey Photo Log

PP12 1025 XSEC3 Mar 05

PP12 1025 XSEC3 Mar 06

PP12 1025 XSEC3 Mar 07

PP13 1030 XSEC3 Mar 04

PP13 1030 XSEC3 Mar 05

PP13 1030 XSEC3 Mar 06

Mickey Photo Log

PP13 1030 XSEC3 Mar 07

PP14 1051 Dec 02

PP14 1051 Mar 04

PP14 1051 Mar 05

PP14 1051 Mar 06

PP14 1051 Mar 07

Mickey Photo Log

PP15 1075 Mar 04

PP15 1075 Mar 05

PP15 1075 Mar 05_C

PP15 1075 Mar 06

PP15 1075 Mar 07

PP16 1123 Dec 02

Mickey Photo Log


PP16 1123 Mar 04


PP16 1123 Mar 05


PP16 1123 Mar 06


PP16 1123 Mar 07


PP17 1225 Mar 03


PP17 1225 Oct 03

Mickey Photo Log

PP17 1225 Mar 04

PP17 1225 Mar 05

PP17 1225 Mar 06

PP17 1225 Mar 07

PP18 1382 B4 cxn July 02

PP18 1382 Dec 02

Mickey Photo Log


PP18 1382 Mar 05


PP18 1382 Mar 06


PP18 1382 Mar 07


PP19 1500 B4 cxn July 02


PP19 1500 Mar 07


PP19a 1540 Mar 04

Mickey Photo Log


PP19 1540a Mar 05


PP19 1540a Mar 06


PP19 1540a Mar 07


PP20 2049 XSEC 6 Dec 02


PP20 2049 Mar 04


PP20 2049 Mar05

Mickey Photo Log

PP20 2049 XSEC6 Mar05

PP20 2049 Mar 06

STATE	EEP PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	109664	1	37

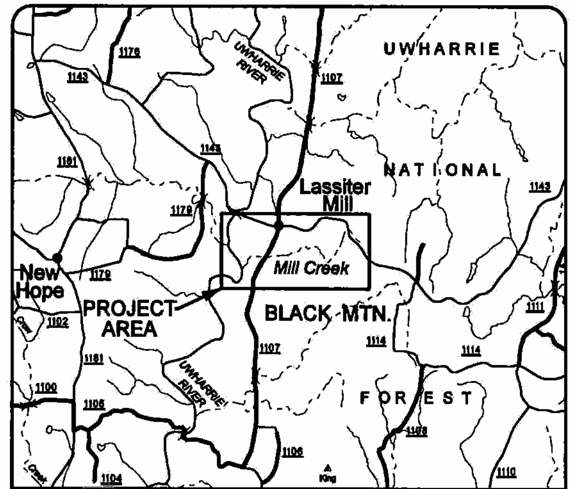
PROJECT: 109664 MILL CREEK

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

RANDOLPH COUNTY

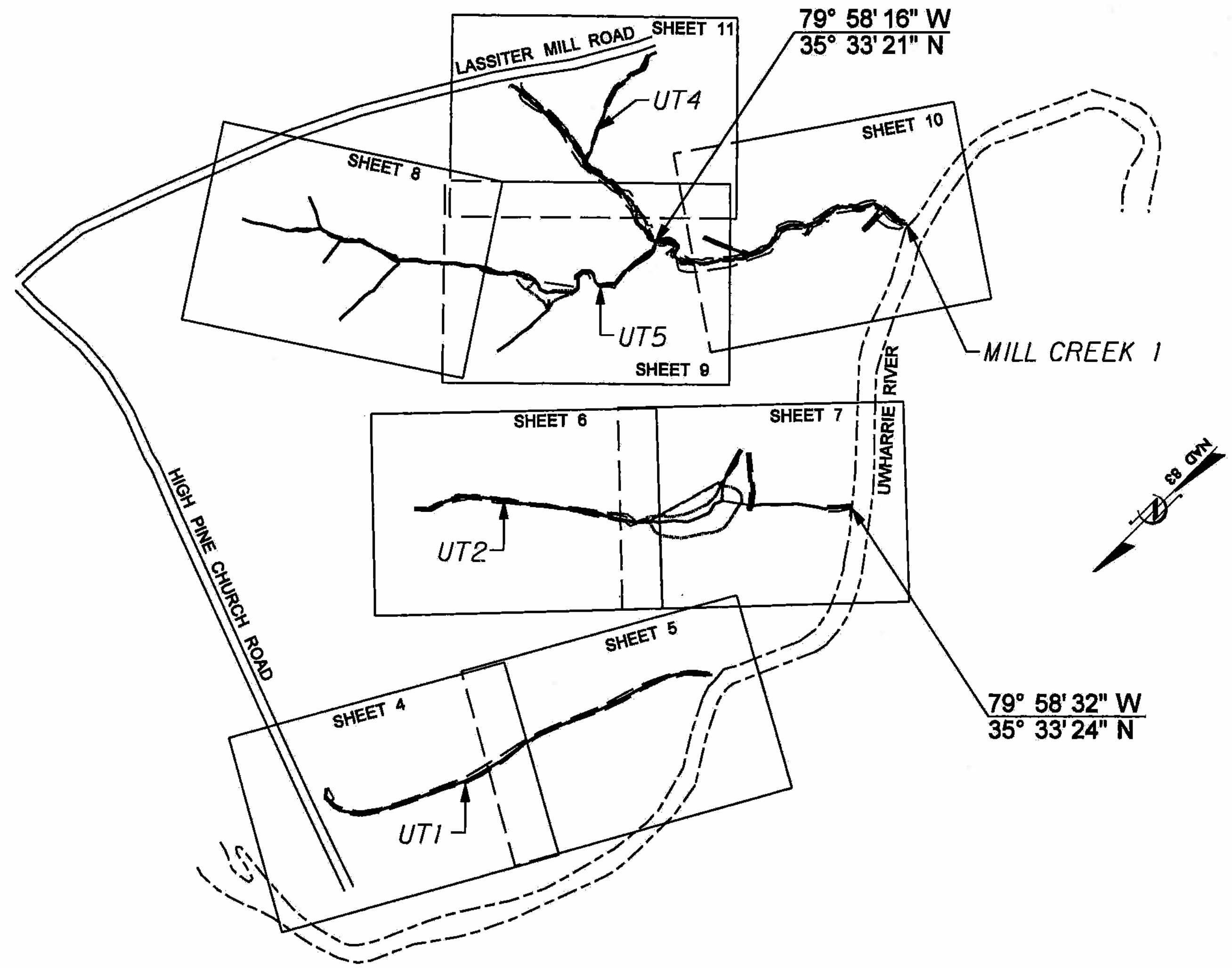
LOCATION: LASSITER MILL - OFF HIGH PINE CHURCH ROAD

TYPE OF WORK: STREAM RESTORATION/ENHANCEMENT/PRESERVATION WETLAND CREATION



VICINITY MAP

INDEX OF SHEETS



GRAPHIC SCALES

40 20 0 40 80
PLANS

40 20 0 40 80
PROFILE (HORIZONTAL)

5 0 5 10
PROFILE (VERTICAL)

DESIGN DATA

EXISTING STREAM LENGTH	= 21,644 FEET
PROPOSED RESTORATION STREAM LENGTH	= 983 FEET
PROPOSED ENHANCEMENT STREAM LENGTH	= 4,859 FEET
PROPOSED PRESERVATION STREAM LENGTH	= 15,802 FEET
PROPOSED RIVERINE WETLAND CREATION	= 1.10 AC

PREPARED FOR THE OFFICE OF:

Ecosystem Enhancement PROGRAM

CONTACT: WATSON ROSS
PROJECT MANAGER

PREPARED IN THE OFFICE OF:

Baker
Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490

SUMMER '08
LETTING DATE:

KEVIN TWEEDY, PE
PROJECT ENGINEER

WARD ELIS
PROJECT MANAGER

JOSHUA WHITE, PG
PROJECT DESIGNER

PROJECT ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

SIGNATURE: P.E.

STREAM CONVENTIONAL SYMBOLS
SUPERCEDES SHEET 1B

ROCK J-HOOK	SAFETY FENCE
ROCK VANE	TAPE FENCE
OUTLET PROTECTION	100 YEAR FLOOD PLAIN
ROCK CROSS VANE	CONSERVATION EASEMENT
DOUBLE DROP ROCK CROSS VANE	EXISTING MAJOR CONTOUR
SINGLE WING DEFLECTOR	EXISTING MINOR CONTOUR
DOUBLE WING DEFLECTOR	FOOT BRIDGE
TEMPORARY SILT CHECK	TEMPORARY STREAM CROSSING
ROOT WAD	PERMANENT STREAM CROSSING
LOG J-HOOK	TRANSPLANTED VEGETATION
LOG VANE	TREE REMOVAL
LOG WEIR	TREE PROTECTION
LOG CROSS VANE	DITCH PLUG
CONSTRUCTED RIFFLE	
BOULDER CLUSTER	
ROCK STEP POOL	

**NOTE: ALL ITEMS ABOVE MAY NOT BE USED ON THIS PROJECT

GENERAL NOTES

1. THE CONTRACTOR IS REQUIRED TO INSTALL INSTREAM STRUCTURES USING A TRACK HOE WITH A HYDRAULIC THUMB OF SUFFICIENT SIZE TO PLACE BOULDERS 5' X 4' X 3', LOGS, AND ROOTWADS.
2. WORK IS BEING PERFORMED AS AN ENVIRONMENTAL RESTORATION PLAN. THE CONTRACTOR SHOULD MAKE ALL REASONABLE EFFORTS TO REDUCE SEDIMENT LOSS AND MINIMIZE DISTURBANCE OF THE SITE WHILE PERFORMING THE CONSTRUCTION WORK.
3. CONSTRUCTION IS SCHEDULED TO BEGIN WINTER 2007.
4. CONTRACTOR SHOULD CALL NORTH CAROLINA "ON-CALL" BEFORE EXCAVATION STARTS. (1-800-632-4949)

PROJECT REFERENCE NO.	SHEET NO.
109664	1-A

PROJECT ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

Baker

Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
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STANDARD SPECIFICATIONS

EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL DECEMBER 1993

6.06 CONSTRUCTION ENTRANCE

6.62 SILT FENCE

6.63 ROCK DAM

VEGETATION SELECTION

BARE-ROOT VEGETATION

The following table lists bare-root vegetation selection for the project site. Species shall be planted at a density of 460 stems per acre. Exact placement of species will be determined prior to site planting and based on apparent wetness of planting locations.

Common Name	Scientific Name	Percent Planted by Species	Planting Density
	Stream Restoration Buffer		
River Birch	*Betula nigra*	15%	42 stems per acre
Sugarberry	*Celtis laevigata*	5%	14 stems per acre
Green Ash	*Fraxinus pennsylvanica*	10%	28 stems per acre
Black Walnut	*Juglans nigra*	5%	14 stems per acre
Sycamore	*Platanus occidentalis*	20%	56 stems per acre
Swamp Chestnut Oak	*Quercus michauxii*	10%	28 stems per acre
Willow Oak	*Quercus phellos*	8%	22 stems per acre
Northern Red Oak	*Quercus rubra*	7%	19 stems per acre
Persimmon	*Diospyros virginiana*	10%	28 stems per acre
Black Gum	*Nyssa sylvatica*	10%	28 stems per acre
	Early Successional Shrubs and Trees		
Coralberry	*Symphoricarpos orbiculatus*	5%	9 stems per acre
Southern Arrowwood	*Viburnum dentatum*	10%	18 stems per acre
Virginia Sweetspire	*Itea virginica*	5%	9 stems per acre
Common Elderberry	*Sambucus Canadensis*	10%	18 stems per acre
Chicksaw Plum	*Prunus augustifolia*	5%	9 stems per acre
Common Winterberry	*Ilex verticillata*	10%	18 stems per acre
Silky Dogwood	*Cornus amomum*	15%	27 stems per acre
Flowering Dogwood	*Cornus florida*	15%	27 stems per acre
Eastern Redbud	*Cercis canadensis*	10%	18 stems per acre
Swamp Rose	*Rosa palustris*	10%	18 stems per acre
Parsely-leaf Hawthorn	*Crataegus marshallii*	5%	9 stems per acre

BARE-ROOT WETLAND VEGETATION

The following table lists bare-root vegetation selection for the project site. Species shall be planted at a density of 460 stems per acre. Exact placement of species will be determined prior to site planting and based on apparent wetness of planting locations.

Green Ash	*Fraxinus pennsylvanica*	20%	92 stems per acre
Sycamore	*Platanus occidentalis*	20%	92 stems per acre
Sugarberry	*Celtis laevigata*	10%	46 stems per acre
Cottonwood	*Populus deltoidies*	5%	23 stems per acre
Overcup Oak	*Quercus lyrata*	15%	69 stems per acre
Tag Alder	*Alnus serrulata*	15%	69 stems per acre
Silky Dogwood	*Cornus amomum*	15%	69 stems per acre

LIVE STAKING

Live staking will be applied to all restored streambanks following the details in this plan set and according to the construction specifications.

Silky Willow	*Salix sericea*	30%	1452 stems per acre
Black Willow	*Salix nigra*	10%	484 stems per acre
Silky Dogwood	*Cornus amomum*	40%	1936 stems per acre
Elderberry	*Sambucus canadensis*	20%	968 stems per acre

TEMPORARY SEEDING

The following table temporary seed mix for the project site. All disturbed areas will be stabilized using mulch and temporary seed.

Common Name	Rate	Dates
ANNUAL RYE (COOL SEASON)	70 LBS/ACRE	SEPTEMBER TO MARCH
MILLET (WARM SEASON)	25 LBS/ACRE	APRIL TO AUGUST

PERMANENT SEEDING

Permanent seed mixtures for the restoration site. Permanent see mixtures shall be applied with temporary seed, as defined in the construction specifications.

Common Name	Scientific Name	Percent of Mixture	Seeding Density (lbs/acre)	Wetness Tolerance
	Streambank, Floodplain and Wetland Areas			
Big bluestem	*Andropogon gerardii*	5%	0.8	FAC
Tick seed	*Bidens frondosa*	8%	1.3	FACW
Hop sedge	*Carex lupulina*	5%	0.8	OBL
Shallow sedge	*Carex lurida*	5%	0.8	OBL
Tussock sedge	*Carex stricta*	5%	0.8	OBL
Fox sedge	*Carex vulpinoidea*	5%	0.8	OBL
River oats	*Chasmanthium latifolium*	5%	0.8	FAC-
Lance leaf coreopsis	*Coreopsis lanceolata*	5%	0.8	FACU
Virginia wildrye	*Elymus virginicus*	15%	2.4	FAC
Purple lovegrass	*Eragrostis spectabilis*	2%	0.3	FACU
Soft rush	*Juncus effusus*	5%	0.8	FACW+
Pink Muhly grass	*Muhlenbergia capillaris*	2%	0.3	FACU
Switchgrass	*Panicum virgatum*	10%	1.6	FAC+
Pennsylvania Smartweed	*Polygonum pennsylvanicum*	8%	1.3	FACW
Little bluestem	*Schizachyrium scoparium*	5%	0.8	FACU
Indian grass	*Sorgastrum nutans*	5%	0.8	FACU
Gamma grass	*Tripsicum dactyloides*	5%	0.8	FAC+

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PROJECT REFERENCE NO.	SHEET NO.
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*S.U.E = SUBSURFACE UTILITY ENGINEER

STATE OF NORTH CAROLINA
DIVISION OF HIGHWAYS
CONVENTIONAL SYMBOLS

ROADS & RELATED ITEMS

- Edge of Pavement
- Curb
- Prop. Slope Stakes Cut — C
- Prop. Slope Stakes Fill — F
- Prop. Woven Wire Fence
- Prop. Chain Link Fence
- Prop. Barbed Wire Fence
- Prop. Wheelchair Ramp — WCR
- Curb Cut for Future Wheelchair Ramp — CCFR
- Exist. Guardrail
- Prop. Guardrail
- Equality Symbol
- Pavement Removal

RIGHT OF WAY

- Baseline Control Point
- Existing Right of Way Marker
- Exist. Right of Way Line w/Marker
- Prop. Right of Way Line with Proposed R/W Marker (Iron Pin & Cap)
- Prop. Right of Way Line with Proposed (Concrete or Granite) R/W Marker
- Exist. Control of Access Line — C/A
- Prop. Control of Access Line
- Exist. Easement Line — E
- Prop. Temp. Construction Easement Line — E
- Prop. Temp. Drainage Easement Line — TDE
- Prop. Perm. Drainage Easement Line — PDE

HYDROLOGY

- Stream or Body of Water
- River Basin Buffer — RBB
- Flow Arrow
- Disappearing Stream
- Spring
- Swamp Marsh
- Shoreline
- Falls, Rapids
- Prop Lateral, Tail, Head Ditches — FLOW

STRUCTURES

MAJOR

- Bridge, Tunnel, or Box Culvert — CONC
- Bridge Wing Wall, Head Wall and End Wall — CONC WW

MINOR

- Head & End Wall — CONC HW
- Pipe Culvert
- Footbridge
- Drainage Boxes — CB
- Paved Ditch Gutter

UTILITIES

- Exist. Pole
- Exist. Power Pole
- Prop. Power Pole
- Exist. Telephone Pole
- Prop. Telephone Pole
- Exist. Joint Use Pole
- Prop. Joint Use Pole
- Telephone Pedestal
- U/G Telephone Cable Hand Hold
- Cable TV Pedestal
- U/G TV Cable Hand Hold
- U/G Power Cable Hand Hold
- Hydrant
- Satellite Dish
- Exist. Water Valve
- Sewer Clean Out
- Power Manhole
- Telephone Booth
- Cellular Telephone Tower
- Water Manhole
- Light Pole
- H-Frame Pole
- Power Line Tower
- Pole with Base
- Gas Valve
- Gas Meter
- Telephone Manhole
- Power Transformer
- Sanitary Sewer Manhole
- Storm Sewer Manhole
- Tank; Water, Gas, Oil
- Water Tank With Legs
- Traffic Signal Junction Box
- Fiber Optic Splice Box
- Television or Radio Tower
- Utility Power Line Connects to Traffic Signal Lines Cut Into the Pavement — TS
- Recorded Water Line
- Designated Water Line (S.U.E.*)
- Sanitary Sewer — SS
- Recorded Sanitary Sewer Force Main — FSS
- Designated Sanitary Sewer Force Main(S.U.E.*) — FSS
- Recorded Gas Line — G
- Designated Gas Line (S.U.E.*) — G
- Storm Sewer — S
- Recorded Power Line — P
- Designated Power Line (S.U.E.*) — P
- Recorded Telephone Cable — T
- Designated Telephone Cable (S.U.E.*) — T
- Recorded U/G Telephone Conduit — TC
- Designated U/G Telephone Conduit (S.U.E.*) — TC
- Unknown Utility (S.U.E.*) — ?UTL
- Recorded Television Cable — TV
- Designated Television Cable (S.U.E.*) — TV
- Recorded Fiber Optics Cable — FO
- Designated Fiber Optics Cable (S.U.E.*) — FO
- Exist. Water Meter
- U/G Test Hole (S.U.E.*)
- Abandoned According to U/G Record — ATTUR
- End of Information — E.O.I.

BOUNDARIES & PROPERTIES

- State Line
- County Line
- Township Line
- City Line
- Reservation Line
- Property Line
- Property Line Symbol — PL
- Exist. Iron Pin — EIP
- Property Corner
- Property Monument — ECM
- Property Number — 123
- Parcel Number — 6
- Fence Line — WW & ISBW
- Existing Wetland Boundaries — WLB
- High Quality Wetland Boundary — HQ WLB
- Medium Quality Wetland Boundaries — MQ WLB
- Low Quality Wetland Boundaries — LQ WLB
- Proposed Wetland Boundaries — WLB
- Existing Endangered Animal Boundaries — EAB
- Existing Endangered Plant Boundaries — EPB

BUILDINGS & OTHER CULTURE

- Buildings
- Foundations
- Area Outline
- Gate
- Gas Pump Vent or U/G Tank Cap
- Church
- School
- Park
- Cemetery
- Dam
- Sign — S
- Well — W
- Small Mine
- Swimming Pool

TOPOGRAPHY

- Loose Surface
- Hard Surface
- Change in Road Surface
- Curb
- Right of Way Symbol — R/W
- Guard Post — GP
- Paved Walk
- Bridge
- Box Culvert or Tunnel
- Ferry
- Culvert
- Footbridge
- Trail, Footpath
- Light House

VEGETATION

- Single Tree
- Single Shrub
- Hedge
- Woods Line
- Orchard
- Vineyard — VINEYARD

RAILROADS

- Standard Gauge — CSX TRANSPORTATION
- RR Signal Milepost — MILEPOST 35
- Switch — SWITCH

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2/26/03

PROJECT REFERENCE NO.	SHEET NO.
109664	2

PROJECT ENGINEER

PRELIMINARY PLANS
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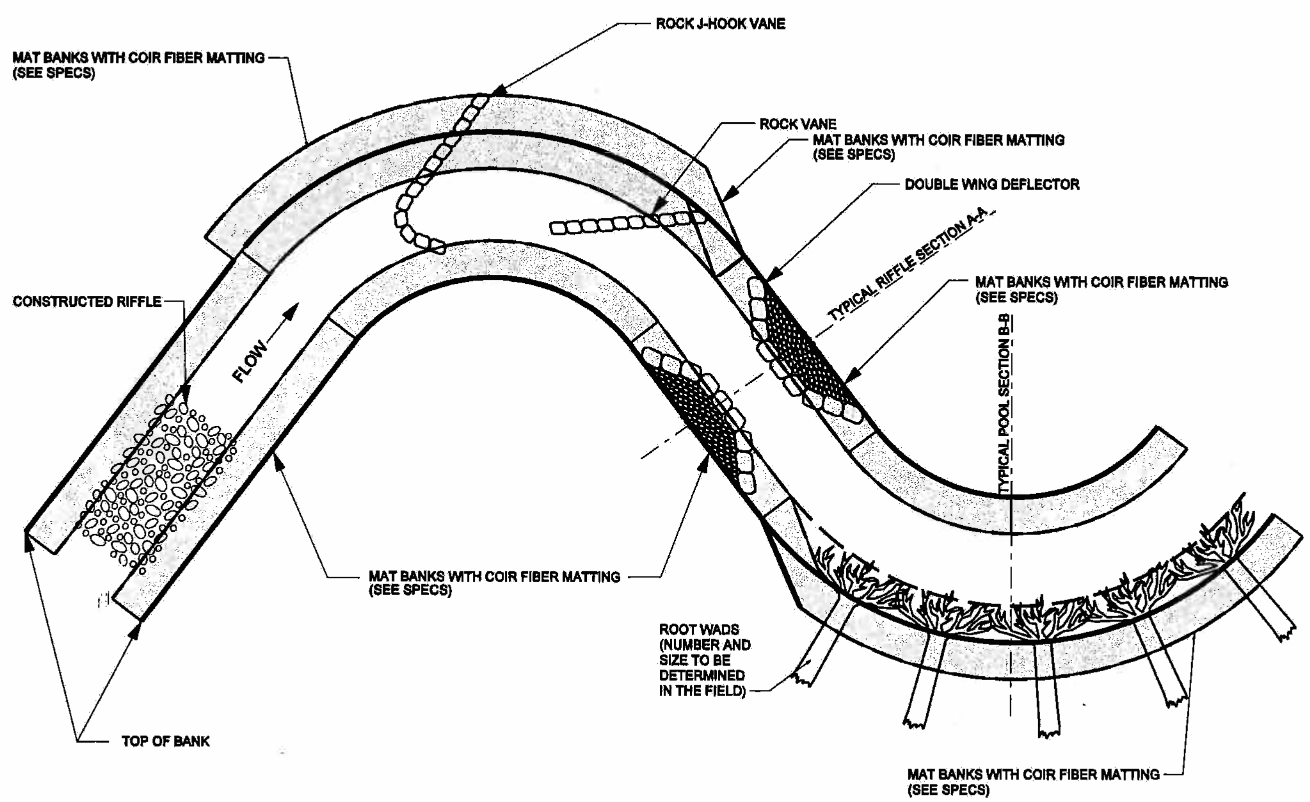
TYPICAL STRUCTURE PLACEMENT

STRUCTURE NOTES:

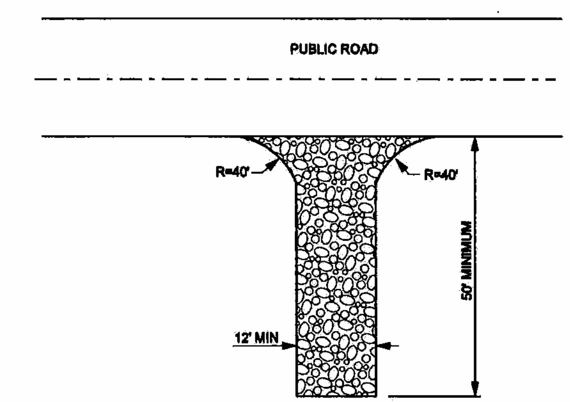
1. GENERALLY D-WING DEFLECTOR, J-HOOKS, ROOT WADS, VANES, CONSTRUCTED RIFFLES AND COIR FIBER MATTING WILL BE INSTALLED IN THE LOCATION AND SEQUENCE AS SHOWN.
2. ADDITIONAL STRUCTURES OR CHANGES TO STRUCTURE LOCATIONS MAY BE MADE BY THE DESIGN ENGINEER DURING CONSTRUCTION.

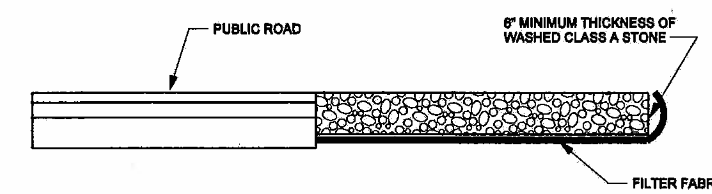
NOTES:

1. COIR FIBER MATTING TO BE INSTALLED ON ALL RESTORED STREAMBANKS.
2. IF ROOT WADS DO NOT COVER ENTIRE SLOPE ON OUTSIDE OF MEANDER BENDS, COIR FIBER MATTING IS NEEDED.



TEMPORARY GRAVEL CONSTRUCTION ENTRANCE

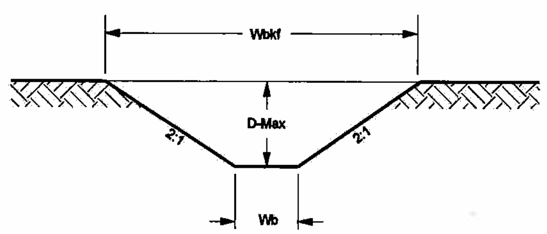




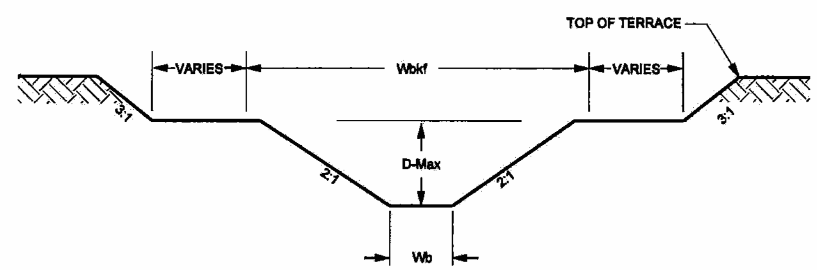
NOTES:

SPECIFICATION NO. 6.06 - CONSTRUCTION ACCESS "N.C. EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL DECEMBER 1993"

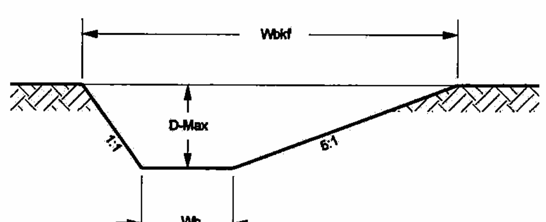
TYPICAL RIFFLE, POOL, AND BANKFULL BENCH CROSS SECTIONS



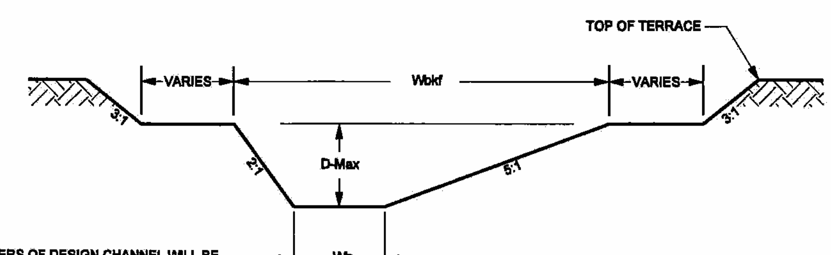
RIFFLE A-A



RIFFLE WITH BANKFULL BENCH



POOL B-B



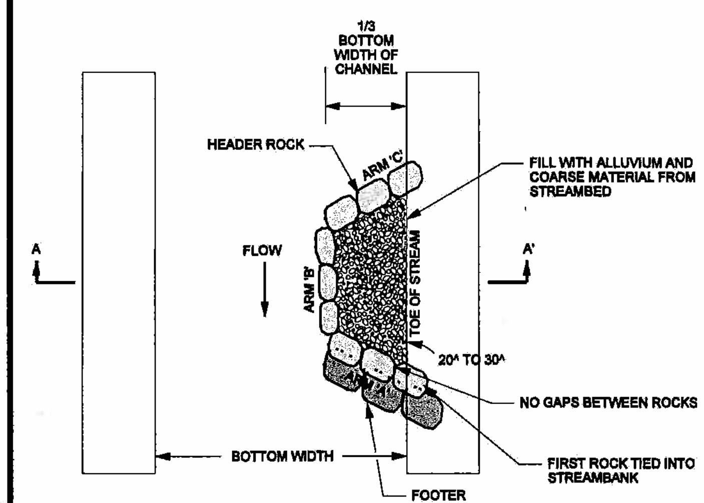
POOL WITH BANKFULL BENCH

NOTES:

1. DURING CONSTRUCTION CORNERS OF DESIGN CHANNEL WILL BE ROUNDED AND A THALWEG WILL BE SHAPED PER DIRECTION OF ENGINEER.
2. POOLS SHOWN ABOVE ARE LEFT POOLS ONLY.

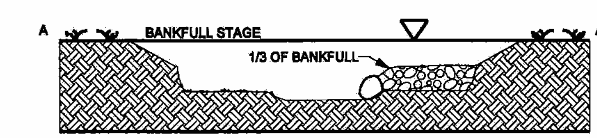
MILL CREEK		UT2 AND UT5		UT2 SWALE	
RIFFLE	POOL	RIFFLE	POOL	RIFFLE	
18.2	30.0	6.8	10.0	5.5	Wbkf (FT)
1.9	4.4	0.7	1.8	0.4	D-Max (FT)
12.0	12.2	12.0	10.1	15.0	WIDTH TO DEPTH RATIO
27.6	73.9	3.8	9.9	2.0	BANKFULL AREA (SQ FT)
10.5	3.6	3.9	1.0	3.7	Wb (FT)

SINGLE WING DEFLECTOR

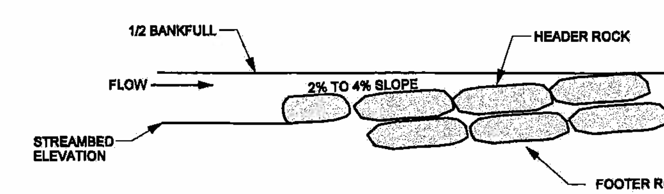


PLAN VIEW

NOTE:
BOULDERS MUST BE AT LEAST 4' X 3' X 2'.



SECTION A - A'



ARM 'A' PROFILE VIEW

NOTE: NO SLOPE FOR ARMS B & C

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PROJECT REFERENCE NO.	SHEET NO.
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PROJECT ENGINEER

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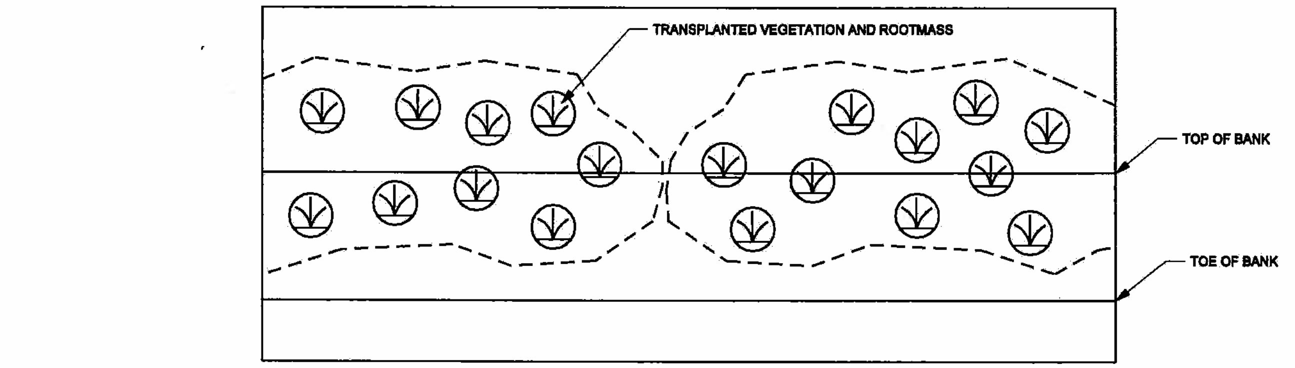
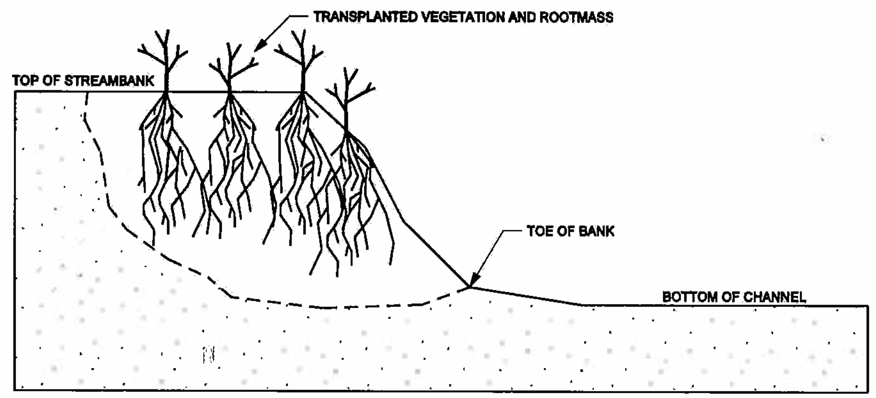
Fax: 919.463.5490

TRANSPLANTED VEGETATION



PLAN VIEW

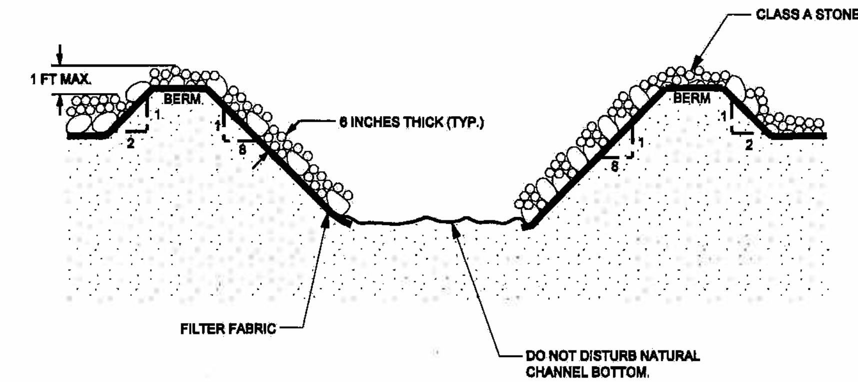


CROSS SECTION VIEW

NOTES:

1. EXCAVATE A HOLE IN THE BANK TO BE STABILIZED THAT WILL ACCOMMODATE THE SIZE OF TRANSPLANT TO BE PLACED. BEGIN EXCAVATION AT THE TOE OF THE BANK.
2. EXCAVATE TRANSPLANT USING A FRONT END LOADER. EXCAVATE THE ENTIRE ROOT MASS AND AS MUCH ADDITIONAL SOIL MATERIAL AS POSSIBLE. IF ENTIRE ROOT MASS CANNOT BE EXCAVATED IN ONE BUCKET LOAD, THE TRANSPLANT IS TOO LARGE AND ANOTHER SHOULD BE SELECTED.
3. PLACE TRANSPLANT IN THE BANK TO BE STABILIZED SO THAT VEGETATION IS ORIENTATED VERTICALLY.
4. FILL IN ANY HOLES AROUND THE TRANSPLANT AND COMPACT.
5. ANY LOOSE SOIL LEFT IN THE STREAM SHOULD BE REMOVED.
6. PLACE MULTIPLE TRANSPLANTS CLOSE TOGETHER SUCH THAT THEY TOUCH.

PERMANENT FORD STREAM CROSSING

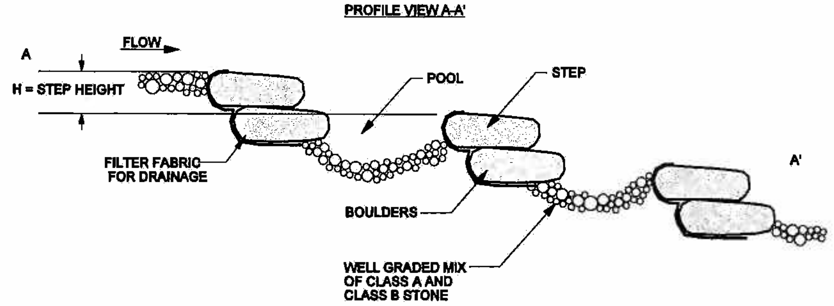


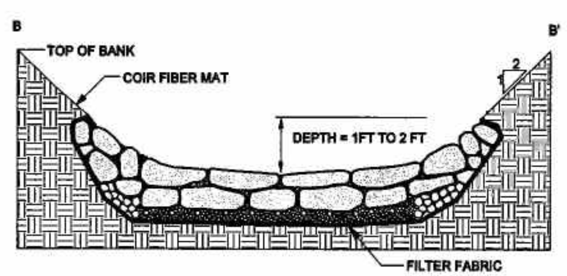
NOTES:

1. CONSTRUCT STREAM CROSSING WHEN FLOW IS LOW.
2. HAVE ALL NECESSARY MATERIALS AND EQUIPMENT ON-SITE BEFORE WORK BEGINS.
3. MINIMIZE CLEARING AND EXCAVATION OF STREAMBANKS. DO NOT EXCAVATE CHANNEL BOTTOM. COMPLETE ONE SIDE BEFORE STARTING ON THE OTHER SIDE.
4. INSTALL STREAM CROSSING AT RIGHT ANGLE TO THE FLOW.
5. GRADE SLOPES TO A 8:1 SLOPE. TRANSPLANT SOD FROM ORIGINAL STREAMBANK ONTO SIDE SLOPES NOT COVERED WITH STONE.
6. MAINTAIN CROSSING SO THAT RUNOFF IN THE ADJACENT ROAD DOES NOT ENTER EXISTING CHANNEL.
7. A STABILIZED PAD OF CLASS A STONE, 6 INCHES THICK, LINED WITH FILTER FABRIC FOR DRAINAGE SHALL BE USED OVER THE BERM AND ACCESS SLOPES.
8. WIDTH OF THE CROSSING SHALL BE SUFFICIENT TO ACCOMMODATE THE LARGEST VEHICLE CROSSING THE CHANNEL.

STEP POOL CHANNEL

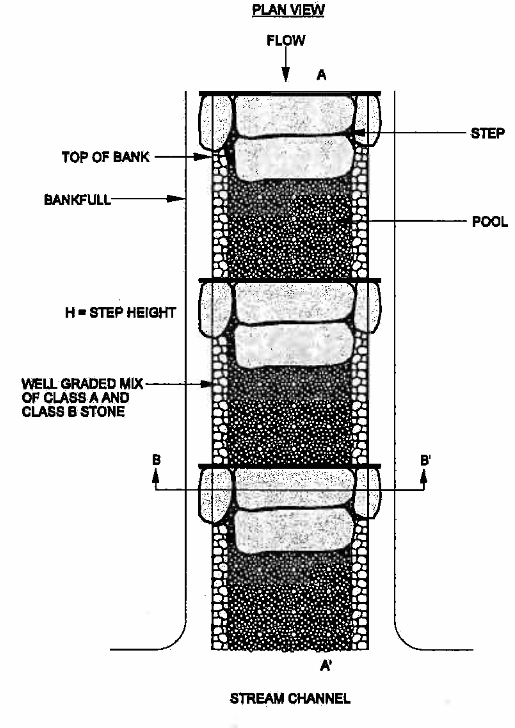
PROFILE VIEW A-A'





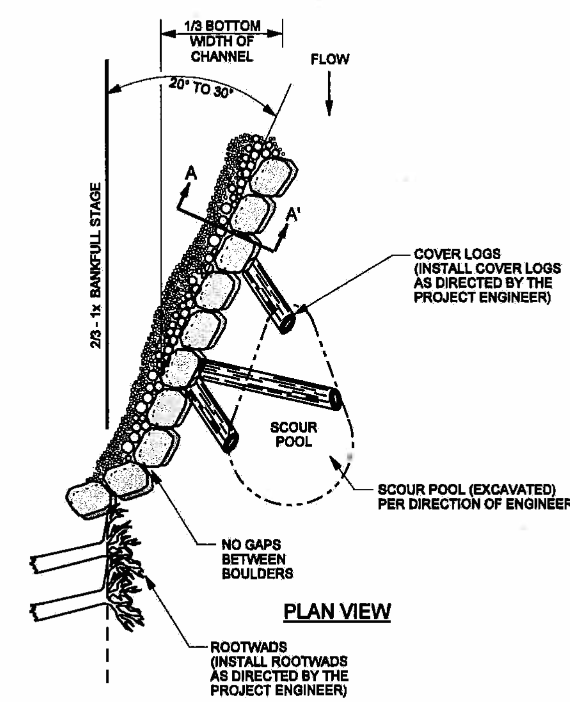
CROSS SECTION B-B'

PLAN VIEW

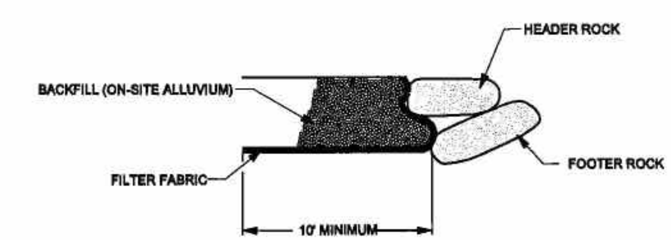


STREAM CHANNEL

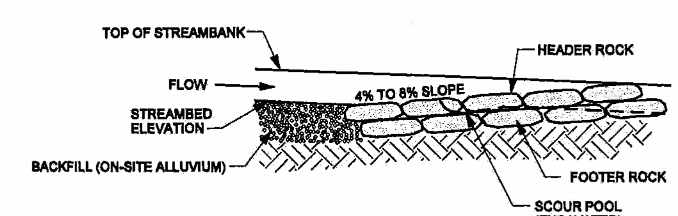
ROCK VANE



PLAN VIEW



SECTION A - A'



PROFILE VIEW

NOTES FOR ALL VANE STRUCTURES:

1. BOULDERS MUST BE AT LEAST 4' X 3' X 2'..
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF TEN FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARM, BETWEEN THE ARM AND STREAMBANK.
4. START AT BANK AND PLACE FOOTER ROCKS FIRST AND THEN HEADER (TOP) ROCK.
5. CONTINUE WITH STRUCTURE, FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
6. AN EXTRA BOULDER CAN BE PLACED IN SCOUR POOL FOR HABITAT IMPROVEMENT.
7. USE ON-SITE ALLUVIUM TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS TO THE ELEVATION OF THE TOP OF THE HEADER ROCK.
8. START SLOPE AT 2/3 TO 1 TIMES THE BANKFULL STAGE.

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PROJECT REFERENCE NO.	SHEET NO.
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PROJECT ENGINEER

PRELIMINARY PLANS
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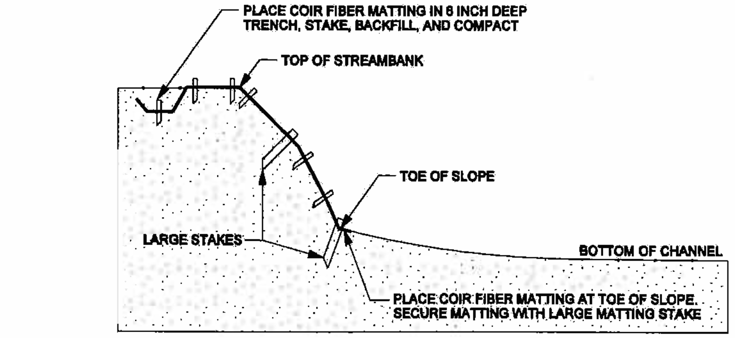
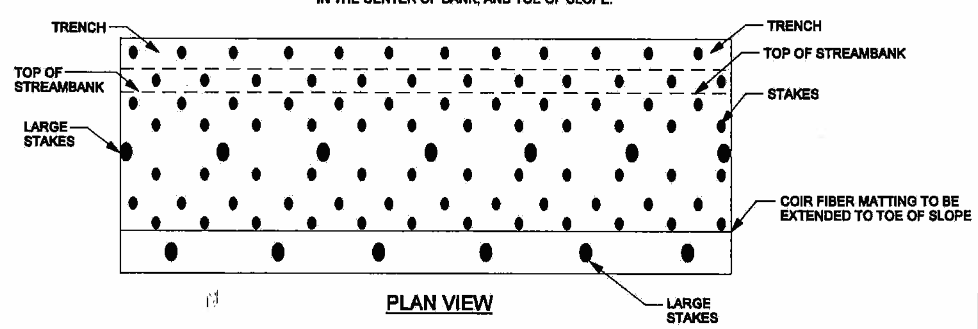
EROSION CONTROL MATTING

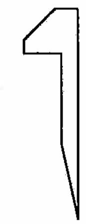


CROSS SECTION VIEW

NOTES:
1. BANKS SHOULD BE SEEDED PRIOR TO PLACEMENT OF MATTING.
2. USE C-7 MATTING.
3. LARGE STAKES SHOULD NOT BE SPACED FURTHER THAN 18" APART.
4. PLACE LARGE STAKES ALONG ALL SEAMS, IN THE CENTER OF BANK, AND TOE OF SLOPE.



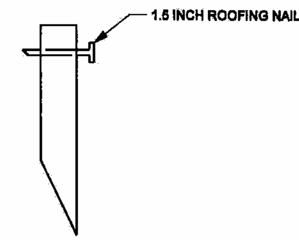
PLAN VIEW



TYPICAL SMALL MATTING STAKE

THE WOOD STAKE SHALL BE THE NORTH AMERICAN GREEN ECO-STAKE OR APPROVED EQUAL WITH THE FOLLOWING DIMENSIONS:

LEG LENGTH	11.00 IN (27.94 CM)
HEAD WIDTH	1.25 IN (3.18 CM)
HEAD THICKNESS	0.40 IN (1.02 CM)
LEG WIDTH	0.60 IN (1.52 CM) (TAPERED TO POINT)
LEG THICKNESS	0.40 IN (1.02 CM)
TOTAL LENGTH	12.00 IN (30.48 CM)

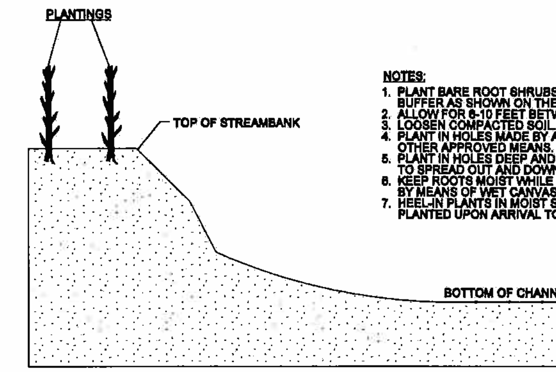


TYPICAL LARGE MATTING STAKE

THE WOOD STAKE SHALL BE THE NORTH AMERICAN GREEN ECO-STAKE OR APPROVED EQUAL WITH THE FOLLOWING DIMENSIONS:

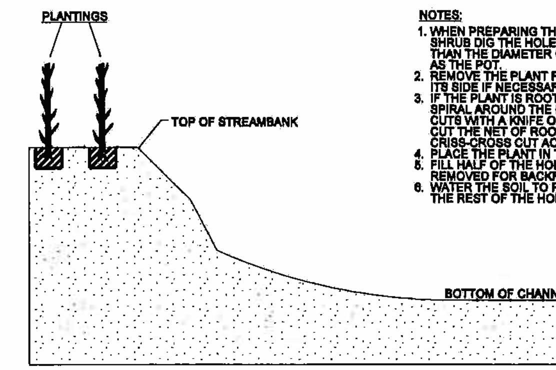
LEG LENGTH	17.00 IN (43.18 CM) (TAPERED TO POINT)
WIDTH	1.00 IN (2.54 CM)
THICKNESS	1.00 IN (2.54 CM)

PLANTING SPECIFICATIONS



CROSS SECTION VIEW OF BARE ROOT PLANTING

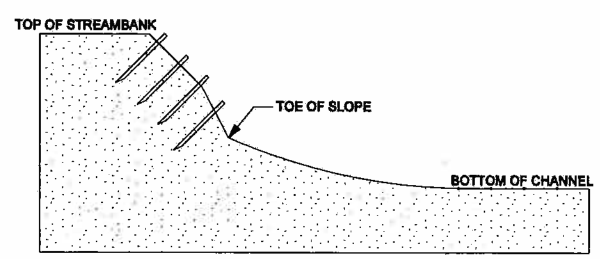
NOTES:
1. PLANT BARE ROOT SHRUBS AND TREES TO THE WIDTH OF THE BUFFER AS SHOWN ON THE PLANS.
2. ALLOW FOR 6-10 FEET BETWEEN PLANTINGS, DEPENDING ON SIZE.
3. LOOSEN COMPACTED SOIL.
4. PLANT IN HOLES MADE BY A MATTOCK, DIBBLE, PLANTING BAR, OR OTHER APPROVED MEANS.
5. PLANT IN HOLES DEEP AND WIDE ENOUGH TO ALLOW THE ROOTS TO SPREAD OUT AND DOWN WITHOUT J-ROOTING.
6. KEEP ROOTS MOIST WHILE DISTRIBUTING OR WAITING TO PLANT BY MEANS OF WET CANVAS, BURLAP, OR STRAW.
7. HEEL-IN PLANTS IN MOIST SOIL OR SAWDUST IF NOT PROMPTLY PLANTED UPON ARRIVAL TO PROJECT SITE.



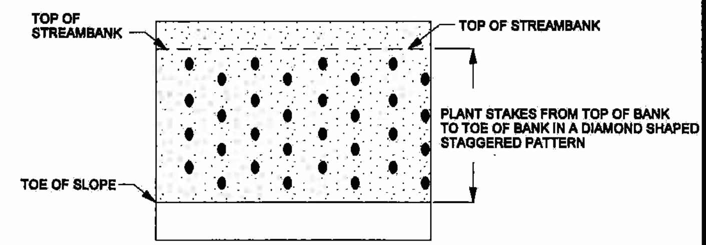
CROSS SECTION VIEW OF CONTAINER PLANTING

NOTES:
1. WHEN PREPARING THE HOLE FOR A POTTED PLANT OR SHRUB DIG THE HOLE 8 - 12 INCHES LARGER THAN THE DIAMETER OF THE POT AND THE SAME DEPTH AS THE POT.
2. REMOVE THE PLANT FROM THE POT. LAY THE PLANT ON ITS SIDE IF NECESSARY TO REMOVE THE POT.
3. IF THE PLANT IS ROOTBOUND (ROOTS GROWING IN A SPIRAL AROUND THE ROOT BALL), MAKE VERTICAL CUTS WITH A KNIFE OR SPADE JUST DEEP ENOUGH TO CUT THE NET OF ROOTS. ALSO MAKE A CRISS-CROSS CUT ACROSS THE BOTTOM OF THE BALL.
4. PLACE THE PLANT IN THE HOLE.
5. FILL HALF OF THE HOLE WITH SOIL (SAME SOIL REMOVED FOR BACKFILL).
6. WATER THE SOIL TO REMOVE AIR POCKETS AND FILL THE REST OF THE HOLE WITH THE REMAINING SOIL.

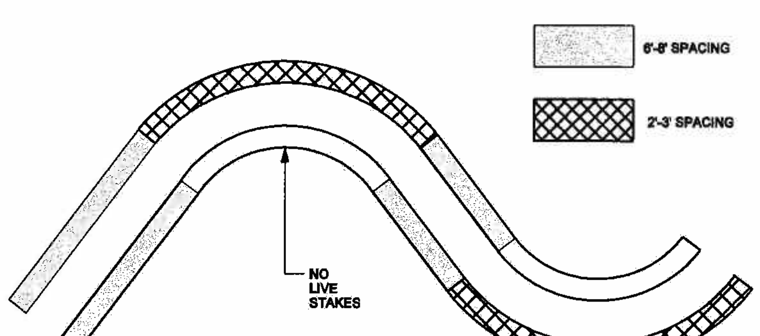
LIVE STAKING



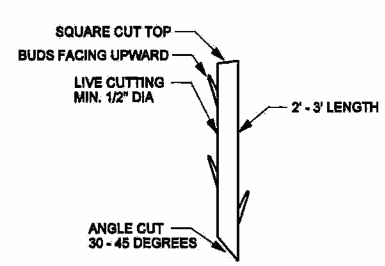
CROSS SECTION VIEW



PLAN VIEW



PLAN VIEW



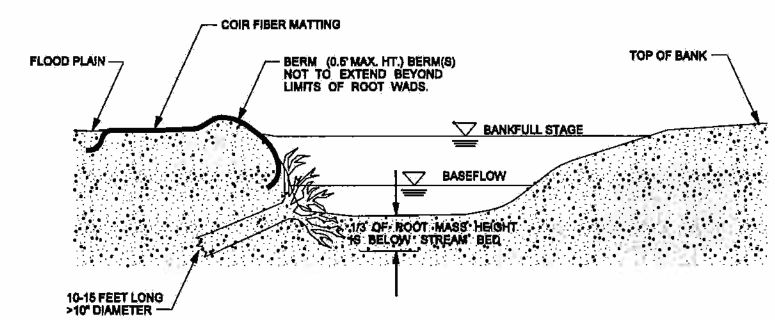
LIVE STAKE DETAIL

NOTES:
1. STAKES SHOULD BE CUT AND INSTALLED ON THE SAME DAY.
2. DO NOT INSTALL STAKES THAT HAVE BEEN SPLIT.
3. STAKES MUST BE INSTALLED WITH BUDS POINTING UPWARDS.
4. STAKES SHOULD BE INSTALLED PERPENDICULAR TO BANK.
5. STAKES SHOULD BE 1/2 TO 2 INCHES IN DIAMETER AND 2 TO 3 FT LONG.
6. STAKES SHOULD BE INSTALLED LEAVING 1/5 OF STAKE ABOVE GROUND.

ROOT WADS WITH COVER LOGS

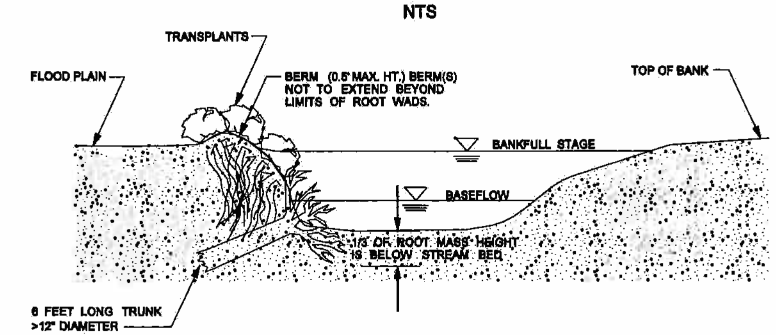
ROOT WADS WITHOUT TRANSPLANTS

CROSS SECTION VIEW
NTS



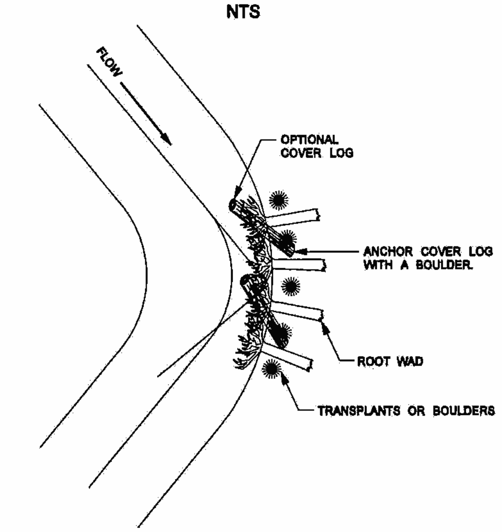
ROOT WADS WITH TRANSPLANTS

CROSS SECTION VIEW
NTS



ROOT WADS

PLAN VIEW
NTS



NOTES:

TRENCHING METHOD:
IF THE ROOT WAD CANNOT BE DRIVEN INTO THE BANK OR THE BANK NEEDS TO BE RECONSTRUCTED, THE TRENCHING METHOD SHOULD BE USED. THIS METHOD REQUIRES THAT A TRENCH BE EXCAVATED FOR THE LOG PORTION OF THE ROOT WAD. ONE-THIRD OF THE ROOT WAD SHOULD REMAIN BELOW NORMAL BASE FLOW CONDITIONS.

NOTES:

DRIVE POINT METHOD:
SHARPEN THE END OF THE LOG WITH A CHAINSAW BEFORE "DRIVING" IT INTO THE BANK. ORIENT ROOT WADS UPSTREAM SO THAT THE STREAM FLOW MEETS THE ROOT WAD AT A 90-DEGREE ANGLE, DEFLECTING THE WATER AWAY FROM THE BANK. A TRANSPLANT OR BOULDER SHOULD BE PLACED ON THE DOWNSTREAM SIDE OF THE ROOT WAD IF A BACK EDDY IS FORMED BY THE ROOT WAD. THE BOULDER SHALL BE APPROXIMATELY 4'X 3'X 2'.

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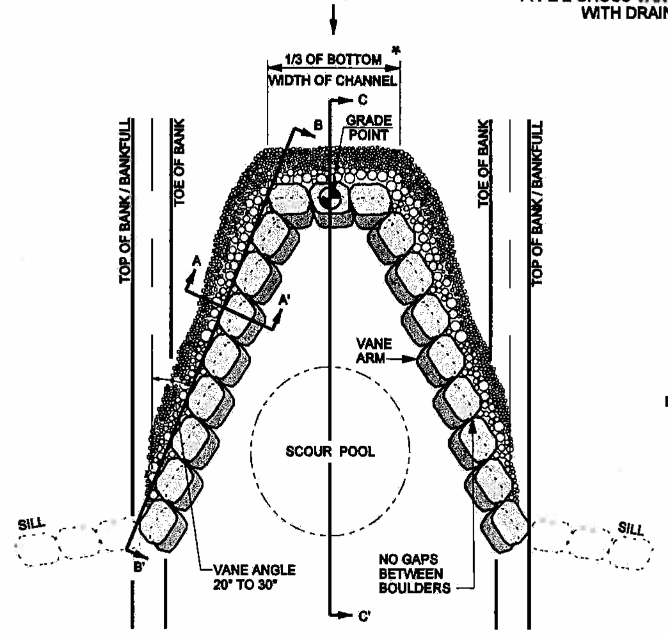
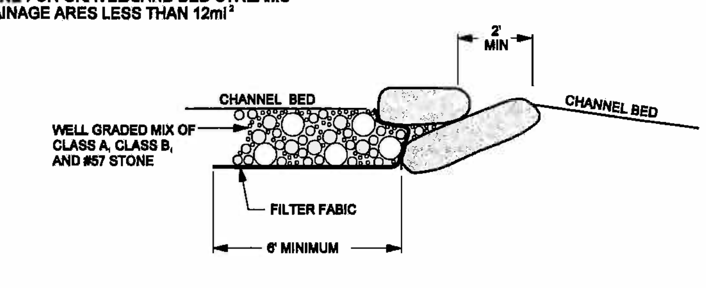
ROCK CROSS VANE TYPE 2

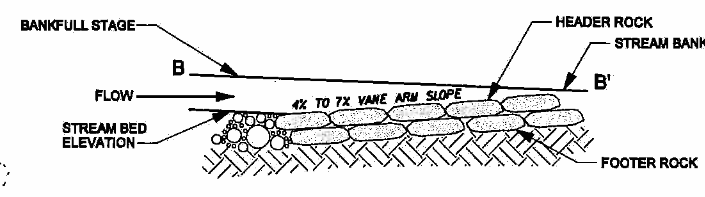
TYPE 2 CROSS VANE FOR GRAVEL/SAND BED STREAMS
WITH DRAINAGE ARES LESS THAN 12mi²



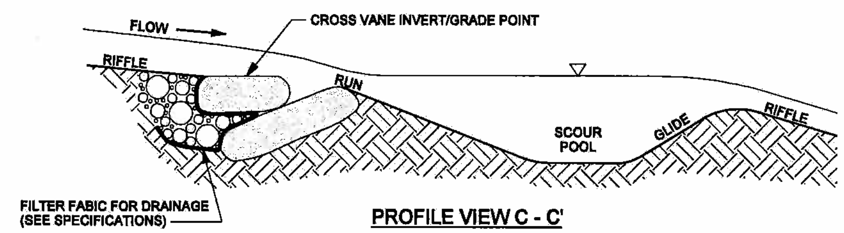
PLAN VIEW



SECTION A - A'



PROFILE VIEW B - B'
VANE ARM

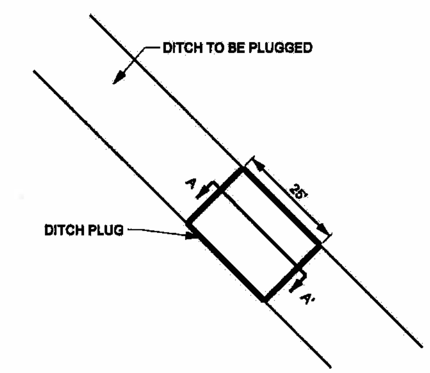


PROFILE VIEW C - C'

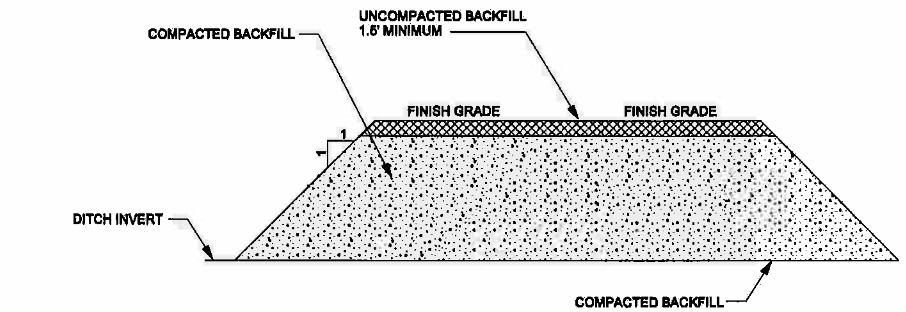
NOTES FOR ALL VANE STRUCTURES:

1. BOULDERS MUST BE AT LEAST 4' x 3' x 2'.
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF SIX FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARM, BETWEEN THE ARM AND STREAMBANK.
4. CONSTRUCT FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
5. USE CLASS B STONE TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS, AND CLASS A STONE AND #57 STONE TO FILL GAPS ON UPSTREAM SIDE OF CLASS B STONE.
6. AFTER ALL STONE HAS BEEN PLACED, FILL IN THE UPSTREAM SIDE OF THE STRUCTURE WITH ON-SITE ALLUVIUM TO THE ELEVATION OF ONE HALF THE HEADER ROCK.

DITCH PLUG



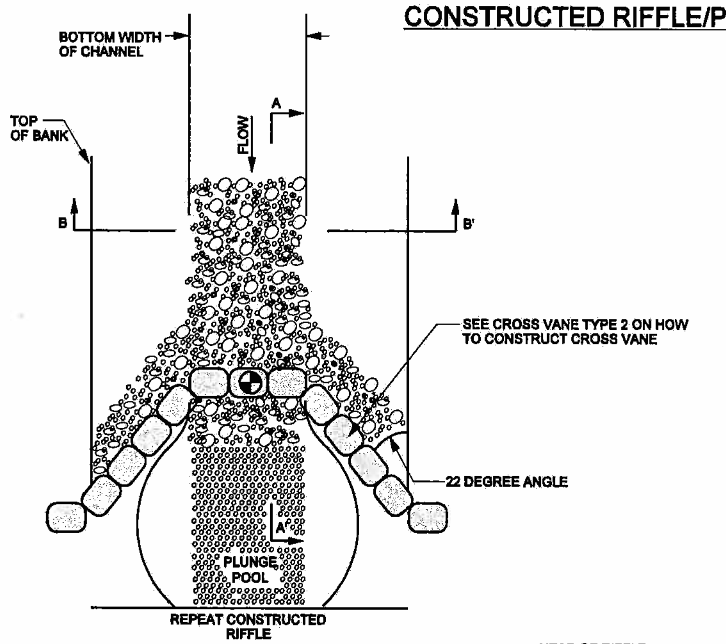
PLAN VIEW



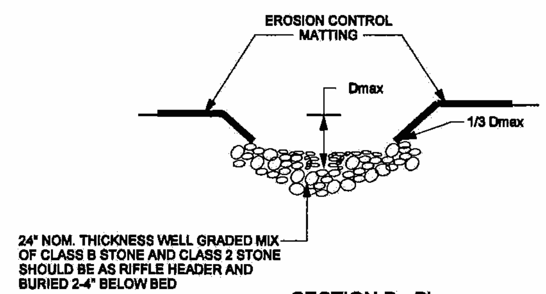
NOTE:
COMPACT BACKFILL USING ON-SITE HEAVY EQUIPMENT IN 10 INCH LIFTS.

SECTION A - A'

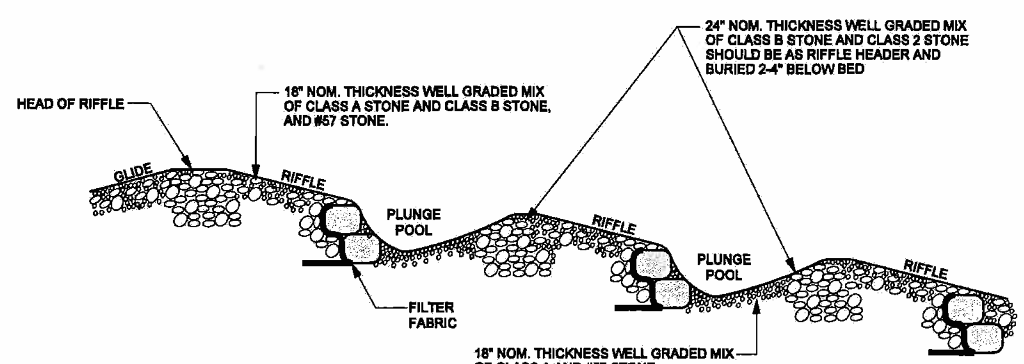
CONSTRUCTED RIFFLE/PLUNGE POOL SEQUENCE



PLAN VIEW

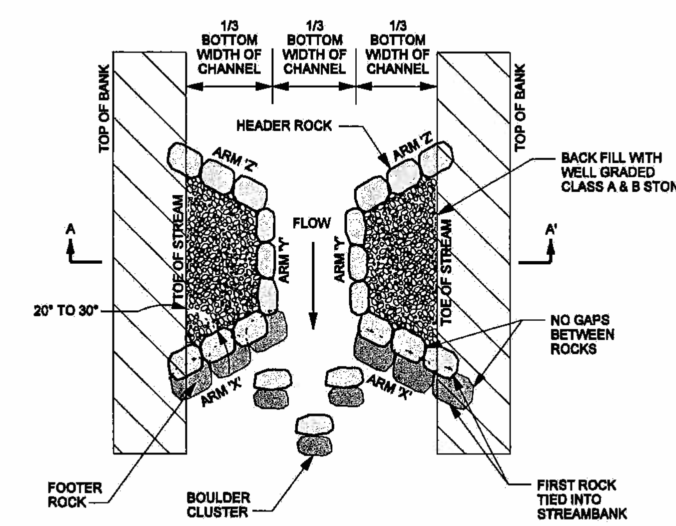


SECTION B - B'

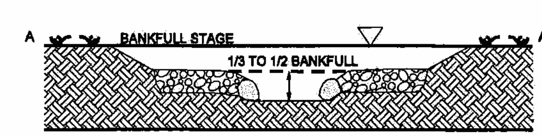


PROFILE A - A'
(WITH REPETITION)

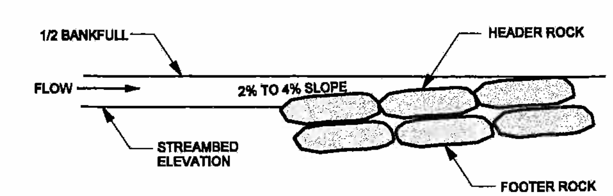
DOUBLE WING DEFLECTOR



PLAN VIEW



SECTION A - A'



ARM 'X' PROFILE VIEW
NOTE: NO SLOPE FOR ARMS Y & Z

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CONSTRUCTION SEQUENCE

Reach UT2

1. Contractor shall contact North Carolina "One Call" Center (1.800.632.4949) before any excavation.
2. Contractor shall prepare stabilized construction entrances and haul roads as indicated on plans.
3. The Contractor shall mobilize equipment, materials, prepare staging area(s) and stockpile area(s) as shown on plans.
4. Construction traffic shall be restricted to the area denoted as "Limits of Disturbance" on the construction plans.
5. Clear and grub an area adequate to construct the UT2 stream channel operations.
6. The Contractor shall install temporary rock dams at locations indicated on plans.
7. The Contractor shall install temporary silt fence around the staging area(s). Temporary silt fencing will also be placed around the temporary stockpile areas as material is stockpiled throughout the construction period.
8. The Contractor shall install all temporary and permanent stream crossings as shown on plans in accordance with the NC Erosion and Sediment Control Planning and Design Manual. Ditches and stream reaches on site will be left open during the initial stages of construction to allow for drainage and to maintain site accessiblity.
9. Contractor shall begin construction on each stream reach and complete that stream reach before moving to the next stream.
10. Begin construction of stream channel at Station 28+87 and proceed in an upstream direction to Station 25+25. This section of channel will be constructed offline and in the dry, since it will be excavated through the field to the Uwharrie River.
11. Excavate channel to design grades, install in-stream structures, grassing, matting, and transplants in this section, and ready the channel to accept flow.
12. Simultaneously, the grading operator shall lower the pond dam to the design elevation. Stockpile excavated material in areas shown on the plans and plug the drainage ditch at the toe of the dam, as shown on plans.
13. Excavated material from the stockpiles will be spread on the eroded hillslope, used to plug drainage ditches, hauled to the silage pit near the top of UT2, or hauled to the top of UT1; as shown on plans and per direction of engineer. Filling in the upper section of UT1 will be the last option when dispersing the excavated material.
14. The section between station 20+00 and 24+30 requires the use of a temporary pump-around operation as noted in the Erosion Control Plans. The Contractor shall install temporary silt checks and pump-around operation for these sections. The portion of the channel isolated shall be dewatered and the removed water shall flow through a special stilling basin according to project special provisions. The contractor shall setup the outflow of the pump-around near the breech in the old pond as shown on plans.
15. Begin construction of stream channel at Station 20+00 and proceed in an upstream direction to Station 24+30. The contractor shall create the swale through the wetland creation area per direction of engineer.
16. Once construction in a pump-around area has been completed, remove pump-around materials and turn the water into the Wetland creation area.
17. Use the excess material to plug the breech in the dam to design elevations and then remove the temporary stream crossing.
18. The section between station 24+30 and 25+25 requires the use of a temporary pump-around operation as noted in the Erosion Control Plans. The Contractor shall install temporary silt checks and pump-around operations for these sections. The portion of the channel isolated shall be dewatered and the removed water shall flow through a special stilling basin according to project special provisions. The contractor shall setup the outflow of the pump-around near the breech in the old pond or the toe of slope drainage ditch.
19. Begin excavation of the stream channel at Station 24+30 and proceed in a downstream direction to Station 25+25.
20. Excavate channel to design grades, install in-stream structures, grassing, matting, and transplants in this section, and ready the channel to accept flow.
21. Once construction in a pump-around area has been completed, remove pump-around materials, and turn the water into the new channel.
22. Once a stream work phase is complete, apply temporary seeding, permanent seeding, and mulch to any areas disturbed during construction. Apply permanent seeding mixtures, as shown on the vegetation plan. Temporary seeding shall be applied in all areas susceptible to erosion (i.e. disturbed ditch banks, steep slopes, and spoil areas) such that ground cover is established within 15 working days following completion of any phase of grading. Permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction.
23. All areas should be seeded and mulched before leaving the project reach. Remove temporary stream crossings and any in-stream temporary rock dams. All waste material must be removed from the project site.
24. The contractor shall treat areas of invasive species along UT2 according to the plans prior to demobilization.
25. The contractor shall plant woody vegetation and live stakes, according to planting details and specifications. They should complete the reforestation (bare root planting) phase of the project and apply permanent seeding at the appropriate time of the year.
26. The contractor shall ensure that the site is free of trash and leftover materials prior to demobilization of equipment from the site.

Reach Mill Creek and UT5

1. Contractor shall contact North Carolina "One Call" Center (1.800.632.4949) before any excavation.
2. Contractor shall prepare stabilized construction entrances and haul roads as indicated on plans.
3. The Contractor shall mobilize equipment, materials, prepare staging area(s) and stockpile area(s) as shown on plans.
4. Construction traffic shall be restricted to the area denoted as "Limits of Disturbance" on the construction plans.
5. Clear and grub an area adequate to construct the Mill Creek stream channel operations.
6. The Contractor shall install temporary rock dams for Mill Creek at locations indicated on plans.
7. The Contractor shall install temporary silt fence around the staging area(s). Temporary silt fencing will also be placed around the temporary stockpile areas as material is stockpiled throughout the construction period.
8. The Contractor shall install all temporary and permanent stream crossings as shown on plans in accordance with the NC Erosion and Sediment Control Planning and Design Manual. Ditches and stream reaches on site will be left open during the initial stages of construction to allow for drainage and to maintain site accessiblity.
9. The section between station 18+00 and 32+00 requires the use of temporary pump-around operations as noted in the Erosion Control Plans. The Contractor shall install temporary silt checks and pump-around operations for these sections. The portion of the channel isolated shall be dewatered and the removed water shall flow through a special stilling basin according to project special provisions.
10. Begin construction of Mill Creek channel at Station 32+00 and proceed in an upstream direction to Station 18+00.
11. Excavate channel to design grades, install in-stream structures, grassing, matting, and transplants in this section, and ready the channel to accept flow.
12. Once construction in a pump-around area has been completed, remove pump-around materials, and turn the water into the new channel.
13. Once a stream work phase is complete, apply temporary seeding, permanent seeding, and mulch to any areas disturbed during construction. Apply permanent seeding mixtures, as shown on the vegetation plan. Temporary seeding shall be applied in all areas susceptible to erosion (i.e. disturbed ditch banks, steep slopes, and spoil areas) such that ground cover is established within 15 working days following completion of any phase of grading. Permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction.
14. All areas should be seeded and mulched before leaving the Mill Creek reach. Remove temporary stream crossings and any in-stream temporary rock dams. All waste material must be removed from the project site.
15. Mill Creek construction should be completed and the contractor shall focus on UT5 construction.
16. The Contractor shall install temporary rock dams for UT5 at locations indicated on plans.
17. The Contractor shall install temporary silt fence around the staging area(s). Temporary silt fencing will also be placed around the temporary stockpile areas as material is stockpiled throughout the construction period.
18. The Contractor shall install all temporary and permanent stream crossings as shown on plans in accordance with the NC Erosion and Sediment Control Planning and Design Manual. Ditches and stream reaches on site will be left open during the initial stages of construction to allow for drainage and to keep site accessible.
19. The section between station 22+50 and 28+99 requires the use of temporary pump-around operations as noted in the Erosion Control Plans. The Contractor shall install temporary silt checks and pump-around operations for these sections. The portion of the channel isolated shall be dewatered and the removed water shall flow through a special stilling basin according to project special provisions.
20. Clear and grub an area adequate to construct the UT5 stream channel operations. Begin construction of UT5 channel at Station 28+99 and proceed in an upstream direction to Station 26+35.
21. Once construction in the pump-around area has been completed, remove pump-around materials and turn the water into the downstream UT5 area.
22. Begin construction of UT5 channel at Station 25+80 and proceed in an upstream direction to Station 24+75.
23. The grading operator will lower the pond dam to the design elevation, stockpile excavated material in areas shown on the plans, and plug the old channel below the dam, as shown on plans.
24. Excavate channel to design grades, install in-stream structures, grassing, matting, and transplants in this section, and ready the channel to accept flow.
25. Once construction in a pump-around area has been completed, remove pump-around materials, and turn the water into the new channel.
26. Once a stream work phase is complete, apply temporary seeding, permanent seeding, and mulch to any areas disturbed during construction. Apply permanent seeding mixtures, as shown on the vegetation plan. Temporary seeding shall be applied in all areas susceptible to erosion (i.e. disturbed ditch banks, steep slopes, and spoil areas) such that ground cover is established within 15 working days following completion of any phase of grading. Permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction.
27. All areas should be seeded and mulched before leaving the project reach. Remove temporary stream crossings and any in-stream temporary rock dams. All waste material must be removed from the project site.
28. The contractor shall treat areas of invasive species along Mill Creek and UT5 according to the plans prior to demobilization.
29. The contractor shall plant woody vegetation and live stakes, according to planting details and specifications. They should complete the reforestation (bare root planting) phase of the project and apply permanent seeding at the appropriate time of the year.
30. The contractor shall ensure that the site is free of trash and leftover materials prior to demobilization of equipment from the site.

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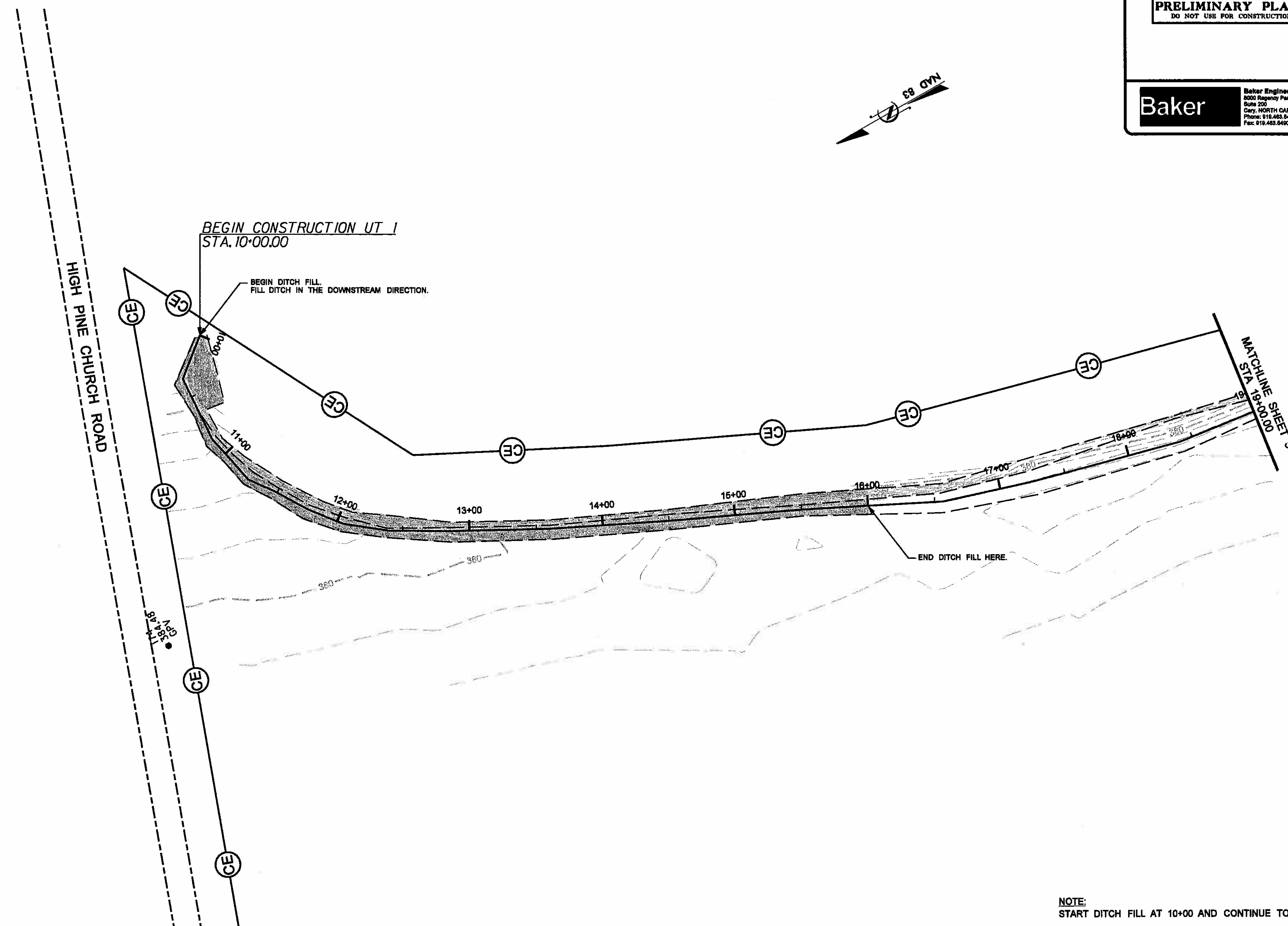

NOTE:
START DITCH FILL AT 10+00 AND CONTINUE TO 16+00.

PLAN VIEW

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SCALE (FT)

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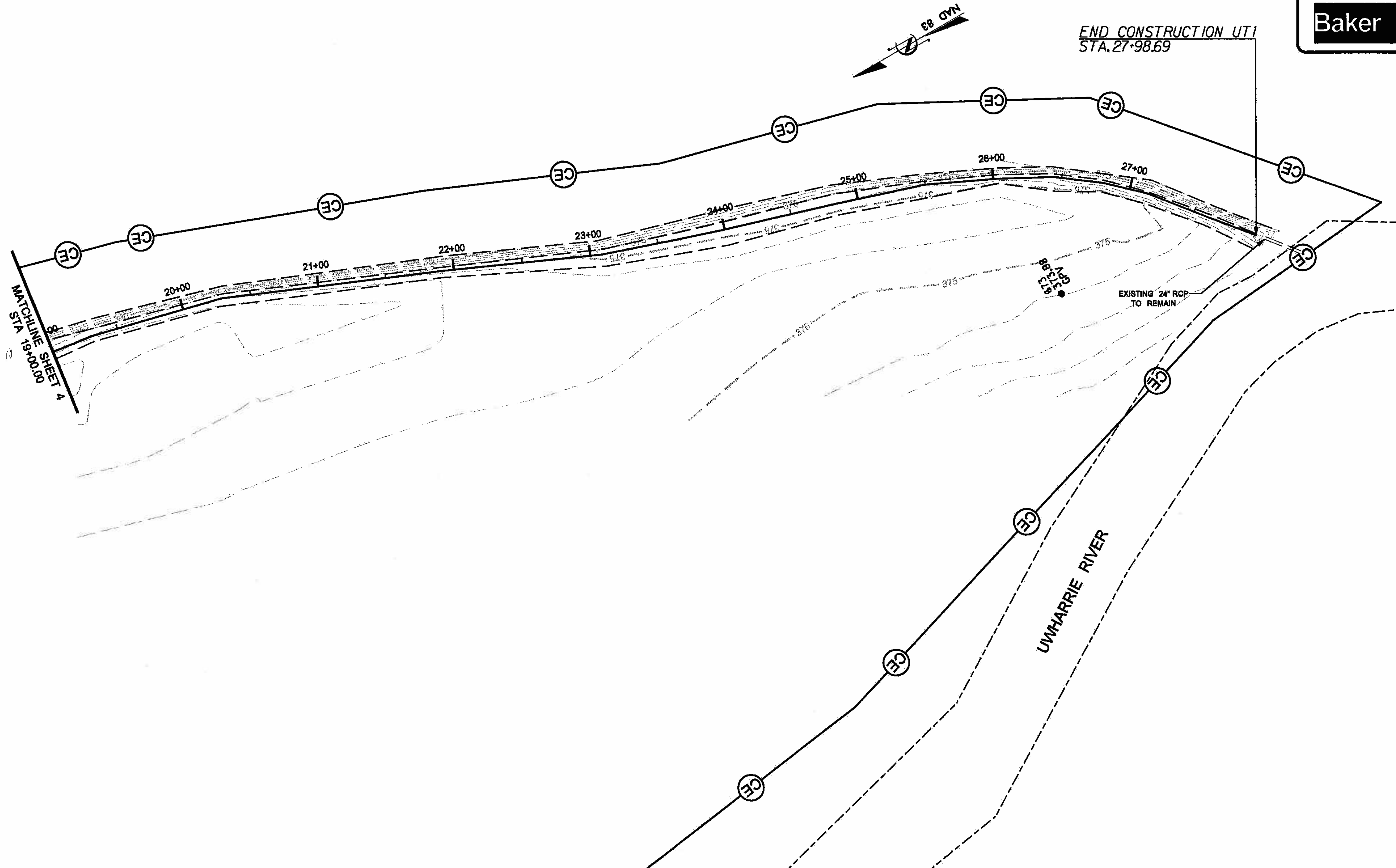

PLAN VIEW

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SCALE (FT)

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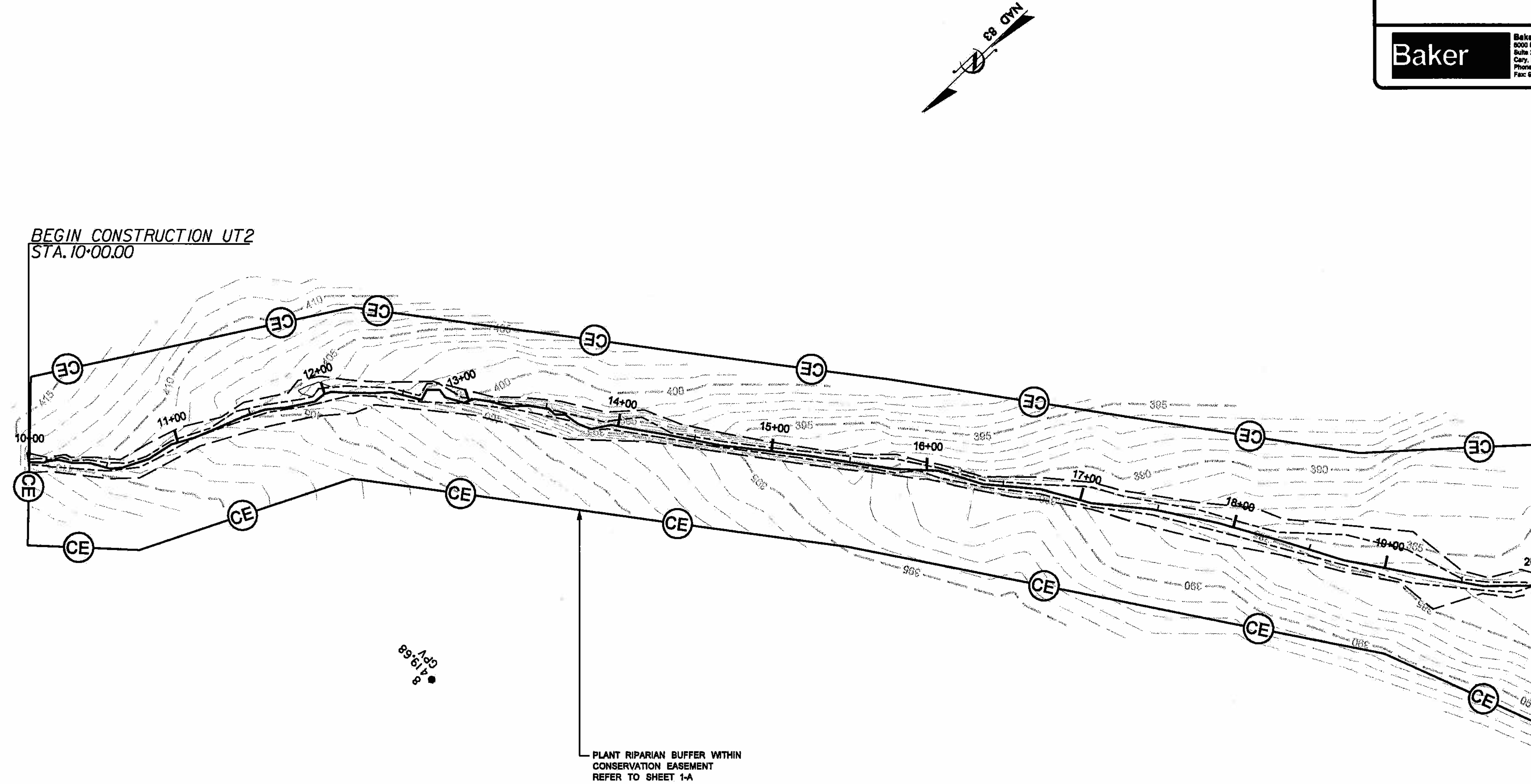

PLAN VIEW

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SCALE (FT)

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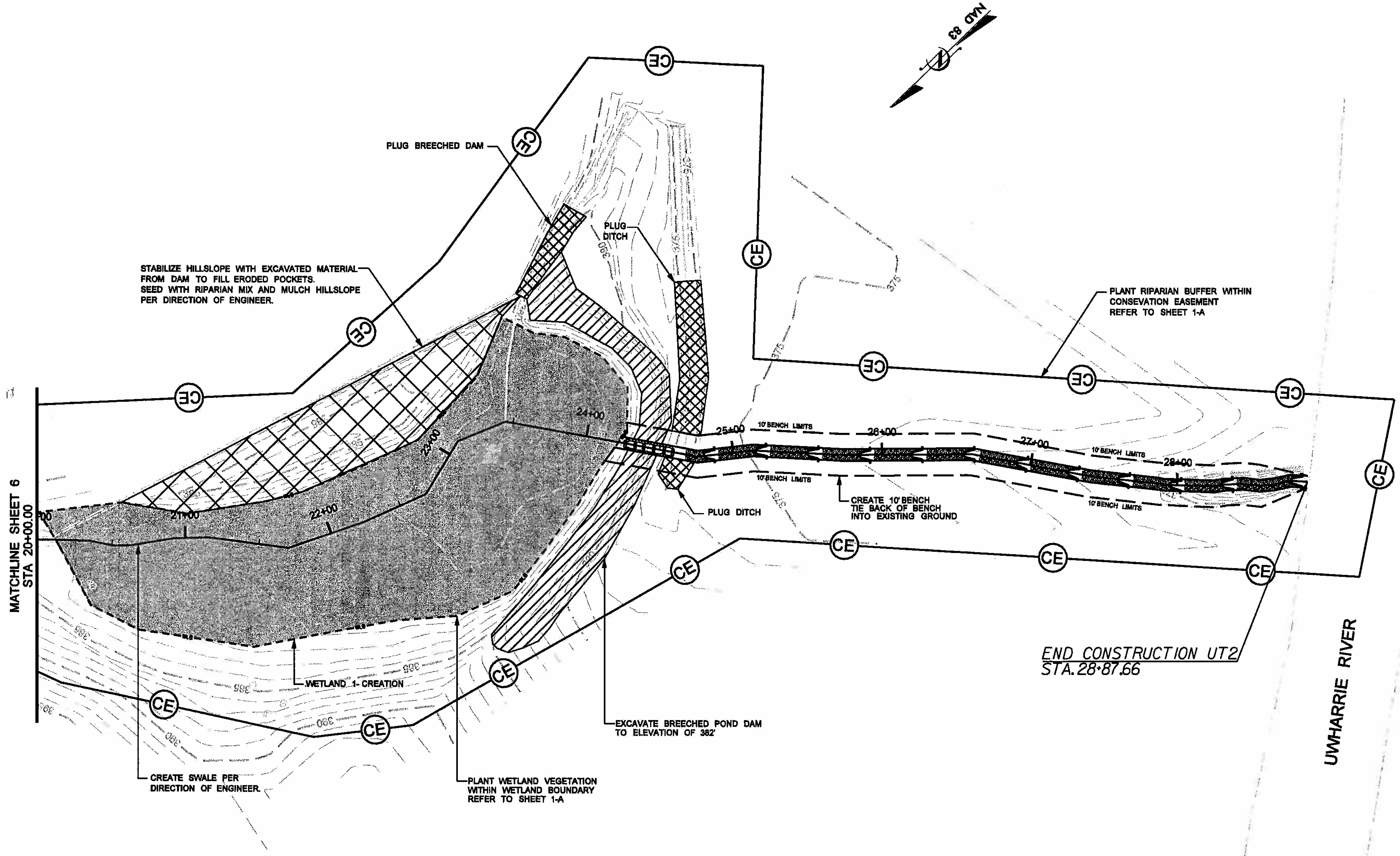

NOTE:

1. USE 4x3x2 BOULDERS TO CONSTRUCT STEP POOLS AND CROSS VANES ALONG UT2 AND UT5.

2. EXCAVATED MATERIAL FROM DAM AND NEW CHANNEL WILL BE USED TO STABILIZE HILLSLOPE, PLUG DITCHES, HAULED TO SILAGE PIT NEAR TOP OF UT2, OR HAULED TO THE TOP OF UT1, PER DIRECTION OF ENGINEER.

PLAN VIEW

40 20 0 40 80
SCALE (FT)

2/26/03

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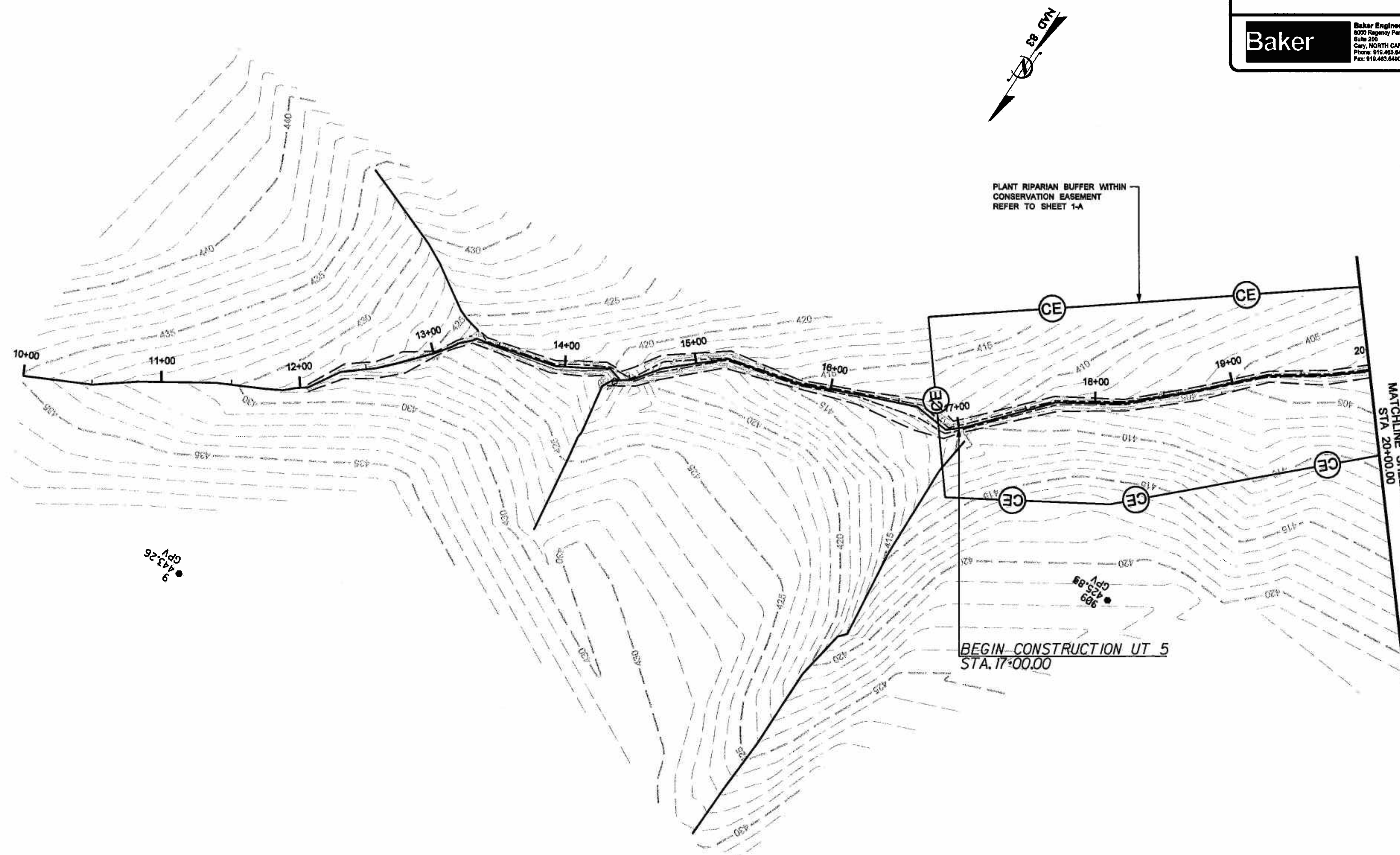

PLAN VIEW

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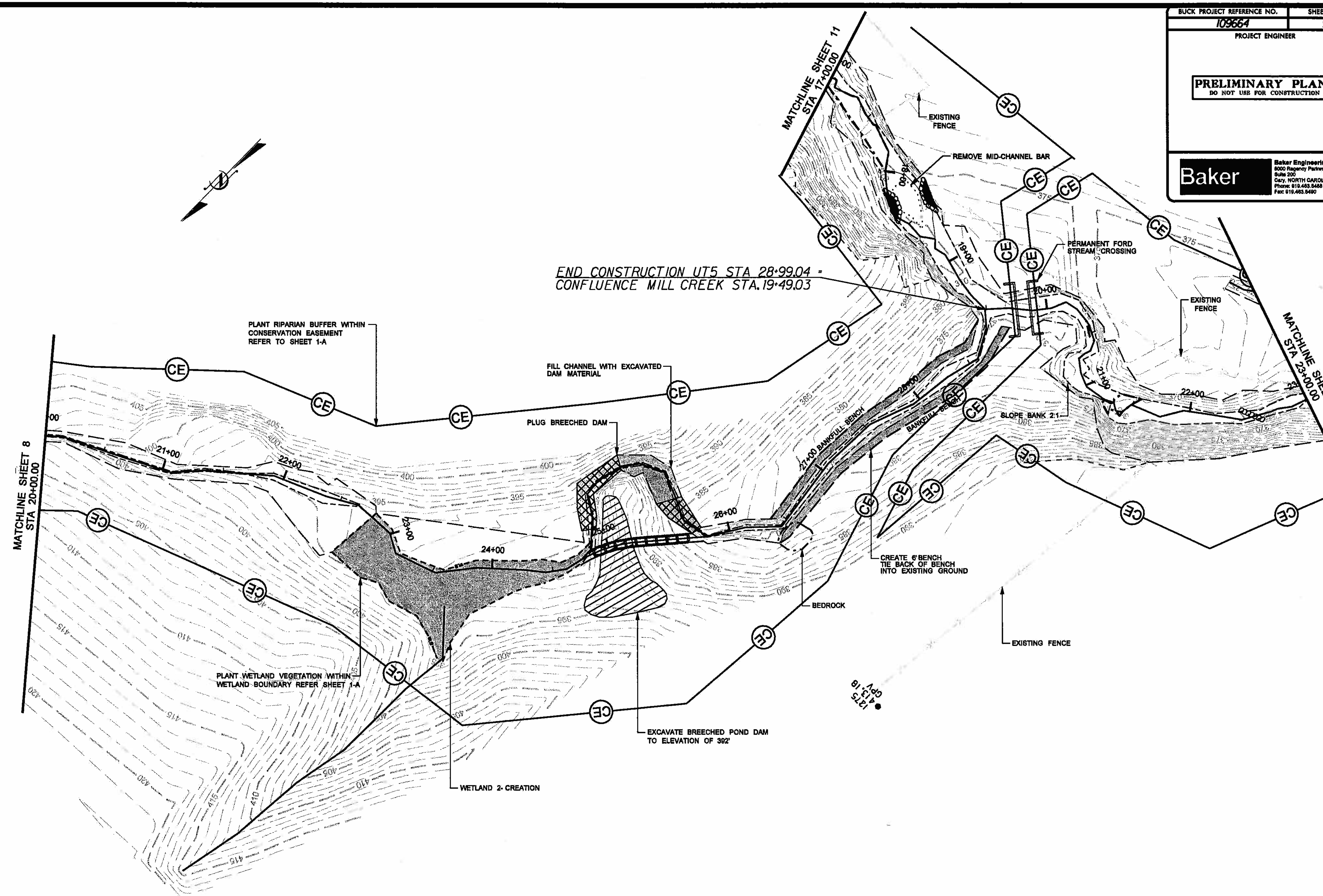

NOTE:

1. USE 4x3x2 BOULDERS TO CONSTRUCT STEP POOLS AND CROSS VANES ALONG UT2 AND UT5.

2. EXCESS FILL MATERIAL FROM UT5 DAM EXCAVATION WILL BE SPREAD ON THE WESTERN SLOPE OF THE VALLEY AND TO PLUG THE OLD CHANNEL PER DIRECTION OF ENGINEER.

PLAN VIEW

40 20 0 40 80
SCALE (FT)

2/26/03

4/21/2008
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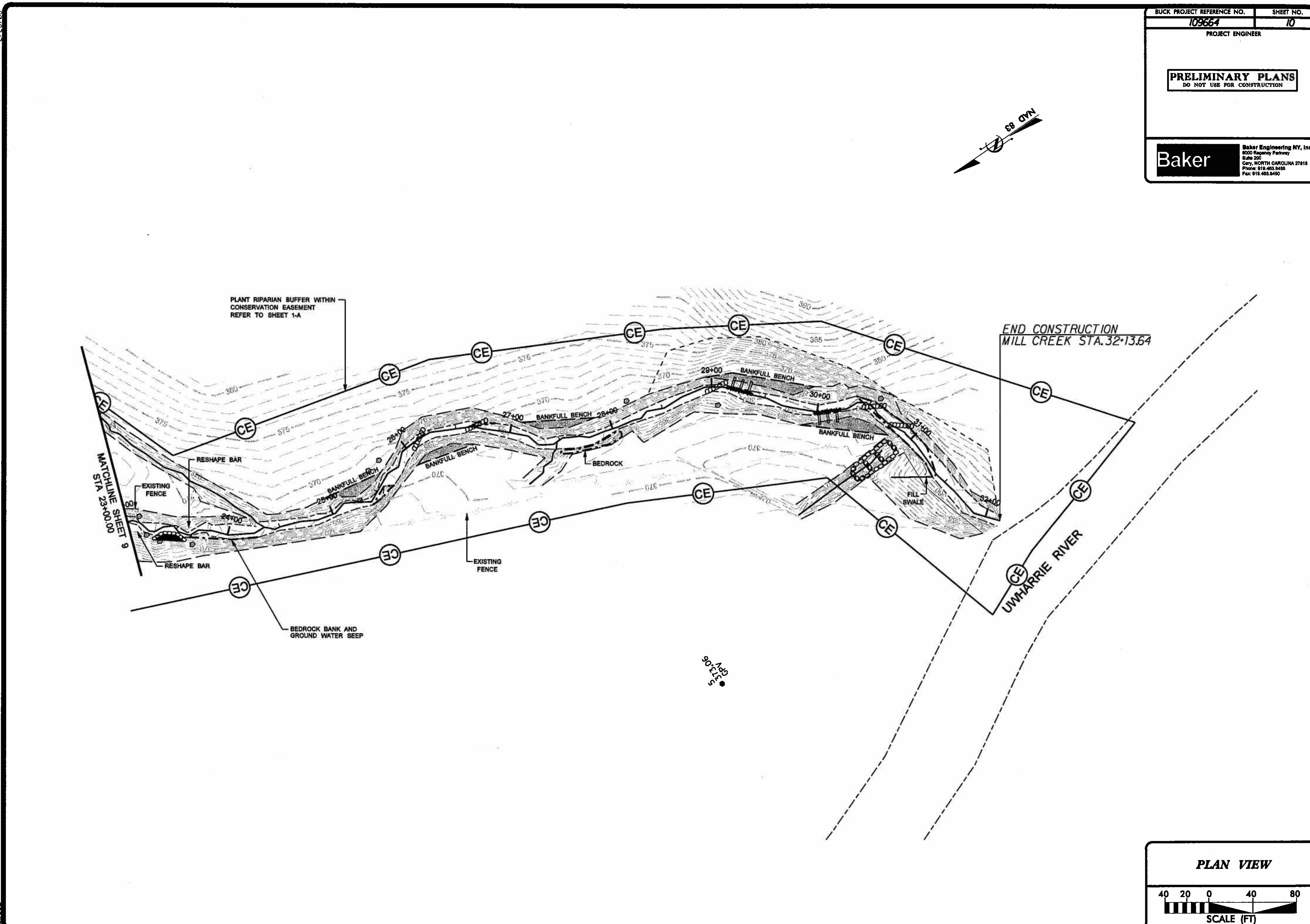

BUCK PROJECT REFERENCE NO.
109664
SHEET NO.
10
PROJECT ENGINEER
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
Baker
NAD 83
PLANT RIPARIAN BUFFER WITHIN CONSERVATION EASEMENT REFER TO SHEET 1-A
END CONSTRUCTION
MILL CREEK STA.32+13.64
MATCHLINE SHEET 9
STA 23+00.00
RESHAPE BAR
EXISTING FENCE
BANKFULL BENCH
BEDROCK
FILL SWALE
UWHARRIE RIVER
BEDROCK BANK AND GROUND WATER SEEP
PLAN VIEW
SCALE (FT)

BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	11

PROJECT ENGINEER

PRELIMINARY PLANS
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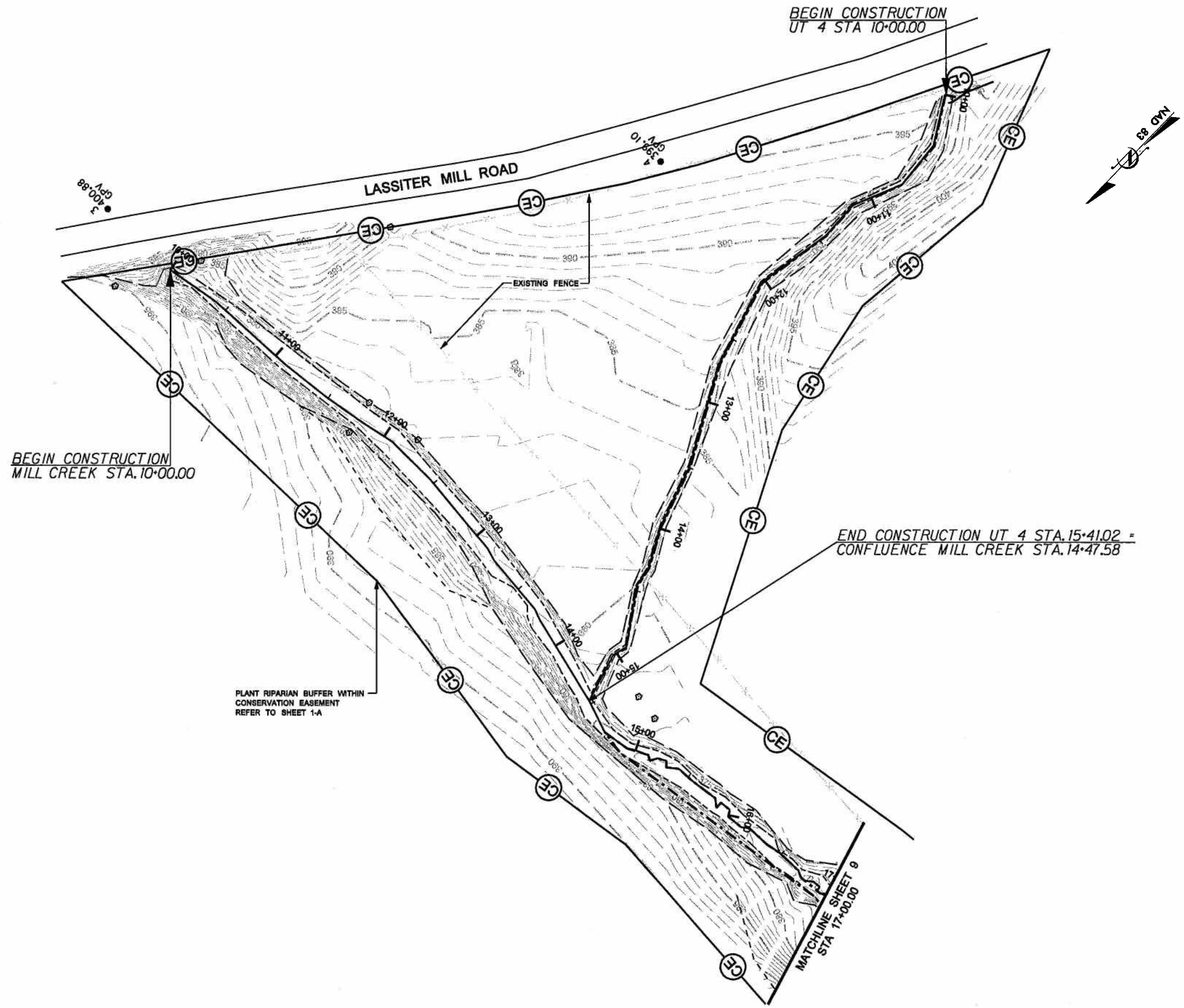

PLAN VIEW

40 20 0 40 80
SCALE (FT)

2/26/03

4/2/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	12

PROJECT ENGINEER

PRELIMINARY PLANS
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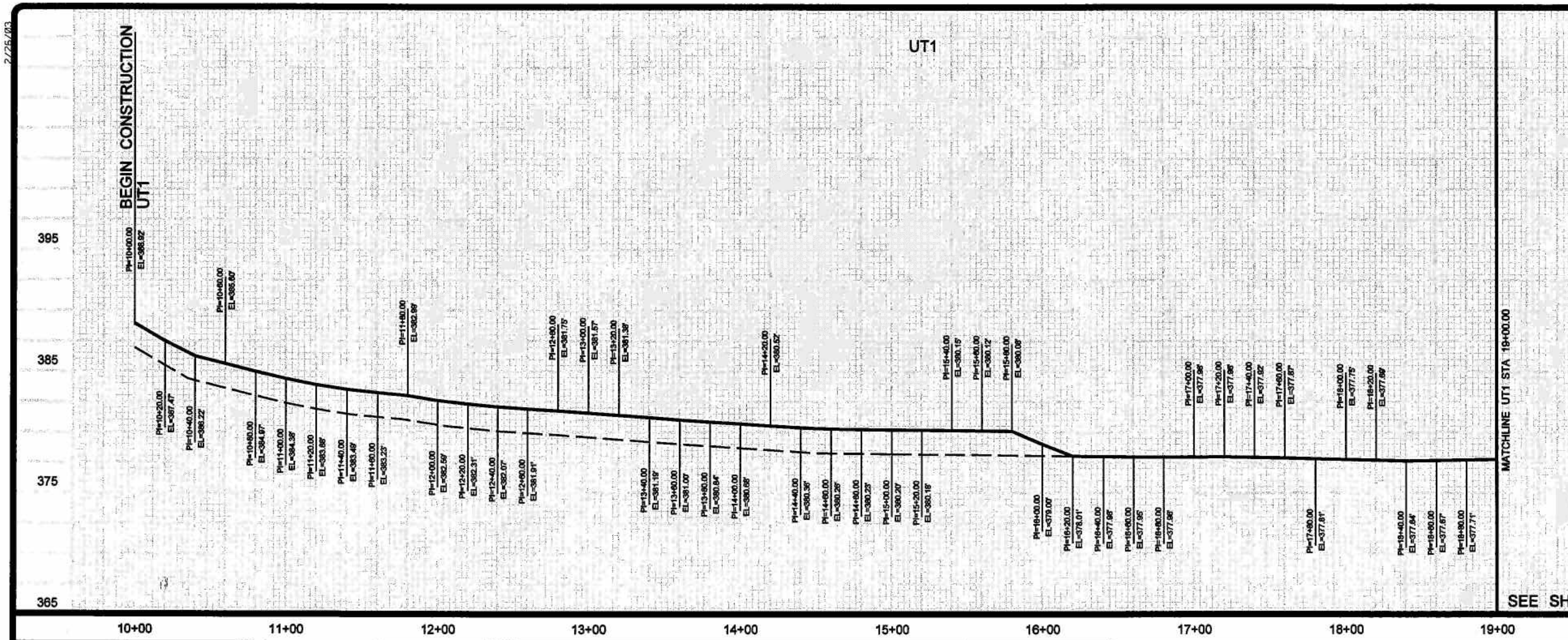
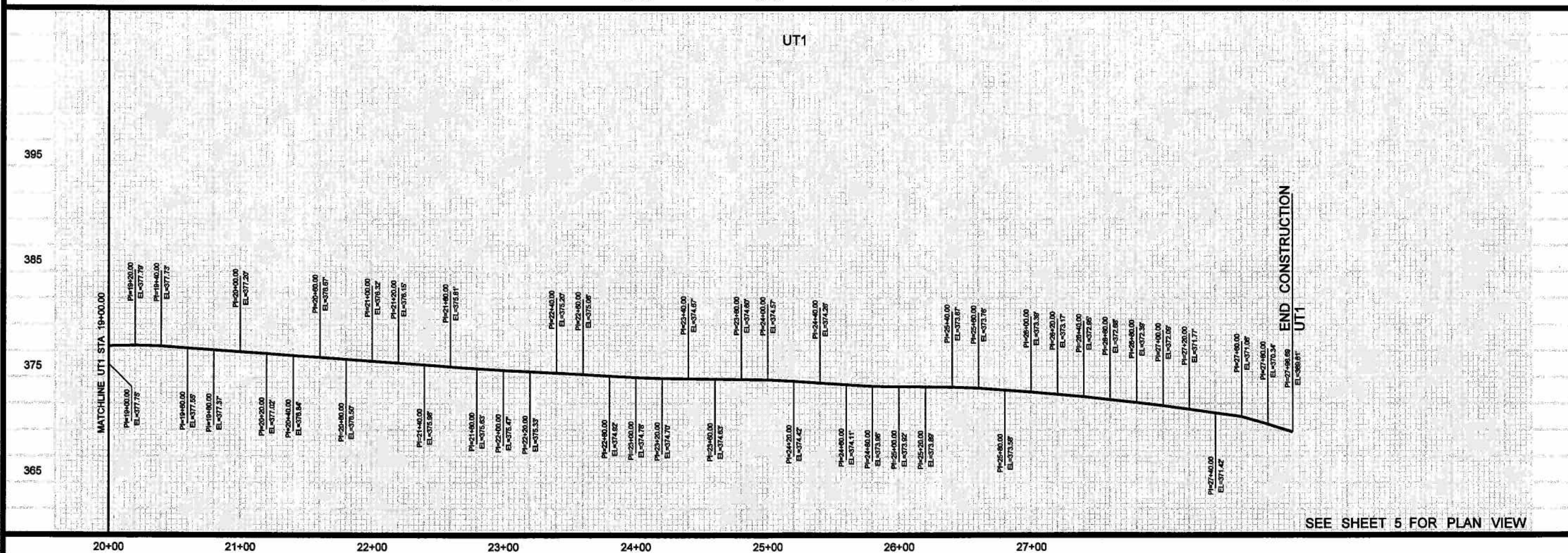


SEE SHEET 4 FOR PLAN VIEW



SEE SHEET 5 FOR PLAN VIEW

2/25/03
4/2/2008
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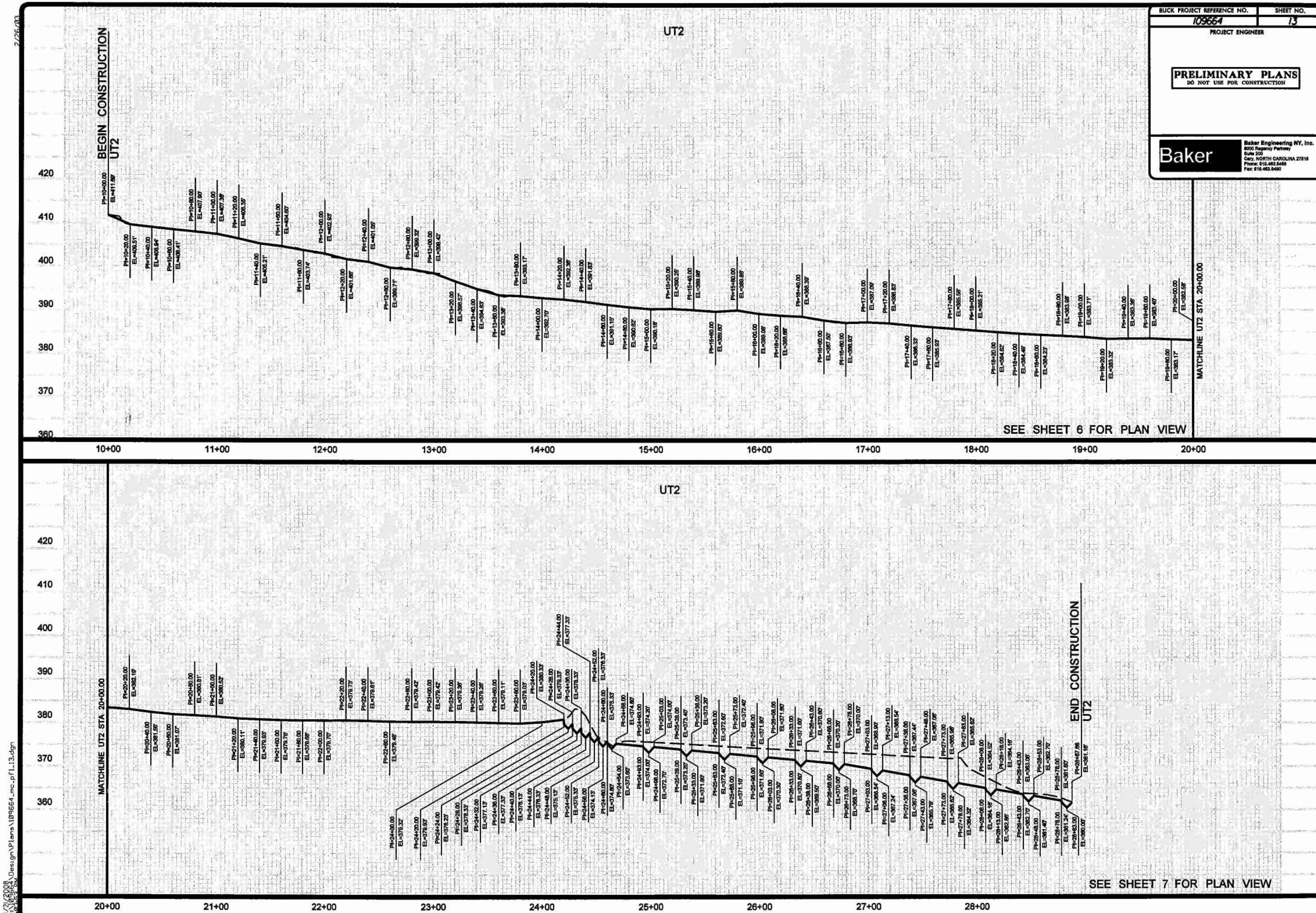

BUCK PROJECT REFERENCE NO.
109664
SHEET NO.
13
PROJECT ENGINEER
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
Baker
Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
UT2
BEGIN CONSTRUCTION UT2
MATCHLINE UT2 STA 20+00.00
SEE SHEET 6 FOR PLAN VIEW
END CONSTRUCTION UT2
SEE SHEET 7 FOR PLAN VIEW
420
410
400
390
380
370
360
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
28+00
2/26/03
4/2/2008
109664_mc_pf1_13.dgn

BUCK PROJECT REFERENCE NO. 109664 | SHEET NO. 14

PROJECT ENGINEER

PRELIMINARY PLANS
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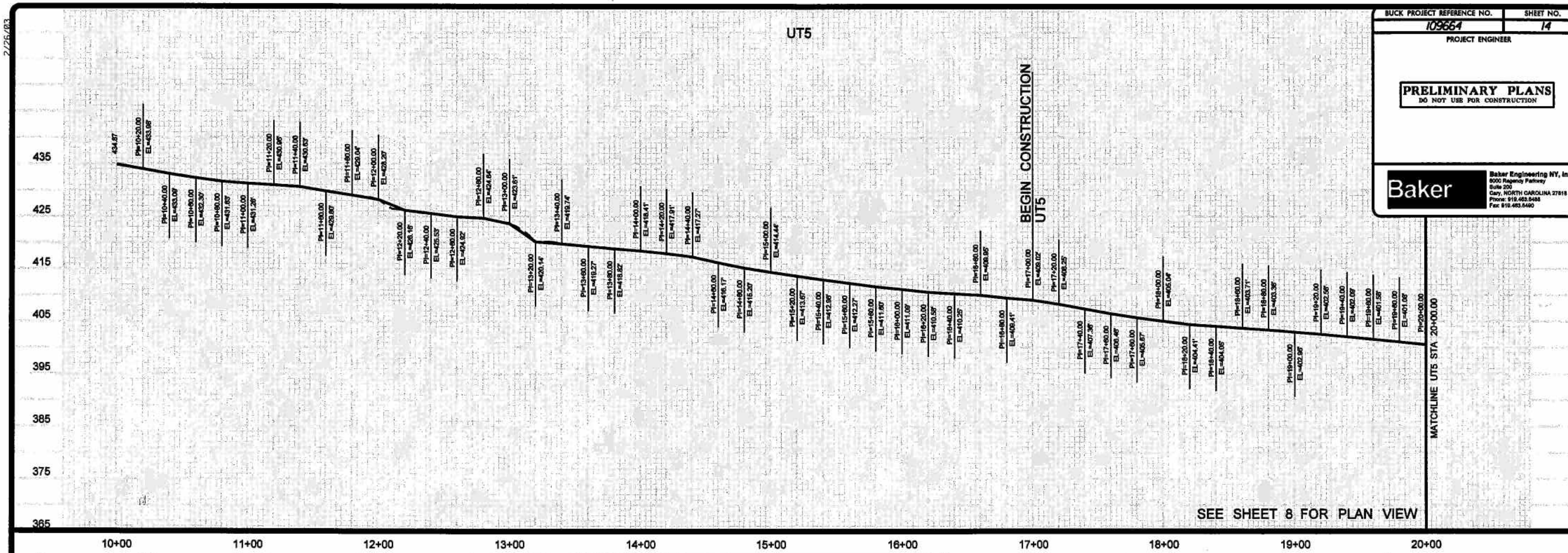

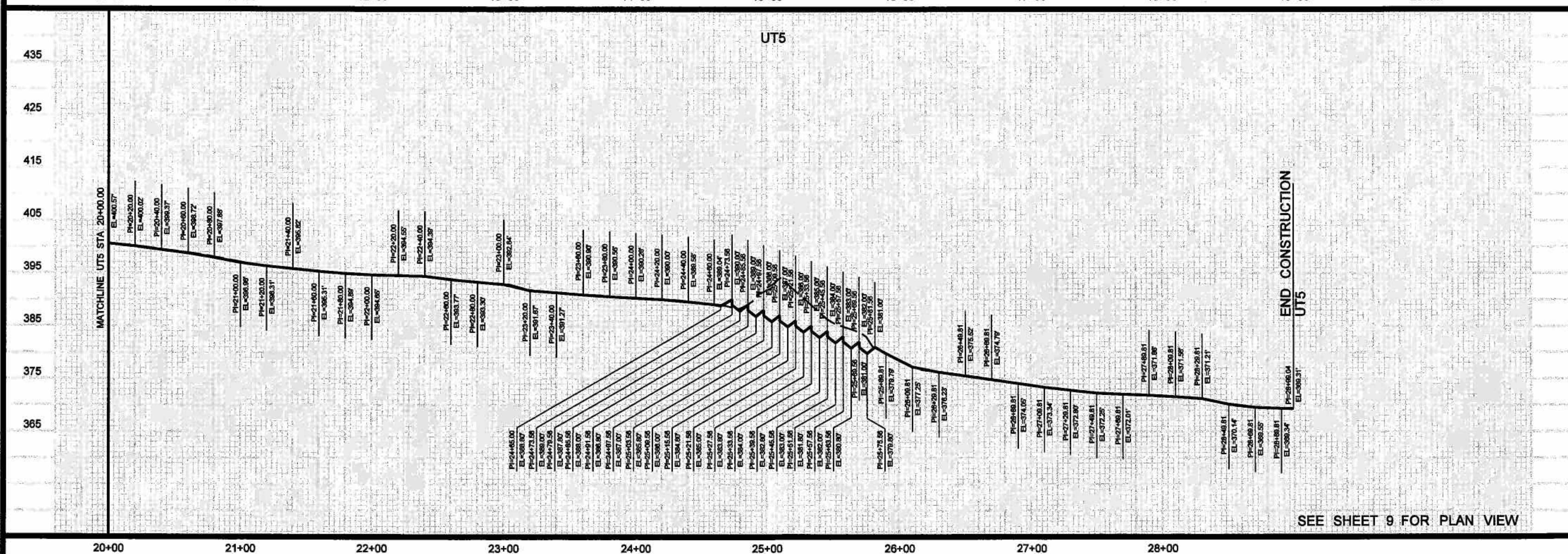

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4/2/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	15

PROJECT ENGINEER

PRELIMINARY PLANS
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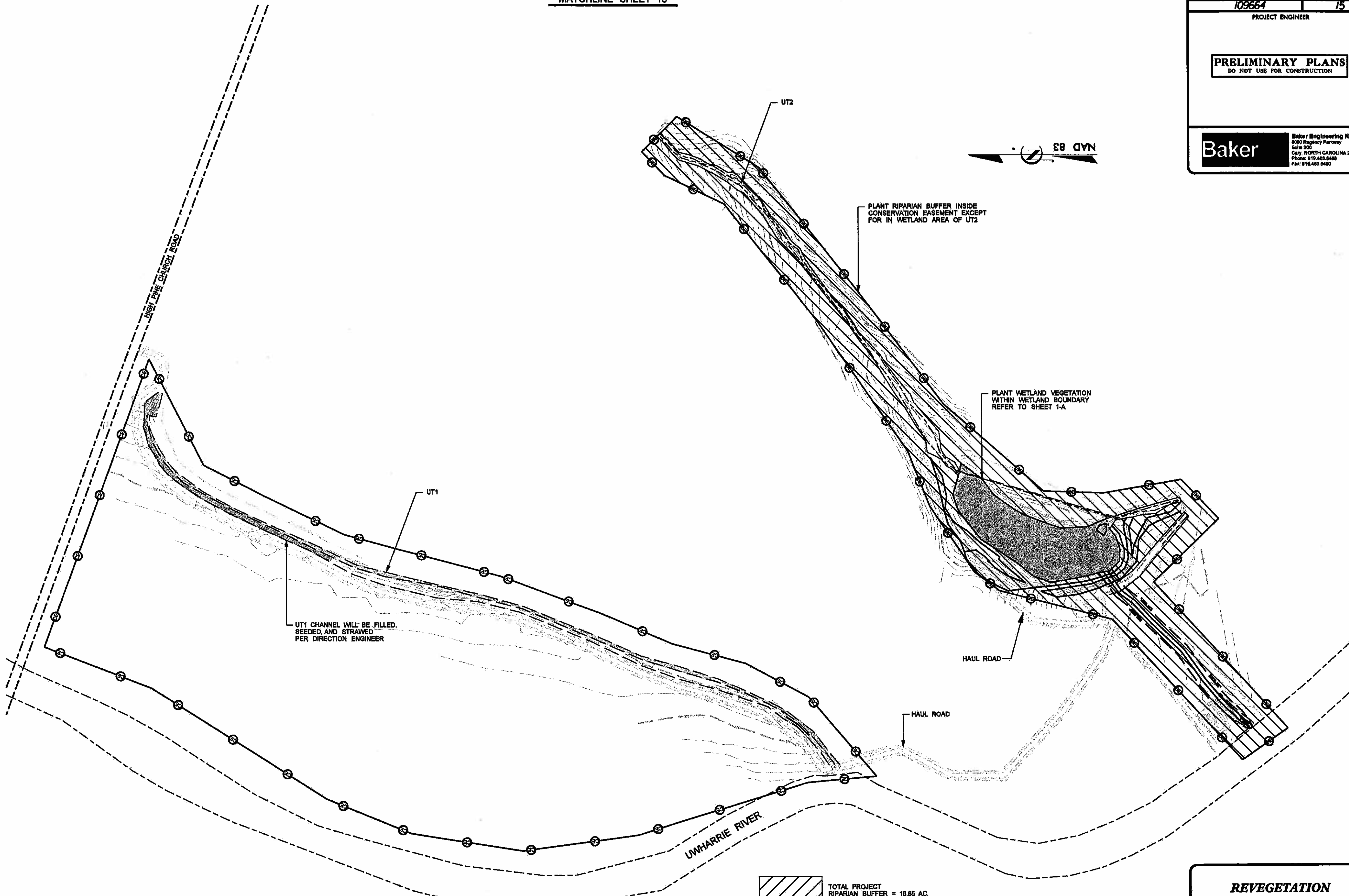
MATCHLINE SHEET 16



TOTAL PROJECT RIPARIAN BUFFER = 16.85 AC.

TOTAL PROJECT WETLAND PLANTING AREA = 1.10 AC.

NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/STABILIZATION DOES NOT OCCUR.

REVEGETATION

100 50 0 100 200
SCALE (FT)

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4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	16

PROJECT ENGINEER

PRELIMINARY PLANS
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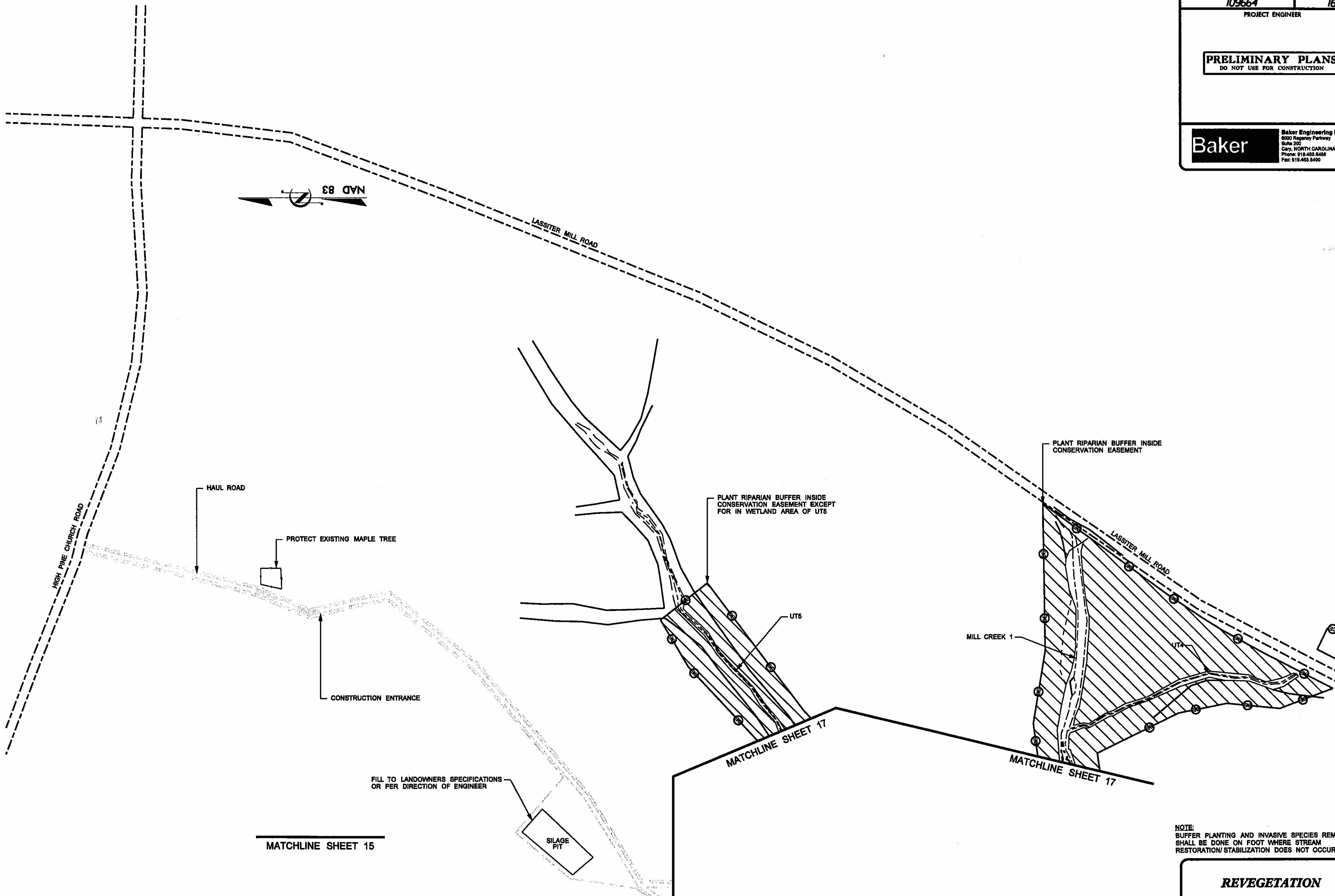

NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

TOTAL PROJECT RIPARIAN BUFFER = 16.85 AC.

REVEGETATION

100 50 0 100 200
SCALE (FT)

2/26/03
4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	17

PROJECT ENGINEER

PRELIMINARY PLANS
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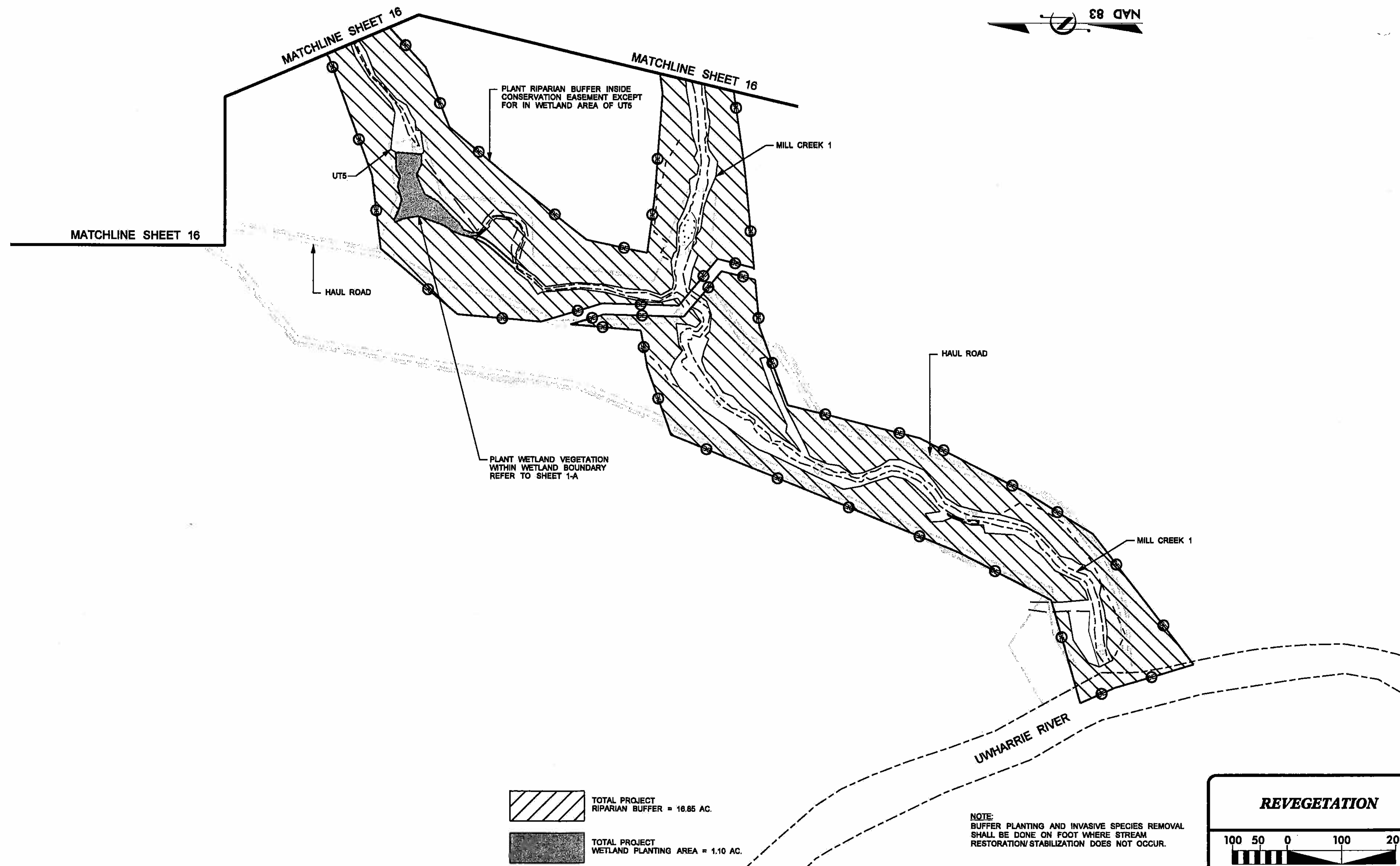

NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

REVEGETATION

100 50 0 100 200
SCALE (FT)

2/26/03

4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	18

PROJECT ENGINEER

PRELIMINARY PLANS
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PRESERVATION AREAS

400 200 0 400 800
SCALE (FT)

2/26/03
4/21/2008
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STATE	BAKER PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	109664	EC-1	14

PROJECT STANDARDS

THE FOLLOWING ROADWAY ENGLISH STANDARDS AS THEY APPEAR IN THE "ROADWAY STANDARD DRAWINGS" – ROADWAY UNIT – N.C. DEPARTMENT OF TRANSPORTATION – RALEIGH, N.C. DATED JANUARY 20, 2002 AND THE LATEST REVISION THERETO ARE APPLICABLE TO THIS PROJECT AND BY REFERENCE HEREBY ARE CONSIDERED A PART OF THESE PLANS

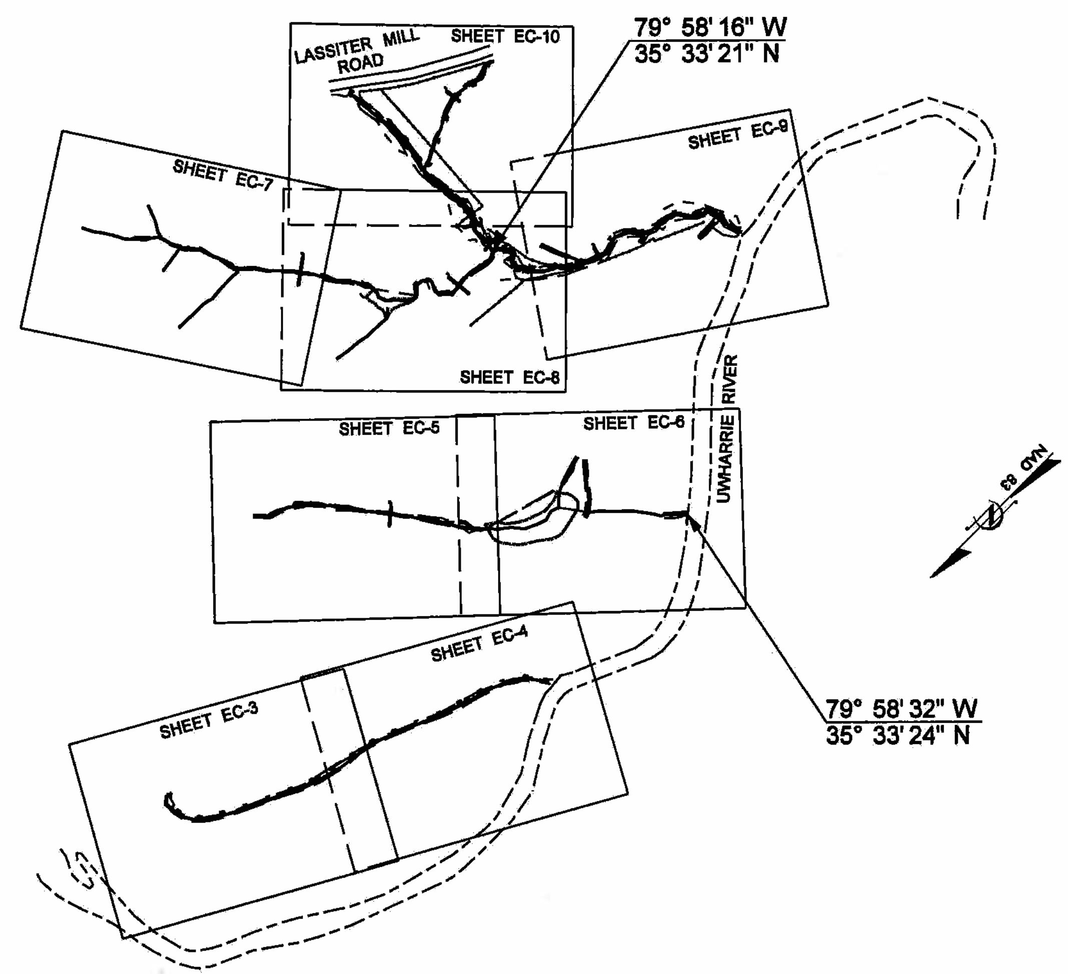
STD. NO.	DESCRIPTION	SYMBOL
6.06	TEMPORARY CONSTRUCTION ACCESS	
6.60	TEMPORARY SEDIMENT TRAP	
6.62	SILT FENCE	
6.63	TEMPORARY ROCK DAM	

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

EROSION CONTROL PLAN

LOCATION: LASSITER MILL – OFF
HIGH PINE CHURCH ROAD

TYPE OF WORK: STREAM RESTORATION/ENHANCEMENT
WETLAND CREATION



PROJECT:

GRAPHIC SCALES

30 15 0 30 60
PLANS

THIS PROJECT CONTAINS EROSION CONTROL PLANS FOR ALL PHASES OF CONSTRUCTION.

TOTAL DISTURBED AREA = 17.00 Acres

PREPARED IN THE OFFICE OF:

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Fax: 919.463.5490

SUMMER '08
LETTING DATE:

KEVIN TWEEDY, PE
PROJECT ENGINEER

WARD ELIS
PROJECT MANAGER

JOSHUA WHITE, PG
PROJECT DESIGNER

PROJECT ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

SIGNATURE: P.E.

PROJECT REFERENCE NO.	SHEET NO.
109664	EC-2

PROJECT ENGINEER

PRELIMINARY PLANS
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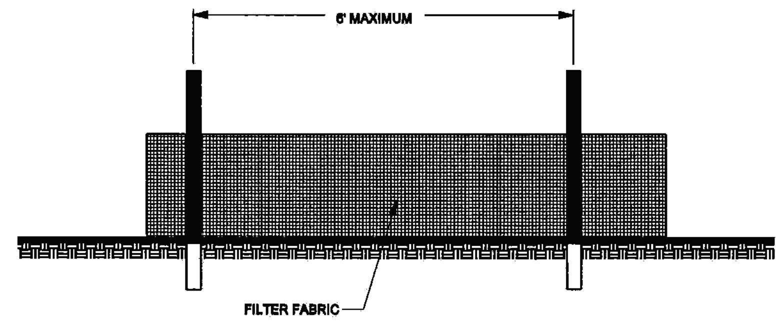
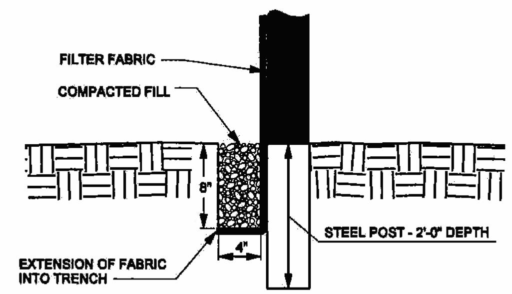
TEMPORARY SILT FENCE

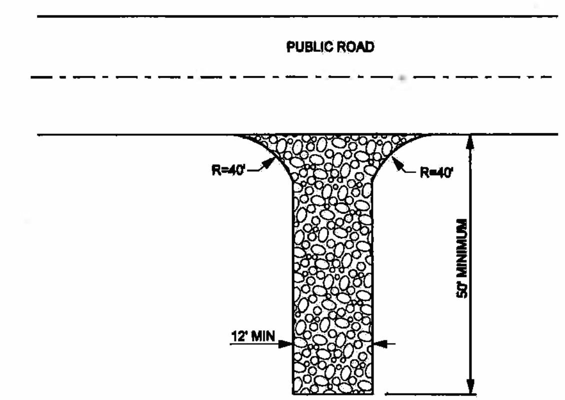


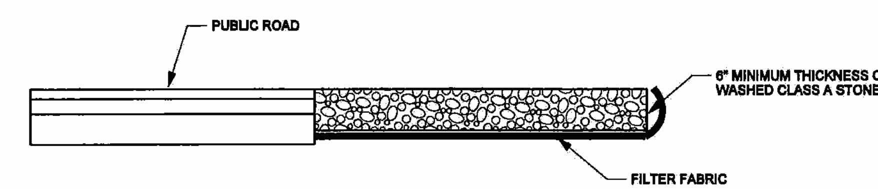


NOTES:

1. USE FILTER FABRIC A MINIMUM OF 36" IN WIDTH AND FASTEN ADEQUATELY TO THE WIRE AS DIRECTED BY THE ENGINEER.
2. PROVIDE 5' STEEL POST OF THE SELF-FASTENER ANGLE STEEL TYPE.

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE

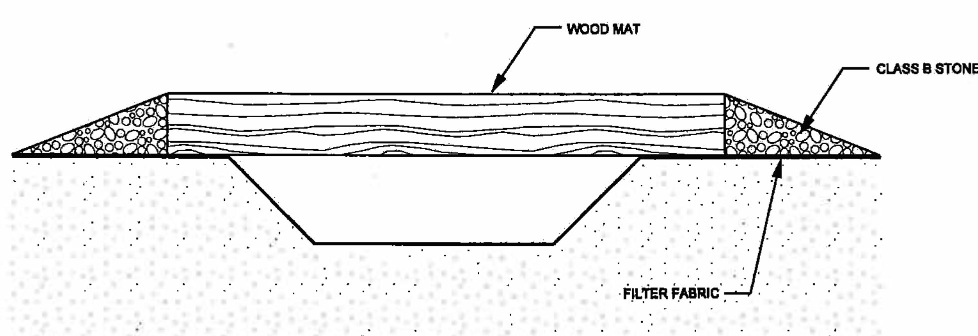




NOTES:

SPECIFICATION NO. 6.06 - CONSTRUCTION ACCESS "N.C. EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL DECEMBER 1993"

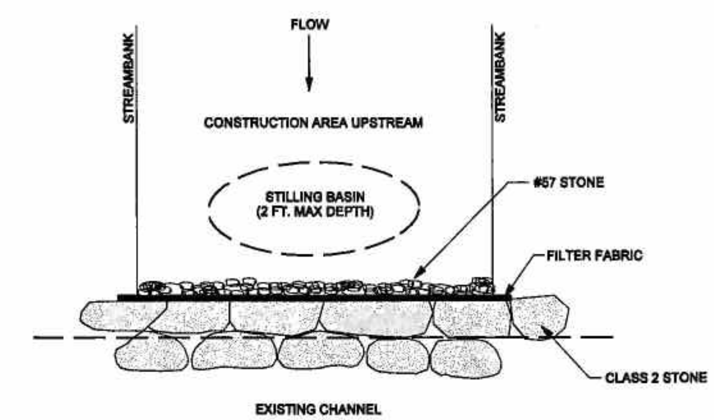
TEMPORARY STREAM CROSSING - WOOD MAT



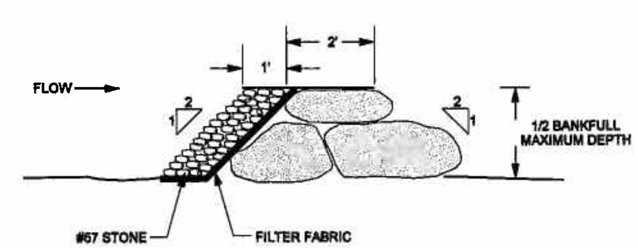
NOTES:

1. CONSTRUCT STREAM CROSSING WHEN FLOW IS LOW.
2. HAVE ALL NECESSARY MATERIALS AND EQUIPMENT ON-SITE BEFORE WORK BEGINS.
3. MINIMIZE CLEARING AND EXCAVATION OF STREAMBANKS. DO NOT EXCAVATE CHANNEL BOTTOM.
4. LINE STREAMBANK AND ACCESS RAMP AREA WITH NON-WOVEN FILTER FABRIC.
5. INSTALL STREAM CROSSING AT RIGHT ANGLE TO THE FLOW.
6. TRANSPLANT SOD FROM ORIGINAL STREAMBANK ONTO SIDE SLOPES FOR LATER USE.
7. MAINTAIN CROSSING SO THAT RUNOFF IN THE CONSTRUCTION ROAD DOES NOT ENTER EXISTING CHANNEL.
8. STABILIZE AN ACCESS RAMP OF CLASS B STONE TO THE EDGE OF THE MUD MAT.
9. THE WOOD MAT SHALL BE OF SUFFICIENT SIZE AND WIDTH TO SUPPORT THE LARGEST VEHICLE CROSSING THE CHANNEL.
10. CONTRACTOR SHALL DETERMINE AN APPROPRIATE RAMP ANGLE ACCORDING TO EQUIPMENT UTILIZED, RECOMMENDED AT A 5:1 SLOPE.

TEMPORARY ROCK DAM



PLAN VIEW



CROSS SECTION

Baker
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8000 Regency Parkway
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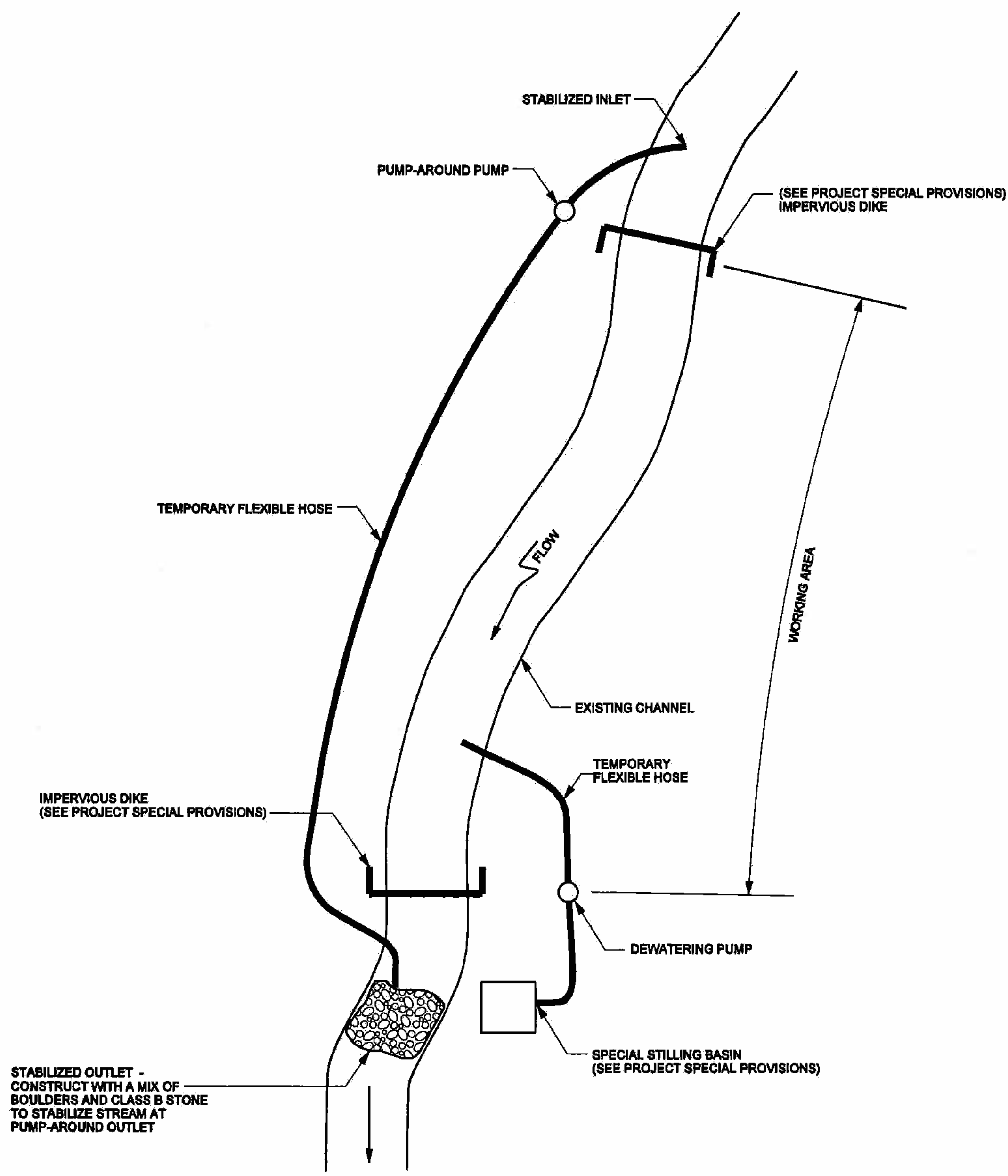
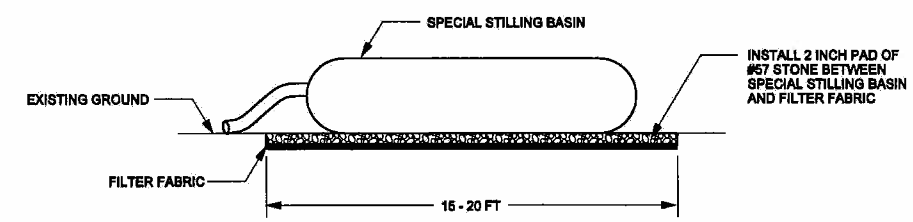
TYPICAL PUMP-AROUND OPERATION



NOTES:

1. EXCAVATION SHALL BE PERFORMED IN ONLY DRY SECTIONS OF CHANNEL.
2. IMPERVIOUS DIKES SHOULD BE USED TO ISOLATE WORK AREAS FROM STREAM FLOW.
3. THE CONTRACTOR SHALL NOT DISTURB MORE AREA THAN CAN BE STABILIZED IN ONE WORKING DAY.
4. THE PUMP-AROUND PUMP SHOULD ADEQUATELY CONVEY 1.5 CFS (675 GALLONS PER MINUTE).



SEQUENCE OF CONSTRUCTION FOR TYPICAL PUMP-AROUND

1. INSTALL STABILIZED OUTLET AT THE DOWNSTREAM END OF THE DESIGNATED PROJECT WORKING AREA.
2. THE CONTRACTOR WILL INSTALL THE PUMP-AROUND PUMP AND THE TEMPORARY FLEXIBLE HOSE THAT WILL CONVEY THE BASE FLOW FROM UPSTREAM OF THE WORK SITE TO THE SPECIAL STILLING BASIN OR STABILIZED OUTLET.
3. INSTALL UPSTREAM IMPERVIOUS DIKE AND BEGIN PUMPING OPERATIONS FOR STREAM DIVERSION.
4. INSTALL THE DOWNSTREAM IMPERVIOUS DIKE AND PUMPING APPARATUS IF NEEDED TO DEWATER THE ENTRAPPED AREA. THE PUMP AND HOSE FOR THIS PURPOSE SHALL BE OF SUFFICIENT SIZE TO DEWATER THE WORK AREA. THIS WATER WILL FLOW INTO A SPECIAL STILLING BASIN.
5. THE CONTRACTOR WILL PERFORM STREAM RESTORATION WORK IN ACCORDANCE WITH THE PLAN AND FOLLOWING THE GENERAL CONSTRUCTION SEQUENCE.
6. THE CONTRACTOR WILL EXCAVATE ANY ACCUMULATED SILT AND DEWATER BEFORE REMOVAL OF THE IMPERVIOUS DIKE. REMOVE IMPERVIOUS DIKES, PUMPS, AND TEMPORARY FLEXIBLE HOSE STARTING WITH THE DOWNSTREAM DIKE FIRST.
7. THE CONTRACTOR WILL COMPLETE ALL GRADING AND STABILIZATION IN ONE DAY WITHIN THE PUMP-AROUND AREA BETWEEN THE IMPERVIOUS DIKES.
8. ONCE THE WORKING AREA IS COMPLETED, REMOVE THE SPECIAL STILLING BASIN AND STABILIZED OUTLET AND STABILIZE DISTURBED AREAS WITH SEED AND MULCH.

BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-3

PROJECT ENGINEER

PRELIMINARY PLANS
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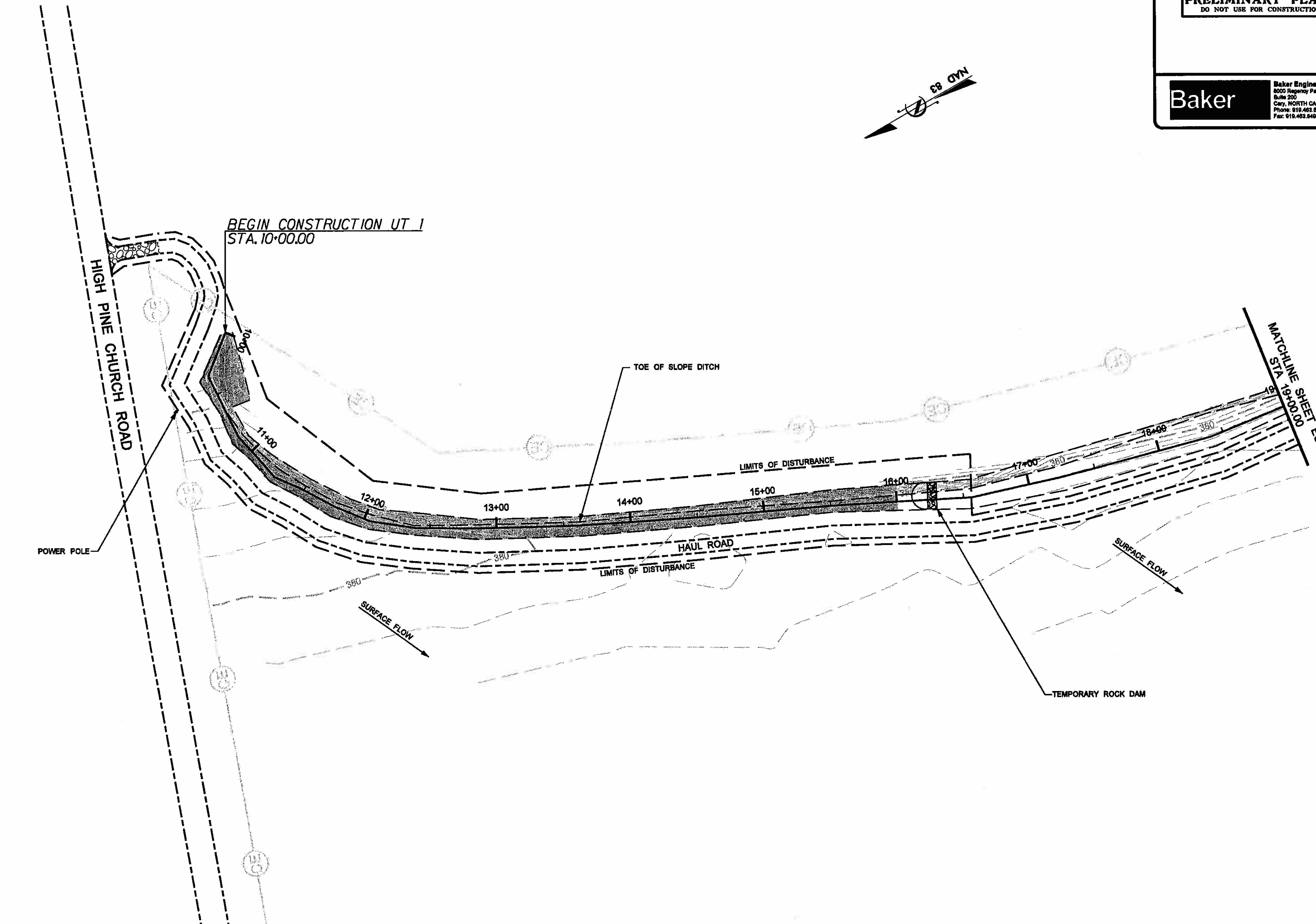
Fax: 919.463.5490



NOTE:
CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03

4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-4

PROJECT ENGINEER

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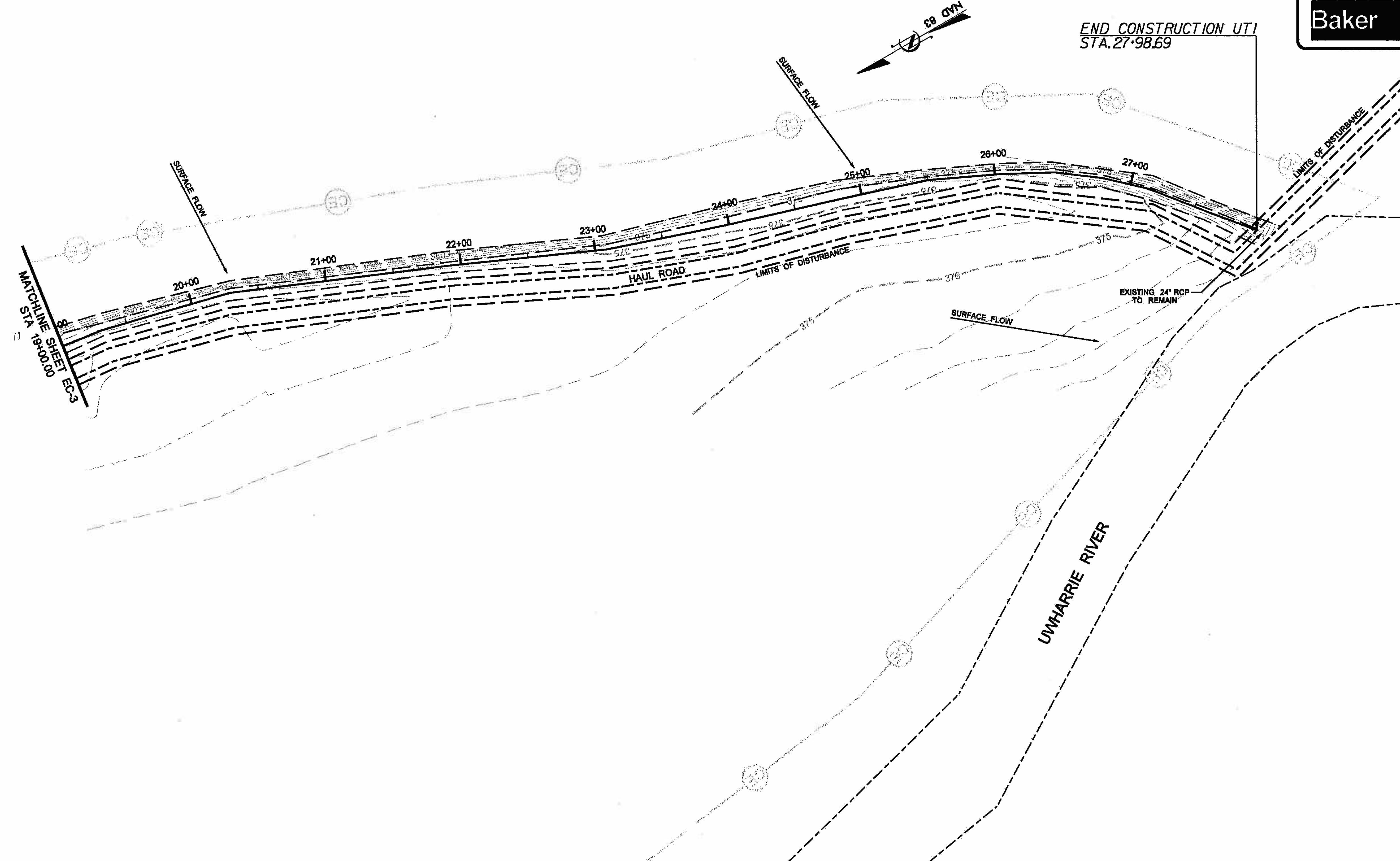

NOTE:
CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03

4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-5

PROJECT ENGINEER

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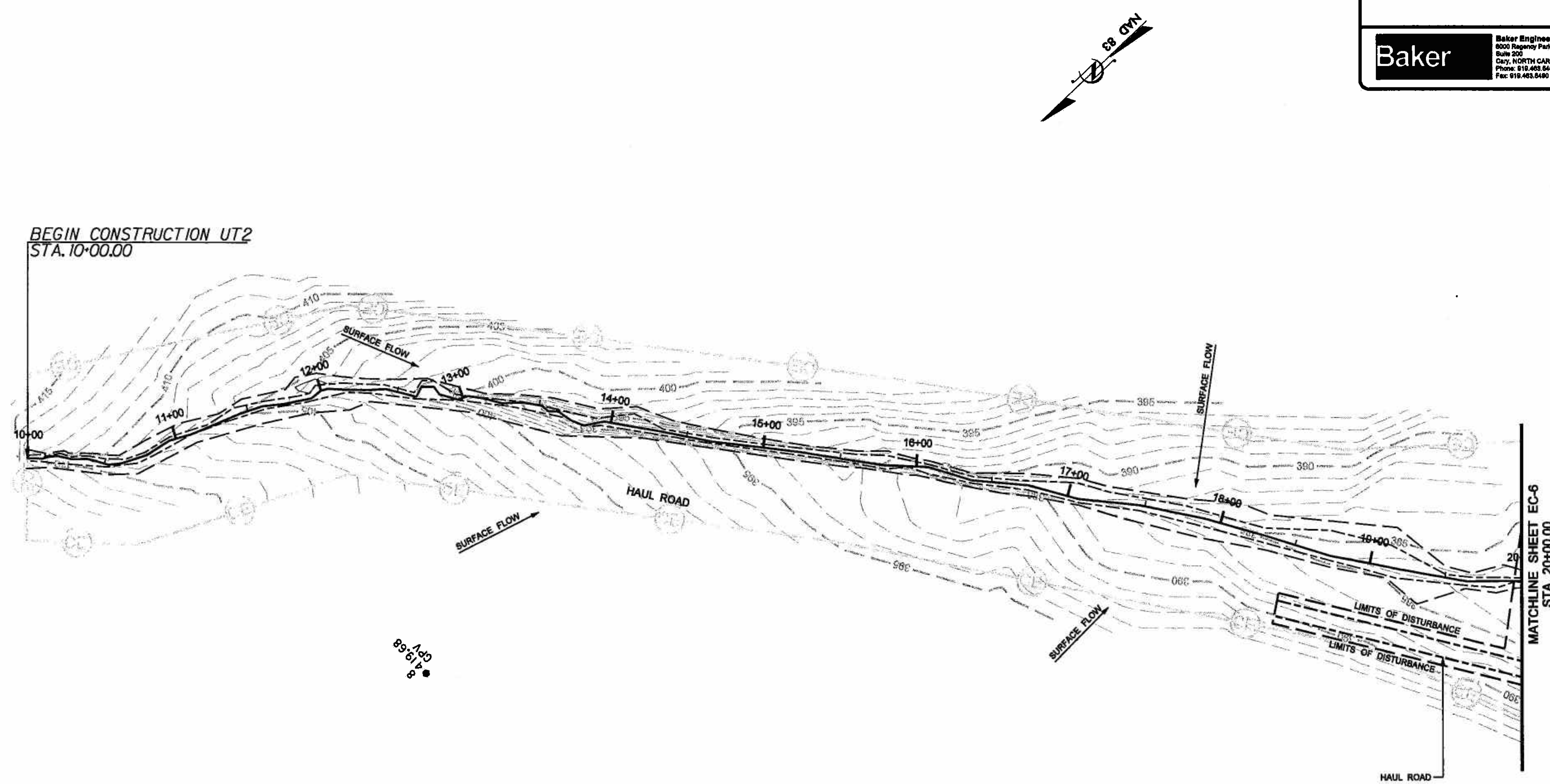

NOTE:
CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03
4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-6

PROJECT ENGINEER

PRELIMINARY PLANS
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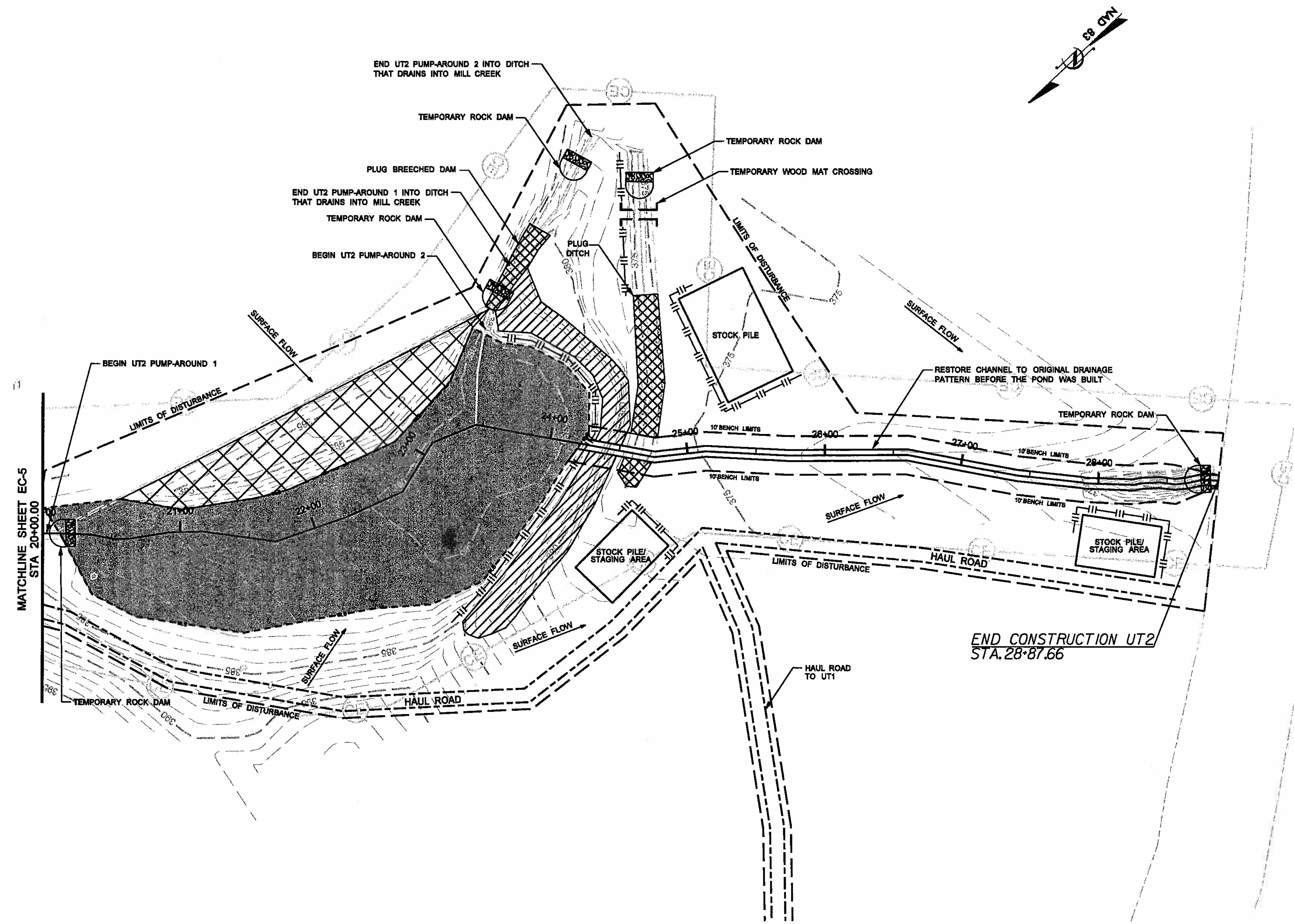

NOTE:
CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03
4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-7

PROJECT ENGINEER

PRELIMINARY PLANS
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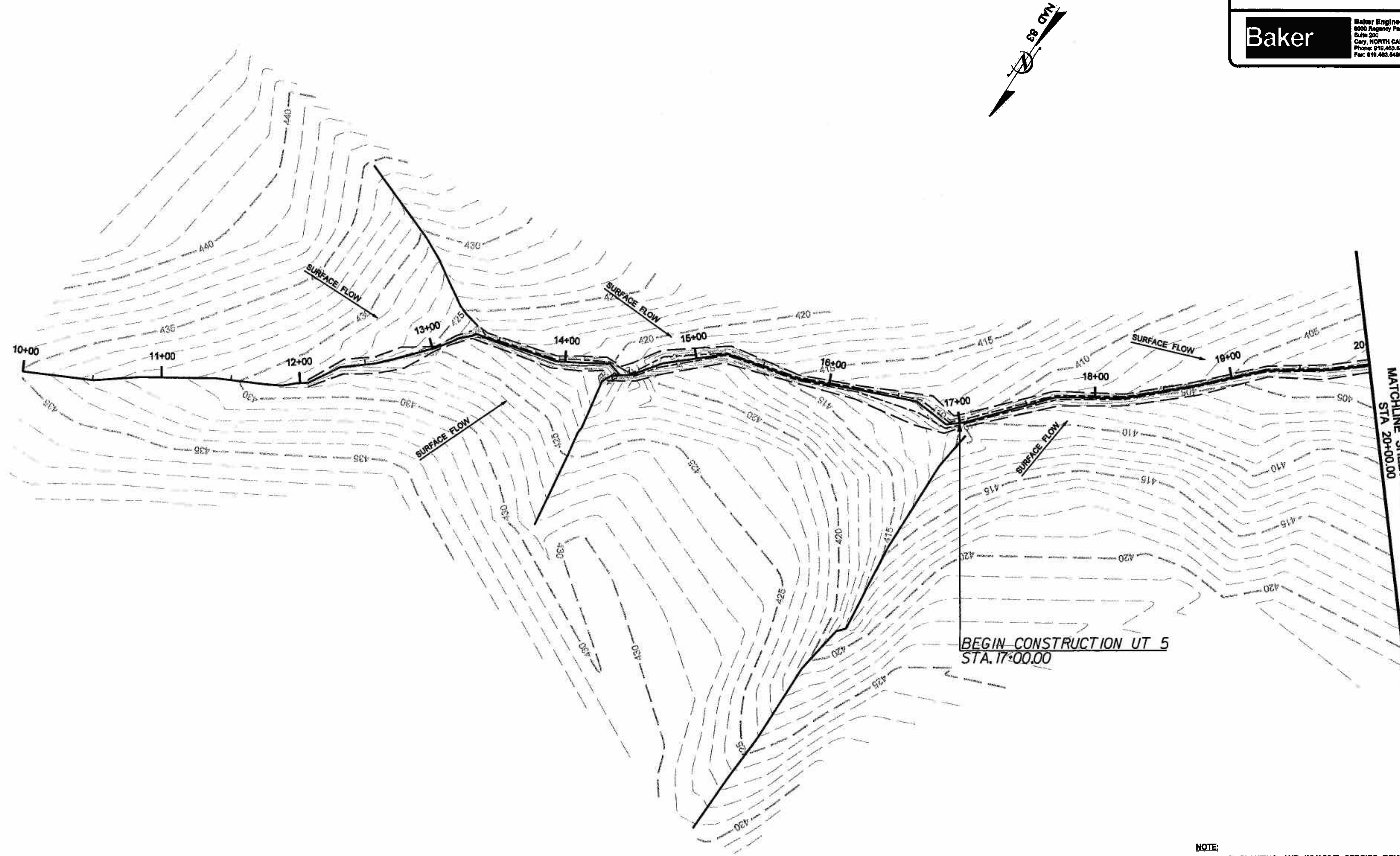

NOTE:
1. BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.
2. CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03
4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-8

PROJECT ENGINEER

PRELIMINARY PLANS
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Baker
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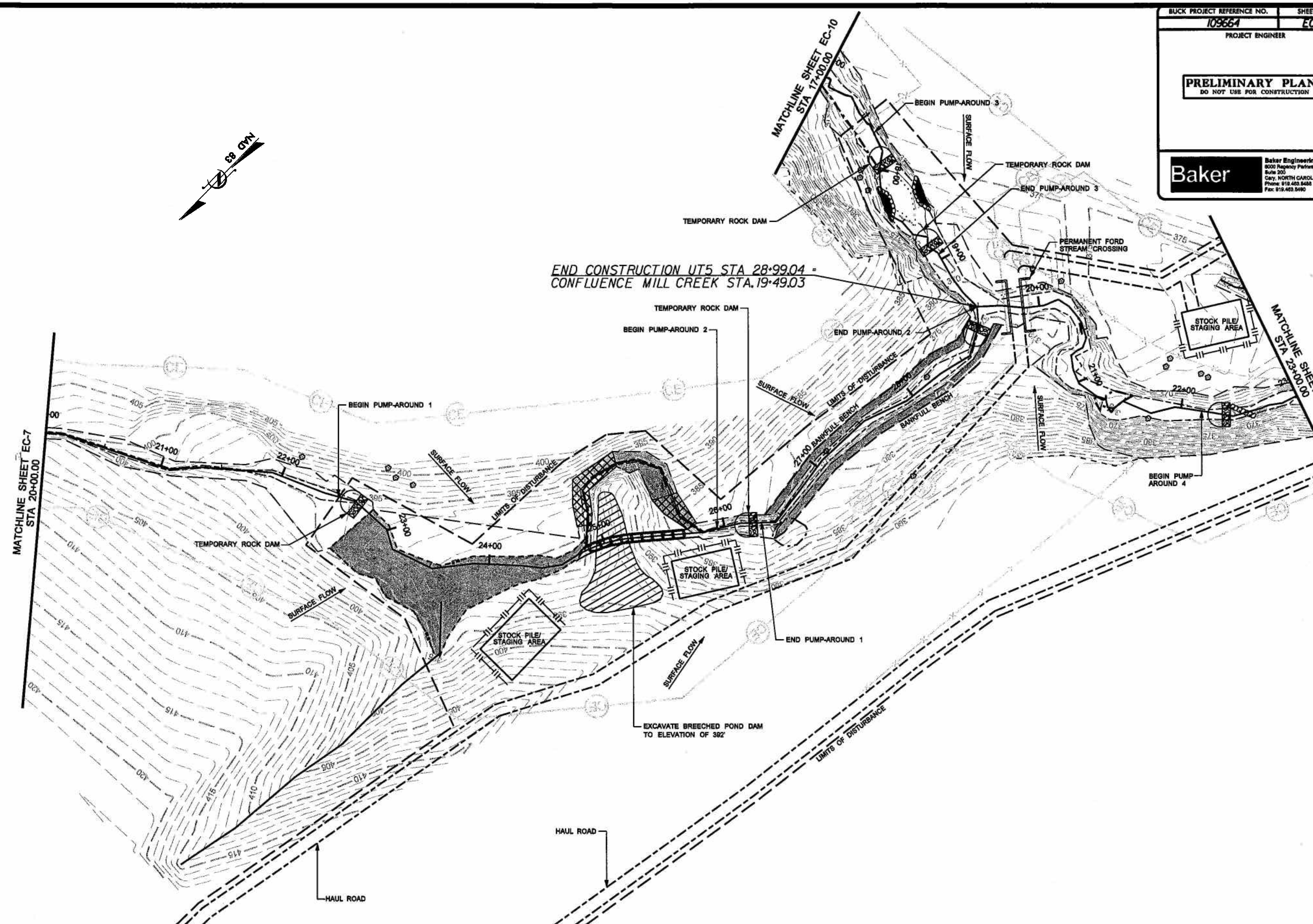

NOTE:

1. BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

2. CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03

4/2/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-9

PROJECT ENGINEER

PRELIMINARY PLANS
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8000 Regency Parkway
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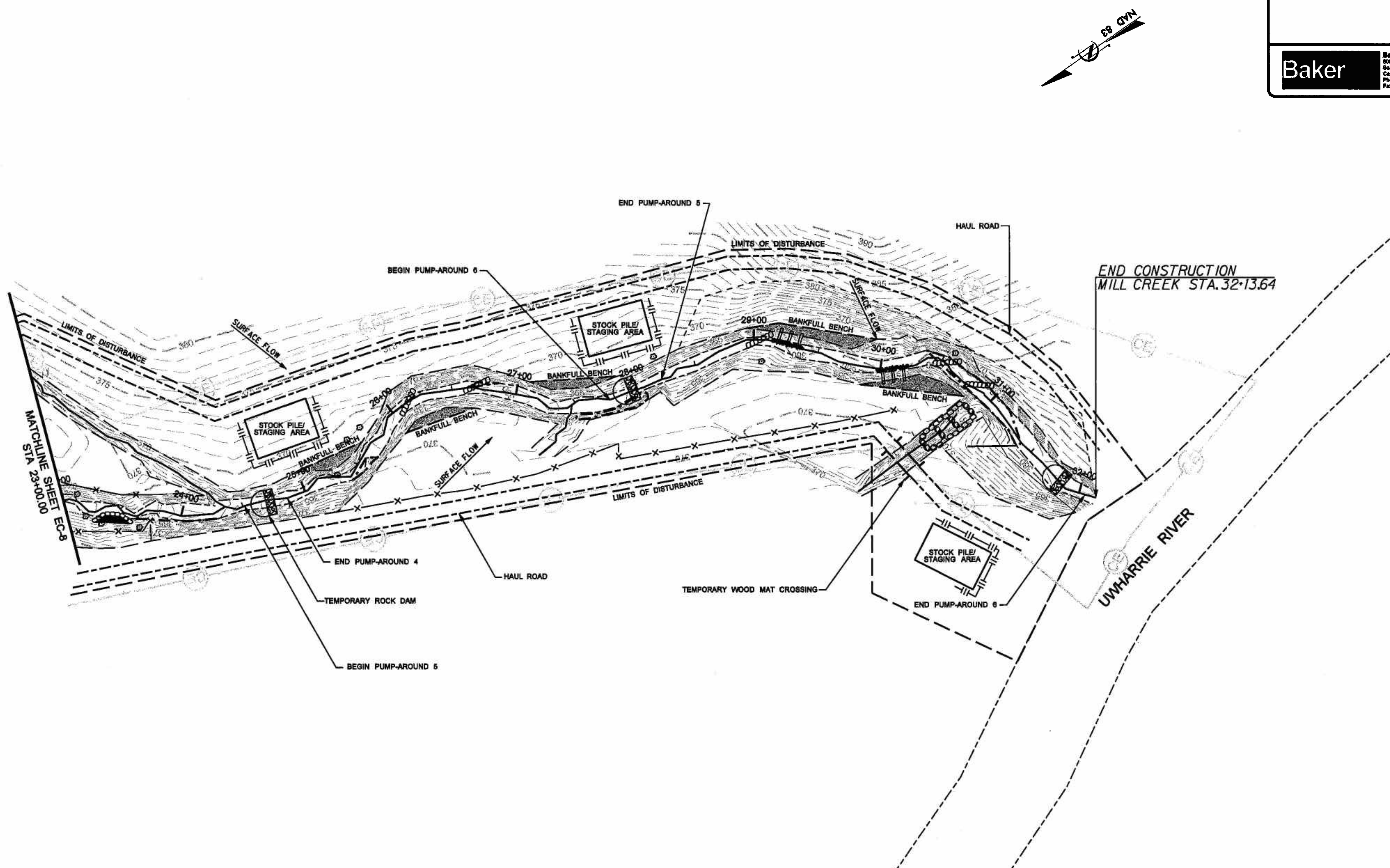
Phone: 919.463.5488
Fax: 919.463.5490



NOTE:
CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03

4/2/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-10

PROJECT ENGINEER

PRELIMINARY PLANS
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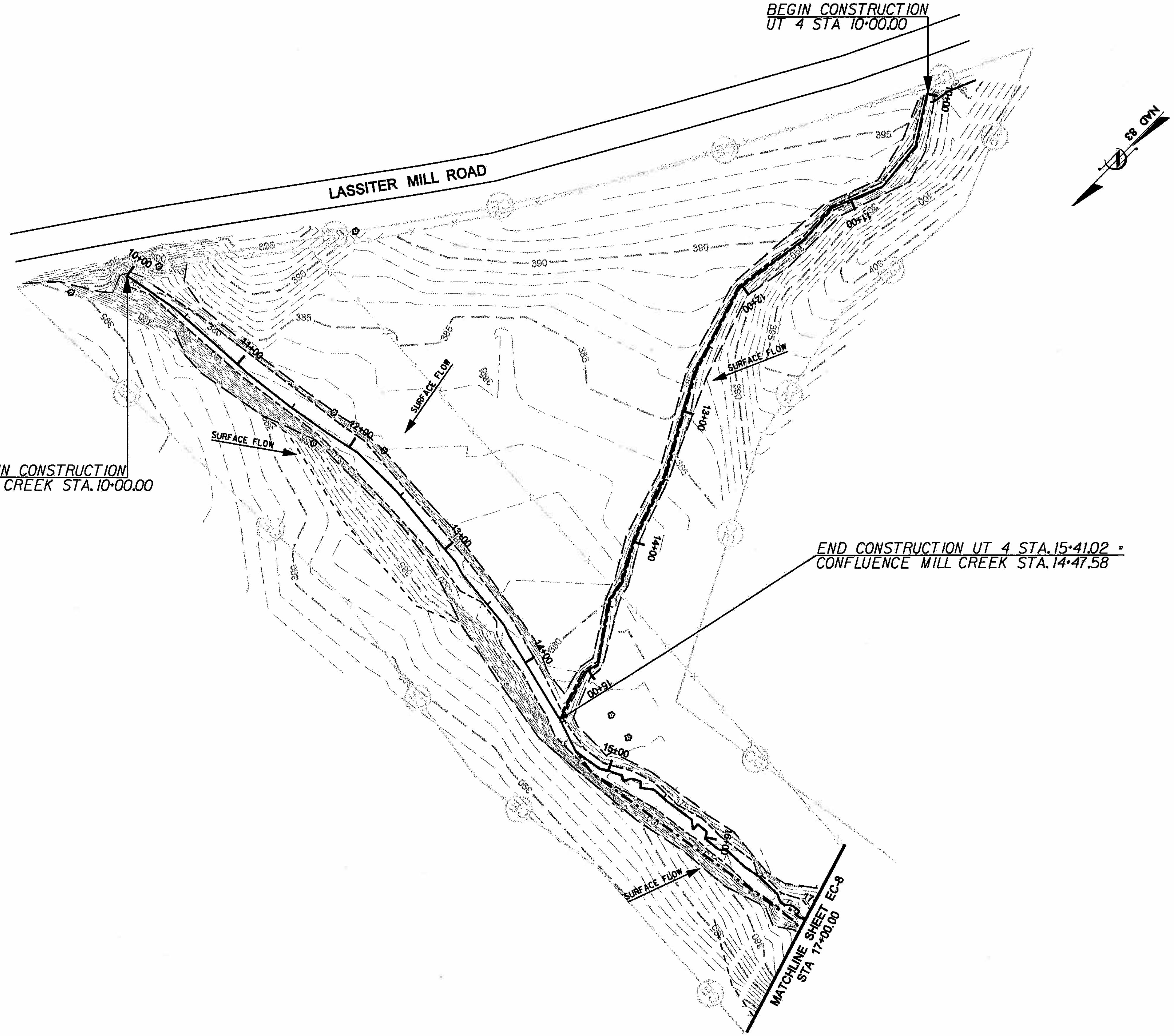
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490



NOTE:
1. BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.
2. CONTRACTOR WILL WORK WITHIN LIMITS OF DISTURBANCE.

EROSION AND SEDIMENT CONTROL

40 20 0 40 80
SCALE (FT)

2/26/03

4/21/2008
r:\109664\Design\Plans\109664_mc_EC_10.dgn

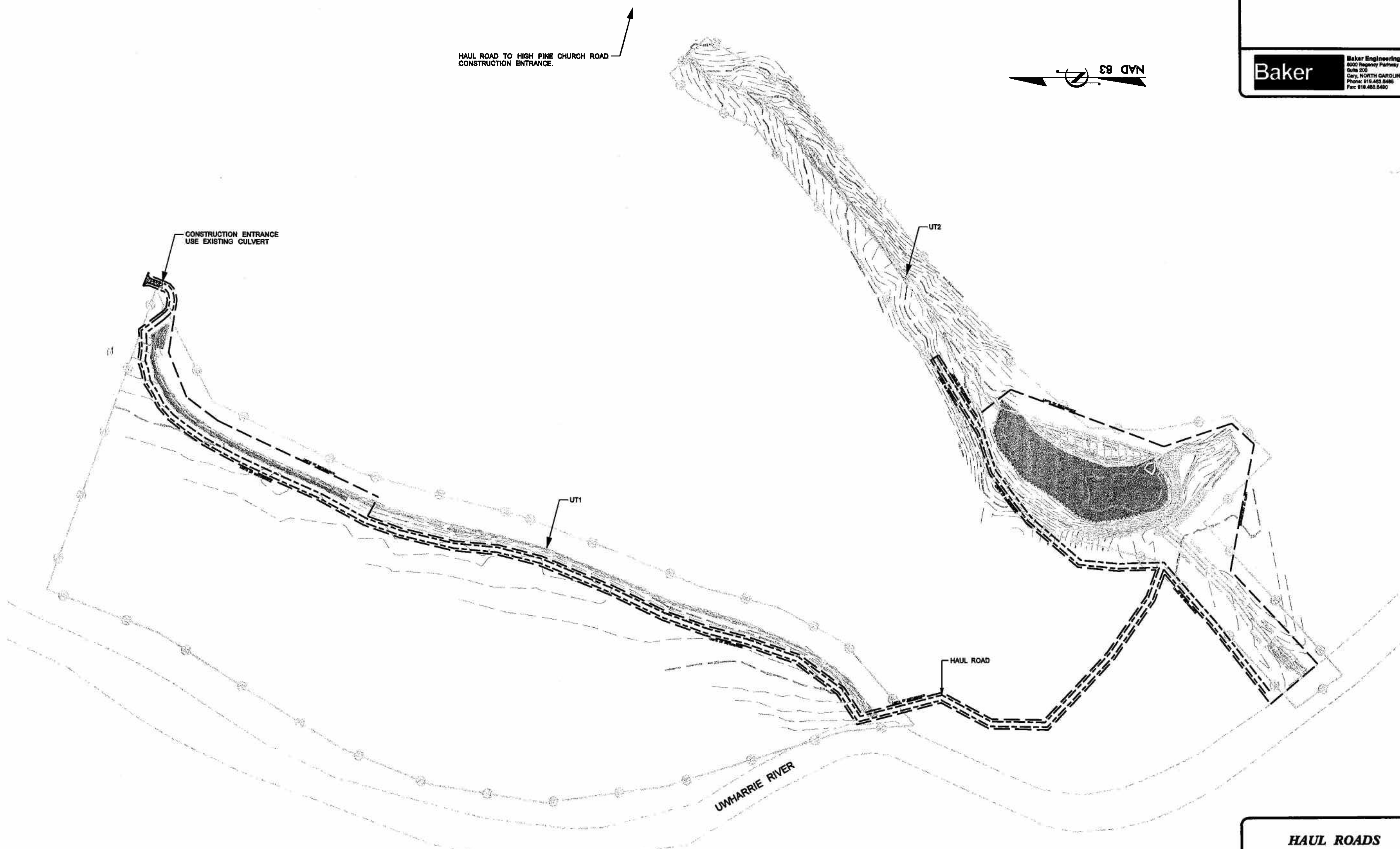
BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-11

PROJECT ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

Baker
Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490

MATCHLINE SHEET EC-12



NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

HAUL ROADS

100 50 0 100 200
SCALE (FT)

2/26/03

4/21/2008
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BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-12

PROJECT ENGINEER

PRELIMINARY PLANS
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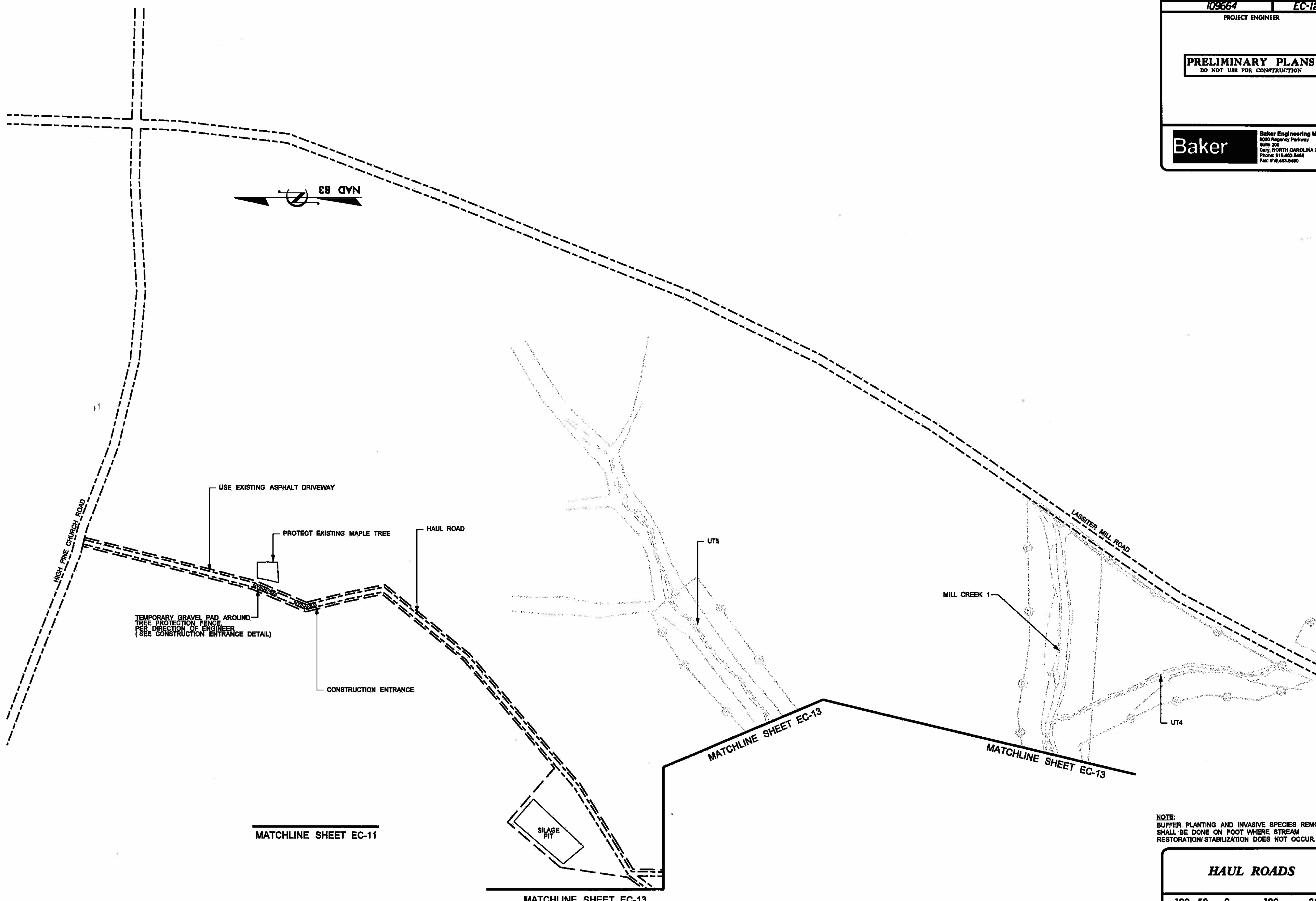

NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

HAUL ROADS

100 50 0 100 200
SCALE (FT)

2/26/03
4/21/2008
r:\109664\Design\Plans\109664_mc_EC_12.dgn

BUCK PROJECT REFERENCE NO.	SHEET NO.
109664	EC-13

PROJECT ENGINEER

PRELIMINARY PLANS
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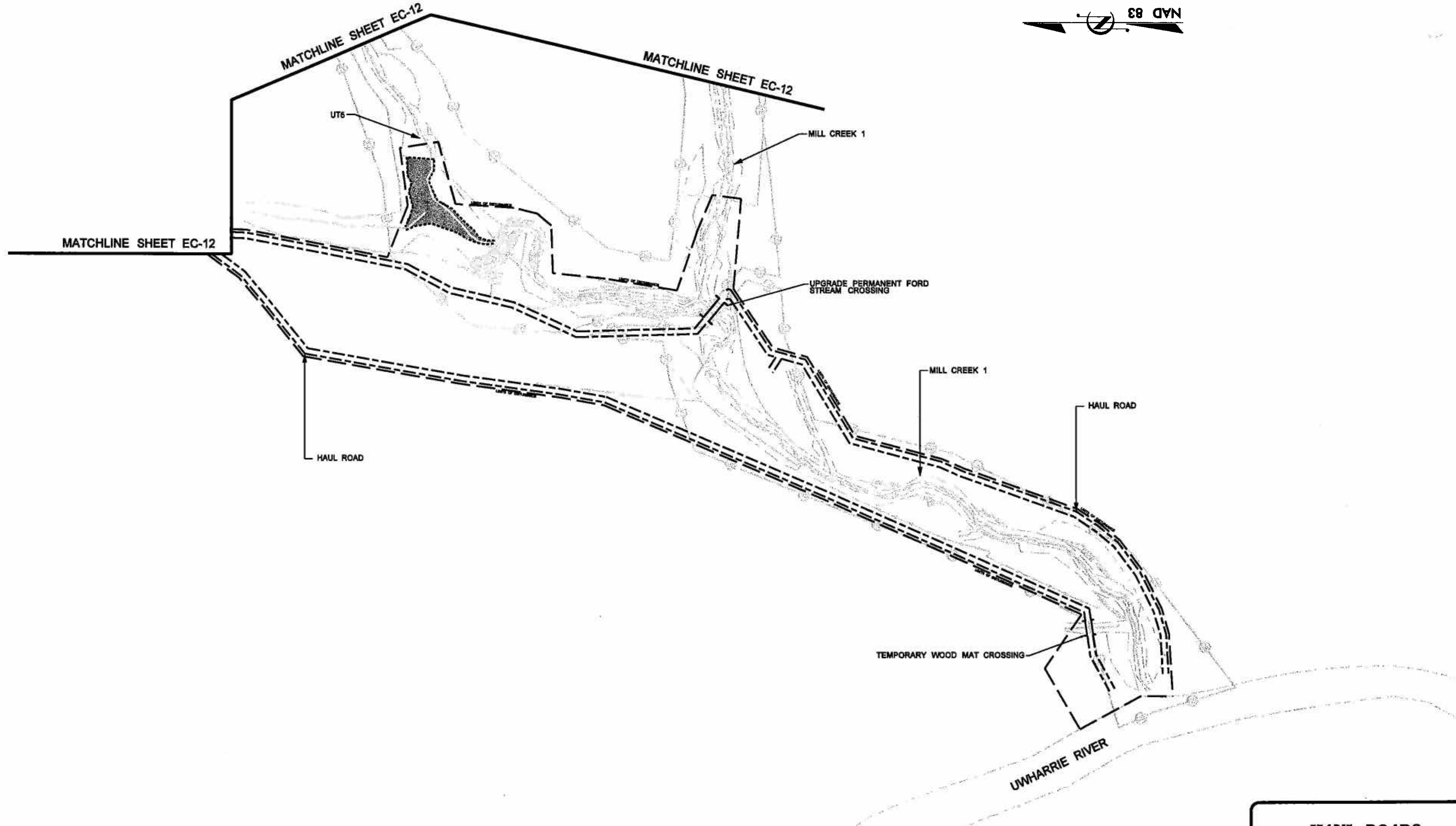

NOTE:
BUFFER PLANTING AND INVASIVE SPECIES REMOVAL SHALL BE DONE ON FOOT WHERE STREAM RESTORATION/ STABILIZATION DOES NOT OCCUR.

HAUL ROADS

100 50 0 100 200
SCALE (FT)

4/21/2008
r:\109664\Design\Plans\109664_mc_EC_13.dgn