Cane Creek Tributary Site
Stream Restoration Plan

Person County, North Carolina

State Contract No. D06002

Prepared for:
North Carolina Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

DECEMBER 2007

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Prepared for:
NCDENR-EEP
1652 Mail Service Center
Raleigh, NC 27699-1652

Prepared by:
KCI Technologies, Inc.
4601 Six Forks Road, Suite 220
Raleigh, NC 27609

Gary M. Myrncza, Project Manager
gmryncza@kci.com
919-783-9214

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EXECUTIVE SUMMARY

The Cane Creek Tributary Site (CCTS) is a full-delivery stream mitigation project located in northwestern Person County, North Carolina. The project site is situated within the upper portion of the Roanoke Basin in the 03010104 8-digit hydrologic unit code and the North Carolina Division of Water Quality Subbasin 03-02-05. The project watershed is located in a rural setting within the Northern Inner Piedmont ecoregion of the Piedmont physiographic province.

The CCTS is made up of 17,375 existing linear feet of tributaries. On the western side of the site, there are 9,110 existing linear feet of stream with Tributary 1 forming the main drainage into which five smaller tributaries flow. There are 8,265 existing linear feet on the eastern side of the CCTS where Tributary 7 receives flow from three additional tributaries. The project streams all drain into Cane Creek, which then flows into Hyco Lake. The project watershed includes 0.70 square mile (448 acres) on the western portion of the site and 0.62 square mile (397 acres) on the eastern side.

Historic aerial photographs are available for the site starting in 1955. From 1955 to 1976, the CCTS was forested. Between 1976 and 1998, the property was cleared and converted into pasture except for patches of riparian vegetation that remain along the streams. The entire property is currently used as pasture for cattle.

All of the project streams have been impacted by livestock and land clearing. These impacts have resulted in bank erosion on all of the tributaries and severe incision on selected tributaries. There are also spoil piles remaining from land clearing, which disrupt overland flowpaths. Bank erosion within the project streams is producing excess sediment into the streams. The riparian zones remain at least partially vegetated, which has helped to minimize the degradation of certain reaches, but overall the CCTS contains a series of tributaries in varying degrees of instability.

The CCTS offers the opportunity to restore a significant headwater system. By developing a healthy, interconnected riparian corridor, the site will also help to reduce nutrient and excess sediment inputs. The proposed project reaches were designed as restoration or enhancement based on the level of departure from a stable stream system. The streams at the CCTS will be restored to Bc and B channels, although C channels will exist in isolated areas where there is a floodplain. Riparian vegetation at the CCTS site will be restored using Piedmont Alluvial Forest species in floodplain areas and Mesic Mixed Hardwood Forest species in the stream valleys and slopes leading away from floodplains.

The project goals are to:

- Improve water quality with reduced nutrient and sediment levels.
- Create high-quality aquatic and terrestrial habitat.

In order to meet these goals, the following objectives must be accomplished:

- Plant a functional Piedmont Alluvial Forest floodplain community along with a Mesic Mixed Hardwood Forest to create an effective riparian buffer.
- Arrest bed elevation lowering and stabilize seep outlets.
- Stop bank erosion by developing the appropriate channel dimension and stabilizing with vegetation.
- Remove relic spoil piles that disrupt overland flowpaths.
- Exclude livestock from the riparian areas with fencing.

Project success will be assessed by utilizing measurements of stream dimension, pattern, and profile; site photographs, and vegetation sampling. The monitoring report format will be similar to that set out in the most recent EEP monitoring protocol. Monitoring shall be conducted annually for a total period of five years or until the project meets its success criteria.

Mitigation Summary

Reach	Existing Stationing	Proposed Stationing	Mitigation Type	Priority Approach	Existing Linear Footage	Designed Linear Footage
T1-1	10+00-17+26	10+00-17+59*	Enhancement I	-	726	759
T1-2	17+26-21+50	17+59-21+50	Enhancement I	-	361	328
T1-3	21+50-24+63	21+50-24+74	Restoration	P3	313	324
T1-4	24+63-35+19	24+74-34+94	Restoration	P3	1,056	1,020
T1-5	35+19-38+38	34+94-37+64	Restoration	P3	319	270
T2-1	50+00-53+05	50+00-53+05	Enhancement II	-	305	305
T2-2	53+05-55+32	53+05-54+91	Restoration	P2	227	186
T2-3	55+32-56+92	54+91-56+51	Enhancement I	-	160	160
T2-4	56+92-58+63	56+51-58+51	Restoration	P3	151	180
T3-1	60+00-61+07	60+00-61+05*	Enhancement I	-	107	105
T3-2	61+07-75+83	61+05-76+79	Restoration	P3	1,457	1,554
T4-1	80+00-81+90	80+00-82+66	Restoration	P3	190	266
T4-2	81+90-99+99	82+66-102+53	Restoration	P3	1,789	1,967
T5-1	110+00-112+64	110+00-112+64	Enhancement II	-	244	244
T5-2	112+64-113+82	112+64-113+85	Restoration	P3	118	121
T6A	240+00-240+89	240+00-240+89	Enhancement II	-	89	89
T6B	250+00-251+03	250+00-251+03	Enhancement II	-	103	103
T6AB	240+89-241+19	240+89-241+29	Restoration	P3	30	40
T6C	120+00-121+80	120+00-121+88	Restoration	P3	180	188
T6	121+80-134+75	121+88-134+38	Restoration	P3	1,275	1,230
T7A	260+00-261+36	260+00-261+36	Enhancement II	-	136	136
T7-1	140+00-144+69	140+00-144+69	Enhancement II	-	469	469
T7-2	144+69-148+00	144+69-148+00	Enhancement I	-	331	331
T7-3	148+00-168+43	148+00-169+08	Restoration	P2/3	2,023	2,088
T7-4	168+43-180+89	169+08-181+54	Enhancement I	-	1,246	1,246
T7-5	180+89-182+74	181+54-183+08	Restoration	P3	185	154
T7-6	182+74-190+49	183+08-190+83	Enhancement I	-	755	755
T7-7	190+49-196+59	190+83-196+93	Enhancement I	-	610	610
T8A	270+00-271+10	270+00-271+10	Enhancement II	-	110	110
T8	200+00-204+49	200+00-204+49	Enhancement I	-	449	449
T9	210+00-213+69	210+00-213+69	Enhancement I	-	369	369
T10-1	220+00-233+00	220+00-233+00	Enhancement II	-	1,300	1,300
T10-2	233+00-235+82	233+00-235+82	Enhancement I	-	282	282
				Total	17,465	17,738
					Total Proposed Stream Enhancement I	**5,394**
					Total Proposed Stream Enhancement II	**2,756**
					Total Proposed Stream Restoration	**9,588**

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1.0 INTRODUCTION

The Cane Creek Tributary Site (CCTS) is a full-delivery stream mitigation project being developed for the North Carolina Ecosystem Enhancement Program (EEP). This restoration plan presents detailed information about the existing site and watershed conditions, the morphological design criteria, and the project design parameters based upon natural channel restoration methodologies.

2.0 PROJECT SITE IDENTIFICATION AND LOCATION

2.1 Directions to Project Site

The CCTS is located northwest of Hyco Lake in northwestern Person County and its location is shown in Figure 1. The center of the site is situated at approximately 36.5038 degrees north and –79.1310 degrees west (WGS1984). The project area is located at the center of the United States Geological Survey (USGS) Quadrangles Alton, Leasburg, Milton, and Olive Hill.

To reach the site from Raleigh, proceed west on US-70 until it merges with I-85/US-15 south. Continue on I-85 for approximately 1.5 miles and then take exit 176B for Duke St/US-501 Bypass. Take a right off of the exit and travel on US-501 for 27.5 miles. Within the town of Roxboro, turn left onto Court St/US-158 west. Follow US-158 west 0.4 mile and turn right onto NC-57, continuing northwest for another 12.3 miles. Once within the small community of Semora, turn right onto NC-119 and drive north 0.5 mile. Turn right onto Cunningham Road and continue east for 0.85 mile. The CCTS is accessible through a metal gate on the right.

2.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The project site is situated within the upper portion of the Roanoke Basin in the 03010104 8-digit hydrologic unit code (HUC) and the 03010104061040 14-digit HUC. This 14-digit HUC is not a Targeted Local Watershed as identified by the EEP. The site is found within the North Carolina Division of Water Quality (DWQ) Subbasin 03-02-05.

3.0 WATERSHED CHARACTERIZATION

The project watershed is located in a rural setting within the Northern Inner Piedmont ecoregion of the Piedmont physiographic province (Figure 2). The topography within the project watershed is characterized by rugged hills and has more mountain outliers than other areas in the Piedmont region. Streams also tend to have higher gradients in this ecoregion when compared to outer parts of the Piedmont (Griffith et al. 2002). Elevations within the project watershed range from 600 feet above mean sea level (AMSL) at the top of the drainage to 447 feet AMSL at the confluence with Cane Creek.

3.1 Project Drainage Area

The project streams all drain into Cane Creek, which then ultimately flows into Hyco Lake (Figure 3). The western portion of the site has a 0.70 square mile (448 acres) drainage area, which flows into Tributary 1 before reaching Cane Creek approximately 2,500 feet below the project boundary. This portion of the CCTS watershed is bounded by NC 119 to the west, Cunningham Road to the north, and ridgelines to the south and east. The remainder of the site on the eastern side has a drainage area of 0.62 square mile (397 acres) and has tributaries that drain directly into Cane Creek. This drainage area is formed partially by Cunningham Road to the north and site topography in the remaining areas. Together, the two project drainage areas form a total of 1.32 square miles.

3.2 Water Surface Classification/Water Quality

The DWQ assigns surface water classifications in order to help protect, maintain, and preserve water quality. The project tributaries do not have classifications, but Cane Creek has a designation of Class C.

- **Class C Waters** in North Carolina are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development or types of discharges (NCDENR, DWQ 2007).

None of the project streams or streams downstream of the site are currently designated as impaired under Section 303(d) of the Clean Water Act (NCDENR, DWQ 2006).

3.3 Geology and Soils

The underlying rocks at the site include biotite gneiss and schist, which is described as a metamorphic rock from the Inner Piedmont, Chauga Belt, Smith River Allochthon and Sauratown Mountains Anticlinorium. There is also felsic mica gneiss, a metamorphic rock from the Charlotte and Milton belts (NCDENR, NCGS 1985).

The Soil Survey of Person County indicates that the primary soils at the project site are Chewacla and Wehadkee loam, Helena sandy loam, Wedowee sandy loam, and Wilkes loam as shown in Figure 4 (USDA, NRCS 1995). The Chewacla and Wehadkee loam series is typically found along floodplains and consists of a somewhat poorly drained to poorly drained brown loam. The Helena series has very deep, moderately well drained, slowly permeable soils that are found on broad ridges and toe slopes of the Piedmont uplands. The Wedowee series consists of very deep, well-drained, moderately permeable soils on narrow ridges and the side slopes of uplands. The Wilkes series consists of shallow, well-drained soils with moderately slow to slow permeability. Wilkes soils are found on gently sloping narrow ridges and sloping to steep sides of ridges between intermittent and permanent streams in the southern Piedmont.

3.4 Historical Land Use and Development Trends

3.4.1 Historical Resources

Historical aerial photographs were obtained from the Person County Natural Resources Conservation Service (NRCS) office in order to assess the existing and historic site conditions. A review of the site history helps to understand the chronology of land disturbance and aid in the development of an appropriate restoration strategy. Aerial photographs of the site were obtained from 1955, 1966, 1976, 1993, 1998, and 2004 (Appendix A).

The earliest aerial photograph available is from 1955. At this point, the western parcel is approximately 60% wooded with the northeast corner of the parcel in agriculture. The eastern parcel contains a narrow strip of agricultural fields through its center, which coincides with a ridge running through the property. Farm buildings are visible in the center of the eastern parcel as well. Distinct stream patterns are not distinguishable in the photograph, but the project streams are all wooded at this point in time. The surrounding area has a similar distribution of agriculture, rangeland, and forest as the project area.

In 1966, the site has not experienced any substantial changes in land use. There are a couple of additional farm buildings within the original cluster of buildings. The riparian zones surrounding the project streams are still forested. A pond has been constructed just north of the project easement on the eastern parcel.

By 1976, there is still little change in the land use on the site and the riparian zones along the project streams remain forested. There is a new house on the north end of the western parcel.

Between 1976 and 1993, the property experienced significant changes. The two parcels have been cleared and converted into pasture except for narrow strips of riparian vegetation along the streams and intact forest in the southern portion of the western parcel. The two northwestern tributaries in particular have lost the majority of their riparian buffers. There have also been several ponds constructed by 1993: a pond just off the subject property in the southwestern corner of the site; a small pond on the eastern side of the western parcel; and a larger pond along the northeastern corner of the eastern parcel.

The site did not experience as much change between 1993 and 1998. By this time, the remaining forest in the southern portion of the eastern parcel has been cleared, thus converting the entire two parcels into pasture. The riparian areas remain sparsely vegetated, but there are still no distinct stream patterns visible. No additional ponds have been constructed.

No noticeable changes occurred to the project area or the surrounding areas between 1998 and 2002.

3.4.2 Land Use and Development Potential

The CCTS is situated on two properties: a western parcel and an eastern parcel. The entire property is currently used as pasture for cattle. Various portions of the site have been logged between 1976 and 1998. However, there are small wooded areas remaining along some of the tributaries. Using an Anderson Level I classification, the predominate land uses in the project watershed consist of 49% agriculture, 35% forest, 12% pasture, 3% wetland, 1% water, and less than 1% urban or built-up land (See Table 2 and Figure 5) (McKerrow 2003). The surrounding area is rural with low development pressure.

3.5 Endangered/Threatened Species

A formal review by the North Carolina Natural Heritage Program (NHP) was requested in November 2005 to identify the presence of rare species, critical habitats, and priority natural areas on the project site and to determine the potential impact of the proposed project on these resources. In their letter dated December 7, 2005, the NHP indicated "no record of rare species, significant natural communities, or priority natural areas at the site nor within 2 miles of the project area" (See Appendix B). In addition, no threatened or endangered species were identified in the project area during the existing conditions site assessment.

3.6 Cultural Resources

To evaluate the presence of significant cultural resources on the subject property and the potential to impact these properties, KCI requested a formal review by the North Carolina Department of Cultural Resources, State Historic Preservation Office (SHPO). The formal SHPO review identified "no historic resources which would be affected by the project." The formal review by the State Archeology Office identified no potential archeology sites on or around the subject property (See Appendix B).

3.7 Potential Constraints

The site was evaluated for any site constraints that have the potential to hinder a successful mitigation project. Below is a description of any potential issues that may affect the project's success.

3.7.1 Property Ownership and Boundary

The proposed restoration project is located on two adjacent parcels (Person County PINs 9060-00-02-7485 and 9060-00-32-4307) owned by Sidney and Angela Thompson. KCI has facilitated the purchase of a conservation easement on the site, which has been transferred to the State of North Carolina (see Appendix C). The conservation easement will protect the project streams in perpetuity.

3.7.2 Site Access

The site is reached from Cunningham Road as shown in Figure 1. Once on Cunningham Road, the site entrance is approximately 0.85 mile further east and is accessible through a metal gate on the southern side. Once onto the property, there is a 0.25-mile dirt road that travels to the center of the property, where parking is available.

3.7.3 Utilities
There are no utilities mapped on the project site.

3.7.4 FEMA/Hydrologic Trespass
No portion of the site is located in a significant flood hazard area as recognized by the Federal Emergency Management Agency (FEMA). The far western portion of the site is found on FEMA Map 3711904000J (Caswell County Flood Insurance Study, Effective September 27, 2007) and is shown as Zone X. The remainder of the site is not mapped by FEMA.

The proposed restoration is not anticipated to produce hydrologic trespass conditions on the existing property or on any neighboring properties.

4.0 PROJECT SITE STREAMS (EXISTING CONDITIONS)

The CCTS is made up of 17,375 existing linear feet of tributaries that all ultimately drain into Cane Creek. On the western side of the site, there are 9,110 existing linear feet of stream with Tributary 1 (T1) forming the main drainage into which five smaller tributaries flow. There are 8,265 existing linear feet on the eastern side of the CCTS where Tributary 7 (T7) is the primary drainage feature that receives flow from three additional tributaries before reaching Cane Creek at the southeastern corner of the site.

The existing site conditions and site assessment locations for cross-sections and longitudinal profiles are shown in Figure 6. The project site photographs (Appendix D) show the current conditions at the CCTS and the existing conditions data (Appendix E) summarize the site assessment. All the project streams receive perennial flow and the DWQ stream identification forms are included in Appendix F.

4.1 General Site Description

All of the project streams have been impacted by livestock and land clearing. These impacts have resulted in bank erosion in all of the tributaries and an increase in the sediment supply. Severe incision has also occurred on selected tributaries. During the land clearing, numerous linear spoil piles were also placed parallel to some of the smaller tributaries. These spoil piles block overland drainage from entering the tributaries and funnel this drainage into side drains. Riparian zones remain at least partially vegetated, which has helped to minimize the degradation of certain reaches, but overall the CCTS contains a series of tributaries in varying degrees of instability.

T1 is a third-order hydrologic feature that flows northwest to southeast for approximately 2,775 linear feet within the project site boundaries. T1 extends from the western property boundary at Station 10+00 until the southern property boundary at Station 38+38 before continuing into Cane Creek, which is approximately 2,500 linear feet below the property line. As it comes onto the CCTS, T1 has moderate riparian coverage, but this begins to decrease around Station 21+00.

Five tributaries drain into T1: Tributary 2 (T2) at Station 12+27, Tributary 3 (T3) at Station 17+26, Tributary 4 (T4) at Station 21+50, Tributary 5 (T5) at Station 24+63, and Tributary 6 (T6) at Station 35+19.

T2 begins as a first-order hydrologic feature and then quickly turns into a second-order stream when a small tributary from the southeast enters. T2 starts at the southwest corner of the western parcel boundary at Station 50+00 and then flows northeast for approximately 843 linear feet before its confluence with T1 at Station 58+63. Along the eastern side of the stream, there is a linear spoil pile that parallels the stream. At Station 53+05, the stream runs along the edge of the valley wall with a floodplain on the right bank. The stream then goes back into a confined valley. There is a cattle crossing at Station 56+92, after which the stream has been straightened for 150 feet before it joins T1. T2 is forested throughout the length of the reach with mature trees in the overstory, but with little understory vegetation due to cattle grazing.

T3 is a first-order hydrologic feature that flows north to south for approximately 1,564 linear feet before it joins T1. T3 starts at a wetland seep at Station 60+00 and ends at Station 75+83 at the confluence with T1. The first 107 feet of T3 consist of a meandering, low gradient channel that runs through a forested wetland. At Station 61+07, there is a 3-foot headcut and the stream becomes deeply incised. Cattle have free range of the stream and many banks have exposed soil. Linear spoil piles run parallel to the stream. There is an existing cattle crossing at Station 67+20. Aside from the forested seep area at the beginning of the reach, the vegetation consists of less desirable riparian species such as red maple (*Acer rubrum*) and sweetgum (*Liquidambar styraciflua*).

Running parallel to T3 is T4, which is a stream that flows north to south for approximately 1,979 linear feet from Station 80+00 to Station 99+99. T4 is similar to T3 in that the tributary has a low gradient headwater reach followed by a large drop in elevation. For T4, this headcut occurs at Station 81+90 and after this point the stream can be characterized as a gully. T4 also has linear spoil piles that parallel the stream at varying locations. At Station 86+25, there is a crossing used by livestock. At the beginning of T4, there is overstory vegetation, but it is largely composed of less desirable species. Once the bed elevation drops, the riparian vegetation is characterized by Chinese privet (*Ligustrum sinense*), eastern red cedar (*Juniperus virginiana*), red maple, and sweetgum.

The next hydrologic feature that drains into T1 is T5, which is a first-order stream that flows south to north for approximately 362 linear feet. The beginning of T5 at Station 110+00 flows through a section with established riparian vegetation. After 244 linear feet, the stream reaches a crossing where cattle have impacted the channel. Downstream of the crossing, there is no riparian vegetation and the channel is not well defined. The last 20 feet of the stream goes underground before T5 ties into T1 at Station 113+82.

T6 is another tributary that runs roughly parallel to T3 and T4 and flows from north to south before flowing into T1. T6 has a steep drainage area with its drainage features cut deeply into the landscape; the drainage area flattens as it nears the confluence with T1. It starts as three small, seep-driven tributaries (T6A, T6B, and T6C) that come together to form a larger channel of 1,275 existing linear feet from Stations 121+80 to 134+75. T6A and T6B join into a short reach called T6AB and this reach then meets T6C to form T6. The headwater reaches are well forested, but the downstream portion of T6 has only moderate riparian vegetation coverage.

T7 is the primary drainage feature on the eastern side of the CCTS and has approximately 5,619 existing linear feet of stream. It begins at Station 140+00 as a small, first-order drainage and becomes a third-order stream before it reaches Cane Creek at the southeastern property corner at Station 196+59. T7 begins at a groundwater seep below a farm pond. Tributary 7A (T7A) is another small, seep-driven stream that joins T7. Both of these headwater reaches have a meandering channel pattern, but have been subject to bank erosion. The riparian area is forested with an established overstory surrounding the top portion of T7 and all of T7A.

Approximately 275 linear feet after the confluence of T7 and T7A at Station 144+69, T7 flows into a more confined valley and experiences more bank erosion as it meets the valley wall. At Station 148+00, the stream becomes even more impacted from cattle with little riparian vegetation protecting the banks. This impacted reach continues for approximately 2,000 linear feet until Station 168+43 where T7 enters into a more confined valley. Bedrock outcrops and clusters of boulders become dominant features in the stream channel. T7 continues to have large sections of bedrock controlling the bed elevation all the way until the confluence with Cane Creek. The riparian vegetation along this lower portion of T7 consists of a mixture of hardwood species such as red maple, tulip poplar, beech (*Fagus grandifolia*), northern red oak (*Quercus rubra)*, black willow (*Salix nigra*), and tag alder (*Alnus serrulata*).

Three additional tributaries drain into T7: Tributary 8 (T8) at Station 148+00, Tributary 9 (T9) at Station 150+88, and Tributary 10 (T10) at Station 190+49.

T8 begins as a first-order stream and turns into a second-order feature that flows northeast to southwest for approximately 449 linear feet from Stations 200+00 to 204+49 before flowing into T7. Tributary 8A (T8A) is a small seep-fed tributary that extends from Stations 270+00 to 271+10 and joins T8 145 linear feet downstream of its start. T8 has moderate vegetative coverage in its riparian zone.

The next tributary to enter T7 is T9, which is a first-order stream that flows west to east for approximately 369 linear feet from Stations 210+00 to 213+69. The tributary is fed by a groundwater seep and is downstream of a farm pond at the upper portion of its drainage area. A linear spoil pile parallels the stream on its southern side.

The final project stream is T10, which is a first-order hydrologic feature that flows north to south for approximately 1,582 linear feet from Stations 220+00 to 235+82. T10 enters the CCTS at the eastern property boundary and the channel is shaped by large sections of bedrock and confining valley walls. A cattle crossing is located before T10 enters T7.

4.2 Channel Stability Assessment

A qualitative stability assessment was performed to estimate the level of departure for a stable stream system and determine the likely causes of any channel disturbance. This assessment facilitates the decision-making process with respect to restoration alternatives and establishing goals for successful restoration.

At the start of T1, the stream is not yet incising, but it is experiencing bank erosion in combination with a loss of bed feature diversity. Cattle have caused overwidening and exposed soil in the banks. Riffles and pools are still evident features along this reach, but sedimentation from bank erosion and incoming tributaries is filling in pools. Riparian vegetation has also been reduced, which has eliminated rooting strength to maintain bank integrity. Bank height ratios from Stations 10+00 to 21+50 range from 2.3 to 3.6.

Upstream of the confluence with T4, T1 begins to have fewer defined bed features except for in those areas where bedrock has maintained the bed structure. The bank height ratios from Stations 21+50 to 38+38 range from 1.9 to 2.3. Immediately downstream of the confluence with T4, there are large deposits of sand. Existing trees have helped maintain the channel dimensions in some areas, but areas without rooting protection are raw and eroding.

Along T2, cattle seek refuge in the shaded areas and have regular access to the stream. For the first 300 linear feet, the stream has a meandering pattern, but cattle have created overwidened sections and induced bank erosion. In this section, the stream has a bank height ratio of 1. At Station 53+05, the stream runs adjacent to the valley wall and receives large amounts of sediment from an unstable slope. Once T2 comes away from the valley wall, it continues down the slope and starts to become incised. The lower 150 feet of T2 just before it enters T1 have been straightened and lack bed diversity. Linear spoil piles keep overland drainage from entering the stream except at isolated locations. From Station 53+05 to the end of T2, the bank height ratios range from 1 to 2.5.

T3 begins at a wetland seep where the stream is moving up the valley as a 2-foot headcut is migrating into the seep area. Below this initial headcut, the stream pattern and profile is stable for approximately 100 feet, although the banks are experiencing erosion and are vertical in places. At Station 61+75, the channel experiences another headcut and the stream loses 4 feet over 13 feet of channel. After this headcut, the channel becomes deeply incised with an unstable bed and banks. The bank height ratios range from 1.9 to

3.2. This lower reach of T3 has experienced extensive degradation as a result of livestock impacts and other human disturbances. The channel has downcut to weathered bedrock in many areas and the exposed banks show erodible sandy soil in the upper portion of the bank continuing down to a gravel layer where the current bed elevation is. Numerous cattle paths cross the stream channel. There are also linear spoil piles that run along the stream channel and alter the flowpath of overland drainage. Any drainage features flowing into T3 have also cut down to the incised bed elevation. At the bottom of T3, the channel has accumulated sediment from upstream erosion and has a more gradual slope than the upstream reaches.

T4 is experiencing a similar channel evolution as T3. It also has experienced extensive degradation as a result of livestock impacts and human disturbances. At the beginning of T4, there is a small channel running through a seep area with overstory vegetation, but there is no herbaceous understory vegetation due to cattle impacts. The channel continues for approximately 190 linear feet before it reaches a severe headcut at Station 82+00 that is migrating up the valley. Downstream of the headcut, the channel is deeply incised with vertical banks and has developed into a small ravine. Bank height ratios range from 3.1 to 4.2. Sections of bank are falling into the stream and bringing down rooted vegetation. Spoil piles paralleling the stream also affect the overland drainage paths. Before the confluence with T1, T4 has a gentler slope and large accumulations of sand from upstream bank erosion have been deposited in the channel.

The beginning of T5 from Station 110+00 to 112+64 exhibits characteristics of stable channel morphology and is well shaded by riparian vegetation. This upper reach has experienced bank erosion due to grazing impacts. After the cattle crossing at Station 112+64, the stream becomes unstable with bank height ratios around 2.7. From this point on until the confluence with T1, T5 has eroding banks, sparse riparian vegetation, and a series of headcuts. The base elevation of the stream has been lowered and the last 20 feet of channel go underground before reaching T1.

T6A and T6B are seep-fed, forested reaches that have stable beds and planform. The banks, however, have been impacted by grazing cattle. T6C is a steeper, more incised reach and has a series of headcuts and blockages until it reaches the confluence with T6AB. It has severe bank erosion and lacks bed diversity. Once T6 begins at Station 121+80, the channel continues to lose bed elevation as the stream headcuts up the valley. Bank height ratios range from 3.0 to 6.8. There also is a lack of understory riparian vegetation to provide rooting strength in the banks, which combined with cattle grazing has led to bank erosion and a loss of bed features.

Both of the headwater reaches of T7 and T7A have meandering patterns, but have been subject to bank erosion. The riparian zones along these two reaches have established overstory and understory vegetation, which helps prevent further degradation on these tributaries. Approximately 275 linear feet after the confluence of T7 and T7A, a large debris blockage marks the transition into a more heavily degraded section. The stream has areas of bank erosion against the valley wall and the bed features are less defined. The instability of the T7 worsens after the confluence with T8 where the stream has a lower slope and more erodible soils. This heavily impacted reach continues for approximately 2,000 linear feet until Station 168+43. In this section, bank height ratios range from 2.8 to 4.5.

After Station 168+43, T7 enters a more confined valley. Bedrock has helped to prevent further incision, allowing the channel to maintain defined riffles and pools. These bed features, however, are being filled in by sediment from upstream bank erosion. At Station 180+89, T7 flows along a steep valley wall, which is unstable and experiencing bank erosion. After another 20 feet downstream, T7 has a large elevation drop and then returns to its bedrock-controlled profile. From the confluence with T10 at Station 190+49 until it reaches Cane Creek, T7 has a stable planform, but the banks are still eroding from cattle impacts and the bed diversity is being impacted from upstream sediment. Bank height ratios are around 4 in this section.

T8 begins at a groundwater seep, but the stream is headcutting up to its source. The stream has several unstable elevation drops and eroding banks from cattle impacts. The bank height ratio in this tributary is 1.7. T8A has a stable pattern, but is incised within its banks and has few defined bed features.

T9 starts at a groundwater seep and the channel is headcutting up to this location. After flow begins, there is a short meandering reach that exhibits stable channel morphology. However, a sizeable knickpoint exists at Station 210+88 and there are three other substantial headcuts at Stations 211+62, 212+60, and 213+38. The stream does not have connected riffle-pool sequences and the banks are not stabilized.

T10 is defined by large sections of bedrock and confining valley walls. Overall, the stream is stable with a mature riparian zone, but erosion has resulted where the channel cuts into the valley walls or where cattle have impacted the banks. Once T10 nears the confluence with T7, bank erosion and poor grazing management have degraded the overall condition of this reach and differentiate it from the more stable area immediately upstream. A cattle crossing at this location has caused the channel to become overwidened.

4.3 Bankfull Verification

The standard methodology used in natural channel design is based on the ability to select the appropriate bankfull discharge and generate the corresponding bankfull hydraulic geometry from a stable reference system. The determination of bankfull stage is the most critical component of the natural channel design process.

Bankfull can be defined as "the stage at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of the channels" (Dunne and Leopold 1978). Several characteristics that commonly indicate the bankfull stage include breaks in slope, changes in vegetation, highest depositional features (i.e. point bars), and highest scour line. The identification of bankfull stage, especially in a degraded system, can be difficult. Therefore, verification measures were undertaken to facilitate the correct identification of the bankfull stage on the CCTS. The two methods used to verify bankfull stage at CCTS were pressure transducer gauges and regional hydraulic geometry relationships (regional curves).

Stream stage data were collected from pressure transducer gauges at six locations on the CCTS: Gauge 1 on T3 at Station 71+70; Gauge 2 on T4 at Station 96+68; Gauge 3 on T6 at Station 130+84; Gauge 4 on T1 at Station 37+05; Gauge 5 on T7 at Station 183+44 upstream of the confluence with T10; and Gauge 6 on T7 at Station 192+85 approximately 400 feet upstream of the confluence with Cane Creek. An on-site rain gauge was also installed. Data were collected for 9 months (January through September 2007) and are summarized in Appendix G. Water levels were correlated to an estimated discharge using a rating curve generated for each gauged section. An approximate bankfull event occurred on March 2, 2007 with an additional 0.7 inch falling on top of several rain events during the preceding week. The storm caused approximate discharges of 53 cfs on T1, 17 cfs on T3, 30 cfs on T4, 29 cfs on T6, 71 cfs on T7 upstream on the confluence with T10, and 64 cfs on T7 after the confluence with T10.

Regional curves are typically utilized in ungauged areas to approximate bankfull discharge, area, width, and depth as a function of drainage area based on interrelated variables from other similar streams in the same hydrophysiographic province. The regional curve for the rural Piedmont of North Carolina and its corresponding equations were used to verify the bankfull discharges in the project reaches (Harman et al. 1999). Based on the regional curve, the following bankfull discharges were calculated for the project tributaries: 90 cfs for T1, 26 cfs for T2, 26 cfs for T3, 33 cfs for T4, 15 cfs for T5, 29 cfs for T6, 73 cfs for T7, 5 cfs for T8, 11 cfs for T9, and 53 cfs for T10. However, the calculations for the tributaries with small drainage areas (T2, T3, T4, T5, T6, T8, and T9) should be used with caution, because the smallest drainage area used in the regional geometry regression to relate drainage area and discharge was 0.2 square mile.

4.4 Vegetation

The uplands surrounding the project streams have all been cleared of trees and mature woody vegetation only remains along riparian corridors in varying age classes and densities. Because of previous impacts to the existing forest stands, no distinct vegetative communities exist on the site. Below is a description of the distribution of common plant species across the CCTS.

Along T1, the upper portion of the stream (Existing Stations 10+00 to 21+50) contains red maple, tulip poplar, sweetgum, northern red oak, sycamore (*Plantanus occidentalis*), green ash (*Fraxinus pennsylvanica*), black walnut (*Juglans nigra*), southern red oak (*Quercus falcata*), flowering dogwood (*Cornus florida*), willow oak (*Quercus phellos*), white oak (*Quercus alba*), possumhaw (*Viburnum nudum*), and American elm (*Ulmus americana*). From Station 21+50 on, the mature trees are less dense, reducing available rooting strength along the banks; the trees along this section also include American beech. T2 has similar species along its banks as those described above. Along T3 and T4, there is a similar composition of species, but early successional species such as red cedar, sweetgum, tulip poplar, and red maple are most common and the stands are younger and less dense. T4 also had a large population of Chinese privet along the upper portion of the tributary. The top of T5 has the same species as T1, but the lower reach of T5 has only sparse vegetation with a few young trees. T6 has mature trees at its headwaters, but the trees vary in age and composition along the lower portion of the stream. There is only sparse understory vegetation along T6.

The eastern portion of the CCTS contains similar species to the western side of the site. Common species in this area include black walnut, eastern red cedar, sycamore, green ash, sugarberry (*Celtis laevigata*), American beech, southern red oak, northern red oak, willow oak, white oak, sugar maple (*Acer saccharum*), red maple, persimmon (*Diospyros virginiana*), American elm, winged elm (*Ulmus alata*), flowering dogwood, and shagbark hickory (*Carya ovata*). From Stations 148+00 to 168+43 on T7, there are also several individuals of tag alder, mature black willow, and ironwood (*Carpinus caroliniana*). At the bottom of T7 after the confluence with T10, there is a stand of common pawpaw (*Asimina triloba*). T8, T9, and T10 all have forested riparian zones that consist of the species listed above.

Spicebush (*Lindera benzoin*) is a prominent understory species across the CCTS, but it is limited to areas where the cattle have not impacted the site as heavily. Other understory species found at the CCTS include muscadine grape (*Vitis spp.),* greenbriar (*Smilax spp.),* and blackberry (*Rubus spp*.).

During construction, the number of mature trees removed from the existing riparian areas will be minimized as much as possible. Any valuable trees that may provide immediate shade to the restored channel will be left in place if feasible. In the enhancement areas, certain trees may be able to remain on one bank if the opposite bank can be reshaped to accommodate the appropriate dimension for the stream.

Chinese privet is the one dominant invasive species at the CCTS. In particular, it exists in thickets at the upper portion of T4. These individuals will be removed during the construction phase of the project and any remaining plants will be treated with a glyphosate herbicide.

5.0 REFERENCE STREAMS

A reference reach is a channel with a stable dimension, pattern, and profile within a particular valley morphology. The reference reach is used to develop dimensionless morphological ratios (based on bankfull stage) that can be extrapolated to disturbed/unstable streams to restore a stream of the same type and disposition as the reference stream (Rosgen 1998). For this project, only one suitable reference reach was found that was appropriate to design the proposed restoration reaches: an unnamed tributary to Fisher River in Surry County, North Carolina (see Appendix H for detailed reference reach data).

5.1 UT to Fisher River Reference Site

An unnamed tributary to Fisher River (UTFR), a first order rural stream in Surry County, was selected as a reference reach for the restoration of the project streams (Figure 7). The reference reach is located on Fisher Valley Road off of Exit 93 from Interstate 77. UTFR is approximately 95 miles to the west of the CCTS. The valley slope is approximately 1.6%. The sediment distribution and transport closely match the project streams. The local topography is characterized by rolling hills. Approximately 300 linear feet of UTFR was surveyed and was classified as a B4c channel.

UTFR flows northeast into Fisher River and drains approximately 0.38 square mile of predominantly forested land with a small section of rangeland (Figure 8). The reference reach watershed is within the Northern Inner Piedmont ecoregion in the Piedmont physiographic province. The site is in the 14-digit hydrologic unit 03040101090010 in the Yadkin Basin and is in the DWQ Subbasin 03-07-02. The reference reach watershed elevations range from 1,420 feet AMSL at the headwaters of the site to 1,210 at the bottom of the reference reach.

5.2 Reference Vegetative Communities

There are two communities described by Schafale and Weakley that are representative of reference systems appropriate for the CCTS site (1990).

The natural community identified as representative of the floodplain areas was the Piedmont Alluvial Forest. This community type is described as existing along river and stream floodplains in more isolated patches when compared to broader floodplain forests. The canopy species that are typically found within a Piedmont Alluvial Forest include river birch (*Betula nigra*), green ash, sycamore, sweetgum, sugarberry, black walnut, shagbark hickory, American elm, and tulip poplar. Species that dominate the understory are ironwood, common pawpaw, American holly (*Ilex opaca*), spicebush, and painted buckeye (*Aesculus sylvatica*) (Schafale and Weakley 1990).

Mesic Mixed Hardwood Forest was identified as the community type appropriate for stream valleys and slopes leading away from small stream floodplains. Typical species found in the Mesic Mixed Hardwood Forest canopy include American beech, northern red oak, tulip poplar, red maple, and sugar maple. The understory layer commonly has flowering dogwood, hop hornbeam (*Ostrya virginiana*), and American holly along with shrub species such as deerberry (*Vaccinium stamineum*), downy arrowwood (*Viburnum rafinesquianum*), and strawberry bush (*Euonymus americana*) (Schafale and Weakley 1990).

6.0 PROJECT SITE RESTORATION PLAN

6.1 Restoration Project Goals and Objectives

The CCTS has experienced degradation along all of its tributaries from livestock and the removal of upland and riparian vegetation. These impacts have left the streams with large amounts of excess sediment, unstable banks, and incised streambeds. There is considerable potential to improve and protect these headwater tributaries and provide an interconnected assemblage of aquatic and terrestrial habitat upstream of Hyco Lake.

Based on these site-specific conditions, the restoration goals for the CCTS are as follows:

- Improve water quality with reduced nutrient and sediment levels.
- Create high-quality aquatic and terrestrial habitat.

In order to meet these goals, the following objectives must be accomplished:

- Plant a functional Piedmont Alluvial Forest floodplain community along with a Mesic Mixed Hardwood Forest to create an effective riparian buffer.
- Arrest bed elevation lowering and stabilize seep outlets.
- Stop bank erosion by developing the appropriate channel dimension and stabilizing with vegetation.
- Remove relic spoil piles that disrupt overland flowpaths.
- Exclude livestock from the riparian areas with fencing.

6.1.1 Design Approach

When approaching the design for the CCTS, the project objectives were balanced against the existing site constraints. Below is a description of the site-specific approach used for the design for the CCTS.

One of the major site constraints is the amount of incision that has taken place on the CCTS. In particular, T3, T4, and T6 have become deeply incised and formed gullies. Many of the smaller tributaries (T8 and T9) also have steep headcuts that are making these channels unstable. KCI decided to approach these streams by leaving them at the existing bed elevations and tying them into their respective downstream tributaries. The streams have incised too much to be brought back up to their original bed elevations (Priority 1) and many are entrenched within a confined valley. However, in order to stabilize the reaches with large drops in elevation, a number of grade control and step pool structures will be required. The proposed step pool channels are the natural stable channel types given the valley type, valley slope, and sediment regime of the existing conditions.

In addition to vertical instability at the CCTS, another challenge was determining bankfull elevations on the range of rural tributaries. It was difficult to set a bankfull elevation in these channels given that many are incised. Bankfull elevations were field estimated during the site assessment, but required verification by other measures (see Section 4.3). The pressure tranducer gauges at the CCTS provided useful data, but the frequency of a bankfull flow events was limited to less than a year of data and 2007 saw extreme drought conditions in Person County. Several storm events did indicate of the type of response and magnitude of flow events that can occur at the site. The discharges from these storm events were verified with regional curve data, although these data were used cautiously in the smaller tributaries. A number of the project streams have perennial flow despite having unusually small drainage areas. All of these factors were balanced against each other to identify the appropriate bankfull discharge for each project reach.

There was also a lack of appropriate reference reaches for the CCTS. In the Piedmont region of North Carolina, stable B4 streams with slopes ranging from 2-3% are scarce. KCI has conducted numerous reference reach searches throughout North Carolina and has not been able to find a stable B4 channel with this slope. The UT to Fisher River is a stable B4c channel and is an adequate reference reach for a B4-type channel. This reference was used to develop the geometry of the proposed cross-sectional areas. The proposed pattern data were developed using a combination of criteria from the UT to Fisher River site and from on-site streams with stable planform. For example, radius of curvature, meander length, and meander width ratios were taken from the more stable sections of T2 to develop design criteria for the lower sections of this tributary.

6.1.2 Designed Channel Classification

The streams at the CCTS will be restored to Bc and B channels. In isolated areas where the streams are not entrenched in a valley, they will be able to access a floodplain and function as C channels. The tributaries are divided into reaches based on the drainage areas entering the streams and the restoration or enhancement approach needed to design the proposed channels (Table 1). The morphological design criteria for each of the reaches are found in Tables 4a through 4e. The project reaches are identified in Figure 9.

All of T1 will be designed as a B4c channel with small sections of C channel in those areas with no valley walls. T1 has been divided into five different reaches in order to develop the appropriate design as the drainage area increases or if a different type of action is required. T1-1 runs from Station 10+00 to 17+59 and stops at the confluence with T3. A second reach, T1-2, goes from this confluence with T3 at Station 17+59 until Station 21+50, where the stream starts to experience more instability. Both T1-1 and T1-2 will be improved as Enhancement I, which involves adjusting the stream to have the appropriate profile and dimension (USACE et. al 2003). For this section of T1 specifically, this will involve grading back the banks to the appropriate dimension. Existing bedrock provides stable grade control, but pools that have filled in will require excavation. One grade control structure will be installed at Station 19+85 downstream of a 60-foot easement exception.

Beginning at Station 21+50 until it ends at the property boundary, T1 will be restored. There are three separate reaches in this section that are distinguished by drainage area: T1-3 from Stations 21+50 to 24+74 where T4 enters; T1-4 from Stations 24+74 to 34+94 where T6 flows into T1, and T1-5 from Stations 34+94 to 37+64. These three lower reaches of T1 will be restored using a Priority 3 approach, which takes an F or G channel type and converts it to a B or Bc stream (Rosgen 1997). This type of restoration develops the appropriate stream dimension, pattern, and profile at the existing bed elevation. Along this section of T1, the restoration will reestablish riffle and pool features within the streambed while also utilizing existing bedrock as grade control. The pattern will be moved away from the existing stream channel from Stations 25+50 to 28+00 and Stations 31+50 to 34+00.

T2 has been divided into four separate reaches and the majority of the tributary will be a B4 stream. T2-1 begins at Station 50+00 and ends at Station 53+05. This reach will be improved as Enhancement II and actions will include sloping back and stabilizing banks that are eroding and planting vegetation to help establish an understory riparian community. Beginning at Station 53+05 and ending at Station 54+91, T2-2 will be restored using a Priority 3 approach. In this section, the stream has run against a steep, eroding valley wall. The proposed pattern will be realigned into an open floodplain to avoid this hillside and reconnect with the existing stream at Station 54+91. T2-2 will be a small E/C4 reach in between a B channel up and downstream. It will have two separate double step pool structures to stabilize the bed elevation. The next reach, T2-3, will be improved as Enhancement I and modifications will include grading back the vertical banks to an appropriate dimension and developing pool features. At Station 56+51, T2-4 begins and it will be restored using a Priority 3 approach. This bottom section of T2 has been straightened and the new pattern will incorporate a meander bend before tying into T1.

The next tributary to join T1, T3 has been divided into two different reaches and will be designed as a B4 stream type. T3-1 is a short headwater reach that runs from Stations 60+00 to 61+05 and it will be an Enhancement I section. At its beginning, T3-1 will be stabilized with a seep development structure to protect from further headcutting up the valley. The remainder of T3-1 will receive bank shaping and stabilization. At the end of T3-1, there will be a step pool structure to lower the bed elevation down to T3-2 where there is currently a 3-foot headcut. Once T3-2 begins, the stream will be restored using a Priority 3 approach. Because T3-2 is so heavily incised and downcut, a number of step pools and other grade control structures will be utilized to bring the bed elevation down to the confluence with T1 in a stable manner. These structures are concentrated from Stations 61+05 to 64+00 where the large headcut exists and from Stations 67+50 to 70+00 below an existing crossing that has caused bed lowering.

T4 has also been separated into two reaches and the entire length will be restored as a B4 channel. T4-1 runs from Station 80+00 to Station 82+66 and will be restored using a Priority 3 approach. The new planform for T4-1 will include more sinuosity than currently exists in this section along with five double step pool structures in an effort to lower the bed elevation in stable increments. T4-2 continues from Station 82+66 until the confluence with T1 and will also be restored using a Priority 3 approach. Step pool and cross vane structures are necessary along T4-2 to ensure that the bed elevation remains stable and to meet the elevation at T1.

T5 has two reaches for the proposed conditions and both will be designed as B4 channels. T5-1 runs from Stations 110+00 to 112+64 and has a stable bed and pattern, but minor bank impacts. Under Enhancement II, the stream banks will be sloped back where necessary and planted with vegetation to stabilize any erosion. T5-2, which goes from Station 112+64 to Station 113+85 at the confluence with T1, will be restored using a Priority 3 approach. The new pattern will meander to the left of the existing channel and avoid the existing confluence with T1. Five double step pools are necessary to bring down the elevation from this short, steep reach to the confluence with T1.

T6 and its headwater tributaries will consist of B4 channels. The two headwater reaches, T6A and T6B, will receive bank stabilization under Enhancement II. Both reaches will have seep development structures installed to protect them from additional headcuts. Once these two reaches come together to form T6AB from Stations 240+89 to 241+29, the existing stream begins to headcut and the proposed design will restore the reach using a Priority 3 approach. T6C, currently a steep, incised channel, will also be restored using a Priority 3 approach. The proposed T6C channel will avoid the tortuous bends in the existing channel by taking the pattern offline in these locations. Several step pools will lower T6C to the confluence with T6AB at Station 121+88. T6 will be restored using a Priority 3 approach and avoids sections of the existing incised channel by coming offline from Station 124+50 to 127+00. After this point, the channel will then come back onto the existing streambed until the confluence with T1.

On the eastern side of the property, T7 has been divided into seven different reaches for the proposed stream design. T7-1 begins at Station 140+00 and continues until Station 144+69. It will be a B4/C4 stream that will receive seephead protection, bank stabilization, and revegetation under Enhancement II. T7A is similar to T7-1 and will also be improved as a B4/C4 channel with Enhancement II actions. T7-2 is more degraded than T7-1 and will receive adjustments to the bank dimensions and pattern as a B4 channel under Enhancement I. Vertical or incised banks will be graded back to create the appropriate cross-section and step pool structures will be installed to stabilize the drops in bed elevation.

T7-3 begins at Station 148+00 where T7-2 and T8 join together. From this location forward, the existing stream has extensive bank erosion and bed impairments. T7-3 will be restored as a B4c channel with a Priority 3 approach. Several step pool structures will be used at the beginning of this reach to bring the elevation down to the confluence with T9 and to meet an existing crossing shortly thereafter. The proposed pattern for T7-3 meanders away from and then back along the existing stream, avoiding overwidened or otherwise unstable areas when possible. At Station 168+08, T7-4 begins where the stream enters a more confined valley with numerous bedrock features. The proposed B4/1 channel will be improved as Enhancement I. The banks will be sloped back to accommodate the appropriate channel dimension and to stabilize eroding banks. Removing accumulated excess sediment will enhance existing pool features. Because bedrock is so prominent throughout this reach, no additional grade control structures are necessary.

T7-5 is a short B4 reach of restoration that will flow from Station 181+54 to 183+08. The design proposes to meander the stream away from a steep valley wall and a subsequent headcut using a Priority 3 approach. To compensate for the elevation lost to the headcut, a step pool will be installed to bring down the bed elevation. From Station 183+08 to Station 190+49, T7-6 has frequent bedrock in the streambed, but the banks are experiencing erosion from cattle impacts. The proposed B4/1 reach will have the banks sloped back and stabilized. As part of the Enhancement I process, T7-6 will also have several pools enhanced by removing accumulated material. T7-7 begins at the confluence with T10 and continues until the stream enters Cane Creek at Station 196+93. This final reach along T7 will also be modified as Enhancement I with adjustments to the banks and profile. The existing vertical and eroding banks in many sections will be graded back to the appropriate dimension. Bedrock provides stable grade control along the length of T7-7, but several pools along the reach will be enhanced.

The headwater reaches of T8 and T8A are proposed for Enhancement I and Enhancement II actions, respectively. Both reaches will also be a B4 stream type. T8 begins as a groundwater seep and this outlet will be stabilized with a seep development structure. As T8 continues down toward its confluence with T7, the profile will be modified with step pool structures to bring the stream down to the necessary bed elevation. The banks will be graded back to create the necessary cross-sectional dimension. T8A forms from seep drainage at the head of its watershed. The banks along T8A will be enhanced by grading them back and stabilizing them with vegetation. T9 is a similar headwater reach to T8 and will receive Enhancement I. The seep at the top of T9 will receive a seep development structure. A series of step pool structures will bring down the bed elevation of T9 instead of allowing the stream to headcut as it is currently. The banks will also be shaped to the appropriate dimension.

T10 has been divided into two separate reaches for the proposed actions. T10-1 forms the majority of the tributary and goes from Stations 220+00 to 233+00. It is a gravel stream underlain by extensive bedrock features that shape the profile. T10-1 is proposed as a B4/1 channel with improvements under Enhancement II. The pattern and profile are stable, but the banks are experiencing erosion from cattle impacts or from running against steep valley walls. These sections will be sloped back and stabilized. T10-2 begins at 233+00 and continues a short distance until the confluence with T7 at Station 235+82. The design for this reach calls for Enhancement I of a B4/1 channel. The enhancement actions would include deepening several existing pools and grading back the eroding and unstable banks.

6.1.3 Targeted Buffer Communities

Once all of the work on the project tributaries has been completed, livestock exclusion fencing will be installed around the easement area to eliminate the impacts by cattle on the CCTS.

The project will restore a Piedmont Alluvial Forest community along the floodplains of T1 and T7 as well as in other floodplain communities as appropriate. Piedmont Alluvial Forests are typical of the small floodplain areas that will be restored at the CCTS. This community will fit into the natural topography and setting created by the newly restored channels.

The buffer areas along the headwater tributaries will be planted as Mesic Mixed Hardwood Forest. This community typically exists along lower slopes, north-facing slopes, ravines, and occasionally on well-drained small stream bottoms (Schafale and Weakley 1990).

6.2 Sediment Analysis

The sediment competency of the CCTS was studied in detail and the assessment data are available in Appendix E. Pebble counts, bulk samples from 0-0.2 feet and 0.2-0.4 feet below the riffle bed, and bar samples were taken from most of the project reaches. Based on this analysis, the majority of the project reaches are dominated by gravel material, although T1, T7, and T10 all have portions that are underlain with bedrock.

As T1 comes onto the project site, it has primarily a gravel bed with small amounts of sand. A pebble count at Station 11+68 (Existing) found the channel to be 92% gravel with a D84 of 27 mm. Further downstream near Station 13+10 (Existing), a bulk sample provided a measured D84 of 24.5 mm and 72% gravel in the upper 0.2 feet. The lower 0.2 feet had a D84 of 14.2 mm, which is similar to the D84 of 17.3 mm that was taken from a bar sample in the same area. T1 continues to have gravel in the range of 83-90% of the sampled pebble counts until the sample taken around Station 29+14 (Existing). At this point, the confluences with T2, T3, and T4 are all upstream. Although gravel is still the dominant material, the bed becomes more heterogeneous with larger percentages of both sand and cobble. Bulk sampling at

Station 32+90 indicated 77% gravel and 23% sand with a D84 of 51.9 mm within the upper 0.2 feet. However, the lower 0.2 feet had 100% gravel material with a D84 of 50.2 mm. This indicates that sand is accumulating in the bed at this location. Near the end of T1 at Station 37+05, a pebble count shows that the stream is still a gravel-dominated bed with 52% gravel, 32% cobble and 15% sand with a D84 of 110 mm.

T2 begins as a gravel stream; a pebble count near the beginning of the tributary had a D84 of 31 mm and 66% gravel. At the bottom of the stream before it joins T1, T2 has accumulated more sand in the bed. A pebble count at a location approximately 130 feet upstream of the confluence with T1 had 54% sand and 42% gravel with a D84 of 16 mm. At this location, T2 is receiving excessive sediment from the surrounding unstable banks as well as from occasional backwater events from T1.

The sediment competency in T3 has been affected by the severity of bank erosion and bed incision along the length of this tributary. A pebble count was performed downstream of the large headcut at the top of T3 and this sample had 64% sand, most of which likely came from surrounding bank erosion. Another pebble count was completed further downstream at Station 64+40 and at this location there was 70% sand along with 30% gravel. This trend toward a sand bed continues throughout T3. However, there is a gravel bed that is under the large depositions of sand. A bulk sample at approximately 200 feet above the confluence with T1 showed 87% gravel and a D84 of 54 mm from 0-0.2 feet and 77% gravel and a D84 of 40.7 mm from 0.2-0.4 feet.

T4 is also receiving large amounts of sediment from its impacted banks and bed. Near the top of the stream at Station 83+60 (Existing), a pebble count revealed 83% gravel and 14% sand with a D84 of 38 mm. As T4 progresses down the valley, a pebble count shows that the streambed is comprised of greater amounts of sand (28% at Station 88+83) than at the point measured upstream. Bulk sampling was performed at Station 91+45 (Existing) and the results show that gravel is dominant at 78% and that this riffle section has a D84 of 50 mm within the first 0.2 feet of the bulk sample. From 0.2-0.4 feet below the riffle bed, there was 56% gravel and 44% sand along with a D84 of 27.5.

T6 is also experiencing elevated sediment inputs from bank erosion and bed incision. A pebble count was completed on T6 at Station 121+87 (Existing) right after the confluence of T6AB and T6C. This sample showed that the stream has 56% sand and 44% gravel with a D84 of 9.5 mm. Further downstream, another pebble count at Station 130+84 found 49% sand and 47% gravel in the bed with a D84 of 13 mm, indicating that the tributary receives large amounts of sand along its length. However, a bulk sample performed at Station 128+50 (Existing) had 79% gravel and 21% sand with a D84 of 41 mm within the first 0.2 feet and 71% gravel and 29% sand with a D84 of 34.6 mm from 0.2-0.4 feet below the bed. The results from the bulk sample signify the presence of a gravel bed under sand material.

T7 is a gravel stream with frequent inclusions of bedrock along its length. A pebble count was conducted just downstream of where T8 enters T7 and the stream had 90% gravel material with a D84 of 39 mm. Near this same location at Station 149+73 (Existing), the bulk sampling indicated a D84 of 32.9 mm along with 77% gravel and 23% sand in the upper 0.2 feet. From 0.2 to 0.4 feet, the bed had 56% gravel and 44% sand.

Another pebble count was completed on T7 at Station 152+55. Because the stream is starting to experience greater amounts of erosion from cattle impacts at this point, the percentage of sand rises to 22% and the gravel drops to 76% with a D84 of 23 mm. The slope of the channel also decreases along this section of stream. Further downstream at Station 169+25 (Existing), T7 enters a section controlled by bedrock and a bulk sample showed 89% gravel and 11% sand with a D84 of 53 mm in upper 0.2 feet and 74% gravel and 26% sand with a D84 of 33.4 mm from 0.2-0.4 feet. At Station 183+44, a pebble count showed 55% gravel with D84 of 55 mm. A bulk sample in the same location had 79% gravel and D84 of 49.4 mm in the upper 0.2 feet and 72% gravel and a D84 of 48.5 mm in the lower 0.2 feet.

After the confluence with T10, T7 continues to be dominated by gravel material. A bulk sample was taken at Station 193+35 (Existing) with 77% gravel and 23% sand with a D84 of 32 mm in the upper 0.2 feet and 66% gravel and 34% sand with a D84 of 36.5 mm in the lower 0.2 feet. A pebble count conducted at Station 195+08 (Existing) had a D84 of 42.0 mm and a predominantly gravel bed with 78% gravel and 16% sand. Shortly after this point, T7 joins Cane Creek and the lower portion of T7 indicates sediment deposits from backwater events.

T10, despite being a predominantly gravel stream, is controlled by bedrock and larger cobble. A pebble count on T10 at Station 222+92 (Existing) shows that the stream has a heterogeneous bed mixture with 31% gravel, 30% cobble, 29% sand, and 4% bedrock. Further downstream, a pebble count conducted at Station 233+53 found that the bed remains mixed with 38% cobble, 35% gravel, 22% sand, and 1% bedrock and a D84 of 160 mm.

After analyzing the existing sediment conditions, the site was studied with respect to sediment transport in the proposed reaches. T1 and T7 are active bed channels and have been designed as such. In active bed systems, there is a threshold level of bedload movement. At low flow levels, only the smallest particles will move, with the larger particles resisting the flow of the stream; this is the condition of partial sediment transport. As the stream flow increases, eventually every particle on the streambed will show threshold movement. This is the condition of full sediment transport. If the largest particle that moves during a bankfull event can be identified, then the flow conditions that produced this movement can be determined and this flow condition (channel competency) can be used in the design of the restored stream. Determinations of the design shear stresses were made based on the sediment distribution from the surface and subsurface sampling.

These shear stresses were validated for the design riffle cross-sections and channel gradient using the equation:

$$\tau = \gamma R s$$

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

The shear stress values for the designed reaches were calculated and related to the movement of a particular grain size using Shield's threshold of motion curve (Shields et al. 1936). On T1-1, T1-3, and T1-5, the proposed channel has critical shear stress values of 0.56 lbs/ft^2, 0.81 lbs/ft^2, and 0.64 lbs/ft^2, which correspond to mobilized particle sizes of 43, 62, and 49 mm, respectively. These values are higher than the sampled D84 particles on these existing reaches, which should help to keep the bed from aggrading like it is currently under the existing conditions. For T7-2, T7-3, T7-4, T7-5/6, and T7-7, the shear stress values range from 0.58 lbs/ft^2, 0.56 lbs/ft^2, 1.18 lbs/ft^2, 1.15 lbs/ft^2, and 0.68 lbs/ft^2, and these values would move particles of 44, 42, 93, 90, and 53 mm, respectively. The predicted particle sizes for T7-4, T7-5/6, and T7-7 are larger than the existing conditions data show for these reaches, but this length of T7 is also controlled by bedrock, so there is little risk of bed degradation.

The remaining tributaries – T2, T3, T4, T5, T6 and its headwater tributaries, T7A, T8, T8A, T9, and T10 – are threshold channels, which are defined as streams where the bed material inflow is negligible and the channel boundary is immobile even at high flows (Shields et al. 2003). At the CCTS, these tributaries are threshold channels due either to the lack of incoming bed material from the small surrounding watersheds or the hardening of the bed from bedrock or cobble. As opposed to an active bed system, a threshold channel never achieves full sediment transport; the system only achieves partial sediment transport. Therefore, the threshold mobility evaluation provided for T1 and T7 is not appropriate for the other tributaries at the CCTS.

Based on this analysis, the designed channels provide sufficient competency for the type of streams proposed and are capable of transporting sediment during bankfull events.

6.3 Natural Plant Community Restoration

Riparian plantings shall consist of native woody species. To achieve a mature survivability of 320 stems per acre, 436 stems per acre (10 feet by 10 feet spacing) will be planted. Plant placement and groupings will be randomized during installation in order to develop a more naturalized appearance. Woody vegetation planting will take place during dormancy. Species to be planted in the floodplain area as Piedmont Alluvial Forest will consist of at least five of the following:

Tag Alder	*Alnus serrulata*	Sycamore	*Platanus occidentalis*
River Birch	*Betula nigra*	Swamp Chestnut Oak	*Quercus michauxii*
Persimmon	*Diospyros virginiana*	Willow Oak	*Quercus phellos*
Green Ash	*Fraxinus pennsylvanica*	Coralberry	*Symphoricarpos orbiculatas*
Winterberry	*Ilex verticillata*	Possumhaw	*Viburnum nudum*
Spicebush	*Lindera benzoin*	Yellowroot	*Xanthorhiza simplicissima*
Tulip Poplar	*Liriodendron tulipifera*		

The slopes leading from the floodplain will be planted as Mesic Mixed Hardwood Forest and may consist of the following species:

Sweetshrub	*Calycanthus florida*	Tulip Poplar	*Liriodendron tulipifera*
Shagbark hickory	*Carya ovata*	Southern Red Oak	*Quercus falcata*
Persimmon	*Diospyros virginiana*	Willow Oak	*Quercus phellos*
Witchhazel	*Hamamelis virginiana*	Coralberry	*Symphoricarpos orbiculatas*
Black Walnut	*Juglans nigra*	Possumhaw	*Viburnum nudum*
Spicebush	*Lindera benzoin*		

On the restored stream banks, live stakes will be used to provide natural stabilization. Appropriate species identified for live staking include:

Silky Dogwood	*Cornus amomum*	Silky Willow	*Salix sericea*
Black Willow	*Salix nigra*	Elderberry	*Sambucus canadensis*

A herbaceous seed mix composed of appropriate native species will also be developed and used to further stabilize and restore the riparian and bank zones following construction.

In addition to planting the proposed community types, vegetative restoration will also include eliminating invasive species that have taken over portions of the site. The targeted species (Chinese privet and Japanese honeysuckle) will be treated with a glyphosate herbicide as needed to control populations.

7.0 PERFORMANCE CRITERIA

Monitoring shall consist of the collection and analysis of stream stability and riparian/stream bank vegetation survivability data to support the evaluation of the project in meeting established restoration objectives. Specifically, project success will be assessed utilizing measurements of stream dimension, pattern, and profile; site photographs, and vegetation sampling.

7.1 Stream Stability

The purpose of monitoring is to evaluate the stability of the restored stream. Following the procedures established in the USDA Forest Service Manual, *Stream Channel Reference Sites* (Harrelson et al. 1994) and the methodologies utilized in the Rosgen stream assessment and classification system (1994 and 1996), data collected will consist of detailed dimension and pattern measurements, longitudinal profiles, and bed materials sampling.

Dimension – Permanent cross-sections will be established at 14 riffle and 6 pool locations along the restored project reaches. The following cross-sections will be used to evaluate stream dimension:

- 2 riffles and 1 pool on T1-3, T1-4, or T1-5
- 1 riffle on T2-2
- 2 riffles and 1 pool on T3-2
- 3 riffles and 1 pool on T4-1 or T4-2
- 1 riffle on T5-2
- 2 riffles and 1 pool on T6
- 2 riffles and 1 pool on T7-3
- 1 riffle on T7-5

Permanent monuments will be established by conventional survey. The cross-section surveys shall provide a detailed measurement of the stream and banks and will include points on the adjacent floodplain or valley, at the top of bank, bankfull, at all breaks in slope, the edge of water, and thalweg. Width/depth and entrenchment ratios will be calculated for each cross-section based on the survey data.

Cross-section measurements should show little or no change from the as-built cross-sections. If changes do occur, they will be evaluated to determine whether they are minor adjustments associated with settling and increased stability or whether they indicate movement toward an unstable condition.

Profile – Longitudinal profiles will be conducted on approximately 3,000 linear feet of the project reaches as described below:

- 500 linear feet along T1-3, T1-4 or T1-5
- 500 linear feet along T3-2
- 750 linear feet along T4-2
- 500 linear feet along T6 or its headwater tributaries
- 750 linear feet along T7-3

Measurements will include slopes (average, pool, and riffle) as well as calculations of pool-to-pool spacing. Annual measurements should indicate that bedform features are stable with little change from the as-built survey. The pools should maintain their depth with lower water surface slopes, while the riffles should remain shallower and steeper than the average values for the stream.

Pattern - Measurements associated with the restored channel pattern shall be taken on the section of the stream included in the longitudinal profiles. These data will include belt width, meander length, and radius of curvature. Subsequently, sinuosity, meander width ratios, radius of curvature, and meander length/bankfull width ratios will be calculated.

Bed Materials **–** Pebble counts will be conducted at each monitored cross-section for the purpose of repeated classification and to evaluate sediment transport.

Verification of Bankfull Events – During the monitoring period, a minimum of two bankfull events must be recorded within the five-year monitoring period. These two bankfull events must occur in separate monitoring years. A bankfull event will be verified using pressure transducer gauges.

Photograph Reference Points – Fifty photograph reference points (PRP) will be established to assist in characterizing the site and to allow qualitative evaluation of the site conditions. The location and bearing/orientation of each photo point will be documented to allow for repeated use.

Cross-section Photograph Reference Points – Each cross-section will be photographed to show the form of the channel with the tape measure stretched over the channel for reference in each photograph. An effort will be made to consistently show the same area in each photograph.

7.2 Vegetation

The success of the riparian buffer plantings will be evaluated using 20 ten by ten meter vegetative sampling plots and will use the stream vegetation monitoring protocol set out by the EEP. The corners of each monitoring plot will be permanently marked in the field. The coordinates of the plot corners will be recorded using conventional survey. The monitoring will consist of the following data inventory: composition and number of surviving species, total number of stems per acre, diameter at decimeter height, diameter at breast height for trees greater than 5 feet in height, and vigor. Additionally, a photograph will be taken of each plot that will be replicated each monitoring year. Riparian vegetation must meet a minimum survival success rate of 320 stems/acre after five years. If monitoring indicates that the specified survival rate is not being met, appropriate corrective actions will take place, which may include invasive species control, the removal of dead/dying plants and replanting.

7.3 Schedule/Reporting

The first scheduled monitoring will be conducted during the first full growing season following project completion. Monitoring shall subsequently be conducted annually for a total period of five years or until the project meets its success criteria.

Annual monitoring reports will be prepared and submitted after all monitoring tasks for each year are completed. The report will document the monitored components of the restoration plan and include all collected data, analyses, and photographs. Each report will provide the new monitoring data and compare the most recent results against previous findings. The monitoring report format will be similar to that set out in the most recent EEP monitoring protocol.

Variations from the designed project reaches can be anticipated due to unknown site conditions, inputs from outside the restoration site, regional climatic variations, or acts of God, etc. Regular management activities will be implemented as necessary to ensure that the goals and objectives of the project are met. These activities will be conducted throughout the year and may include invasive species control or other management activities. If the monitoring identifies failures in the project site, a remedial action plan will be developed to investigate the causes of the failure and propose actions to rectify the problem.

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Tables

Table 1. Project Restoration Structure and Objectives

Reach	Existing Stationing	Proposed Stationing	Mitigation Type	Priority Approach	Existing Linear Footage	Designed Linear Footage	Comments
T1-1	10+00 - 17+26	10+00 - 17+59*	Enhancement I	-	726	759	
T1-2	17+26 – 21+50	17+59 - 21+50*	Enhancement I	-	361	328	Excludes 60-ft crossing
T1-3	21+50 – 24+63	21+50 - 24+74	Restoration	P3	313	324	
T1-4	24+63 – 35+19	24+74 - 34+94	Restoration	P3	1,056	1,020	
T1-5	35+19 – 38+38	34+94 - 37+64	Restoration	P3	319	270	
T2-1	50+00 – 53+05	50+00 – 53+05	Enhancement II	-	305	305	
T2-2	53+05 – 55+32	53+05 – 54+91	Restoration	P2	227	186	
T2-3	55+32 – 56+92	54+91 – 56+51	Enhancement I	-	160	160	
T2-4	56+92 – 58+63	56+51 – 58+51	Restoration	P3	151	180	Excludes 20-ft crossing
T3-1	60+00 – 61+07	60+00 – 61+05*	Enhancement I	-	107	105	
T3-2	61+07 – 75+83	61+05 – 76+79	Restoration	P3	1,457	1,554	Excludes 20-ft crossing
T4-1	80+00 – 81+90	80+00 – 82+66	Restoration	P3	190	266	
T4-2	81+90 – 99+99	82+66 – 102+53	Restoration	P3	1,789	1,967	Excludes 20-ft crossing
T5-1	110+00 – 112+64	110+00 – 112+64	Enhancement II	-	244	244	Excludes 20-ft crossing
T5-2	112+64 – 113+82	112+64 – 113+85	Restoration	P3	118	121	
T6A	240+00 – 240+89	240+00 – 240+89	Enhancement II	-	89	89	
T6B	250+00 – 251+03	250+00 – 251+03	Enhancement II	-	103	103	
T6AB	240+89 – 241+19	240+89 – 241+29	Restoration	P3	30	40	
T6C	120+00 – 121+80	120+00 – 121+88	Restoration	P3	180	188	
T6	121+80 – 134+75	121+88 – 134+38	Restoration	P3	1,275	1,230	Excludes 20-ft crossing
T7A	260+00 – 261+36	260+00 – 261+36	Enhancement II	-	136	136	
T7-1	140+00 - 144+69	140+00 - 144+69	Enhancement II	-	469	469	
T7-2	144+69 - 148+00	144+69 - 148+00	Enhancement I	-	331	331	
T7-3	148+00 - 168+43	148+00 - 169+08	Restoration	P2/3	2,023	2,088	Excludes 20-ft crossing
T7-4	168+43 - 180+89	169+08 - 181+54	Enhancement I	-	1,246	1,246	
T7-5	180+89 - 182+74	181+54 - 183+08	Restoration	P3	185	154	
T7-6	182+74 - 190+49	183+08 - 190+83	Enhancement I	-	755	755	Excludes 20-ft crossing
T7-7	190+49 - 196+59	190+83 - 196+93	Enhancement I	-	610	610	
T8A	270+00 – 271+10	270+00 – 271+10	Enhancement II	-	110	110	
T8	200+00 - 204+49	200+00-204+49	Enhancement I	-	449	449	
T9	210+00 - 213+69	210+00 – 213+69	Enhancement I	-	369	369	
T10-1	220+00 – 233+00	220+00 – 233+00	Enhancement II	-	1,300	1,300	
T10-2	233+00 – 235+82	233+00 – 235+82	Enhancement I	-	282	282	
				Total	17,465	17,738	
						Total Proposed Stream Enhancement I (lf)	5,394
						Total Proposed Stream Enhancement II (lf)	2,756
						Total Proposed Stream Restoration (lf)	9,588

*The length of selected enhancement reaches changed if the confluence with a restoration reach was altered.

Table 2. Project Watershed Land Use

Land Use	Acreage	Percentage of Watershed
Agriculture	414.1	49%
Forest land	295.3	35%
Rangeland	100.3	12%
Wetland	22.0	3%
Water	8.7	1%
Urban or built-up	2.2	<1%

Table 3. Project Drainage Areas

Reach	Drainage Area (Acres)	Drainge Area (Square Miles)
T1-1	249.9	0.39
T1-2	304.4	0.48
T1-3	310.5	0.49
T1-4	400.0	0.62
T1-5	447.8	0.70
T2-1	66.1	0.10
T2-2	67.8	0.11
T2-3	70.3	0.11
T2-4	71.1	0.11
T3-1	15.5	0.02
T3-2	48.2	0.08
T4-1	36.4	0.06
T4-2	61.4	0.10
T5-1	13.1	0.02
T5-2	13.8	0.02
T6A	2.6	0.00
T6B	2.5	0.00
T6AB	5.2	0.01
T6C	8.2	0.01
T6	42.6	0.07
T7A	5.8	0.01
T7-1	31.6	0.05
T7-2	34.2	0.05
T7-3	113.2	0.18
T7-4	154.9	0.24
T7-5	156.5	0.24
T7-6	166.9	0.26
T7-7	397.1	0.62
T8A	0.5	0.00
T8	13.7	0.02
T9	22.8	0.04
T10-1	218.7	0.34
T10-2	220.6	0.34

Table 4a. Morphological Criteria for T1.

Variables		Existing T1-1	Existing T1-2	Existing T1-3	Existing T1-4	Existing T1-5	Ref. Reach UTFR	Proposed T1-1	Proposed T1-2	Proposed T1-3	Proposed T1-4	Proposed T1-5
Rosgen Stream Type		G	G	E	B/G/F	G	B4c	C/B4	C/B4	C/B4	C/B4	C/B4
Mitigation Type		Enh. I	Enh. I	Restoration	Restoration	Restoration	N/A	Enh. I	Enh. I	Restoration	Restoration	Restoration
Drainage Area (mi^2)		0.390	0.587	0.596	0.736	0.811	0.38	0.390	0.587	0.596	0.736	0.811
Bankfull Width (W_{bkf}) (ft)		8.6-8.8	8.4	10.2	10.5-17.0	13.9	9.0-10.0	12.8	13.6	13.6	15	15
Bankfull Mean Depth (d_{bkf}) (ft)		1.1-1.2	1.0	1.3	1.2-1.5	1.2	1.1-1.2	1.2	1.2	1.2	1.3	1.3
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		9.8-10.9	8.2	12.9	15.3-20.1	16.8	10.4-10.7	14.5	16.4	16.4	20	20
Width/depth Ratio (W_{bkf}/d_{bkf})		7.1-7.6	8.5	8.1	7.2-17.2	11.5	8.0-10.0	10.7	11	11	12	12
Maximum Depth (d_{mbkf}) (ft)		1.4-1.5	1.2	1.9	1.2-2.3	1.7	1.3-1.5	1.8	1.9	1.9	2	2
Width of flood prone area (W_{fpa}) (ft)		11-12	12.2	25.4	15-35	19.4	13.1-20.5	28	30	30	33	33
Entrenchment Ratio (ER)		1.3-1.4	1.5	2.5	1.2-3.3	1.4	1.3-2.3	2.2	2.2	2.2	2.2	2.2
Sinuosity (stream length/valley length) (K)		1.1	1.1	1.1	1.2	1	1.2	1.1	1.1	1.1	1.1	1
Dimension	Pool Depth (ft)	1.8	2.0	1.3	1.3-1.8	1.7	1.2-1.4	1.5	1.5	1.5	1.6	1.6
	Riffle Depth (ft)	1.1-1.2	1.0	1.3	1.2-1.5	1.2	1.1-1.2	1.2	1.2	1.2	1.3	1.3
	Max Pool Depth (ft)	1.9-2.2	2.7	2.5	2.2-3.0	3.0	2.1-2.4	2.4	2.4	2.4	2.6	2.6
	Pool Width (ft)	9.3-10.0	9.1	12.3	7.8-17.7	17.3	8.4-11.6	16.6	18	18	20	20
	Riffle Width (ft)	8.6-8.8	8.4	10.2	10.5-17.0	13.9	9.0-9.9	12.8	13.6	13.6	15	15
	Pool XS Area (sf)	16.8-17.6	18.1	16.6	14.2-23.1	28.9	11.6-13.4	24.7	26.4	26.4	32.5	32.5
	Riffle XS Area (sf)	9.8-10.9	8.4	12.9	15.3-20.1	16.8	10.4-10.7	14.5	16.4	16.4	20	20
	Pool depth/mean riffle depth	1.5-1.6	2.0	1.0	0.9-1.5	1.4	1.0-1.3	1.3	1.3	1.3	1.3	1.3
	Pool width/riffle width	1.1-1.2	1.1	1.2	0.5-1.7	1.2	0.8-1.3	1.3	1.3	1.3	1.3	1.3
	Pool area/riffle area	1.5-1.8	2.2	1.3	0.7-1.5	1.7	1.1-1.3	1.7	1.6	1.6	1.7	1.7
	Max pool depth/d_{bkf}	1.6-2.0	2.7	1.9	1.5-2.5	2.5	1.9-2.0	2	2	2	2	2
	Bank Height Ratio (BHR)	2.3-3.0	3.6	1.9	1.4-2.1	2.3	1	1	1	1	1	1
	Mean Bankfull Velocity (V) (fps)	4.3	4.4	4.5	4.0-5.2	4.9	4.1-4.5	4.1	4.4	4.4	3.9	4.2
	Bankfull Discharge (Q) (cfs)	42-47	36	60	66-101	83	42-46	59	73	73	84	90
Pattern	Meander length (L_m) (ft)	121-146	112-120	90-117	106-230	188	93-136	121-146	112-120	160-170	140-240	115-180
	Radius of curvature (R_c) (ft)	19-36	17-26	7-19	12-54	30-64	13-42	19-36	17-26	30-40	30-50	30-40
	Belt width (W_{blt}) (ft)	27-33	34	21	25-49	51	45	27-33	34	40-70	40-60	25-40
	Meander width ratio (W_{blt}/W_{bkf})	3.0-3.8	4.0	2.0	1.5-4.7	3.7	4.5-5.0	2.1-2.6	2.5	3.0-5.0	2.7-4.0	1.7-2.7
	Radius of curvature/bankfull width	2.2-4.2	2.0-3.0	0.7-1.9	0.7-5.1	2.2-4.6	1.3-4.4	1.5-2.8	1.3-1.9	2.2-3.0	2.0-3.3	2-2.7
	Meander length/bankfull width	13.8-17.0	13.3-14.3	8.8-11.4	6.2-21.9	13.5	9.0-15.0	9.4-11.4	8.2-8.8	11.9-12.6	9.3-16	7.7-12
Profile	Valley slope	0.0102	0.0118	0.0115	0.0077	0.0120	0.016	0.0102	0.0118	0.0115	0.0077	0.0120
	Average water surface slope	0.0083	0.0134	0.0077	0.0072	0.0090	0.013	0.0083	0.0134	0.0089	0.0079	0.0080
	Riffle slope	0.0090-0.0230	0.0290-0.0299	0.0138-0.0427	0.0110-0.0407	0.0211-0.0289	0.013-0.028	0.0090-0.0230	0.0290-0.0299	0.010-0.014	0.006-0.013	0.005-0.010
	Pool slope	0-0.0012	0.0004-0.0014	0-0.0008	0.0012-0.0038	0-0.0003	0.000-0.001	0-0.0012	0.0004-0.0014	0.002	0.001-0.002	0.002
	Pool to pool spacing	44-56	80-107	21-49	29-34	88	30-59	40-60	60-100	75-100	60-150	50-70
	Pool length	16-24	14-58	13-38	11-29	16-30	3-25	15-25	15-25	10-20	10-30	10-15
	Riffle slope/avg water surface slope	1.10-2.80	2.16-2.23	1.79-5.55	1.53-5.65	2.34-3.21	1.00-2.20	1.10-2.80	2.16-2.23	1.12-1.57	0.75-1.65	0.63-1.25
	Pool slope/avg water surface slope	0-0.14	0.03-0.10	0-0.10	0.17-0.52	0-0.03	0.0	0-0.14	0.03-0.10	0.22	0.13-0.25	0.25
	Pool length/bankfull width	1.8-2.8	1.7-6.9	1.2-3.7	0.6-2.8	1.2-2.2	0.3-2.5	1.2-2.0	1.1-1.8	0.7-1.5	0.7-2.0	0.7-1.0
	Pool to pool spacing/bankfull width	5.0-6.5	9.5-12.7	2.1-4.8	1.7-3.2	6.3	3.3-6.0	3.1-4.7	4.4-7.3	5.5-7.4	4.0-10.0	3.3-4.7

Table 4b. Morphological Criteria for T2.

Variables		Existing T2-2*	Existing T2-3+	Existing T2-4**	Ref. Reach UTFR	Proposed T2-2	Proposed T2-3	Proposed T2-4
Rosgen Stream Type		E4	E4	G4	B4c	C/E4	B4	B4
Mitigation Type		Restoration	Enh. I	Restoration	N/A	Restoration	Enh. I	Restoration
Drainage Area (mi^2)		0.106	0.110	0.111	0.38	0.106	0.110	0.111
Bankfull Width (W_{bkf}) (ft)		-	-	6.2	9.0-10.0	7.4	7.4	7.4
Bankfull Mean Depth (d_{bkf}) (ft)		-	-	0.9	1.1-1.2	0.8	0.8	0.8
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		-	-	5.7	10.4-10.7	5.7	5.7	5.7
Width/depth Ratio (W_{bkf}/d_{bkf})		-	-	6.7	8.0-10.0	9.3	9.3	9.3
Maximum Depth (d_{mbkf}) (ft)		-	-	1.3	1.3-1.5	1.3	1.3	1.3
Width of flood prone area (W_{fpa}) (ft)		-	-	11	13.1-20.5	19	14.8	14.8
Entrenchment Ratio (ER)		-	-	1.8	1.3-2.3	2.5	2	2
Sinuosity (stream length/valley length) (K)		1.7	1.2	1.1	1.2	1.4	1.2	1.3
Dimension	Pool Depth (ft)	-	-	1.1	1.2-1.4	1.2	1.2	1.2
	Riffle Depth (ft)	-	-	0.9	1.1-1.2	0.8	0.8	0.8
	Max Pool Depth (ft)	-	-	2.0	2.1-2.4	2	2	2
	Pool Width (ft)	-	-	9.4	8.4-11.6	8.2	8.2	8.2
	Riffle Width (ft)	-	-	6.2	9.0-9.9	7.4	7.4	7.4
	Pool XS Area (sf)	-	-	9.9	11.6-13.4	9.6	9.6	9.6
	Riffle XS Area (sf)	-	-	5.7	10.4-10.7	5.7	5.7	5.7
	Pool depth/mean riffle depth	-	-	1.2	1.0-1.3	1.5	1.5	1.5
	Pool width/riffle width	-	-	1.5	0.8-1.3	1.1	1.1	1.1
	Pool area/riffle area	-	-	1.7	1.1-1.3	1.7	1.7	1.7
	Max pool depth/d_{bkf}	-	-	2.2	1.9-2.0	2.5	2.5	2.5
	Bank Height Ratio (BHR)	-	-	2.5	1	1.0	1.0	1.0
	Mean Bankfull Velocity (V) (fps)	-	-	3.9	4.1-4.5	5.2	4.4	4.5
	Bankfull Discharge (Q) (cfs)	-	-	21	42-46	30	25	26
Pattern	Meander length (L_m) (ft)	39-61	29-52	-	93-136	40-53	29-52	50-90
	Radius of curvature (R_c) (ft)	5-18	5-19	-	13-42	7-10	5-19	15-20
	Belt width (W_{blt}) (ft)	11-19	16-25	-	45	14-23	16-25	26-44
	Meander width ratio (W_{blt}/W_{bkf})	2.5-3.3	3.6-5.7	-	4.5-5.0	1.9-3.1	2.2-3.4	3.5-5.9
	Radius of curvature/bankfull width	1.1-4.1	1.1-4.3	-	1.3-4.4	1-1.4	0.7-2.6	2.0-2.7
	Meander length/bankfull width	8.9-13.9	6.6-11.8	-	9.0-15.0	5.4-7.2	3.9-7.0	6.8-12.2
Profile	Valley slope	0.0160	0.0131	0.0159	0.016	0.0174	0.0131	0.0159
	Average water surface slope	0.0179	0.0164	0.0137	0.013	0.0231	0.0164	0.017
	Riffle slope	-	-	0.0224-0.0304	0.013-0.028	0.018-0.022	-	0.017
	Pool slope	-	-	0-0.0005	0.000-0.001	0.002	0.002	0.002
	Pool to pool spacing	-	-	39	30-59	23-40	24-67	35-60
	Pool length	-	-	10-20	3-25	8-16	5-6	5-25
	Riffle slope/avg water surface slope	-	-	1.64-2.22	1.0-2.2	0.78-0.95	-	1
	Pool slope/avg water surface slope	-	-	0-0.04	0.0	0.09	0.12	0.12
	Pool length/bankfull width	-	-	1.6-3.2	0.3-2.5	1.1-2.2	0.8-0.9	0.7-3.4
	Pool to pool spacing/bankfull width	-	-	6.3	3.3-6.0	3.2-5.4	3.6-10.2	4.7-8.1

*T2-2 shares the same dimensional character as T2-1. The existing conditions pattern data is specific to the T2-2, but profile data were not collected for T2-2.

+ T2-3 shares the same dimensional character as T2-4. The existing conditions pattern data are specific to T2-2, but profile data were not collected for T2-2.

Table 4c. Morphological Criteria for T3 and T4.

Variables		Existing T3-1***	Existing T3-2	Ref. Reach UTFR	Proposed T3-1	Proposed T3-2	Existing T4	Ref. Reach UTFR	Proposed T4-2	Proposed T4-1
Rosgen Stream Type		E4/5	G4	B4c	C/E	B4	G4	B4c	B4	B4
Mitigation Type		Enh. I	Restoration	N/A	Enh. I	Restoration	Restoration	N/A	Restoration	Restoration
Drainage Area (mi^2)		0.024	0.075	0.38	0.024	0.075	0.096	0.38	0.096	0.057
Bankfull Width (W_{bkf}) (ft)		2.3-3.4	4.2-5.8	9.0-10.0	4.4	7.8	4.5-6.7	9.0-10.0	9.2	6.2
Bankfull Mean Depth (d_{bkf}) (ft)		0.8-1.1	0.6-0.9	1.1-1.2	0.6	0.7	1.1-1.4	1.1-1.2	0.8	0.5
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		2.4-2.7	2.5-4.8	10.4-10.7	2.5	5.6	5.4-7.2	10.4-10.7	7.1	3
Width/depth Ratio (W_{bkf}/d_{bkf})		2.1-4.3	5.4-8.0	8.0-10.0	7.3	10.9	3.3-6.2	8.0-10.0	11.5	12.4
Maximum Depth (d_{mbkf}) (ft)		1.2-1.3	1.0-1.3	1.3-1.5	0.8	1.1	1.4-1.7	1.3-1.5	1.2	0.8
Width of flood prone area (W_{fpa}) (ft)		6-56	6-9	13.1-20.5	11	16	7-10	13.1-20.5	18.4	12.4
Entrenchment Ratio (ER)		2.5-16.3	1.1-1.7	1.3-2.3	2.4	2.1	1.5-1.6	1.3-2.3	2	2
Sinuosity (stream length/valley length) (K)		1.1	1.1	1.2	1.1	1.2	1.1	1.2	1.2	1.5
Dimension	Pool Depth (ft)	-	0.9	1.2-1.4	0.8	1.2	1.3-1.5	1.2-1.4	1.2	0.8
	Riffle Depth (ft)	0.8-1.1	0.6-0.9	1.1-1.2	0.6	0.7	1.1-1.4	1.1-1.2	0.8	0.5
	Max Pool Depth (ft)	-	1.3	2.1-2.4	1.4	2	1.5-2.1	2.1-2.4	2	1.4
	Pool Width (ft)	-	4.3	8.4-11.6	5.8	10	3.3-4.5	8.4-11.6	12	8
	Riffle Width (ft)	2.3-3.4	4.2-5.8	9.0-9.9	4.4	7.8	4.5-6.7	9.0-9.9	9.2	6.2
	Pool XS Area (sf)	-	3.7	11.6-13.4	4.8	11.5	5.0-6.8	11.6-13.4	14	6.4
	Riffle XS Area (sf)	2.4-2.7	2.5-4.8	10.4-10.7	2.5	5.6	5.4-7.2	10.4-10.7	7.1	3
	Pool depth/mean riffle depth	-	1.0-1.5	1.0-1.3	1.3	1.7	0.9-1.4	1.0-1.3	1.5	1.6
	Pool width/riffle width	-	0.7-1.0	0.8-1.3	1.3	1.3	0.5-1.0	0.8-1.3	1.3	1.3
	Pool area/riffle area	-	0.8-1.5	1.1-1.3	1.9	2.1	0.7-1.3	1.1-1.3	1.9	2.1
	Max pool depth/d_{bkf}	-	1.4-2.2	1.9-2.0	2.3	2.9	1.1-1.9	1.9-2.0	2	2.8
	Bank Height Ratio (BHR)	1.1-1.6	1.9-3.2	1	1	1	3.1-4.2	1	1	1
	Mean Bankfull Velocity (V) (fps)	4.2-6.7	4.7-6.3	4.1-4.5	3.8	4.7	5.0-7.5	4.1-4.5	4.7	4.4
	Bankfull Discharge (Q) (cfs)	11-16	12-30	42-46	9	26	25-51	42-46	33	13
Pattern	Meander length (L_m) (ft)	-	80-420	93-136	-	48-130	35-290	93-136	50-130	77-95
	Radius of curvature (R_c) (ft)	-	8-30	13-42	-	10-30	7-26	13-42	10-30	15-20
	Belt width (W_{blt}) (ft)	-	20-25	45	-	40-45	15-58	45	25-60	39-50
	Meander width ratio (W_{blt}/W_{bkf})	-	6.0-3.4	4.5-5.0	-	5.1-5.8	2.2-12.9	4.5-5.0	2.7-6.5	6.3-8.1
	Radius of curvature/bankfull width	-	1.4-7.1	1.3-4.4	-	1.3-3.8	1.0-5.8	1.3-4.4	1.1-3.3	2.4-3.2
	Meander length/bankfull width	-	13.8-100.0	9.0-15.0	-	6.1-16.7	5.2-64.4	9.0-15.0	5.4-14.1	12.4-15.3
Profile	Valley slope	0.0439	0.0226	0.016	0.0439	0.0226	0.0211	0.016	0.0216	0.043
	Average water surface slope	0.0195	0.0202	0.013	0.0195	0.0215	0.0224	0.013	0.0181	0.0296
	Riffle slope	0.0129-0.0350	0.0102-0.0640	0.013-0.028	0.0129-0.0350	0.014-0.045	0.0134-0.0381	0.013-0.028	0.009-0.030	0.022
	Pool slope	0.0001-0.0089	0.0014-0.0063	0.000-0.001	0.0001-0.0089	0.002	0.0008-0.0032	0.000-0.001	0.002	0.002
	Pool to pool spacing	105	11-68	30-59	14-17	25-90	20-80	30-59	30-85	60-70
	Pool length	5-6	6-23	3-25	5-6	6-20	10-35	3-25	5-40	18-30
	Riffle slope/avg water surface slope	0.66-1.79	0.45-2.83	1.0-2.2	0.66-1.79	0.7-2.1	0.60-1.70	1.0-2.2	0.50-1.66	0.07-0.74
	Pool slope/avg water surface slope	0-0.46	0.06-0.28	0.0	0-0.46	0.1	0.04-0.14	0.0	0.11	0.07
	Pool length/bankfull width	1.5-2.4	1.1-5.7	0.3-2.5	1.1-1.4	0.8-2.6	1.5-7.8	0.3-2.5	0.54-4.3	2.9-4.8
	Pool to pool spacing/bankfull width	30.9-45.7	1.9-16.2	3.3-6.0	3.2-3.9	3.2-11.5	3.0-17.8	3.3-6.0	3.3-9.2	9.7-11.3

***There are no defined bed features on T3-1; existing conditions data are from representative cross-sections that are neither defined riffles or pools.

Table 4d. Morphological Criteria for T5 and T6.

Variables		Existing T5-2***	Ref. Reach UTFR	Proposed T5-2	Existing T6	Ref. Reach UTFR	Proposed T6C	Proposed T6
Rosgen Stream Type		G4	B4c	B4	G	B4c	B4	B4
Mitigation Type		Restoration	N/A	Restoration	Restoration	N/A	Restoration	Restoration
Drainage Area (mi^2)		0.022	0.38	0.022	0.067	0.38	0.013	0.067
Bankfull Width (W_{bkf}) (ft)		3.3	9.0-10.0	5	3.4-5.3	9.0-10.0	6	8
Bankfull Mean Depth (d_{bkf}) (ft)		0.7	1.1-1.2	0.5	0.4-0.8	1.1-1.2	0.6	0.7
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		2.3	10.4-10.7	2.5	1.3-4.0	10.4-10.7	3.4	5.7
Width/depth Ratio (W_{bkf}/d_{bkf})		4.7	8.0-10.0	10	7.0-8.7	8.0-10.0	10.6	11.4
Maximum Depth (d_{mbkf}) (ft)		0.9	1.3-1.5	0.8	0.5-1.0	1.3-1.5	0.9	1.1
Width of flood prone area (W_{fpa}) (ft)		4.3	13.1-20.5	10	4-8	13.1-20.5	12	16
Entrenchment Ratio (ER)		1.3	1.3-2.3	2	1.1-1.5	1.3-2.3	2	2
Sinuosity (stream length/valley length) (K)		1.1	1.2	1.2	1.2	1.2	1.1	1.2
Dimension	Pool Depth (ft)	-	1.2-1.4	0.9	0.6-1.1	1.2-1.4	1	1.1
	Riffle Depth (ft)	0.7	1.1-1.2	0.5	0.4-0.8	1.1-1.2	0.6	0.7
	Max Pool Depth (ft)	-	2.1-2.4	1.5	0.8-2.3	2.1-2.4	1.7	1.9
	Pool Width (ft)	-	8.4-11.6	6.5	4.5-6.4	8.4-11.6	7.8	10.4
	Riffle Width (ft)	3.3	9.0-9.9	5	3.4-5.3	9.0-9.9	6	8
	Pool XS Area (sf)	-	11.6-13.4	5.8	2.7-7.1	11.6-13.4	7.9	11.8
	Riffle XS Area (sf)	2.3	10.4-10.7	2.5	1.3-4.0	10.4-10.7	3.4	5.7
	Pool depth/mean riffle depth	-	1.0-1.3	1.7	0.8-1.9	1.0-1.3	1.7	1.6
	Pool width/riffle width	-	0.8-1.3	1.3	0.8-1.9	0.8-1.3	1.3	1.3
	Pool area/riffle area	-	1.1-1.3	2.3	0.7-5.5	1.1-1.3	2.1	1.9
	Max pool depth/d_{bkf}	-	1.9-2.0	2.9	1-4.5	1.9-2.0	2.9	2.7
	Bank Height Ratio (BHR)	2.7	1	1.0	3.0-6.8	1	1.0	1.0
	Mean Bankfull Velocity (V) (fps)	4.4	4.1-4.5	6	3.0-5.7	4.1-4.5	5.7	5.1
	Bankfull Discharge (Q) (cfs)	34	42-46	15	3.8-23.9	42-46	22	29
Pattern	Meander length (L_m) (ft)	-	93-136	45-63	14-116	93-136	54-90	72-120
	Radius of curvature (R_c) (ft)	-	13-42	15	3-16	13-42	7.8-26.4	10.4-35.2
	Belt width (W_{blt}) (ft)	-	45	15-30	16-36	45	27-30	36-40
	Meander width ratio (W_{blt}/W_{bkf})	-	4.5-5.0	3.0-6.0	2.6-34.1	4.5-5.0	4.5-5.0	4.5-5.0
	Radius of curvature/bankfull width	-	1.3-4.4	3.0	0.6-4.7	1.3-4.4	1.3-4.4	1.3-4.4
	Meander length/bankfull width	-	9.0-15.0	9.0-13.0	2.6-34.1	9.0-15.0	9.0-15.0	9.0-15.0
Profile	Valley slope	0.0190	0.016	0.064	0.0274	0.016	0.0396	0.029
	Average water surface slope	0.0590	0.013	0.055	0.0245	0.013	0.0361	0.024
	Riffle slope	-	0.013-0.028	0.02	0.0090-0.0295	0.013-0.028	0.02	0.013-0.025
	Pool slope	-	0.000-0.001	0.002	0.0005-0.0045	0.000-0.001	0.002	0.002
	Pool to pool spacing	-	30-59	20-50	26-48	30-59	16-40	25-70
	Pool length	-	3-25	10-15	9-13	3-25	6-15	6-15
	Riffle slope/avg water surface slope	-	1.0-2.2	0.36	0.39-1.27	1.0-2.2	0.55	0.54-1.0
	Pool slope/avg water surface slope	-	0.0	0.04	0.02-0.19	0.0	0.06	0.08
	Pool length/bankfull width	-	0.3-2.5	2.0-3.0	1.7-3.8	0.3-2.5	1.0-2.5	0.8-1.9
	Pool to pool spacing/bankfull width	-	3.3-6.0	4.0-10.0	4.9-14.1	3.3-6.0	2.7-6.7	3.1-8.8

***There are no defined bed features on T5-2; existing conditions data are from representative cross-sections that are neither defined riffles or pools.

[#]Existing conditions survey data were not collected on T5-1; a visual inspection was conducted.

Table 4e. Morphological Criteria for T7-2, T7-3, and T7-4.

Variables		Existing T7-2	Existing T7-3	Existing T7-4[#]	Ref. Reach UTFR	Proposed T7-2	Proposed T7-3	Proposed T7-4
Rosgen Stream Type		G4	G4c	E4/1	B4c	B4	B4c	B4/1
Mitigation Type		Enh. I	Restoration	Enh. I	-	Enh. I	Restoration	Enh. I
Drainage Area (mi^2)		0.053	0.177	0.242	0.38	0.053	0.177	0.242
Bankfull Width (W_{bkf}) (ft)		4.0	6.0-6.9	-	9.0-10.0	5.8	8.2	9.6
Bankfull Mean Depth (d_{bkf}) (ft)		0.7	0.9-1.0	-	1.1-1.2	0.5	0.7	0.9
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		2.8	5.6-6.0	-	10.4-10.7	2.8	6.0	8.2
Width/depth Ratio (W_{bkf}/d_{bkf})		5.7	6.0-7.9	-	8.0-10.0	11.8	11.2	11.3
Maximum Depth (d_{mbkf}) (ft)		0.8	1.1-1.3	-	1.3-1.5	0.7	1.1	1.2
Width of flood prone area (W_{fpa}) (ft)		5.2	7.6-8.7	-	13.1-20.5	11.6	16.4	19.2
Entrenchment Ratio (ER)		1.3	1.2-1.4	-	1.3-2.3	2	2	2
Sinuosity (stream length/valley length) (K)		1.1	1.1	1.1	1.2	1.1	1.1	1.1
Dimension	Pool Depth (ft)	0.8	0.8-1.3	-	1.2-1.4	0.6	1.0	1.1
	Riffle Depth (ft)	0.7	0.9-1.0	-	1.1-1.2	0.5	0.7	0.9
	Max Pool Depth (ft)	1.0	1.3-1.6	-	2.1-2.4	1.2	1.8	2.0
	Pool Width (ft)	4.0	4.8-7.2	-	8.4-11.6	6.4	9	11.2
	Riffle Width (ft)	4.0	6.0-6.9	-	9.0-9.9	5.8	8.2	9.6
	Pool XS Area (sf)	3.2	6.1-6.2	-	11.6-13.4	3.8	8.7	11.8
	Riffle XS Area (sf)	2.8	5.6-6.0	-	10.4-10.7	2.8	6.0	8.2
	Pool depth/mean riffle depth	1.1	0.8-1.4	-	1.0-1.3	1.2	1.4	1.2
	Pool width/riffle width	1.0	0.7-1.2	-	0.8-1.3	1.1	1.1	1.2
	Pool area/riffle area	1.1	1.0-1.1	-	1.1-1.3	1.4	1.5	1.4
	Max pool depth/d_{bkf}	1.4	1.3-1.8	-	1.9-2.0	2.4	2.6	2.2
	Bank Height Ratio (BHR)	2.6	2.8-4.5	-	1.0	1.0	1.0	1.0
	Mean Bankfull Velocity (V) (fps)	4.7	4.5-4.9	-	4.1-4.5	3.6	4.5	5.4
	Bankfull Discharge (Q) (cfs)	13	25-29	-	42-46	10	27	44
Pattern	Meander length (L_m) (ft)	52-62	52-115	52-138	93-136	52-62	55-106	52-138
	Radius of curvature (R_c) (ft)	17-29	22-58	29-77	13-42	17-29	15-35	29-77
	Belt width (W_{blt}) (ft)	13-16	24-42	28-45	45	13-16	29-47	28-45
	Meander width ratio (W_{blt}/W_{bkf})	3.3-4.0	3.5-7.0	-	4.5-5.0	2.2-2.8	3.5-5.7	2.9-4.7
	Radius of curvature/bankfull width	4.3-7.3	3.2-9.7	-	1.3-4.4	2.9-5.0	1.8-4.3	3.0-8.0
	Meander length/bankfull width	13.0-15.5	7.5-19.2	-	9.0-15.0	9.0-10.7	6.7-12.9	5.4-14.4
Profile	Valley slope	0.0263	0.0144	0.0229	0.016	0.0263	0.0263	0.0229
	Average water surface slope	0.0200	0.0132	0.0216	0.013	0.0200	0.0128	0.0216
	Riffle slope	0.0220-0.0461	0.0070-0.0119	-	0.013-0.028	0.0220-0.0461	0.0200-0.0300	-
	Pool slope	0.0032-0.0068	0-0.0050	-	0.000-0.001	0.0032-0.0068	0.001	-
	Pool to pool spacing	16-26	17-42	-	30-59	16-26	32-86	-
	Pool length	5-13	6-12	-	3-25	5-13	7-30	-
	Riffle slope/avg water surface slope	1.10-2.31	0.53-0.90	-	1.0-2.2	1.10-2.31	1.56-2.34	-
	Pool slope/avg water surface slope	0.16-0.34	0-0.38	-	0.0	0.16-0.34	0.078	-
	Pool length/bankfull width	1.3-3.3	0.7-2.0	-	0.3-2.5	0.9-2.2	0.9-3.7	-
	Pool to pool spacing/bankfull width	4.0-6.5	2.5-7.0	-	3.3-6.0	2.8-4.5	3.9-10.5	-

[#] Complete existing conditions survey data were not collected on T7-4.

Table 4f. Morphological Criteria for T7-5, T7-6, and T7-7.

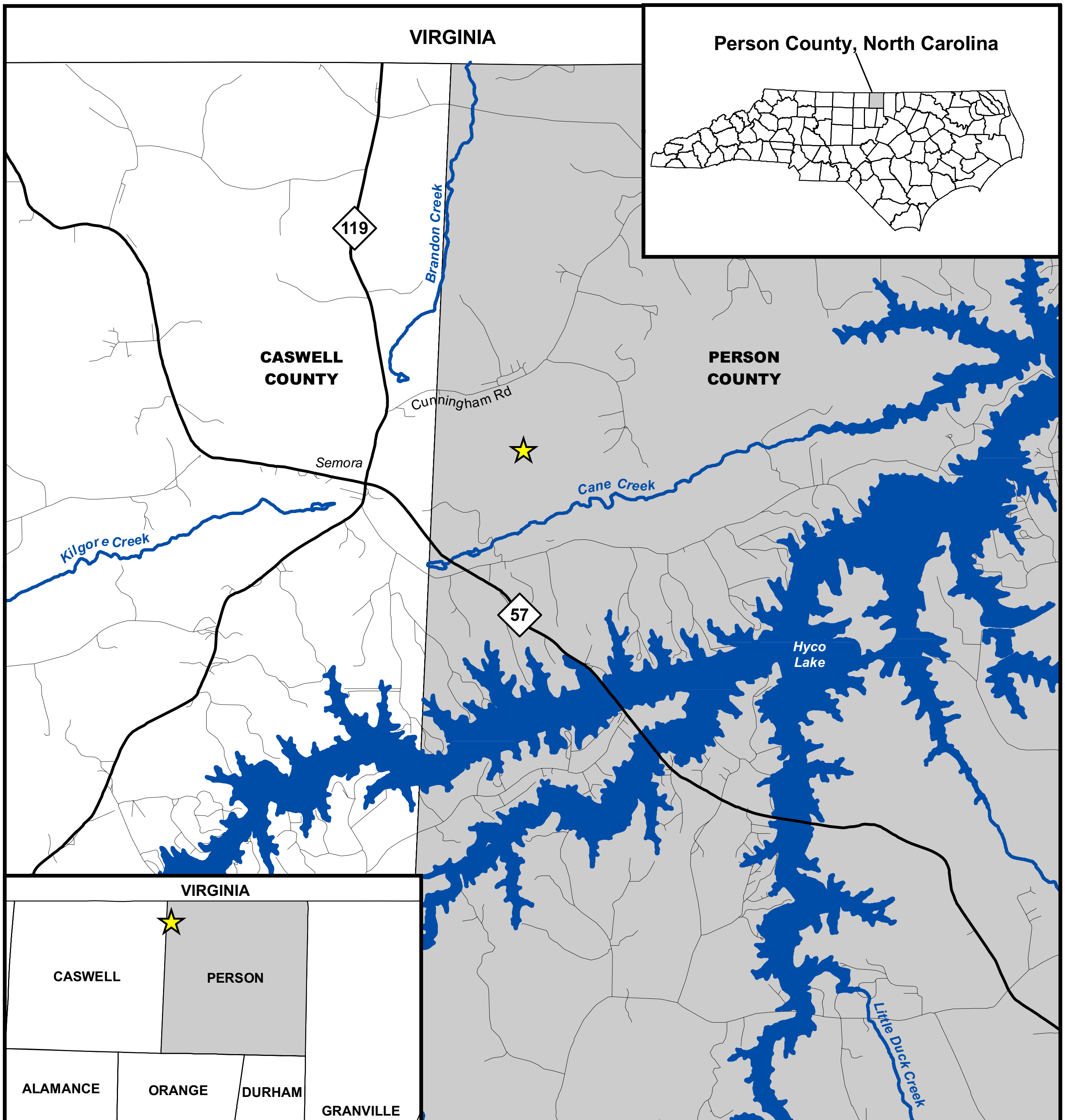
Variables		Existing T7-5[#]	Existing T7-6	Existing T7-7	Ref. Reach UTFR	Proposed T7-5	Proposed T7-6	Proposed T7-7
Rosgen Stream Type		E4	E4b/1	F4/1	B4c	B4c/C4	B4/1	B4c/1
Mitigation Type		Restoration	Enh. I	Enh. I	N/A	Restoration	Enh. I	Enh. I
Drainage Area (mi^2)		0.245	0.261	0.620	0.38	0.245	0.261	0.620
Bankfull Width (W_{bkf}) (ft)		-	9.2	15.0-17.0	9.0-10.0	10.4	10.4	15.0
Bankfull Mean Depth (d_{bkf}) (ft)		-	0.9	0.9-1.0	1.1-1.2	0.9	0.9	1.0
Bankfull Cross-Sectional area (A_{bkf}) (ft^2)		-	8.2	15.1-15.2	10.4-10.7	9.0	9.0	15.6
Width/depth Ratio (W_{bkf}/d_{bkf})		-	10.2	14.8-19.1	8.0-10.0	12	12	14.4
Maximum Depth (d_{mbkf}) (ft)		-	1.2	1.1-1.4	1.3-1.5	1.2	1.2	1.4
Width of flood prone area (W_{fpa}) (ft)		-	23.6	20.0-22.6	13.1-20.5	20.8	20.8	30.0
Entrenchment Ratio (ER)		-	2.6	1.2-1.5	1.3-2.3	2	2	2
Sinuosity (stream length/valley length) (K)		1.2	1.1	1.0	1.2	1.0	1.1	1.0
Dimension	Pool Depth (ft)	-	0.9	1.2	1.2-1.4	1.0	1.0	1.2
	Riffle Depth (ft)	-	0.9	0.9-1.0	1.1-1.2	0.9	0.9	1.0
	Max Pool Depth (ft)	-	1.3	1.7	2.1-2.4	2.0	2.0	2.4
	Pool Width (ft)	-	9.1	13.1	8.4-11.6	12.2	12.2	17.0
	Riffle Width (ft)	-	9.2	15.0-17.0	9.0-9.9	10.4	10.4	15.0
	Pool XS Area (sf)	-	8.3	15.8	11.6-13.4	12.6	12.6	20.8
	Riffle XS Area (sf)	-	8.2	15.1-15.2	10.4-10.7	9.0	9.0	15.6
	Pool depth/mean riffle depth	-	1.0	1.3	1.0-1.3	1.1	1.1	1.2
	Pool width/riffle width	-	1.0	0.8	0.8-1.3	1.2	1.2	1.1
	Pool area/riffle area	-	1.0	1.1	1.1-1.3	1.4	1.4	1.3
	Max pool depth/d_{bkf}	-	1.4	1.9	1.9-2.0	2.2	2.2	2.4
	Bank Height Ratio (BHR)	-	2.6	4.0	1.0	1.0	1.0	1.0
	Mean Bankfull Velocity (V) (fps)	-	6.7	4.8-5.1	4.1-4.5	5.6	5.6	4.7
	Bankfull Discharge (Q) (cfs)	-	56	73-77	42-46	50	50	73
Pattern	Meander length (L_m) (ft)	62	112-205	245-289	93-136	64-68	112-205	245-289
	Radius of curvature (R_c) (ft)	12	35-67	64-140	13-42	20-25	35-67	64-140
	Belt width (W_{blt}) (ft)	28	27-33	60-63	45	21-24	27-33	60-63
	Meander width ratio (W_{blt}/W_{bkf})	-	2.9-3.6	3.5-4.2	4.5-5.0	2.0-2.3	2.6-3.2	4.0-4.2
	Radius of curvature/bankfull width	-	3.8-7.3	3.8-9.3	1.3-4.4	1.9-2.4	3.4-6.4	4.3-9.3
	Meander length/bankfull width	-	12.2-22.3	14.4-19.3	9.0-15.0	6.2-6.5	10.8-19.7	16.3-19.3
Profile	Valley slope	0.0284	0.0191	0.0110	0.016	0.0284	0.0191	0.0110
	Average water surface slope	0.0145	0.0229	0.0122	0.013	0.0193	0.0229	0.0122
	Riffle slope	-	0.0188	0.0180-0.0218	0.013-0.028	0.0240-0.0250	0.0188	0.0180-0.0218
	Pool slope	-	0.0022	0-0.0042	0.000-0.001	0.001	0.0022	0-0.0042
	Pool to pool spacing	-	9	66-118	30-59	31-38	9	66-118
	Pool length	-	11	16-25	3-25	4-14	11	16-25
	Riffle slope/avg water surface slope	-	0.82	1.47-1.79	1.0-2.2	1.24-1.30	0.82	1.47-1.79
	Pool slope/avg water surface slope	-	0.10	0-0.34	0.0	0.052	0.10	0-0.34
	Pool length/bankfull width	-	1.2	0.9-1.7	0.3-2.5	0.4-1.3	1.1	1.1-1.7
	Pool to pool spacing/bankfull width	-	1.0	3.9-7.9	3.3-6.0	3.0-3.7	0.9	4.4-7.9

[#] Complete existing conditions survey data were not collected on T7-5.

Table 4g. Morphological Criteria for T8, T9, and T10-2.

	Variables	Existing T8	Existing T9	Ref. Reach UTFR	Proposed T8	Proposed T9	Existing T10-2	Ref. Reach UTFR	Proposed T10-2
	Rosgen Stream Type	B4	G4	B4c	B4	G4	B4/1	B4c	B4/1
	Mitigation Type	Enh. I	Enh. I	N/A	Enh. I	Enh. I	Enh. I	N/A	Enh. I
	Drainage Area (mi^2)	0.021	0.036	0.38	0.021		0.345	0.38	0.345
	Bankfull Width (W_{bkf}) (ft)	4.0	3.8	9.0-10.0	4.0	5.0	16.7	9.0-10.0	12.6
	Bankfull Mean Depth (d_{bkf}) (ft)	0.3	0.6	1.1-1.2	0.4	0.4	0.6	1.1-1.2	0.9
	Bankfull Cross-Sectional area (A_{bkf}) (ft^2)	1.3	2.2	10.4-10.7	1.5	2.2	10.6	10.4-10.7	10.9
	Width/depth Ratio (W_{bkf}/d_{bkf})	12.3	6.6	8.0-10.0	11.1	11.6	26.3	8.0-10.0	12.6
	Maximum Depth (d_{mbkf}) (ft)	0.5	0.8	1.3-1.5	0.5	0.6	0.8	1.3-1.5	1.2
	Width of flood prone area (W_{fpa}) (ft)	7.5	6.5	13.1-20.5	8.0	8.0	24.8	13.1-20.5	25.2
	Entrenchment Ratio (ER)	1.9	1.7	1.3-2.3	2	2	1.5	1.3-2.3	2
	Sinuosity (stream length/valley length) (K)	1.1	1.1	1.2	1.1	1.1	1.0	1.2	1.0
Dimension	Pool Depth (ft)	0.6	0.8	1.2-1.4	0.5	0.5	0.9	1.2-1.4	1.0
	Riffle Depth (ft)	0.3	0.6	1.1-1.2	0.4	0.4	0.6	1.1-1.2	0.9
	Max Pool Depth (ft)	0.8	1.0	2.1-2.4	1.0	1.1	1.6	2.1-2.4	2.0
	Pool Width (ft)	2.7	3.0	8.4-11.6	5.0	5.7	12.5	8.4-11.6	14.0
	Riffle Width (ft)	4.0	3.8	9.0-9.9	4.0	5	16.7	9.0-9.9	12.6
	Pool XS Area (sf)	1.5	2.4	11.6-13.4	2.3	3	11.8	11.6-13.4	14.1
	Riffle XS Area (sf)	1.3	2.2	10.4-10.7	1.5	2.2	10.6	10.4-10.7	10.9
	Pool depth/mean riffle depth	2.0	1.3	1.0-1.3	1.3	1.3	1.5	1.0-1.3	1.1
	Pool width/riffle width	0.7	0.8	0.8-1.3	1.3	1.1	0.8	0.8-1.3	1.1
	Pool area/riffle area	1.2	1.1	1.1-1.3	1.5	1.4	1.1	1.1-1.3	1.3
	Max pool depth/d_{bkf}	2.7	1.7	1.9-2.0	2.5	2.8	2.7	1.9-2.0	2.2
	Bank Height Ratio (BHR)	1.7	2.0	1	1.0	1.0	4.7	1	1.0
	Mean Bankfull Velocity (V) (fps)	3.8	4.8	4.1-4.5	3.6	3.9	4	4.1-4.5	4.9
	Bankfull Discharge (Q) (cfs)	5	11	42-46	5.0	8	42-63	42-46	53
Pattern	Meander length (L_m) (ft)	17-72	23-49	93-136	17-72	23-49	168	93-136	168
	Radius of curvature (R_c) (ft)	7-22	6-29	13-42	7-22	6-29	116-137	13-42	116-137
	Belt width (W_{blt}) (ft)	13-14	9-11	45	13-14	9-11	33-34	45	33-34
	Meander width ratio (W_{blt}/W_{bkf})	3.3-3.5	2.4-2.9	4.5-5.0	3.3-3.5	1.8-2.2	2.0	4.5-5.0	2.6-2.7
	Radius of curvature/bankfull width	1.8-5.5	1.6-7.6	1.3-4.4	1.8-5.5	1.2-5.8	6.9-8.2	1.3-4.4	9.2-10.9
	Meander length/bankfull width	4.3-18.0	6.1-12.9	9.0-15.0	4.3-18.0	4.6-9.8	10.0	9.0-15.0	13.3
Profile	Valley slope	0.0390	0.0360	0.016	0.0390	0.0360	0.0115	0.016	0.0115
	Average water surface slope	0.0300	0.0276	0.013	0.0300	0.0276	0.0170	0.013	0.0170
	Riffle slope	0.0169-0.0219	0.0125-0.0301	0.013-0.028	0.0169-0.0219	0.0125-0.0301	0.0254	0.013-0.028	0.0254
	Pool slope	0.0105	0-0.0042	0.000-0.001	0.0105	0-0.0042	0.0008	0.000-0.001	0.0008
	Pool to pool spacing	24-37	43-45	30-59	12-42	29-52	7	30-59	7
	Pool length	5-6	5-7	3-25	6-10	5-11	7-50	3-25	7-50
	Riffle slope/avg water surface slope	0.56-0.73	0.45-1.09	1.0-2.2	0.56-0.73	0.45-1.09	1.49	1.0-2.2	1.49
	Pool slope/avg water surface slope	0-0.04	0-0.15	0.0	0-0.04	0-0.15	0.05	0.0	0.05
	Pool length/bankfull width	1.3-1.5	1.3-1.8	0.3-2.5	1.5-2.5	1.0-2.2	0.4-3.0	0.3-2.5	0.4-3.0
	Pool to pool spacing/bankfull width	6.0-9.3	11.3-11.8	3.3-6.0	3.0-10.5	5.8-10.4	0.4	3.3-6.0	0.4

Figures



KCI TECHNOLOGIES

Figure 1. Vicinity Map

- Project Site Location
- Major Roads
- Other Roads
- Major Streams and Rivers
- Major Lakes and Reservoirs
- County Boundaries

N
W E
S

1:63,360
1 inch equals 1 miles

1 0.5 0 1 Miles

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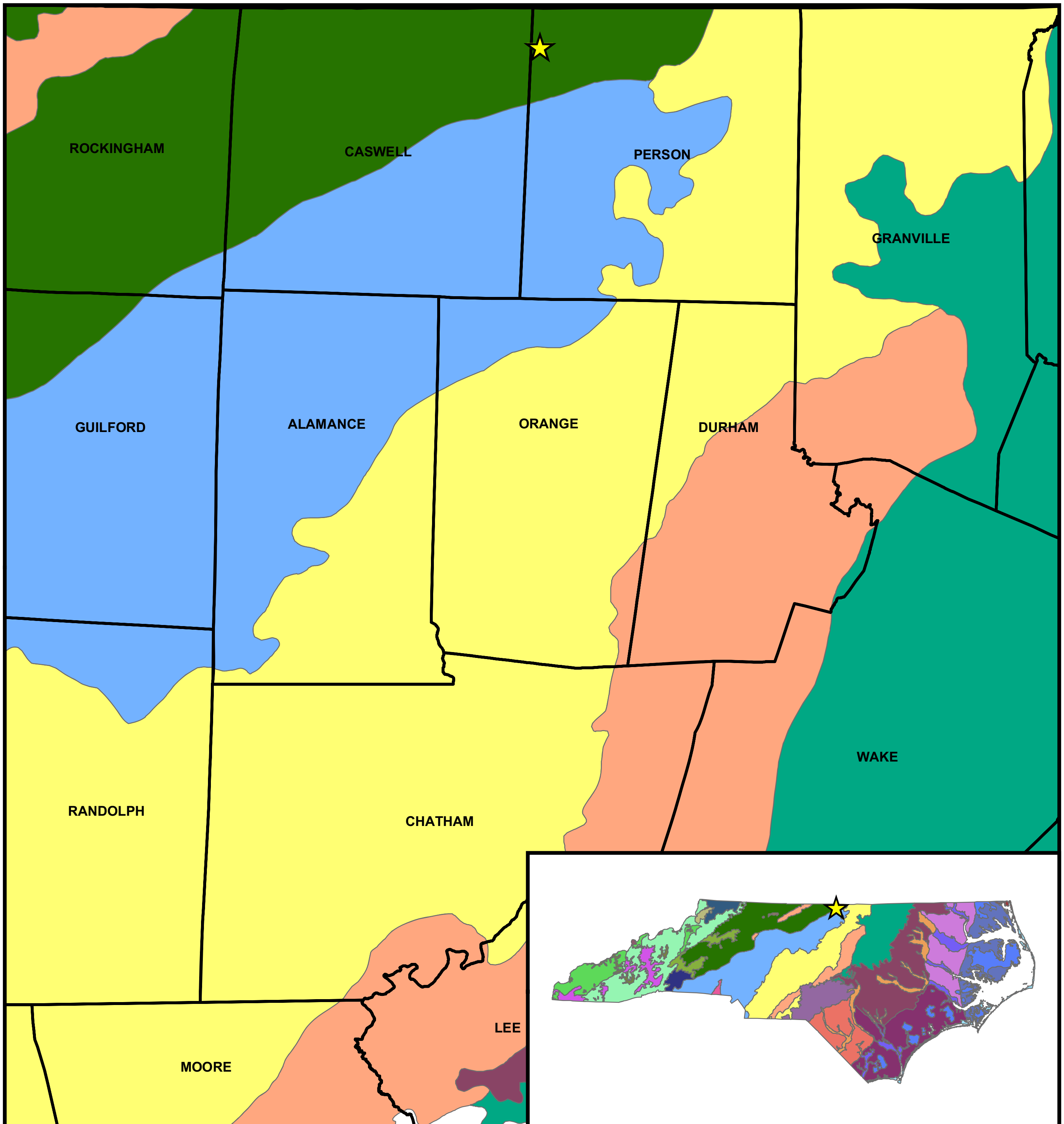

KCI TECHNOLOGIES

Figure 2. North Carolina Ecoregions

- Carolina Slate Belt
- Northern Inner Piedmont
- Northern Outer Piedmont
- Rolling Coastal Plain
- Southern Outer Piedmont
- Triassic Basins
- County Boundaries
- ★ Project Site Location

1:633,600
1 inch equals 10 miles

N, E, S, W

10 5 0 10 Miles

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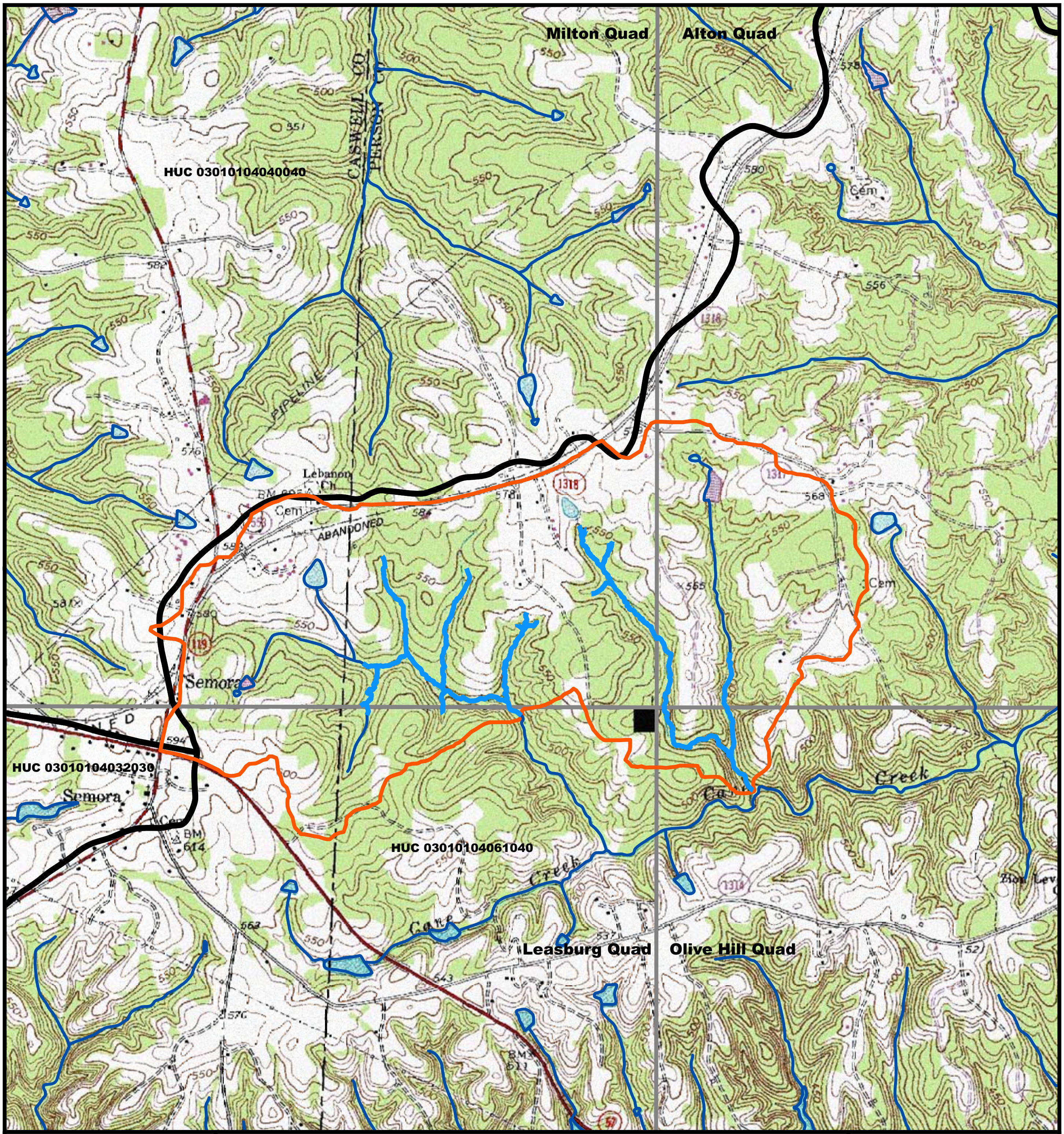

KCI TECHNOLOGIES

Figure 3. Project Watershed

Project Streams
Other Streams
Project Watershed (1.32 sq. miles)
14-digit HUC Boundaries
USGS Quadrangle Boundaries

Source: USGS Topographic Quadrangles Alton (1968), Leasburg (1968), Milton (1983), and Olive Hill (1968)

1:24,000
1 inch equals 2,000 feet
2,000 1,000 0 2,000 Feet

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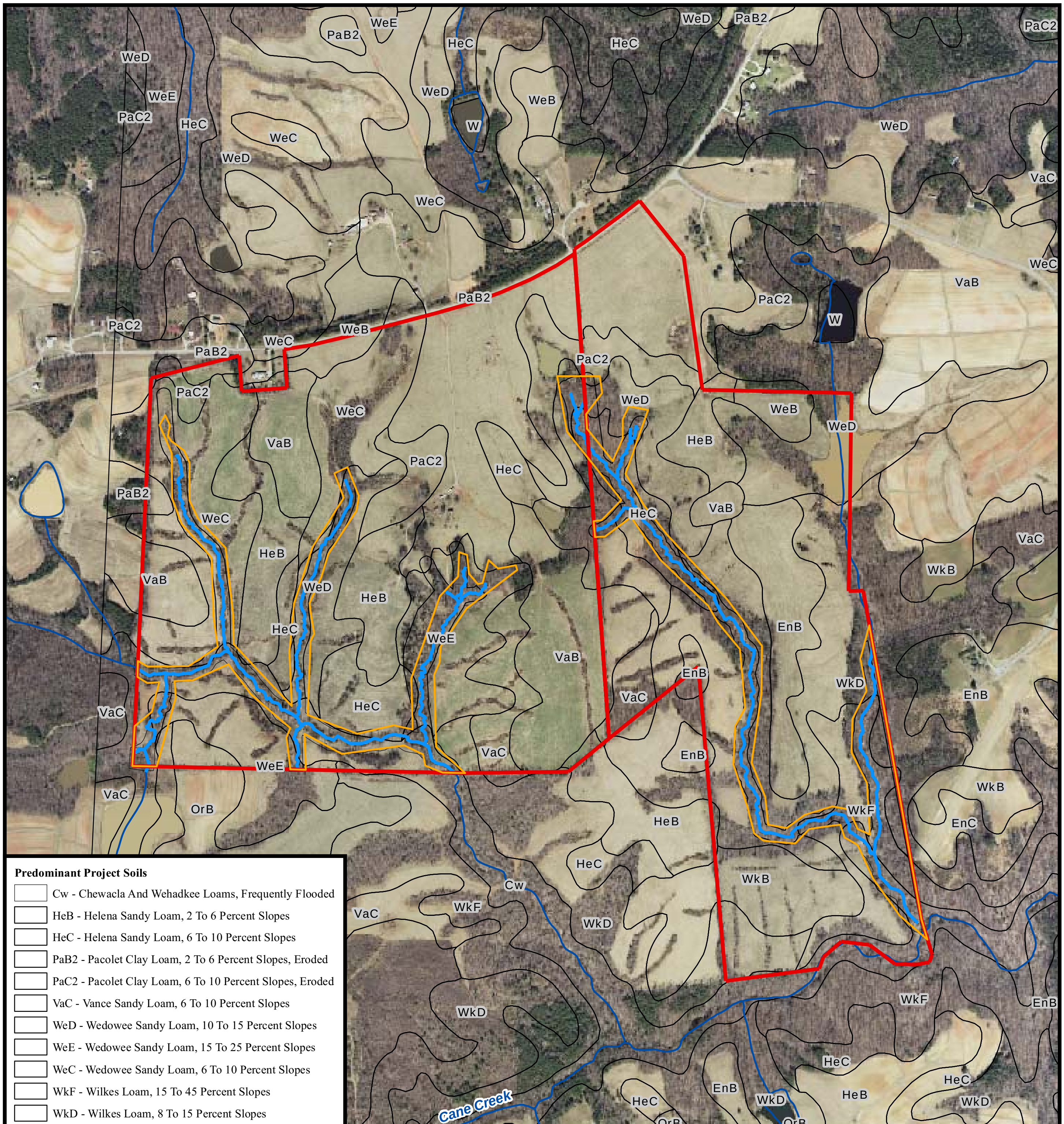

KCI TECHNOLOGIES

Figure 4. Project Site NRCS Soil Survey Map

Project Easement

Extent of Project Parcels

Project Streams

Other Streams

N
W E
S

1:12,000
1 inch equals 1,000 feet

1,000 500 0 1,000
Feet

Image Source: 2004 Person County GIS
Soil Data: Soil Survey of Person County, NRCS 1995

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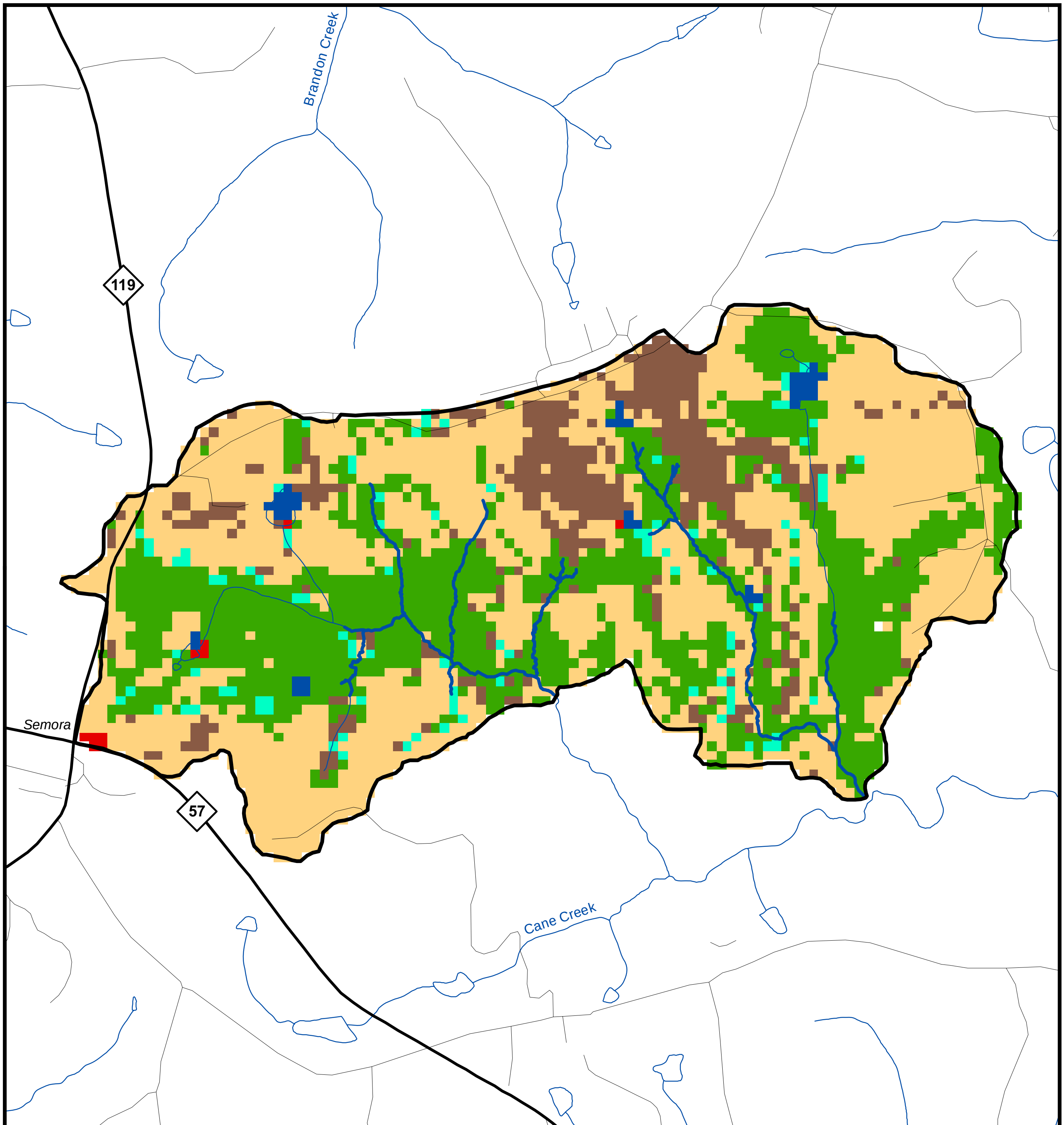

Figure 5. Project Watershed Land Use

- Urban or built-up land (<1%)
- Agriculture (49%)
- Rangeland (12%)
- Forest land (35%)
- Water (1%)
- Wetland (3%)
- Project Watershed
- Major Roads
- Other Roads
- Project Streams
- Other Streams

1:18,000

1 inch equals 1,500 feet

1,500 750 0 1,500 Feet

N W E S

Source: NC GAP Land Cover Dataset, Published 2003
Classified Using Anderson I

KCI TECHNOLOGIES

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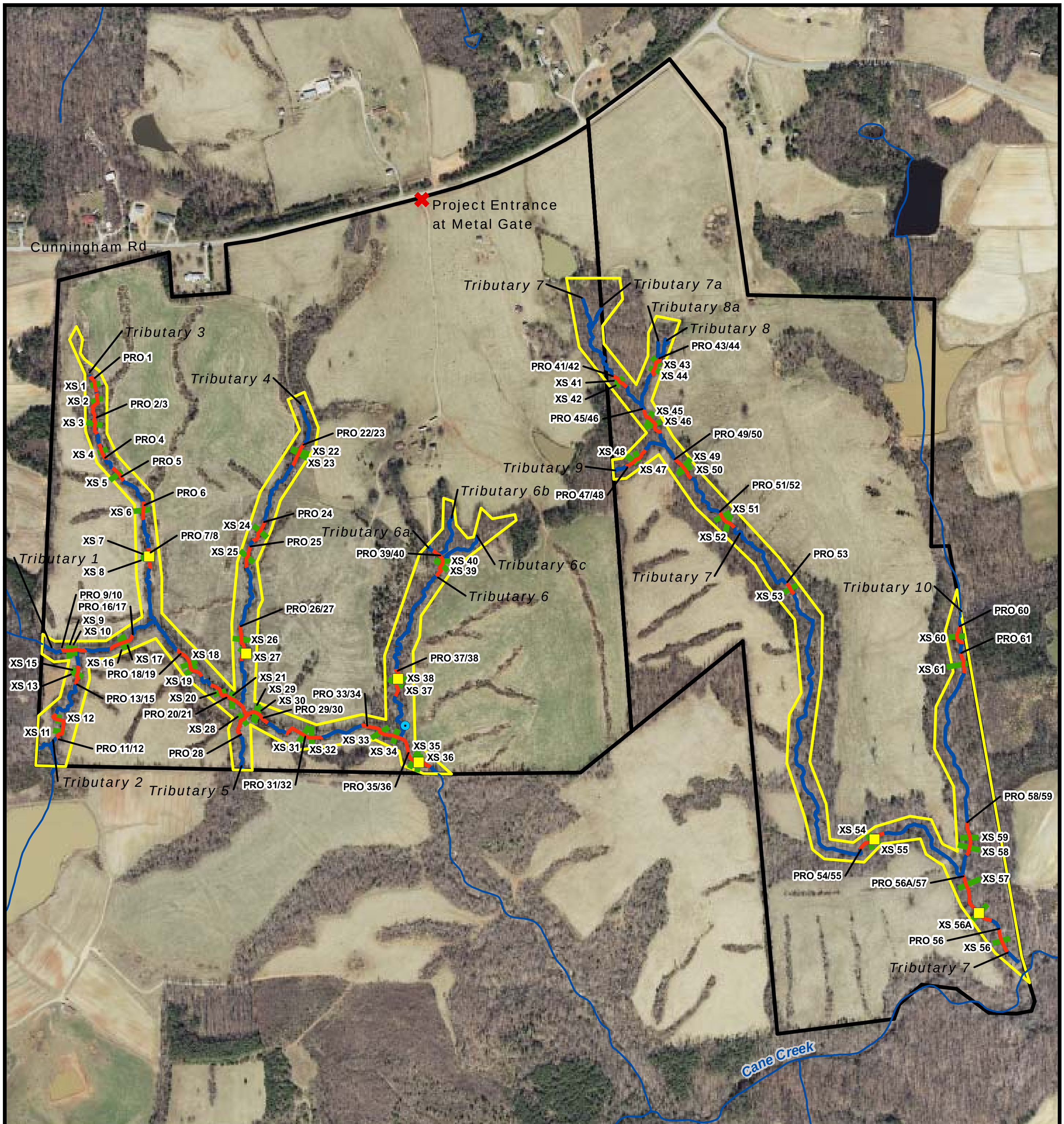

Figure 6. Existing Conditions

Project Easement
Project Streams
Other Streams
Surveyed Longitudinal Profiles
Surveyed Cross-Sections
Project Parcel Boundaries
Rain Gauge/Barologger
Stream Gauge

1:9,600
1 inch equals 800 feet

800 400 0 800 Feet

Image Source: Person County GIS, Orthoimagery 2004

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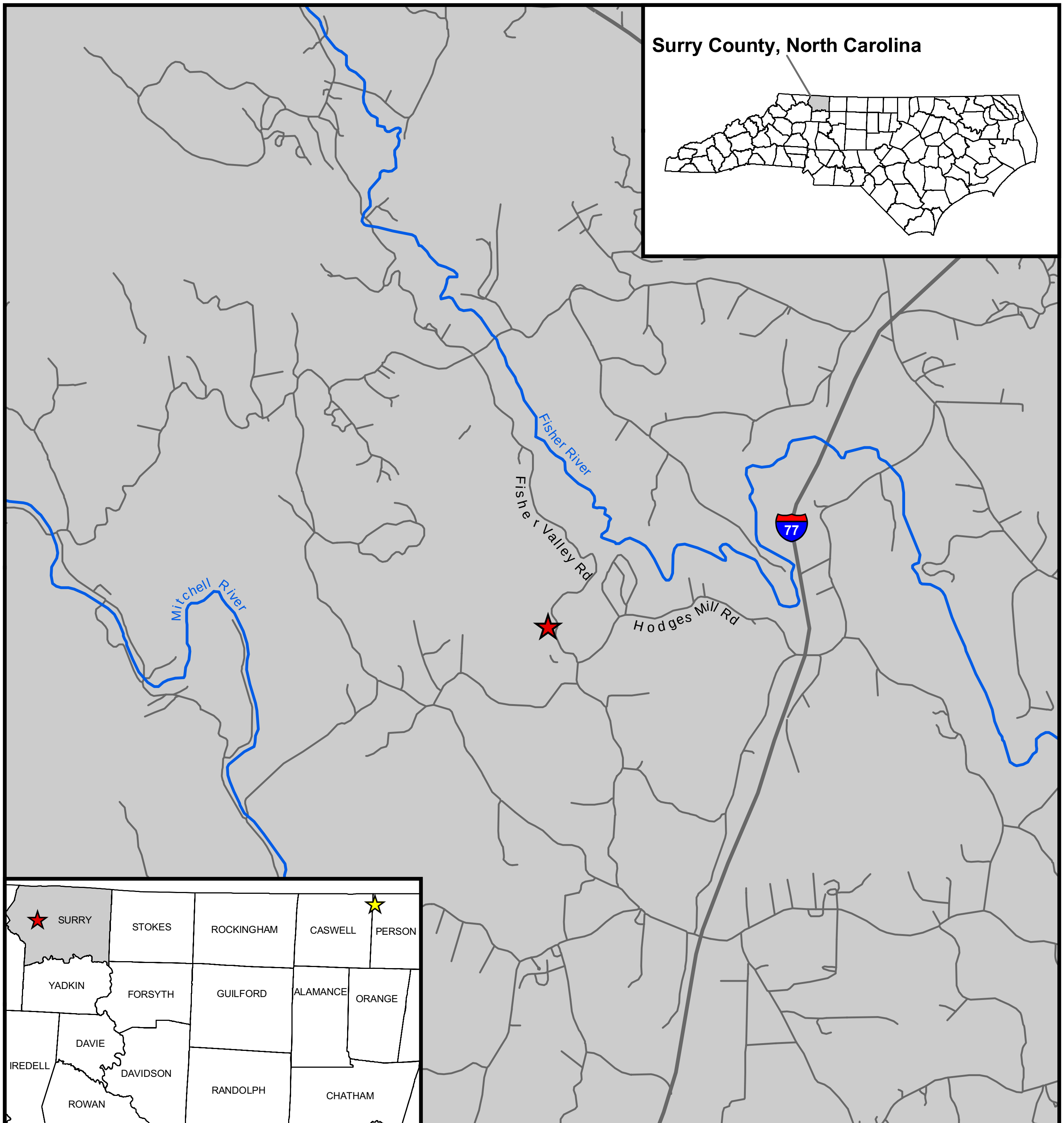

KCI TECHNOLOGIES

Figure 7. Reference Site Vicinity Map (UT to Fisher River)

- Project Site
- Reference Site (UT to Fisher River)
- Major Streams
- Major Roads
- Other Roads
- County Boundaries

N W E S

1:63,360
1 inch equals 1 miles

1 0.5 0 1 Miles

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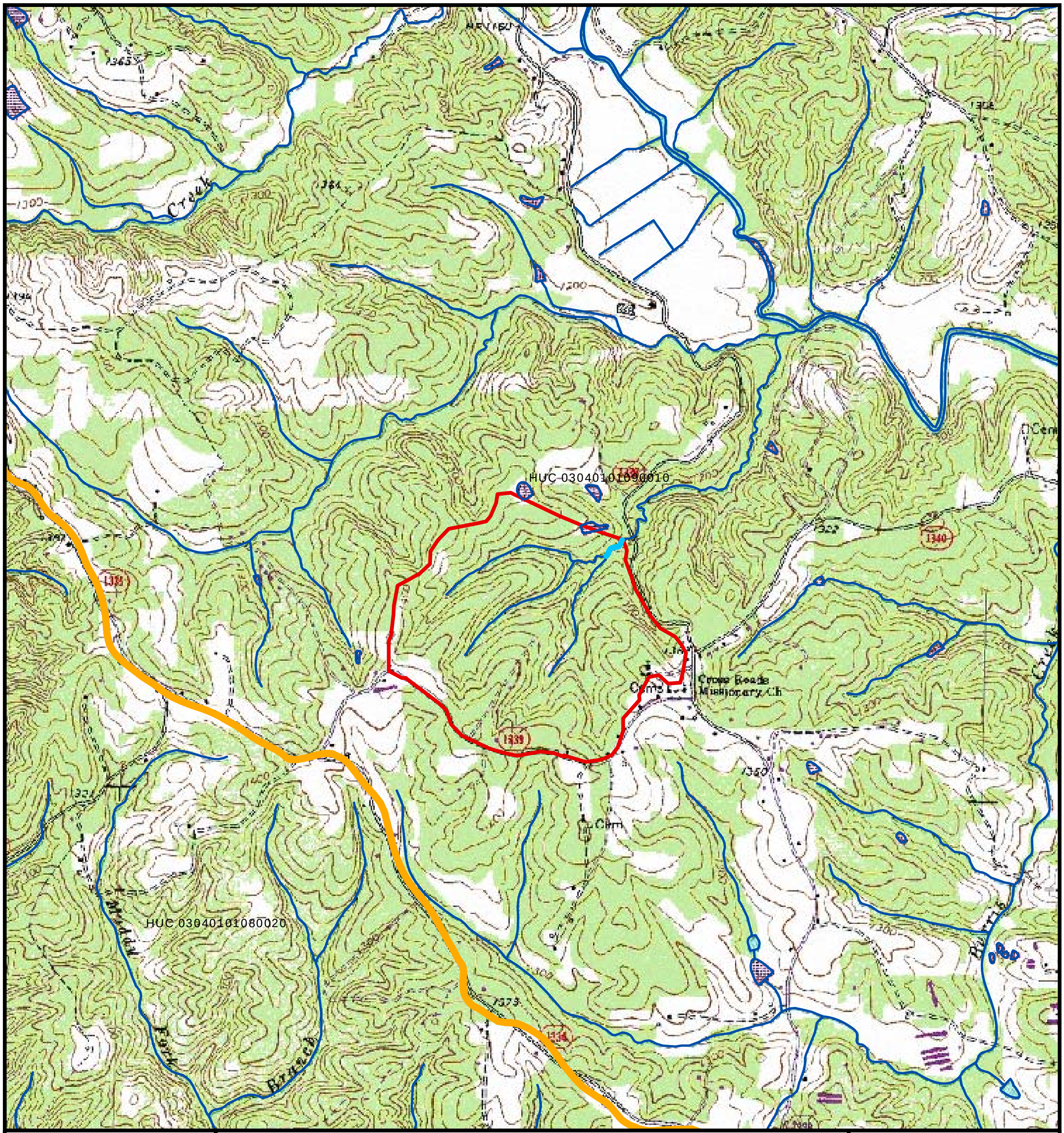

Figure 8. Reference Site Watershed (UT to Fisher River)

- Reference Reach Watershed (0.38 sq. mile)
- 14-digit HUC boundaries
- Reference Reach (UT to Fisher River)
- Other Streams

1:24,000
1 inch equals 2,000 feet

2,000 1,000 0 2,000 Feet

Source: USGS Topographic Quadrangle Bottom (1971)

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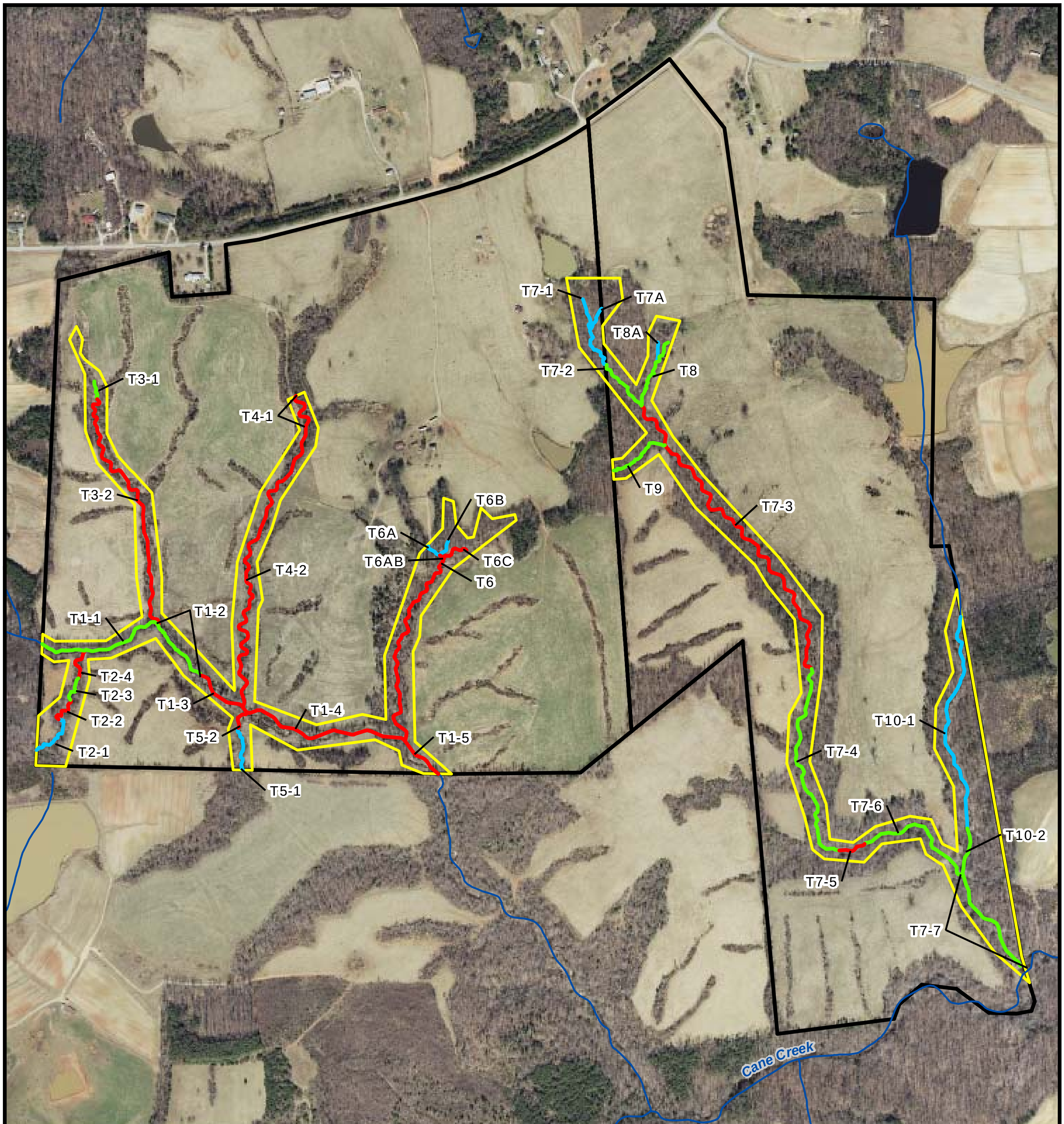

KCI TECHNOLOGIES

Figure 9. Proposed Site Plan

Enhancement I Reach
Enhancement II Reach
Restoration Reach
Project Easement
Other Streams
Project Parcel Boundaries

N W E S

1:9,600
1 inch equals 800 feet

800 400 0 800 Feet

Image Source: Person County GIS, Orthoimagery 2004

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ENVIRONMENTAL TECHNOLOGIES AND CONSTRUCTION, INC.

Stream Plan Sheets

KCI JOB# : 12054725-01

CONTRACT #: D06002

STATE	CONTRACT NUMBER	SHEET NO.	TOTAL SHEETS
N.C.	D06002	1	75

SYM.	DESCRIPTION	DATE	APPROVED
A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

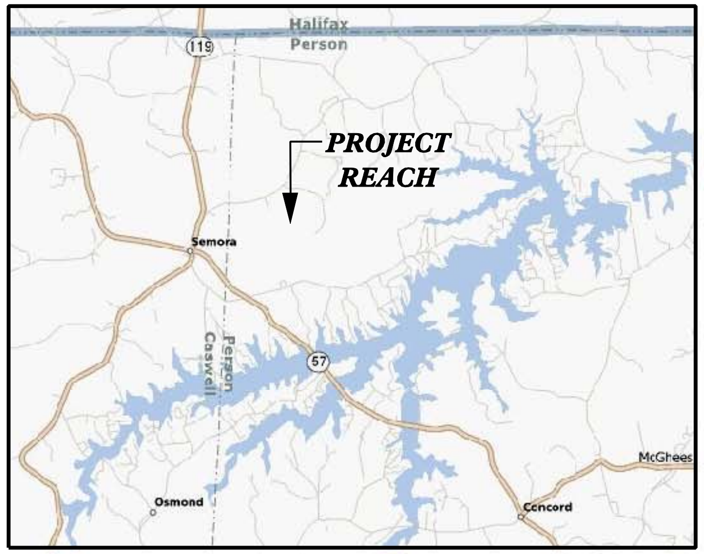
REVISIONS

STATE OF NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

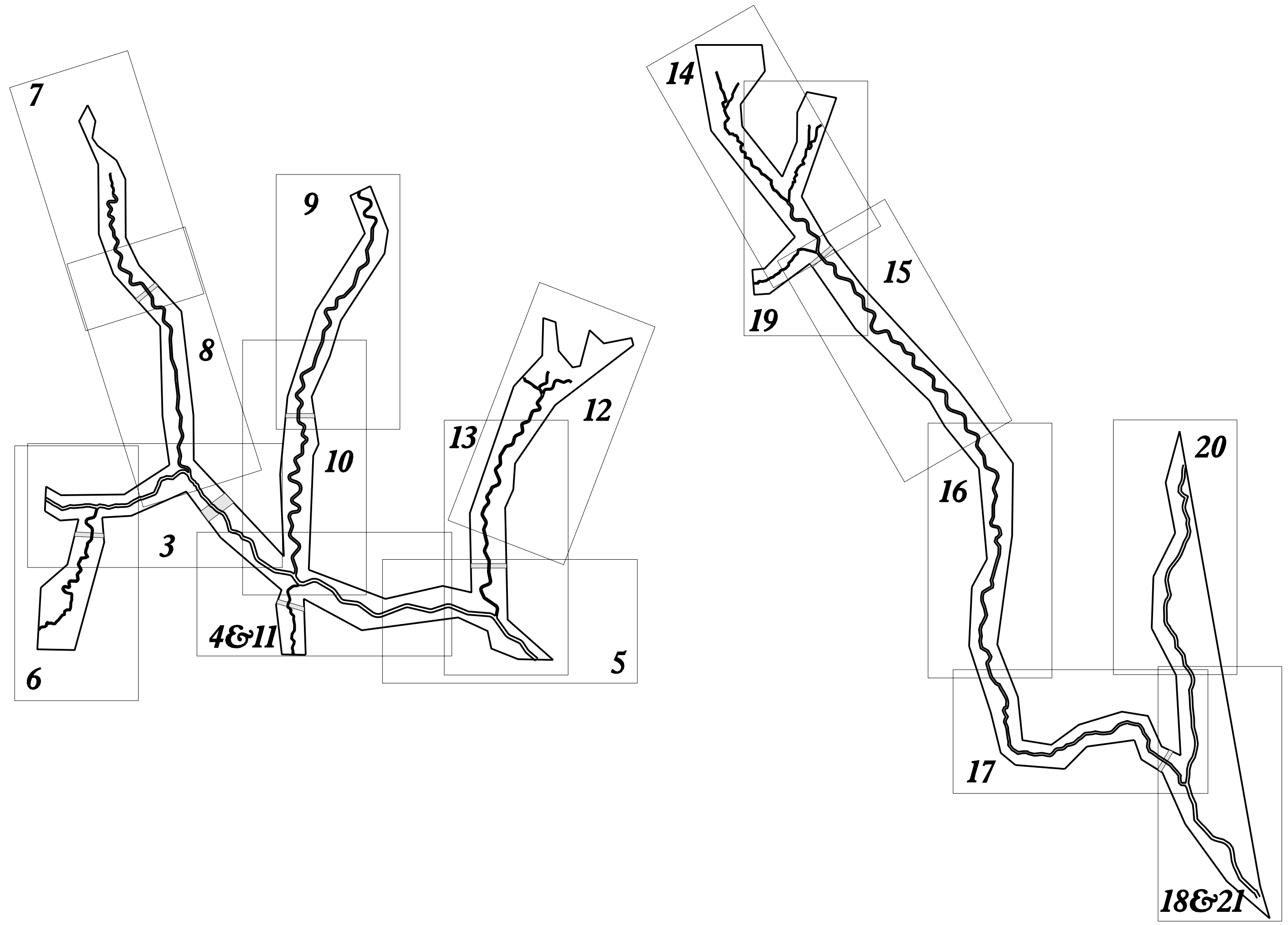
PERSON COUNTY

LOCATION: CANE CREEK TRIBUTARY SITE
UNNAMED TRIBUTARIES TO CANE CREEEK
SEMORA, NORTH CAROLINA

TYPE OF WORK: STREAM RESTORATION AND ENHANCEMENT



VICINITY MAP
NOT TO SCALE



NC GRID NAD '83

DIRECTIONS TO SITE

TO REACH THE SITE FROM RALEIGH, PROCEED WEST ON US–70 UNTIL IT MERGES WITH I–85/US–15 SOUTH. CONTINUE ON I–85 FOR APPROXIMATELY 1.5 MILES AND THEN TAKE EXIT 176B FOR DUKE ST/US–501 BYPASS. TAKE A RIGHT OFF OF THE EXIT AND TRAVEL ON US–501 FOR 27.5 MILES. WITHIN THE TOWN OF ROXBORO, TURN LEFT ONTO COURT ST/US–158 WEST. FOLLOW US–158 WEST 0.4 MILE AND TURN RIGHT ONTO NC–57, CONTINUING NORTHWEST FOR ANOTHER 12.3 MILES. ONCE WITHIN THE SMALL COMMUNITY OF SEMORA, TURN RIGHT ONTO NC–119 AND DRIVE NORTH 0.5 MILE. TURN RIGHT ONTO CUNNINGHAM ROAD AND CONTINUE EAST FOR 0.85 MILE. THE SITE WILL BE ACCESSIBLE BY A METAL GATE ON THE RIGHT.

INDEX OF SHEETS

* INCLUDED IN RESTORATION PLAN

GRAPHIC SCALES

–40 –20 0 40 80
PLANS

–40 –20 0 40 80
PROFILE (HORIZONTAL)

–4 –2 0 4 8
PROFILE (VERTICAL)

PROJECT DATA

STREAM RESTORATION LENGTH = 9,588 FEET

STREAM ENHANCEMENT LENGTH = 8,150 FEET

Prepared In the Office of:

KCI TECHNOLOGIES
ENGINEERS•PLANNERS•ECOLOGISTS
SUITE 220 LANDMARK CENTER II
4601 SIX FORKS RD., RALEIGH, NC

GARY M. MRYNCZA, PE
PROJECT ENGINEER

ADAM SPILLER / KRISTIN KNIGHT-MENG
NATURAL CHANNEL DESIGN

PROJECT ENGINEER

SIGNATURE: *P.E.*

Prepared for:

Ecosystem Enhancement PROGRAM

GUY PEARCE
CONTRACT ADMINISTRATOR

PROJECT LEGEND

STREAM RESTORATION

Proposed Thalweg w/Approximate Bankfull Limits
Proposed Offset Rock Cross Vane
Proposed Modified Rock Cross Vane
Proposed Step Pool
Proposed Channel Block
Proposed Riffle Grade Control
Proposed Constructed Riffle with Constrictor
Proposed Stone Toe Stabilization
Proposed Rock Ford Crossing
Seep Development Structure
Existing Bedrock

TOPOGRAPHY

Minor Contour Line
Major Contour Line (720)

SEDIMENT & EROSION CONTROL

Stabilized Construction Entrance (SCE)
Silt Fence (SF)
Limits of Disturbance (LOD)
Temporary Stream Crossing
Silt Fence Rock Outlet
Rock Silt Screen (Std. Drawing 1636.01)

SYM.	DESCRIPTION	DATE	APPROVED
A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

REVISIONS

Ecosystem Enhancement PROGRAM

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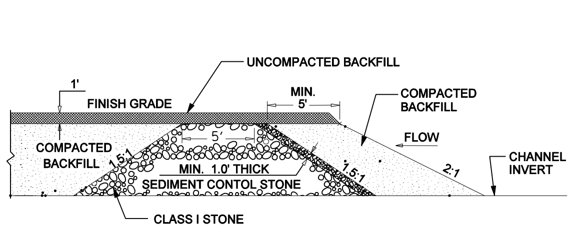
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA

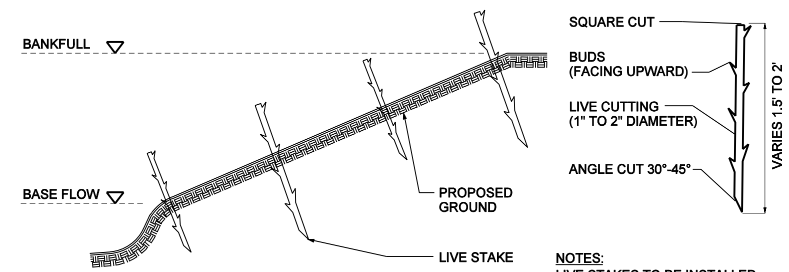
DATE: DEC 2007
SCALE: N.T.S.

PROJECT LEGEND

SHEET 1A OF 68

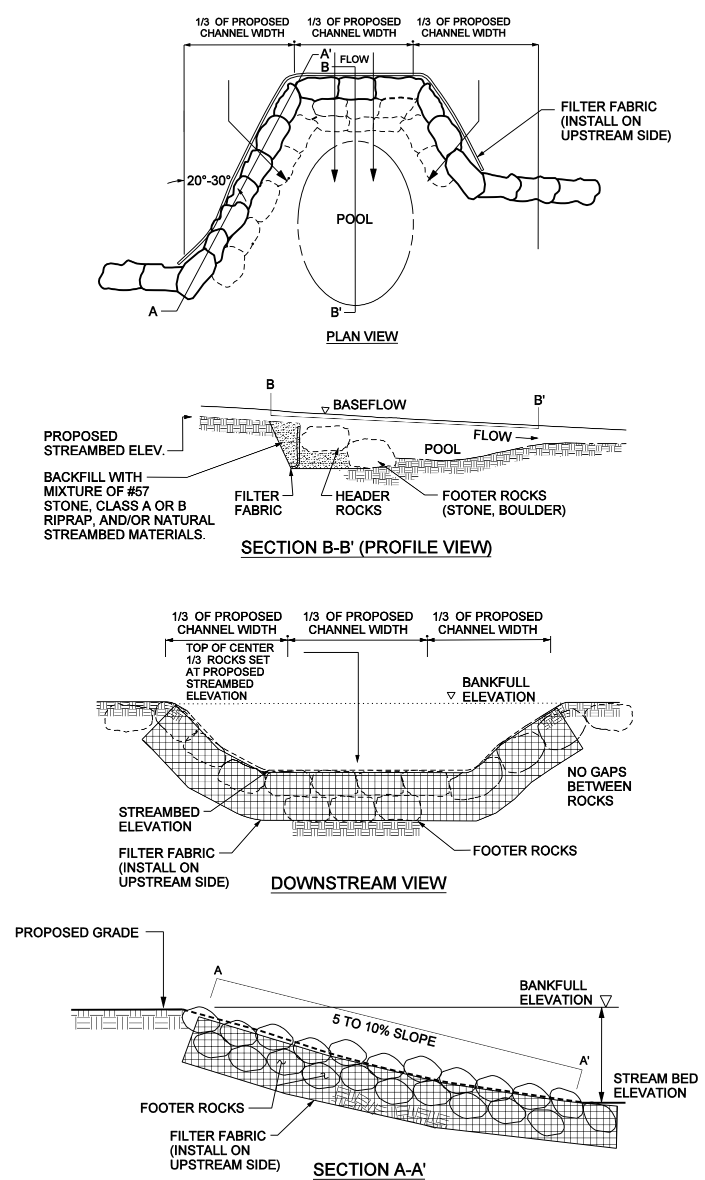


CHANNEL BLOCK
SCALE: NTS



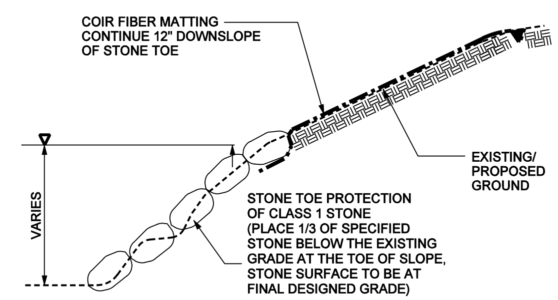
NOTES:
- LIVE STAKES TO BE INSTALLED IN ACCORDANCE WITH PROJECT SPECIAL PROVISIONS AND AS DIRECTED BY THE ENGINEER.

LIVE STAKES
SCALE: NTS

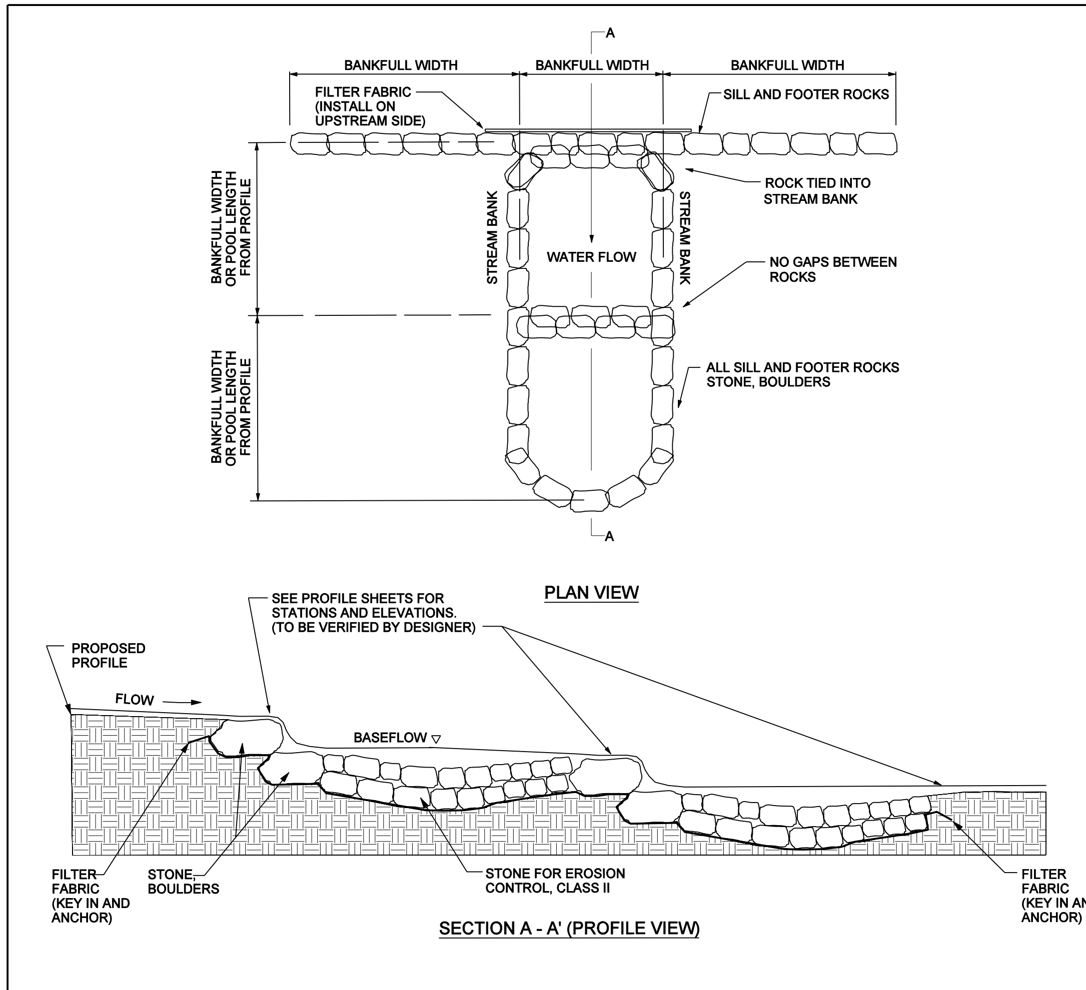


OFFSET ROCK CROSS VANE
SCALE: NTS

NOTE: (1) ALL ROCKS OR STONES IN THE VANE STRUCTURE ARE STONE BOULDERS.
(2) SHORT CROSS VANE ARM TO BE HALF THE SLOPE OF THE FULL ARM SLOPE.

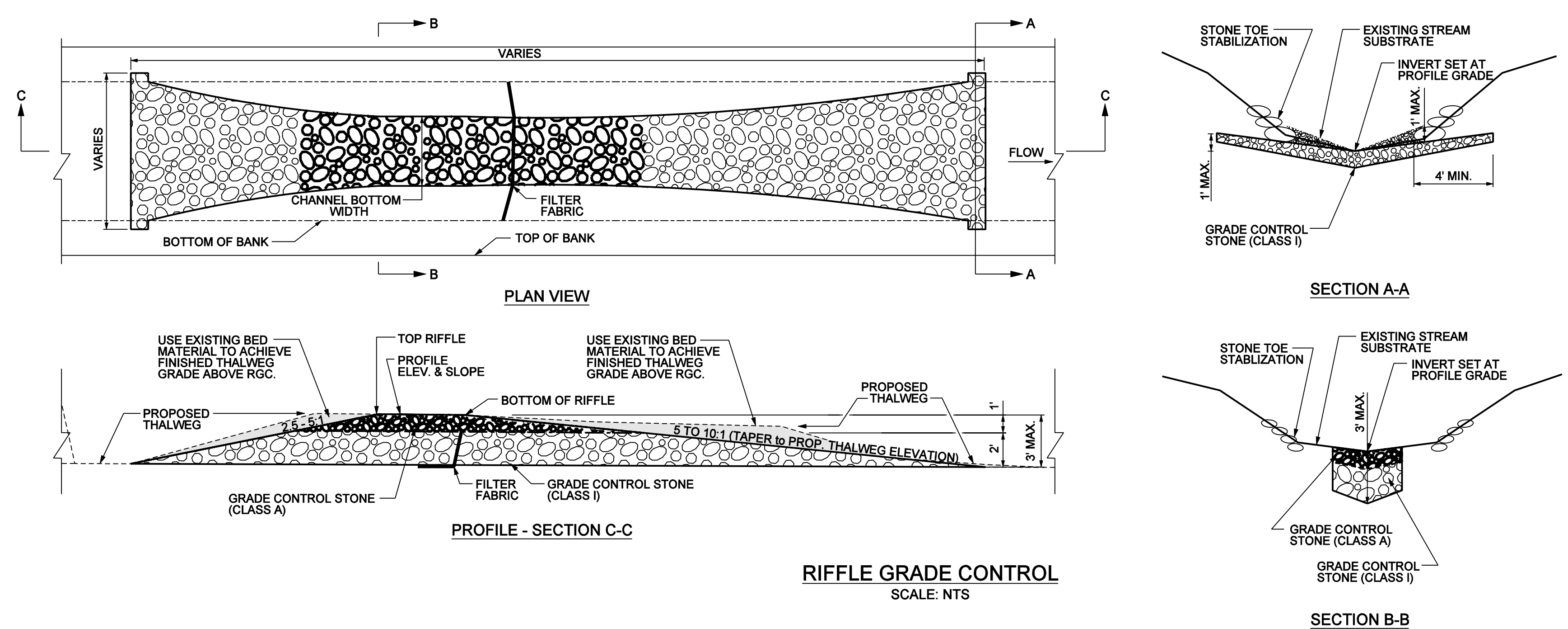


STONE TOE STABILIZATION
SCALE: NTS



DOUBLE STEP POOL
SCALE: NTS

NOTES: - ALL SILL OR FOOTER ROCKS ARE STONE, BOULDERS
- DETAIL SHOWN IS FOR A DOUBLE STEP POOL. ADJUST ACCORDINGLY FOR SINGLE AND TRIPLE STEP POOLS. (SEE PROFILE SHEET TO DETERMINE AMOUNT OF STEPS)



RIFFLE GRADE CONTROL
SCALE: NTS

SYM.	DESCRIPTION	DATE	APPROVED
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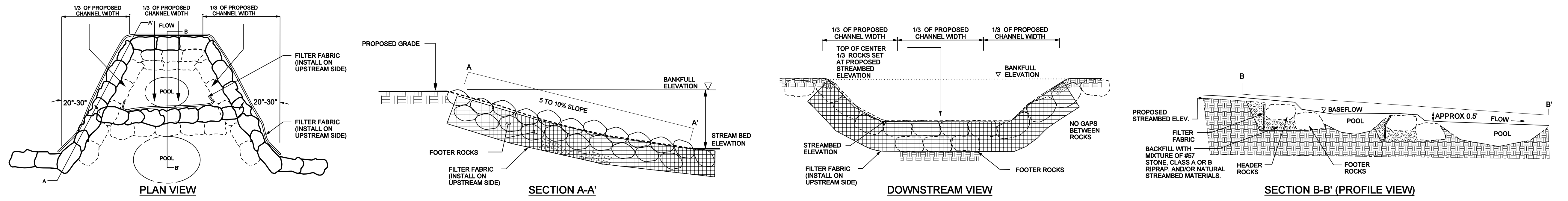
DATE: DEC 2007
SCALE: N.T.S.

DETAILS:
STABILIZATION

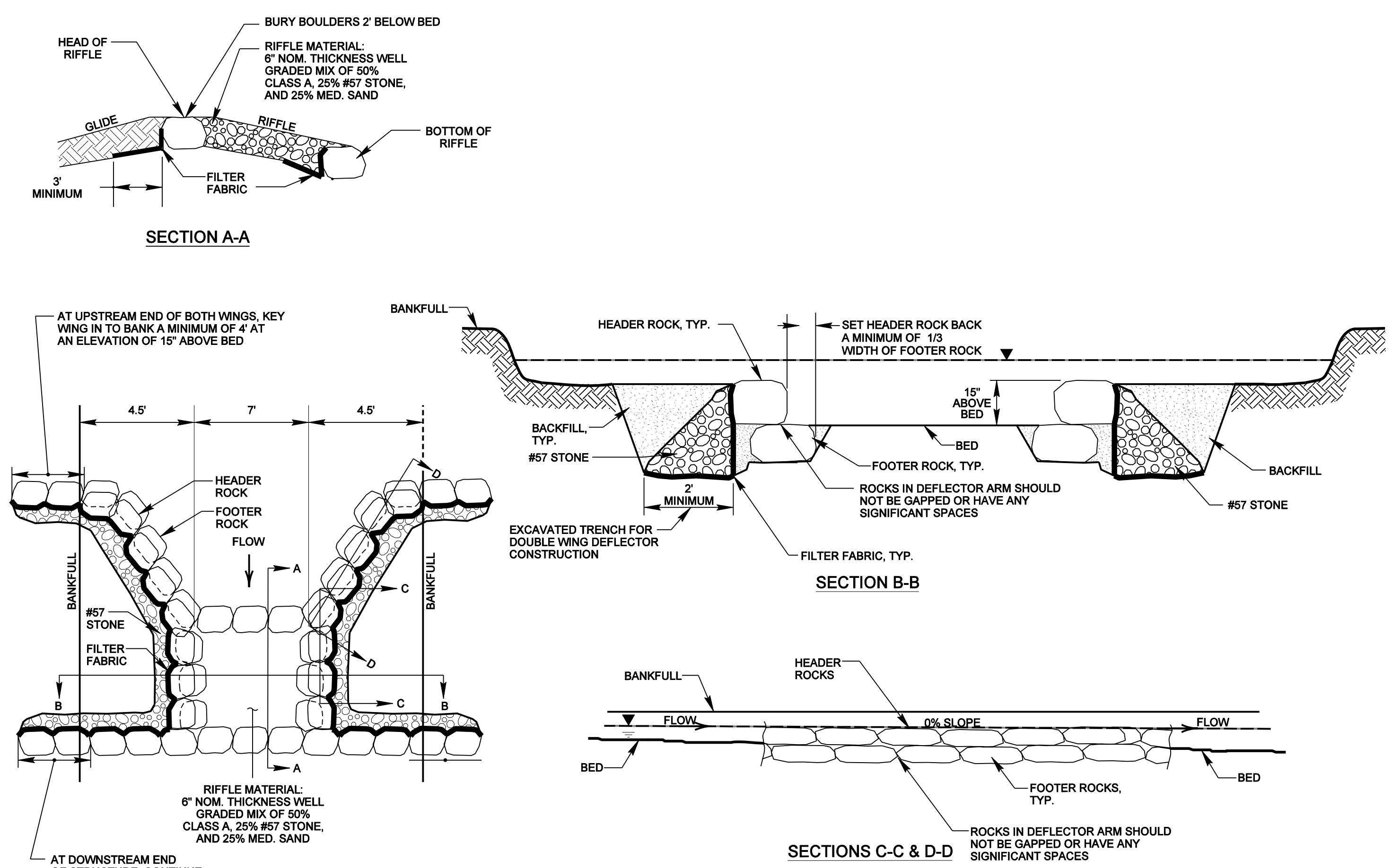
SHEET 2 OF 68



MODIFIED ROCK CROSS VANE

SCALE: NTS

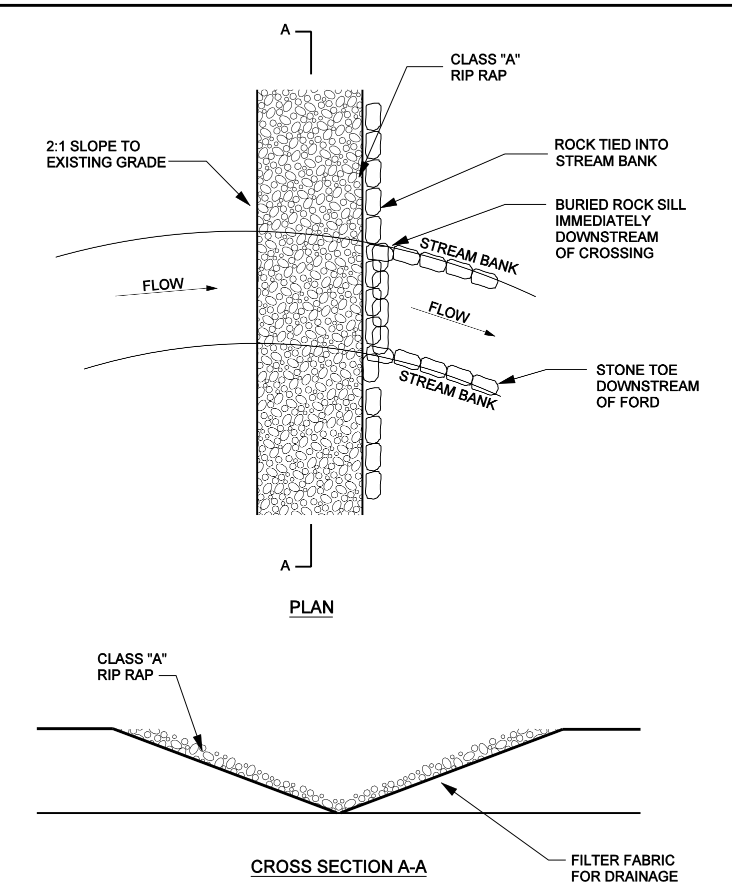
NOTE: ALL ROCKS OR STONES IN THE VANE STRUCTURE ARE STONE, BOULDERS



NOTES:
1. CLASS "A" STONE CAN BE USED TO REDUCE VOIDS BETWEEN HEADERS AND FOOTERS.
2. COMPACT BACKFILL TO EXTENT POSSIBLE OR AT THE DIRECTION OF THE DESIGNER.

CONSTRUCTED RIFFLE WITH CONSTRICTOR

SCALE: NTS



1. A STABILIZED PAD OF CLASS "A" RIP RAP, 18 INCHES THICK, LINED WITH FILTER FABRIC SHALL BE LOCATED WHERE FARM EQUIPMENT AND LIVESTOCK WILL BE CROSSING THE RESTORED STREAM CHANNEL.
2. EXCLUSION FENCING SHALL BE INSTALLED ON ALL APPROACHES TO AND ADJACENT TO THE CROSSING.
3. THE CROSSING SHALL BE BUILT TO THE DIMENSIONS SPECIFIED ON THE PLANS.
4. THE ENGINEER SHALL DETERMINE AN APPROPRIATE RAMP ANGLE FOR THE STREAM CROSSING ACCORDING TO THE CHANNEL MORPHOLOGY.
5. THE CROSSING LOCATIONS ARE DEPICTED IN THE PLANS.

ROCK FORD CROSSING

SCALE: NTS

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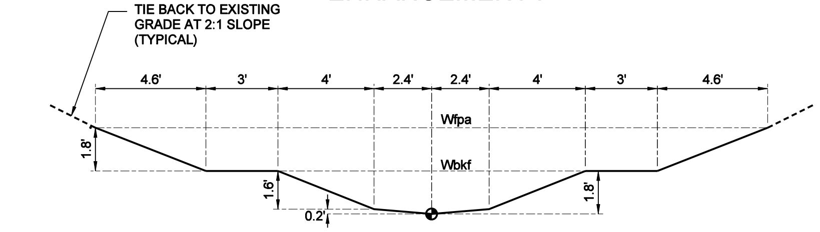
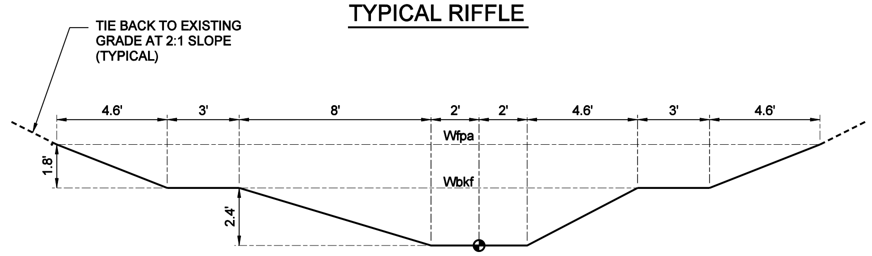
DETAILS:
STABILIZATION

SHEET 2A OF 68

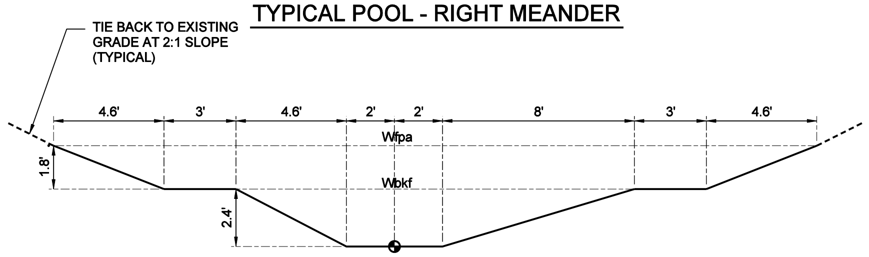
TRIBUTARY 1-1
STATION 10+00 TO STATION 17+59
"C4/B4c" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



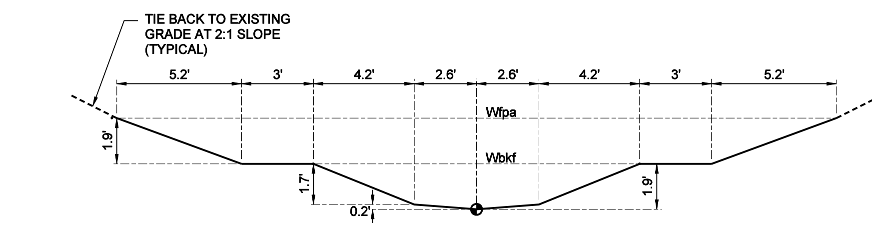
TYPICAL POOL - RIGHT MEANDER



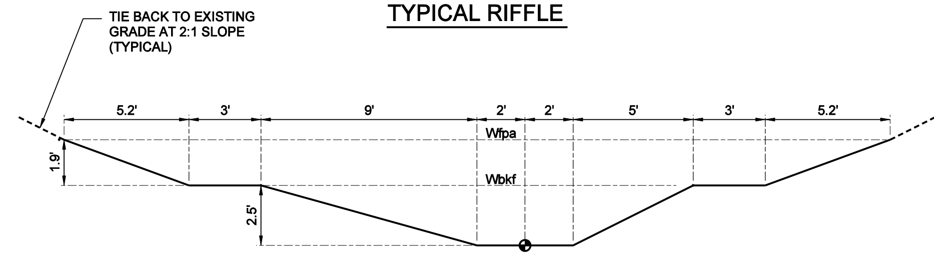
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

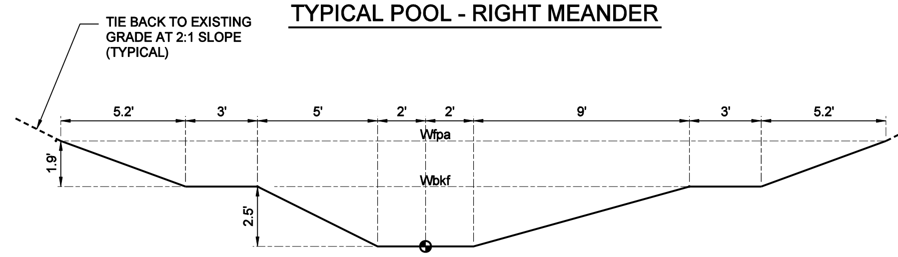
TRIBUTARY 1-2 AND 1-3
STATION 17+59 TO STATION 24+74
"C4/B4c" STREAM TYPE
ENHANCEMENT I AND RESTORATION



TYPICAL RIFFLE



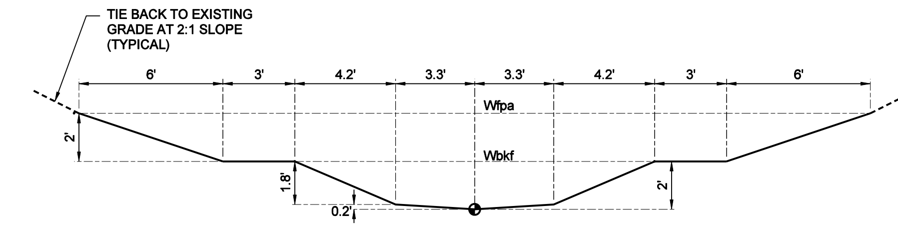
TYPICAL POOL - RIGHT MEANDER



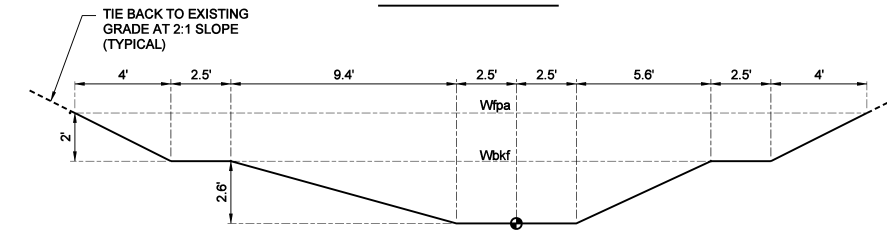
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

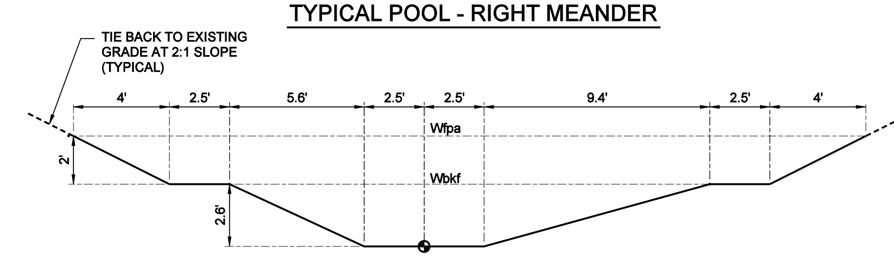
TRIBUTARY 1-4
STATION 24+74 TO STATION 34+94
"C4/B4c" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



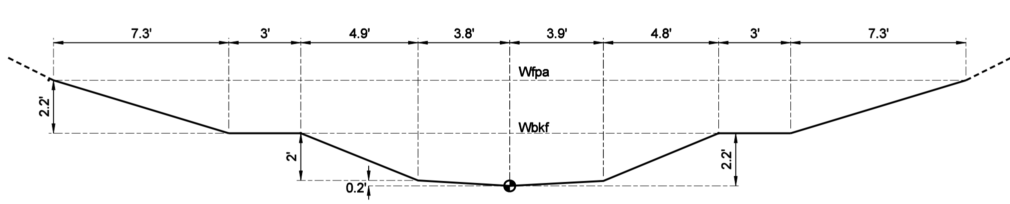
TYPICAL POOL - RIGHT MEANDER

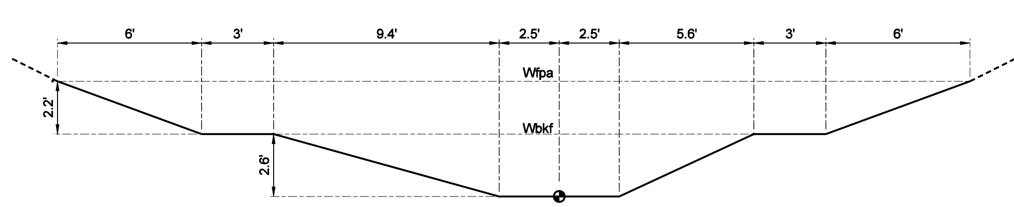


TYPICAL POOL - LEFT MEANDER

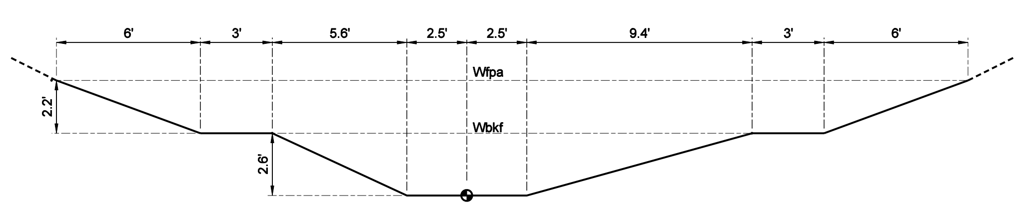
⊘ = THALWEG LOCATION

TRIBUTARY 1-5
STATION 34+94 TO STATION 37+64
"C4/B4c" STREAM TYPE
RESTORATION





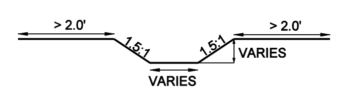
TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

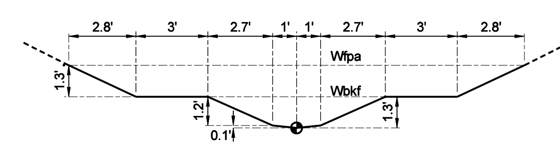
⊘ = THALWEG LOCATION

TRIBUTARY 2-1
STATION 50+00 TO STATION 53+05
"E4" STREAM TYPE
ENHANCEMENT II

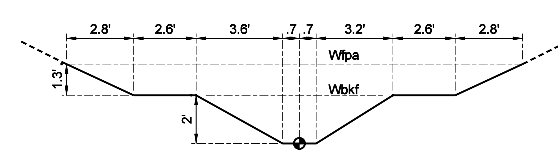


TYPICAL CROSS-SECTION

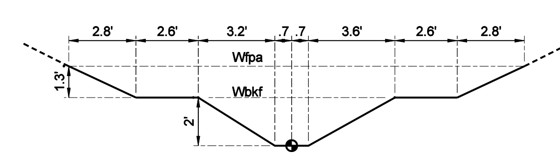
TRIBUTARY 2-2
STATION 53+05 TO STATION 54+91
"C4/E4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



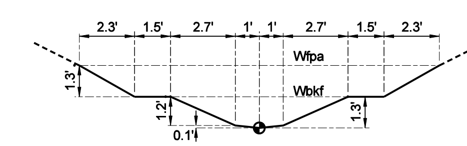
TYPICAL POOL - RIGHT MEANDER



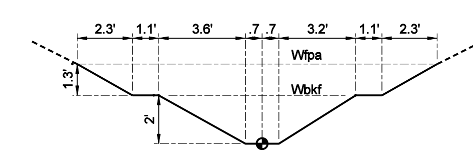
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

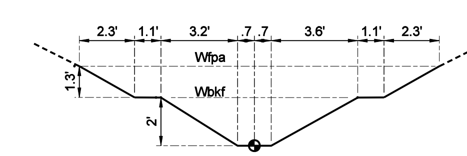
TRIBUTARY 2-3 AND 2-4
STATION 54+91 TO STATION 58+51
"B4" STREAM TYPE
ENHANCEMENT I AND RESTORATION



TYPICAL RIFFLE

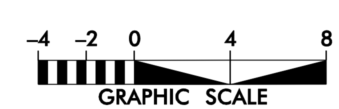


TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION



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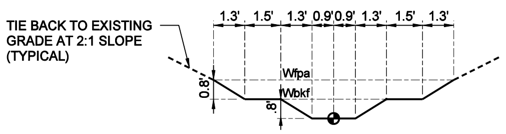
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA

DATE: DEC 2007
SCALE: SEE SHEET

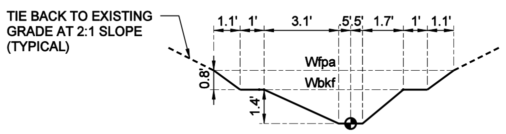
DETAILS:
TYPICAL XS

SHEET 28 OF 68

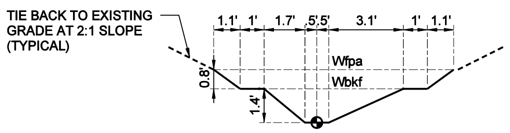
TRIBUTARY 3-1
STATION 60+00 TO STATION 61+05
"C4/E4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



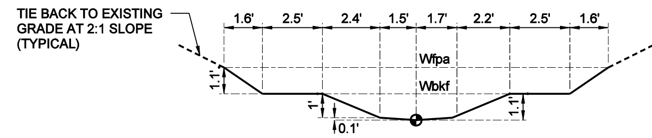
TYPICAL POOL - RIGHT MEANDER



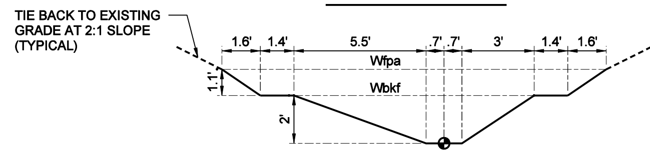
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

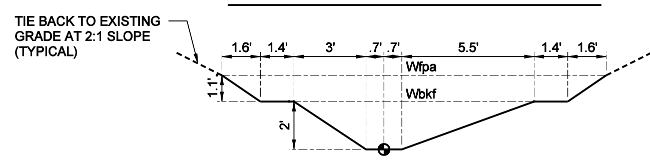
TRIBUTARY 3-2
STATION 61+05 TO STATION 76+79
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



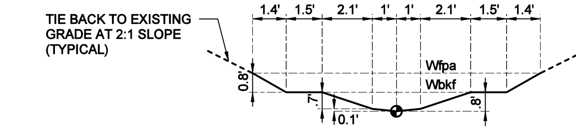
TYPICAL POOL - RIGHT MEANDER



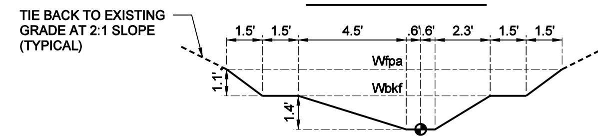
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

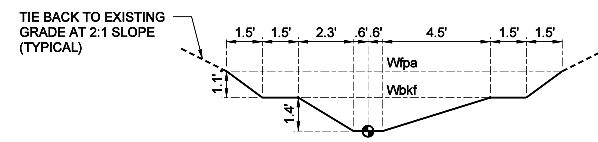
TRIBUTARY 4-1
STATION 80+00 TO STATION 82+66
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



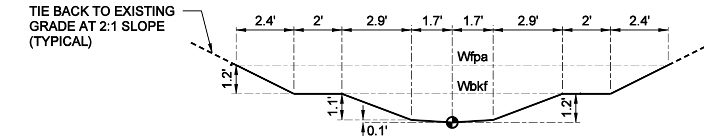
TYPICAL POOL - RIGHT MEANDER



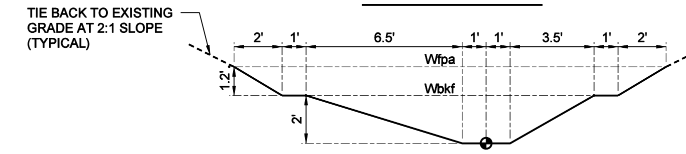
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

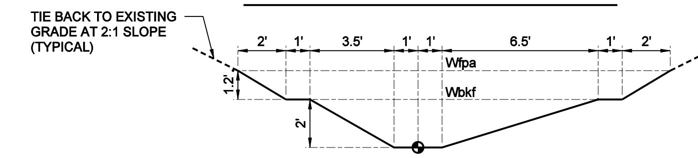
TRIBUTARY 4-2
STATION 82+66 TO STATION 102+53
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



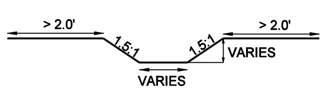
TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

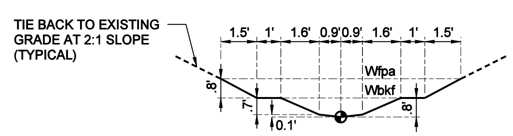
⊘ = THALWEG LOCATION

TRIBUTARY 5-1
STATION 110+00 TO STATION 112+64
"C4/B4" STREAM TYPE
ENHANCEMENT II

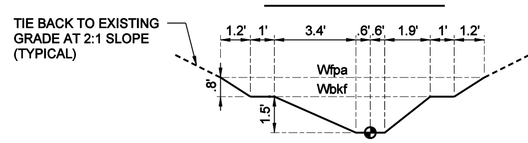


TYPICAL CROSS-SECTION

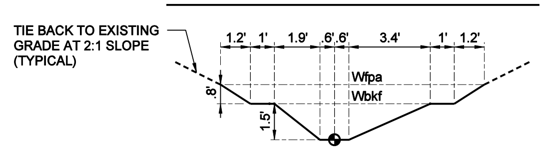
TRIBUTARY 5-2 AND 6AB
STATION 112+64 TO STATION 113+85
AND STATION 240+89 TO STATION 241+29
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



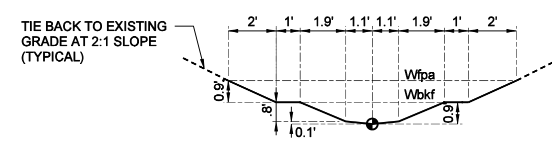
TYPICAL POOL - RIGHT MEANDER



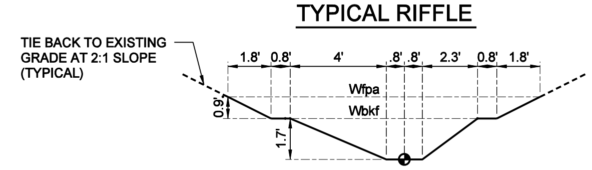
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

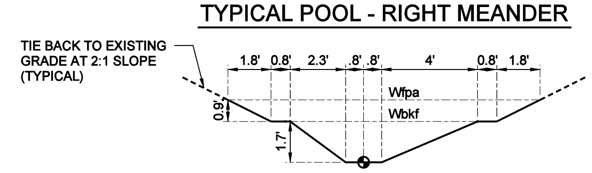
TRIBUTARY 6C
STATION 120+00 TO STATION 121+88
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



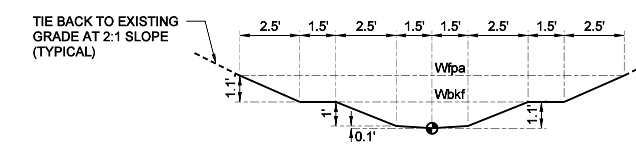
TYPICAL POOL - RIGHT MEANDER



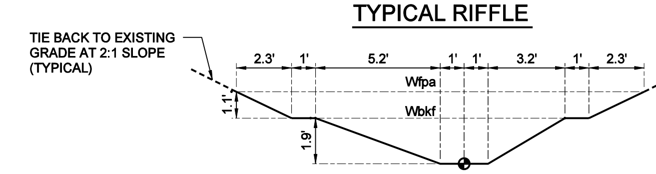
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

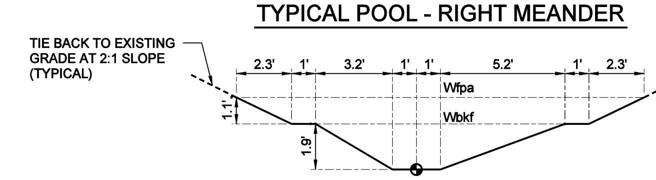
TRIBUTARY 6
STATION 121+88 TO STATION 134+38
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



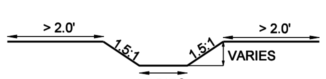
TYPICAL POOL - RIGHT MEANDER



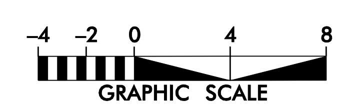
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

TRIBUTARY 6A AND 6B
STATION 240+00 TO STATION 240+89
AND STATION 250+00 TO STATION 251+03
"C4/B4" STREAM TYPE
ENHANCEMENT II



TYPICAL CROSS-SECTION



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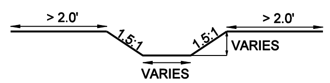
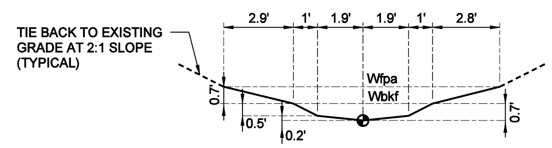
TRIBUTARY 7A AND 7-1
STATION 260+00 TO STATION 261+36
AND STATION 140+00 TO STATION 144+69
"C4/E4" STREAM TYPE
ENHANCEMENT II

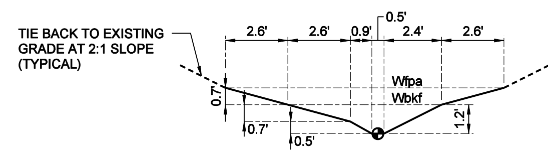


TYPICAL CROSS-SECTION

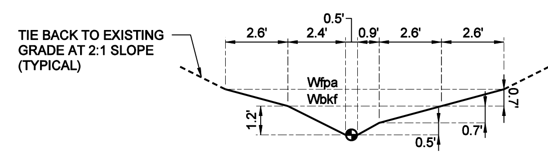
TRIBUTARY 7-2
STATION 144+69 TO STATION 148+00
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



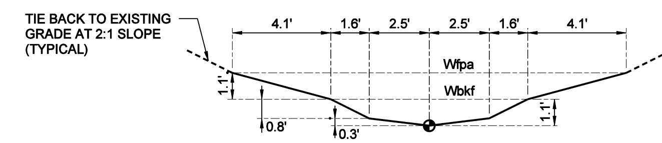
TYPICAL POOL - RIGHT MEANDER



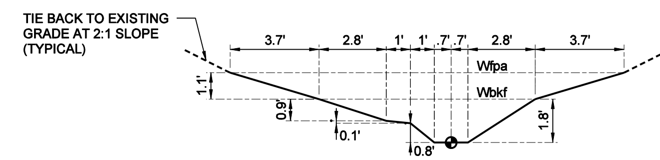
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

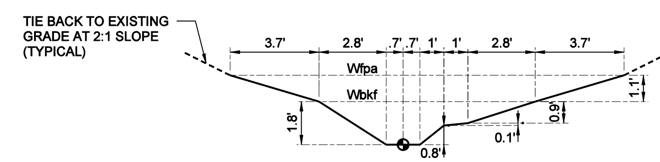
TRIBUTARY 7-3
STATION 148+00 TO STATION 169+08
"B4" STREAM TYPE
RESTORATION



TYPICAL RIFFLE



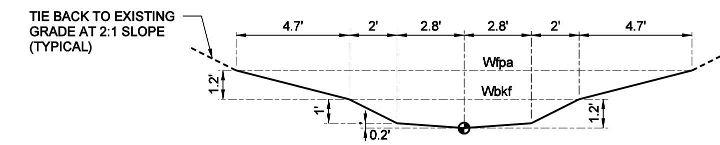
TYPICAL POOL - RIGHT MEANDER



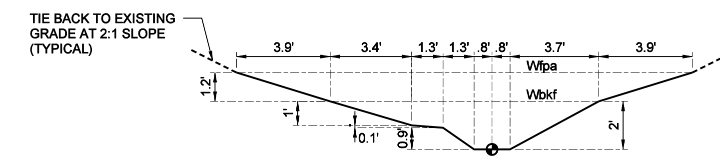
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

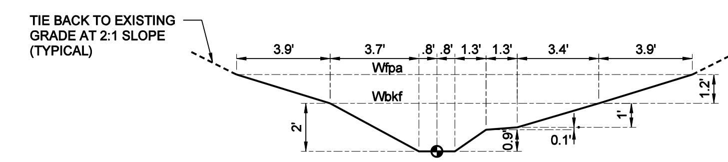
TRIBUTARY 7-4
STATION 169+08 TO STATION 181+54
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



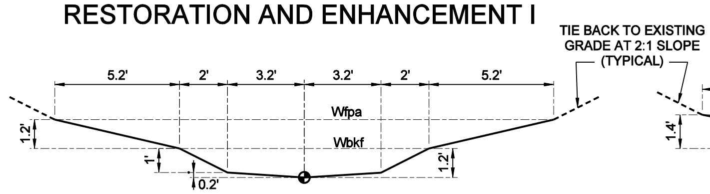
TYPICAL POOL - RIGHT MEANDER



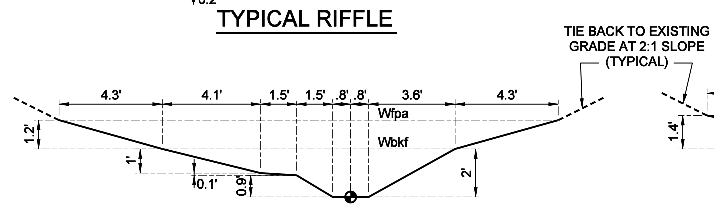
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

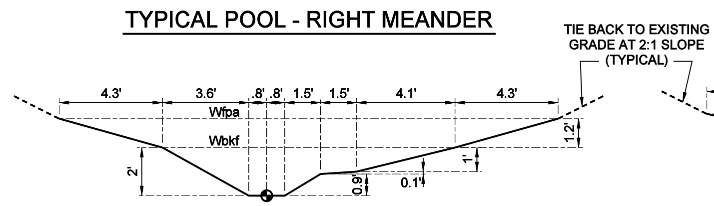
TRIBUTARY 7-5 AND 7-6
STATION 181+54 TO STATION 190+83
"B4" STREAM TYPE
RESTORATION AND ENHANCEMENT I



TYPICAL RIFFLE



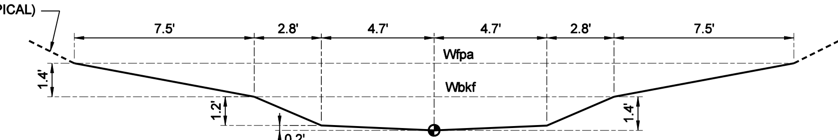
TYPICAL POOL - RIGHT MEANDER



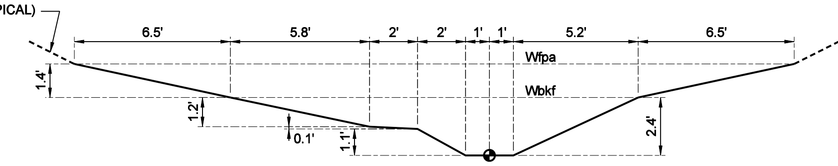
TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION

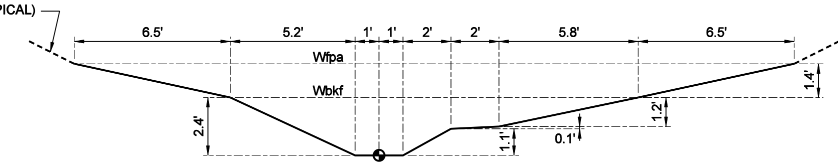
TRIBUTARY 7-7
STATION 190+83 TO STATION 196+93
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



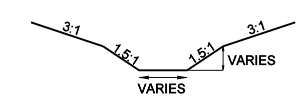
TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

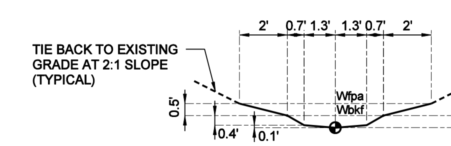
⊘ = THALWEG LOCATION

TRIBUTARY 8A
STATION 270+00 TO STATION 271+10
"B4" STREAM TYPE
ENHANCEMENT II

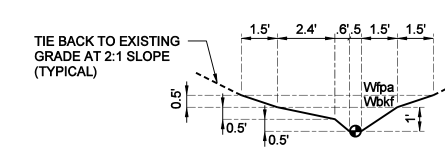


TYPICAL CROSS-SECTION

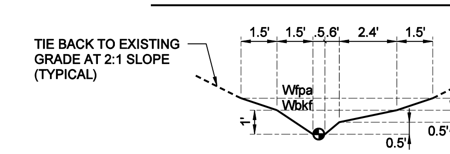
TRIBUTARY 8
STATION 200+00 TO STATION 204+49
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE

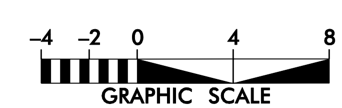


TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION



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TYPICAL XS

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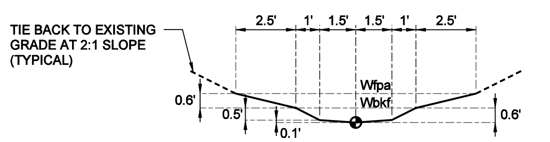
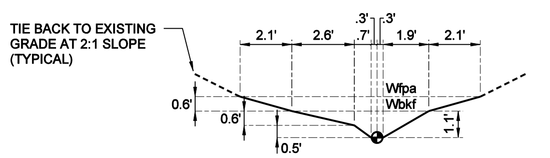
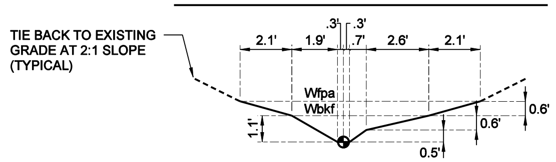
TRIBUTARY 9
STATION 210+00 TO STATION 213+69
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE



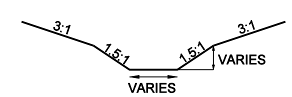
TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

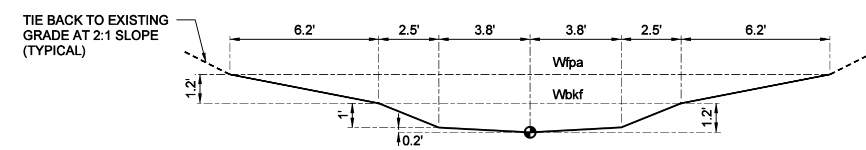
⊘ = THALWEG LOCATION

TRIBUTARY 10-1
STATION 220+00 TO STATION 233+00
"B4/1" STREAM TYPE
ENHANCEMENT II

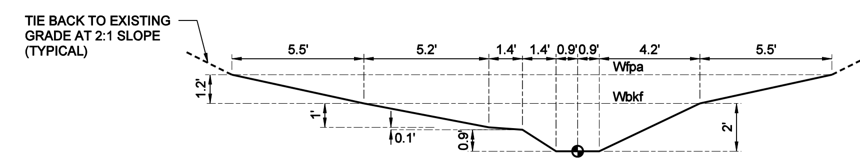


TYPICAL CROSS-SECTION

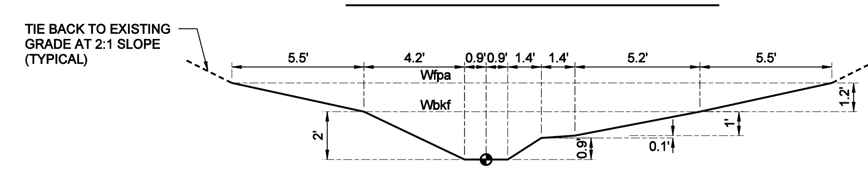
TRIBUTARY 10-2
STATION 233+00 TO STATION 235+82
"B4" STREAM TYPE
ENHANCEMENT I



TYPICAL RIFFLE

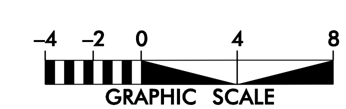


TYPICAL POOL - RIGHT MEANDER



TYPICAL POOL - LEFT MEANDER

⊘ = THALWEG LOCATION



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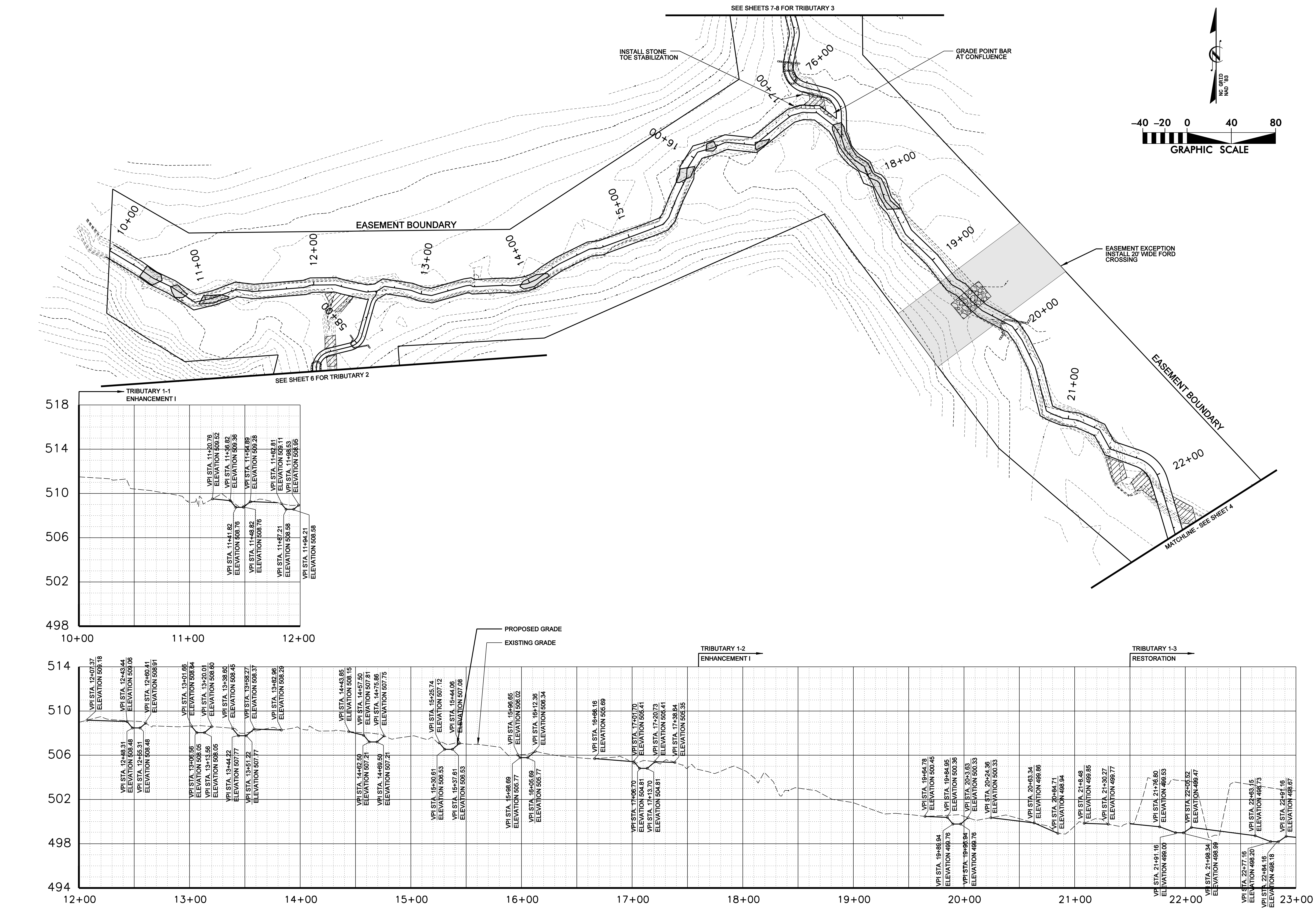

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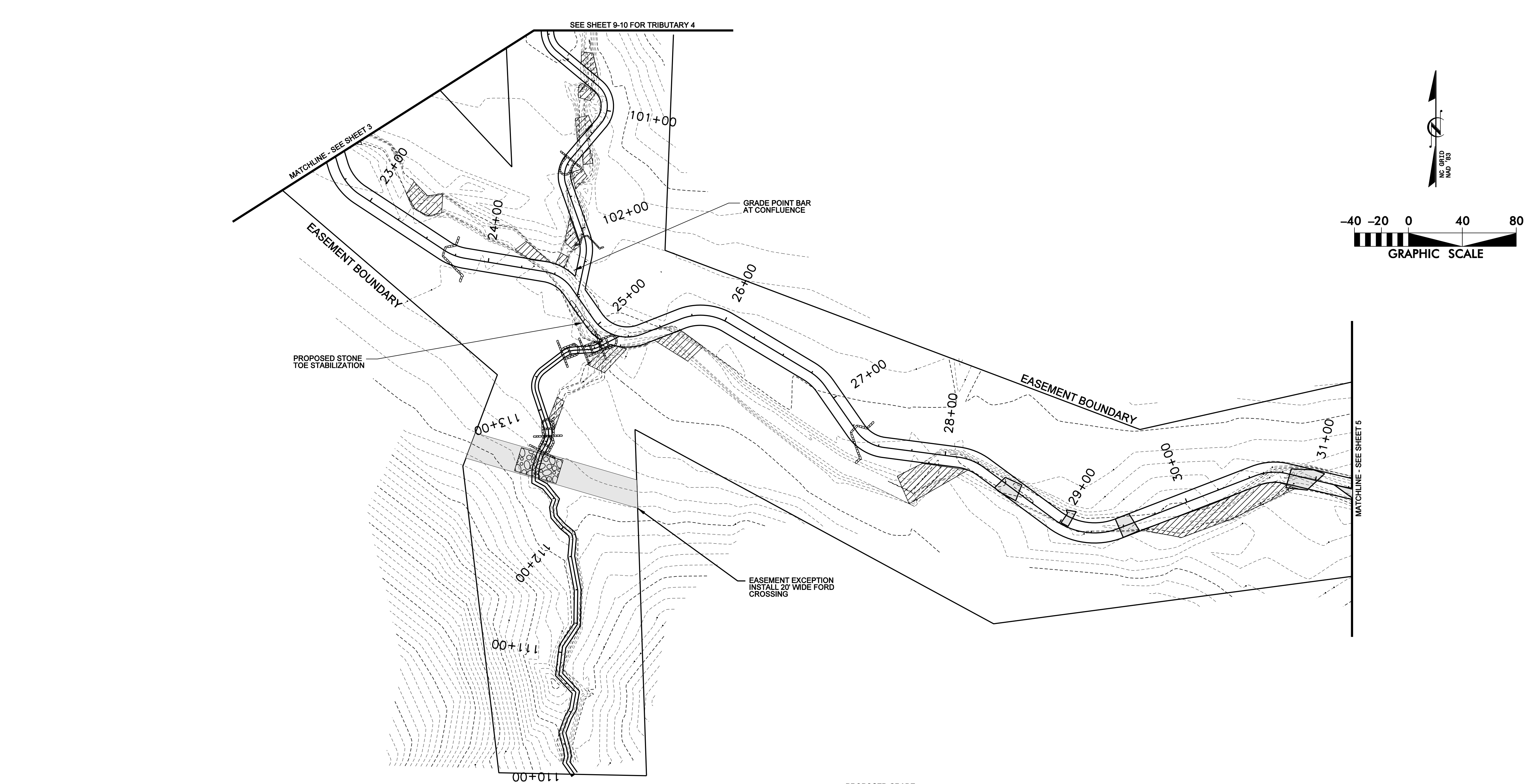
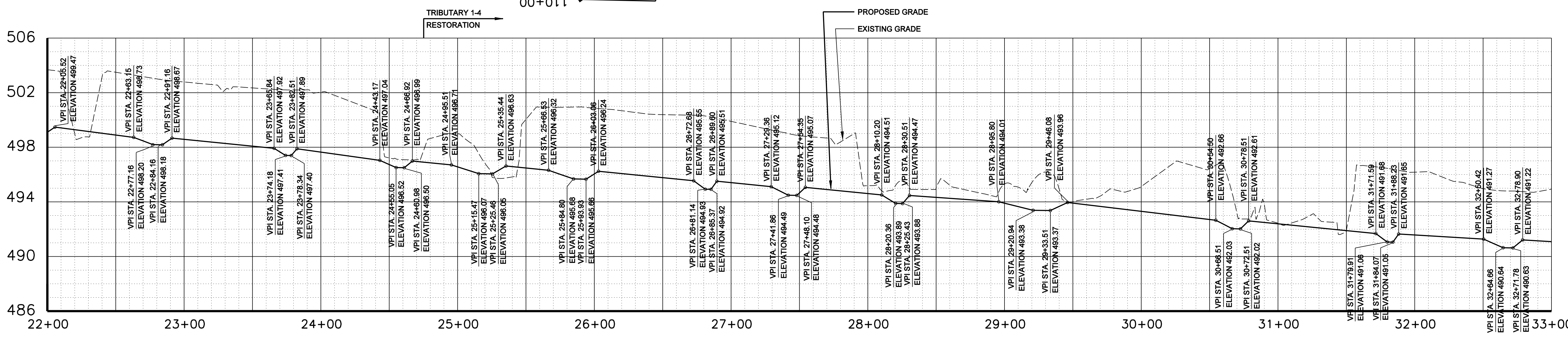
SEMORA, PERSON COUNTY, NORTH CAROLINA
T1-1, T1-2, T1-3: STATION 10+00 TO STATION 22+56

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 3 OF 68





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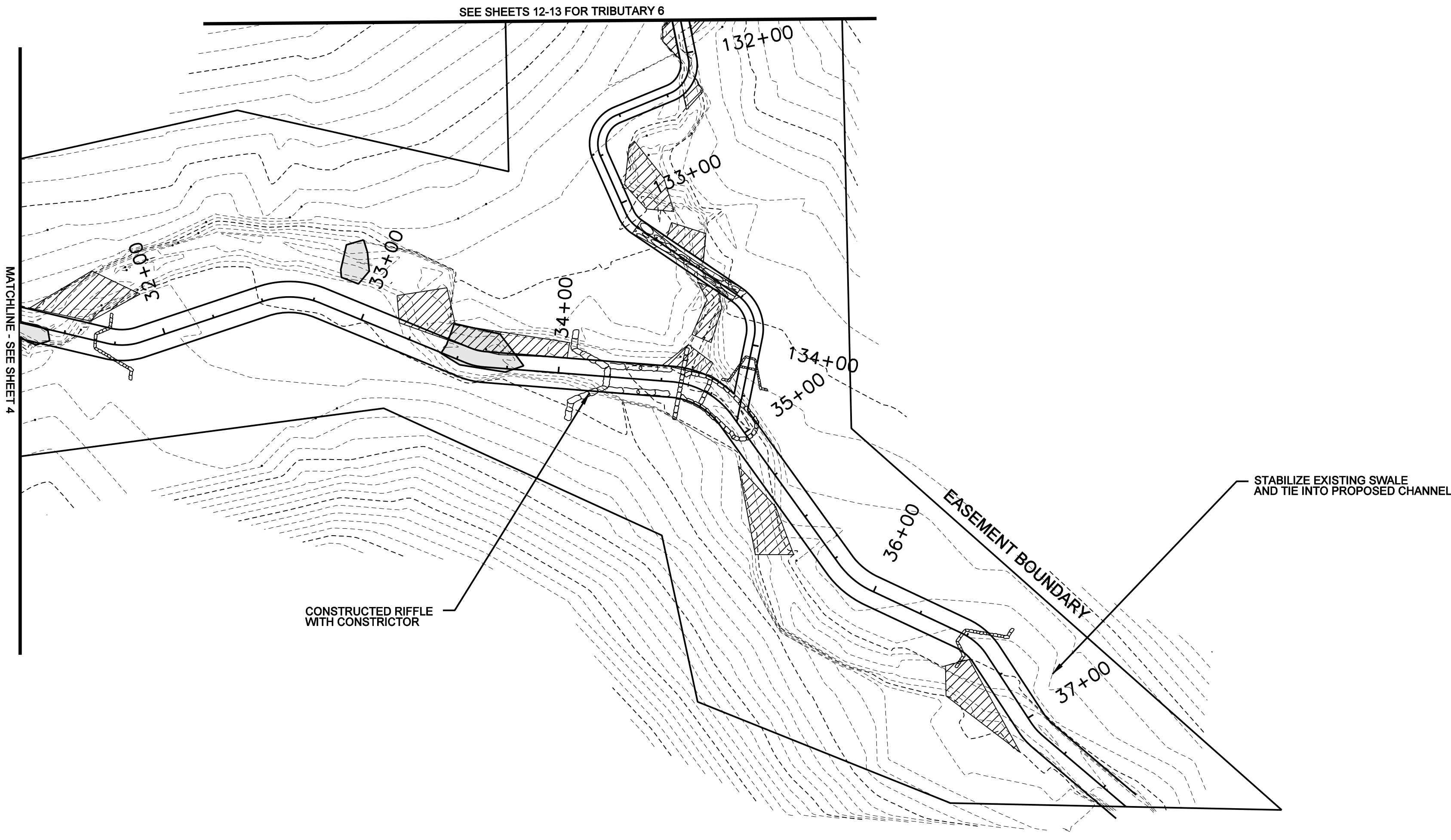
SEMORA, PERSON COUNTY, NORTH CAROLINA

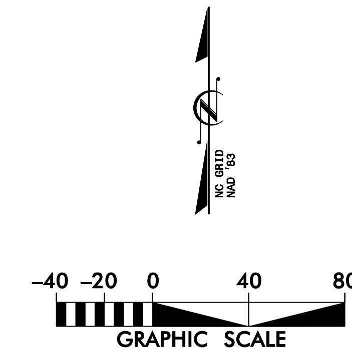
T1-3, T1-4: STATION 22+56 TO STATION 31+28

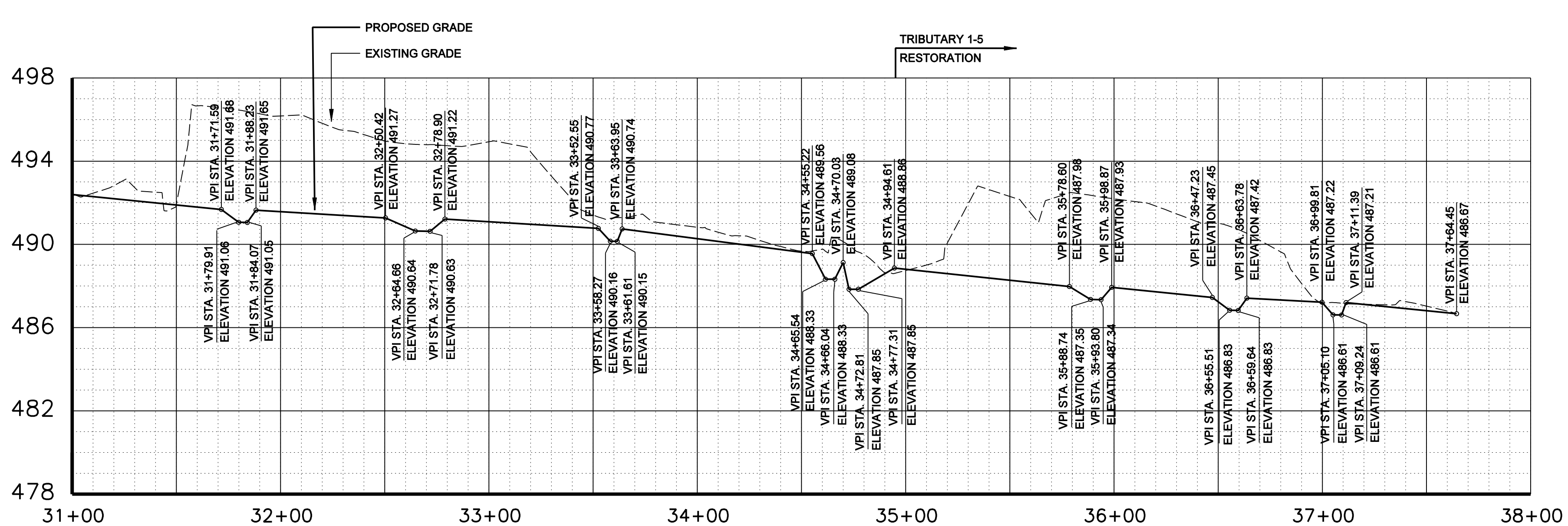
DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 4 OF 68







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SEMORA, PERSON COUNTY, NORTH CAROLINA

T1-4, T1-5: STATION 31+28 TO STATION 37+64

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

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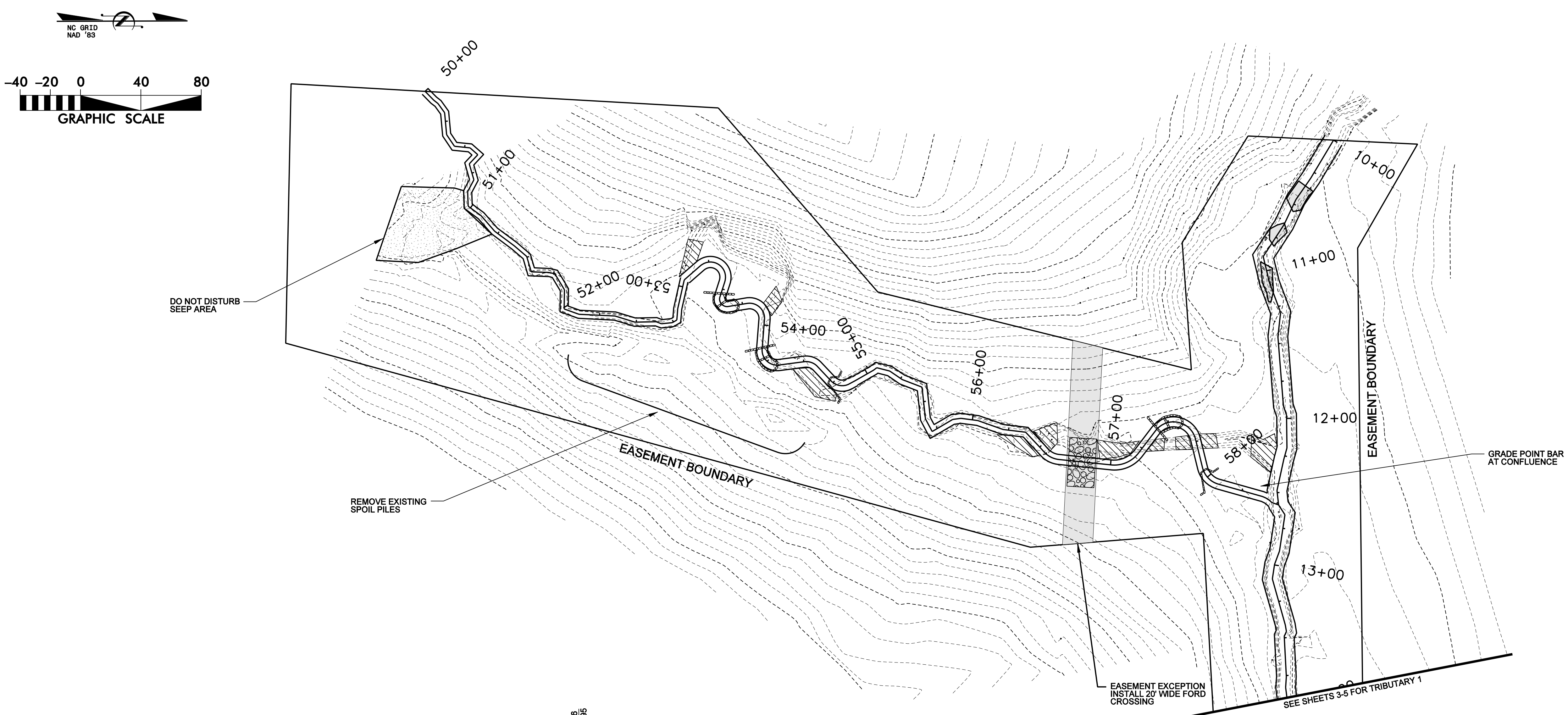

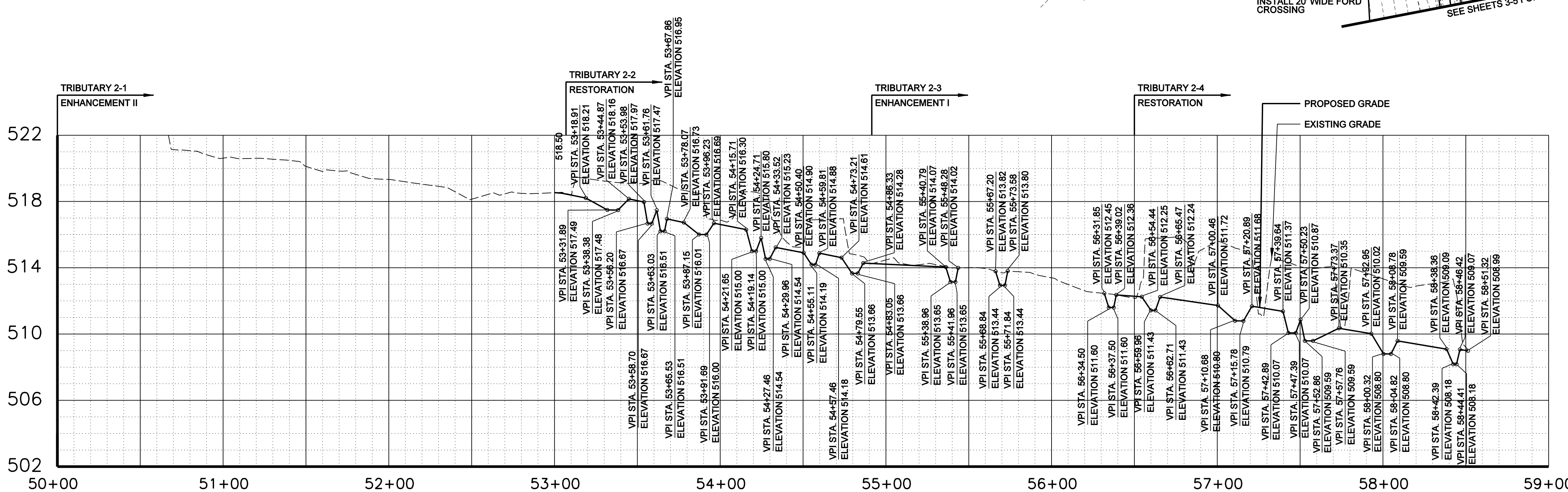

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T2-1, T2-2, T2-3, T2-4: STATION 50+00 TO STATION 58+63

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

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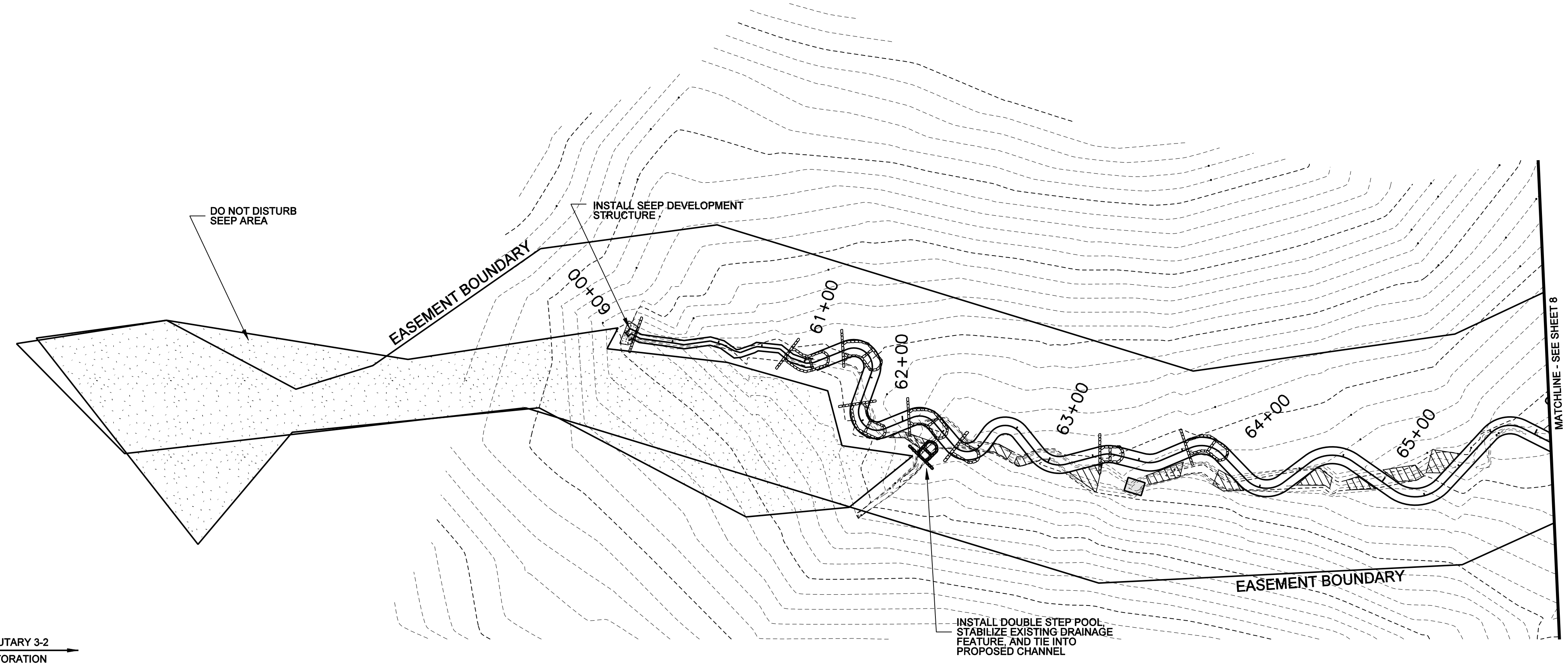

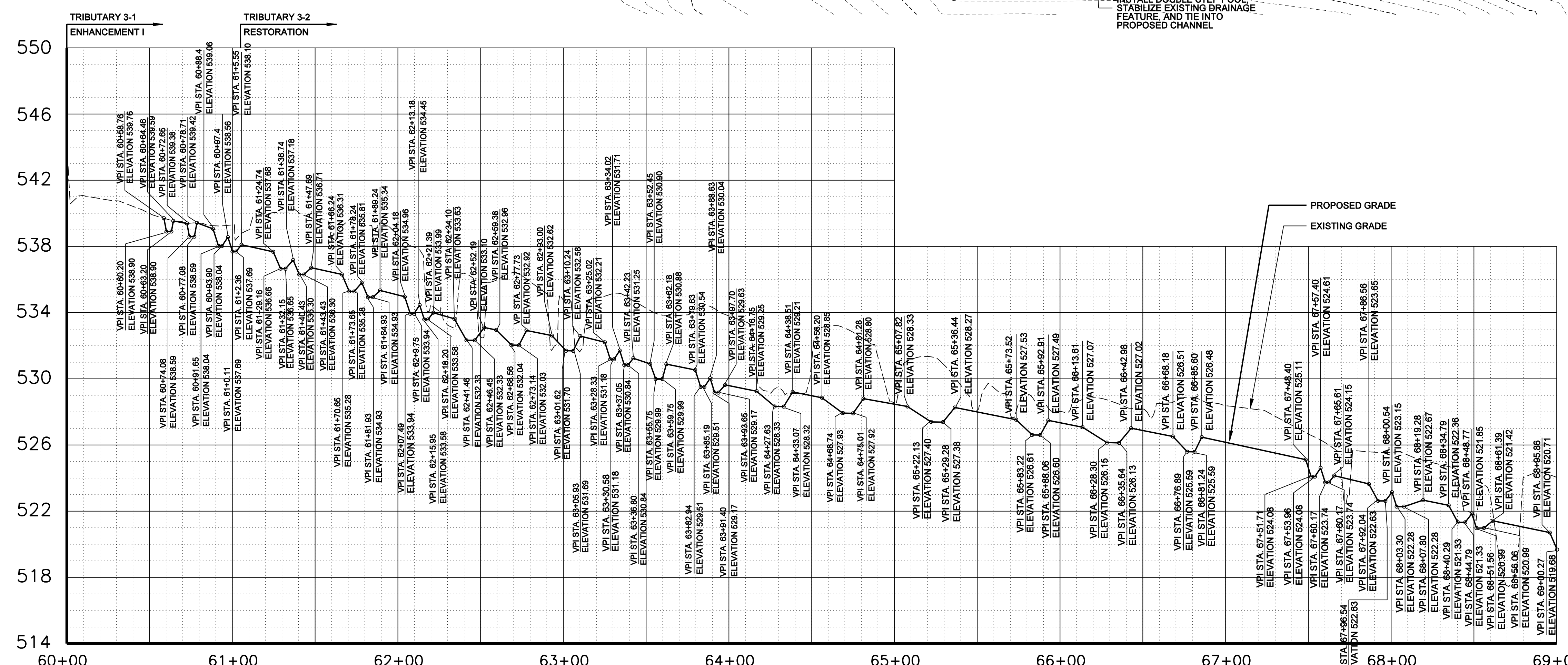

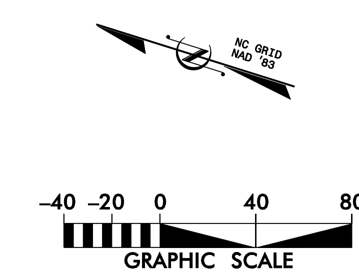

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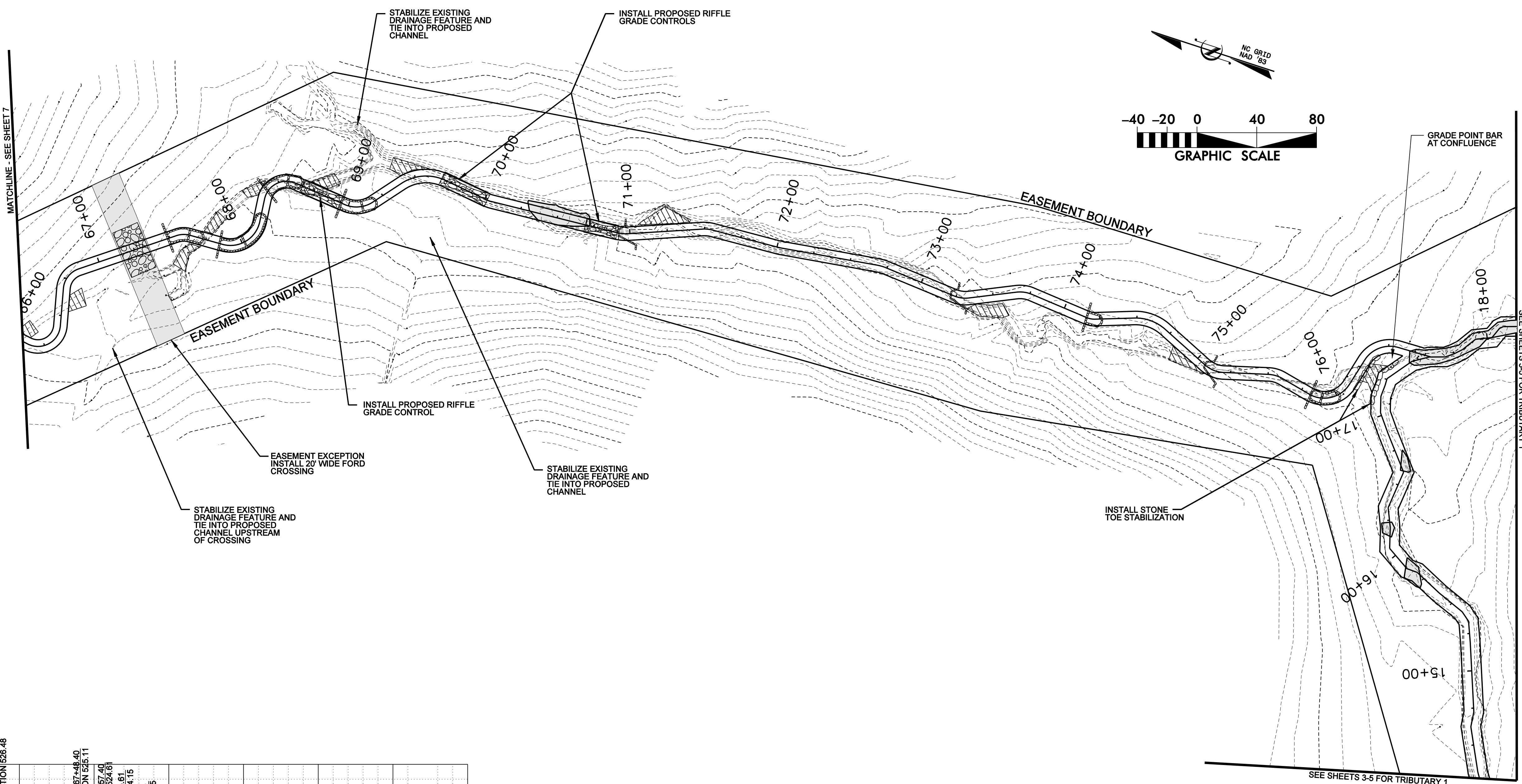
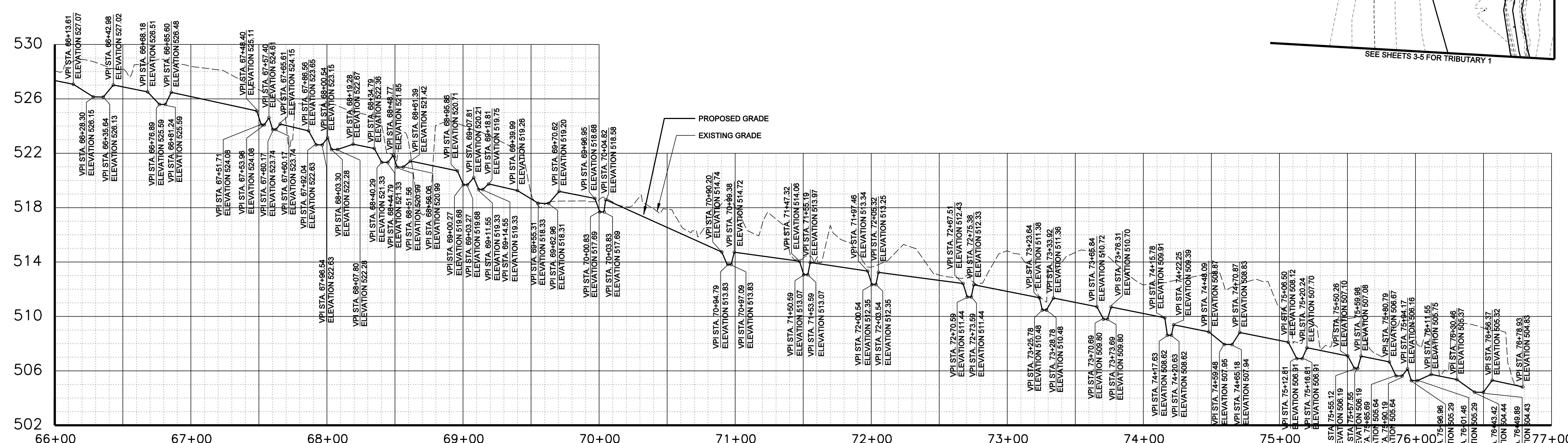
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T3-1, T3-2: STATION 60+00 TO STATION 66+10

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 7 OF 68





A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	
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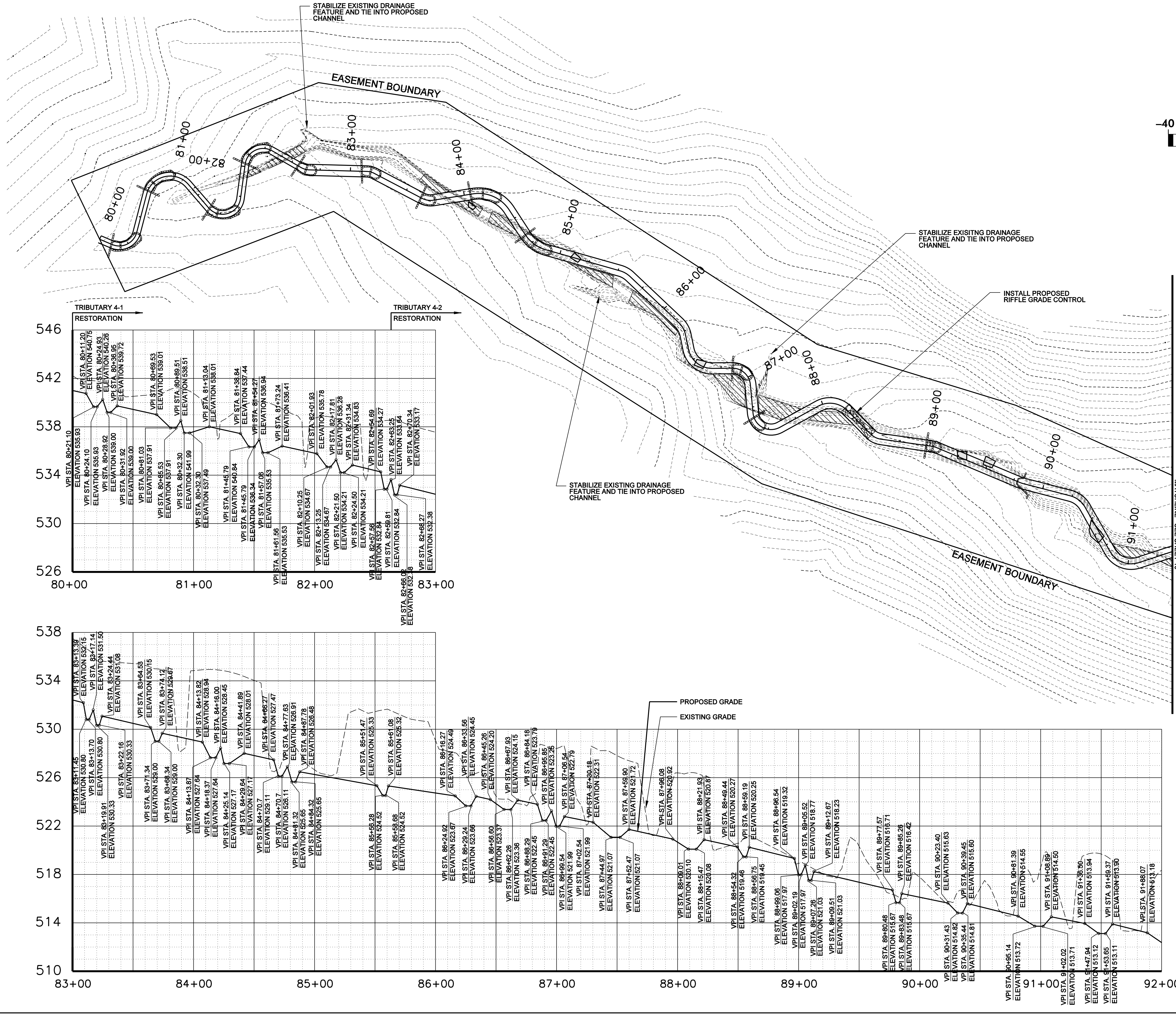
SEMORA, PERSON COUNTY, NORTH CAROLINA
T3-2: STATION 66+10 TO STATION 76+79

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 8 OF 68



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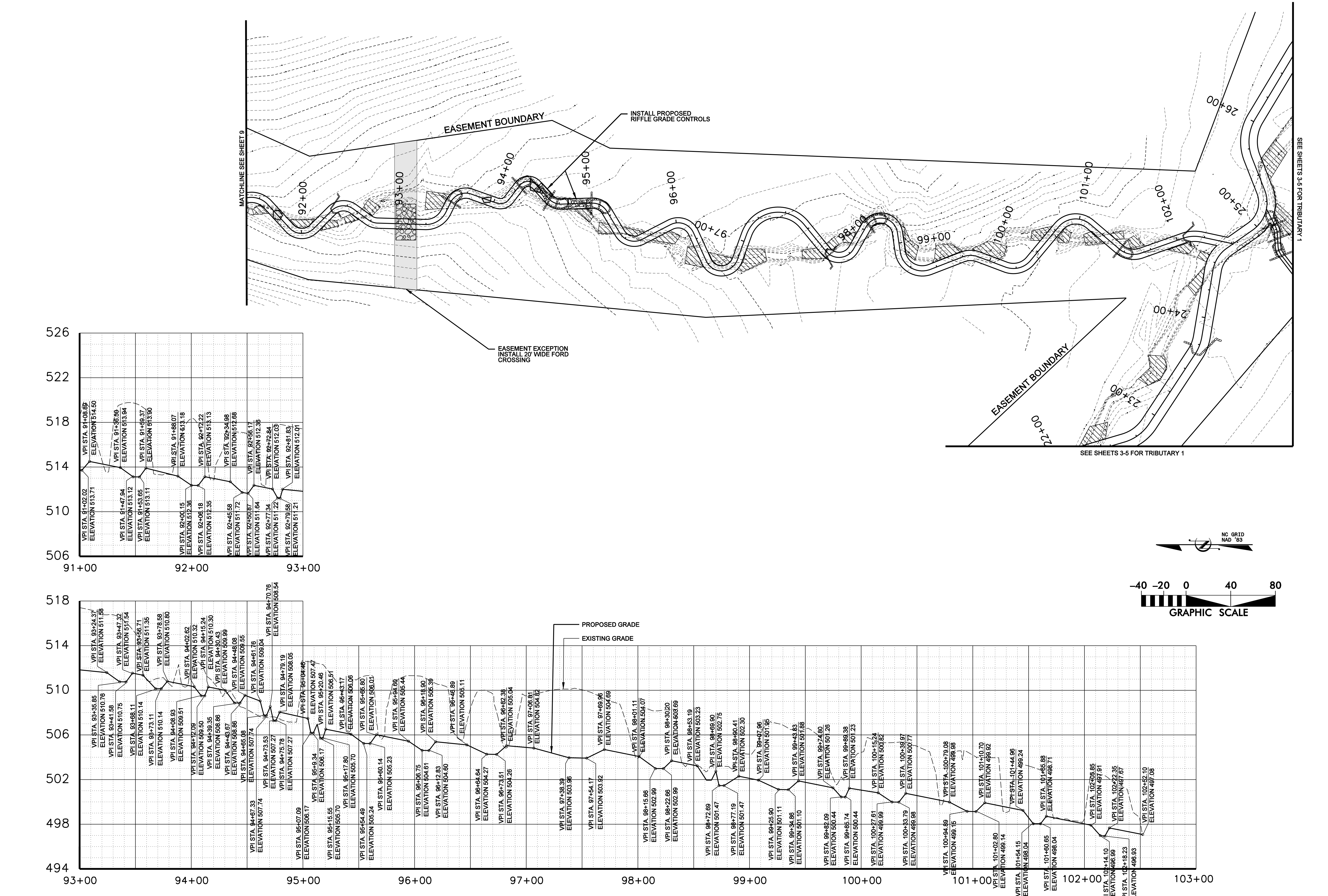
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T4-1, T4-2: STATION 80+00 TO STATION 91+38

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 9 OF 68



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CANE CREEK STREAM RESTORATION PROJECT

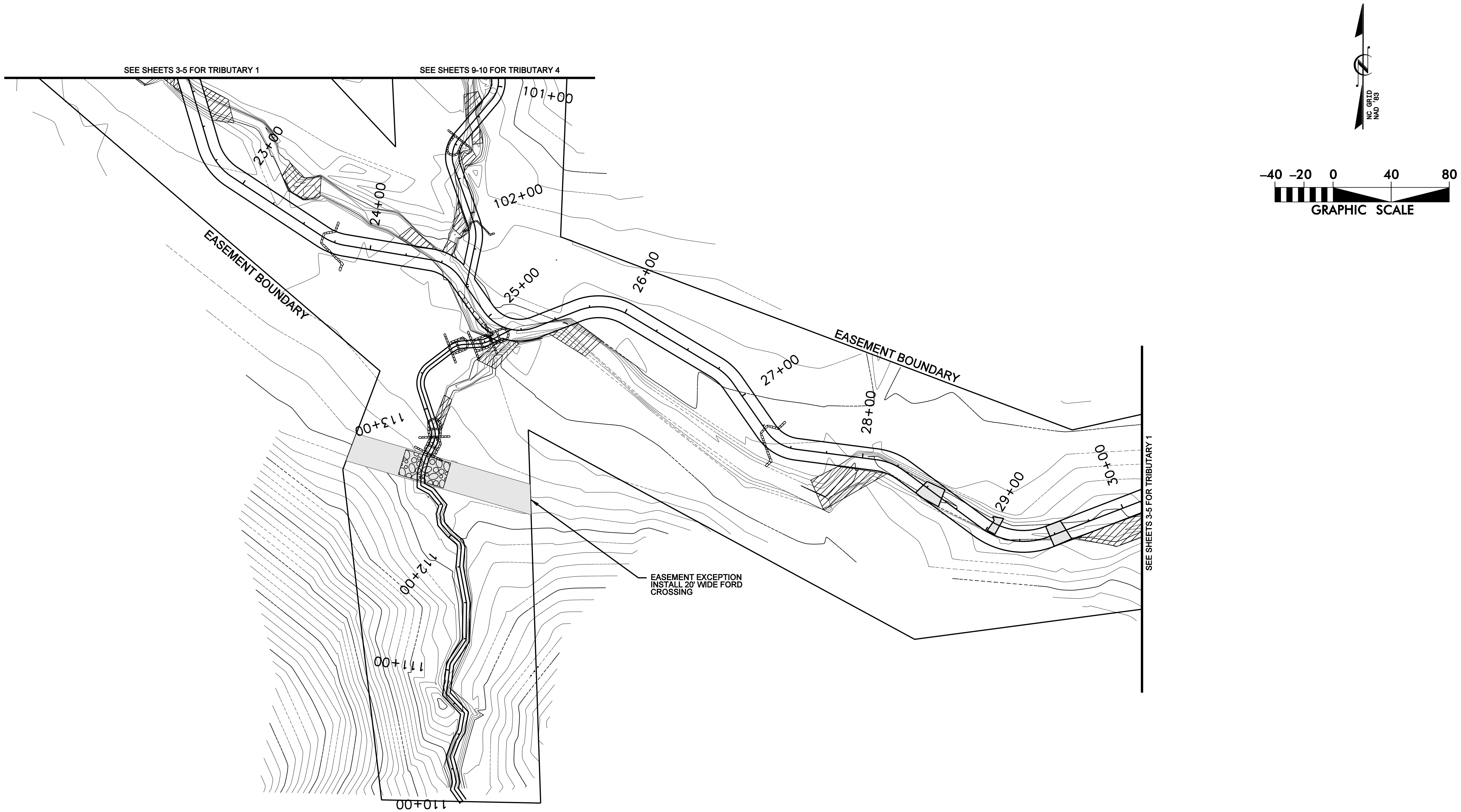
SEMORA, PERSON COUNTY, NORTH CAROLINA

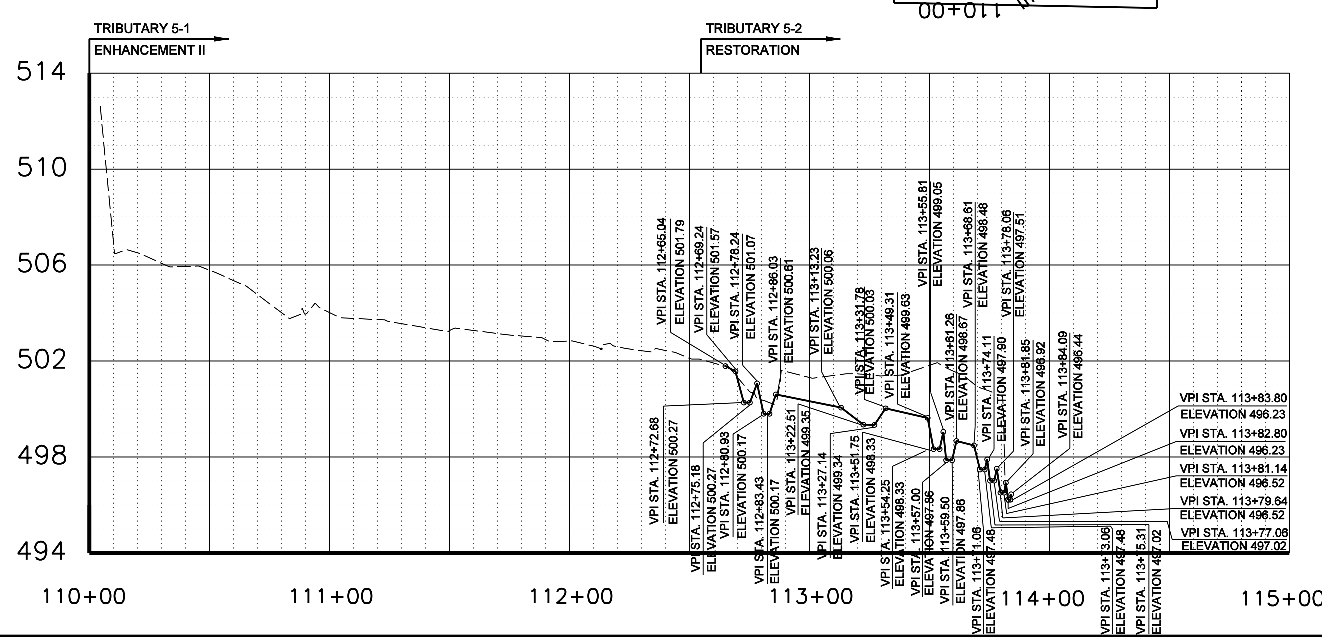
T4-2: STATION 91+38 TO STATION 102+52

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 10 OF 68





A	SUBMITTED WITH RESTORATION PLAN — DEC 2007
SYM.	DESCRIPTION — DATE — APPROVED

REVISIONS

Ecosystem Enhancement PROGRAM

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RALEIGH, NORTH CAROLINA 27609

CANE CREEK
STREAM RESTORATION PROJECT

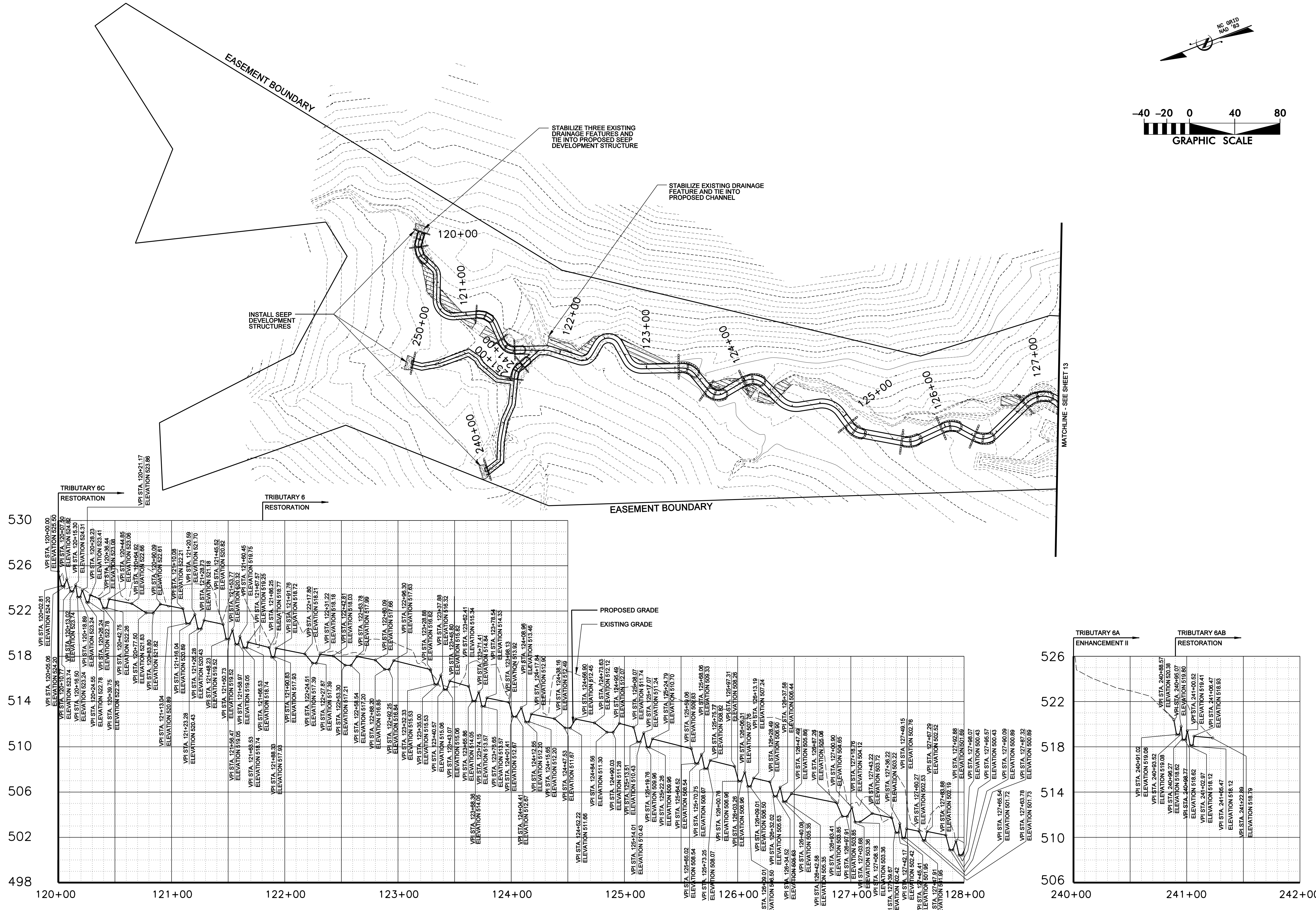
SEMORA, PERSON COUNTY, NORTH CAROLINA

T5-1, T5-2: STATION 110+00 TO STATION 113+85

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 11 OF 68



A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	
SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

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CANE CREEK STREAM RESTORATION PROJECT

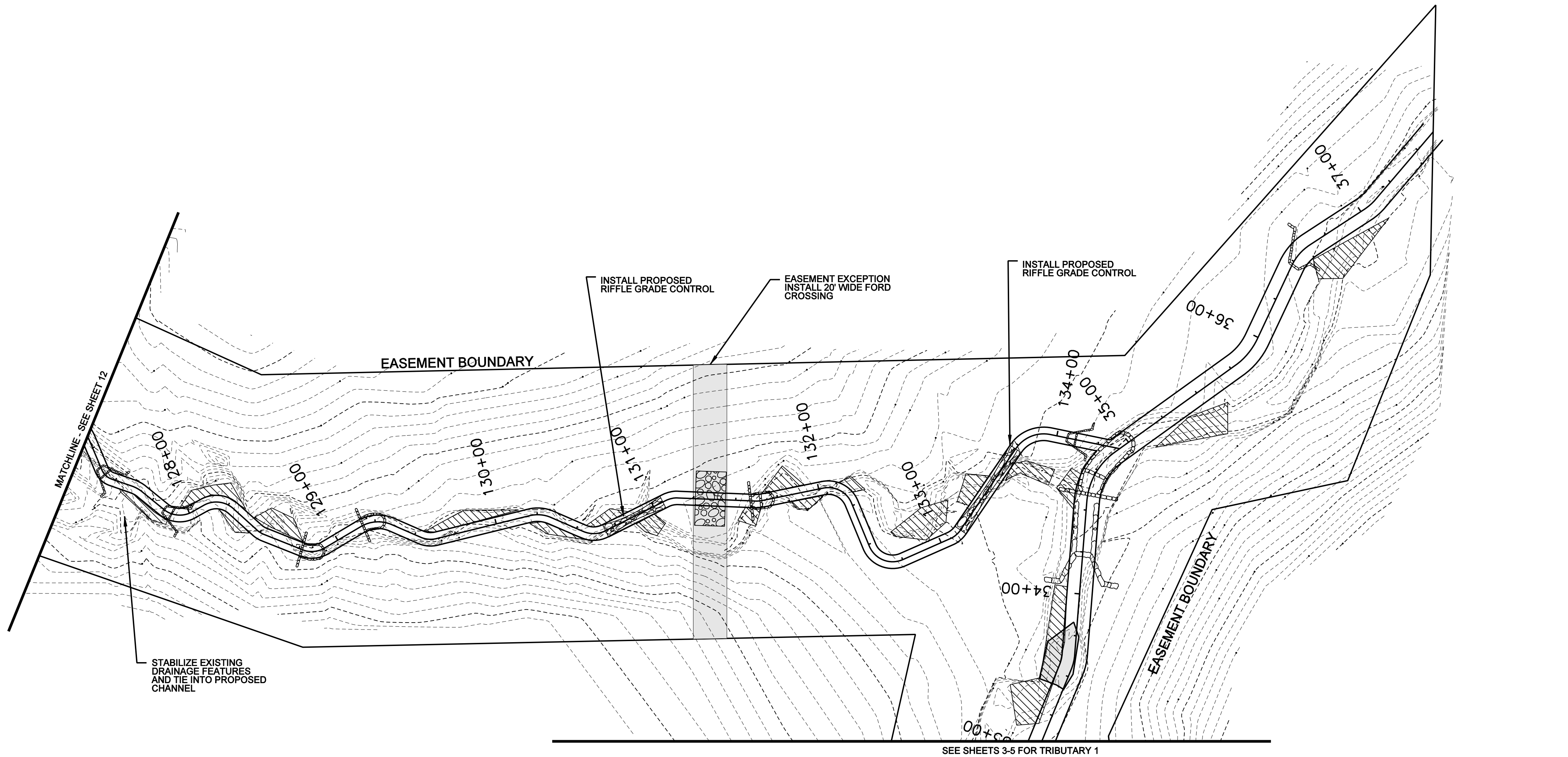
SEMORA, PERSON COUNTY, NORTH CAROLINA

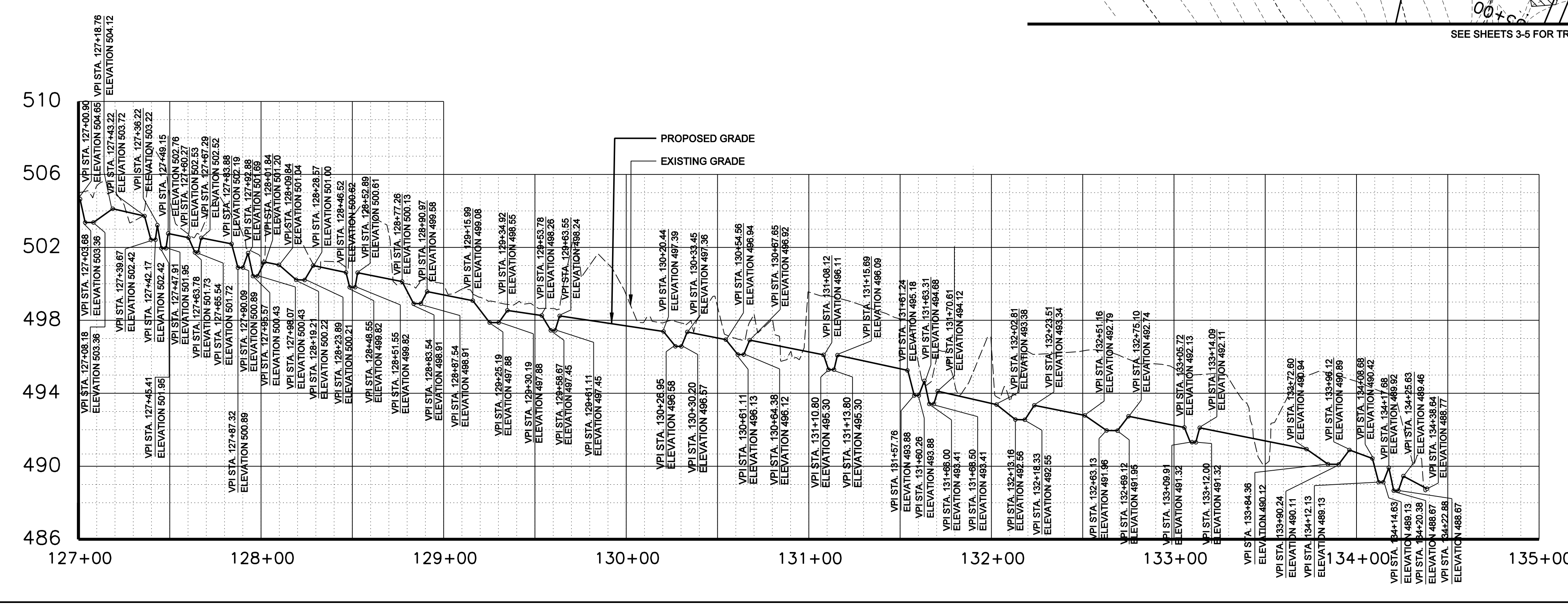
T6A, T6B, T6AB, T6C, T6: STA 240+00 TO 241+19, STA 250+00 TO 251+03, AND STA 120+00 TO 127+18

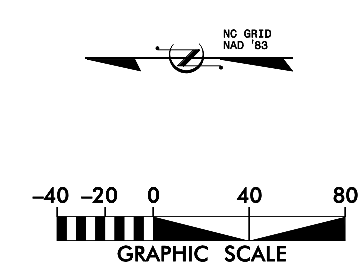
DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 12 OF 68







SYM.	DESCRIPTION	DATE	APPROVED
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CANE CREEK STREAM RESTORATION PROJECT

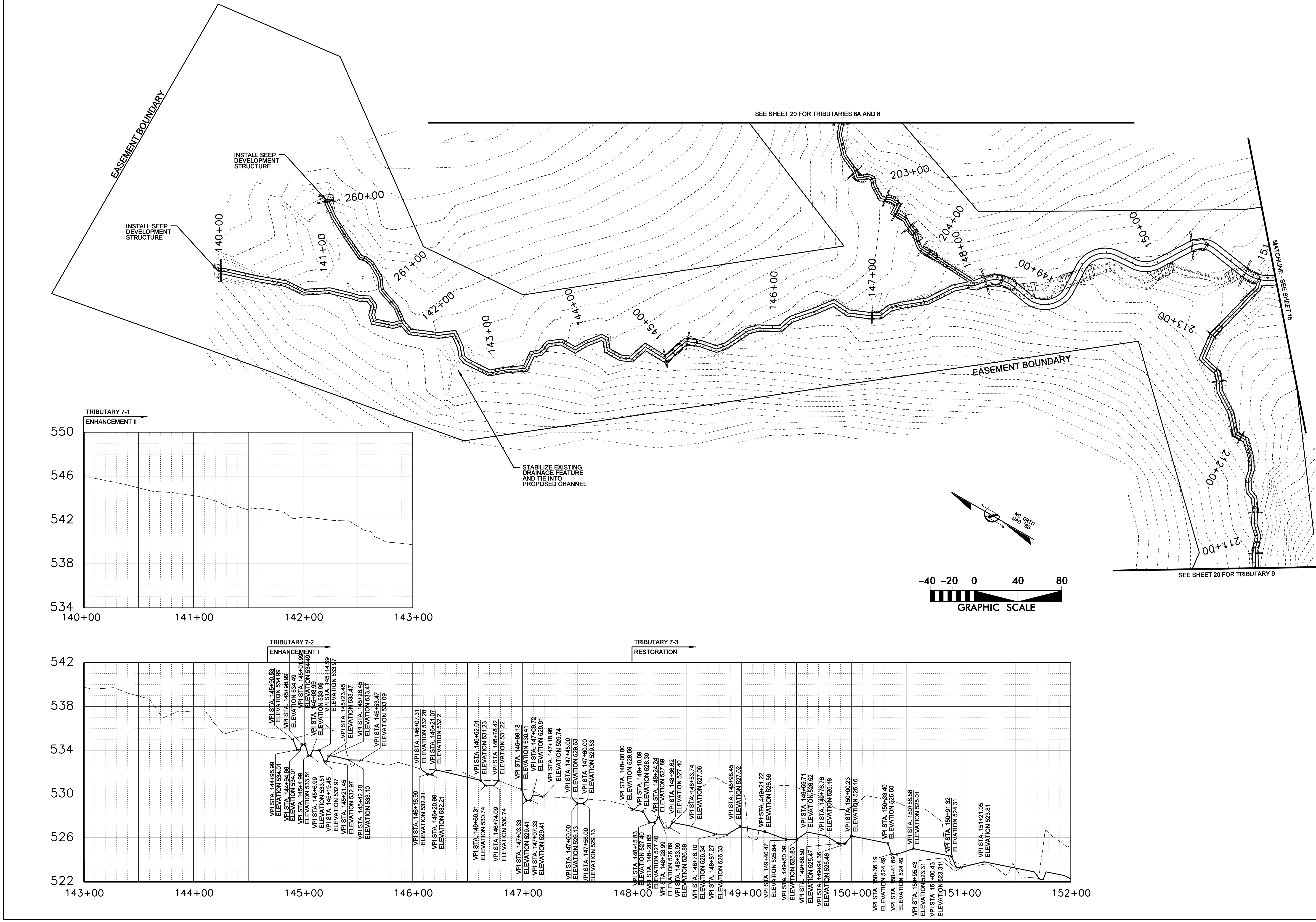
SEMORA, PERSON COUNTY, NORTH CAROLINA

T6: STATION 127+18 TO STATION 134+38

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 13 OF 68



A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	
SYM.	DESCRIPTION	DATE	APPROVED

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CANE CREEK STREAM RESTORATION PROJECT

SEMORA, PERSON COUNTY, NORTH CAROLINA

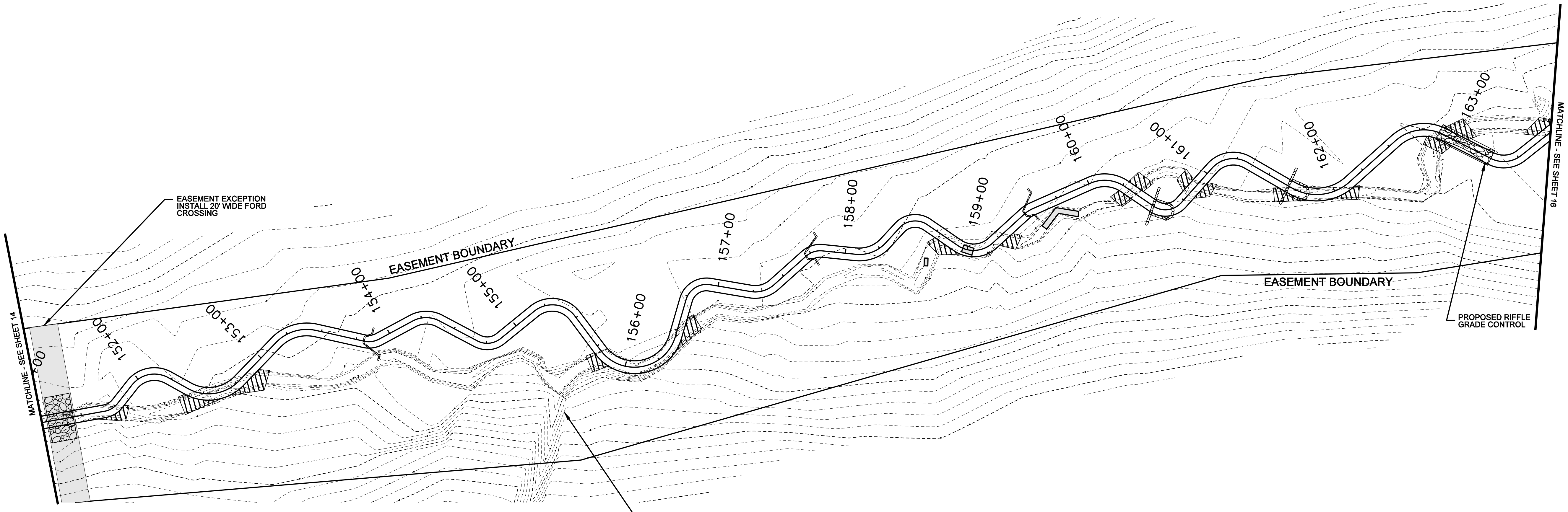
T7A, T7-1, T7-2, T7-3: STA 260+00 TO 261+36 AND STA 140+00 TO 151+22

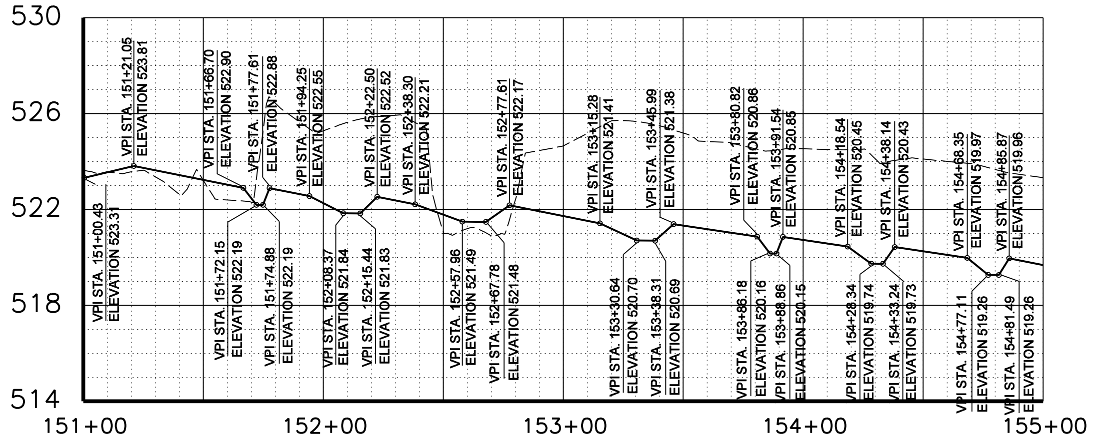
DATE: DEC 2007

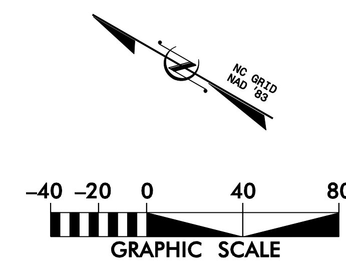
SCALE: 1"=40'

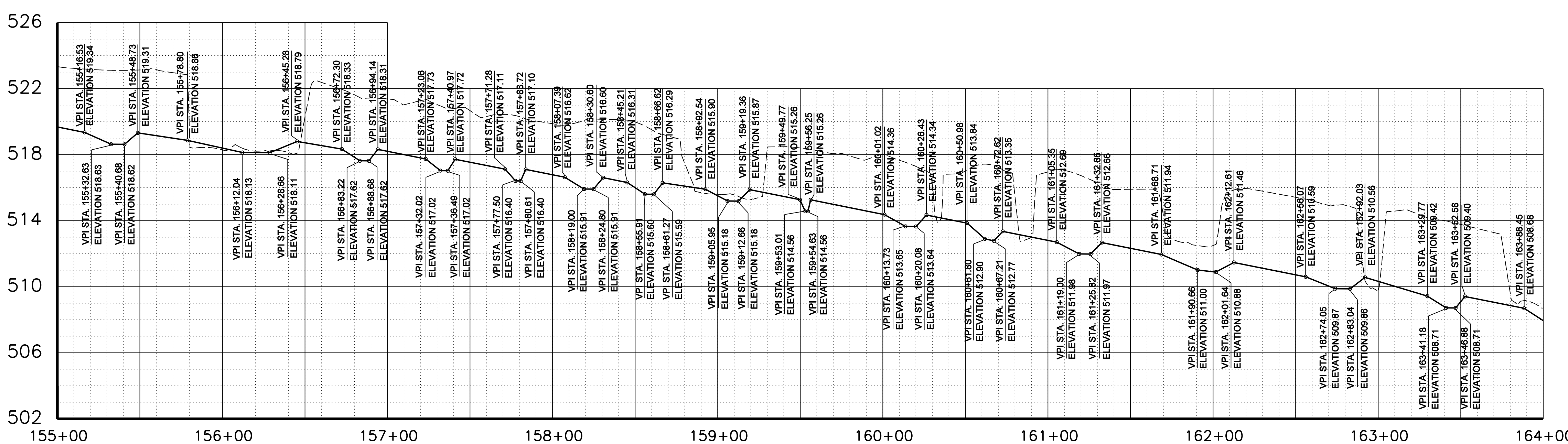
PLAN AND PROFILE

SHEET 14 OF 68









SYM.	DESCRIPTION	DATE	APPROVED
A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

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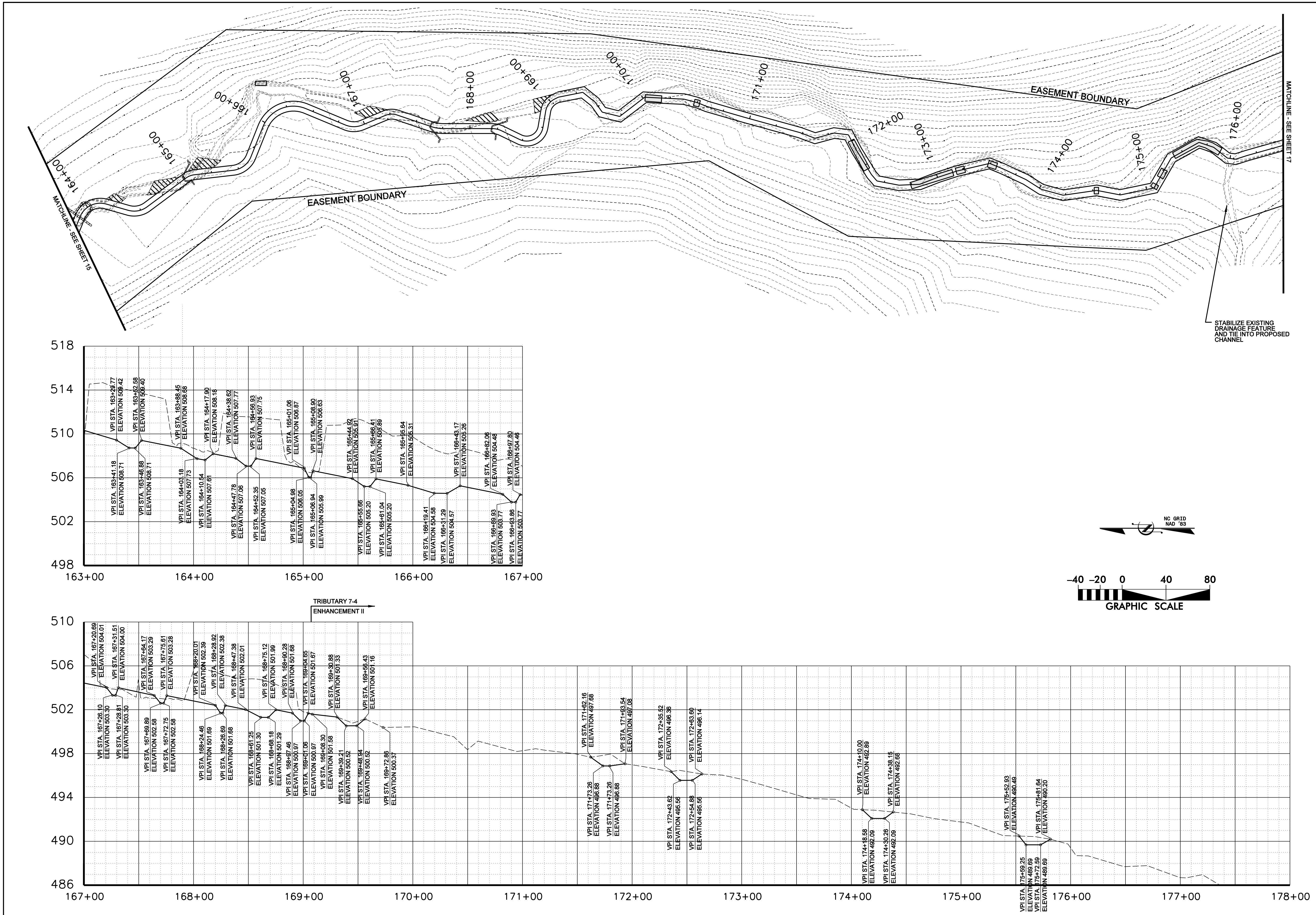
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-3: STATION 151+22 TO STATION 163+79

DATE: DEC 2007
SCALE: 1"=40'

PLAN
AND
PROFILE

SHEET 15 OF 68



A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	
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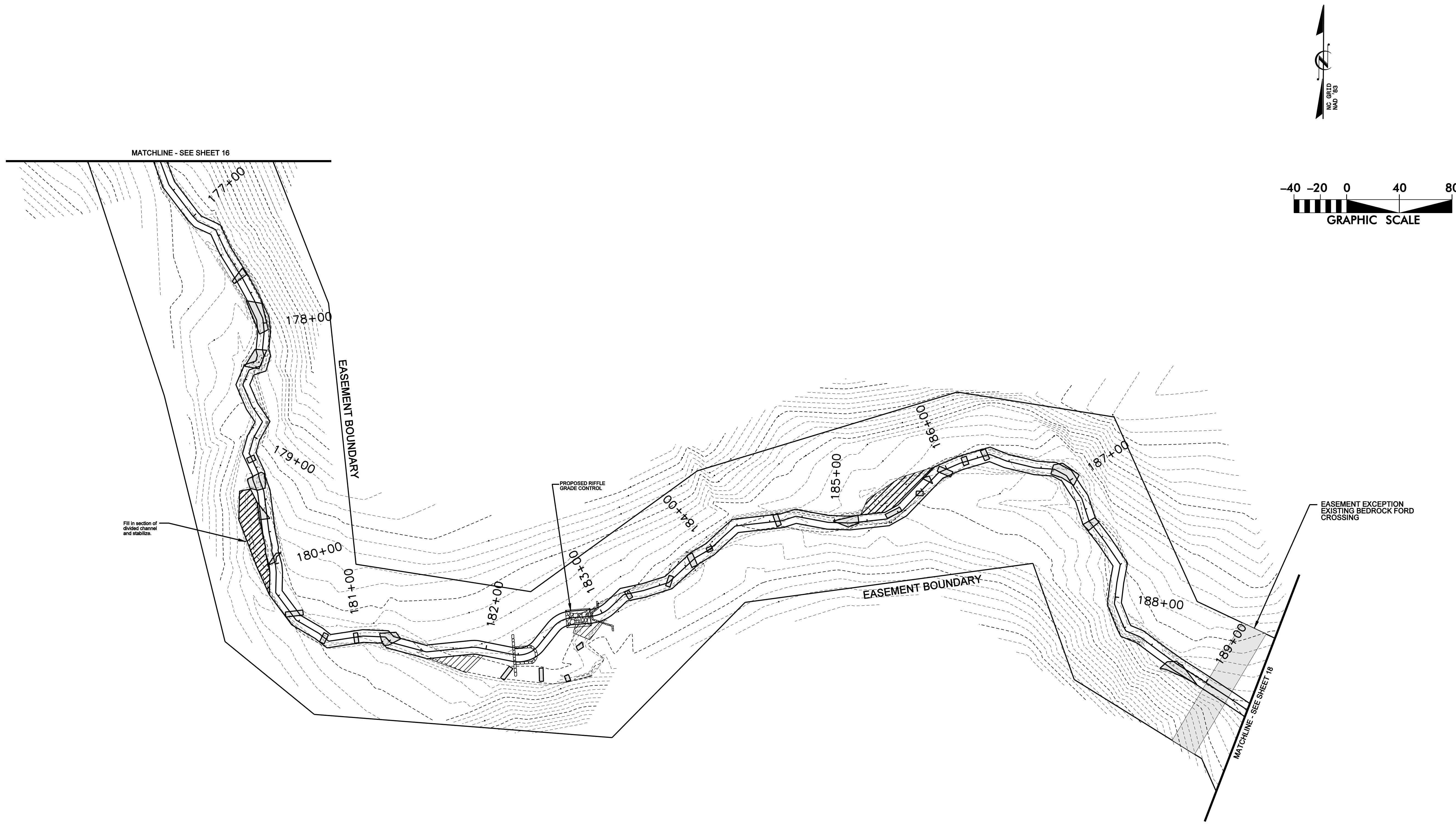
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-3, T7-4: STATION 163+79 TO STATION 176+51

DATE: DEC 2007
SCALE: 1"=40'

PLAN
AND
PROFILE

SHEET 16 OF 68



SYM.	DESCRIPTION	DATE	APPROVED
A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

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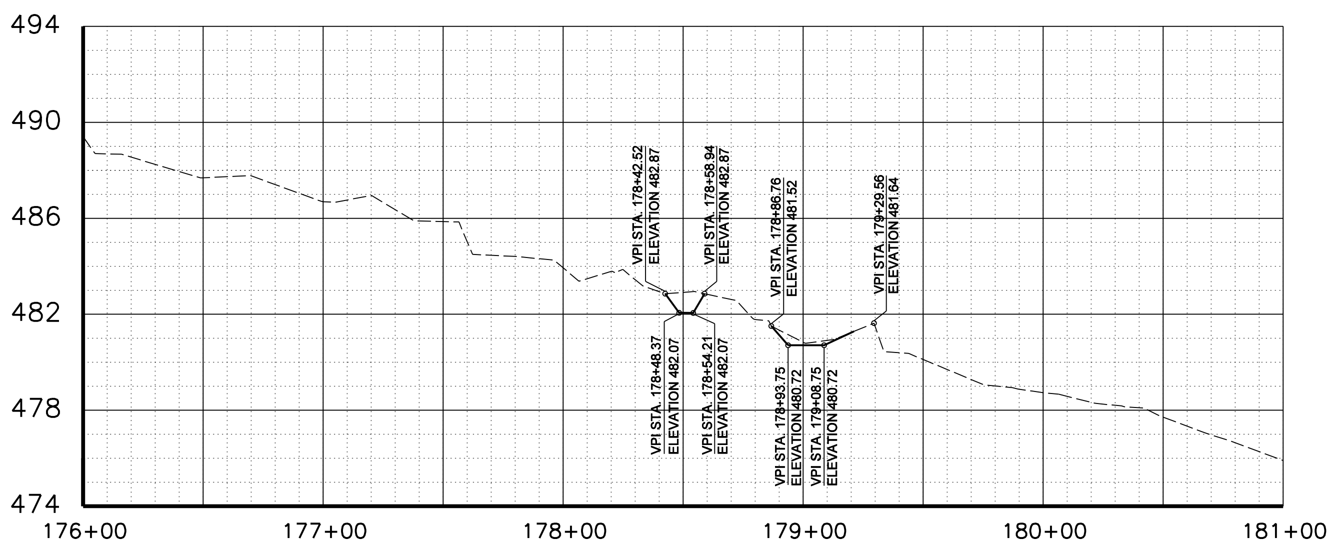
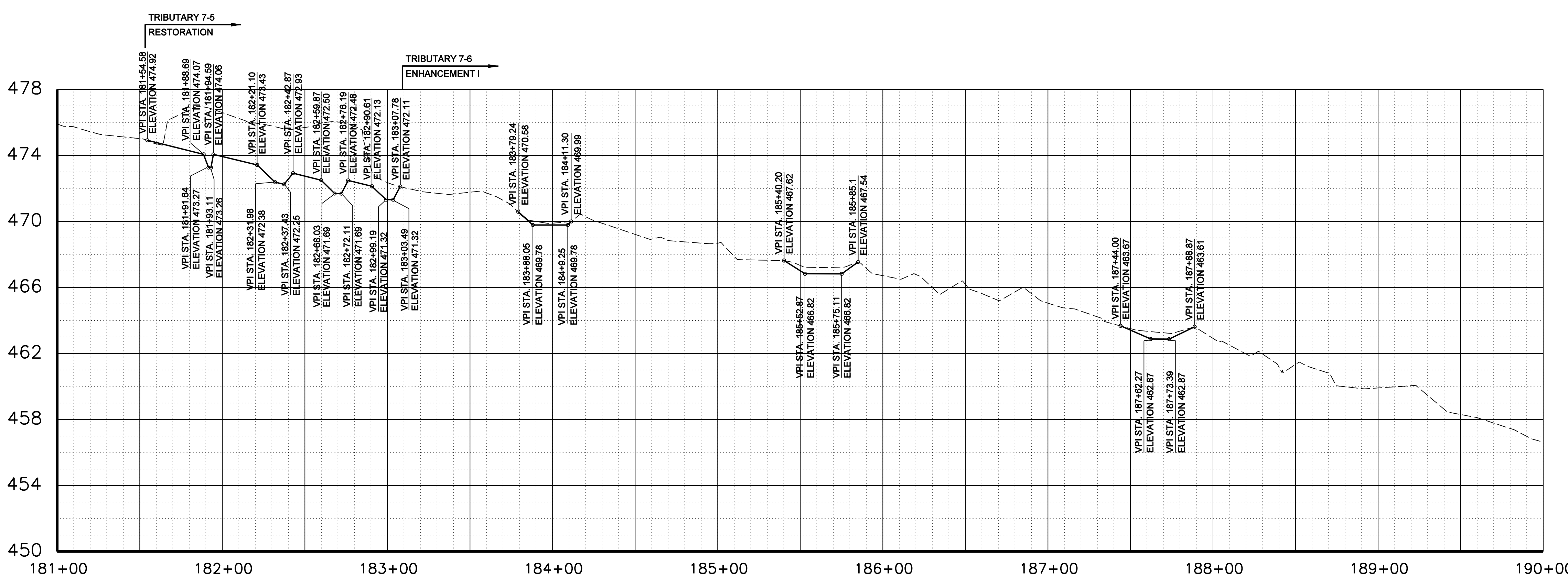
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-4, T7-5, T7-6: STATION 176+51 TO STATION 189+38

DATE: DEC 2007
SCALE: 1"=40'

PLAN
AND
PROFILE

SHEET 17 OF 68





SYM.	DESCRIPTION	DATE	APPROVED
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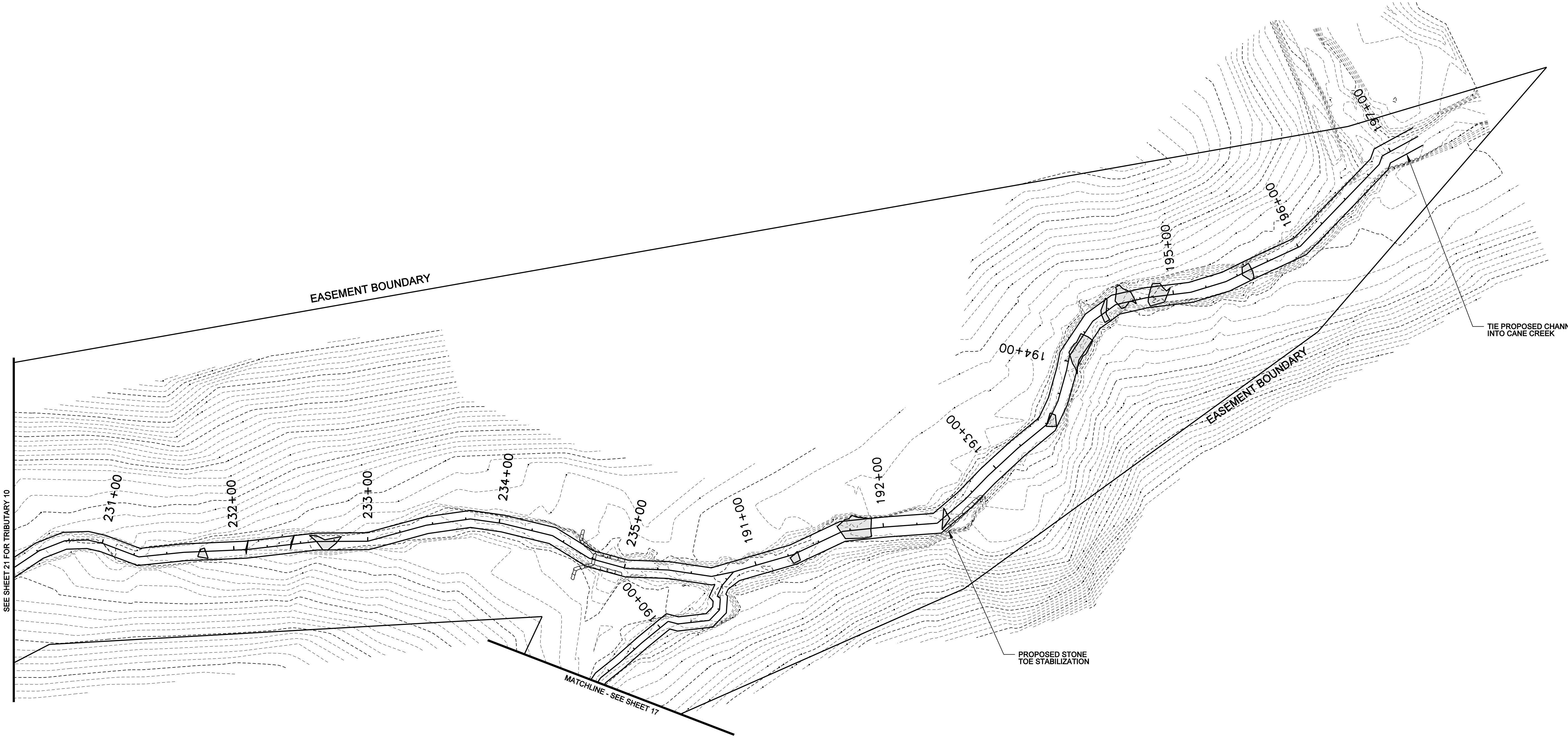
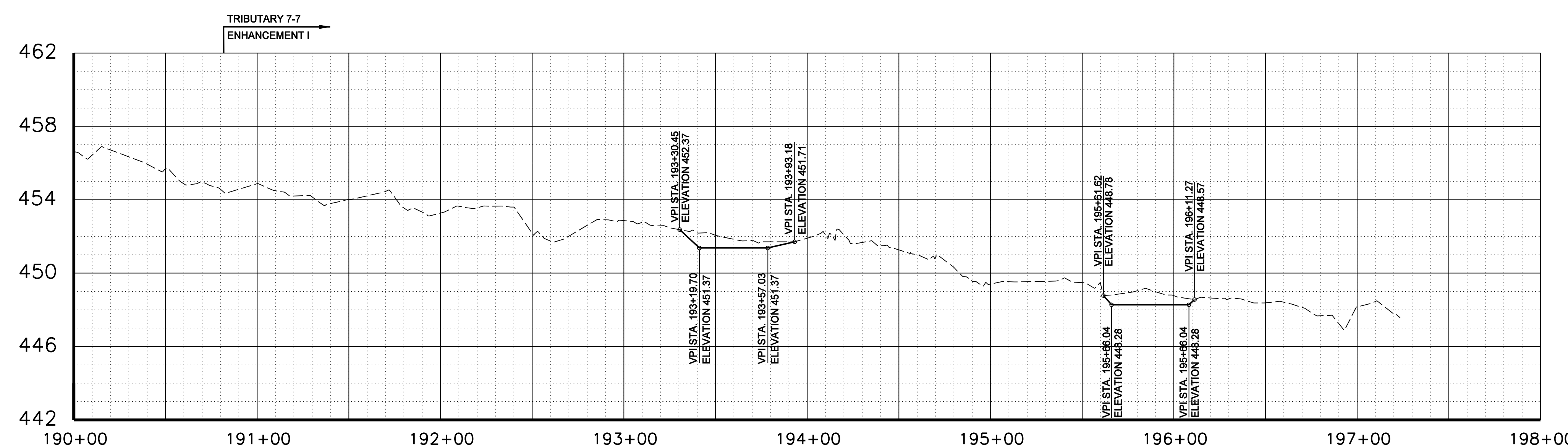
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-4, T7-5, T7-6: STATION 176+51 TO STATION 189+38

DATE: DEC 2007
SCALE: 1"=40'

PLAN
AND
PROFILE

SHEET 17A OF 68





SYM.	DESCRIPTION	DATE	APPROVED
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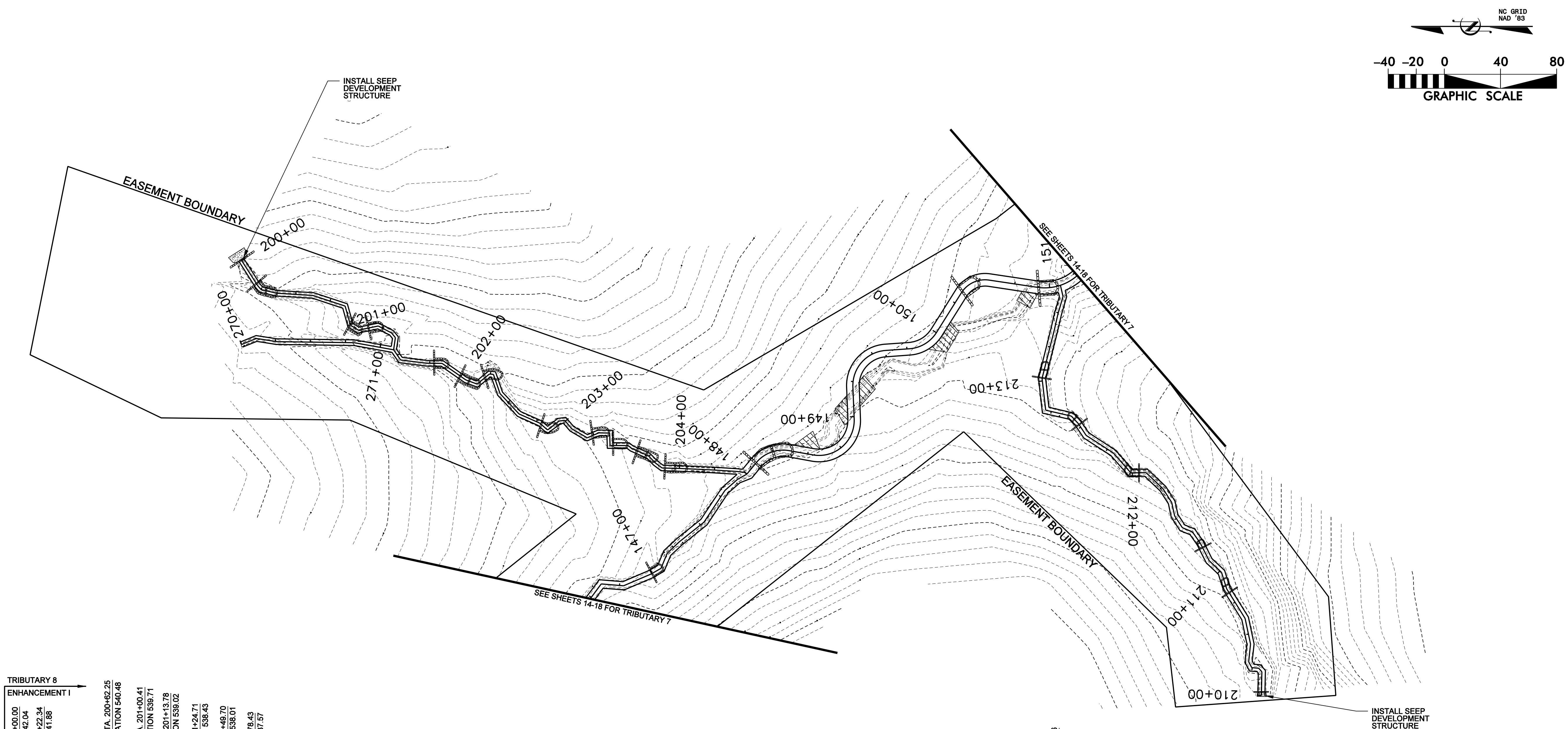
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA

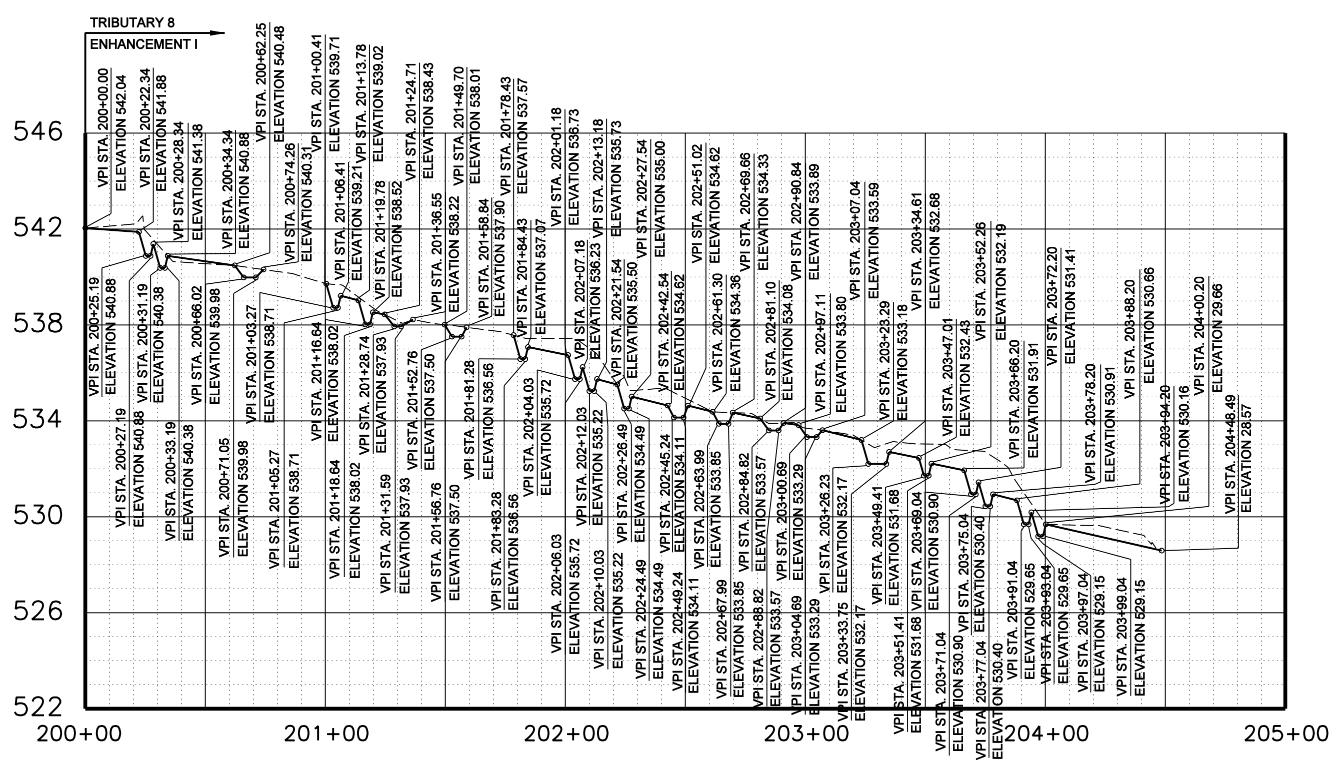
T7-6, T7-7: STATION 189+38 TO STATION 196+93

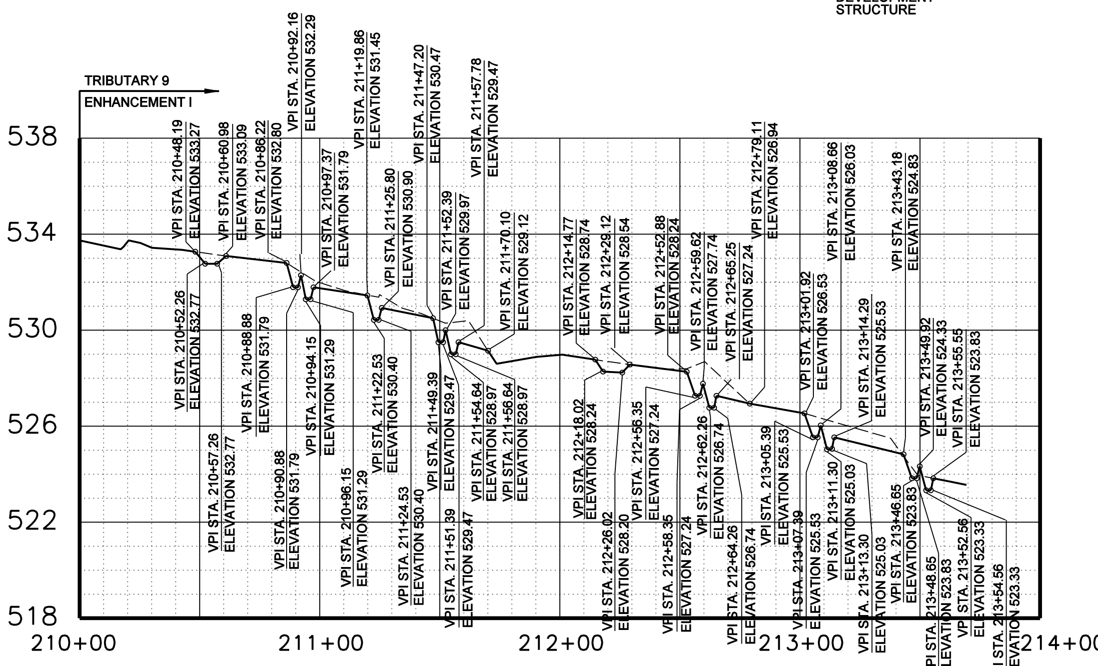
DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 18 OF 68







SYM.	DESCRIPTION	DATE	APPROVED
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CANE CREEK STREAM RESTORATION PROJECT

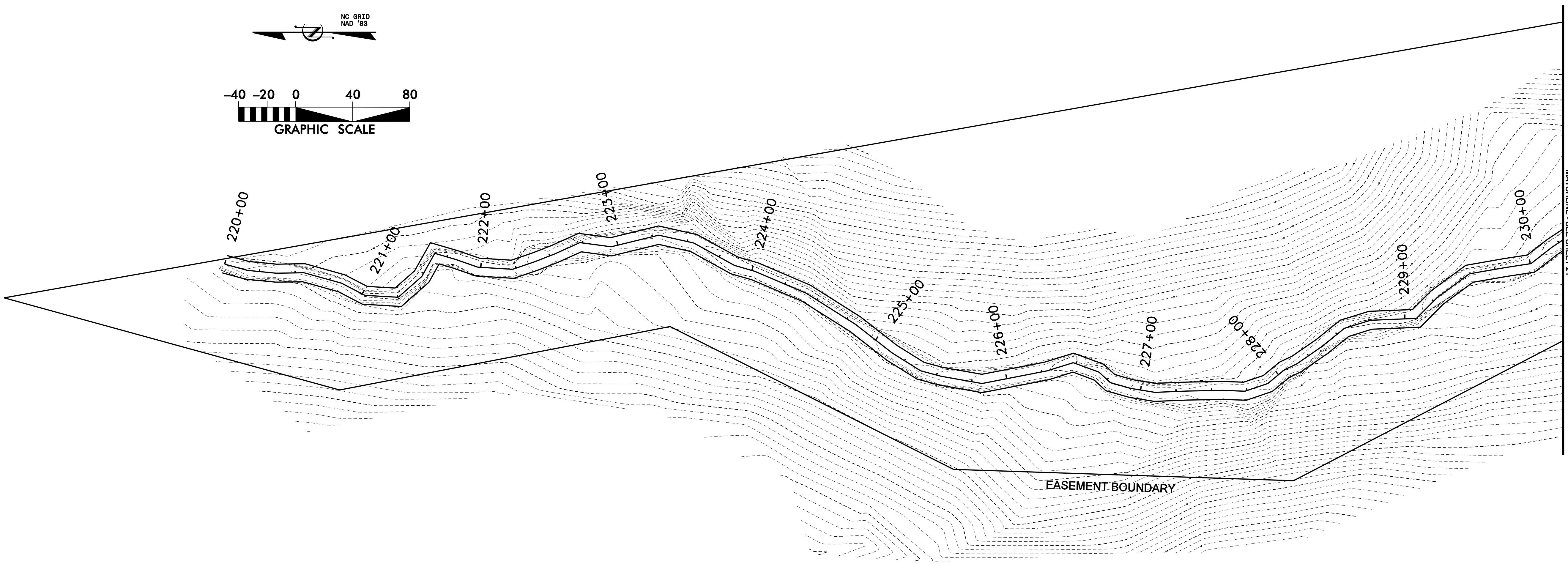
SEMORA, PERSON COUNTY, NORTH CAROLINA

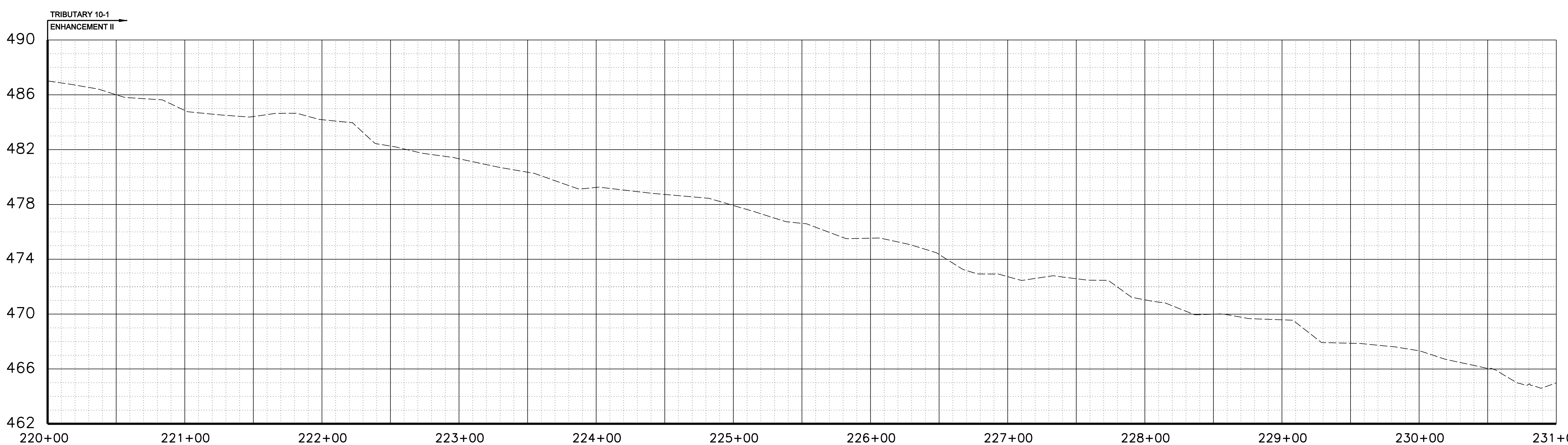
T8A, T8, T9: STA 270+00 TO 271+10, STA 200+00 TO 204+49, AND STA 210+00 TO 213+69

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 19 OF 68





SYM.	DESCRIPTION	DATE	APPROVED
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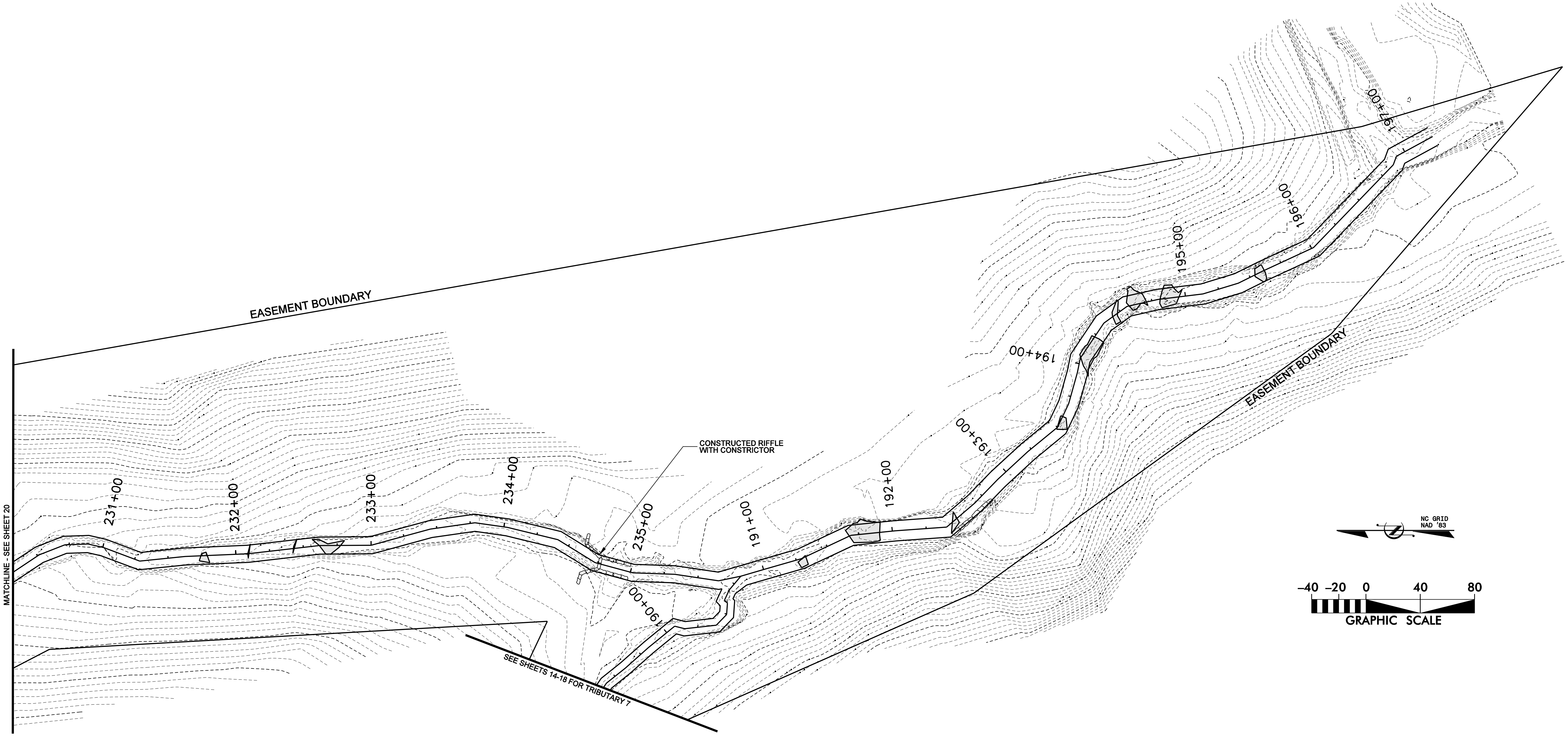
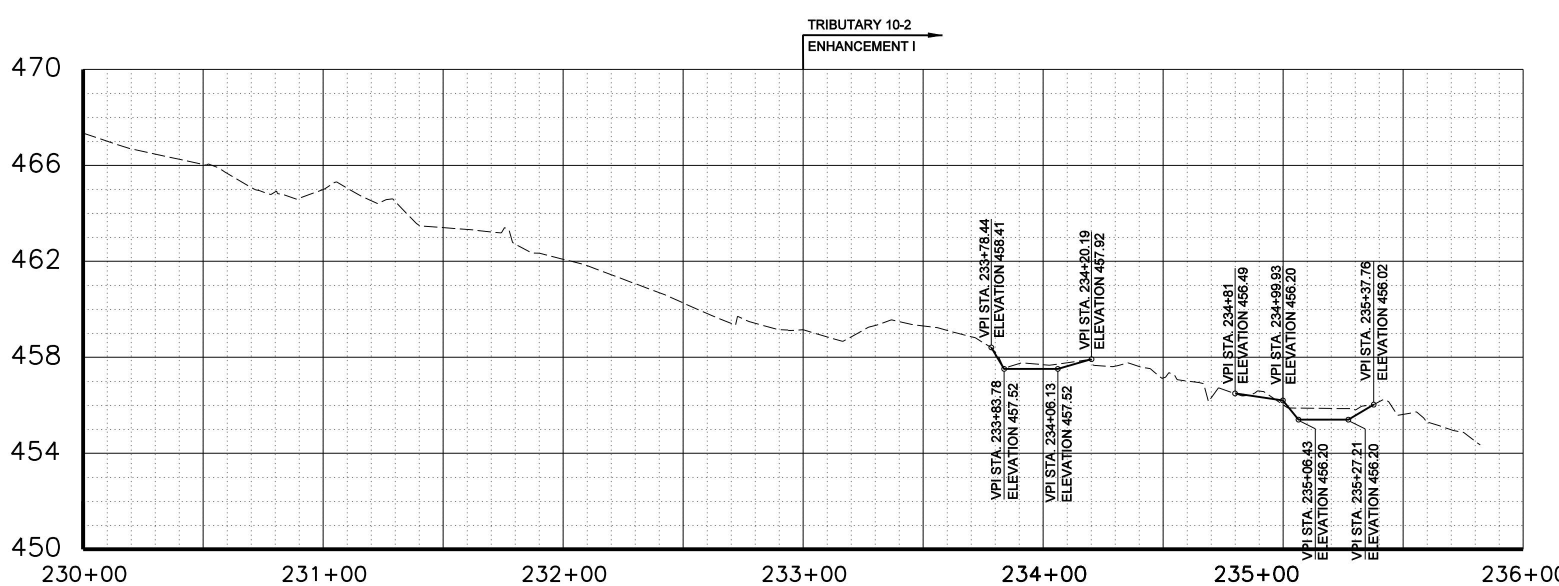
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T10: STATION 220+00 TO STATION 230+29

DATE: DEC 2007
SCALE: 1"=40'

PLAN
AND
PROFILE

SHEET 20 OF 68





SYM.	DESCRIPTION	DATE	APPROVED
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CANE CREEK STREAM RESTORATION PROJECT

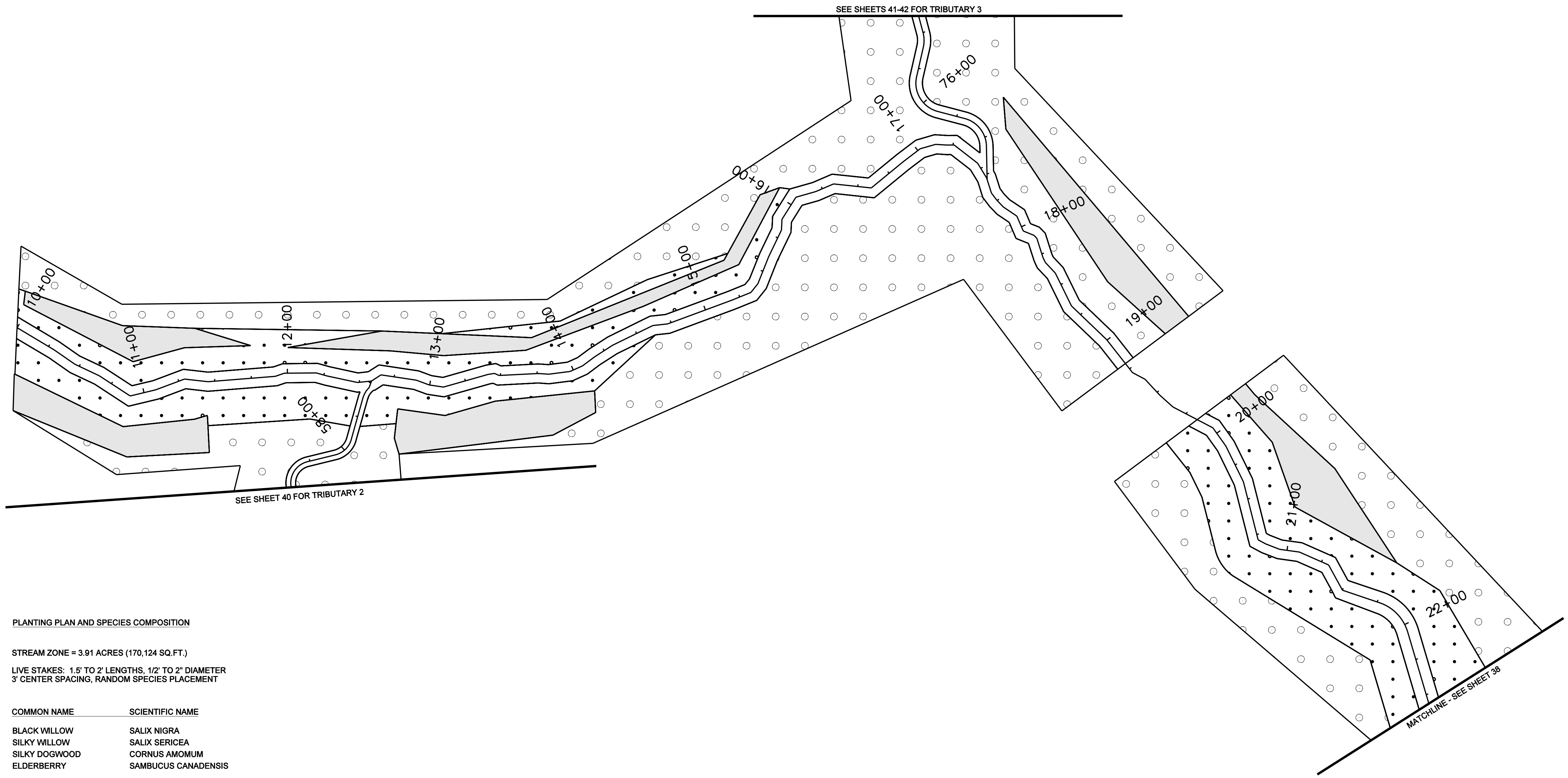
SEMORA, PERSON COUNTY, NORTH CAROLINA

T10-1, T10-2: STATION 230+29 TO STATION 235+82

DATE: DEC 2007
SCALE: 1"=40'

PLAN AND PROFILE

SHEET 21 OF 68



PLANTING PLAN AND SPECIES COMPOSITION

ZONE A

STREAM ZONE = 3.91 ACRES (170,124 SQ.FT.)

LIVE STAKES: 1.5' TO 2' LENGTHS, 1/2" TO 2" DIAMETER
3' CENTER SPACING, RANDOM SPECIES PLACEMENT

COMMON NAME	SCIENTIFIC NAME
BLACK WILLOW	SALIX NIGRA
SILKY WILLOW	SALIX SERICEA
SILKY DOGWOOD	CORNUS AMOMUM
ELDERBERRY	SAMBUCUS CANADENSIS

NOTE: NO SINGLE LIVE STAKING SPECIES SHALL COMPOSE MORE THAN 40% OF THE 21,776 TOTAL NUMBER OF LIVE STAKES TO BE INSTALLED

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA = 3.20 ACRES

12" - 18" BARE ROOT MATERIAL
436 STEMS/ACRE (10' X 10' SPACING), RANDOM SPECIES PLACEMENT

COMMON NAME	SCIENTIFIC NAME	% OF TOTAL	# OF PLANTS
CORALBERRY	SYMPHORICARPOS ORBICULATAS	5	85
SPICEBUSH	LINDERA BENZOIN	5	85
WINTERBERRY	ILEX VERTICILLATA	10	170
POSSUMHAW	VIBURNUM NUDUM	10	170
GREEN ASH	FRAXINUS PENNSYLVANICA	10	170
SYCAMORE	PLATANUS OCCIDENTALIS	10	170
RIVER BIRCH	BETULA NIGRA	10	170
SWAMP CHESTNUT OAK	QUERCUS MICHAUXII	10	170
WILLOW OAK	QUERCUS PHELLOS	10	170
PERSIMMON	DIOSPYROS VIRGINIANA	10	170
TAG ALDER	ALNUS SERRULATA	10	170
		100	1,700

* UNDISTURBED FORESTED AREAS WITHIN PLANTING ZONE WILL NOT BE PLANTED

ZONE C

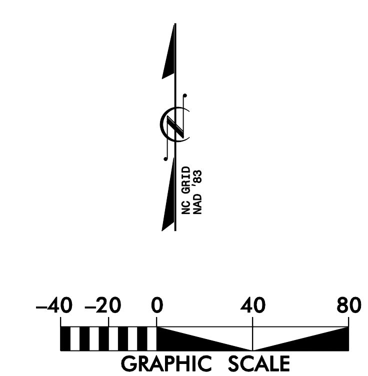
MESIC MIXED HARDWOOD FOREST PLANTING AREA = 25.28 ACRES

12" - 18" BARE ROOT MATERIAL
436 STEMS/ACRE (10' X 10' SPACING), RANDOM SPECIES PLACEMENT

COMMON NAME	SCIENTIFIC NAME	% OF TOTAL	# OF PLANTS
CORALBERRY	SYMPHORICARPOS ORBICULATAS	5	676
SPICEBUSH	LINDERA BENZOIN	10	1,352
POSSUMHAW	VIBURNUM NUDUM	5	676
PERSIMMON	DIOSPYROS VIRGINIANA	10	1,352
BLACK WALNUT	JUGLANS NIGRA	10	1,352
SHAGBARK HICKORY	CARYA OVATA	15	2,028
S. RED OAK	QUERCUS FALCATA	15	2,028
WITCHHAZEL	HAMAMELIS VIRGINIANA	15	2,028
TULIP POPLAR	LIRIODENDRON TULIPIFERA	15	2,028
		100	13,520

* UNDISTURBED FORESTED AREAS WITHIN PLANTING ZONE WILL NOT BE PLANTED

EXISTING TREES



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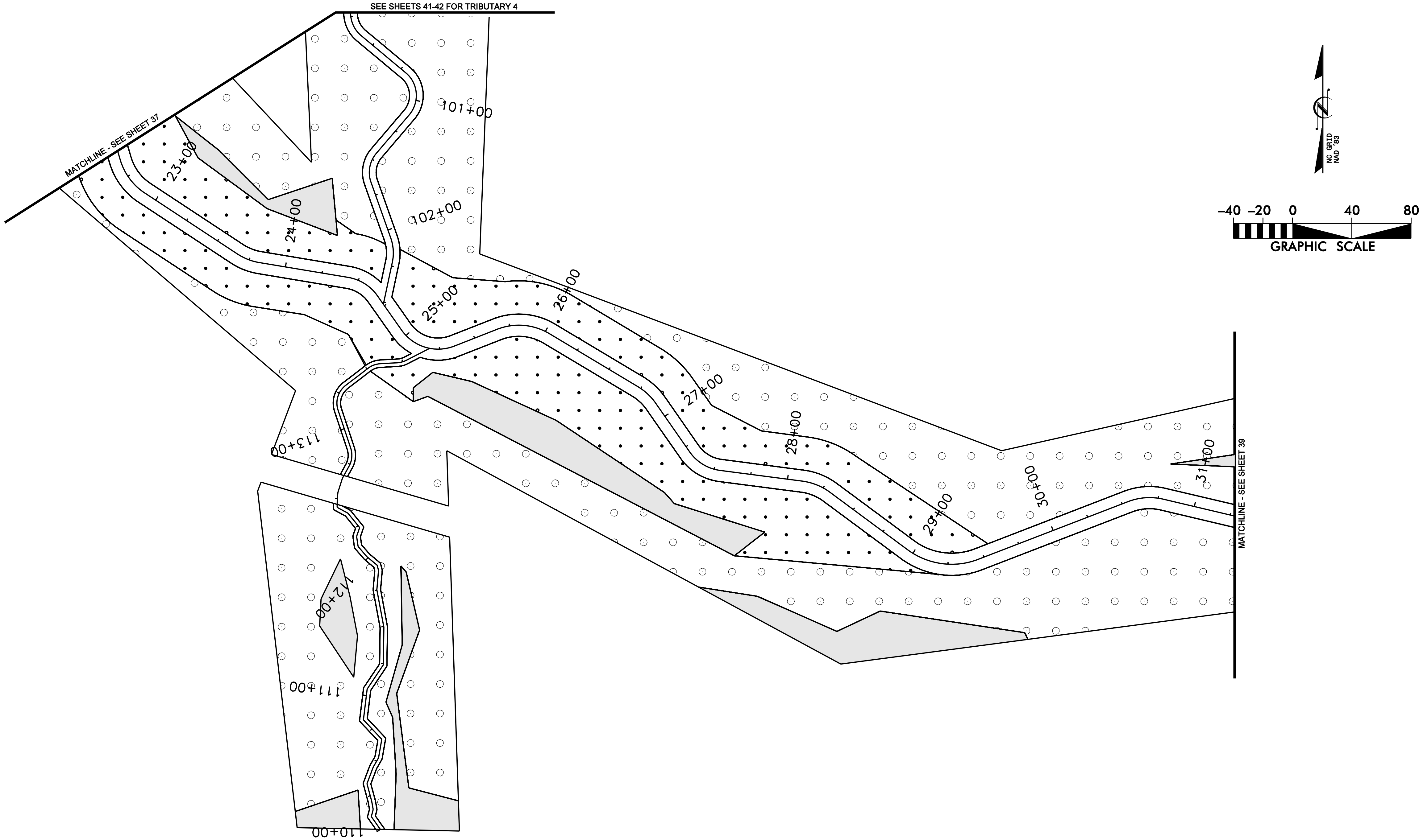
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T1-1, T1-2, T1-3: STATION 40+00 TO STATION 54+71

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 37 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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CANE CREEK STREAM RESTORATION PROJECT

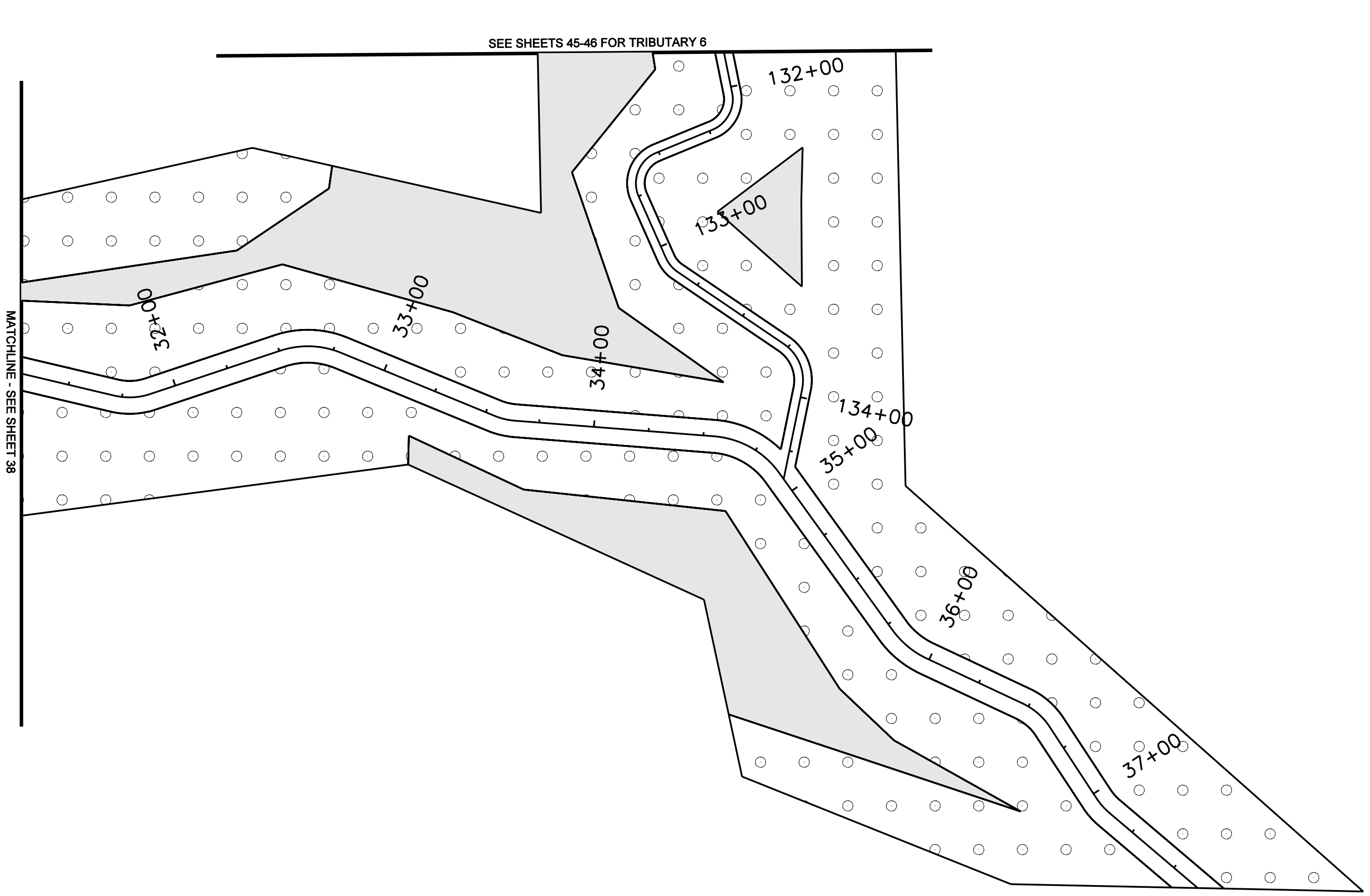
SEMORA, PERSON COUNTY, NORTH CAROLINA

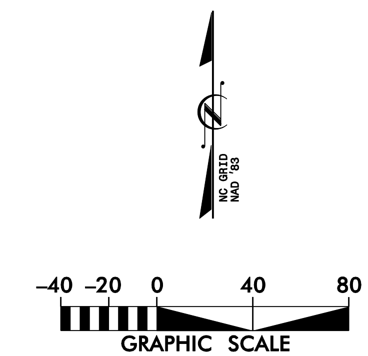
T1-3, T1-4, T1-5: STA 22+56 TO 31+28 AND STA 110+00 TO 113+82

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 38 OF 68





ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

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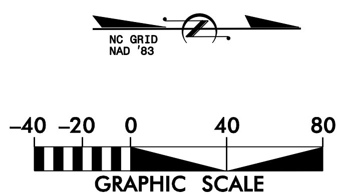
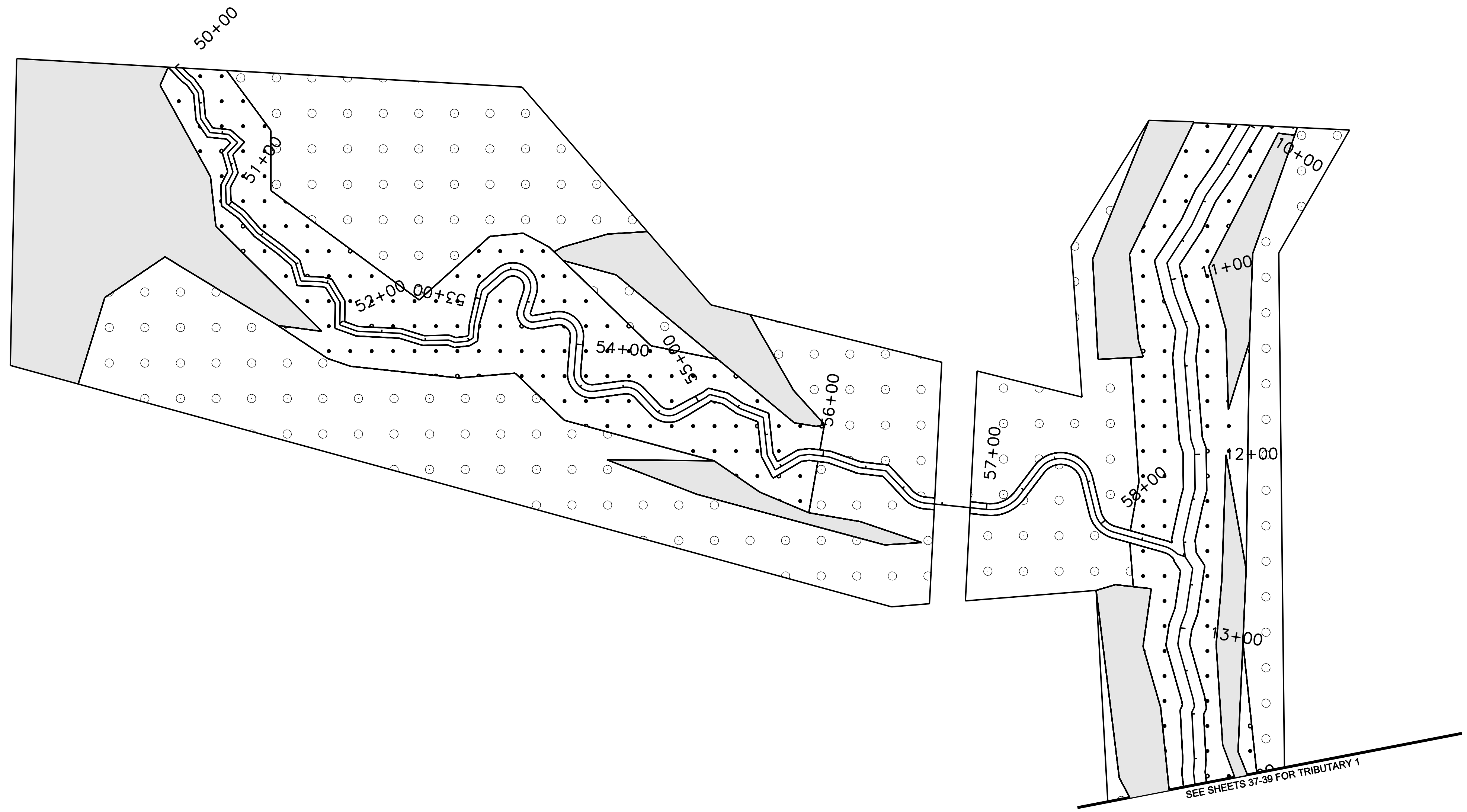
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T1-4, T1-5: STATION 31+28 TO STATION 37+64

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 39 OF 68





ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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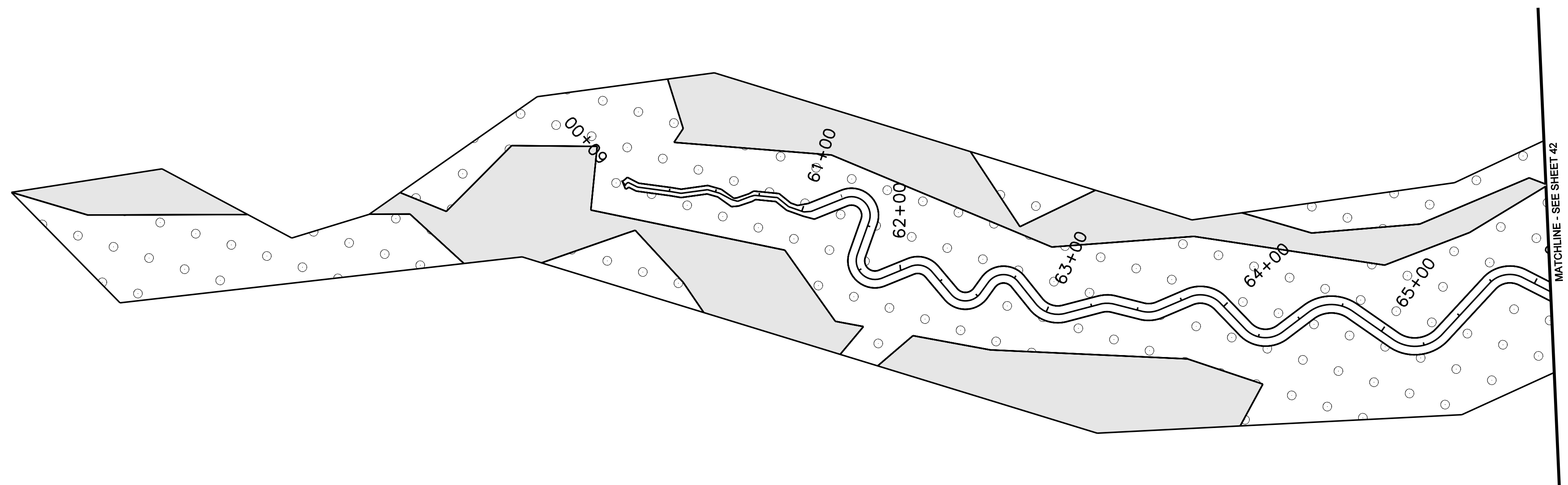
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T2-1, T2-2, T2-3, T2-4: STATION 50+00 TO STATION 58+63

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 40 OF 68



ZONE A

STREAM ZONE PLANTING AREA

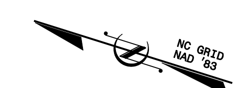
ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES



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CANE CREEK STREAM RESTORATION PROJECT

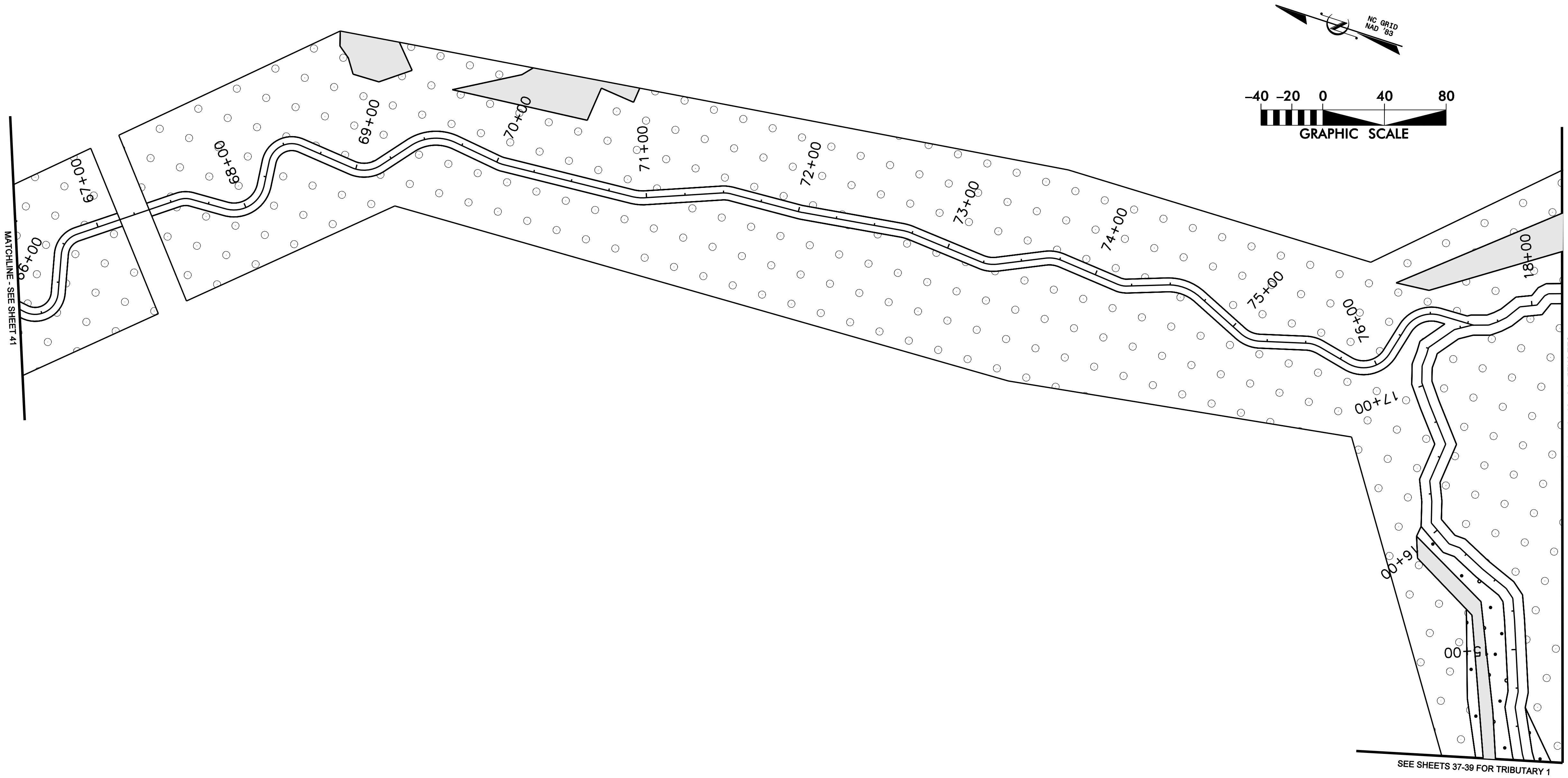
SEMORA, PERSON COUNTY, NORTH CAROLINA

T3-1, T3-2: STATION 60+00 TO STATION 66+10

DATE: DEC 2007

SCALE: 1"=40'

PLANTING PLAN



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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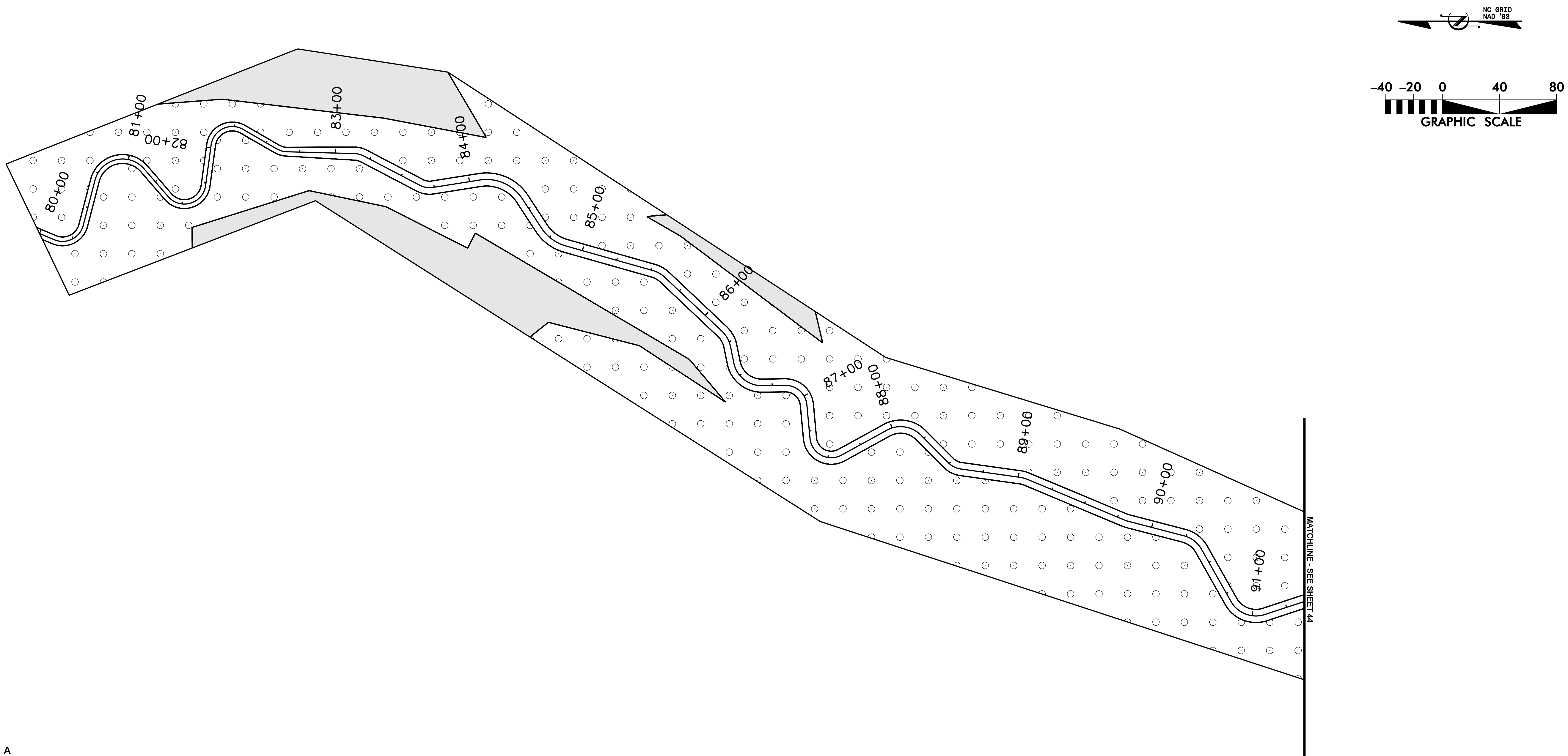
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T3-2: STATION 66+10 TO STATION 76+79

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

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A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

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Ecosystem Enhancement PROGRAM

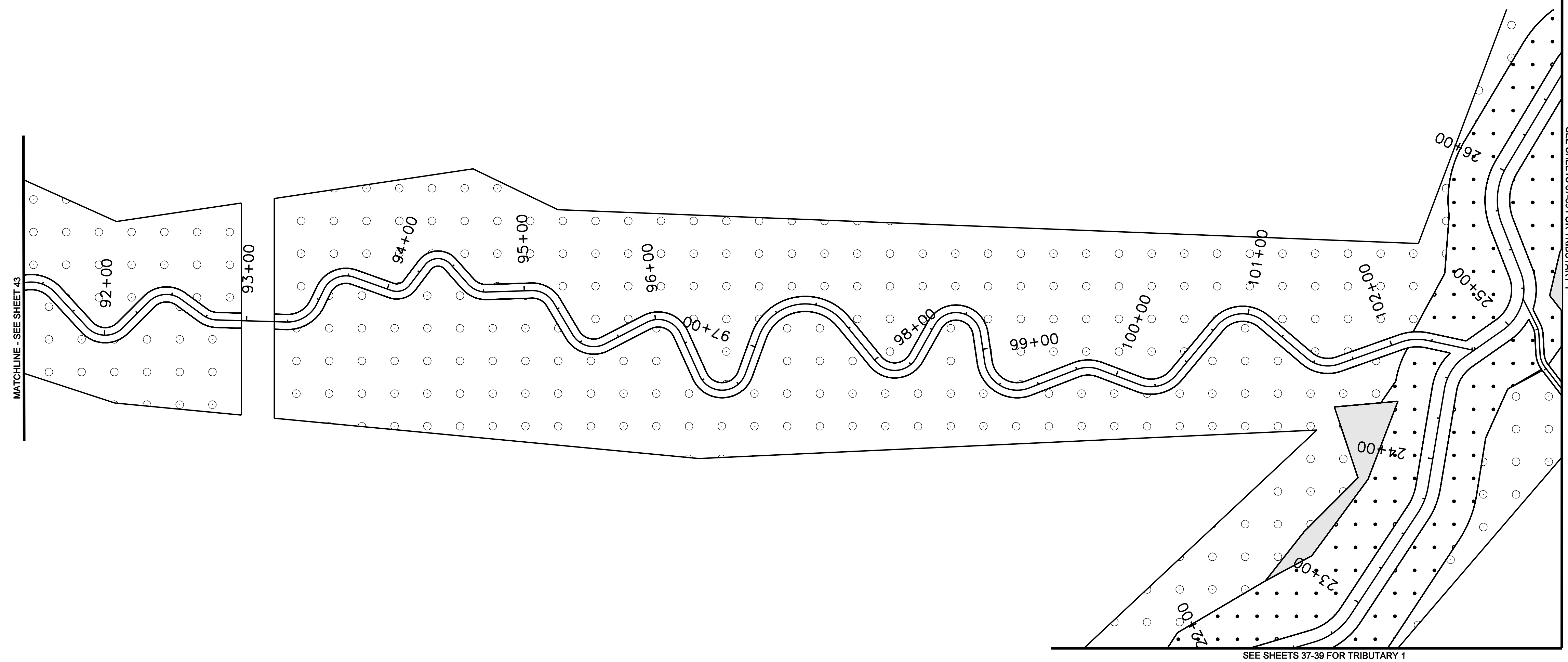
KCI TECHNOLOGIES
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

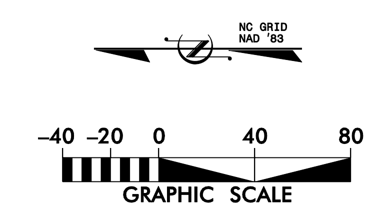
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T4-1, T4-2: STATION 80+00 TO STATION 91+38

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 43 OF 68





ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
A	SUBMITTED WITH RESTORATION PLAN	DEC 2007	

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Ecosystem Enhancement PROGRAM

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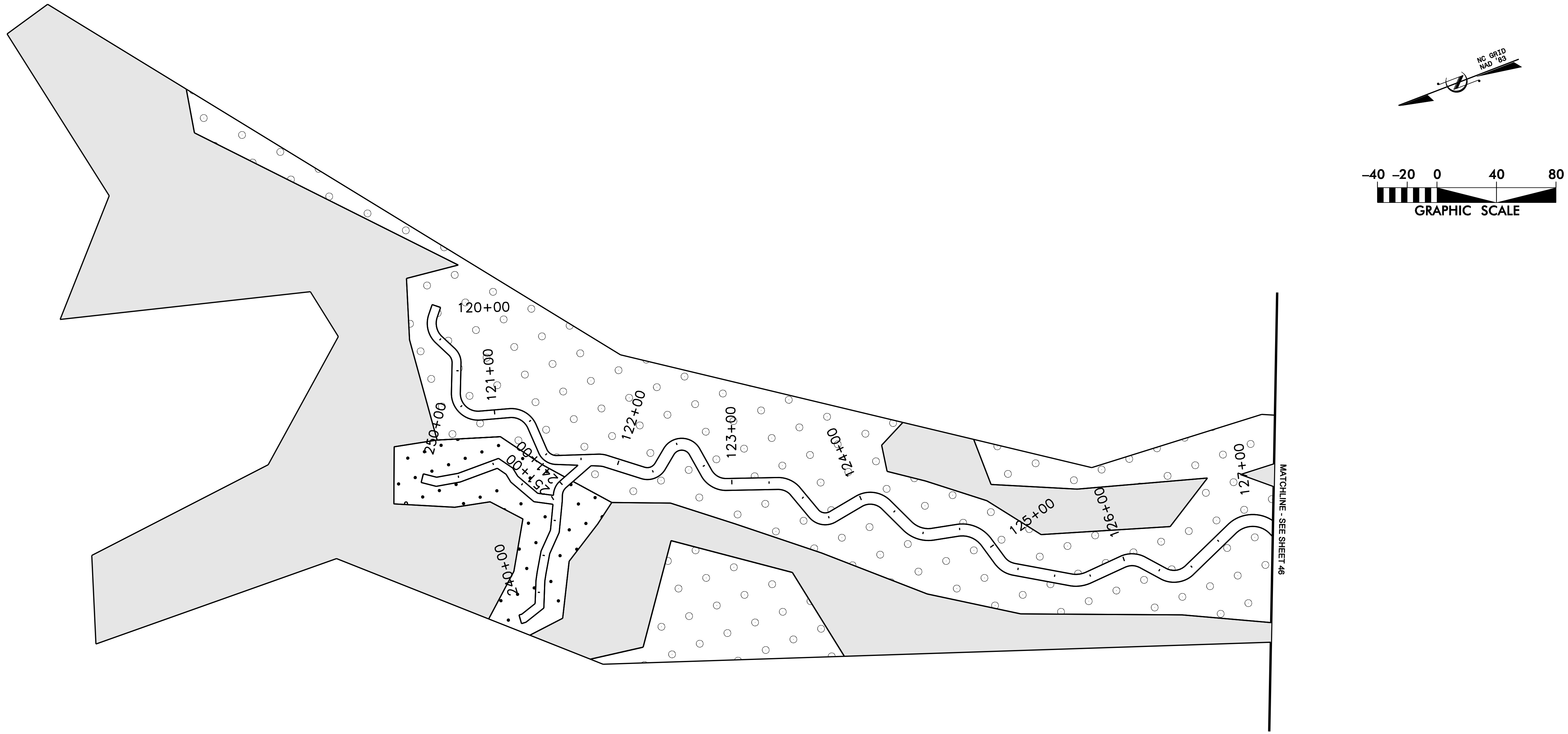
RALEIGH, NORTH CAROLINA 27609

CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T4-2: STATION 91+38 TO STATION 102+52

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN



ZONE A — STREAM ZONE PLANTING AREA

ZONE B — PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C — MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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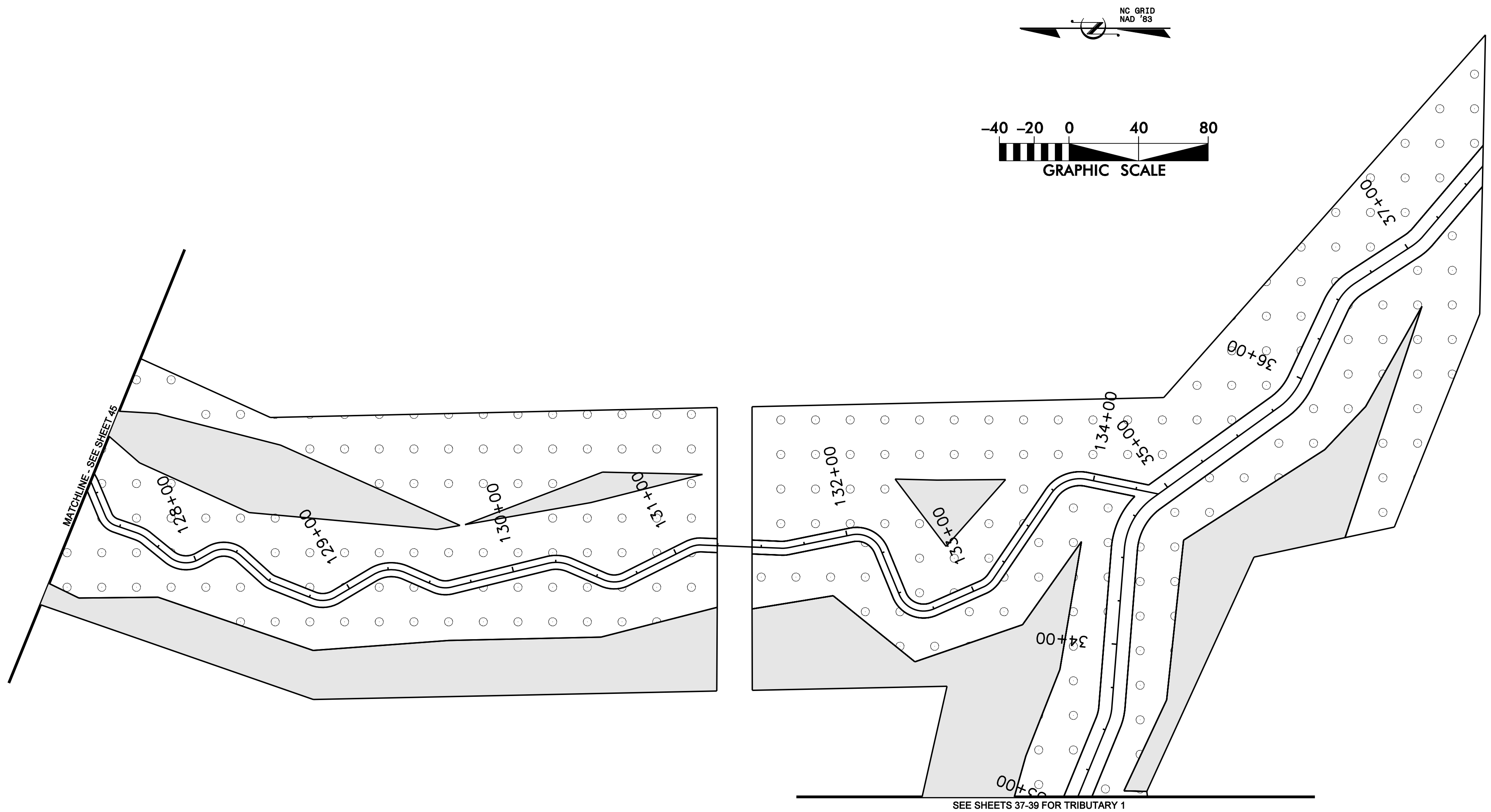
RALEIGH, NORTH CAROLINA 27609

CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T6A, T6B, T6AB, T6C, T6: STA 240+00 TO 241+19
AND STA 120+00 TO 127+18

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 45 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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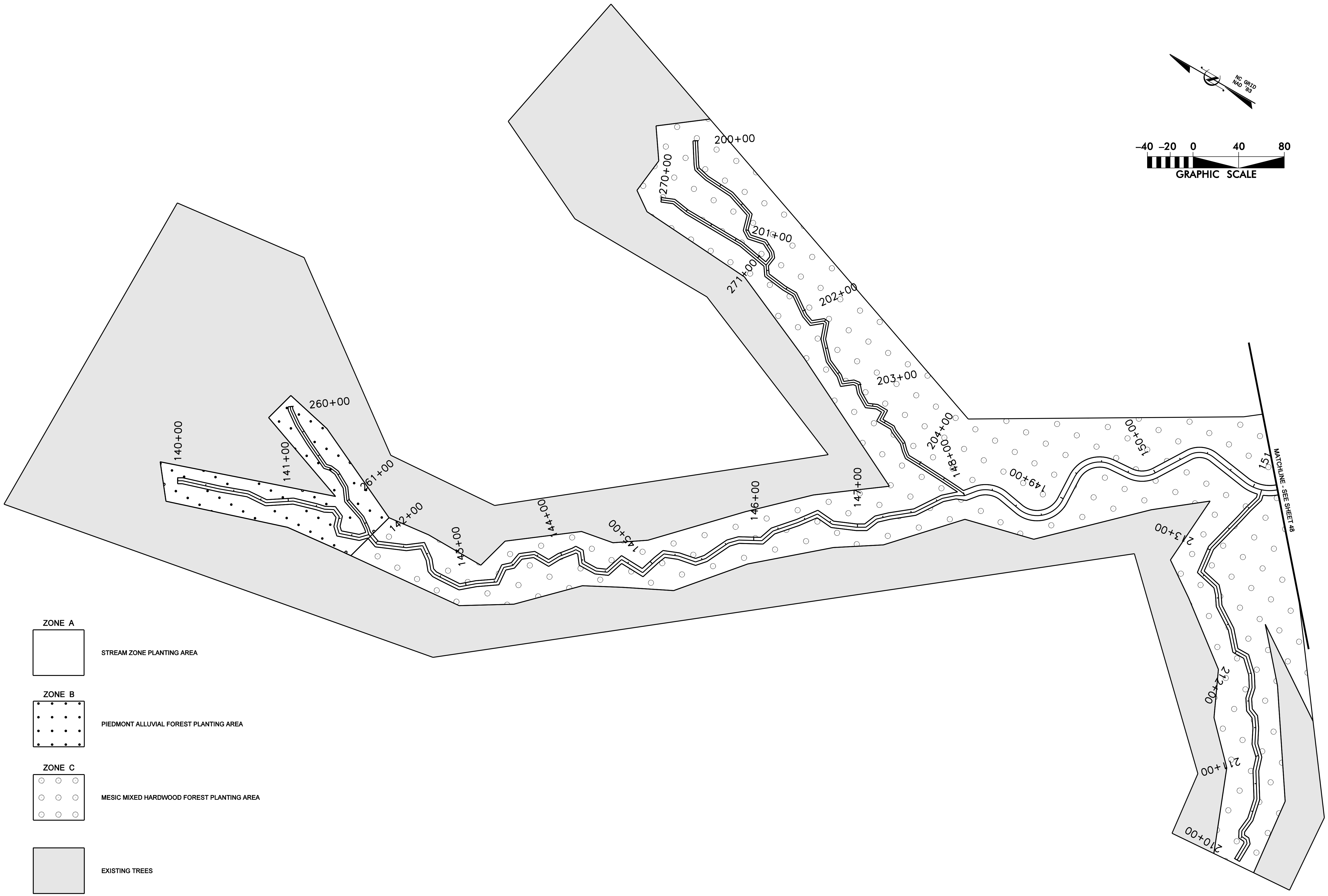
CANE CREEK
STREAM RESTORATION PROJECT

SEMORA, PERSON COUNTY, NORTH CAROLINA

T6: STATION 127+18 TO STATION 134+38

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN



SYM.	DESCRIPTION	DATE	APPROVED
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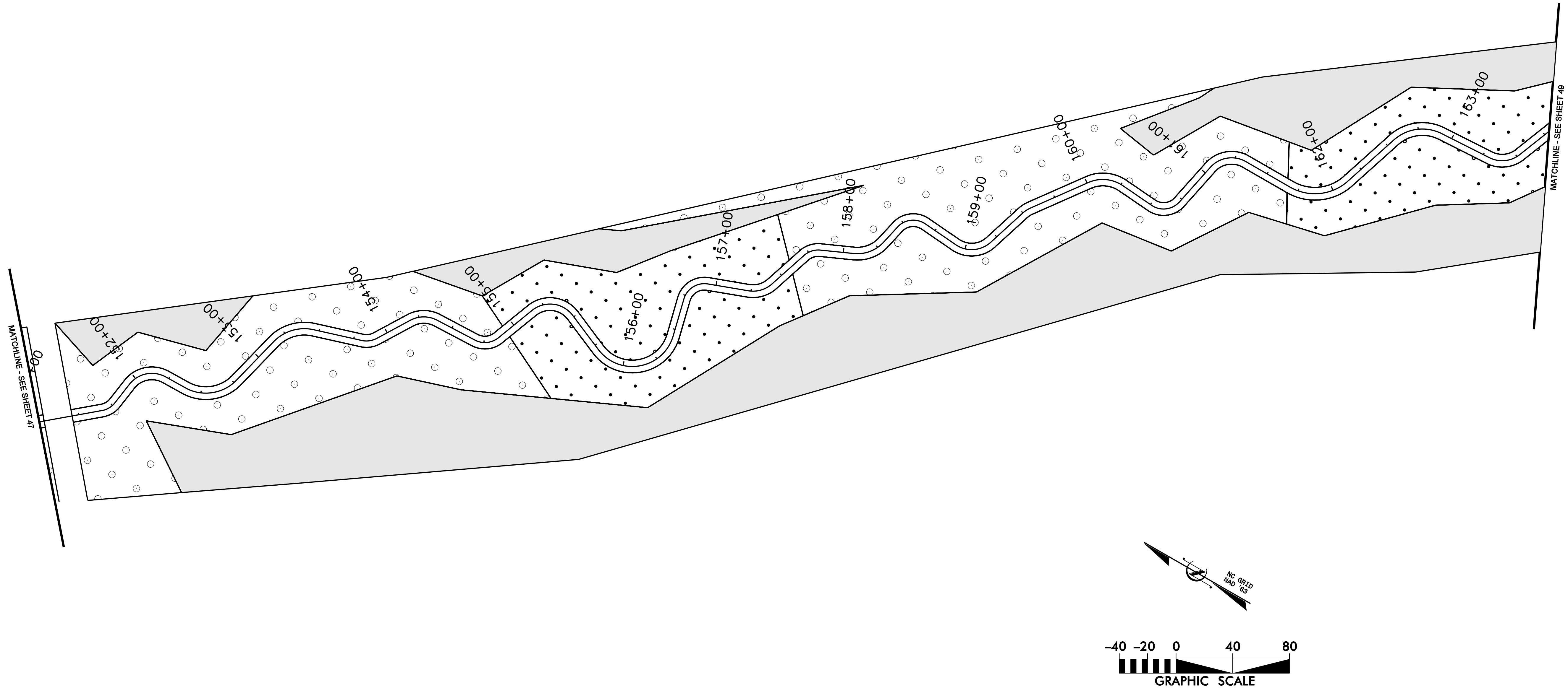
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7A, T7-1, T7-2, T7-3, T8A, T8, T9: STA 260+00 TO 261+36,
STA 140+00 TO 151+22, STA 270+00 TO 271+10,
STA 200+00 TO 204+49 AND STA 210+00 TO 213+69

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 47 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

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CANE CREEK STREAM RESTORATION PROJECT

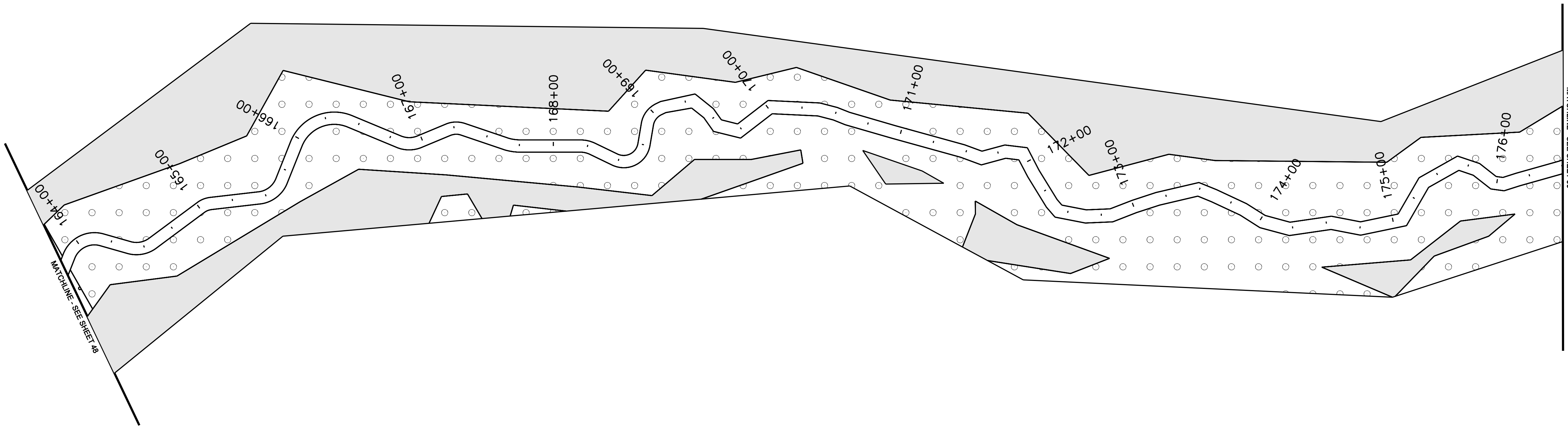
SEMORA, PERSON COUNTY, NORTH CAROLINA

T7-3: STATION 151+22 TO STATION 163+79

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 48 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

NC GRID NAD '83

-40 -20 0 40 80

GRAPHIC SCALE

SYM.	DESCRIPTION	DATE	APPROVED
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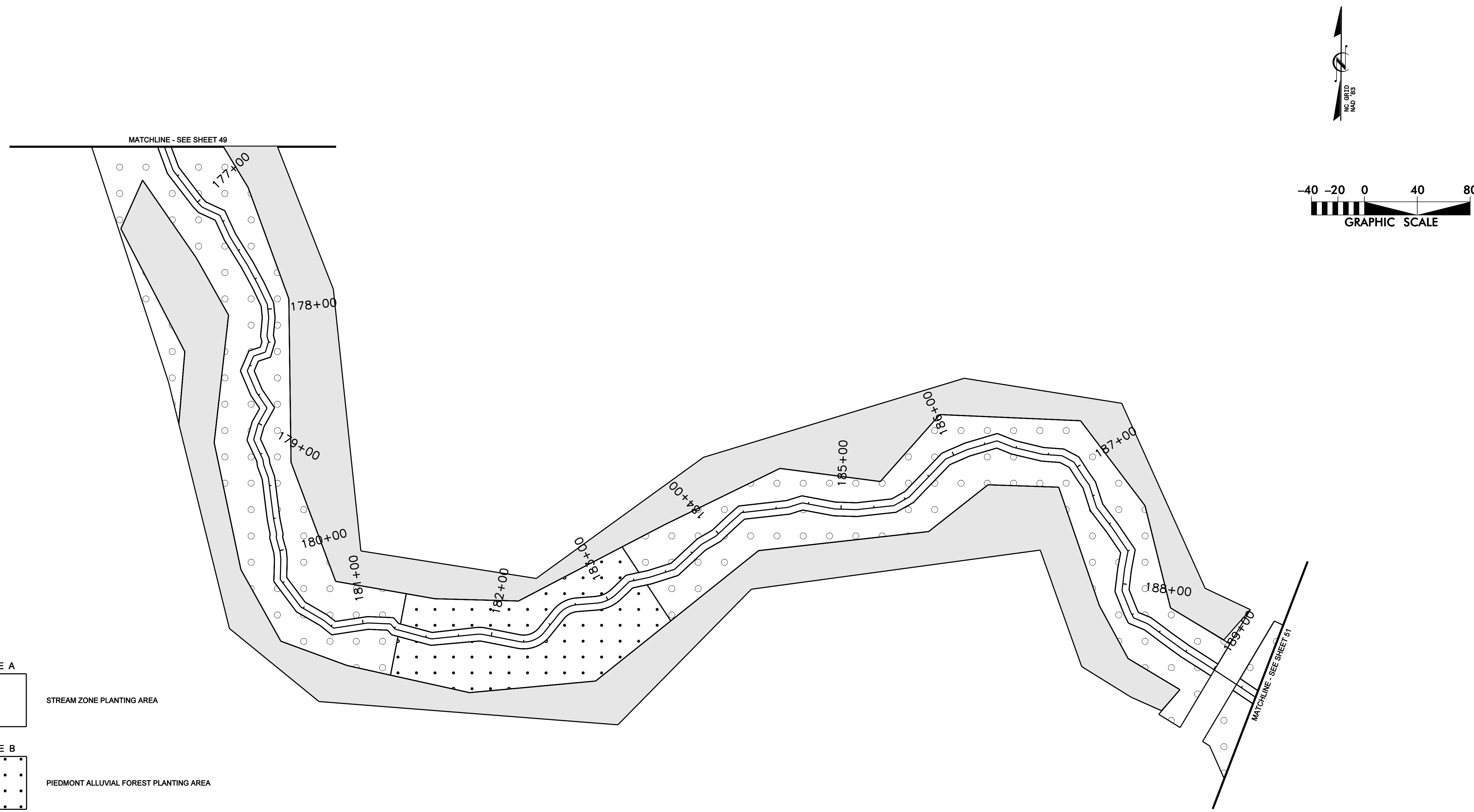
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-3, T7-4: STATION 163+79 TO STATION 176+51

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 49 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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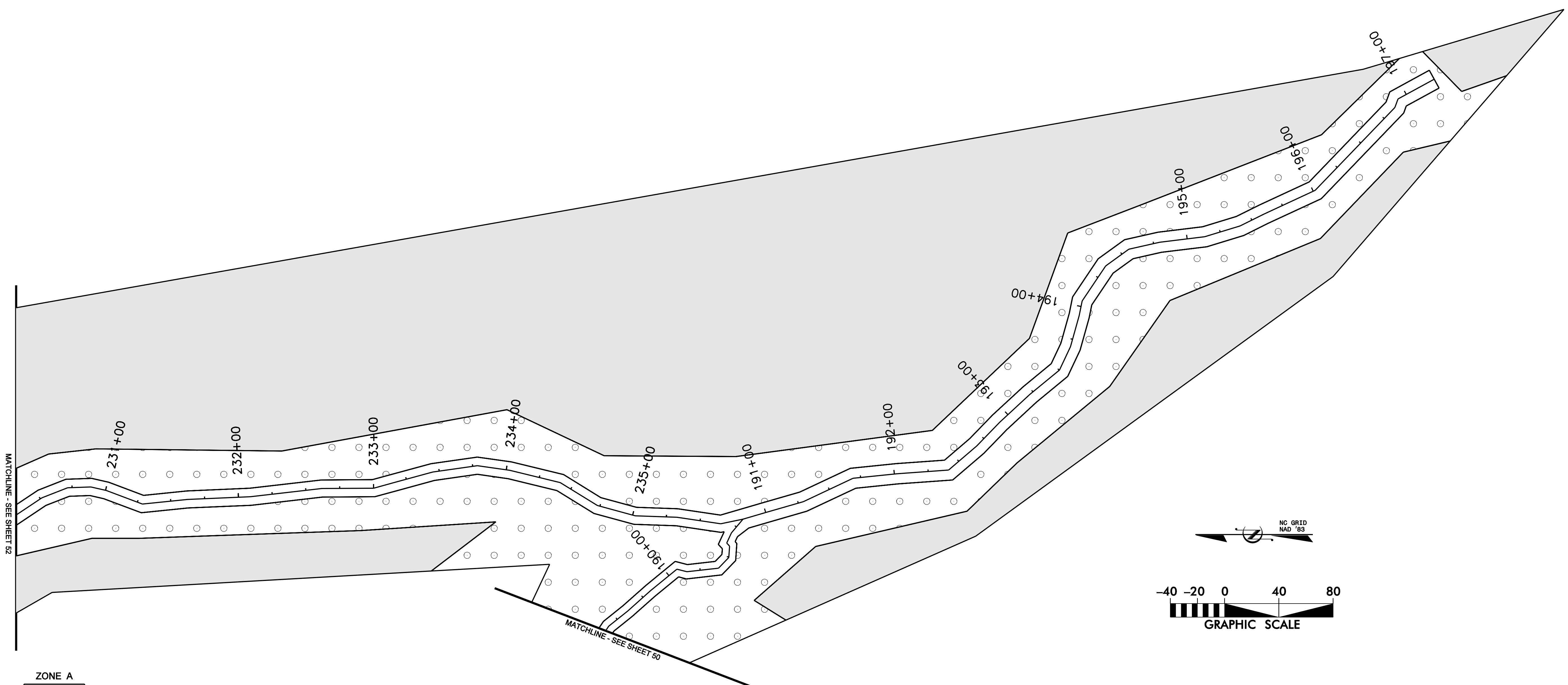
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T7-4, T7-5, T7-6: STATION 176+51 TO STATION 189+38

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 50 OF 68



ZONE A

STREAM ZONE PLANTING AREA

ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES

SYM.	DESCRIPTION	DATE	APPROVED
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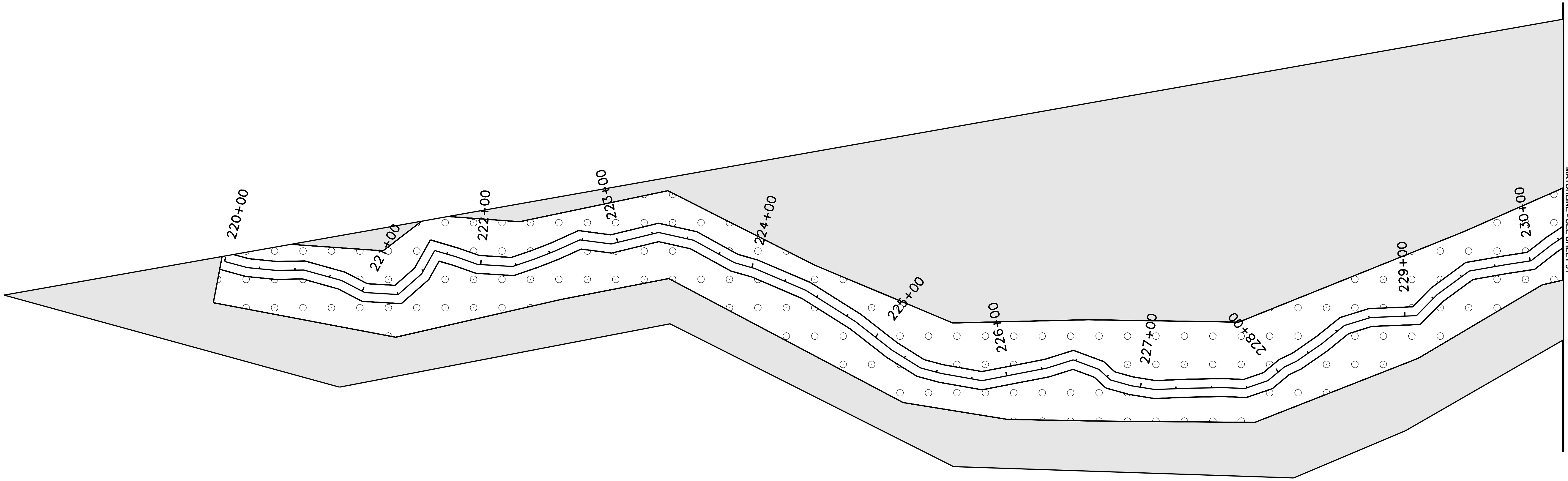
CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T10-1, T10-2: STATION 230+29 TO STATION 235+82

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 51 OF 68



ZONE A

STREAM ZONE PLANTING AREA

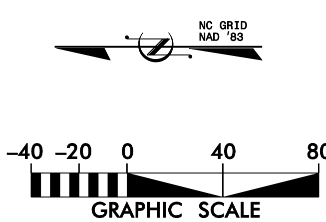
ZONE B

PIEDMONT ALLUVIAL FOREST PLANTING AREA

ZONE C

MESIC MIXED HARDWOOD FOREST PLANTING AREA

EXISTING TREES



SYM.	DESCRIPTION	DATE	APPROVED
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CANE CREEK
STREAM RESTORATION PROJECT
SEMORA, PERSON COUNTY, NORTH CAROLINA
T10: STATION 220+00 TO STATION 230+29

DATE: DEC 2007
SCALE: 1"=40'

PLANTING PLAN

SHEET 52 OF 68

Click on the Desired Link Below

Appendices