Beaverdam Creek and Unnamed Tributaries Restoration Plan

Union County, North Carolina
SCO # D06054-C

Prepared for:
NCDENR – EEP
2728 Capital Blvd, Suite 1H 103
Raleigh NC 27604

Ecosystem Enhancement PROGRAM

Submitted: January 16, 2008

TABLE OF CONTENTS

8.0 Figures

9.0 Appendices

Report Tables

EXECUTIVE SUMMARY

For this project, the restoration goal is to restore the physical and biological integrity beyond current stream conditions. Current conditions consist of modified or impaired stream channels, exacerbated by cattle intrusion. Restoration of the streams will provide the desired habitat and stability features necessary to improve the quality of the streams. Objectives to meet the goal of restoring the stream channels are listed below.

- Provide a stable stream channel with features characteristic of a biologically diverse environment
- Restore the connection between the bankfull width and floodprone width of the channels by improving the floodplain area
- Stabilize eroding streambanks
- Provide a functional, native riparian corridor where deficient, and preserve any existing forested corridor
- Improve the physical aquatic habitat features
- Minimize land development impacts to the streams
- Provide long-term protection of the stream corridors, including preservation of existing wooded corridors

The restoration techniques proposed for Beaverdam Creek mainstem and the unnamed tributary streams (UT1 and UT2) will provide the attributes described above by incorporating a variety of features recognized to support stability and biological diversity essential to ecosystem enhancement. Presently, these features are not present or are diminished within the project stream reaches.

The restoration of the Beaverdam Creek mainstem, UT1 and UT2 includes assessing and quantifying stable geomorphologic reference reach conditions that is the foundation for the design and construction of stable natural channels. Considerations that have been applied to the design of this project are listed below.

- Channels designed with appropriate bankfull dimensions, cross-sectional areas and profile slopes to convey predicted bankfull flows and to entrain bedload readily available to the streams, without aggrading or degrading.
- Channel pattern, profile and dimension extrapolated from data collected at a stable reference reach within the same physiographic province, ecoregion, geologic setting and valley type as the Beaverdam Creek watershed.
- Grade control and bank stabilization structures to enhance environmental and ecological attributes of the stream channels through the use of natural materials and indigenous, native revetment.
- In-stream habitat features, such as pool/riffle complexes, and re-establishment of the appropriate substrate material will be applied consistently. In-stream structures, such as cross-vanes, bank stabilization structures, or combinations thereof, will be utilized where needed to alleviate near-bank shear stress, provide grade control, stabilize streambanks and create aquatic habitat.
- Reconnection of the stream channels to functional floodplains by making improvements to the stream channels, floodprone areas and riparian zones that restores dimension, pattern and profile based on reference reach conditions.
- Indigenous instream, overbank and riparian herbaceous ground cover, shrub, understory and canopy species will be planted throughout the project riparian corridors, where

deficient. Existing woody vegetation present along the streams will be preserved to the maximum extent practicable.

- Bankfull channels designed with the appropriate dimension and cross-sectional area to convey anticipated bankfull flows and to entrain bedload material.

Proven natural geometry relationships, as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, provide the basis for designing stable, self-maintaining stream channels. Empirical and quantitative relationships between drainage area, discharge, channel pattern, profile and dimension form the foundation for restoring the physical and biological functions of streams. An evaluation of stream mitigation approaches including preservation, enhancement, and full-scale restoration was conducted for each of the project reaches. An Enhancement Level I approach, as defined in the multi-agency April 2003 Stream Mitigation Guidelines, was evaluated in terms of meeting project goals for the impaired project reaches. Due to historical stream modifications (channelization) and existing agricultural land use impacts (livestock encroachment), restoring dimension and profile only would not achieve the required level of ecological enhancement needed to return the impaired project reaches to a stable, natural condition. Restoring profile and dimension alone will not create in-stream conditions critical to support aquatic diversity and ecological functions inherent of high quality, healthy, headwater streams. To achieve the most beneficial outcome, from an ecosystem enhancement perspective, the inclusion of sinuous pattern, together with restored profile and dimension is required to reverse prior hydo-modifications along the project reaches. In doing so, the ecological function of these headwater streams, will achieve project goals and objectives, and in turn, support and enhance ecological function in the downstream watershed.

Priority Level I and II restoration is therefore proposed for Beaverdam Creek mainstem and the tributaries. Restoration work will focus on Beaverdam mainstem, UT1 and UT2. Approximately 449 linear feet of channel will be restored on the mainstem, approximately 2,282 linear feet on UT1, and approximately 282 feet on UT2. The sum of the total stream lengths designated in the restoration plan is approximately 3,013 linear feet. Pre-existing and proposed stream lengths and restoration approach are summarized in the following table, including proposed Stream Mitigation Units (SMUs):

Beaverdam Creek and Unnamed Tributary Restoration Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)

Reach/Approach	Existing Length	Proposed Length	Credit Ratio	SMUs
Beaverdam Creek Priority Level I Restoration	416 ft	449 ft*	1	449
UT1 Priority Level I/ II Restoration	1867 ft	2,282 ft*	1	2,282
UT2 Priority Level I/ II Restoration	203 ft	282 ft	1	282
Totals	2,486 ft	3,013 ft	-	3,013

*Proposed channel lengths are for only the length within the permanent conservation easement.

The stream restoration project will be monitored for a period of five consecutive years or until the required success criteria has been met as determined by the North Carolina Division of Water Quality (DWQ) and the U.S. Army Corps of Engineers (USACE), Wilmington District. Parameters that will be documented during annual stream monitoring, to ensure the success of the stream

restoration project, will include stream channel surveys (longitudinal profiles and cross-sections), analysis of streambed particle distributions, photographs, and vegetation surveys along the streams and riparian buffer zones.

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

The proposed project is located northwest of the intersection of White Store Road (SR 1003) and Snyder Store Road (SR 1945), 3.8 miles south of the town of Wingate, Union County, North Carolina. The site location and vicinity map is presented on **Figure 1**. The project is located on properties owned by Mr. and Mrs. William Earl and Betty H. Parker. The project includes restoration activities along Beaverdam Creek mainstem and two unnamed tributaries, designated UT1 and UT2.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The Beaverdam Creek watershed is located within the North Carolina Wetland Restoration Program (NCWRP) targeted USGS 14-digit HUC watershed 03040105081030 (Beaverdam Creek), in the Lower Yadkin River Basin. Beaverdam Creek is a tributary to Lanes Creek, of the Rocky River in the Yadkin River Basin as shown on **Figure 2**. The project stream reaches are mapped on North Carolina Department of Transportation Light Detection and Ranging (LiDAR) coverage of Union County, North Carolina as shown on **Figure 3**.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The drainage area tributary to the downstream limits of the project on Beaverdam Creek mainstem is 0.4910 square miles or 314.27 acres. UT1 and UT2 have contribution drainage areas of 0.2375 square miles (151.74 acres) and 0.0765 square miles (48.95 acres), respectively. The project contribution drainage areas watershed map is presented on **Figure 3**. Drainage areas for the project reaches are summarized in **Table 1**.

TABLE 1
Drainage Areas
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)

Reach	Drainage Area (Acres)
Beaverdam Creek Mainstem (downstream project limits)	314
UT1 to Beaverdam Creek*	152
UT2 to Beaverdam Creek*	49
Total	314

*UT1 includes the drainage area of UT2. The total contribution drainage area for the Beaverdam Creek stream restoration project is 314 acres. (See **Figure 3**)

2.2 Surface Water Classification/ Water Quality

The Upper Lanes Creek watersheds (03040105-081010, -081020, and -081030) are three of 43 watersheds in the Yadkin-Pee Dee River basin that have been identified by the NCWRP as areas with the greatest need and opportunity for stream and wetland restoration efforts. The Beaverdam Creek restoration project is located within USGS 14-digit HUC watershed 03040105-081030, and has been given higher priority than non-targeted watersheds for the implementation of NCWRP restoration projects. Portions of Lanes Creek are currently listed on the state's draft 303(d) list. (Yadkin Pee - Dee River Basin Watershed Restoration Plan, December 2003). The restoration and protection of the project streams and riparian corridors will help improve instream water quality in the Lower Yadkin – Pee Dee basins by reducing streambank erosion, excluding livestock from the riparian corridors, providing sediment and nutrient storage along the restored streams and revegetated riparian corridors, and perpetual protection of the restored stream project.

2.3 Physiography, Geology, and Soils

Physiography

The Beaverdam Creek watershed is located in the Piedmont Physiographic Province of south central North Carolina in the Carolina Slate Belt Ecoregion (Draft Level III and Level IV Ecoregions of North Carolina, USEPA, USDA-NRCS & NCDENR, August 17, 2000). Valley Type VIII (Rosgen, 1996) is most readily identified landform along the mainstem and unnamed tributaries corridors, with subtle terraces positioned laterally along the broad valleys with gentle, down-valley elevation relief in the project vicinity. Alluvial terraces and floodplains are the predominant depositional features in this fluvial geomorphologic system and produce a high sediment supply. As shown on **Figure 2** and **Figure 3** the first and second order project stream reaches are located in the headwaters of the

Beaverdam Creek watershed. Existing valley slopes for the project reaches range from 0.0068 ft/ft to 0.0300 ft/ft with elevations from the upstream watershed boundary to the downstream limits of the project ranging from 640 feet to 571 feet (NAVD 88), with total site vertical relief of 69 feet.

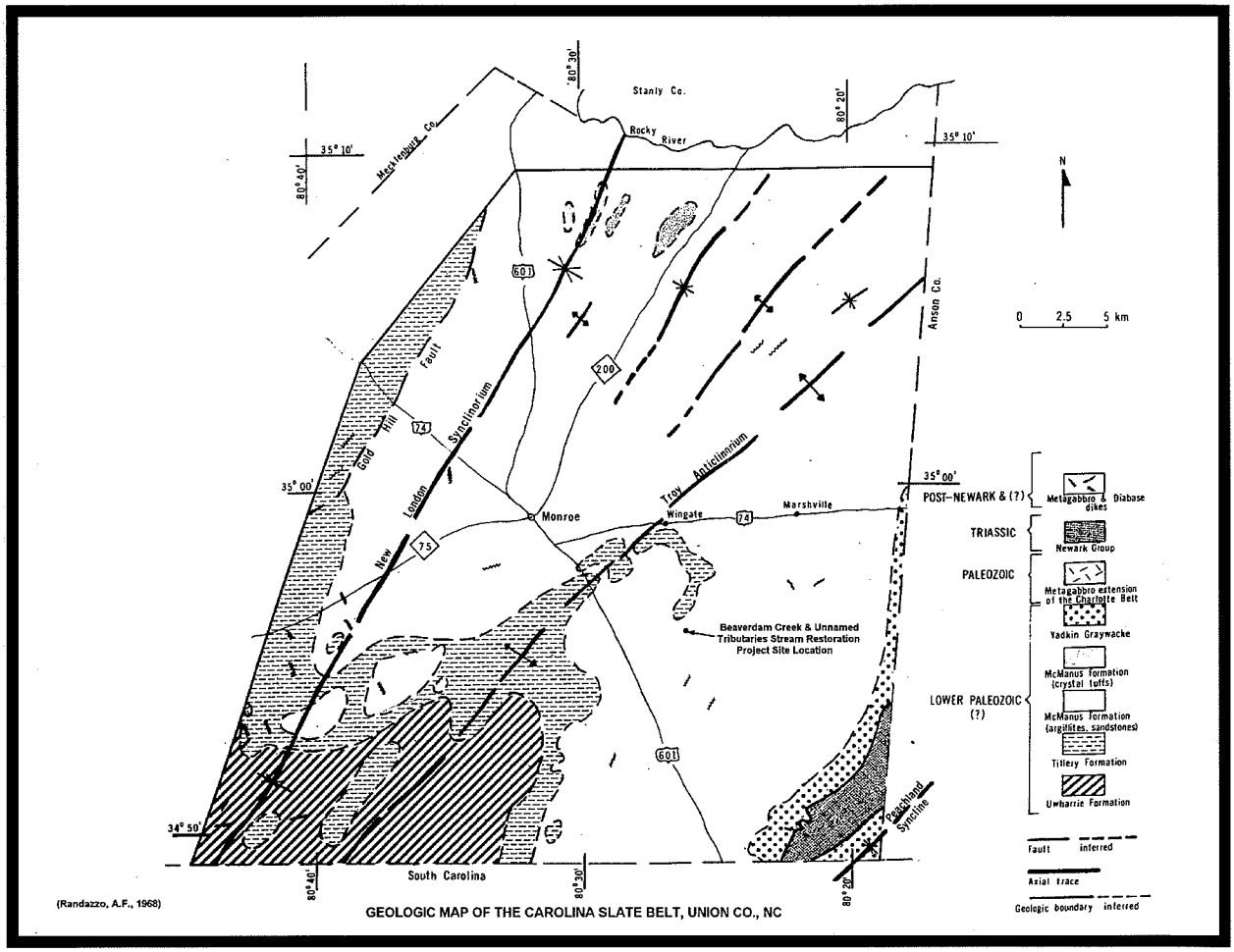
Geology

In the project vicinity, bedrock consists of heated and deformed sedimentary and volcanic rock. The Carolina Slate Belt was the site of a series of oceanic volcanic islands about 550 – 650 million years ago. Metamorphic rocks that occur in this region include meta-mudstone and meta-argillite (slate), thin to thick bedded, bedding planes and axial-planar cleavage common; interbedded with meta-sandstone, meta-conglomerate and meta-volcanic rock. The project site geology map is presented on **Figure 4** (general bedrock descriptions and mapped extent are from the Geologic Map of North Carolina, NCGS, 1985).

The site is located on the southeast limb of the northeast-southwest trending Troy Anticlinorium. The axial plane strikes N49°E (fold crest orientation), with a regional bedding plane dip angle of 29° to the southeast. Across the axial plane to the west, the regional bedding plane dip angle is somewhat steeper, 37° to the northwest. The Troy Anticlinorium represents a series of local anticlines (upward folded arches) and synclines (downward folded troughs) that regionally form a large anticline. The local folds are open and predominantly asymmetric, mimicking the asymmetric bedding plane geometries of the parent fold. Axial plane cleavage (rock splitting planes essentially parallel to the axial plane of the fold) is best developed where only argillites (i.e., slate - metamorphosed, fine-grained mudstone and clay) are involved in the folding.

Four formations are recognized in the Union County portion of the Carolina Slate Belt – from oldest to youngest, the Uwharrie Formation, Tillery Formation, McManus Formation and Yadkin Formation, that together comprise over 16,500 feet of the Lower Paleozoic Section in south-central North Carolina. The Uwharrie Formation represents a period of extensive volcanism with the formation of crystal lithic and devitrified tuffs, a rock formed from compacted volcanic fragments, generally smaller than four millimeters in diameter, incorporated in a micro-crystalline groundmass. The Tillery Formation consists of thin bedded, laminated argillite with some interbedded non-laminated argillite and sandstone. Thick bedded, tuffaceous argillite characterizes the McManus Formation which also contains an appreciable amount of crystal tuff and very fine-grained sandstone. The youngest unit is the is the Yadkin Graywacke which consists of thick bedded graywacke and laminated argillite. Quartz and igneous intrusions are found in all of the units. The age of the rocks studied is Early Paleozoic, probably Cambrian or Ordovician.

Locally, the site is underlain by the McManus Formation which comprises approximately 11,600 feet, or approximately 70 percent of the Union County portion of the Carolina Slate Belt. (Detailed local structure and stratigraphy from Randazzo, A.F., Petrography and Stratigraphy of the Carolina Slate Belt, Union County, North Carolina, Ph.D. Thesis, University of North Carolina at Chapel Hill, 1968). The following map is published in the cited thesis.



Soils

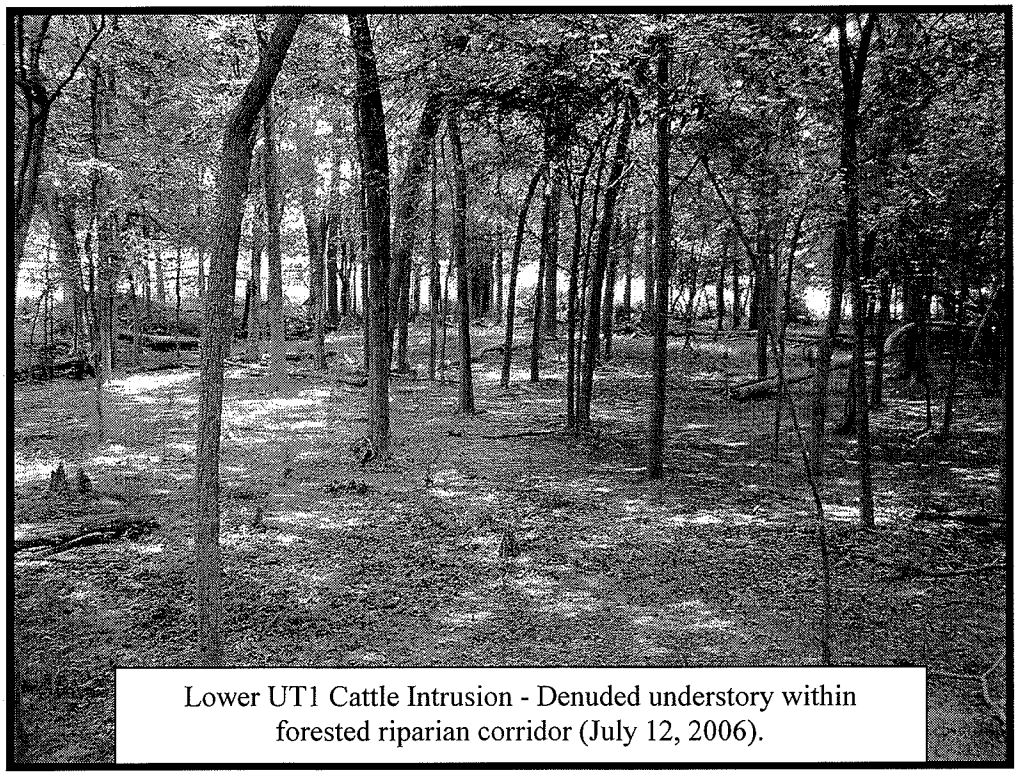
Figure 5 shows the boundaries of mapped soil units within the project site and vicinity. Soils mapping and taxonomic descriptions are from the USDA NRCS, Soil Survey of Union County, North Carolina (USDA NRCS, January 1996). The soils along the mainstem of Beaverdam Creek and along the lower 300-feet reach of UT1 within the project area have been derived from and developed over these metamorphic rock formations and include the Chewacla silt loam, 0 to 2 percent slopes, frequently flooded. This map unit consists mainly of very deep, nearly level, somewhat poorly drained soils developed on floodplains. It is mostly present on broad flats along major streams and rivers and on narrow flats along minor creeks and drainageways. Typically the surface layer is brown silt loam approximately seven inches thick. The subsoil is 45 inches thick. On site, the Chewacla unit is mapped adjacent to the Goldston soils. Where the Chewacla unit occurs adjacent to areas of Goldston soils, small areas of soils encounter bedrock at a depth of less than 60 inches below ground surface. Contrasting inclusions make up about 15 percent of this mapped unit.

The upper reach of UT1 and the entire length of UT2 is mapped Cid channery silt loam, 1 to 5 percent slopes. This map unit consists mainly of moderately deep, moderately well drained and somewhat poorly drained, nearly level and gently sloping Cid and similar soils on flats, on ridges in the uplands, in depressions and in headwater drainageways. Typically, the surface layer is light brownish gray channery silt loam four inches thick. The subsurface layer is a pale yellow channery silt loam 5 inches thick. The subsoil is 18 inches thick. Weathered, fractured bedrock is encountered at a depth of about 27 inches. Hard, fractured bedrock is encountered at a depth of about 32 inches.

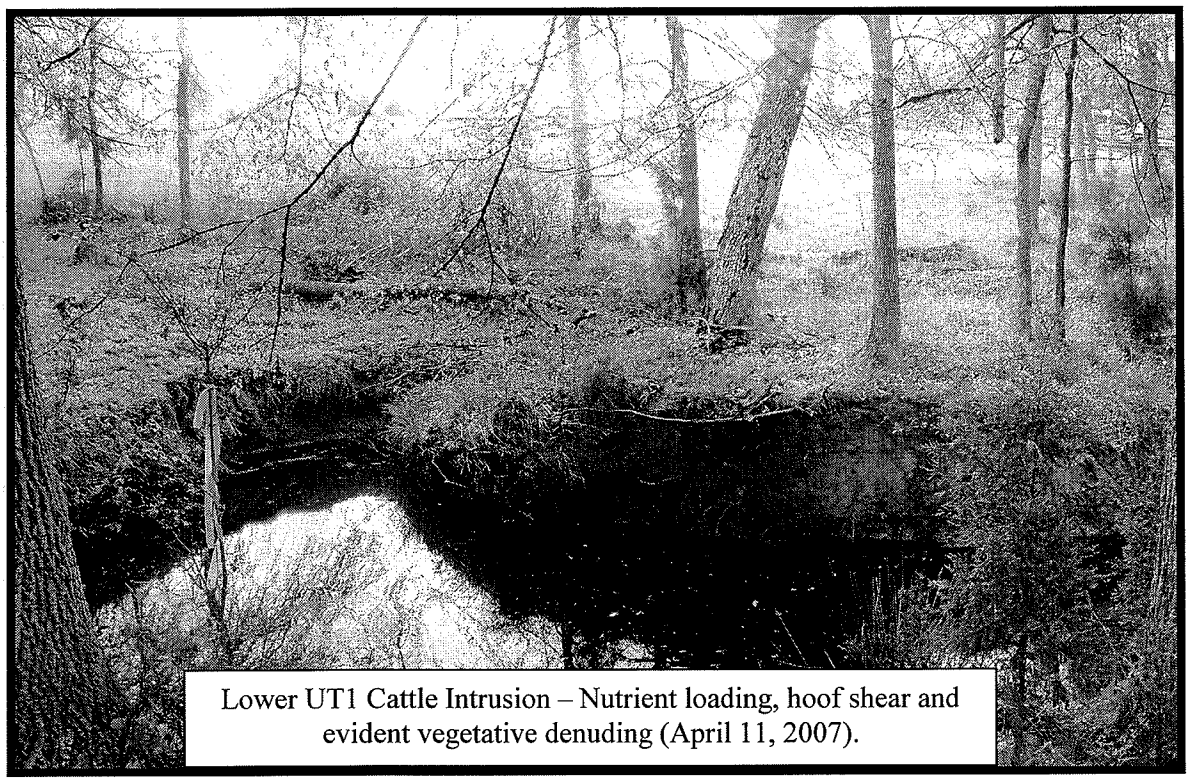
Permeability is slow in the Cid soil. Available water capacity is low to moderate. The shrink-swell potential is moderate. A seasonal high water table is perched between depths of 1.5 to 2.5 feet below ground surface from December through May. The depth to hard bedrock ranges from 20 to 40 inches. The hazard of erosion is moderate on construction sites if the ground cover is removed.

2.4 Historical Land Use and Development Trends

The land surrounding the restoration project is cattle pasture land. Cattle have direct access to the project stream reaches for drinking water, and is areas where established riparian canopy corridors exist, cattle access the project reaches for shade. Presently, the cattle access the stream randomly and, in doing so, have denuded and destabilized the channel banks due to grazing, browsing and hoof shear. The unstable streambanks contribute significant quantities of sediment to the project stream reaches. Sediment eroded from the unstable streambanks is transported downstream and off site into the larger Beaverdam Creek watershed. Runoff from cattle intrusion along the project corridors provides direct nutrient pathways into the streams. Currently, the upper reach of UT1 and the entire UT2 reach have sparse riparian vegetation along their stream corridors. Vegetation along the existing stream corridors is nonfunctional with respect to bank stabilization, nutrient uptake and sediment removal from overland flow (i.e., non-point source pollutants). The approximate lower third of UT1 and Beaverdam Creek mainstem reaches have established hardwood forested riparian corridors. However, cattle intrusion has denuded herbaceous groundcover, and adversely impaired shrub and mid-story canopy vegetation. Cattle intrusion is the primary cause of stream instability on site. The photographs on the following page show the adverse effects of browsing and grazing of shrub and herbaceous vegetation, hoof shear, and resulting nutrient loading, streambank destabilization and erosion, respectively.



Lower UT1 Cattle Intrusion - Denuded understory within forested riparian corridor (July 12, 2006).



Lower UT1 Cattle Intrusion – Nutrient loading, hoof shear and evident vegetative denuding (April 11, 2007).

Table 2 presents a breakdown of land use within the local watershed and is based upon USGS National Land Cover Dataset (NLCD, 2001). Land cover within the watershed is presented spatially on **Figure 6**.

TABLE 2
Beaverdam Creek and Unnamed Tributaries Watershed Land Use Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)

Description	Count	Sq Meters	Acres	Sq Mi	Percent
Developed, open space	63	56,700	14.0	0.022	4.46
Deciduous Forest	345	310,500	76.7	0.120	24.45
Evergreen Forest	68	61,200	15.1	0.024	4.82
Mixed Forest	35	31,500	7.8	0.012	2.48
Grassland/Herbaceous	13	11,700	2.9	0.005	0.92
Pasture/Hay	880	792,000	195.9	0.306	62.37
Cultivated Crops	7	6,300	1.6	0.002	0.50
	Totals	**1,269,900**	**314**	**0.491**	**100.00**

2.5 Endangered/ Threatened Species

The species listed in **Table 3** are Federally-listed Threatened or Endangered Species in Union County, North Carolina, according to the U.S. Fish and Wildlife Service (FWS) website (http://nc-es.fws.gov/es/countyfr.html):

TABLE 3
Federal Threatened and Endangered Species in Union County
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)

Common Name	Scientific Name	Federal Status	Known Occurrences
Schweinitz's Sunflower	*Helianthus schweinitzii*	Endangered	Current
Carolina heelsplitter	*Lasmigona decorata*	Endangered	Current
Michaux's Sumac	*Rhus michauxii*	Endangered	Current

The "Known Occurrences" column refers to the last time the species was observed in a particular county, according to the species distribution maps from the North Carolina Natural Heritage Program dataset. "Current" means that the species was seen in the county within the last 20 years.

As part of the National Environmental Policy Act (NEPA) compliance procedure for the project, a scoping letter was submitted to the US Fish and Wildlife Service on July 11, 2006 to request information on these species and any comments with respect to endangered species that may arise as a result of this project. This scoping letter included language specifying that a lack of response within 30 days would be assumed to mean the USFWS had no comments or recommendations regarding this project. No response was received within the 30 day period ending August 14, 2006.

A scoping letter was also sent to the National Oceanic and Atmospheric Administration (NOAA)-Fisheries Service, Beaufort Field Office, on July 18, 2006 for comments on any issues related to endangered species of essential fish habitat. During a telephone conversation on July 31, 2006, Mr. Ron Sechler of the NOAA-Fisheries Office stated that he had no comments related to this project.
A request for a site-specific search of the North Carolina Natural Heritage Program Database was made to the North Carolina Department of Environmental and Natural Resources (NCDENR). The search results returned on July 12, 2006 indicated that the database had no record of rare species, significant natural communities, or priority natural areas at the site nor within 1 mile of the project area.

Based on a review of available information, including a site visit, no habitat for any of species listed in Table 3 is apparent on the site. Due to a lack of available habitat, the Beaverdam Creek project is not likely to have an adverse effect on any Federally-listed threatened or endangered species. This information was presented in the Categorical Exclusion report submitted to and accepted by the Federal Highway Administration and State of North Carolina on September 18, 2006.

2.6 Cultural Resources

A scoping letter was submitted to the North Carolina Department of Cultural Resources, State Historic Preservation Office (SHPO) for review. In correspondence dated July 27, 2006, the SHPO indicated that they were aware of no historic resources that would be affected by the project. The SHPO had no comments on the undertaking as proposed.

2.7 Potential Constraints

There are no constraints that have potential to adversely impact or limit improvements associated with the restoration of Beaverdam Creek and its associated unnamed tributaries.

2.7.1 Property Ownership History and Boundary

The project site lies entirely within lands owned by Mr. and Mrs. William Earl and Betty H. Parker (1822 Snyder Store Road, Wingate, North Carolina 28174). The project, in its entirety, is located northwest of the intersection of White Store Road and Snyder Store Road, 3.8 miles south of the town of Wingate, Union County, North Carolina.

2.7.2 Site Access

Access to the site is provided from Snyder Store Road and White Store Road as shown the various figures provided within this report. The upstream and downstream limits of stream restoration work on Beaverdam Creek mainstem terminate 30-feet outside the right-of-ways of these state routes. A temporary, stabilized construction entrance will be built onto the site from White Store Road as shown on Restoration Plan Sheet RP-13/17. The detail for this construction egress/ingress entrance is shown on Restoration Plan Sheet RP-14/17. Restoration Plan design sheets are presented in **Appendix 1**. The publicly dedicated right-of-ways of these roads provide direct access to the Conservation Easements for both Beaverdam Creek and the unnamed tributaries. No independent ingress/egress is provided as part of the Conservation Easement.

2.7.3 Utilities

Underground utilities are known to exist within the right-of-ways of Snyder Store Road and White Store Road. No overhead utilities exist on site. The contractor will contact Miss Utility of North Carolina at (800) 632-4949 at least 72 hours prior to any disturbance in this area. The contractor will avoid all underground utilities at this location during land disturbance associated with constructing the temporary project egress/ingress entrance. As shown on the construction detail, a mountable berm will be constructed if installing a temporary culvert to convey surface water is impracticable. To the best of our knowledge, the project stream reaches and perpetual conservation easement areas are neither encumbered nor encroached upon by either overhead or underground utilities.

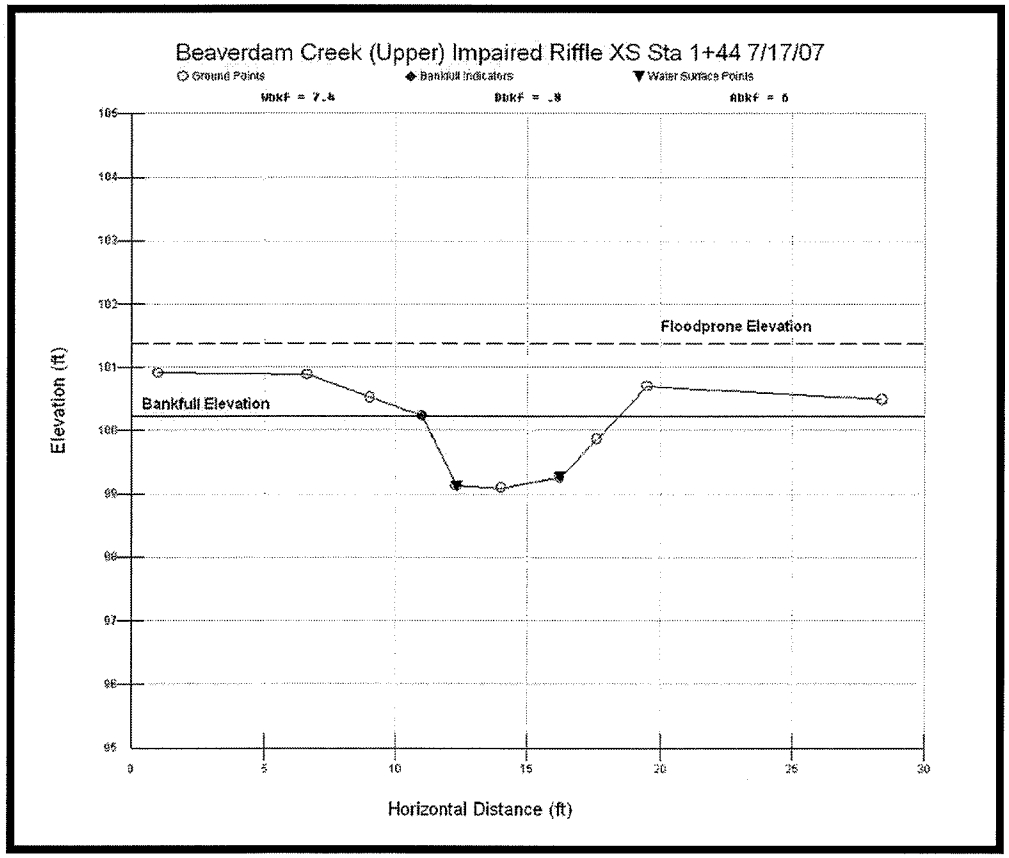
3.0 PROJECT SITE STREAMS

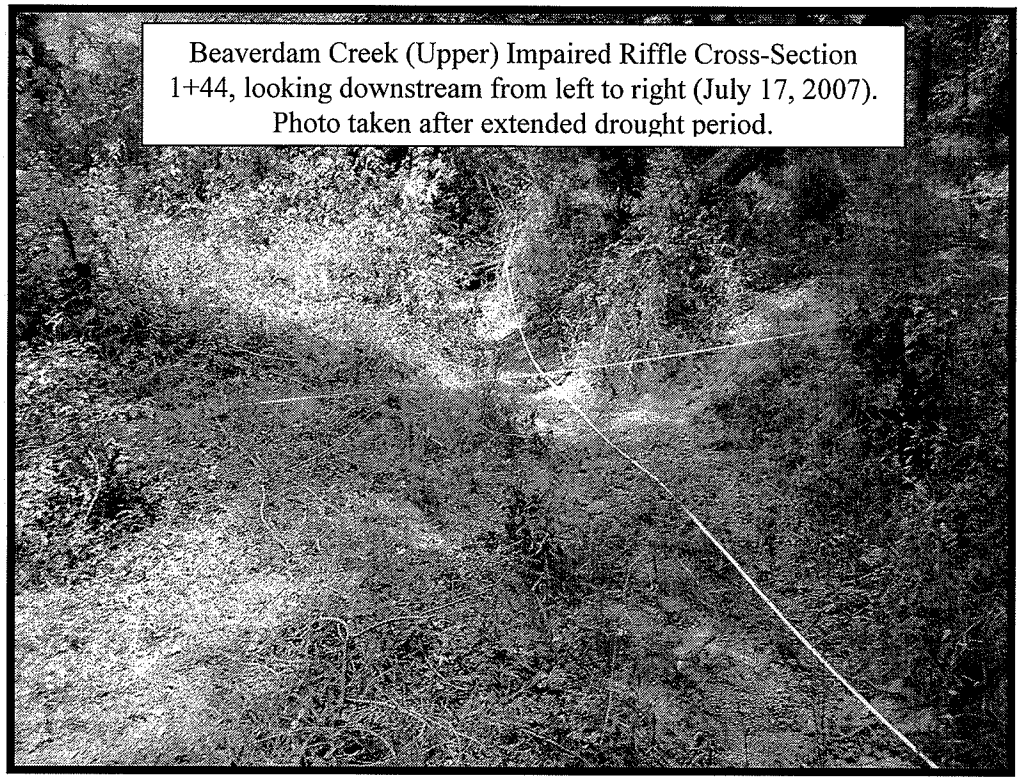
3.1 Channel Classification

Beaverdam Creek Mainstem

North Carolina Division of Water Quality (DWQ) Stream Classification Form was completed for the Beaverdam Creek mainstem and is included in **Appendix 2**. The mainstem received a score of 31, classifying it as a perennial channel. The stable, natural channel form for Beaverdam Creek mainstem is a Rosgen E4 stream type, based on detailed, quantitative analysis of a stable reference reach located off site, upstream from the confluence of Davis Branch with Gourdvine Creek, together with a detailed analysis of the impaired mainstem reach.

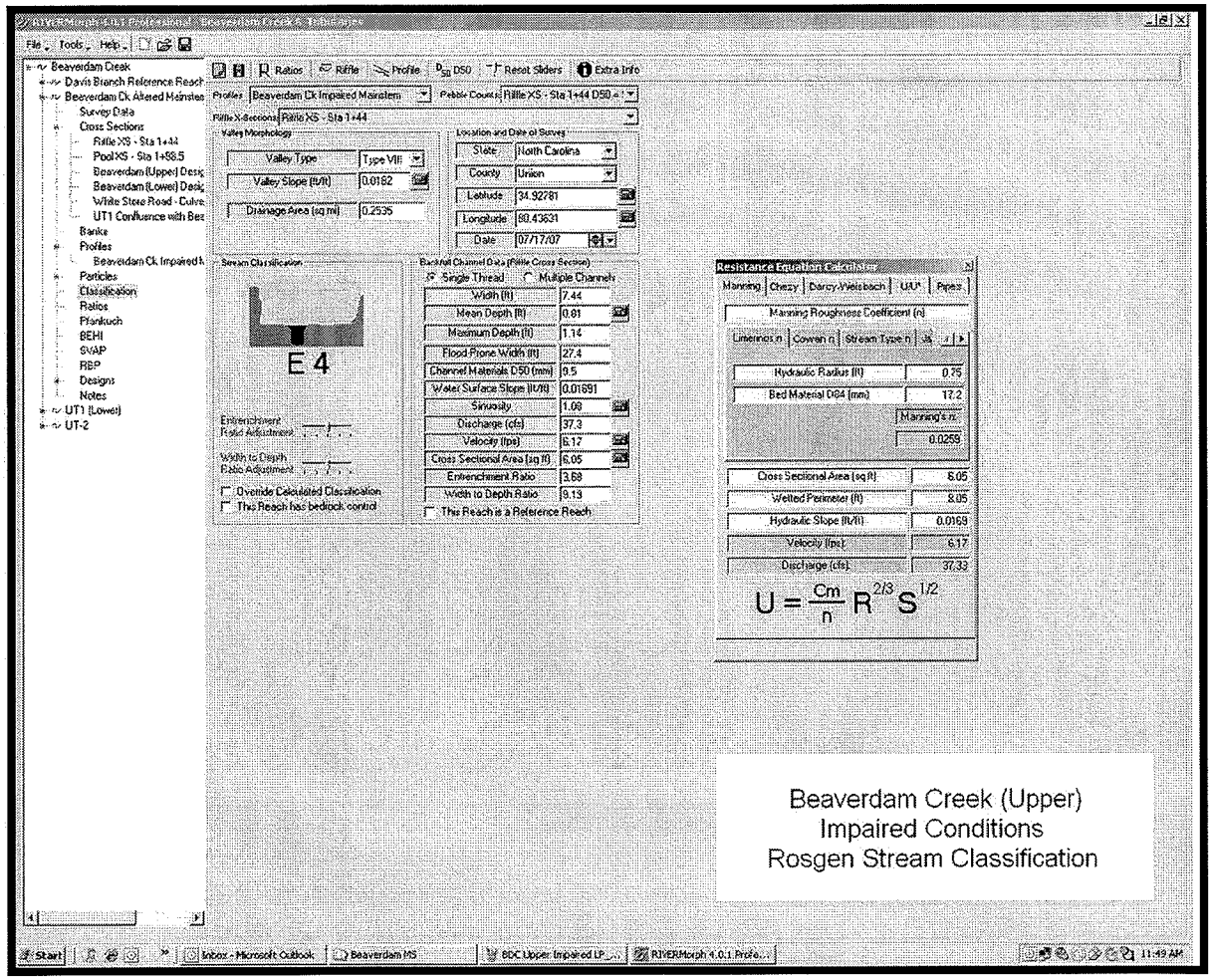
A number of anthropogenic factors have impacted the stream channel and riparian corridor along the impaired mainstem reach, resulting in its present unstable deeply incised condition. Existing bank height ratios (BHR) measured at impaired pool cross-section 1+98.5 and impaired riffle cross-section 1+44, located 107 feet and 161 feet upstream of from the mainstem's confluence with UT1 is 1.56 and 1.60, respectively. The deeply incised nature of the channel is attributed to uncontrolled cattle intrusion (herbaceous groundcover grazing, shrub vegetation browsing and hoof shear) resulting in a denuded riparian corridor and destabilized, eroding streambanks. (Rosgen, D.L., Degree of Channel Incision, River Restoration and Natural Channel Design [Rosgen Level 4] Course Field Manual, 2006).





Beaverdam Creek (Upper) Impaired Riffle Cross-Section 1+44, looking downstream from left to right (July 17, 2007). Photo taken after extended drought period.

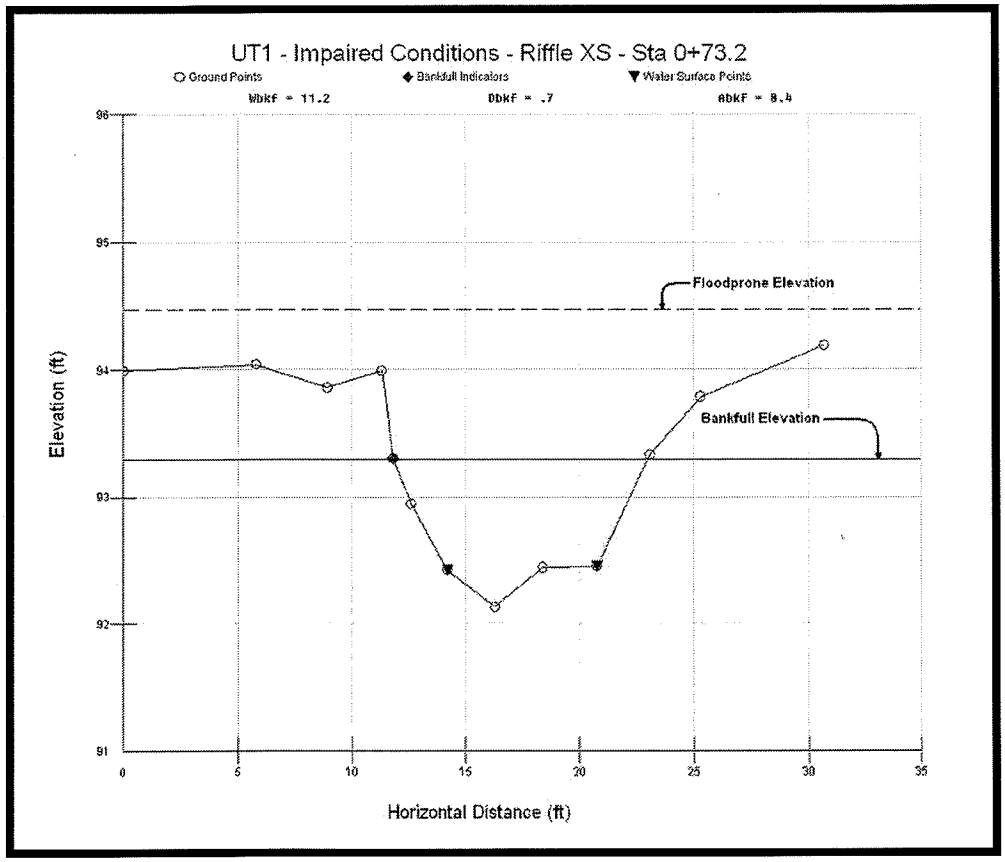
In its existing impaired state, Beaverdam Creek has maintained E channel dimensions, albeit under incised conditions. In addition to cattle intrusion, channelization (impaired conditions sinuosity = 1.08) has increased erosive forces acting on the streambed and channel banks during seasonal precipitation events, and bankfull and greater flows. **Tables 4a – 4b** provide baseline morphologic and hydraulic summaries for reference, existing and proposed channel dimension, pattern, profile and substrate, along with additional reach parameters. The following screenshot from RiverMorph v. 4.0.1, shows impaired project reach Rosgen stream channel classification, dominant substrate materials readily available to the mainstem reach, and morphologic and hydraulic conditions for Beaverdam Creek upstream from its confluence with UT1.

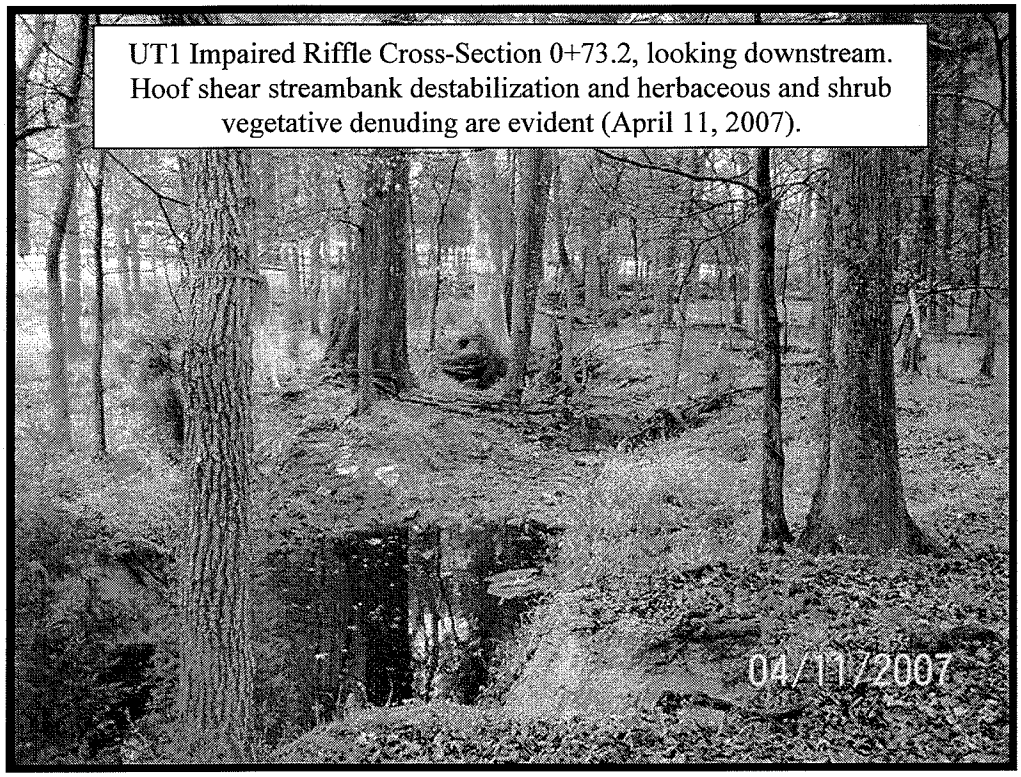


UT1 to Beaverdam Creek

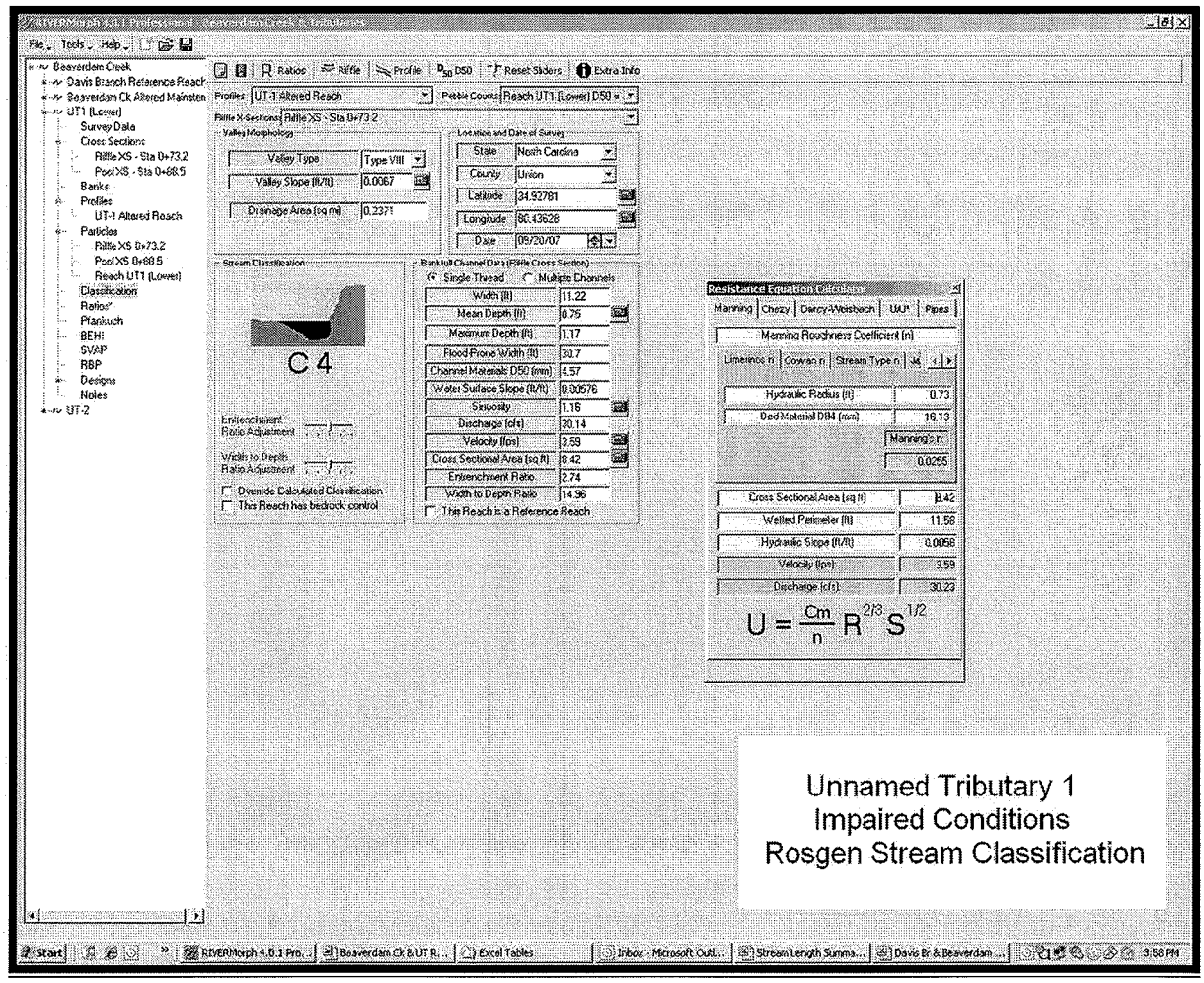
The North Carolina DWQ Stream Classification Form was completed for UT1 and is included in **Appendix 2**. UT1 received a score of 45, classifying it as a perennial channel. The stable, natural channel form for UT1 is Rosgen E4 stream type, based on detailed, quantitative analysis of a stable reference reach located off site, upstream from the confluence of Davis Branch with Gourdvine Creek, and detailed analysis of the impaired UT1 reach.

A number of anthropogenic factors have impacted the stream channel and riparian corridor along the UT1 reach, resulting in its present unstable deeply incised condition. Existing BHRs calculated at impaired riffle cross-section 0+73.2 and impaired pool cross-section 0+88.5, located 227 feet and 212 feet upstream from the confluence of UT1 with Beaverdam Creek mainstem are 1.76 and 1.41, respectively. The deeply incised nature of the channel is attributed to uncontrolled cattle intrusion (herbaceous groundcover grazing, shrub vegetation browsing and streambank hoof shear) resulting in a denuded riparian corridor and destabilized, eroding streambanks.





UT1 Impaired Riffle Cross-Section 0+73.2, looking downstream. Hoof shear streambank destabilization and herbaceous and shrub vegetative denuding are evident (April 11, 2007).



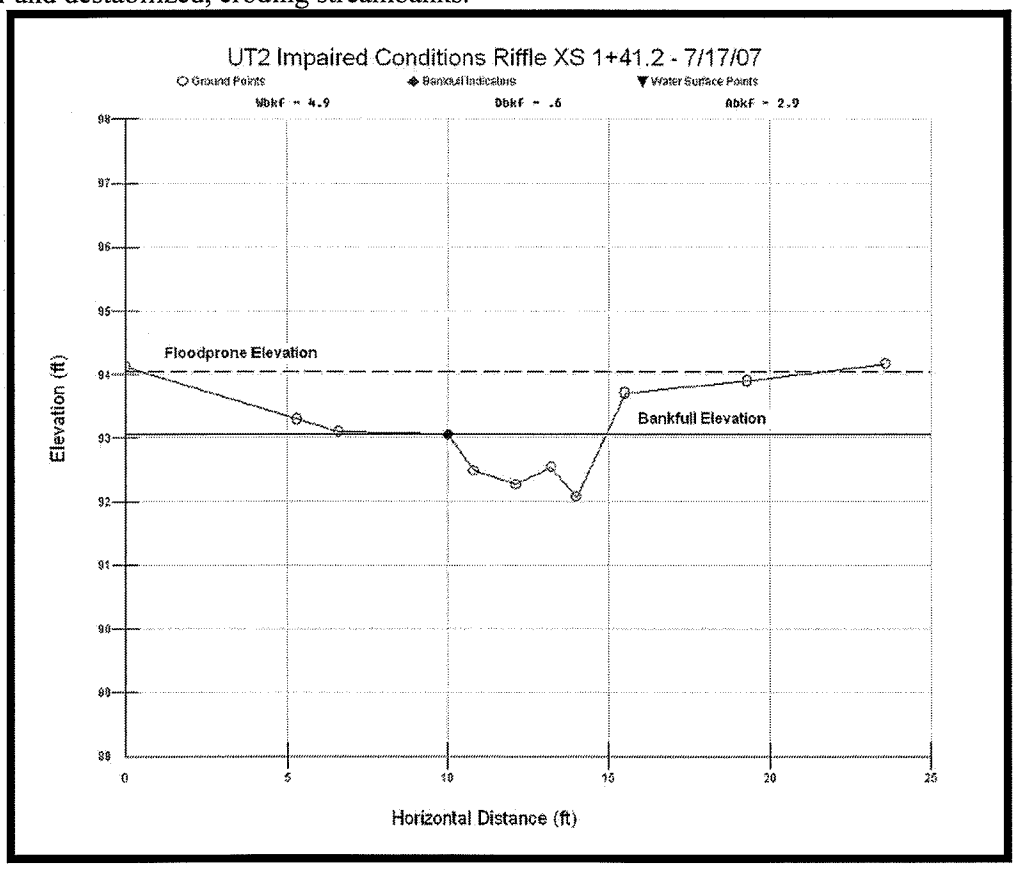
In its existing impaired state, UT1, along its final 300 feet reach, has C4 channel morphology, based on dimensions measured at the selected impaired reach riffle cross-section, albeit under incised conditions. **Tables 4c – 4d** provide baseline morphologic and hydraulic summary of reference, existing and proposed channel dimension, pattern and profile, along with addition reach parameters. The preceding screenshot from RiverMorph v. 4.0.1, shows impaired project reach Rosgen stream channel classification, dominant substrate materials, morphologic and hydraulic conditions for UT1.

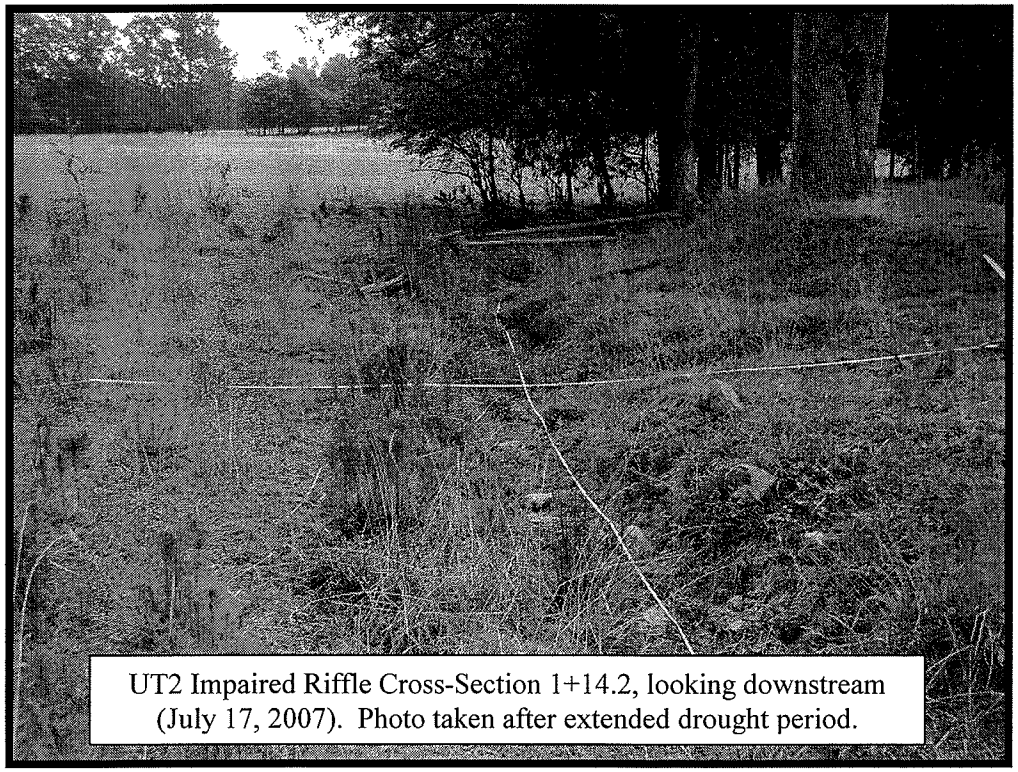
UT2 to Beaverdam Creek

The North Carolina DWQ Stream Classification Form was completed for Unnamed Tributary 2 and is included in **Appendix 2**. Unnamed Tributary 2 received a score of 32.25, classifying it as a perennial channel. The stable, natural channel form for UT1 is a Rosgen E4 stream type, based on detailed, quantitative analysis of a stable reference reach located off site, upstream from the confluence of Davis Branch with Gourdvine Creek, and detailed analysis of the impaired UT2 reach.

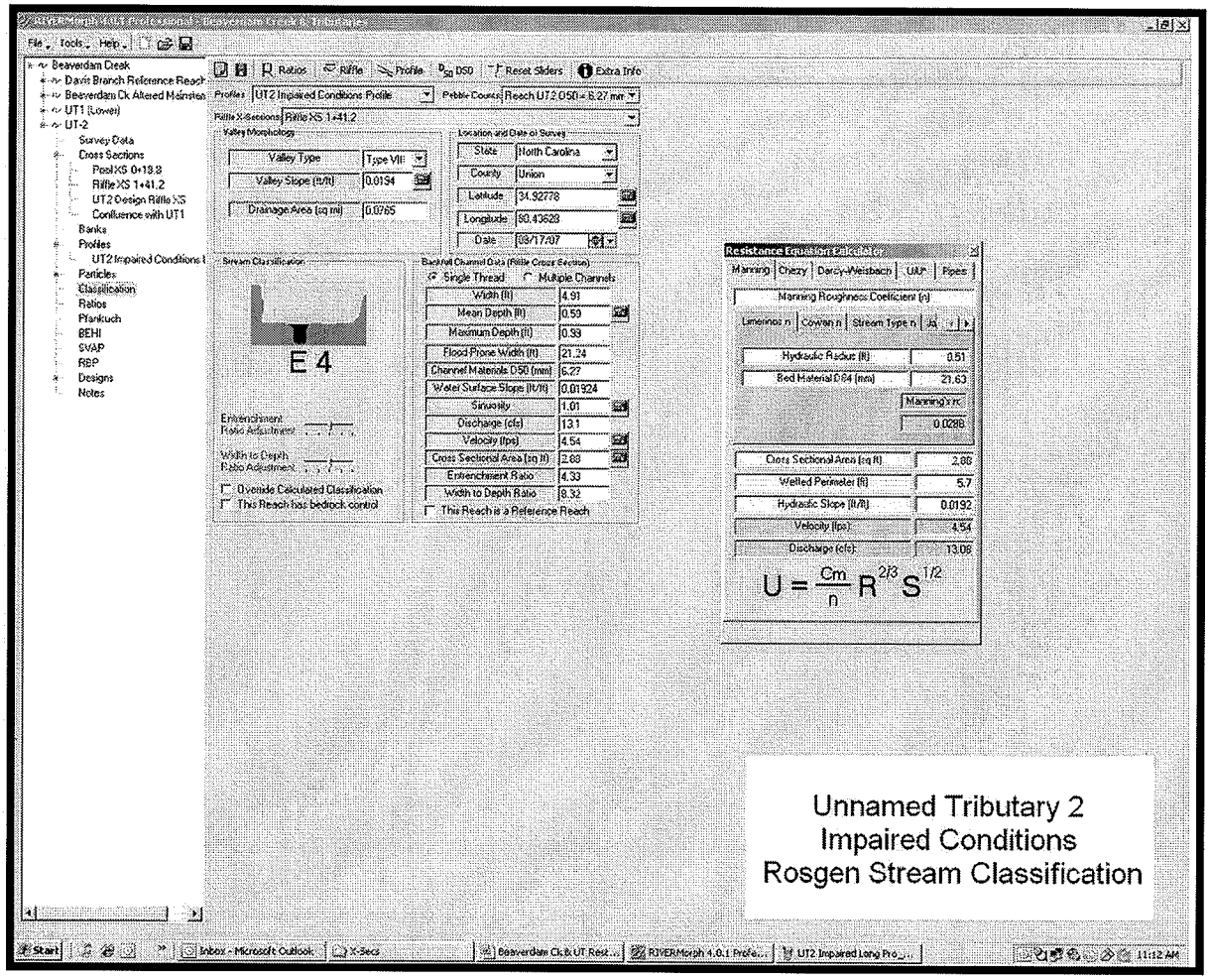
A number of anthropogenic factors have impacted the stream channel and riparian corridor along the UT2 reach, resulting in its present unstable deeply incised condition. Existing BHRs calculated at impaired riffle cross-section 0+73.2 and impaired pool cross-section 0+88.5, located 227 feet and 212 feet upstream from the confluence of UT2 with UT1 are 1.76 and 1.41, respectively. The deeply incised nature of the channel is attributed to uncontrolled cattle intrusion, herbaceous groundcover

grazing, shrub vegetation browsing and streambank hoof shear, resulting in a denuded riparian corridor and destabilized, eroding streambanks.





UT2 Impaired Riffle Cross-Section 1+14.2, looking downstream (July 17, 2007). Photo taken after extended drought period.



In its existing impaired state, UT2, along its final 200 feet reach, has E4 channel morphology, based on dimensions measured at the selected impaired reach riffle cross-section, albeit under incised conditions. In addition to cattle intrusion, channelization (impaired conditions sinuosity = 1.02) has increased erosive forces acting on the streambed and channel banks during seasonal precipitation events, bankfull and greater flows. **Table 4e** provides baseline morphologic and hydraulic summary of reference, existing and proposed channel dimension, pattern and profile, along with addition reach parameters. The preceding screenshot from RiverMorph v. 4.0.1, shows impaired project reach Rosgen stream channel classification, dominant substrate materials, morphologic and hydraulic conditions for UT2.

3.2 Discharge

Bankfull discharge for the project stream reaches was quantified and verified from measured reference reach boundary conditions and compared to empirical relationships using regression equations published with the *Bankfull Hydraulic Relationships for North Carolina Streams*, Rural Piedmont Regional Curve Database (Multi-Agency *Stream Mitigation Guidelines*, April 2003). The rural Piedmont regional curve database includes data for streams with drainage areas ranging from 0.2 to 128 square miles. The regression equations developed from the regional curve database were used to empirically evaluate hydraulic geometry relationships at bankfull stage for each of the project reaches. Based on detailed quantitative analysis of reference reach conditions at a selected stable riffle section located on Davis Branch 43 feet upstream from its confluence Gourdvine Creek, it was determined the rural Piedmont regional curve dataset underestimates bankfull discharge and

geometric relationships for project reach streams. **Appendix 3** presents quantified and verified data analyses from the Davis Branch Reference Reach, Rosgen Level III assessment. This may be due, in part, to scarcity of data from the south-central region of the North Carolina rural Piedmont Physiographic Province in developing the regional curve database. Tables 4a – 4e present hydraulic geometries, based on empirical relationships between drainage area, discharge and bankfull dimensions, in comparison to the same relationships based on quantified and verified reference reach conditions. **Tables 4a – 4e** on the following pages also present regional curve, reference reach, pre-existing and design bankfull discharges for each of the project reaches.

3.3 Channel Morphology

See Section 3.1 and 3.4 for discussion of existing stream reaches channel morphology. **Tables 4a – 4e** on the following pages present baseline morphologic and hydraulic dimension, pattern and profile data for reference reach, existing and proposed conditions. Regional curve empirical relationships to reference and impaired reach conditions is summarized in **Tables 4a – 4e** and interpreted in Section 3.5.

Some fields are left blank within **Tables 4a – 4e** where historic project documentation necessary to provide these data were unavailable at the time of this report submission. Where no min/max values are provided within the tables, and only one value was measured or computed, that value is presented as the mean or median value. Where only two measurements were measured or computed, no mean or median value is presented. Reference reach dimensionless ratios used to size project reach channels included in **Appendix 3**.

Table 4a: Baseline Morphologic and Hydraulic Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)
Station/Reach: Beaverdam Creek Station 0+00 to 4+02

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.2535			0.5710			0.2535			0.2535
Bankfull Discharge (cfs)			19.6			77.6			34.5			34.5
BF Width (ft)			6.59			12.91			7.44			9.00
Floodprone Width (ft)						50.00			27.40			50.00
BF Cross Sectional Area (ft^2)			8.43			15.65			6.05			9.00
BF Mean Depth (ft)			0.97			1.21			0.81			1.00
BF Max Depth (ft)						1.61			1.14			1.50
Width/Depth Ratio			6.82			10.67			9.19			9.00
Entrenchment Ratio						3.87			3.68			5.56
Bank Height Ratio						1.00			1.60			1.00
Wetted Perimeter (ft)			8.52			13.72			8.05			11.00
Hydraulic Radius (ft)			0.99			1.14			0.75			0.82
Pattern												
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	28.00	17.00
*Meander Wavelength (ft)				80.10	116.50	99.20				59.01	93.85	72.68
*Meander Width Ratio				2.15	4.11	2.94						5.56
Profile												
Riffle Length (ft)				12.0	18.5	15.0	41.0	62.0	51.3	11.7	38.7	24.0
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0194	0.0328	0.0246	0.0285	0.0939	0.0458
Pool Length (ft)				12.0	29.1	21.2	17.2	21.9	19.5	16.3	32.4	18.3
Pool Spacing (ft)				33.4	43.7	38.6	67.7	104.9	86.3	28.9	71.1	42.7
Substrate												
D50 (mm)						69.2			9.5			9.5
D84 (mm)						140.1			17.2			17.2
Additional Reach Parameters												
Valley Length (ft)						974			358			334
Channel Length (ft)						1129			386			402
Sinuosity						1.2			1.08			1.21
Water Surface Slope (ft/ft)						0.0311			0.0158			0.0070
BF Slope (ft/ft)						0.0326			0.0169			0.0070
Rosgen Classification			E			E3/1b*			E4			E4
*Habitat Index												
*Macrobenthos												

*E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.

Table 4b: Baseline Morphologic and Hydraulic Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)
Station/Reach: Beaverdam Creek Station 4+02 to 4+62

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition**			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.4910			0.5710			0.4910			0.4910
Bankfull Discharge (cfs)			35.3			77.6			66.7			66.7
BF Width (ft)			8.76			12.91						11.20
Floodprone Width (ft)						50.00						50.00
BF Cross Sectional Area (ft^2)			13.21			15.65						13.68
BF Mean Depth (ft)			1.19			1.21						1.22
BF Max Depth (ft)						1.61						1.80
Width/Depth Ratio			7.33			10.67						9.18
Entrenchment Ratio						3.87						4.46
Bank Height Ratio						1.00						1.00
Wetted Perimeter (ft)			11.15			13.72						12.05
Hydraulic Radius (ft)			1.19			1.14						1.14
Pattern												
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	28.00	17.00
*Meander Wavelength (ft)				80.10	116.50	99.20				59.01	93.85	72.68
*Meander Width Ratio				2.15	4.11	2.94						4.46
Profile												
Riffle Length (ft)				12.0	18.5	15.0				11.7	38.7	24.0
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520				0.0285	0.0939	0.0458
Pool Length (ft)				12.0	29.1	21.2				16.3	32.4	18.3
Pool Spacing (ft)				33.4	43.7	38.6				28.9	71.1	42.7
Substrate												
D50 (mm)						69.2						9.5
D84 (mm)						140.1						17.2
Additional Reach Parameters												
Valley Length (ft)						974			29			53
Channel Length (ft)						1129			30			61
Sinuosity						1.2			1.03			1.15
Water Surface Slope (ft/ft)						0.0311			0.0300			0.0261
BF Slope (ft/ft)						0.0326			0.0300			0.0261
Rosgen Classification			E			E3/1b*			E4			E4
*Habitat Index												
*Macrobenthos												

*E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.

**Due to the similarities of position in the watershed for Lower Beaverdam Creek, below the confluence of Lower UT1, pre-existing dimension, profile and substrate data was collected for Upper Beaverdam Creek above its confluence with UT1 only. There is no appreciable change in riffle substrate material below the confluence.

Table 4c: Baseline Morphologic and Hydraulic Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)
Station/Reach: UT1 Upper Sta. 0+00 to 2+07

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition**			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.1152			0.5710			0.1152			0.1152
Bankfull Discharge (cfs)			9.7			77.6			15.6			15.6
BF Width (ft)			4.69			12.91						7.20
Floodprone Width (ft)						50.00						50.00
BF Cross Sectional Area (ft^2)			4.93			15.65						5.80
BF Mean Depth (ft)			0.75			1.21						0.80
BF Max Depth (ft)						1.61						1.20
Width/Depth Ratio			6.25			10.67						9.00
Entrenchment Ratio						3.87						6.94
Bank Height Ratio						1.00						1.00
Wetted Perimeter (ft)			6.20			13.72						8.80
Hydraulic Radius (ft)			0.80			1.14						0.66
Pattern												
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	25.00	20.00
*Meander Wavelength (ft)				80.10	116.50	99.20				67.75	73.73	
*Meander Width Ratio				2.15	4.11	2.94						6.94
Profile												
Riffle Length (ft)				12.0	18.5	15.0				10.5	35.1	26.2
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520				0.0228	0.0765	0.0307
Pool Length (ft)				12.0	29.1	21.2				21.9	39.0	31.1
Pool Spacing (ft)				33.4	43.7	38.6				49.5	58.3	50.0
Substrate†												
D50 (mm)						69.2						7.8
D84 (mm)						140.1						21.6
Additional Reach Parameters												
Valley Length (ft)						974			261			171
Channel Length (ft)						1129			264			208
Sinuosity						1.2			1.01			1.22
Water Surface Slope (ft/ft)						0.0311			0.0083			0.0040
BF Slope (ft/ft)						0.0326			0.0084			0.0040
Rosgen Classification						E3/1b*			E4			E4
*Habitat Index												
*Macrobenthos												

*E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.

**Due to the similarities of position in the watershed for UT1 and UT2, pre-existing dimension, profile and substrate data was collected for UT2 only.

†UT1 Channel substrate composition is visibly the same as particle distribution collected and analyzed from existing conditions Riffle Cross-Section 1+41.2 on UT2.

Table 4d: Baseline Morphologic and Hydraulic Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)
Station/Reach: UT1 Lower Sta. 2+07 to 23+27

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.2371			0.5710			0.2371			0.2371
Bankfull Discharge (cfs)			18.5			77.6			32.2			32.2
BF Width (ft)			6.40			12.91			11.22			9.00
Floodprone Width (ft)						50.00			30.70			50.00
BF Cross Sectional Area (ft^2)			8.05			15.65			8.42			9.00
BF Mean Depth (ft)			0.95			1.21			0.75			1.00
BF Max Depth (ft)						1.61			1.17			1.50
Width/Depth Ratio			6.77			10.67			14.96			9.00
Entrenchment Ratio						3.87			2.74			5.56
Bank Height Ratio						1.00			1.76			1.00
Wetted Perimeter (ft)			8.30			13.72			14.52			11.00
Hydraulic Radius (ft)			0.97			1.14			1.00			0.82
Pattern												
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	25.00	20.00
*Meander Wavelength (ft)				80.10	116.50	99.20				63.29	93.84	75.00
*Meander Width Ratio				2.15	4.11	2.94						5.56
Profile												
Riffle Length (ft)				12.0	18.5	15.0	47.0	60.0	53.5	10.5	46.1	28.6
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0117	0.0185	0.0151	0.0228	0.0957	0.0381
Pool Length (ft)				12.0	29.1	21.2	24.6	39.4	31.2	18.7	41.0	27.9
Pool Spacing (ft)				33.4	43.7	38.6	35.4	76.6	54.7	32.7	85.1	54.3
Substrate												
D50 (mm)						69.2			5.5			5.5
D84 (mm)						140.1			16.1			16.1
Additional Reach Parameters												
Valley Length (ft)						974			1376			1423
Channel Length (ft)						1129			1603			2120
Sinuosity						1.2			1.16			1.49
Water Surface Slope (ft/ft)						0.0311			0.0051			0.0059
BF Slope (ft/ft)						0.0326			0.0058			0.0059
Rosgen Classification			E			E3/1b*			C4			E4
*Habitat Index												
*Macrobenthos												

*E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.

Table 4e: Baseline Morphologic and Hydraulic Summary
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)
Station/Reach: UT2 Sta. 0+00 to 2+82

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.0765			0.5710			0.0765			0.0765
Bankfull Discharge (cfs)			6.8			77.6			10.4			10.4
BF Width (ft)			3.94			12.91			4.91			6.30
Floodprone Width (ft)						50.00			21.24			50.00
BF Cross Sectional Area (ft^2)			3.73			15.65			2.88			4.30
BF Mean Depth (ft)			0.66			1.21			0.59			0.68
BF Max Depth (ft)						1.61			0.99			1.00
Width/Depth Ratio			5.97			10.67			8.32			9.26
Entrenchment Ratio						3.87			4.33			7.94
Bank Height Ratio						1.00			2.12			1.00
Wetted Perimeter (ft)			5.25			13.72			5.70			6.77
Hydraulic Radius (ft)			0.71			1.14			0.51			0.63
Pattern												
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				12.50	16.00	14.50
*Meander Wavelength (ft)				80.10	116.50	99.20				58.08	59.76	
*Meander Width Ratio				2.15	4.11	2.94						7.94
Profile												
Riffle Length (ft)				12.0	18.5	15.0	33.0	72.4		13.2	27.1	22.7
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0173	0.0306		0.0258	0.0532	0.0308
Pool Length (ft)				12.0	29.1	21.2	25.0	26.9		19.4	51.1	25.8
Pool Spacing (ft)				33.4	43.7	38.6			141.2	42.0	64.3	51.9
Substrate												
D50 (mm)						69.2			7.8			7.8
D84 (mm)						140.1			21.6			21.6
Additional Reach Parameters												
Valley Length (ft)						974			200			194
Channel Length (ft)						1129			203			282
Sinuosity						1.2			1.02			1.45
Water Surface Slope (ft/ft)						0.0311			0.0171			0.0054
BF Slope (ft/ft)						0.0326			0.0192			0.0054
Rosgen Classification						E3/1b*			E4			E4
*Habitat Index												
*Macrobenthos												

*E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.

3.4 Channel Stability Assessment

Beaverdam Creek Mainstem

In its present state, the stream's high degree of channel incision, expressed as the ratio of low bank height to maximum bankfull depth, or Bank Height Ratio (BHR range 1.56 - 1.60), low sinuosity (K = 1.08), denuded and destabilized streambanks composed of stratified sandy soils, relatively steep profile slope (0.0169 ft/ft, or 89.2 ft/mi) has resulted in a deeply incised, unstable channel with a high potential for erosion. The incised, vertical to undercut streambanks, accelerate streambank erosion rates. Utilizing the ratio of near-bank maximum bankfull depth to mean bankfull depth bank erosion hazard index (BEHI) algorithm in RiverMorph® v.4.0.1, it is estimated 21 cubic yards per year (or 28 tons per year) of sediment is being eroded from the unstable, vertical to undercut streambanks along the mainstem impaired reach. This estimate was calculated using the bank height (2.97 ft) measured at impaired pool cross-section 1+98.5 and the total mainstem impaired reach length (386 ft), and represents a bank erosion rate of 0.5 ft/yr. BEHI and sediment export, bank erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

UT1

In its present state along its forested reach, the stream's high degree of channel incision (BHR range 1.41 - 1.76), low sinuosity (K = 1.16), denuded and destabilized streambanks, profile slope (0.0058 ft/ft, or 30.6 ft/mi) has resulted in a deeply incised, unstable channel with a high streambank and bed erosion potential. The incised vertical to undercut denuded streambanks, accelerate erosion rates. Utilizing the ratio of near-bank maximum bankfull depth to mean bankfull depth BEHI algorithm in RiverMorph® v.4.1, it is estimated 67 cubic yards per year (or 87 tons per year) of sediment is being eroded from the unstable streambanks along the forested segment of UT1 impaired reach. This estimate was calculated using the bank height (2.68 ft) measured at impaired pool cross-section 0+88.5 and the lower impaired reach length from the point where the existing channel enters the forested corridor to its confluence with Beaverdam Creek (1351 ft), and represents a bank erosion rate of 0.5 ft/yr. BEHI and sediment export, bank erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

Upstream of the forested corridor on UT1, a separate BEHI was not calculated. This segment of the impaired reach is significantly different from the forested reach. Aggradation is the dominant depositional process as the land use is open pasture with non-uniform channel geometry modified by hoof shear together with low profile gradient. In its existing state, the upper UT1 stream segment lacks suitable features for aquatic habitat.

UT2

In its present state, the stream's high degree of channel incision (BHR range 1.80 – 2.12), low sinuosity (K = 1.01), denuded and destabilized streambanks, relatively steep profile slope (0.0192 ft/ft, or 101.4 ft/mi) has resulted in a deeply incised, unstable channel with a high sediment supply. The incised steep to near vertical denuded streambanks, accelerate erosion rates. Utilizing the ratio of near-bank maximum bankfull depth to mean bankfull depth BEHI algorithm in RiverMorph® v.4.0.1, it is estimated 4 cubic yards per year (or 5 tons per year) of sediment is being eroded from the unstable streambanks along the UT2 impaired reach. This estimate was calculated using the bank height (2.14 ft) measured at impaired pool cross-section 0+18.8 and the total UT2 impaired reach length (203 ft), and represents a bank erosion rate of 0.25 ft/yr. BEHI and sediment export, bank

erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

Channel Stability Summary

Summing the sediment export estimates for each of the project reaches, the impaired streams have the potential to contribute approximate 92 cubic yards (or 120 tons) of nutrient loaded sediment off site into the larger Beaverdam Creek watershed on an annual basis. The rate of erosion, expressed in feet per year per linear foot, is based on estimates from field observations for each of the impaired project reaches and their potential for mass loading of nutrients and sediment due to channel instability from uncontrolled cattle intrusion, agricultural land use and channelization.

Given the impaired condition of project reaches, the estimated annual rates of streambank erosion are reasonable. High, sustained flows typical of heavy rainfall events associated with stalled or slow moving tropical depressions, associated with hurricanes, come close enough to North Carolina to influence weather about twice during an average year. Once in 10 years, on average, hurricanes strike a part of the State with sufficient force to cause severe damage to inland property. The average annual rainfall east of the Blue Ridge Mountains generally ranges between 40 and 55 inches. In North Carolina the most severe weather is due to summer thunderstorms, with July being the wettest month. These storms usually affect localized areas, with hail, high winds and lightning occurring with some of them, accounting for an average yearly loss of over $5 million in property damage. At any given locality, 40 or 50 thunderstorms can be expected in a given year. (Source: State Climate Office of North Carolina). Under prevailing regional climatic patterns, the existing conditions of impaired site streams will continue to deteriorate and contribute significantly to offsite sedimentation and nutrient loading without intervention.

The consequence of channelization, cattle intrusion, confinement (lateral containment), major floods, changes in sediment regime, and loss of riparian vegetation are attributed causes and effects for existing conditions along the impaired project reaches. The effects of these anthropogenic changes are accelerated streambank erosion, channel incision, land loss, aquatic habitat loss, lowering of the water table, land productivity reduction and in-stream and downstream sedimentation and nutrient loading. Weighting each of the mitigation types and categories against stated projected goals, only full-scale restoration can achieve stabilization and the establishment of fully functional aquatic habitat in these streams.

3.5 Bankfull Verification

As noted in Section 3.2, for project stream reaches, bankfull discharge was evaluated through quantitative analysis of stable reference reach data and comparison of predicted bankfull discharge through a stable riffle section located on Davis Branch 43 feet upstream from its confluence with Gourdvine Creek as shown on **Figure 3A** and **Figure 7**. Discharge versus drainage area relationships for the reference reach riffle cross-section were compared to *Bankfull Hydraulic Geometry Relationships for North Carolina Streams (Rural Piedmont)* regional curve dataset. Through this analysis, it was determined the rural Piedmont regional curves underestimate bankfull discharge and geometric relationships for project reach streams. This may be due, in part, to scarcity of data collected from the south-central region of the North Carolina rural Piedmont Physiographic Province in developing the regional curves.

The calculated discharge, using quantified reference reach bankfull riffle geometry, profile slope, and bed roughness yielded a bankfull discharge of 77.6 cubic feet per second (cfs). The regression equations developed from the rural Piedmont regional curve database predicted bankfull discharge

based on the empirical relationship between reference reach drainage area (365.55 acres or 0.571 square miles) and discharge at the same position in the watershed at 40.4 cfs. To investigate the 37.2 cfs difference between the quantified and the empirically derived bankfull discharge, the USGS Water Resources Investigations Report 01-4207, *Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina* (Pope, B.F., Tasker, G.D, and Robbins, J.C., 2001) provides some insight into the poor correlation.

The North Carolina rural flood-frequency peak discharge versus drainage area regression equation, published in Table 5, on page 11 of the cited report for the 2-year flood recurrence interval for the rural Blue Ridge – Piedmont follows:

$$Q_{2\text{-}Yr} = 135DA^{0.702}$$

Where $Q_{2\text{-}Yr}$ is the estimated peak discharge with a 2-year recurrence interval and DA is the drainage area in square miles. Inputting the Davis Branch Reference Reach drainage area (0.571 square miles) into this equation yields the following result:

$$Q_{2\text{-}Yr} = 135 \times 0.571^{0.702} = 91.1 \text{ cfs}$$

The bankfull discharge return interval published with the *Bankfull Hydraulic Geometry Relationships for North Carolina Streams (Rural Piedmont)* regional curve dataset and the Log-Pearson Type III distributions used to develop the rural Piedmont bankfull regression equations ranged from 1.1 to 1.8 years, with a mean return interval of 1.4 years. The coefficient of determination (R^2) for bankfull discharge power function regression equation is 0.97 for the dataset, using best fit regression equations for the upper and lower 95% confidence limit for this relationship.

However, the wide range of values included in within the 95% confidence limits indicates the need for caution when using these empirical relationships. For example, the bankfull cross-sectional area for a 10-square mile watershed ranges from approximately 60 to 180 square feet with a predicted value of 103 square feet. This natural variability results from variations in average annual runoff, stream type (Rosgen, 1994), land use, and the natural variability of stream hydrology (Leopold, 1994).

The *Bankfull Hydraulic Geometry Relationships for North Carolina Streams* (Rural Piedmont) power function regression equation for bankfull discharge is:

$$Q_{bkf} = 66.57A_w^{0.89}$$

where Q_{bkf} = bankfull discharge (cfs) and A_w = watershed drainage area (mi^2). Inputting the Davis Branch Reference Reach drainage area into the power function regression equation yields the following result:

$$Q_{bkf} = 66.57 \times 0.571^{0.89} = 40.4 \text{ cfs.}$$

Since the quantitatively derived discharge of 77.6 cfs, based on carefully measured field parameters falls between the predictions using the two cited references, and given the variability of the estimates themselves, the quantitatively derived discharge, extrapolated proportionally to project sub-watershed drainage areas, has been carried forward into the design.

Refer to **Tables 4a – 4e** for reach specific estimates of bankfull discharge and hydraulic geometries from the regional curve database, reference reach, pre-existing conditions and proposed design conditions.

3.6 Vegetation

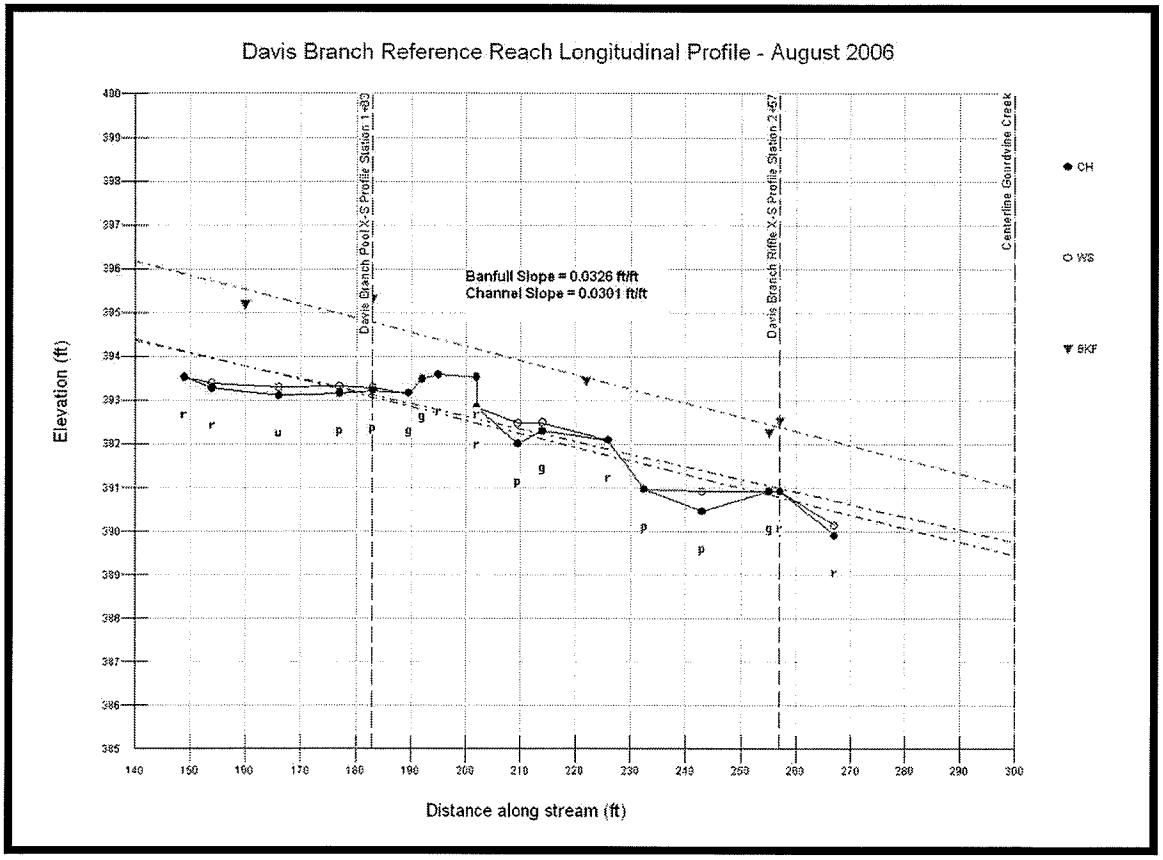
A relatively narrow wooded corridor is currently present along most of the Beaverdam Creek mainstem on site and the downstream half of UT1. These corridors exhibit some denuding of the understory due to cattle disturbance. Typical species observed with the corridor included *Ulmus alata* (winged elm), *Quercus phellos* (willow oak), *Quercus velutina* (black oak), *Acer negundo* (boxelder), *Asimina triloba* (pawpaw), *Lonicera* species (honeysuckle), *Bignonia capreolata* (crossvine), *Carex* species (sedge), *Mitchella repens* (partridgeberry), and *Geranium* species (wild geranium). Little to no riparian corridor is present along the upstream half of UT1, and the entire reach along UT2 is denuded within the project area. Active pasturelands surround the project streams, and cattle have unrestricted access to the streams. This has resulted in significant damage to the stream banks in some areas. No potential wetlands were observed along the project corridor.

4.0 REFERENCE STREAMS

4.1 Watershed Characterization

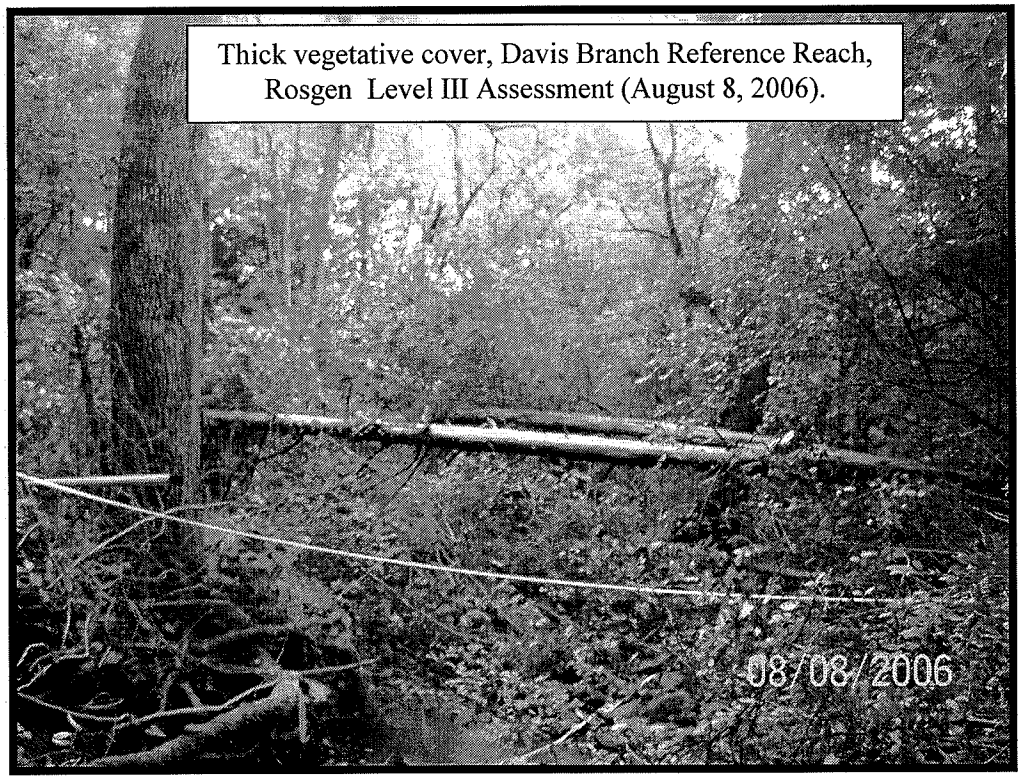
Davis Branch Reference Reach

For Beaverdam Creek, bankfull discharge was determined through a quantitative assessment and analysis of reference reach boundary conditions and comparison of predicted bankfull discharge through a stable riffle cross-section located on Davis Branch 43 feet upstream from its confluence with Gourdvine Creek. The reference reach is a Rosgen Valley Type VIII, E3/1b stream type (i.e., E channel morphology, large cobble substrate with strong bedrock control, profile gradient greater than 2 percent). The reference reach is located within a healthy, deciduous hardwood forested riparian corridor. A complete Rosgen Level III watershed assessment and analysis of the reference reach conditions was conducted during August 8 and 9, 2006. The longitudinal profile that follows, analyzed using RiverMorph® version 4.0.1, shows the best fit trend lines of the streambed, water surface and bankfull indicators:

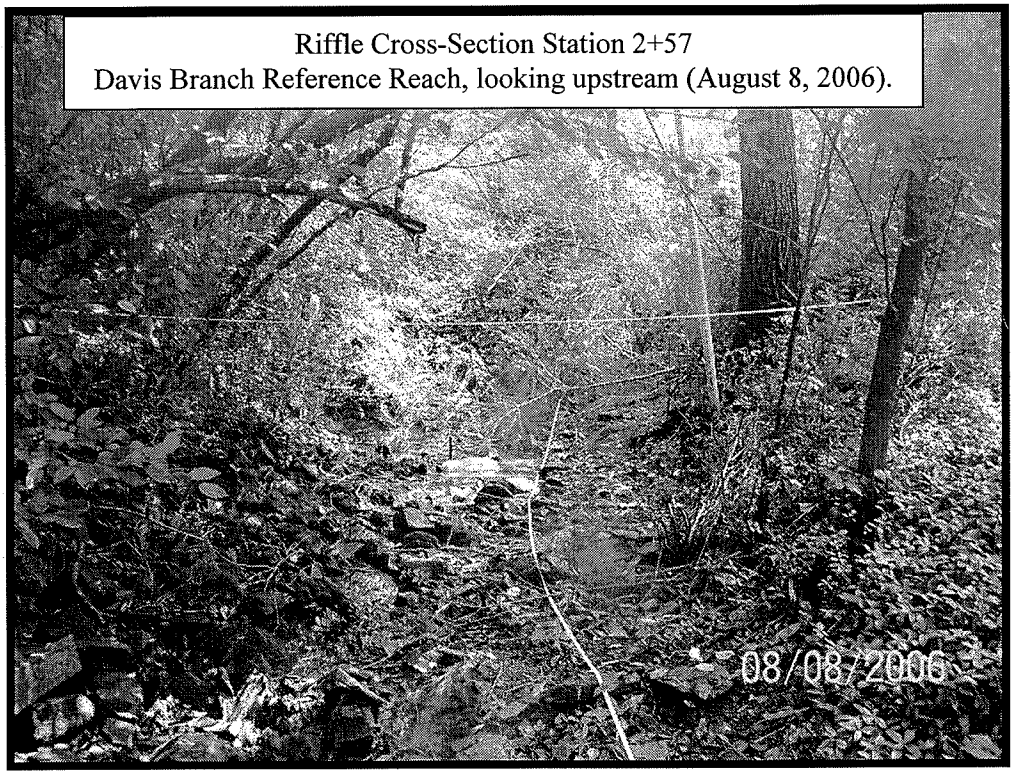


The healthy, robust vegetation and root mass along the reference reach riparian corridor, extending overbank into the channel, is extremely stable and resistant to streambank erosion. The streambed is stable due to hard bedrock control. Large cobble deposited on top of the bedrock is a secondary substrate, resulting from physical weathering of the highly fractured, steeply dipping, thick- to thin-bedded slate bedrock (dominant bedding plane orientation strikes N65°E, with a mean dip angle of 55° to the northwest, average protrusion height 0.57 feet or 174 mm based on field measurements). Due to extremely thick riparian vegetation during August 2006, it was possible to collect profile and cross-section data along a relatively short length of the stable reach. The following photographs

depict field conditions at the time of the field survey and reference reach Rosgen Level III assessment.



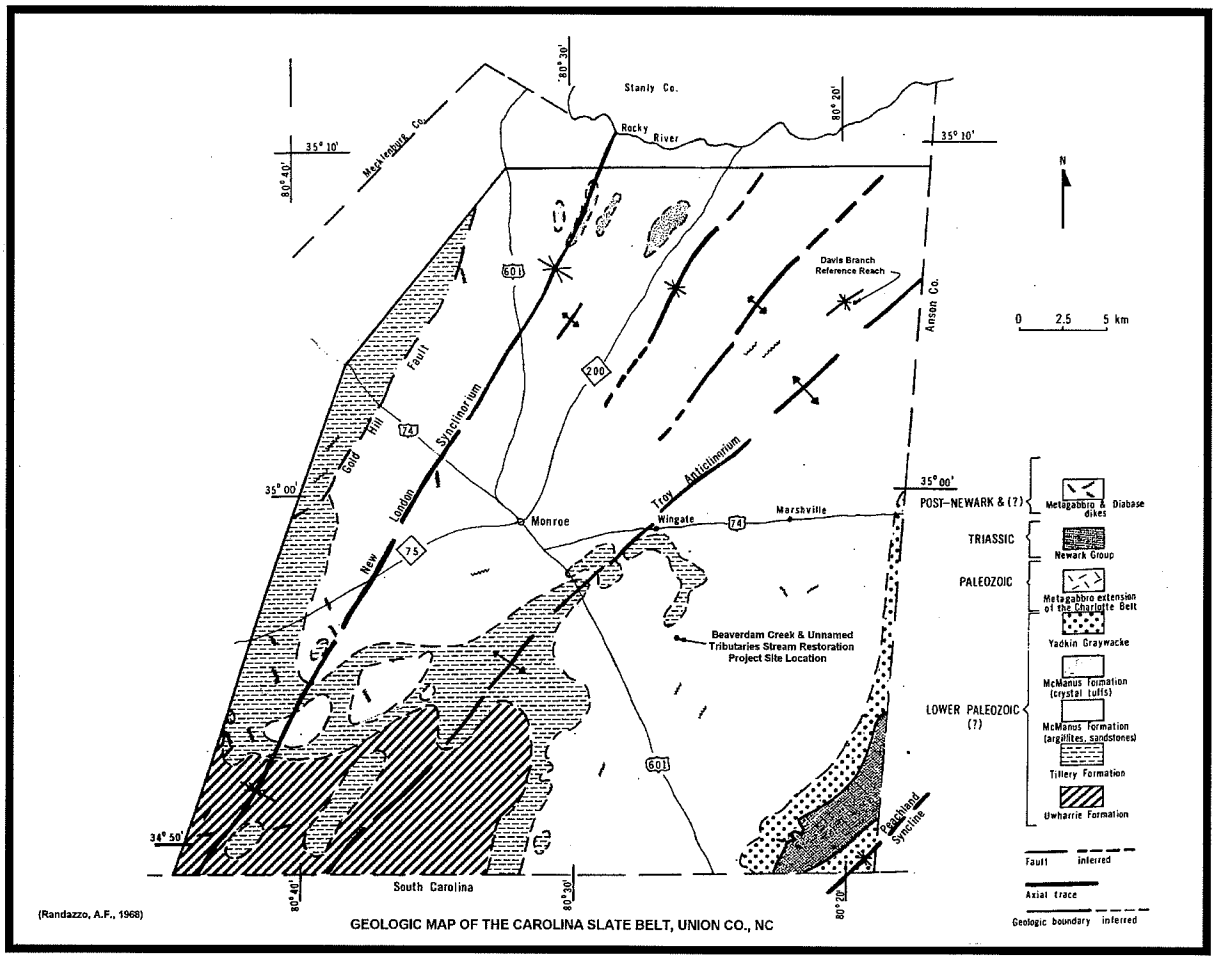
Thick vegetative cover, Davis Branch Reference Reach, Rosgen Level III Assessment (August 8, 2006).



Riffle Cross-Section Station 2+57
Davis Branch Reference Reach, looking upstream (August 8, 2006).

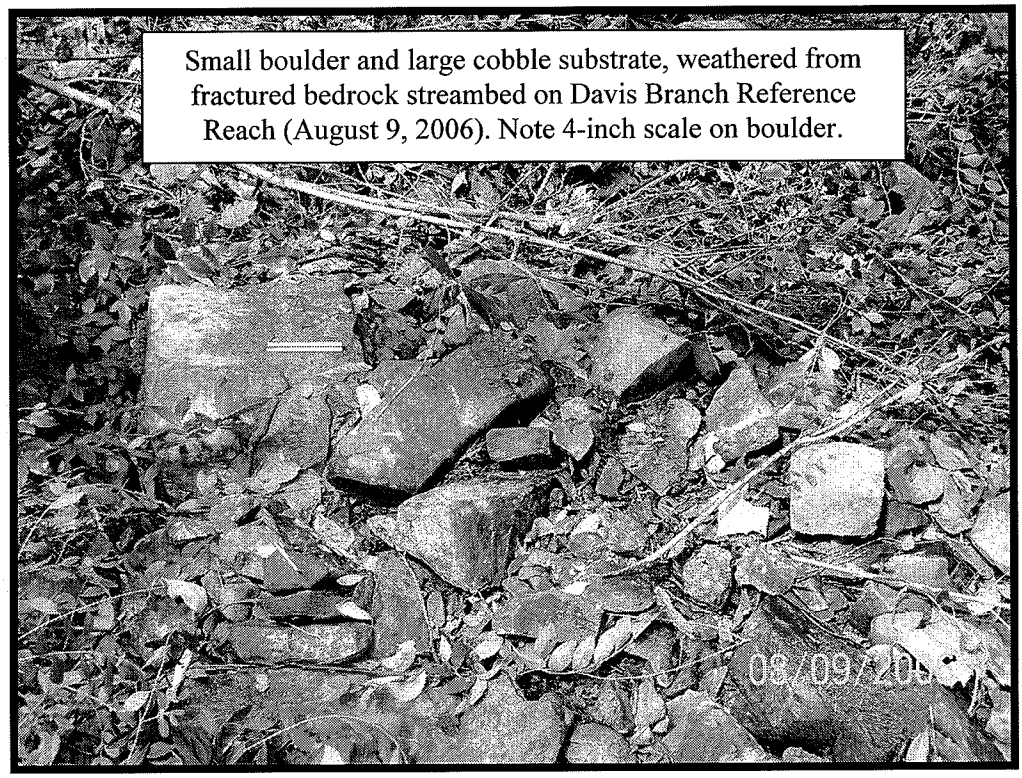
EMH&T staff were able to clear line of site 151 feet deep into the overgrown Davis Branch Reference Reach, accessing the stream from its confluence with Gourdvine Creek. Due to backwater from Gourdvine Creek at the mouth of Davis Branch, 118 linear feet of profile, capturing three pool and four riffle sequences, with one representative riffle and pool cross-section being surveyed in the field. Geologic structural controls and lithology, fluvial geomorphologic processes, depositional materials, climatic influence, riparian vegetation, deposition pattern, debris occurrence, meander pattern, channel stability rating, sediment supply, streambed stability and width/depth ratio state were evaluated following Rosgen Level III stream assessment protocols. Visibility was limited in the field to dense vegetative cover along the Davis Branch Reference Reach; therefore, Union County orthoimagery (2/2004) was used to verify stream pattern. The high-resolution (1 pixel = 6 inches) orthoimagery is included on **Figures 3A** and **7**. A total of 1129 linear feet of the reach was assessed for each Level III stream state and condition parameter consistent with a Rosgen Level III methodologies. The assessment included GPS data spatial analysis to evaluate channel pattern upstream from the surveyed reach, beyond the point where additional differential level surveying was impracticable and channel pattern could not be discerned from recent aerial imagery.

The Davis Branch Reference Reach is located 12.8 miles northeast of the Beaverdam Creek and Unnamed Tributaries Restoration Project. The reference reach is located along the same geologic structural feature, the Troy Anticlinorium (northwest limb near the axial plane of an unnamed syncline), in the same geologic formation, the McManus Formation, is mapped on the same soil series (Chewacla silt loam, Goldston soils and Cid channery silt loam), and is located in the same physiographic province and ecoregion as the Beaverdam Creek project impaired reaches. The reference reach is shown at watershed scale on **Figure 3A** and at reach scale on **Figure 7**. The included geologic map of Union County, North Carolina (Randazzo, A.F., 1968) indicates the reference reach location relative to the site:



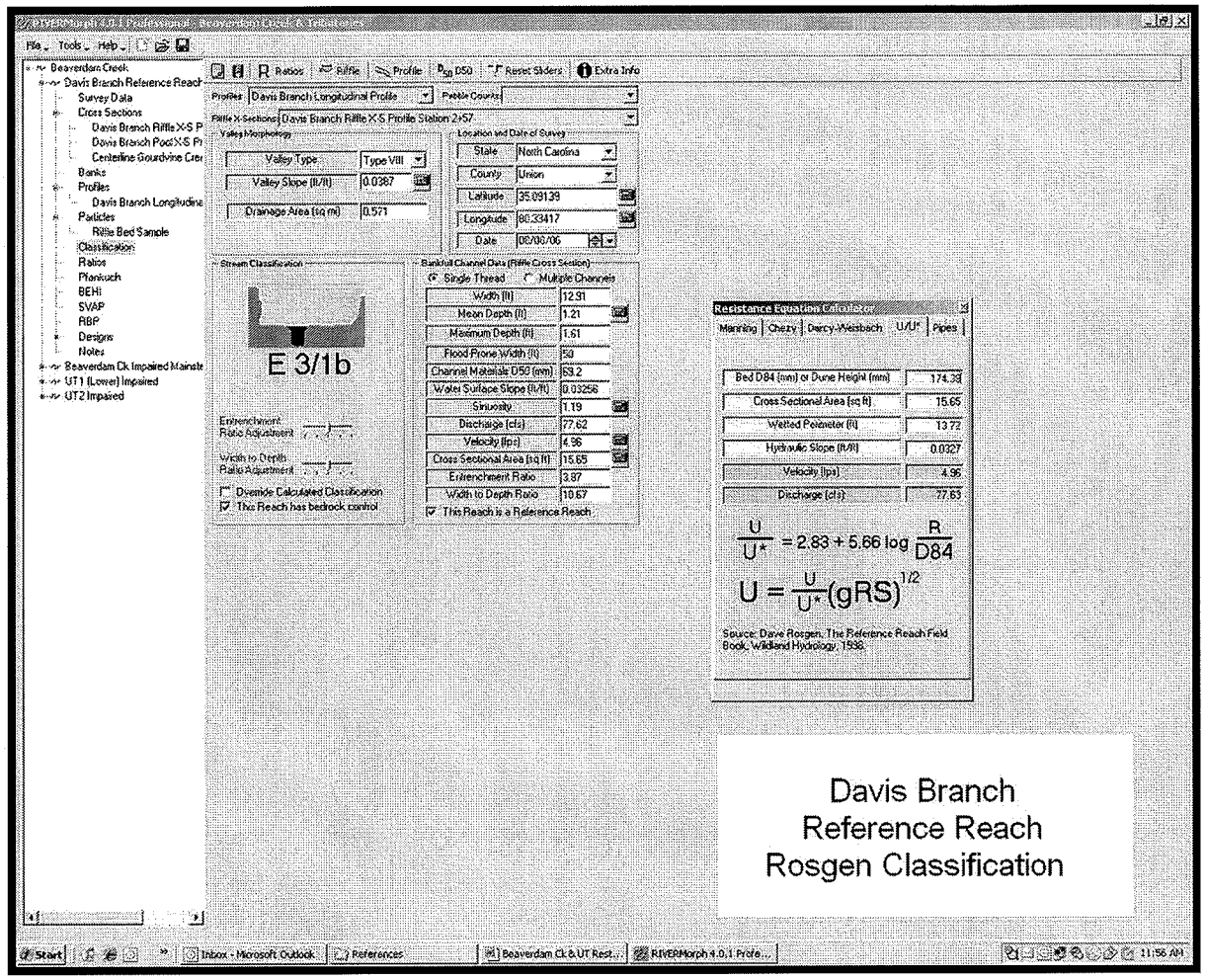
Calculated bankfull discharge for the surveyed reference reach riffle cross-section, was computed using hydraulic radius, wetted perimeter, channel slope and a relative roughness (u/u*) method based on the average protrusion height of the steeply dipping bedrock (Rosgen, 1998). Additionally, a particle distribution was collected from the large angular cobble deposited along the reference reach riffle bed. Based on an average protrusion height of 0.57 feet (or 174 mm), bankfull discharge is quantified at 77.6 cfs. The D84 particle size from the stable riffle particle distribution is 140.1 mm and is consistent with the observed bed thickness and axial splitting planes and observed joint sets in the folded and deformed slate bedrock, as shown on the photographs that follow.

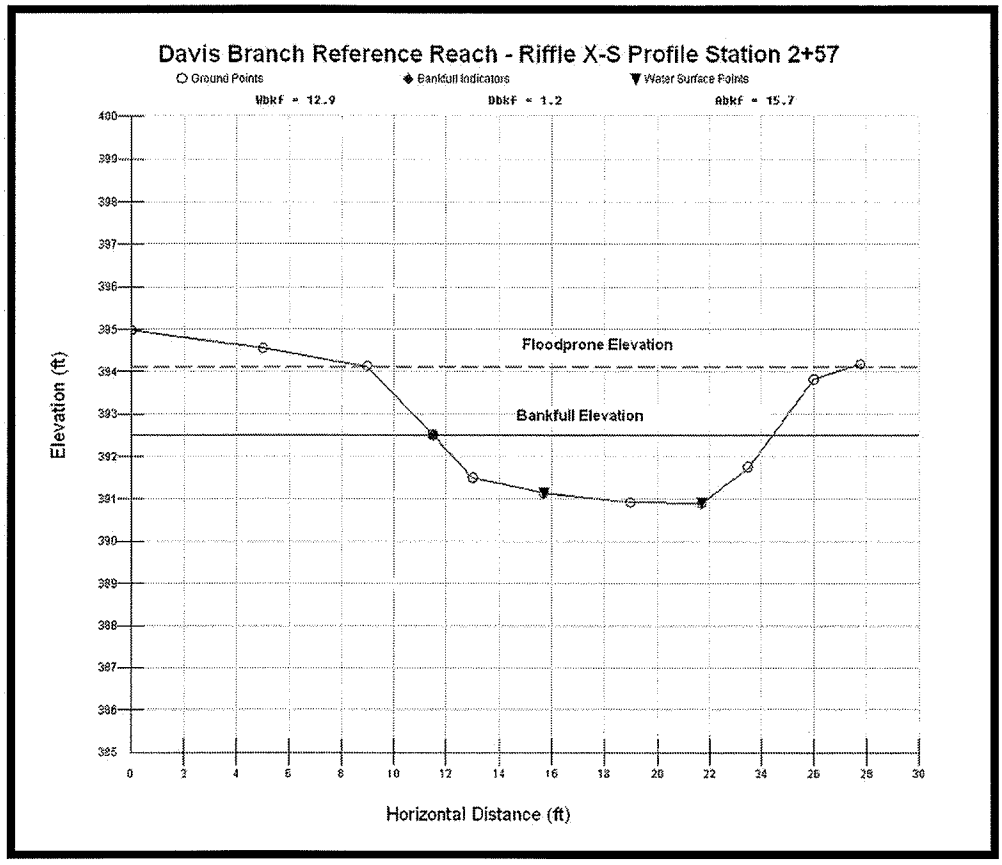
Steeply dipping argillaceous slate bedrock, Davis Branch Reference Reach, looking upstream (August 8, 2006).

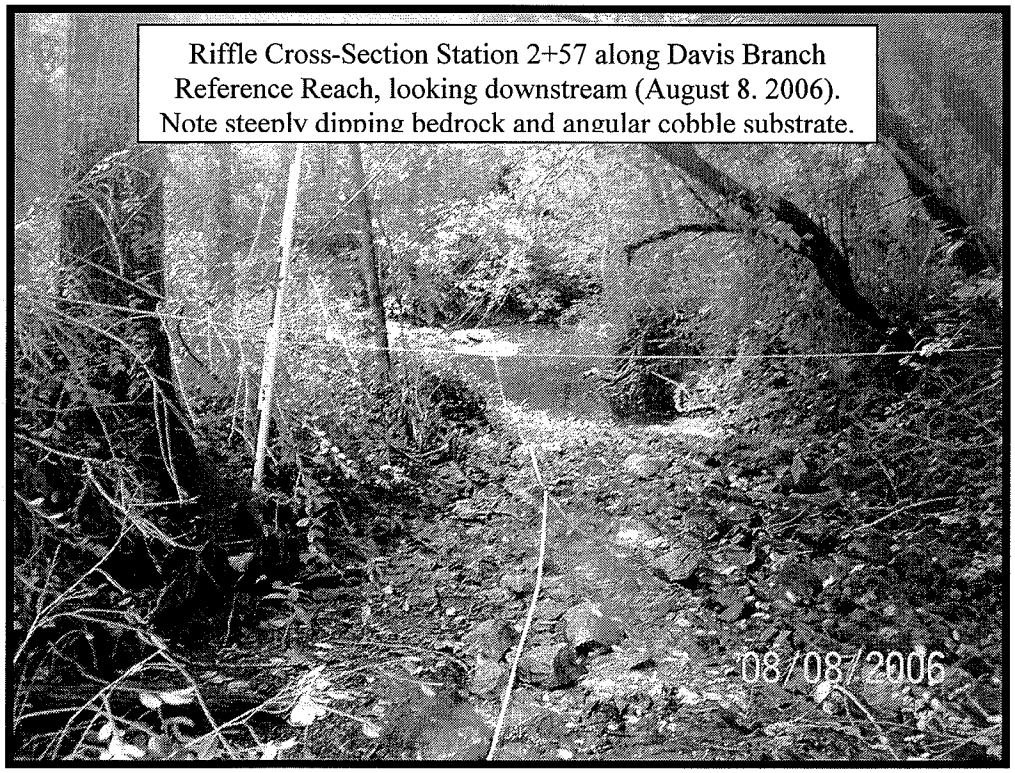


Small boulder and large cobble substrate, weathered from fractured bedrock streambed on Davis Branch Reference Reach (August 9, 2006). Note 4-inch scale on boulder.

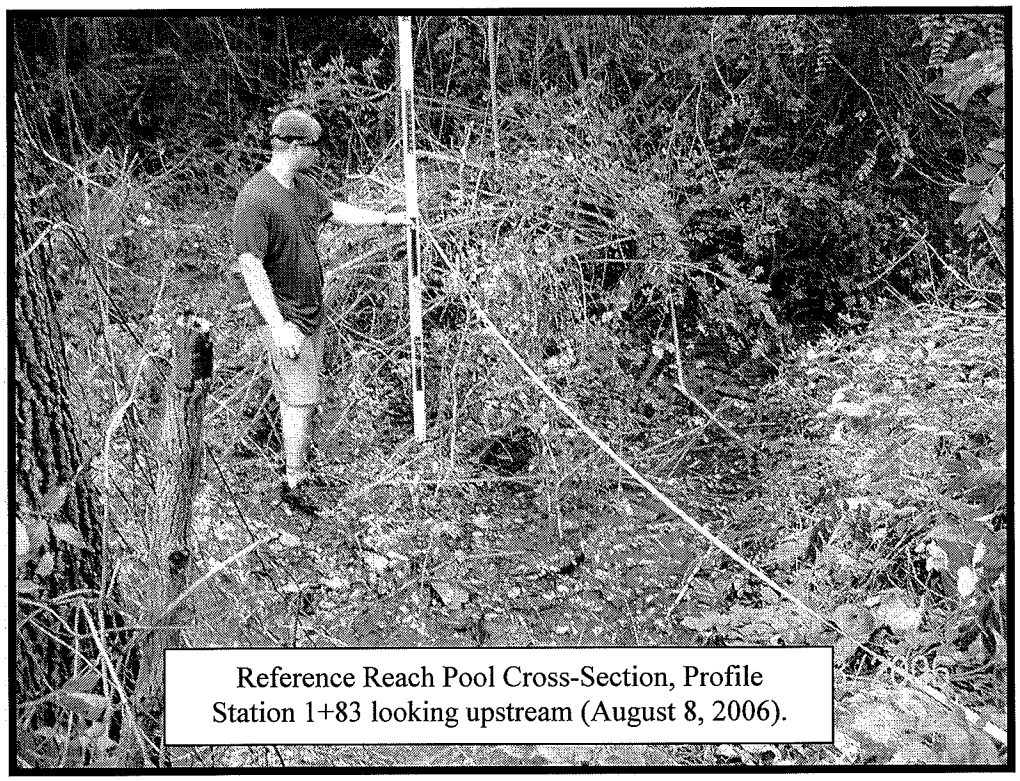
The following screen shot from RiverMorph® shows the boundary conditions and calculated bankfull discharge and mean flow velocity through the reference reach riffle cross-section:


Beaverdam Creek
Davis Branch Reference Reach
Survey Data
Cross Sections
Profiles
Particles
Rifle Bed Sample
Classification
Ratios
Pfankuch
BEHi
SVAP
RBP
Designs
Notes
Beaverdam Ck Impaired Mainste
UT1 (Lower) Impaired
UT2 Impaired
Ratios
Riffle
Profile
Reset Sliders
Extra Info
Davis Branch Longitudinal Profile
Davis Branch Riffle X-S Profile Station 2+57
Valley Type
Type VIII
Valley Slope (ft/ft)
0.0387
Drainage Area (sq mi)
0.571
State
North Carolina
County
Union
Latitude
35.09139
Longitude
80.23417
Date
06/06/06
E 3/1b
Single Thread
Multiple Channels
Width (ft)
12.91
Mean Depth (ft)
1.21
Maximum Depth (ft)
1.61
Flood Prone Width (ft)
50
Channel Materials D50 (mm)
63.2
Water Surface Slope (ft/ft)
0.03256
Sinuosity
1.19
Discharge (cfs)
77.62
Velocity (fps)
4.96
Cross Sectional Area (sq ft)
15.65
Entrenchment Ratio
3.87
Width to Depth Ratio
10.67
Override Calculated Classification
This Reach has bedrock control
This Reach is a Reference Reach
Resistance Equation Calculator
Manning
Chezy
Darcy-Weisbach
U/U*
Pipes
Bed D84 (mm) or Dune Height (mm)
174.38
Cross Sectional Area (sq ft)
15.65
Wetted Perimeter (ft)
13.72
Hydraulic Slope (ft/ft)
0.0327
Velocity (fps)
4.96
Discharge (cfs)
77.63
$\frac{U}{U^*} = 2.83 + 5.66 \log \frac{R}{D84}$
$U = \frac{U}{U^*}(gRS)^{1/2}$
Source: Dave Rosgen, The Reference Reach Field Book, Wildland Hydrology, 1998.
Davis Branch
Reference Reach
Rosgen Classification
Start
Inbox - Microsoft Outlook
References
Beaverdam Ck & UT Rest...
RIVERMorph 4.0.1 Profe...
11:56 AM

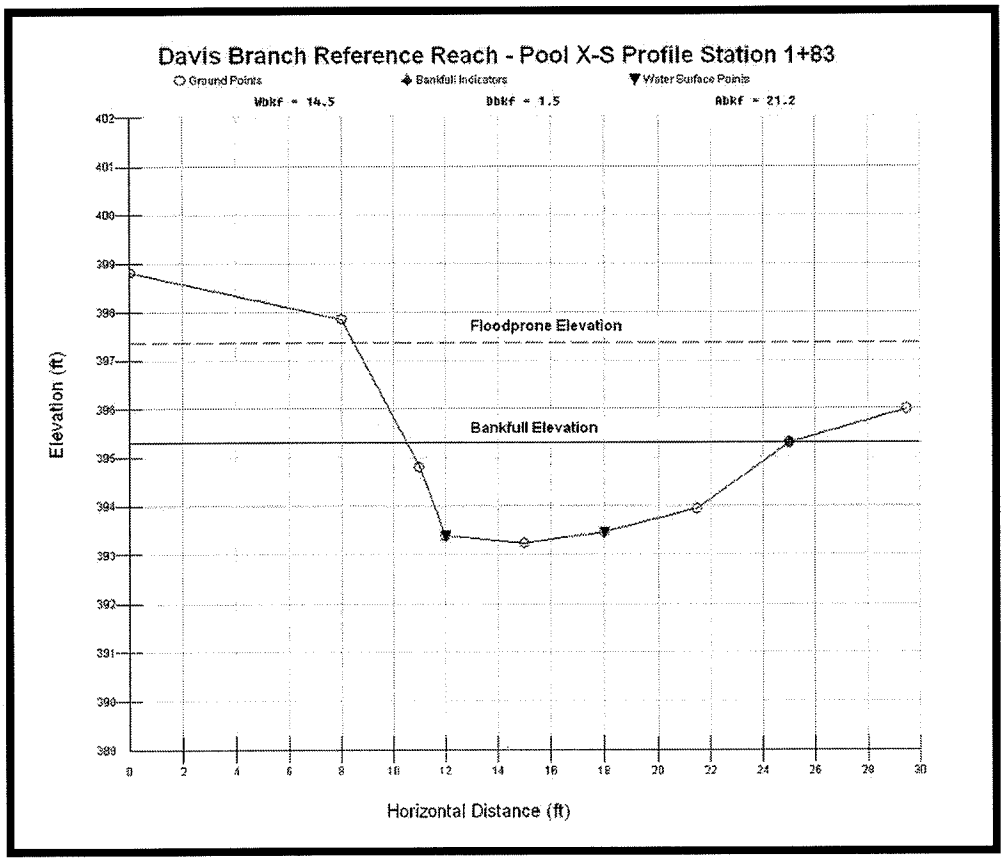




Riffle Cross-Section Station 2+57 along Davis Branch Reference Reach, looking downstream (August 8. 2006). Note steeply dipping bedrock and angular cobble substrate.



Reference Reach Pool Cross-Section, Profile Station 1+83 looking upstream (August 8, 2006).



The Davis Branch reference reach classification, data summary reports and supporting documentation are presented in **Appendix 3**.

4.2 Channel Stability Assessment

Reference reach channel stability was analyzed using the vertical velocity near-bank stress method algorithm in RiverMorph® v.4.0.1 and reach streambank observations and channel morphology from reference reach Pool Cross-Section 1+83, located on Davis Branch 117 feet upstream from its confluence with Gourdvine Creek. The predicted annual erosion rate estimate was calculated for the entire 1129 linear feet of stream evaluated as part of the Rosgen Level III reference reach study. Based on reference reach conditions, the predicted sediment loss is 3.23 cubic yards or 4.2 tons per year. This equates to 0.0043 tons/year per foot of reach, or two one hundredths of a foot (0.02 ft) streambank erosion on an annual basis. The near-bank adjective rating (0.35) is very low for the reference reach, indicating extremely stable channel conditions. The quantitative inputs and analytical results from the reference reach channel stability assessment are included with the information in **Appendix 3**.

4.3 Discharge

Reference reach quantified and verified discharge estimates are presented in Sections 3.2, 3.5 and 4.1. Detailed data analysis and the quantified results from that data are presented in **Appendix 3**.

4.4 Channel Morphology

Reference reach channel morphology is discussed in detail in Section 4.1. Detailed data analysis is included within **Appendix 3**. Morphologic and hydraulic summary data for the reference reach is presented in **Tables 4a – 4e**.

4.5 Bankfull Verification

See Section 3.2, 3.5 and 4.1 for reference reach bankfull verification details and supporting documentation in **Appendix 3**.

4.6 Vegetation

Davis Branch Reference Reach

The Davis Branch reference reach flows through a deciduous hardwood forest area, which provides a wide riparian corridor. The canopy layer is dominated by native tree species including *Plantanus occidentalis* (American sycamore), *Carya* species (hickory), and *Acer negundo* (boxelder). The shrub/ sapling and herbaceous understory is extremely thick and provides significant protection against bank erosion. Species such as *Rosa multiflora* (multiflora rose), *Alnus serrulata* (hazel alder), *Bignonia capreolata* (crossvine), *Viola* sp. (violet), and *Convolvulus species* (bindweed) are present within the understory. Photographs of the reference reach are provided within **Section 4.1**.

5.0 PROJECT SITE RESTORATION PLAN

5.1 Restoration Project Goals and Objectives

The primary goal and objective for the project reaches is to restore stable pattern, profile and dimension along Beaverdam Creek mainstem, UT1 and UT2. This will be accomplished using both on-line and off-line, Priority I and II approaches to improve the connection of the laterally confined and incised existing channel with its floodplain. Grade control structures will be used to reduce critical shear stress in the near-bank region while maintaining flow velocities and critical depths required to entrain coarse gravel (D84 particle size = 17.2 mm), based on analysis of riffle bed particle distributions collected from the impaired mainstem reach riffle conditions.

The restoration plan for Beaverdam Creek mainstem utilizes proven geomorphologic approaches developed by understanding and implementing stable channel dimension, pattern and profile, based on quantified and verified reference reach boundary conditions and then superimposing the stable dimension, pattern and profile on the unstable form. An evaluation of stream mitigation approaches including preservation, enhancement, and full-scale restoration was conducted for each of the project reaches. An Enhancement Level I approach, as defined in the multi-agency April 2003 Stream Mitigation Guidelines, was evaluated in terms of meeting project goals for the impaired project reaches. Due to historical stream modifications (channelization) and existing agricultural land use impacts (livestock encroachment), restoring dimension and profile only would not achieve the required level of ecological enhancement needed to return the impaired project reaches to a stable, natural condition. Restoring profile and dimension alone will not create in-stream conditions critical to support aquatic diversity and ecologic functions inherent of high quality, healthy headwater streams. To achieve the most beneficial outcome, from an ecosystem enhancement perspective, the inclusion of sinuous pattern, together with restored profile and dimension is required to reverse prior hydo-modifications along the project reaches. In doing so, the ecological function of these headwater streams, will achieve project goals and objectives, and in turn, support and enhance ecological function in the downstream watershed.

The restoration approach for the impaired mainstem reach entails improving the realigned channel's connection with its existing forested riparian corridor and floodplain with appropriate elevation, width, valley slope and channel dimensions to maintain entrainment velocities required to move coarse gravel-size particles, readily available to the stream during bankfull flow conditions while maintaining competency to mobilize silt and sand size particles at normal stage. The proposed channel is an E4 stream type designed with stable dimension, pattern and profile to entrain its bedload without aggrading or degrading at bankfull stage. In-stream structures will be utilized to reduce shear stress in the near-bank region and provide grade control at the locations shown on the Restoration Plan Sheets in **Appendix 1**.

In-stream structures proposed include cross-vanes, constructed riffle and pool sequences, and streambank channel reinforcement. The in-stream structures have the added benefit of creating aquatic habitat and preventing the development of deleterious mid-channel sand and gravel bars that increase flow velocities and shear stress in the near-bank region. The plan sheets and design details for the Beaverdam Creek mainstem are presented in **Appendix 1**.

Channel reinforcement materials will be used in high shear stress regions (i.e., along outside meander bends). Reinforcement materials will consist of a combination of: rock toe, coir log, coconut fiber geotextile matting held in place with hardwood stakes and soil nails; live branch plantings; and aggressive seeding, mulching and revetment of streambanks and the riparian corridor. Channel

reinforcement methods are indicated as Detail 'C' on Restoration Plan Sheet RP-10/17 and Planting Plan on RP-17/17 in **Appendix 1**.

The existing forested riparian corridor will be protected and augmented along the realigned Beaverdam Creek mainstem reach and UT1 to enhance streambank stability, provide sediment and nutrient storage, and enhance terrestrial and aquatic habitat. Along the remainder of Beaverdam Creek and UT1, and for the entire project reach of UT2, a native riparian corridor will be established and protected. The stream corridors will be protected by the installation of livestock exclusion fencing placed at the edge of the conservation easement boundary.

5.1.1 Designed Channel Classification

The proposed designed Beaverdam Creek mainstem, UT1 and UT2 channels are stable E4 channels, with restored pattern, profile and dimension to entrain bedload readily available to the reaches. **Table 5** summarizes the restoration structure and objectives for Beaverdam Creek mainstem, UT1 and UT2.

TABLE 5
Restoration Structure and Objectives
Project Number D06054-C (Beaverdam Creek and Unnamed Tributaries)

Reach/Approach	Existing Length	Proposed Length	Stationing	Comment
Mainstem Priority Level I Restoration	416 lf	464 lf	0+00 – 4+64	Restore stable channel pattern profile, dimension, substrate Improve connection to existing floodplain Riparian plantings Livestock exclusion fencing
UT1 Priority Level I/ II Restoration	1,806 lf	2,327 lf	0+00 – 23+27	
UT2 Priority Level I/ II Restoration	203 lf	282 lf	0+00 – 2+82	

Note: Proposed stream lengths include lengths within the permanent conservation easement. Refer to the Restoration Summary Table in the Executive Summary for stream lengths adjusted for breaks in the perpetual NC EEP Conservation Easement on record for the project shown on Restoration Plan Sheet RP-02/17.

5.1.2 Target Buffer Communities

The target buffer community for both riparian planting areas along Beaverdam Creek, UT1 and UT2 is of the Piedmont/Low Mountian Alluvial Forest community type, as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990). According to the Schafale and Weakley publication, hydrology of these areas is palustrine, seasonally or intermittently flooded on various alluvial soils. Important characteristics regarding the Piedmont/Low Mountain Alluvial forest Community according to Schafale and Weakley, 1990 include the following:

- *Flood carried sediment provides nutrient input to these communities, as well as serving as a natural disturbance factor.*

- *Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but almost all alluvial sites are more fertile than surrounding uplands.*

- *Piedmont/Low Mountain alluvial forests may be distinguished from mesic communities by location in a floodplain and by the presence of alluvial species such as Platanus occidentalis, Betula nigra, and Acer negundo.*

- *Piedmont Alluvial Forests may be distinguished from Montane Alluvial Forests by the presence of low elevation alluvial species such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata.*

5.2 Sediment Transport Analysis

5.2.1 Methodology

The modified Shields Equation was used to calculate the largest entrainable particle size, based on reach-specific design boundary conditions for the Beaverdam Creek mainstem, UT1 and UT2. (Rosgen, 1994; Williams and Rosgen, 1989; Andrews, 1984).

5.2.2 Calculations and Discussion

Shields (1936) described shear stress as:

$\tau = \gamma RS$

where:

τ = shear stress (lbs/sq. ft.)
γ = specific weight of water (62.4 lbs/cu. ft.)
R = hydraulic radius (ft.), and
S = channel slope (ft./ft.).

To test the relationship between shear stress and mean stream velocity at multiple flow levels, Rosgen (1994) used an aggregate data set for six stream types. By plotting discharge (cfs) vs. bedload (lbs/sec) it was demonstrated a significant relationship was not found for the aggregate data set. Rosgen found, however, there is a significant empirical relationship when the same data set was stratified by stream type and shear stress (lbs/sq. ft.) was plotted vs. mean velocity (ft/sec) on a log-log scale.

The associated critical dimensionless shear stress (τ_{ci}*) was calculated based on the D50 particle distribution collected at impaired individual reach riffle cross-sections and composite D50 particle distributions approximated by combining particle distributions from both riffles and pools on each reach, respectively.

The critical dimensionless shear stress, returned from RiverMorph®, is calculated using the following equation (Williams & Rosgen, 1989):

$$\tau_{ci}^* = 0.0834(D50_{BED}/D50_{COMP})^{-0.872}$$

The following equation is used to predict the depth and slope needed to move the largest size of sediment available to the channel:

$$d = \frac{(\tau_{ci}^*)\ (\gamma_S)\ (D50_{COMP})}{S}$$

Where:

γ_S = submerged specific weight of sediment (2.65 gm/cm^3)
$D50_{COMP}$ = median diameter of composite sample
d = mean depth
S = mean water surface slope at bankfull

The bankfull critical shear stress, under design conditions, using the Rosgen Modified Shields Curve, and the entrainable particle diameter for each reach is summarized in the following table:

TABLE 6
Sediment Transport Analysis – Design Conditions
Project Number D06054-C (Beaverdam Creek Mainstem, UT1 and UT2)

Reach	Critical Shear Stress (lbs/sq. ft.)	Particle Diameter (mm)
Upper Beaverdam Creek	0.41	78.4
Lower Beaverdam Creek	1.86	239.6
Upper UT1	0.18	43.9
Lower UT1	0.27 – 0.34	58.5 – 69.1
UT2	0.21	48.6

The required bankfull surface slope, hydraulic geometries and critical depths are included within **Appendix 4**. Design particle size by reach are presented in Tables 4a through 4e, and the information used to determine these particle sizes are contained in the appendices.

5.3 Stormwater Best Management Practices

5.4.1 Site-Specific Stormwater Concerns

Properly installed and well maintained Best Management Practices (BMP) applications shall adequately mitigate the impact of sediment laden stormwater flows within the project corridors. The stormwater BMP erosion and sediment control narrative, practices, schedule, contractor responsibilities, inspection, maintenance and soil stabilization measures are presented on restoration plan sheets RP-12/17 through RP-16/17 in **Appendix 1**. All BMP applications will be inspected and maintained throughout the construction process and until the site is stabilized per the planting plan shown on sheets RP-17/18 and RP 18/18 in **Appendix 1** and as described in Section 5.5.

5.5 Natural Plant Community Restoration

5.5.1 Plant Community Restoration Plan

The proposed riparian planting plan was developed by integrating the native plant species observed on site, species recommended within the *Guidelines for Riparian Buffer Restoration* (NCDENR – DWQ, 1/2001), as well selected species known to inhabit the Piedmont/Low Mountain alluvial forest community type as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990) to institute species diversity. Table 7 presents the designed vegetative communities by zone along the streams. Where there is no pre-existing riparian corridor, the restored stream reaches will be fully replanted with the appropriate native species in the form of live stakes or bare-root material, along with some larger specimens (1 gallon container size). Planting zones (Zones 1 – 4) have been designated for the project as described in the tables on the following page. Where a woody riparian corridor is already present along the reaches, the existing corridor will be

preserved to the maximum extent practicable and only Zone 1 and 2 plantings will be installed to provide vegetative cover immediately along the newly restored channel. In addition, it is anticipated that the installation of cattle exclusion fence along the stream easement corridors will allow the impaired understory to eventually redevelop within existing wooded areas. Sheet RP-18/18 in **Appendix 1** indicates the approximate extent of full riparian restoration plantings (Zones 1-4), versus supplemental plantings (Zones 1-2).

Riparian plantings will be installed during the fall or spring season, as soon as possible after the completion of the earthwork associated with the restoration effort. Supplemental shrub and tree species will be planted if survival rates of previous plantings are below target densities. Final species selection will be based upon availability. In addition to plantings described in Table 7, temporary and permanent seeding will occur in Zones 2, 3 & 4. The planting plan is presented in the schematic engineering drawings, included on design sheets RP-17/18 and RP-18/18 in **Appendix 1**.

TABLE 7
Designed Vegetative Communities by Zone
Project Number D06054-C (Beaverdam Creek Mainstem, UT1 and UT2)

- Zone 1 – Stream Edge

Live Branches, 3x3' centers

Common Name	Scientific Name
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Black willow	*Salix nigra*
Silky willow	*Salix sericea*
Elderberry	*Sambucus canadensis*

- Zone 2 – Streamside Shrubs and Trees

Shrubs, Bareroot Material - 4x4' centers

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Tag alder	*Alnus serrulata*
Red chokeberry	*Aronia arbutifolia*
Silky dogwood	*Cornus amomum*
American holly	*Ilex opaca*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*

Trees, 1 Gallon Containers - 100 foot spacing

Common Name	Scientific Name
River birch	*Betula nigra*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Sycamore	*Platanus occidentalis*

Water oak	*Quercus nigra*
Willow oak	*Quercus phellos*
American elm	*Ulmus americana*

- Zone 3 – Floodplain

Bareroot Material - 8x8' centers

Common Name	Scientific Name
Red chokeberry	*Aronia arbutifolia*
Pawpaw	*Asimina triloba*
River birch	*Betula nigra*
American hornbeam	*Carpinus caroliniana*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Sycamore	*Platanus occidentalis*
American elm	*Ulmus americana*

TABLE 7
Designed Vegetative Communities by Zone
Project Number D06054-C (Beaverdam Creek Mainstem, UT1 and UT2)

- Zone 4 – 30' Riparian Buffer

Bareroot Material - 10x10' centers

Common Name	Scientific Name
Pignut hickory	*Carya glabra*
Flowering dogwood	*Cornus florida*
White ash	*Fraxinus americana*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Eastern hophornbeam	*Ostrya virginiana*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Smooth sumac	*Rhus glabra*
Winged elm	*Ulmus alata*

5.5.2 On-Site Invasive Species Management

This project proposes to treat and eradicate exotic woody vegetation by appropriate means. This will help meet one of the overall goals of the restoration project by enhancing buffers and creating habitat for birds and animals. By eradicating non-native vegetation, native vegetation will be allowed to colonize and provide a better food source for the local fauna.

Before treatment, a vegetation assessment would be performed to determine the presence and extent of invasive vegetation. The most appropriate treatment options will be determined after the assessment. Invasive species that may colonize the site after construction will be identified during

post-construction monitoring events, and appropriate eradication methods will be employed. Possible treatments for invasive exotic vegetation include application of appropriate herbicides either through stem cut and spray or spraying of the actively photosynthesizing leaves. This work would most likely be done in the fall or winter, during the dormant season of most native vegetation. The initial treatment would likely take a week to complete. Follow up and maintenance is critical in order to eradicate any root sprouts that may occur in the following seasons.

6.0 PERFORMANCE CRITERIA

6.1 Streams

As discussed in the original proposal, the restoration goal for the stream is to restore the physical and biological integrity beyond current stream conditions. Current conditions consist of modified or impaired stream channels. Objectives to meet that goal of restoring these stream channels are listed below:

- Provide a stable stream channel with features characteristic of a biologically diverse environment
- Restore the connection between the bankfull width and floodprone width of the channels by improving the floodplain area
- Stabilize eroding streambanks
- Provide a functional, native riparian corridor where deficient, and preserve any existing forested corridor
- Improve the physical aquatic habitat features
- Minimize land development impacts to the streams
- Provide long-term protection of the stream corridors, including preservation of existing wooded corridors

Restoration of the streams will provide desired habitat and stability features necessary to improve the quality of the stream. There are many long-term benefits derived from the efforts to restore the streams, such as:

- Reversing the effects of channel incision
- Stabilizing eroding streambanks
- Development of instream habitat features
- Revegetation of the riparian corridor with native vegetation that can be utilized by local wildlife
- Improving connection to the floodplain, with the accompanying benefits of sediment and nutrient storage

The restoration techniques proposed for the project stream reaches will provide the attributes described above by incorporating a variety of features recognized to support the stability and biological diversity that are essential to restoration and ecosystem enhancement. Presently, these features are diminished within Beaverdam Creek and the associated Unnamed Tributaries.

The restoration of the streams includes assessing and predicting the morphological features that will become the foundation for the construction of a stable natural channels. Considerations that have been applied to the design of this project are listed below.

- Bankfull channels designed with the appropriate dimension and cross-sectional area to convey anticipated bankfull flows and to entrain bedload material.
- Stable channel pattern (sinuosity) extrapolated from stable reference reach boundary conditions.
- Grade control and bank stabilization structures to enhance the environmental and ecological attributes of the stream channels though the use of natural materials and native plantings.

- In-stream habitat features such as pool/riffle complexes, cross-vanes, bank stabilization structures, and re-establishment of the appropriate substrate material.
- Improved connections between stream channels and functional floodplains.
- Installation of woody plantings where the riparian corridor is currently deficient, or where it is disturbed for construction. Existing woody vegetation present along the streams will be preserved to the maximum extent practicable.

Proven natural stream geometry relationships as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, is the basis for designing a stable, self-maintaining channel. These empirical relationships between channel pattern, profile and dimension and stream flow form the foundation for the restoration of the physical and biological functions of the stream.

6.2 Stormwater Management Devices

Properly installed and well maintained Best Management Practices (BMP) applications shall adequately mitigate the impact of sediment laden stormwater flows within the project corridors. The stormwater BMP erosion and sediment control narrative, practices, schedule, contractor responsibilities, inspection, maintenance and soil stabilization measures are presented on restoration plan sheet RP-12/17 through RP-16/17 in **Appendix 1**. All BMP applications as shown on restoration plan sheets RP-12/17 through RP-16/17 will be inspected and maintained throughout the construction process and until the site is stabilized per the planting plan shown on sheets RP-17/18 and RP-18/18 in **Appendix 1**.

6.3 Vegetation

The target density for the riparian buffer is to establish a minimum of 320 stems per acre after 3 years, with a minimum of 260 stems per acre at the end of the 5-year monitoring period within the planted areas. This would represent a minimum survival rate of 80% of the plantings.

6.4 Monitoring Schedule and Reporting

The restoration site will be monitored for five consecutive years or until the required success criteria have been met as determined by the EEP, NC DWQ, and USACE. As-built survey data will be collected immediately after construction. Year 1 Monitoring activities will begin will be conducted al least 6 months after the as-built survey. Planting will occur during the fall of 2008 or no later than the spring of 2009; therefore, the riparian buffer restoration will be monitored the following growing season (September 2009). Monitoring activities will follow the guidelines presented in the request for proposal for this project.

Parameters that will be included in the annual stream monitoring to ensure the success of the restoration activities will include stream channel surveys (longitudinal and cross-sectional profiles), pebble counts, photographs, and vegetation surveys. Monitoring reports will be prepared following the EEP Monitoring Report Format, Version 1.2 dated 11/16/06.

Following the submittal of the monitoring reports to the appropriate agency representatives, the recipients of the report will be contacted for the purpose of discussing the monitoring data, required success criteria and whether or not the site is functioning as expected. If the site is not functioning as expected, a site visit will be scheduled with the review agencies so that consideration can be given to whether a remediation plan should be created and implemented. The remediation plans, if required, will directly reflect the requested alterations as discussed with the regulatory agencies, if it is determined that such alterations will correct any identified deficiencies.

Stream Channels

Stream channel stability will be physically monitored by establishing permanent cross-sections located approximately every 500 feet along the restored channels (or no more than 2 per thousand feet). This will include two cross-sections (1 riffle, 1 pool) each on Beaverdam Creek and UT2, as well as six cross-sections (3 riffles, 3 pools) along UT1. Each cross-section will be monumented for future identification and survey. All of these cross-sectional surveys will also be utilized as photographic points. Cross-section locations to be monitored will be established immediately following construction during the completion of the "as-built" survey. A longitudinal profile survey will be conducted along the entire length of each restoration reach. The "as-built" mitigation plan will include the constructed stream channel dimension, pattern, and longitudinal profile. This data will be utilized as baseline to compare future monitoring surveys and subsequently to determine channel stability and transition. Other data collected will include at least six pebble counts for the project, stream pattern data, and riparian vegetation conditions. Annual inspection of in-stream structures will also occur to verify proper function and channel stability. Stream channel monitoring surveys will be completed annually for five consecutive years, starting on Year 1 after completion of the project.

The performance standards for the restoration project are those mandated in the multi-agency *Stream Mitigation Guidelines* (USACE Wilmington District, et al., April 2003). Performance goals for the site are:

- Minimal or negligible development of instream bar deposits.
- Minimal or negligible change in channel pattern, profile and dimension in comparison to As-Built conditions. Adjustments may occur and some may be indicative of stability, for example moderate reductions in width/depth ratios as a result of slight channel narrowing, natural sorting and shaping of bed materials and features, respectively.
- Maintenance of floodplain connectivity (only reductions or very small increases will be considered acceptable).
- Target density of 320 stems per acre after 3 years and 260 stems per acre after 5 years for planted woody vegetation (represents 80% survival after 5 years).

Subsequent monitoring reports will address the attainment of performance goals. If goals are not be attained, then the monitoring reports will document any remedial actions taken during the monitoring period and the success of these actions.

Riparian Buffers

Vegetation within the restored riparian buffer will be monitored for five consecutive years. A total of 8 ten by ten meter square plots will be permanently established within planted areas following completion of the planting phase. At least two opposing corners will be marked and surveyed for future location in the field.

Approximately 2.8% of the project area will be monitored following the CVS-EEP Level 1 Protocol for Recording Vegetation, Version 4.0 (Lee et al., 2006). A stem count of planted species will be performed within each monitoring plot. The species, location, size, density, survival rates, and cause of mortality if identifiable will be reported for each planted species in each plot. Vegetation plots will be sampled annually and reported every year along with the data collected during the physical monitoring of the channel. The primary focus of the vegetative monitoring will be on the planted individuals in the tree and shrub strata. Vegetation monitoring will occur during the month of September.

Monitoring reports and discussions of remedial actions will take place with EEP. EEP will review the monitoring documents and make them available to the agencies after the review period. Decision making regarding remediation will be between EEP and WRC and its agents or representatives. Agency interaction will take place through permit requests for maintenance should they become necessary. Agency interaction will take place at the end of the monitoring period.

7.0 REFERENCES

Andrews, E.D. 1984. Bed-material Entrainment and Hydraulic Geometry of Gravel-Bed Rivers in Colorado, Geological Society of America, Bulletin 95, 371-378.

Fullagar, P.D., and Odom, A.L. 1973. Geochronology of Precambrian Gneisses in the Blue Ridge Province of Northwestern North Carolina and Adjacent Parts of Virginia and Tennessee, Geological Society America Bulletin, v. 84, p. 3065-3079.

Lee, Michael T. et al. 2006. CVS-EEP Protocol for Recording Vegetation – Level 1-2 Plot Sampling Only, Version 4.0. Available Online: http://www.nceep.net/business/monitoring/veg/cvs-eep-manual-v4_lev1-2.pdf.

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

Leopold, L.B., Wolman, M.G., and Miller, J.B. 1964. Fluvial Processes in Geomorphology, W.H. Freeman, San Francisco, CA.

Pfankuch, D.J., 1975. Stream Reach Inventory and Channel Stability Evaluation, USDA Forest Service, R1-75-002. Government Printing Office #696-260/200, Washington, D.C., 26 pp.

Randazzo, Anthony F., 1968. Petrography and Stratigraphy of the Carolina Slate Belt, Union County, North Carolina, Ph.D. Thesis, University of North Carolina at Chapel Hill, 80 pp.

Rosgen, D.L. and Silvey, H.L. 2005. The Reference Reach Field Book, Second Edition, Wildland Hydrology, Inc., Fort Collins, CO.

Rosgen, D.L. 1998. The Reference Reach – A Blueprint for Natural Channel Design, ASCE Conference on River Restoration in Denver Colorado – March 1988, Reston, VA.

Rosgen, D.L. and Silvey, H.L. 1998. Field Guide for Stream Classification, Second Edition, Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L. 1997. A Geomorphological Approach to Restoration of Incised Rivers, Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision, Denver CO.

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

Rosgen, D.L. 2002. The Cross-Vane, W-Weir and J-Hook Vane Structures: Their Description, Design and Application for Stream Stabilization and River Restoration, Wildland Hydrology, Inc. Pagosa Springs, Colorado.

Schafale, Michael P. and Weakley, Alan S. 1990. Classification of the Natural Communities of North Carolina Third Approximation, North Carolina Department of the Environment, Health and Natural Resources

Schumm, S.A., Harvey, M.D., and Watson, C.C. 1984. Incised Channels: Morphology, Dynamics and Control, Water Resource Publication, Littleton, CO.

Shields, A. 1936. Application of Similarity Principles and Turbulence Research to Bedload Movement, Mitt. Preuss. Verschsanst., Berlin. Wasserbau Schiffbau. In W.P. Ott and J.C. Uchelen (translators), California Institute of Technology, Pasadena, CA. Report No. 167; 43 pp.

U.S. Army Corps of Engineers – Wilmington District, U.S. Environmental Protection Agency Region 4, North Carolina Wildlife Resources Commission, North Carolina Division of Water Quality, USDA Natural Resources Conservation Service, April 2003. Stream Mitigation Guidelines, Raleigh, North Carolina.

U.S. Department of Agriculture, Forest Service. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique, General Technical Report RM-245, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

U.S. Department of Agriculture, Natural Resources Conservation Service. January 3, 2006. NRCS Soil Survey of Union County, North Carolina, NRCS, 1996.

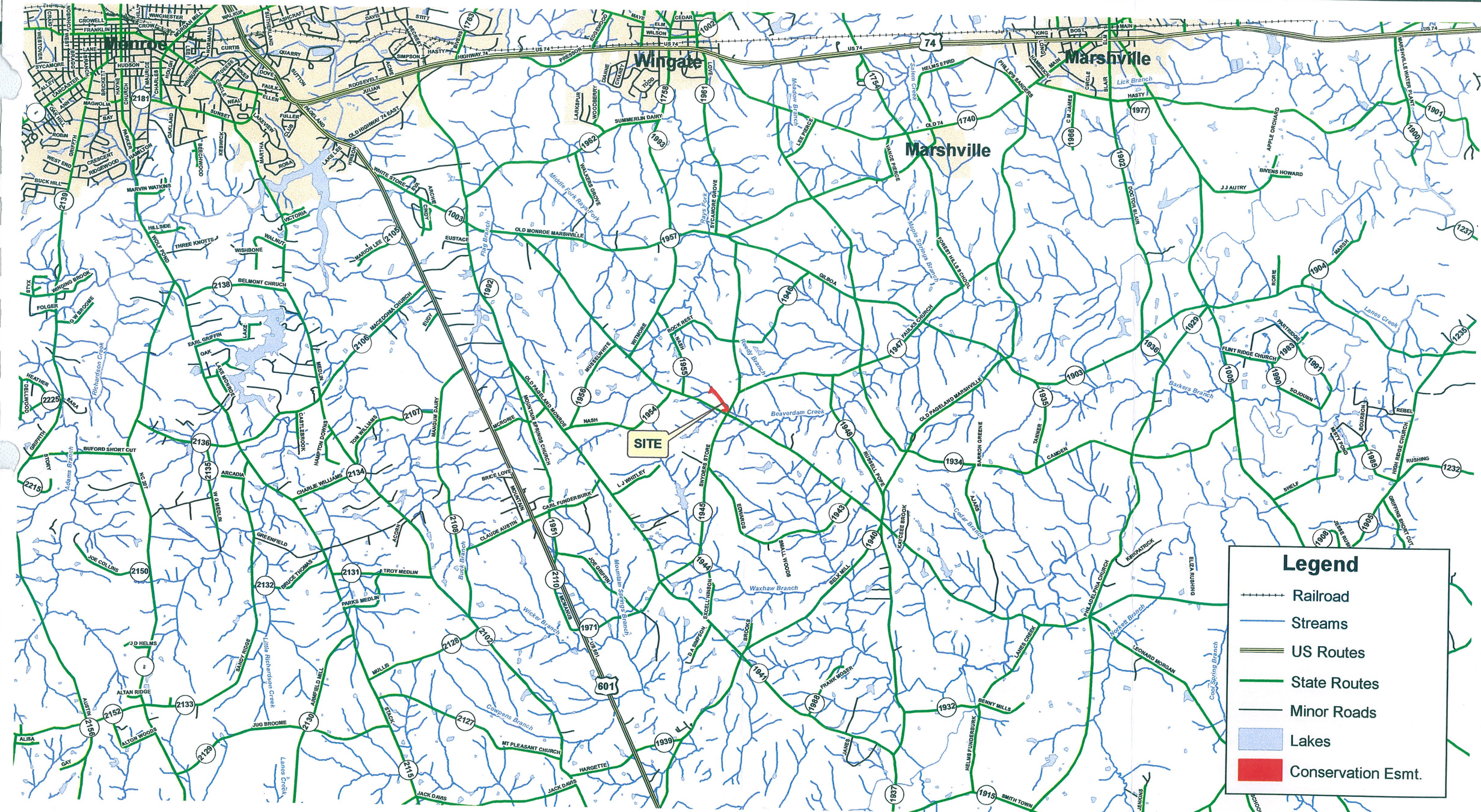
U.S. Geological Survey, 2001. Water Resources Investigations Report 01-4207, Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina (Revised), Benjamin F. Pope, Gary D. Tasker and Jeanne C. Robins.

U.S. Geological Survey. 2001. National Land Cover Dataset. Available for download at: http://www.mrlc.gov/mrlc2k_nlcd.asp.

Williams, G.P. and Rosgen, D.L., 1989. Measured Total Sediment Loads (Suspended Loads and Bedloads) for 93 United States Streams, U.S. Geological Survey Open File Report 89-67, Denver, CO, 128 pp.

Wolman, M.G., 1954. A Method of Sampling Course River-Bed Material, Transactions of American Geophysical Union 35: 951-956.

8.0 Figures



EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

UNION COUNTY, NORTH CAROLINA

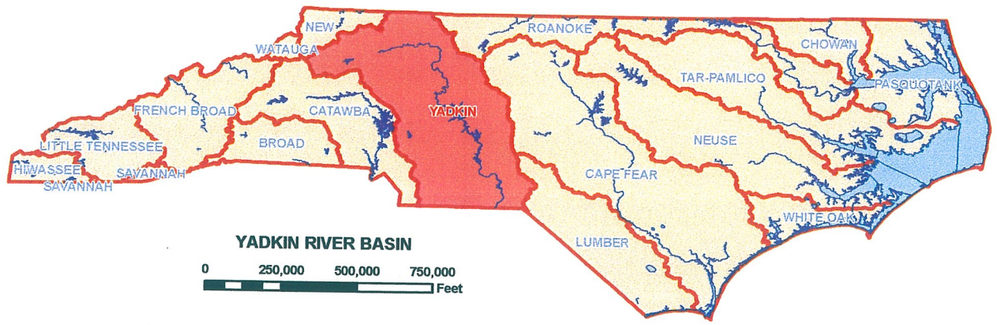
BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
SITE VICINITY MAP
FIGURE 1

Scale: 1" = 5000'
0 2,500 5,000 10,000 15,000 Feet

Sources:
- Roads - NCDOT GIS Branch
- Streams and Lakes - National Hydrography Dataset (medium resoultion)
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar. 2005

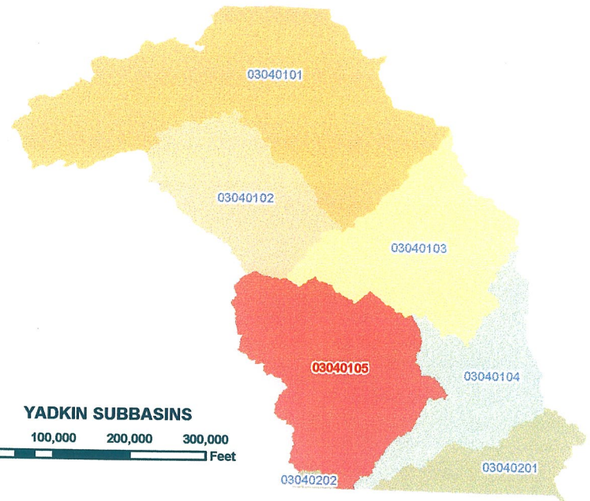
N

Path: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_1_Site_Vicinity_Map.mxd)



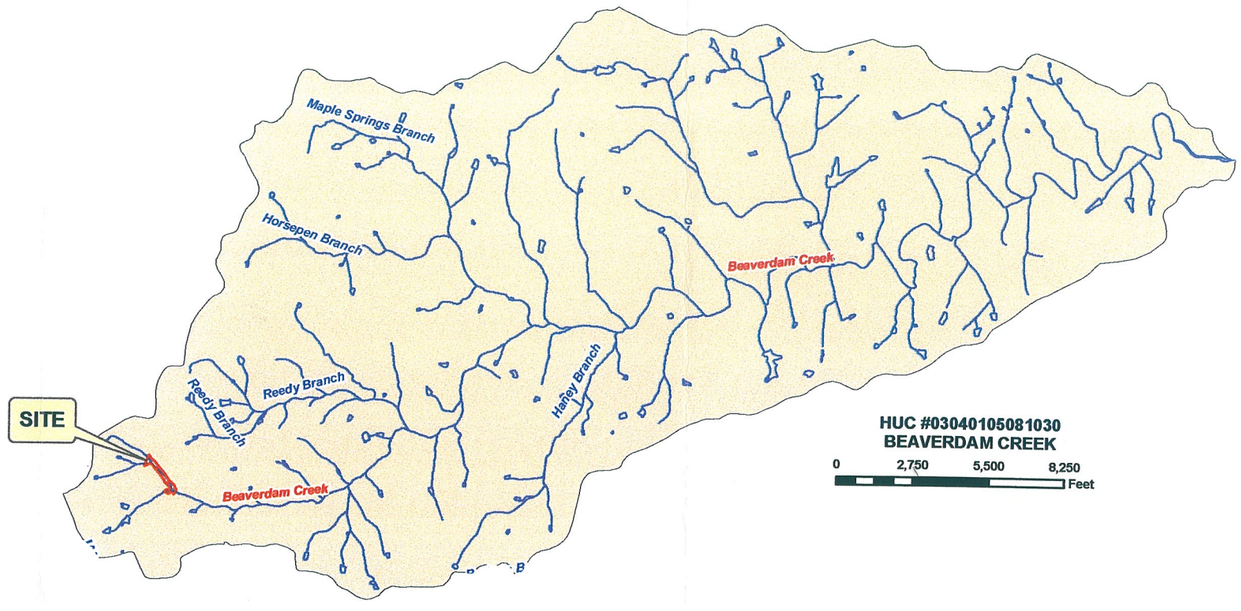
YADKIN RIVER BASIN

0 250,000 500,000 750,000 Feet



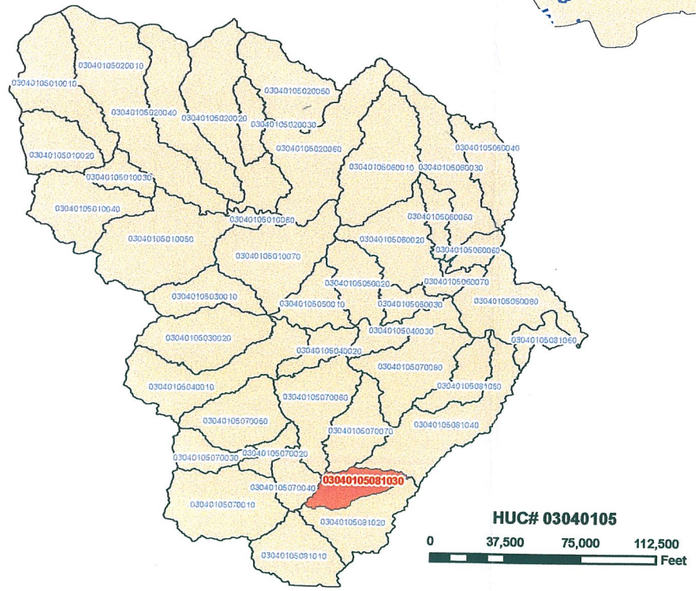
YADKIN SUBBASINS

0 100,000 200,000 300,000 Feet



HUC #03040105081030
BEAVERDAM CREEK

0 2,750 5,500 8,250 Feet



HUC# 03040105

0 37,500 75,000 112,500 Feet

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

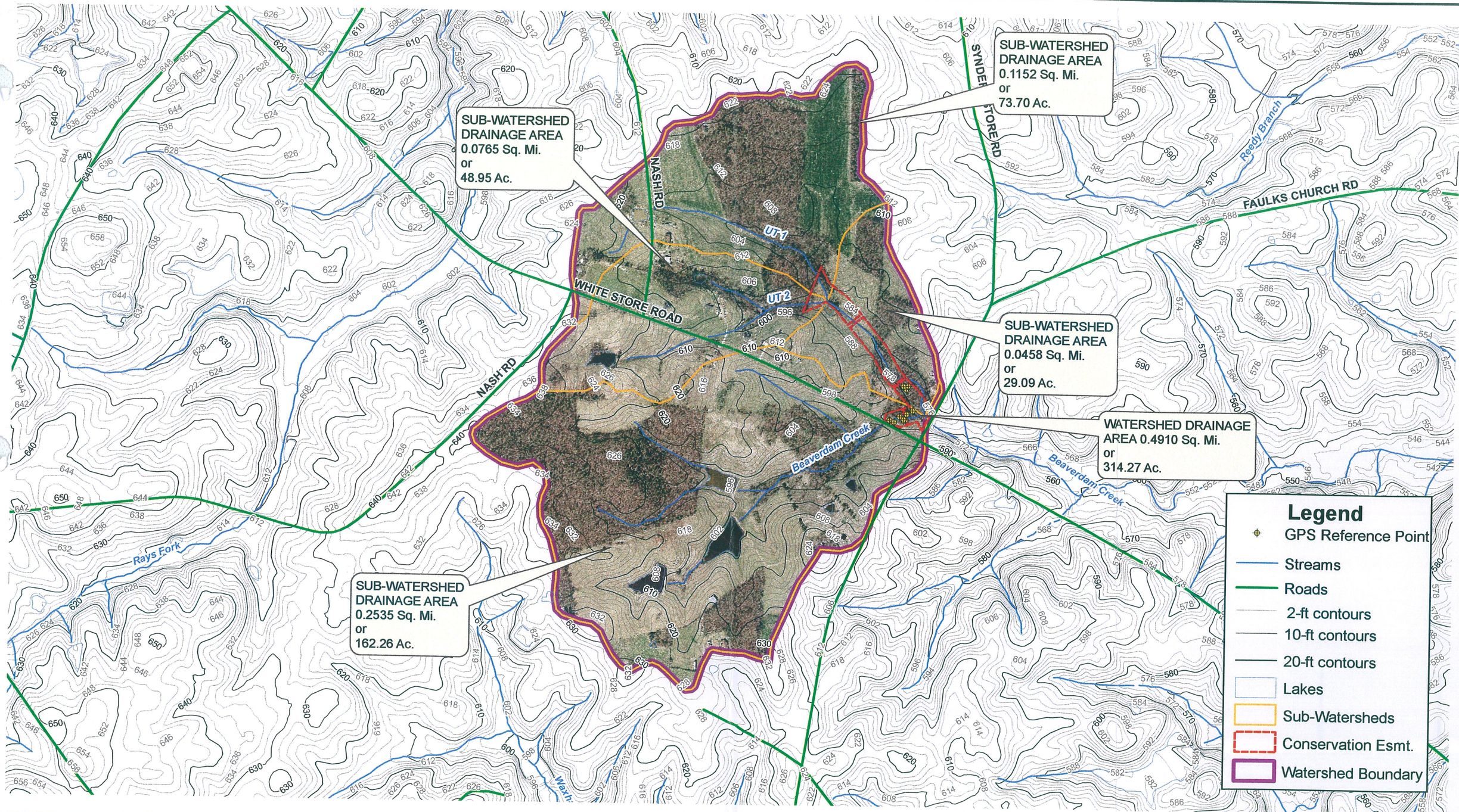
UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
TARGETED LOCAL WATERSHED SUBBASIN MAP
FIGURE 2

SOURCE:
- Hydrology subbasin data obtained from North Carolina Center for Geographic Information and Analysis

N W E S

: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_2_Targeted_Local_Watershed_Subbasin_Map.mxd)



EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
WATERSHED MAP
FIGURE 3

Sources:
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)
- Ortho Imagery - Feb. 2004)

N

nv: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_3_Watershed_Map.mxd)

REFERENCE REACH
DRAINAGE AREA
0.57 Sq. Mi.
or
365.55 Ac.

DAVIS BRANCH
REFERENCE REACH

OLIVE BRANCH RD

MARSHVILLE OLIVE BRANCH RD

HWY 218

UT

Davis Branch

Gourdvine Creek

LANESBORO RD

Legend

- GPS Reference Points
- Streams
- Roads
- 2-ft contours
- 10-ft contours
- 20-ft contours
- Lakes
- Watershed Boundary

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

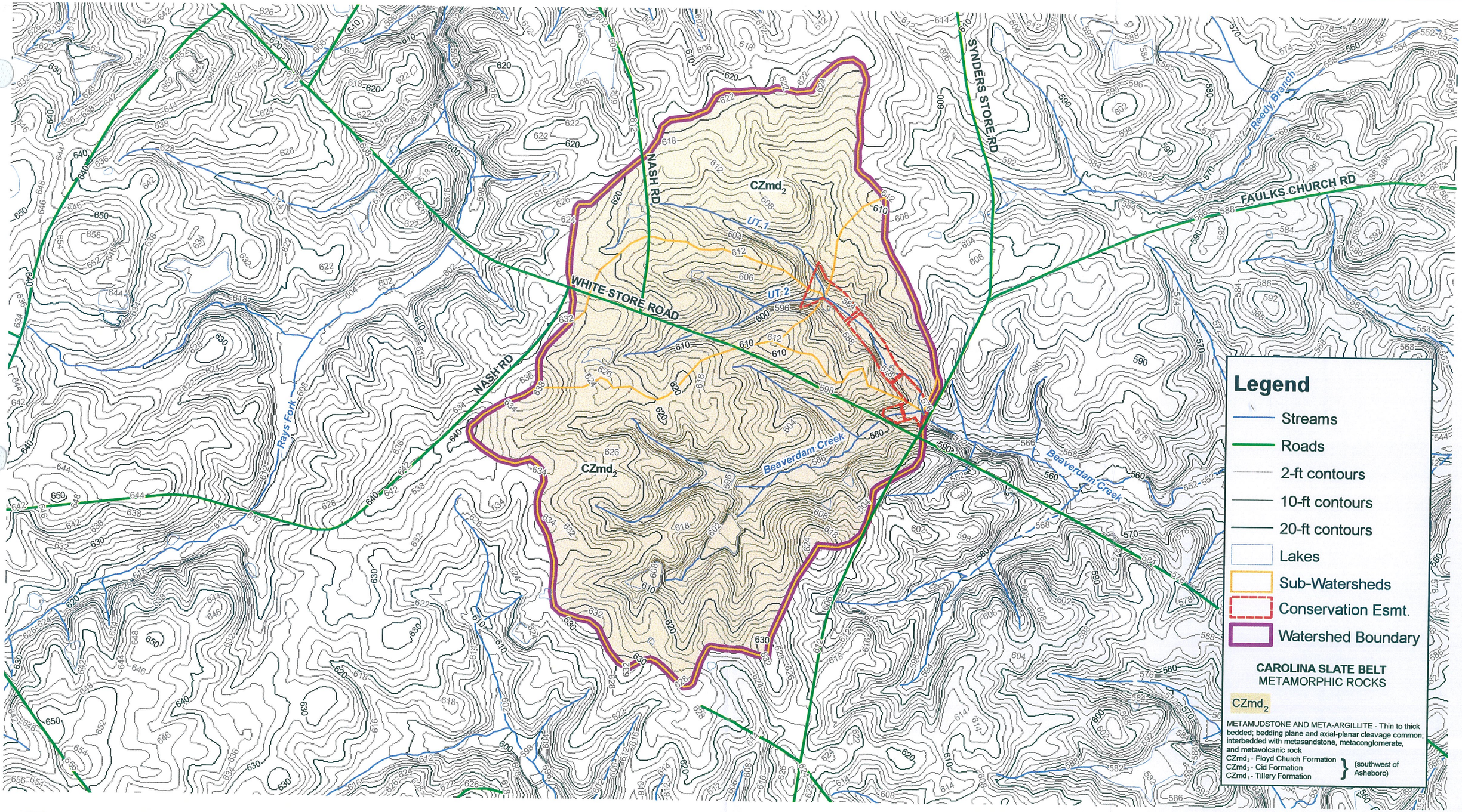
UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
DAVIS BRANCH REFERENCE REACH AND SITE WATERSHED MAP
FIGURE 3A

Sources:
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

N

v:(Q:\PROJECT\20061399\shapefile\Layouts\Fig_3A_Davis_Branch_Reference_Reach_Watershed_Map.mxd)



EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road. Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

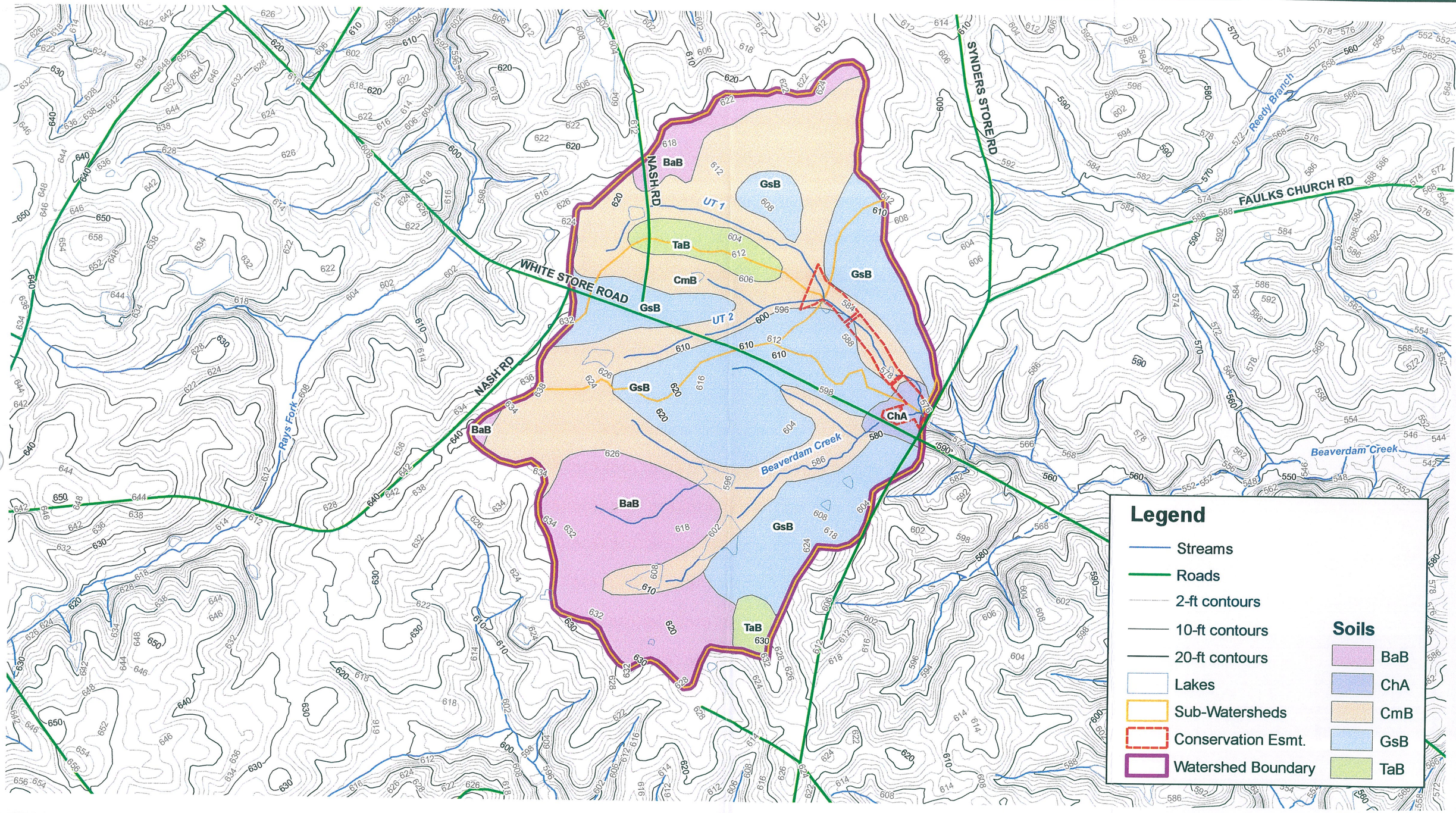
UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
SITE GEOLOGY MAP
FIGURE 4

Sources:
- Geology map - NC Department of Natural Resources and Community Development (1985)
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

N

nv: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_4_Site_Geology_Map.mxd)



EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road. Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

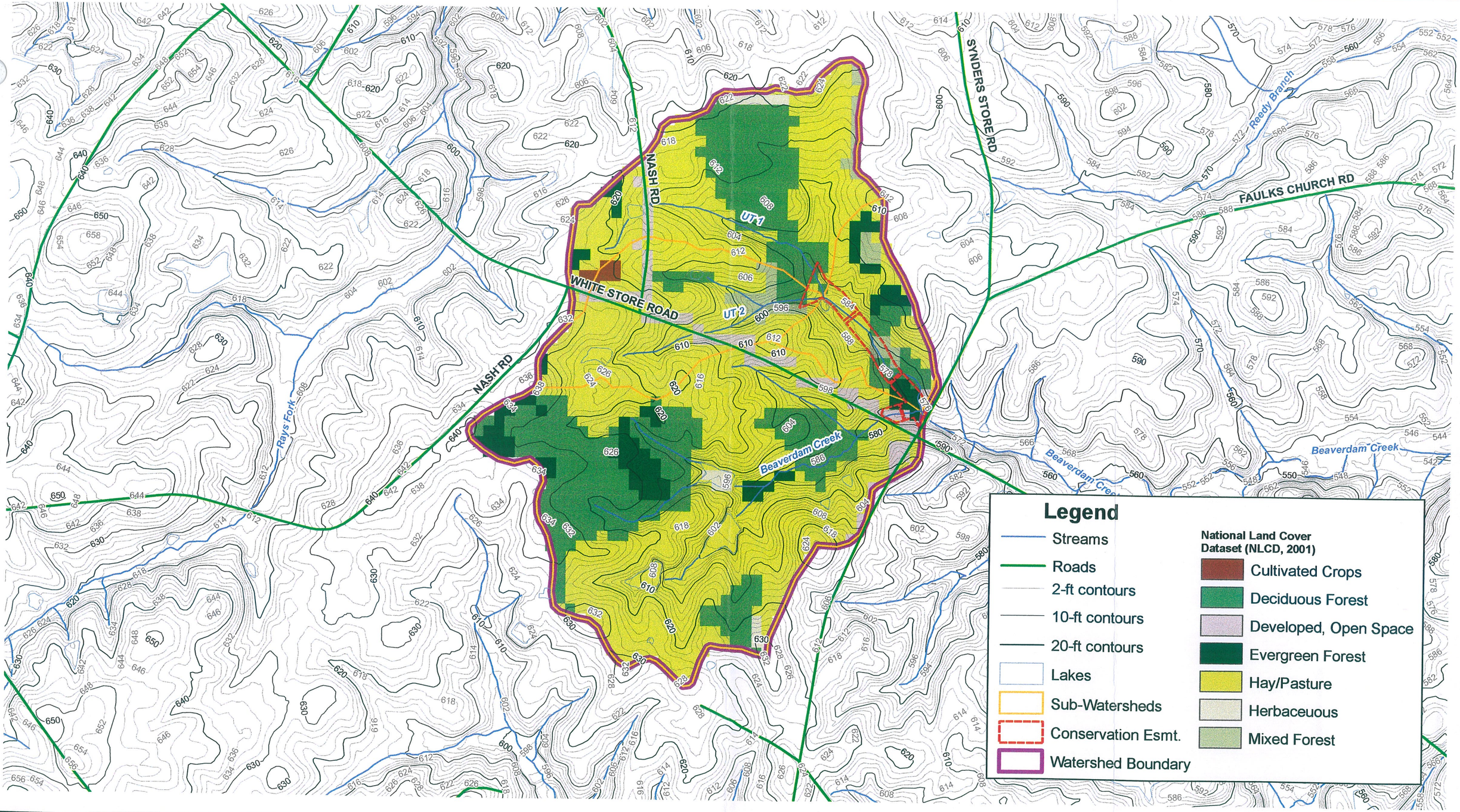
UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
SITE NRCS SOIL SURVEY MAP
FIGURE 5

Sources:
- Soil Data - NRCS SSURGO
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

N

Env: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_5_Site_NRCS_Soil_Survey_Map.mxd)



EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

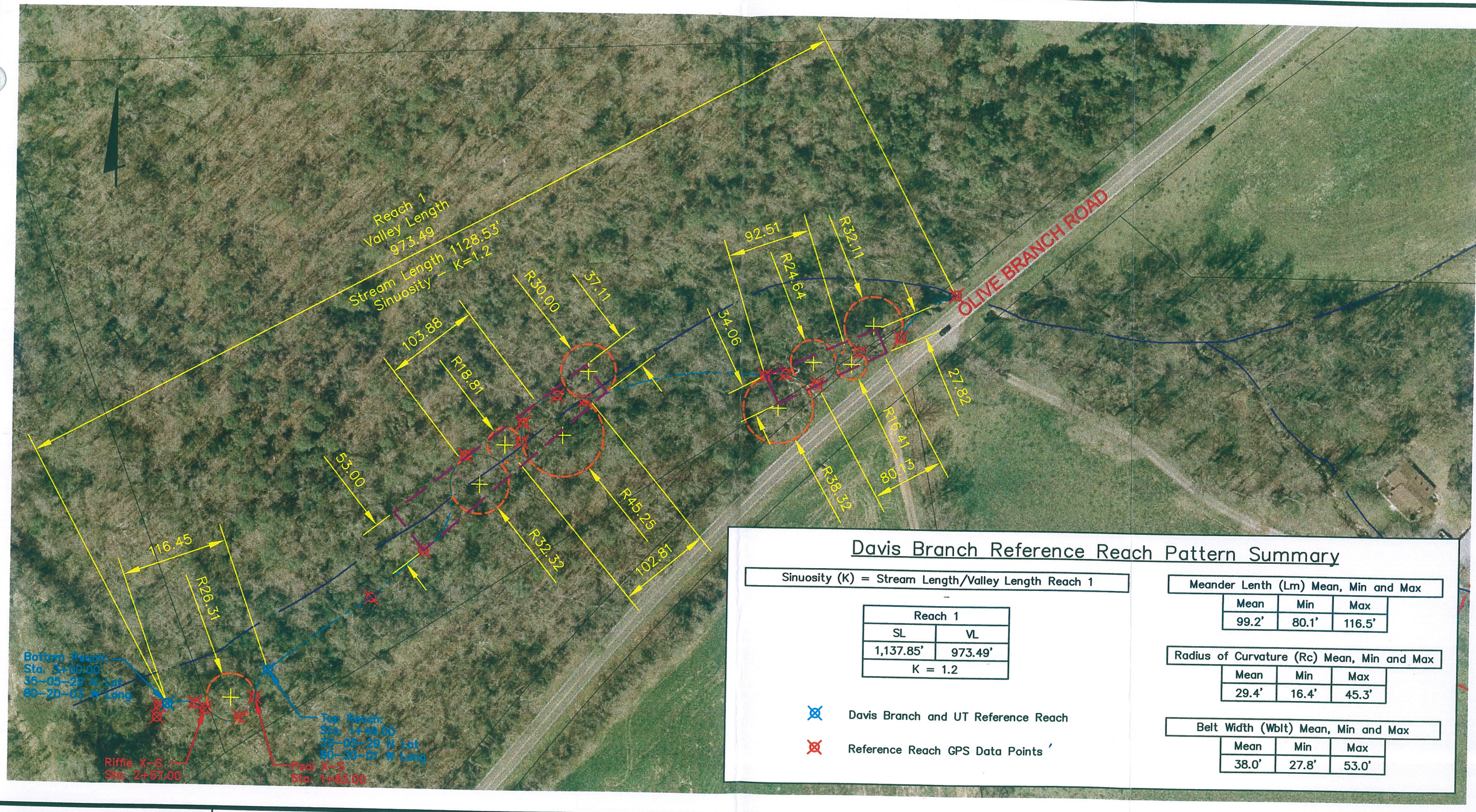
UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK & UNNAMED TRIBUTARIES (PARKER SITE)
SITE NATIONAL LAND COVER DATASET MAP
FIGURE 6

Sources:
- National Land Cover Dataset (2001)
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

N

Env: (Q:\PROJECT\20061399\shapefile\Layouts\Fig_6_Site_National_Land_Cover_Dataset_Map.mxd)



Davis Branch Reference Reach Pattern Summary

Sinuosity (K) = Stream Length/Valley Length Reach 1

Reach 1	
SL	VL
1,137.85'	973.49'
K = 1.2	

Davis Branch and UT Reference Reach

Reference Reach GPS Data Points

Meander Lenth (Lm) Mean, Min and Max		
Mean	Min	Max
99.2'	80.1'	116.5'

Radius of Curvature (Rc) Mean, Min and Max		
Mean	Min	Max
29.4'	16.4'	45.3'

Belt Width (Wblt) Mean, Min and Max		
Mean	Min	Max
38.0'	27.8'	53.0'

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

M C M X X V I

UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY RESTORATION

REFERENCE REACH PATTERN SUMMARY MAP

FIGURE 7

Date: October, 2007

Scale: 1" = 100'

Job No: 2006-1397

9.0 Appendices

Appendix "1"
Restoration Plan Design Sheets

UNION COUNTY, NORTH CAROLINA

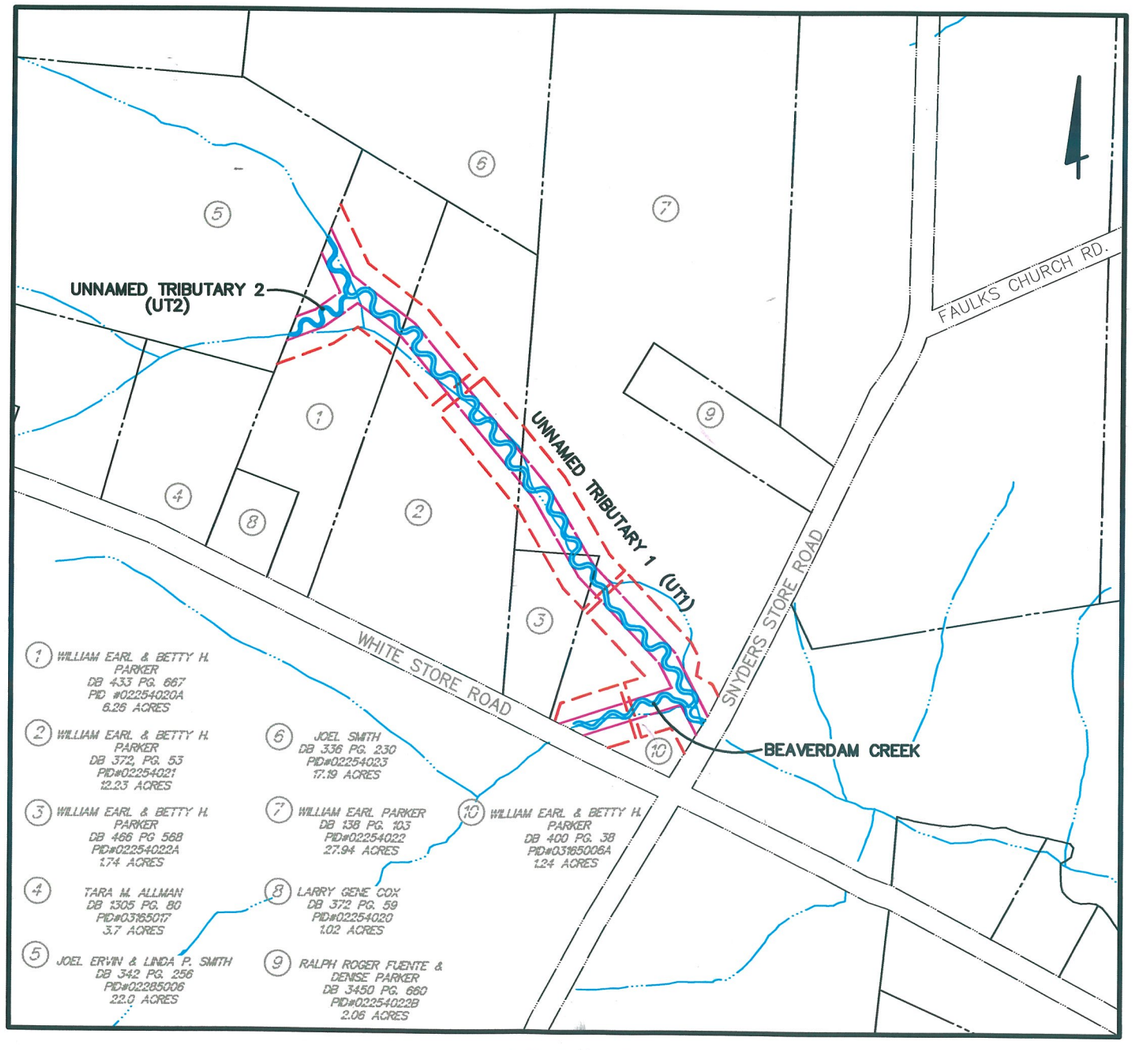
STREAM RESTORATION PLAN

FOR

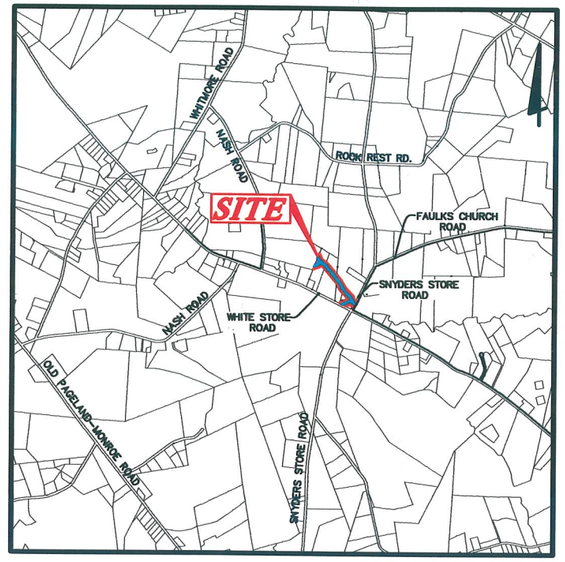
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES

2007

INDEX OF SHEETS



LOCATION MAP
Scale: 1"=400'



VICINITY MAP
Not To Scale

BEAVERDAM CREEK & UNNAMED TRIBUTARIES – STREAM DESIGN STATISTICS

Parameters	Beaverdam Creek	Unnamed Tributary 1	Unnamed Tributary 2
Drainage Area at Downstream Limits (mi^2)	0.4910	0.2371	0.0765
Average Sinuosity	1.21	1.49	1.45
Bankfull Width (ft.)	11.2	9.0	6.3
Bankfull Mean Depth (ft.)	1.3	1.0	0.7
Bankfull Max Depth (ft.)	1.8	1.5	1.0
Bankfull Area ($ft.^2$)	13.7	9.0	4.3
Width/Depth Ratio	8.62	9.00	9.00
Floodprone Width (ft.)	50	50	50
Entrenchment Ratio	4.46	5.56	7.94
Bankfull Discharge (cfs)	66.7	32.2	10.4
Mean Velocity (ft./sec)	4.9	3.6	2.4

Job No. 2006-1399 | Sheet RP-01/18
Date January, 2008 | Scale As Noted

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
TITLE SHEET

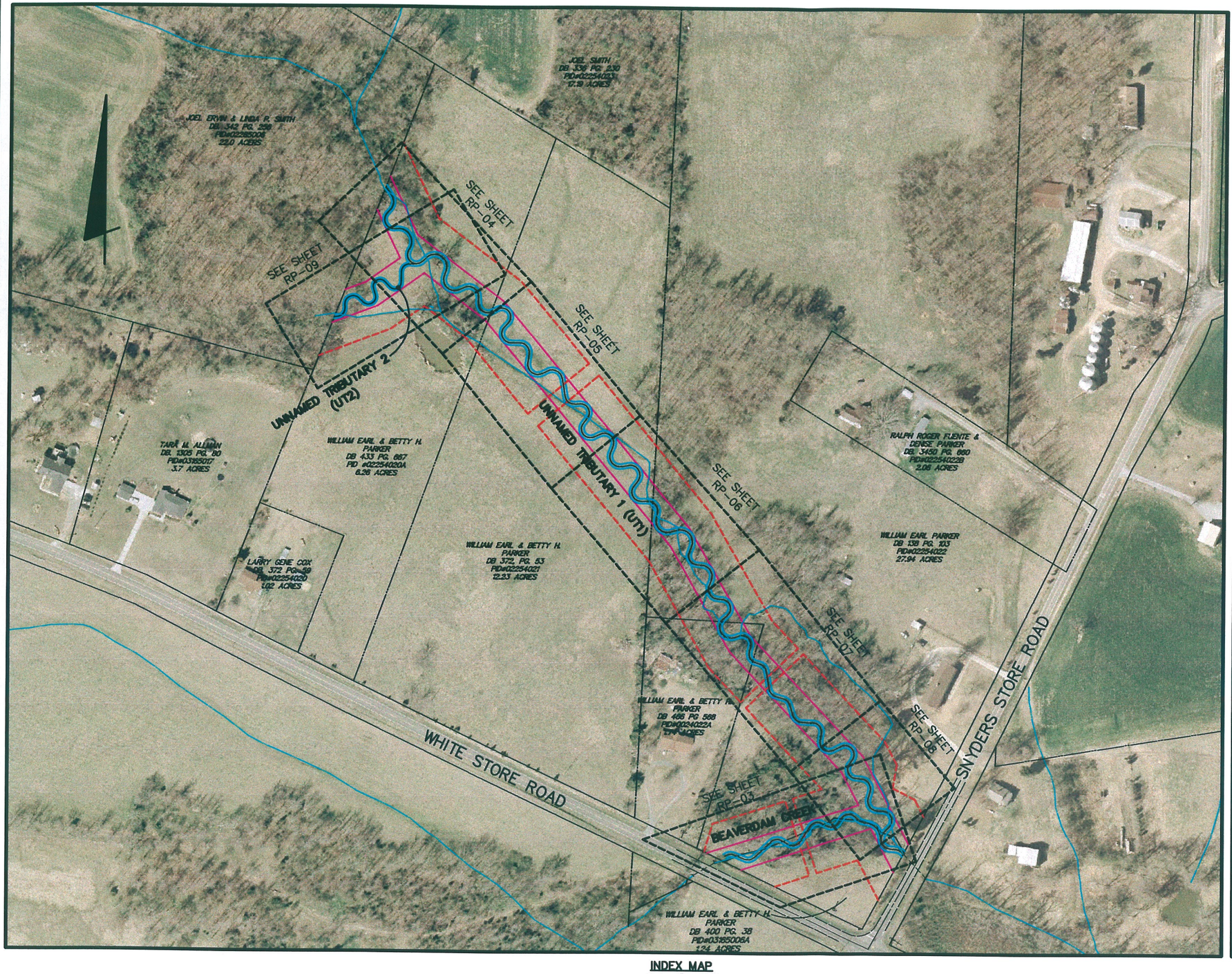
Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500

M C M X V

REVISIONS

MARK	DATE	DESCRIPTION



INDEX MAP
Scale: 1" = 200'

LEGEND

- EX. UTILITY POLE
- EX. TREE
- EX. TREE TO BE REMOVED
- EX. TREE LINE
- EX. 1 FOOT CONTOURS
- EX. 5 FOOT CONTOURS
- EX. FENCE
- EX. PROPERTY LINE
- EX. RIGHT OF WAY
- EX. STREAM
- PROP. THALWEG
- PROP. BANKFULL
- PROP. BELTWIDTH
- PROP. CONSERVATION EASEMENT
- PROP. SEDIMENT FENCE
- PROP. FENCE
- TEMP. STREAM CROSSING
- EARTHEN PLUG
- PROP. RIFFLE
- PROP. POOL
- PROP. CROSS VANE
- PROP. BANK REINFORCEMENT

Job No. 2006-1399 | Sheet RP-02/18
Date January, 2008 | Scale As Noted

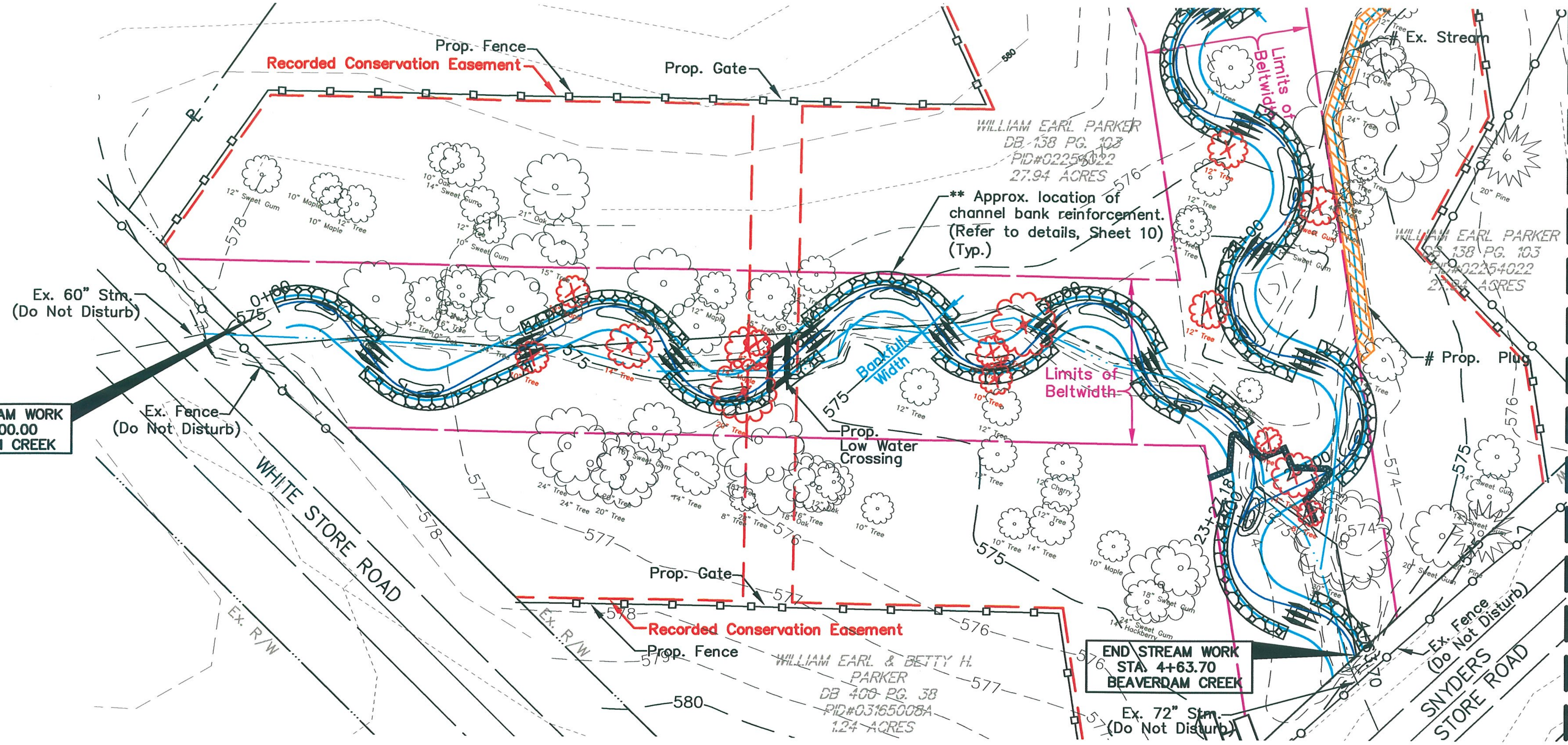
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
INDEX MAP

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

REVISIONS

MARK	DATE	DESCRIPTION



Scale: 1" = 40'

Notes:

See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

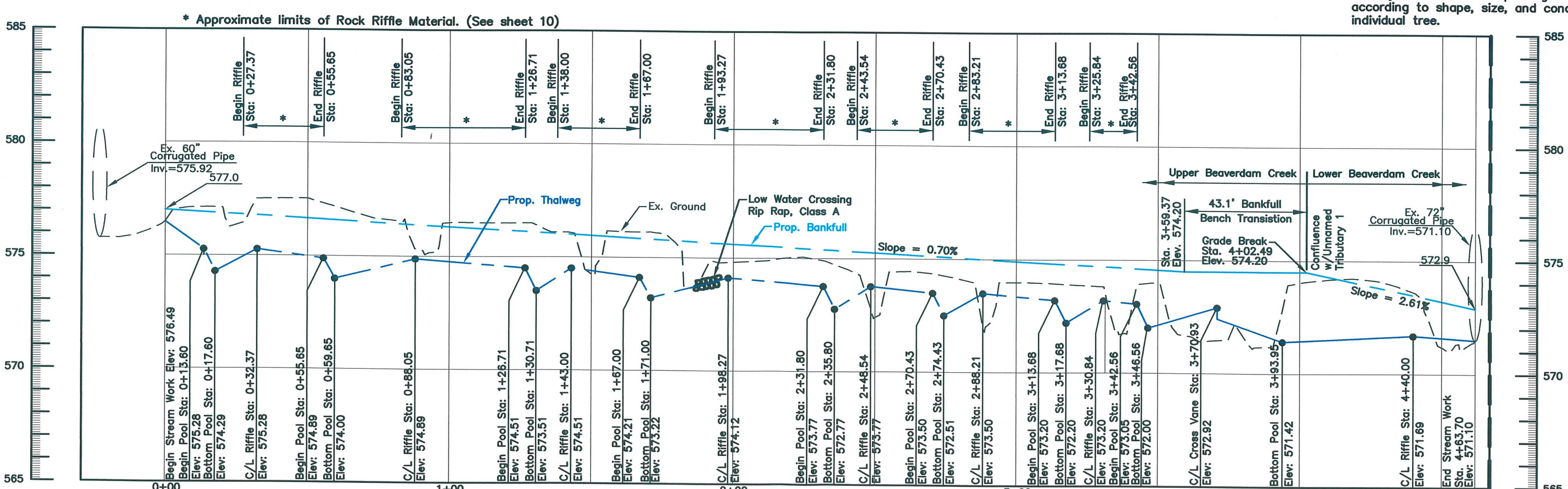
The Existing stream within the Conservation Easement shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Conservation Easement shall be plugged every 100' to promote overland flow to the proposed channel.

Tree Preservation Notes:

1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.



UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (BEAVERDAM CREEK)

Ecosystem Enhancement Program

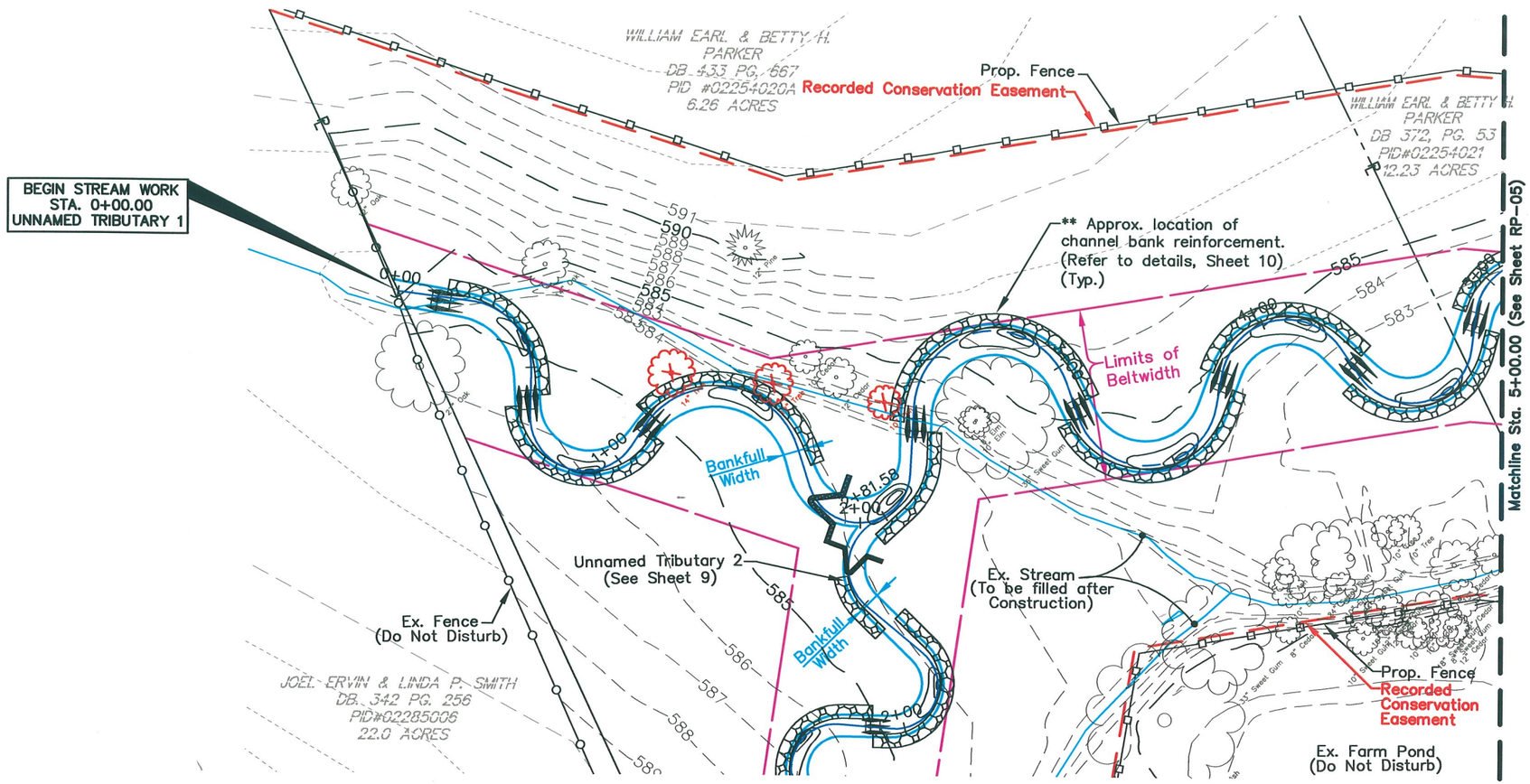
EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

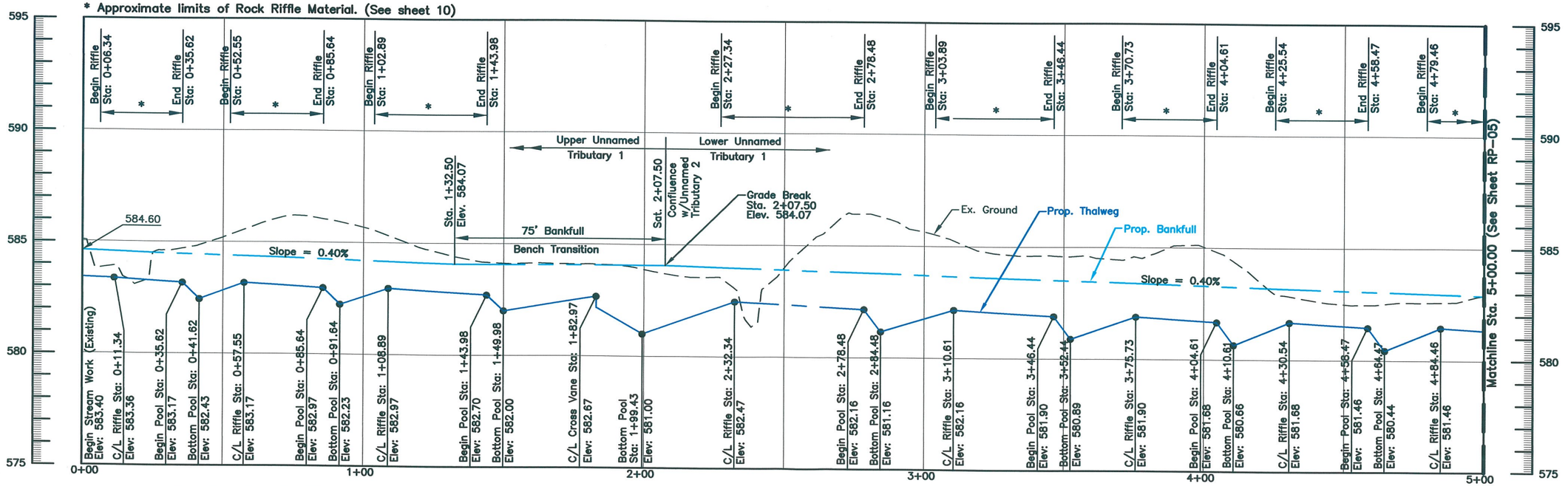
Job No.	2006-1399
Date	January, 2008
Scale	Hor: 1" = 40' Ver: 1" = 5'
Sheet	RP-03/18

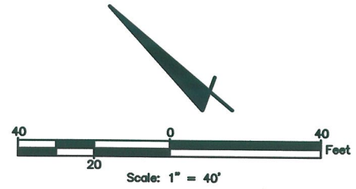
REVISIONS

MARK	DATE	DESCRIPTION

\\CMHDATA2\ENVIRON\PROJECT\20061399\DWG\RESTORATION PLAN\61399RP03-08.DWG-(RP-03) - 1 XREF: 61399EXS - LAST SAVED BY JCRAMER [1/4/2008 12:16:35 PM] - PLOTTED BY JCRAMER [1/4/2008 12:25:33 PM]







Notes:
See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

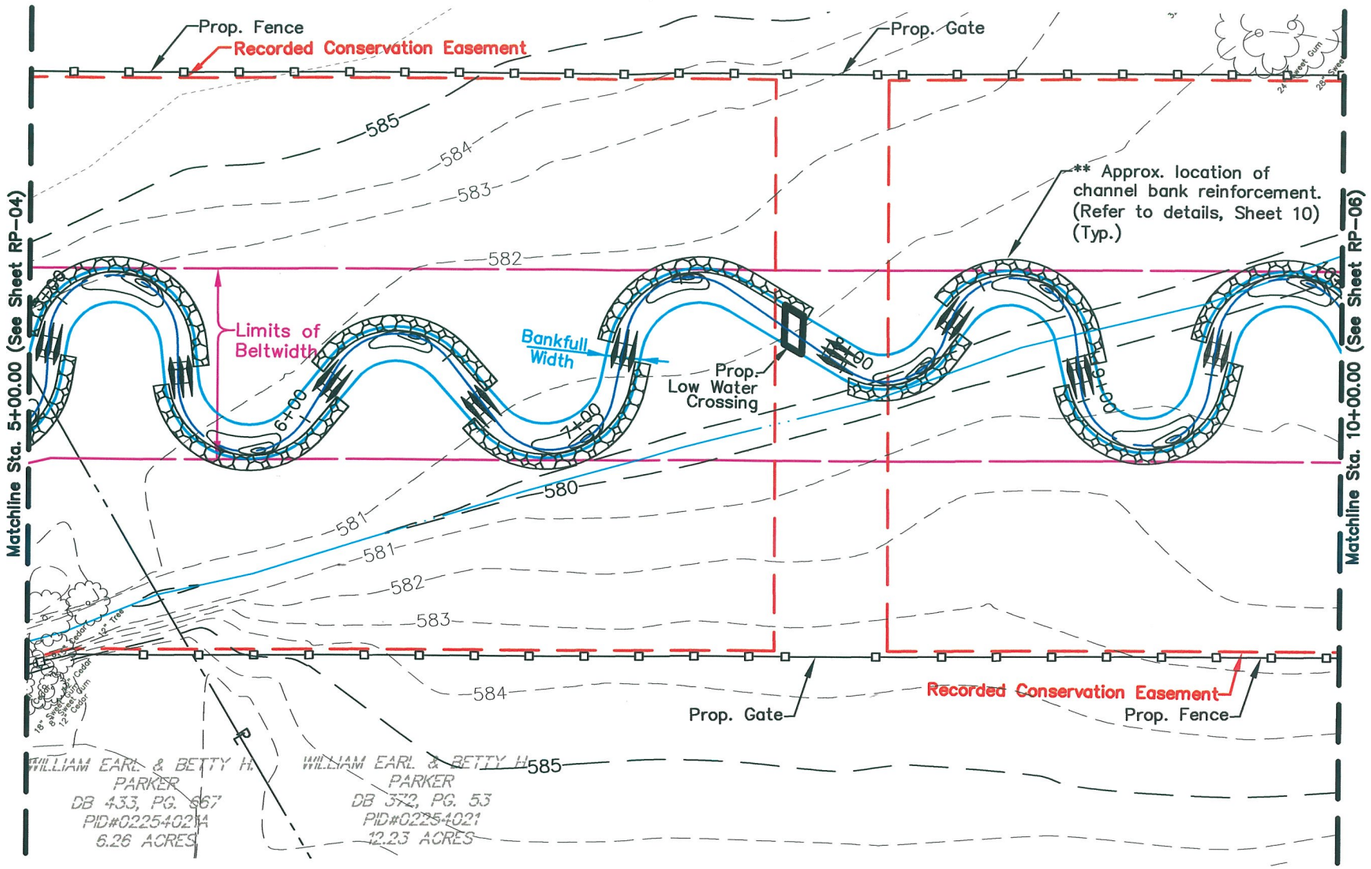
Job No. 2006-1399 | Sheet RP-04/18
Date January, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

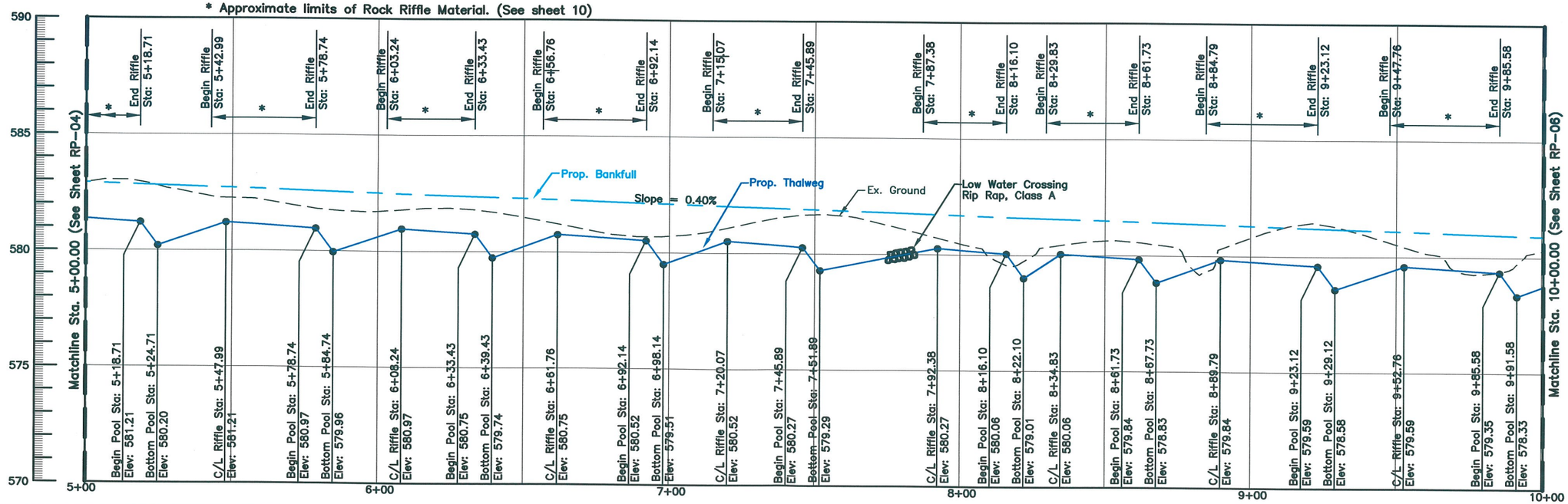
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT1)

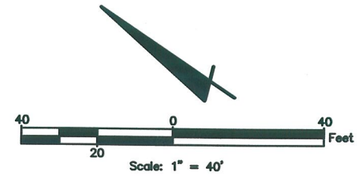
Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone 614.775.4500 Fax 614.775.4800

MARK	DATE	DESCRIPTION
		REVISIONS







Notes:
See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

Job No. 2006-1399 | Sheet RP-05/18
Date January, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

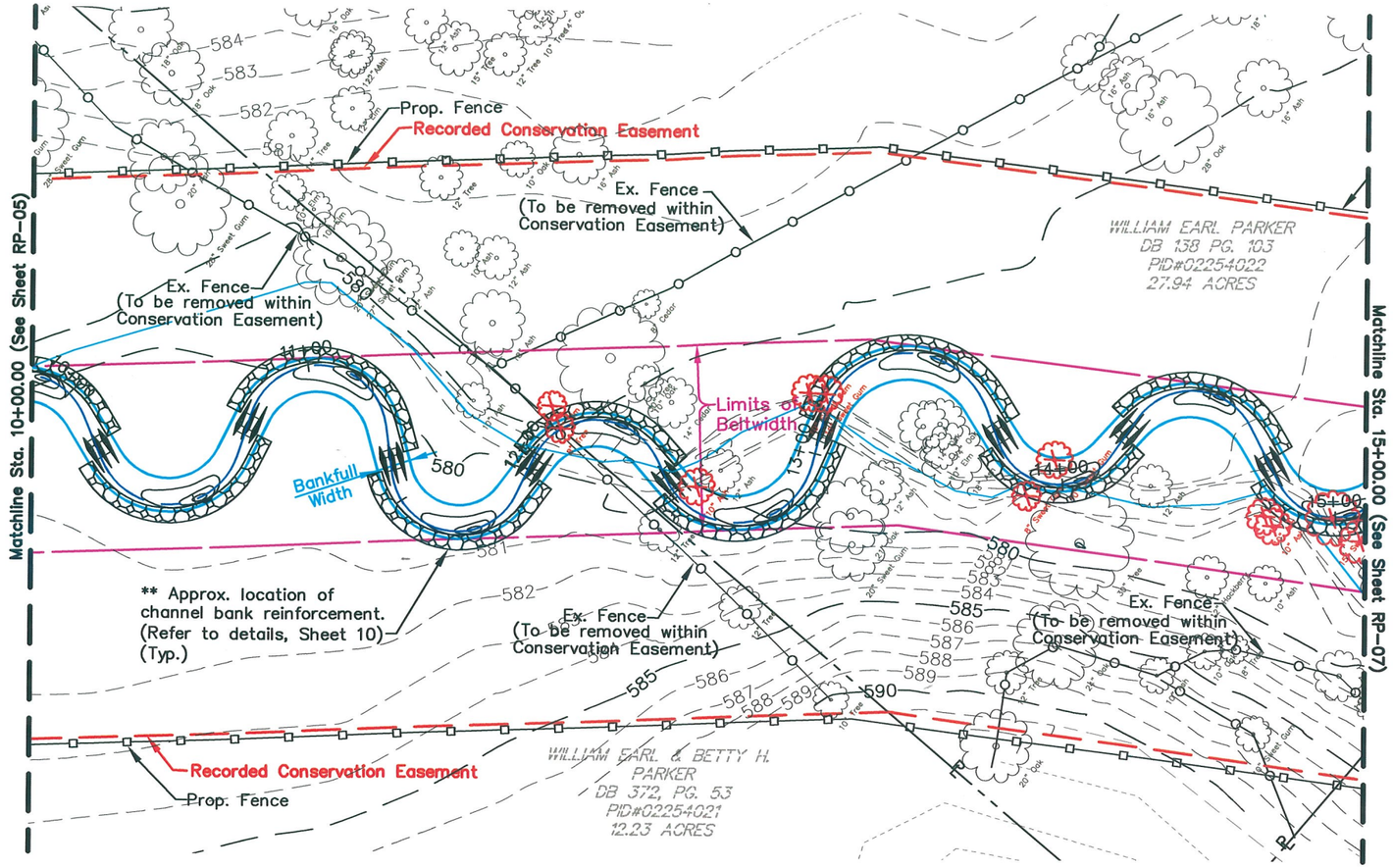
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT1)

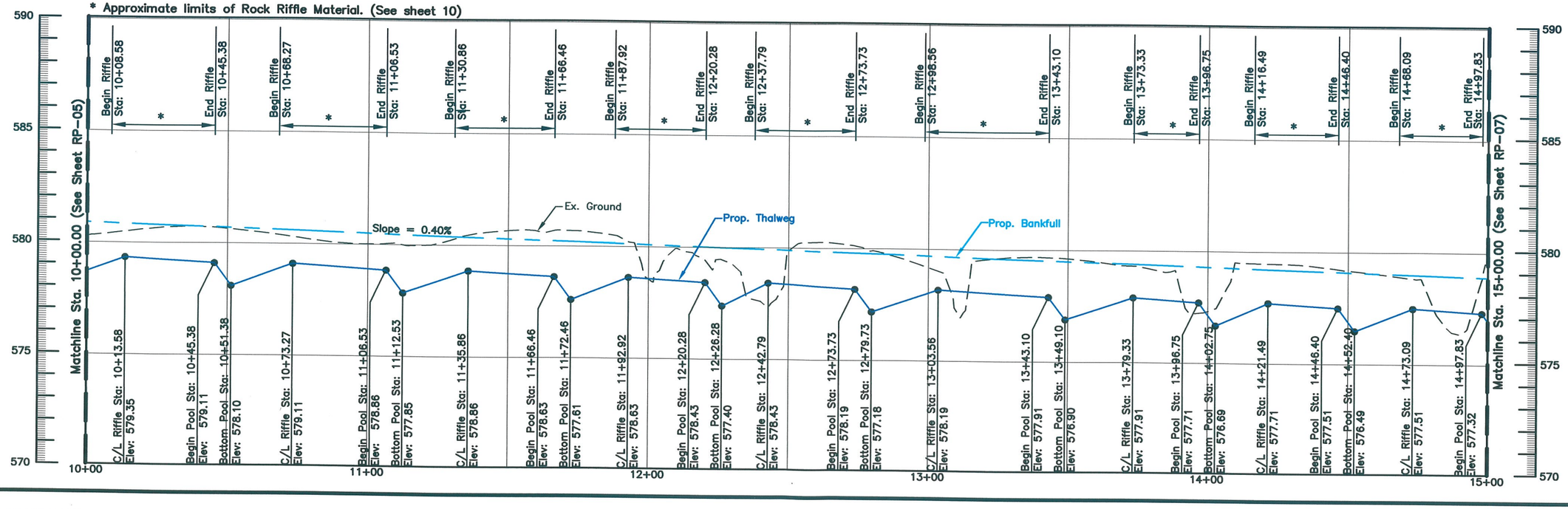
Ecosystem Enhancement Program

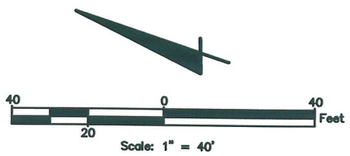
EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
(614) 775-4500 FAX (614) 775-4800

REVISIONS

MARK	DATE	DESCRIPTION







Notes:
See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

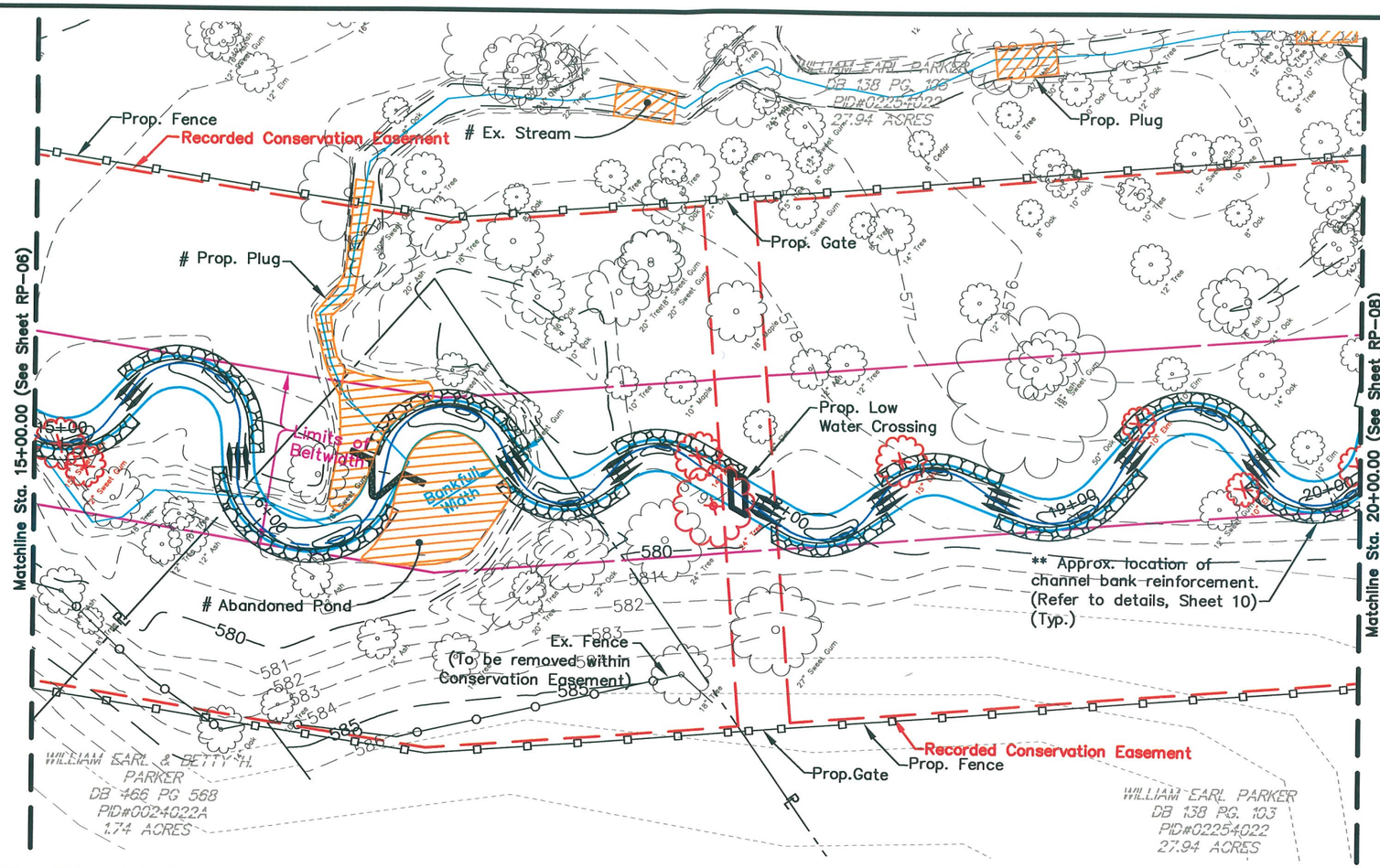
Job No. 2005-1399 | Sheet RP-06/18
Date January, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

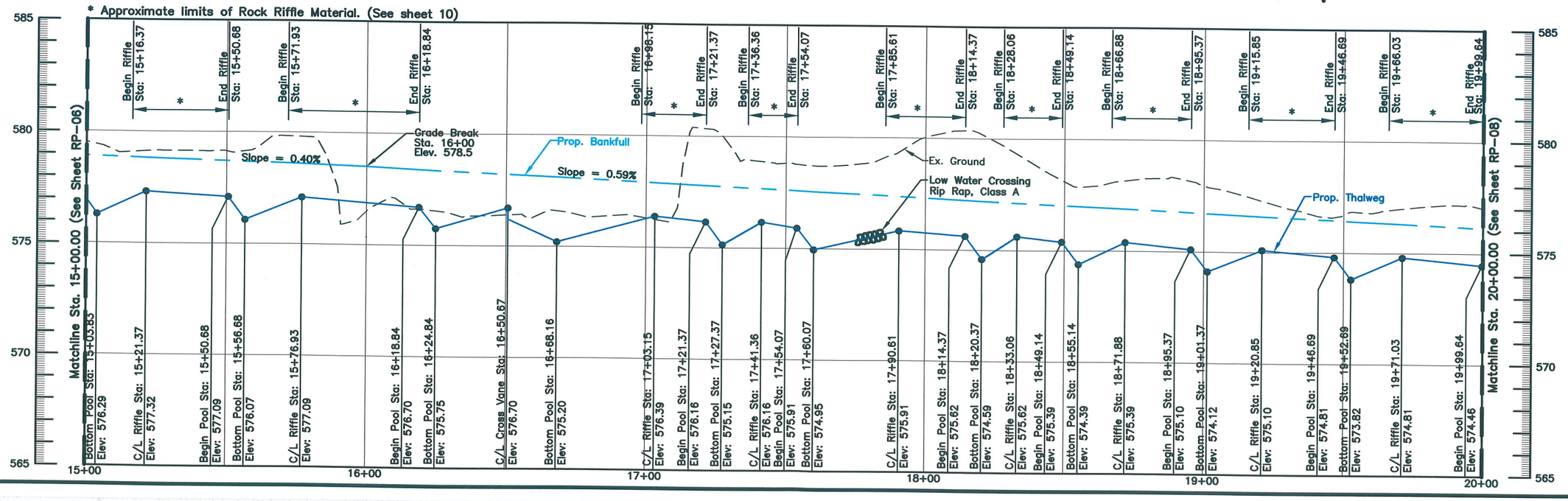
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT1)

Ecosystem Enhancement Program

EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

MARK	DATE	DESCRIPTION
		REVISIONS





40 0 40 Feet
20
Scale: 1" = 40'

Notes:
See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

The Existing stream and abandoned pond within the Conservation Easement shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Conservation Easement shall be plugged every 100' to promote overland flow to the proposed channel.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

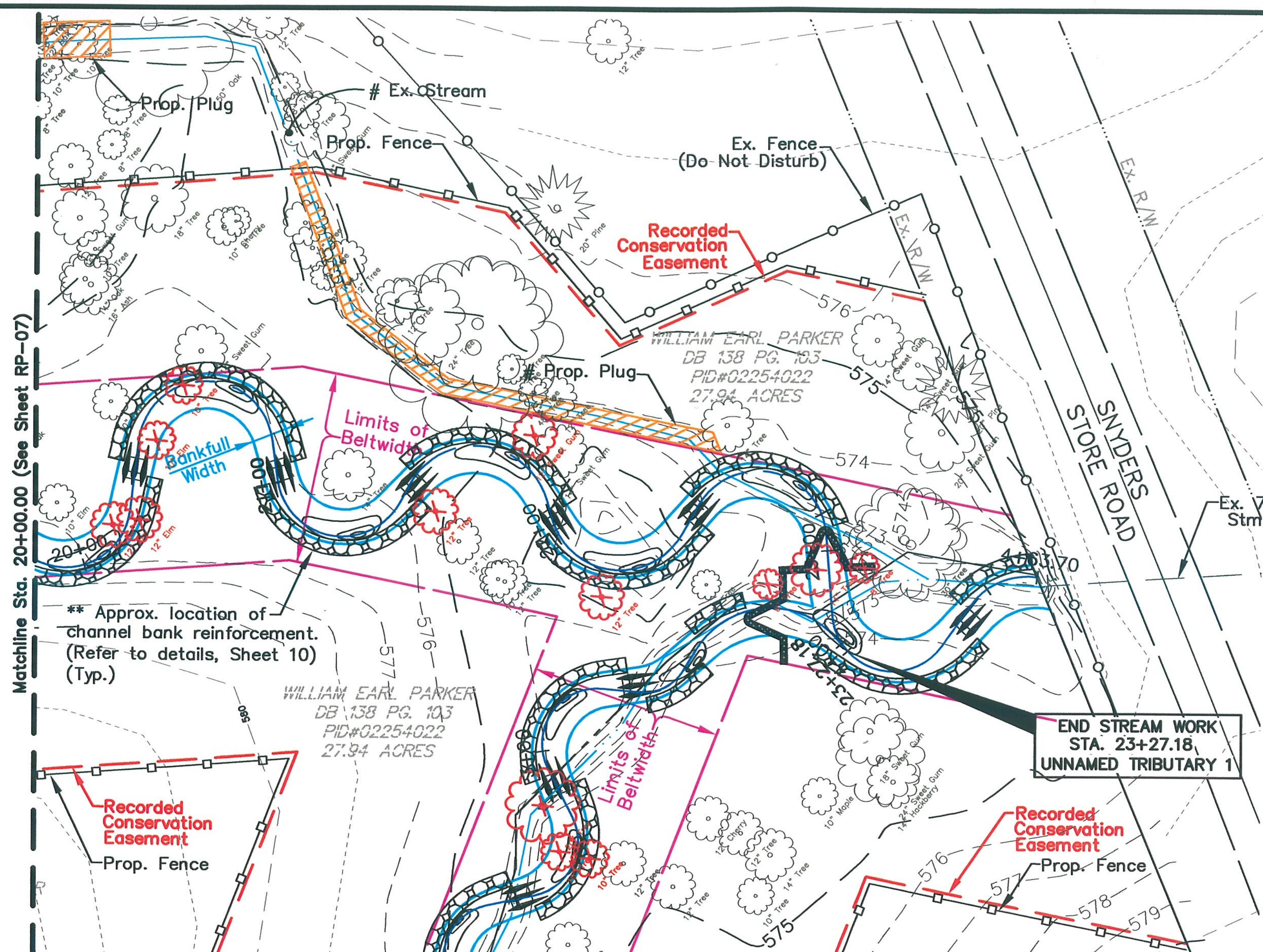
Job No. 2006-1399 | Sheet RP-07/18
Date January, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT1)

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, Ohio 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X V

REVISIONS
MARK | DATE | DESCRIPTION



40 0 40 Feet
20
Scale: 1" = 40'

Notes:

See sheets 10–11 for In-Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

The Existing stream within the Conservation Easement shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Conservation Easement shall be plugged every 100' to promote overland flow to the proposed channel.

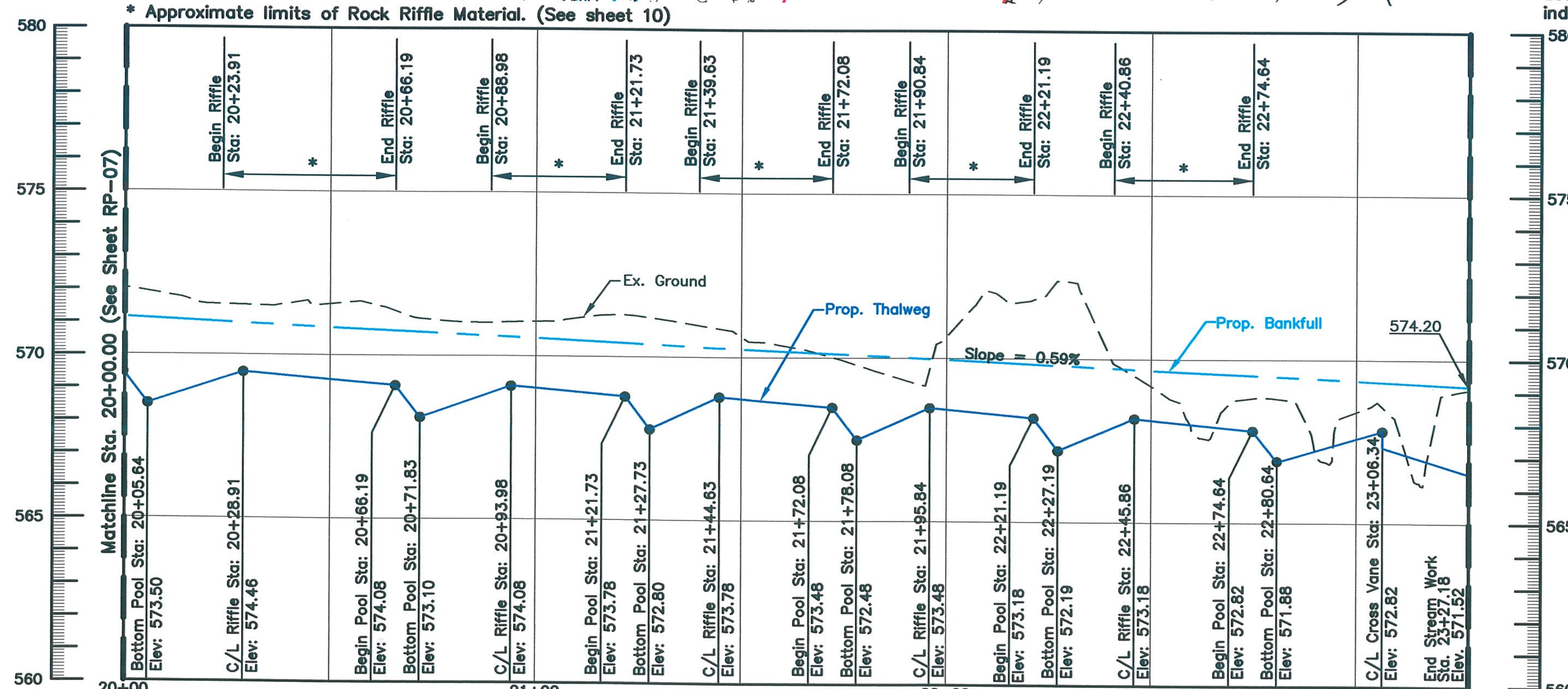
Tree Preservation Notes:

1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

* Approximate limits of Rock Riffle Material. (See sheet 10)



UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT1)

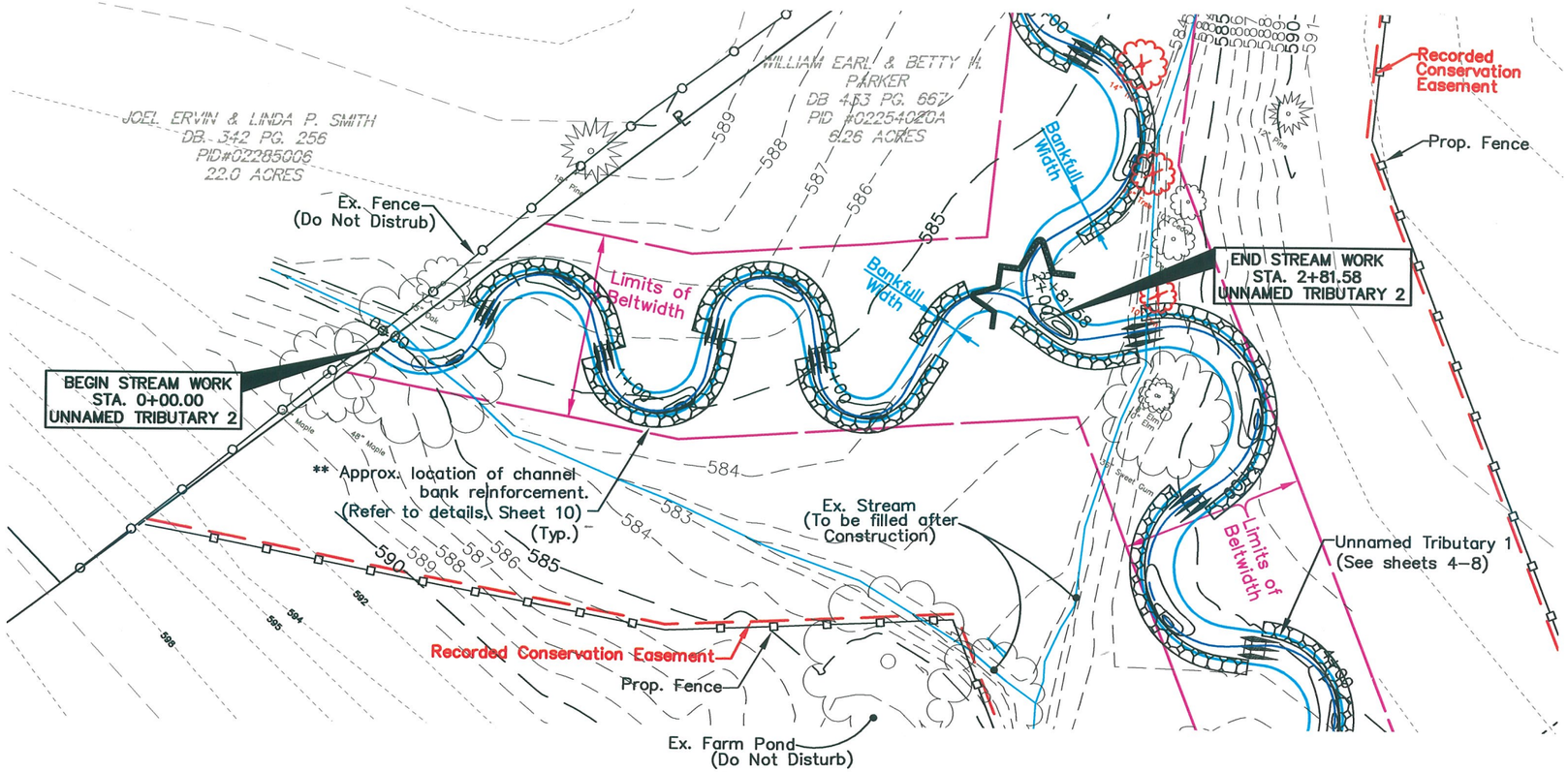
Ecosystem Enhancement PROGRAM

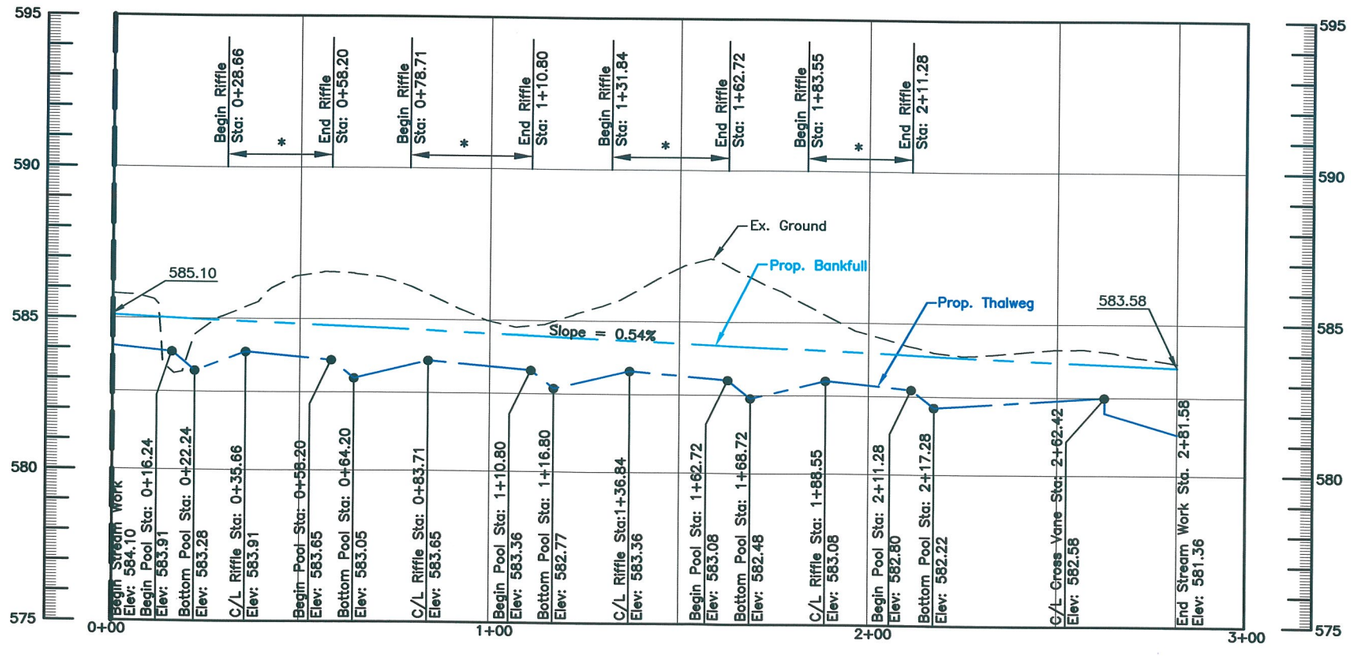
EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054

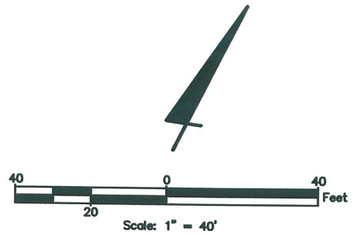
Job No.	2006-1399
Sheet	RP-08/18
Date	January, 2008
Scale	Hor: 1" = 40' Ver: 1" = 5'

REVISIONS

MARK	DATE	DESCRIPTION







Notes:
See sheets 10–11 for In–Stream Stuctures.

See sheets 12–16 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

See sheet 10 for channel dimensions.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

Job No. 2006-1399 | Sheet RP-09/18
Date January, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLAN & PROFILE (UT2)

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone 614.775.4500 Fax 614.775.4800

MARK	DATE	DESCRIPTION
		REVISIONS

ROCK RIFFLES:

All support and crest stone will be quarried granite material. No construction rubble is permissible. All other material used to construct the rock riffle (visible rock) shall be river rock, consisting of rounded stone with natural hues. The Contractor shall review samples of this material with the Engineer for approval prior to installation. See Riffle Materials Table for descriptions and sizes of materials.

1.0 CREST STONE
The crest height is determined in the field by measuring the elevation of the toe of the proceeding upstream riffle. The crest elevation must pool water back to the base of the upstream riffle/run.

Installation:
The crest height must be determined and the center weir stone installed first. Trench into the stream bed approximately 1.5 feet and place the stone(s) so that the center weir stone reaches the crest elevation. Trench and install the remaining crest stones across the stream, elevating them into the banks the specified distance.

2.0 SUPPORT STONE
Installation:
Support stone must be placed tightly on both sides of the crest stone paying close attention to fit on the downstream side. Proper elevation of the support stone must be maintained and must be as high as the crest stone. Ten (10) feet downstream of the crest stone the support stone will be laid more loosely to create turbulence of flow across the riffle. At this point, the stone should start to become trenched into the streambed. At the end of the riffle, the support stone will be trenched fully into the stream bed to a depth of approximately 1.5 feet. Finished elevations of the support stone must concentrate flows across the riffle and create non-laminar (turbulent) flow. Support stones will continue up the banks to the final elevation. Support stone will be trenched into the banks to support the crest stone.

3.0 FILL STONE
Installation:
After the installation of the larger crest and support stones, fill all voids with fill stone materials and compact with an excavator bucket. Final grading and transition with the upper bank area can be accomplished using this stone size.

BOULDER TOE:

1.0 Material:
The boulder toe material may consist of quarried stone (no construction rubble is permissible). The Contractor shall review samples of this material with the Engineer for approval prior to installation. The size of this material shall be consistent with the gradation of Class 2 riprap rock channel protection.

2.0 Installation:
The boulder toe material shall be imbedded into the channel bottom and channel bank to the minimum depths shown on Detail 'C'. Filter fabric material, shall be included in the construction of the boulder toe reinforcement, as demonstrated on Detail 'C'. Over-excavation of the channel bank to install the boulder toe reinforcement shall be back-filled with compactable material that is placed in lifts and graded to conform to the designed channel bank, and reinforced with the geotextile material specified by this plan.

COIR ROLL:

1.0 Material:
Rolls shall consist of biodegradable material 12-inches in diameter with a density of 7 lbs./cu.ft. The coir roll outer netting shall consist of a biodegradable twine 0.24 inches in diameter with the breaking strength of 90 lbs. Hardwood stakes to anchor the coir rolls shall be 2"x2"x36" in size. The specified length is a minimum and may need to be adjusted to allow for sufficient anchoring.

The Contractor may contact RoLanka Products at 800-760-3215 (fax: 770-506-0391) as a supplier of the specified coir roll material.

2.0 Installation:
Refer to Detail 'A' for a schematic of the location of the coir roll material along the channel and Detail 'C' for a schematic of the location of the coir rolls with respect to the other bank reinforcement materials.

The coir rolls shall be installed after the boulder toe is in place. The upstream and downstream ends of the coir roll installation shall be bent back into the channel bank to prevent stream flow from cutting behind the Rolls. The ends of abutting coir rolls shall be tied together with twine. Hardwood stakes shall be driven into the native, undisturbed soil behind the Rolls. The Rolls shall be tied to the stakes with twine. Stakes shall be placed at the beginning and end of each Roll and at a maximum spacing of 2 feet.

*** Coir Rolls may be eliminated and replaced with additional Boulder Toe material.

LIVE BRANCHES:

1.0 Material:
Live branch material shall be dormant and gathered locally (within or in proximity to the project site) or purchased from a reputable commercial supplier. The contractor may contact Ernst Conservation Seeds at 814-336-5191 (fax: 800-873-3321) as a supplier of live branch material. This material shall be planted only during its natural dormancy period, extending from late fall through early spring.

Branches shall be 1/2 to 2-inches in diameter, 2 to 3 feet in length, and living based on the presence of young buds and green bark. Prior to installation, the branches shall be cut so that they are angled on the bottom and flush on the top.

All harvested or purchased live branch material shall be preserved in a cool, moist environment until installation. Plant material that has been allowed to dry out or is not preserved in a dormant state prior to installation shall be discarded.

See Sheet 17 for Plant Material List.

2.0 Installation:
Refer to Detail 'A' for a schematic of the location of the live branches along the channel and Detail 'C' for a schematic of the location of the live branches with respect to the other bank reinforcement materials.

Live branches shall be installed in two rows, with 2.0 foot spacing, between the stakes. Three-fourths of the stake is to be imbedded within the channel bank. The angle of the imbedded branch to the channel bank shall be between 30 and 60 degrees. When installed, at least two (2) buds should remain above the ground surface and those buds shall be oriented upwards.

Live branches that split or become bent or broken during installation shall be removed from the channel bank and discarded

STOCKPILE COBBLE MATERIAL:

Remove and stockpile any available cobble stream bed material through the reach of the existing stream channel to be excavated/relocated. Stockpiled material shall be replaced within excavated /relocated stream bed upon completion. Cost of this work to be included in the price bid for the various related items.

GEOTEXTILES:

The specified geotextile shall meet the specifications identified on this plan, unless otherwise approved by the Engineer.

Geotextile shall be placed in accordance with manufacturer's recommendations.

The geotextile Rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each Roll shall be labeled or tagged to provide product identification sufficient for field inventory and quality control purposes. Rolls shall be stored in a manner which provides identification, as well as protection from the elements. If stored outdoors, the Rolls shall be elevated and protected with a waterproof cover.

INSTALLATION:

- Over-excavation of the channel bank may be necessary to accomplish the installation of the rock toe protection. The rock toe protection shall be imbedded into the bottom of the channel to the depth specified on this detail.
- The live branches shall be placed on top of the imbedded boulder toe material protruding into the native, undisturbed soil of the channel bank.
- Soil material, including the specified top soil, shall be placed to backfill the over-excavated channel bank.
- The specified seeding shall be applied to the disturbed/restored soil material.
- The first (lowest) row of the geotextile material shall be anchored to the restored soil material.
- The coir roll material shall be installed and secured with the hardwood stakes protruding into the native, undisturbed soil of the channel bank.
- Any remaining rows of geotextile material shall be installed and anchored to the channel bank, with the last (highest) row "trenched" in to the bank.

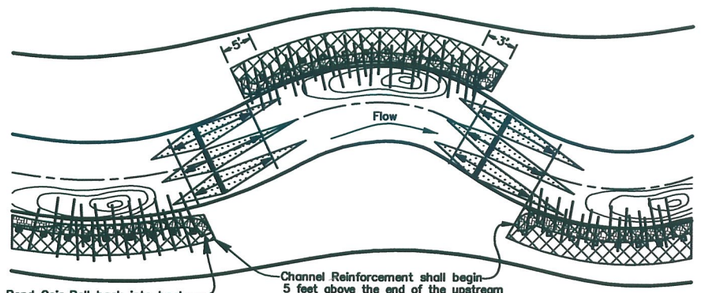
CHANNEL DIMENSION TABLE

	BEAVERDAM CREEK (Upper)	BEAVERDAM CREEK (Lower)	UNNAMED TRIB. 1 (Upper)	UNNAMED TRIB. 1 (Lower)	UNNAMED TRIB. 2
From Station	0+00	4+02	0+00	2+07	0+00
To Station	4+02	4+62	2+07	23+27	2+82
Bankfull max depth – Riffle	1.5	1.8	1.2	1.5	1.0
Bankfull max depth – Pool	2.6	3.1	2.0	2.6	1.7
Bankfull width – Riffle	9.0	11.2	7.2	9.0	6.3
Bankfull width – Pool	10.1	12.5	8.1	10.1	7.1

RIFFLE MATERIAL TABLE

I.D.	DESCRIPTION	SIZE	% OF RIFFLE VOLUME
Crest $ Stone	Crest stone should be angular in shape.	Plain Riprap, Class 1 Class 1 shall consist of sizes such that at least 85 percent of the total material by weight shall be larger than 5 inch but less than an 17 inch square opening.	30%
Support $ Stone	Angular stone that supports the crest stone.	Support Stone shall have a gradation of sizes such that at least 85% of the material by weight shall be between 4" and 8" in diameter.	50%
Fill Stone	Stone that fills the voids between the larger stone: Cobble- rounded river rock	Fill stone shall have a gradation of sizes such that at least 85% of the material by weight shall be between 1" and 4" in diameter.	20%

$ In lieu of crest/support stone, Contractor may use embedded log to establish riffle crest



TYPICAL GEOTEXTILE LOCATION PLAN- DETAIL 'A'
Not to Scale

LEGEND

Limits of boulder toe, coir roll, and geotextile reinforcement*; refer to Detail "C", (This Sheet).

Riffle-Run Complex

Pool

Live Branch (Typ.)

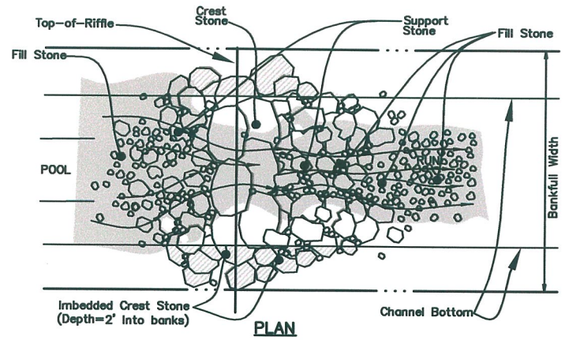
Limits of boulder toe, coir roll & live branches.

Coir Roll (Typ.)

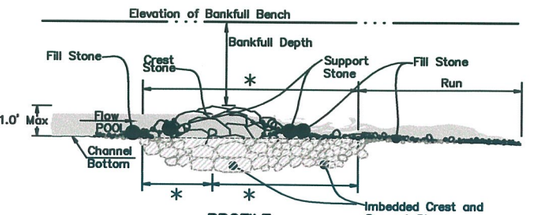
Hardwood Stake (Typ.)

NOTES

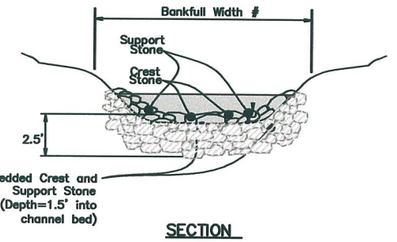
* Geotextile shall be an Erosion Control Mat. Such as Geocoir/Dekowe 700, or approved equivalent.



PLAN

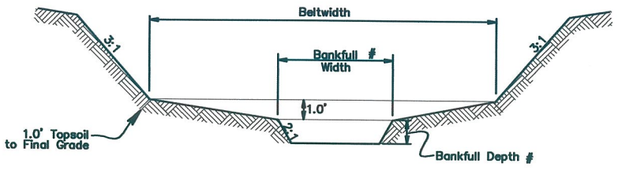


PROFILE

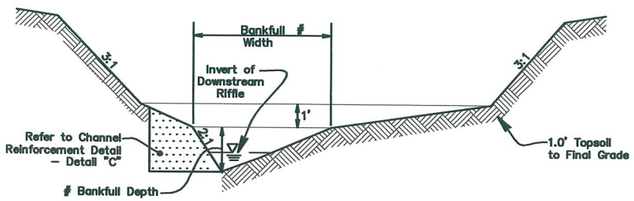


SECTION

ROCK RIFFLE DETAIL – DETAIL 'B'
Not to Scale

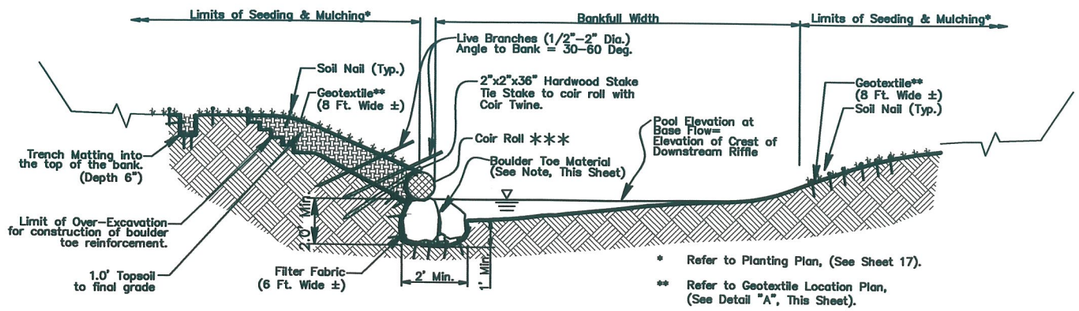


TYPICAL RIFFLE SECTION (See Detail 'B')
Not to Scale



TYPICAL POOL SECTION (See Detail 'C')
Not to Scale

–See Channel Dimension Table (See This Sheet)



* Refer to Planting Plan, (See Sheet 17).

** Refer to Geotextile Location Plan, (See Detail "A", This Sheet).

*** Coir Rolls may be eliminated and replaced with additional Boulder Toe material.

CHANNEL REINFORCEMENT DETAIL – DETAIL 'C'
Not to Scale

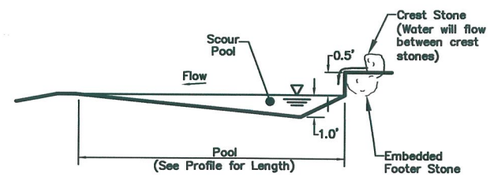
Job No. 2006-1399 | Sheet RP-10/18
Date January, 2008 | Scale 1" = 200'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
STRUCTURE DETAILS

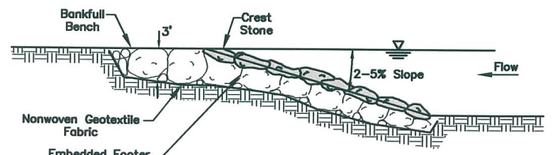
Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 FAX: 614.775.4800

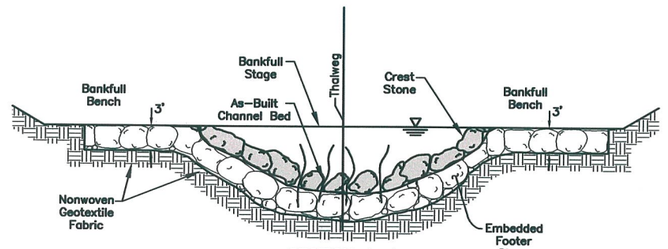
MARK	DATE	DESCRIPTION
		REVISIONS



SECTION C–C
Not to Scale



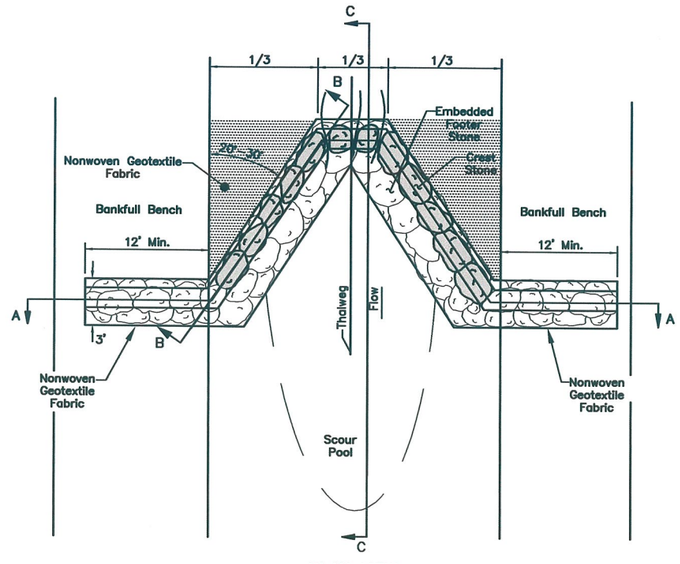
SECTION B–B
Not to Scale



SECTION A–A
Not to Scale

Step Pool, Step Riffle and Cross Vane Construction Specifications:

1. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.
2. Final placement of rocks in Cross Vane to be determined by stream restoration specialist in the field.
3. Dimension slopes and deflection angles of structures may be adjusted by designer based on field conditions during construction.
4. Footer stone and crest stone shall be native stone or shot rock, cubical or rectangular in shape with a minimum diameter of 2.0 feet.
5. Gaps between boulders shall be minimized by tightly fitting stones together and chinking between structure stones using No. 2 sized rock.
6. Slope of vane from arms shall be 2–5%.
7. Crest stones in the center 1\3 of the channel shall have gaps between the stones. Gaps shall be 6" to 8".
8. A 4 oz. non–woven geotextile fabric shall be placed on the upstream side of the structure vane arms to prevent piping of water through the structure. Fabric shall extend from the top of the footer stone, down to the invert of the trench, and back up to the bankfull bench. Fabric shall be placed along the entire length of the vane arms, as shown on the details.
9. A 4oz. non–woven geotextile shall be placed under all embedded footer stone, as shown on the details.
10. Logs can be substituted for the vane arms, or sills as approved by the design Engineer.



PLAN VIEW
Not to Scale

CROSS VANE DETAIL –BEAVERDAM AND UNNAMED TRIBUTARY
Not to Scale

Job No. 2006-1389
Sheet RP-11/18
Date January, 2008
Scale As Noted

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
STRUCTURE DETAILS

Ecosystem Enhancement Program

EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
8000 Windsor Parkway, Columbia, SC 29223
Phone: 614.775.4600 fax: 614.775.4800

REVISIONS

MARK	DATE	DESCRIPTION

EROSION AND SEDIMENT CONTROL NARRATIVE
PLAN DESIGNER:
Evans, Mechwart, Hambleton, & Tilton, Inc.
5500 New Albany Road
Columbus, Ohio 43054
Phone: (614)775-4500 Fax: (614)775-4800

PROJECT OWNER
Cal Miller
Wetlands Resource Center
3970 Bowen Rd
Canal Winchester, Ohio 43110
(614) 327-7034

SITE CONTACT
Bob Koone
South Mountain Forestry
6624 Roper Hollow Road
Morganton, NC 28655
(828) 432-7759

PROJECT LOCATION
The project is located within Union County.

PROJECT DESCRIPTION
The project consists of the restoration and stabilization of stream channels, indicated as Beaverdam Creek and Unnamed tributary 1 and 2 on the restoration plan. The existing eroded stream banks and the stream buffer corridors of the watercourse shall be planted with a variety of trees, shrubs and seedings as indicated on the planting plan.

AREA OF PROJECT SITE & AREAS OF DISTURBANCE
Project Area: 6.5 Acres
Estimated Area of Disturbance: 12.8 Acres

EXISTING SITE CONDITIONS
The Beaverdam Creek corridor predominantly consists of a narrow riparian buffer with adjoining pasture lands to the south and a wooded hillside to the north.

Unnamed tributary 1 contains a wooded corridor on the downstream portion of the channel and an existing pasture on the upstream portion of the channel. Impact to existing wooded areas will be minimized.

Unnamed tributary 2 contains an existing pasture along both sides of the stream corridor.

ADJACENT AREAS
The adjacent areas are predominately pasture or wooded areas. The wooded areas will be protected to the extent possible.

DESCRIPTION OF SOILS
The soils along the mainstem of Beaverdam Creek and along the lower 300-feet reach of UT1 within the project area include the Chewacla silt loam, 0 to 2 percent slopes, frequently flooded. Typically the surface layer is brown silt loam approximatley seven inches thick. The subsoil is 45 inches thick.

The upper reach of UT1 and the entire length of UT2 is mapped Cid channery silt loam, 1 to 5 percent slopes. Typically, the surface layer is light brownish gray channery silt loam four inches thick. The subsurface layer is a pale yellow channery silt loam 5 inches thick. The subsoil is 18 inches thick.

RECEIVING STREAM/SURFACE WATER
Beaverdam Creek

EROSION AND SEDIMENT CONTROL PRACTICES
Sediment Fence:
Sediment fence will be placed before construction begins to prevent sediment from the borrow/spoil areas from entering the existing stream.

Dewatering Sediment Trap:
Dewatering Sediment traps shall be used to dewater the existing channel during the pump around process. Sediment laden water within the work area will be trapped by a temporary plug and pumped into the dewatering sediment trap. The trap should be located so that filtered water flows through existing vegetation before re-entering the existing stream downstream of the work area. These sediment traps will be abandoned once the work area is stabilized. Any accumulated sediment will be removed or stabilized in-place. Filter fabric sediment bags can be used instead of sediment traps, if needed.

the location of these traps will be determined in the field by the Contractor.

EROSION CONTROL SCHEDULE

This project shall be constructed in the dry using temporary earthen plugs and pumps. With this method clean water shall be pumped around the construction area and turbid water shall be pumped to a dewatering sediment trap or filter bag. With this method the project shall be constructed in sections small enough that the entire section can be completed and stabilzed within 5 working days. The following sequence describes the steps that will need to be repeated for each section.

1. Construct a temporary earthen plug at the upstream end of the section to be constructed and begin pumping clean water around the work area and to an outlet stabilization structure before it re-enters the existing stream.

2. Construct a temporary earthen plug at the downstream end of the section and pump any turbid water to a dewatering sediment trap or filter bag.

3. Excavate the valley and channel, construct the in-stream structures.

4. Stabilize the valley with seed, fertilize, mulch and matting per the seeding table and stabilization details.

CONTRACTOR RESPONSIBILITIES
Details have been provided on this plan in an effort to help the Contractor provide erosion and sedimentation control. The details shown on the plan shall be considered a minimum. Erosion and sediment control features indicated on the relocation plan shall be installed per the State of North Carolina Department of Transportation details. The Contractor shall be solely responsibility for providing necessary and adequate measures for proper control of erosion and sediment runoff from the site along with proper maintenance and inspection in compliance with with the North Carolina Department of Environment and Natural Resources erosion and sediment control regulations..

The Contractor shall provide a schedule of operations to the Owner. The schedule should include a sequence of the placement of the sedimentation and erosion control measures that provides for continual protection of the site throughout the earth moving activities.

Prior to Construction Operations in a particular area, all sedimentation and erosion control features shall be in place. Field adjustments with respect to locations and dimensions may be made by the Engineer.

It may become necessary to remove portions of sedimentation controls during construction to facilitate the grading operations in certain areas. However, the controls shall be replaced upon completion of grading or during any inclement weather.

The Contractor shall be responsible to have the current Erosion Control Plan immediately available or posted on site.

The Contractor shall be responsible to ensure that off-site tracking of sediments by vehicles and equipment is minimized. All such off-site sediment shall be cleaned up daily.

The Contractor shall be responsible to ensure that no solid or liquid waste is discharged into the stream tributaries. Untreated sediment-laden runoff shall not flow off of site without being directed through a sediment control practice.

INSPECTIONS
The Owner/Contractor shall provide qualified personnel to conduct site inspections ensuring proper functionality of the erosion and sedimentation controls. All erosion and sedimentation controls are to be inspected once every seven (7) calendar days or within 24 hours of a 1/2 inch storm event or greater. Records of the site inspections shall be kept and made available to jurisdictional agencies if requested.

MAINTENANCE
It is the Contractor's responsibility to maintain the sedimentation and erosion control features on this project. Any sediment or debris that has reduced the efficiency of a control shall be removed immediately. Upon conducting an erosion control inspection, the Contractor shall repair or replace structures if it is determined that the structure is damaged and/or overwhelmed with sediment.

SOIL STABILIZATION
The Contractor shall stabilize disturbed slopes within 15 working days or 30 calendar days following completion of any phase of grading, permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

Disturbed areas within the conservation easement shall be stabilized per deadline listed in the erosion control schedule on this sheet.

Disturbed slopes shall be stabilized per the stream channel bank stabilization details and the planting plan.

Job No. 2006-1399
Sheet RP-12/18
Date January, 2008
Scale As Noted

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
EROSION CONTROL GENERAL NOTES

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone 614.775.4500 Fax 614.775.4800

M C M X X V I

REVISIONS

MARK	DATE	DESCRIPTION

BEGIN STREAM WORK

Sediment Barrier Fence

Borrow/Spoils Area

Limits of Disturbance

Temp. Stream Crossing

Temp. Stream Crossing

UNNAMED TRIBUTARY 2

Prop. Low Water Crossing

Sediment Barrier Fence

Temp. Stream Crossing

Ex. Farm Pond (Do Not Disturb)

UNNAMED TRIBUTARY 1

Recorded Conservation Easement

BEGIN STREAM WORK

Recorded Conservation Easement

Borrow/Spoils Area

Sediment Barrier Fence

Limits of Disturbance

Sediment Barrier Fence

Prop. Low Water Crossing

Recorded Conservation Easement

BEAVERDAM CREEK

Prop. Low Water Crossing

BEGIN STREAM WORK

END STREAM WORK

Stablized Constuction Entrance (See Detail Sht. 14)

Ex. R/W

WHITE STORE ROAD

SNYDERS STORE RD.

100 0 100 Feet

50

Scale: 1" = 100'

Notes:

- Limits of disturbance is approximately 15' outside the conservation easement, unless shown and labeled differantly on this sheet.
- The existing stream channel and abandoned pond within the conservation easement shall be filled after the new channel is active. This fill should be a combination of compacted clay soil and Plain Riprap, Class 1. The area should be graded to drain into the new channel and stabilized with seed and mulch. The existing stream outside the conservatian easement shall be plugged every 100' to promote overland flow to the channel.
- When construction is complete the spoil areas shall be graded to drain to the new channel and stabilized with seed and mulch.
- When construction is complete the borrow areas shall be restored to grade to the extent possible. After grading the area shall be stabilized with seed and mulch.
- Locations of the temporary stream crossings are approximate and will be established in the field by the Contractor throughout the course of constructing the project

LEGEND

- EX. TREE LINE
- EX. 1 FOOT CONTOURS
- EX. 5 FOOT CONTOURS
- EX. FENCE
- EX. PROPERTY LINE
- EX. RIGHT OF WAY
- EX. STREAM
- PROP. THALWEG
- PROP. BANKFULL
- PROP. BELTWIDTH
- PROP. CONSERVATION EASEMENT
- PROP. SEDIMENT BARRIER FENCE
- PROP. FENCE
- EX. UTILITY POLE
- EX. TREE
- TEMP. STREAM CROSSING
- EARTHEN PLUG
- LIMITS OF DISTURBANCE

Job No. 2006-1399 | Sheet RP-13/18

Date January, 2008 | Scale 1" = 100'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
EROSION CONTROL SITE PLAN

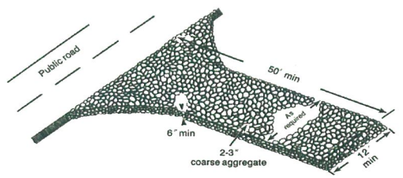
Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, Ohio 43054
Phone: 614.775.4500 Fax: 614.775.4800

REVISIONS

MARK	DATE	DESCRIPTION

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT

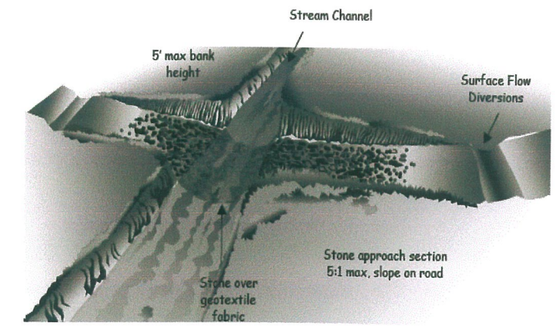


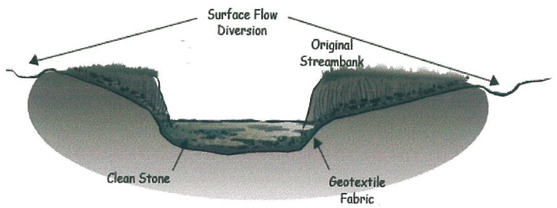
Construction Specifications

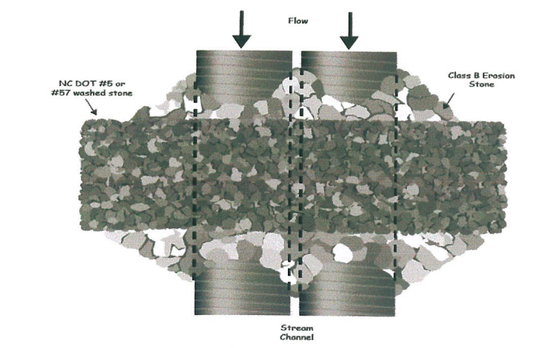
1. Clear the entrance and exit area of all vegetation, roots, and other objectionable material and properly grade it.
2. Place the gravel to the specific grade and dimensions shown on the plans, and smooth it.
3. Provide drainage to carry water to a sediment trap or other suitable outlet.
4. Use geotextile fabrics because they improve stability of the foundation in locations subject to seepage or high water table.

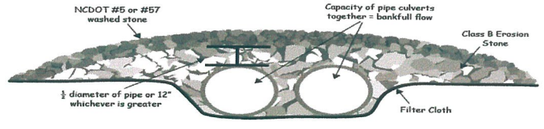
Maintenance Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site. This may require periodic topdressing with 2-inch stone. After each rainfall, inspect any structure used to trap sediment and clean it out as necessary. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.

TEMPORARY STREAM CROSSING







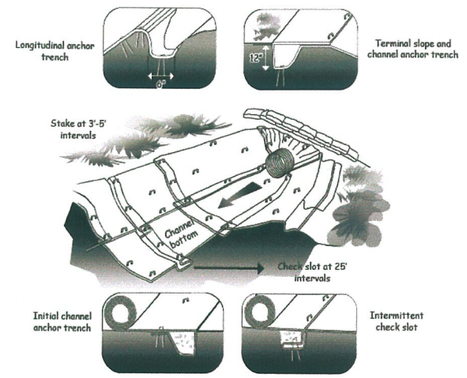


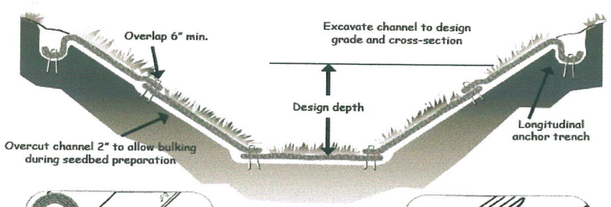
Construction Specifications

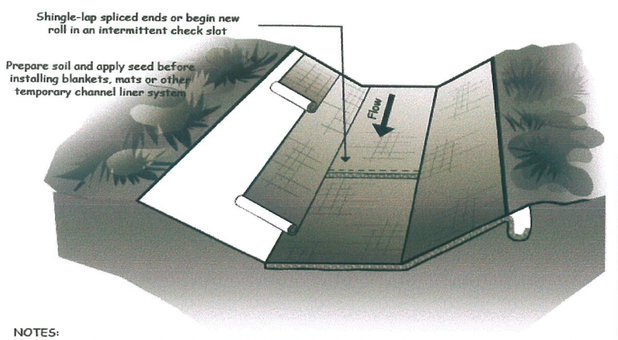
1. Keep clearing and excavation of the stream banks and bed and approach sections to a minimum.
2. Divert all surface water from the construction site onto undisturbed areas adjoining the stream.
3. Keep stream crossings at right angles to the stream flow.
4. Align road approaches with the center line of the crossing for a minimum distance of 30 feet. Raise bridge abutments and culvert fills a minimum of 1 foot above the adjoining approach sections to prevent erosion from surface runoff and to allow flood flows to pass around the structure.
5. Stabilize all disturbed areas subject to flowing water, including planned overflow areas, with riprap or other suitable means if design velocity exceeds the allowable for the in-place soil (Table 8.05a, Appendix 8.05).
6. Ensure that bypass channels necessary to dewater the crossing site are stable before diverting the stream. Upon completion of the crossing, fill, compact, and stabilize the bypass channel appropriately.
7. Remove temporary stream crossings immediately when they are no longer needed. Restore the stream channel to its original cross-section, and smooth and appropriately stabilize all disturbed areas.
8. Any in-stream sediment control measures must be removed upon stabilization of the area.

Maintenance Inspect temporary stream crossings after runoff-producing rains to check for blockage in channel, erosion of abutments, channel scour, riprap displacement, or piping. Make all repairs immediately to prevent further damage to the installation.

ROLLED EROSION CONTROL PRODUCTS







NOTES:
1. Design velocities exceeding 2 ft/sec require temporary blankets, mats or similar liners to protect seed and soil until vegetation becomes established.
2. Grass-lined channels with design velocities exceeding 6 ft/sec should include turf reinforcement mats

Installation

Installation for Slopes- Place the RECP 2-3 feet over the top of the slope and into an excavated end trench measuring approximately 12 inches deep by 6 inches wide. Pin the RECP at 1 foot intervals along the bottom of the trench, backfill, and compact. Unroll the RECP down (or along) the slope maintaining direct contact between the soil and the RECP. Overlap adjacent rolls a minimum of 3 inches. Pin the RECP to the ground using staples or pins in a 3 foot center-to-center pattern. Less frequent stapling/pinning is acceptable on moderate slopes.

Installation in Channels- Excavate terminal trenches (12 inches deep and 6 inches wide) across the channel at the upper and lower end of the lined channel sections. At 25-foot intervals along the channel, anchor the RECP across the channel either in 6 inch by 6 inch trenches or by installing two closely spaced rows of anchors. Excavate longitudinal trenches 6 inches deep and wide along channel edges (above water line) in which to bury the outside RECP edges. Place the first RECP at the downstream end of the channel. Place the end of the first RECP in the terminal trench and pin it at 1 foot intervals along the bottom of the trench.

Note: The RECP should be placed upside down in the trench with the roll on the downstream side of the bench.

Once pinned and backfilled, the RECP is deployed by wrapping over the top of the trench and unrolling upstream. If the channel is wider than the provided rolls, place ends of adjacent rolls in the terminal trench, overlapping the adjacent rolls a minimum of 3 inches. Pin at 1 foot intervals, backfill, and compact. Unroll the RECP in the upstream direction until reaching the first intermittent trench. Fold the RECP back over itself, positioning the roll on the downstream side of the trench, and allowing the mat to conform to the trench.

Then pin the RECP (two layers) to the bottom of the trench, backfill, and compact. Continue up the channel (wrapping over the top of the intermittent trench) repeating this step at other intermittent trenches, until reaching the upper terminal trench. At the upper terminal trench, allow the RECP to conform to the trench, secure with pins or staples, backfill, compact and then bring the mat back over the top of the trench and onto the existing mat (2 to 3 feet overlap in the downstream direction), and pin at 1 foot intervals across the RECP. When starting installation of a new roll, begin in a trench or shingle-lap ends of rolls a minimum of 1 foot with upstream RECP on top to prevent uplifting. Place the outside edges of the RECP(s) in longitudinal trenches, pin, backfill, and compact.

Anchoring Devices-11 gauge, at least 6 inches length by 1 inch width staples or 12 inch minimum length wooden stakes are recommended for anchoring the RECP to the ground.

Drive staples or pins so that the top of the staple or pin is flush with the ground surface. Anchor each RECP every 3 feet along its center. Longitudinal overlaps must be sufficient to accommodate a row of anchors and uniform along the entire length of overlap and anchored every 3 feet along the overlap length. Roll ends may be spliced by overlapping 1 foot (in the direction of water flow), with the upstream/upslope mat placed on top of the downstream/downslope RECP. This overlap should be anchored at 1 foot spacing across the RECP. When installing multiple width mats heat seamed in the factory, all factory seams and field overlaps should be similarly anchored.

Maintenance

1. Inspect Rolled Erosion Control Products at least weekly and after each significant (1/2 inch or greater) rain fall event repair immediately.
2. Good contact with the ground must be maintained, and erosion must not occur beneath the RECP.
3. Any areas of the RECP that are damaged or not in close contact with the ground shall be repaired and stapled.
4. If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.
5. Monitor and repair the RECP as necessary until ground cover as established.

References

Sprague, C. Joel. TRI/ Environmental, Inc. "Green Engineering, Design principles and applications using rolled erosion control products"

Storm Water Management Manual for Western Washington, Washington State Department of Ecology, Water Quality Program http://www.ecy.wa.gov/programs/wq/stormwater/index.html

Erosion Control Technology Council, http://www.ectc.org

Note: Details on this sheet are from the North Carolina Erosion and Sediment Control Planning and Design Manual

Job No.	2006-1399	Sheet	RP-14/18
Date	January, 2008	Scale	Not To Scale

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
EROSION CONTROL DETAILS

Ecosystem Enhancement Program

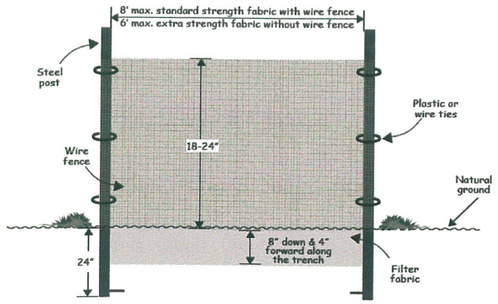
EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 www.emht.com

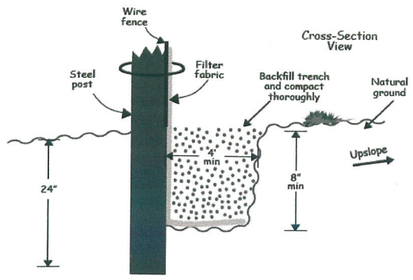
N. C. M. X. X. V.

REVISIONS

MARK	DATE	DESCRIPTION

SEDIMENT FENCE





Construction Specifications

MATERIALS

1. Use a synthetic filter fabric of at least 95% by weight of polyolefins or polyester, which is certified by the manufacturer or supplier as conforming to the requirements in ASTM D 6461, which is shown in part in Table 6.62b.

Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120° F.

2. Ensure that posts for sediment fences are 1.33 lb/linear ft steel with a minimum length of 5 feet. Make sure that steel posts have projections to facilitate fastening the fabric.

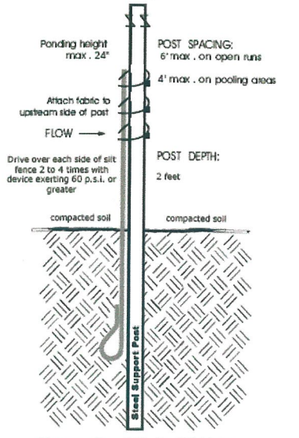
3. For reinforcement of standard strength filter fabric, use wire fence with a minimum 14 gauge and a maximum mesh spacing of 6 inches.

Table 6.62b Specifications For Sediment Fence Fabric

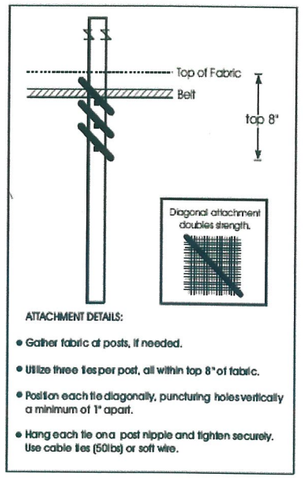
Temporary Silt Fence Material Property Requirements					
	Test Material	Units	Supported[1] Silt Fence	Un-Supported[1] Silt Fence	Type of Value
Grab Strength	ASTM D 4632	N (lbs)			
Machine Direction			400	550	MARV
			(90)	(90)	
X-Machine Direction			400	450	MARV
			(90)	(90)	
Permittivity[2]	ASTM D 4491	sec-1	0.05	0.05	MARV
Apparent Opening Size[2]	ASTM D 4751	mm	0.60	0.60	Max. ARV[3]
		(US Sieve #)	(30)	(30)	
Ultraviolet Stability	ASTM D 4355	% Retained Strength	70% after 500h of exposure	70% after 500h of exposure	Typical

[1] Silt Fence support shall consist of 14 gage steel wire with a mesh spacing of 150 mm (6 inches), or prefabricated poylmer mesh of equivalent strength.
[2] These default values are based on empirical evidence with a variety of sediment. For environmentally sensitive areas, a review of previous experience and/or site or regionally specific geotextile tests in accordance with Test Method D 5141 should be performed by the agency to confirm suitability of these requirements.
[3] As measured in accordance with Test Method D 4632.

The Slicing Method

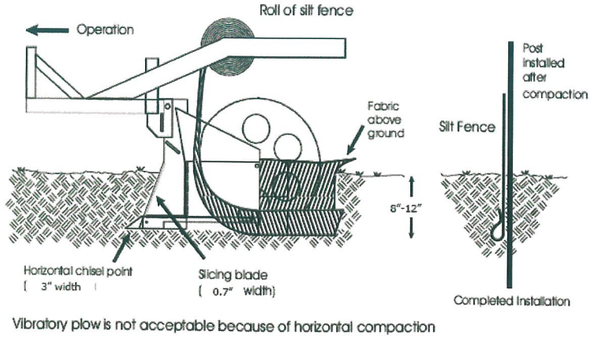


No more than 24" of a 36" fabric is allowed above ground.



ATTACHMENT DETAILS:

- Gather fabric at posts, if needed.
- Utilize three ties per post, all within top 8" of fabric.
- Position each tie diagonally, puncturing holes vertically a minimum of 1" apart.
- Hang each tie on a post nipple and tighten securely. Use cable ties (50lbs) or soft wire.



Vibratory plow is not acceptable because of horizontal compaction

Construction

1. Construct the sediment barrier of standard strength or extra strength synthetic filter fabrics.

2. Ensure that the height of the sediment fence does not exceed 24 inches above the ground surface. (Higher fences may impound volumes of water sufficient to cause failure of the structure.)

3. Construct the filter fabric from a continuous roll cut to the length of the barrier to avoid joints. When joints are necessary, securely fasten the filter cloth only at a support post with 4 feet minimum overlap to the next post.

4. Support standard strength filter fabric by wire mesh fastened securely to the upslope side of the posts. Extend the wire mesh support to the bottom of the trench. Fasten the wire reinforcement, then fabric on the upslope side of the fence post. Wire or plastic zip ties should have minimum 50 pound tensile strength.

5. When a wire mesh support fence is used, space posts a maximum of 8 feet apart. Support posts should be driven securely into the ground a minimum of 24 inches.

6. Extra strength filter fabric with 6 feet post spacing does not require wire mesh support fence. Securely fasten the filter fabric directly to posts. Wire or plastic zip ties should have minimum 50 pound tensile strength.

7. Excavate a trench approximately 4 inches wide and 8 inches deep along the proposed line of posts and upslope from the barrier (Figure 6.62a).

8. Place 12 inches of the fabric along the bottom and side of the trench.

9. Backfill the trench with soil placed over the filter fabric and compact. Thorough compaction of the backfill is critical to silt fence performance.

10. Do not attach filter fabric to existing trees.

SEDIMENT FENCE INSTALLATION USING THE SLICING METHOD
Instead of excavating a trench, placing fabric and then backfilling trench, sediment fence may be installed using specially designed equipment that inserts the fabric into a cut sliced in the ground with a disc (Figure 6.62b).

Installation Specifications

1. The base of both end posts should be at least one foot higher than the middle of the fence. Check with a level if necessary.

2. Install posts 4 feet apart in critical areas and 6 feet apart on standard applications.

3. Install posts 2 feet deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

4. Install posts with the nipples facing away from the silt fabric.

5. Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. Also, each tie should be positioned to hang on a post nipple when tightened to prevent sagging.

6. Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

7. No more than 24 inches of a 36 inch fabric is allowed above ground level.

8. The installation should be checked and corrected for any deviations before compaction.

9. Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first, and then each side twice for a total of 4 trips.

Maintenance

Inspect sediment fences at least once a week and after each rainfall. Make any required repairs immediately. Should the fabric of a sediment fence collapse, tear, decompose or become ineffective, replace it promptly. Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout. Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized.

Note: Details on this sheet are from the North Carolina Erosion and Sediment Control Planning and Design Manual

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
EROSION CONTROL DETAILS

Job No. 2006-1399
Sheet RP-15/18
Date January, 2008
Scale Not To Scale

Ecosystem Enhancement Program

EMH&T
Environmental, Water Resources, Engineers, Surveyors, Planners, Scientists
Evans, Mechwart, Hambleton & Tilton, Inc.
5500 New Albany Road, Columbus, OH 43054
Phone 614.775.4500 Fax 614.775.4800

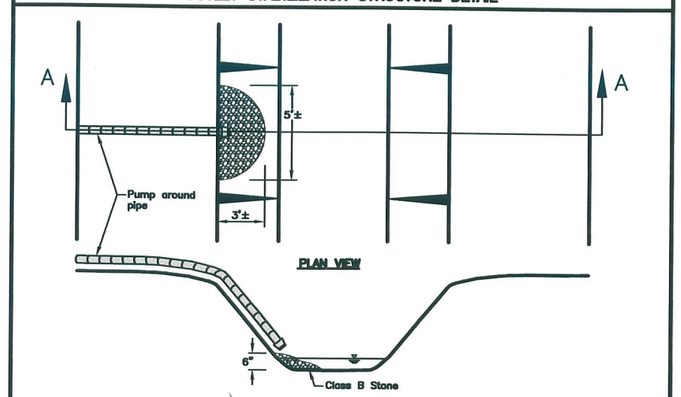
MARK	DATE	DESCRIPTION

REVISIONS

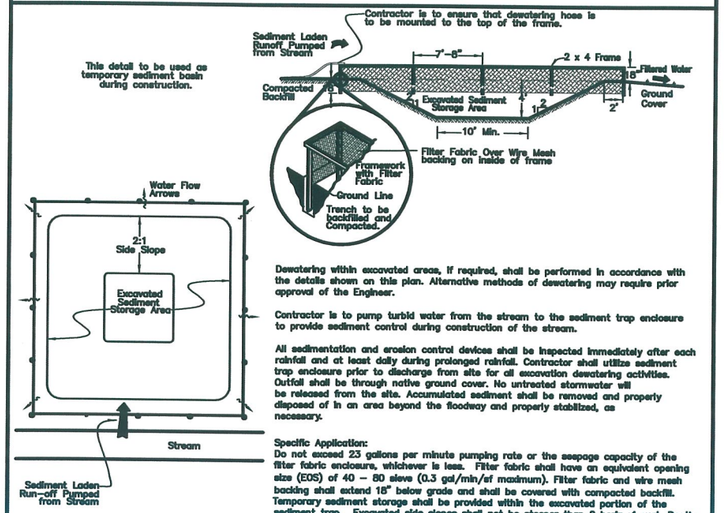
Notes:

- Limits of disturbance is approximately 15' outside the conservation easement, unless shown and labeled differantly on this sheet.
- The existing stream channel and abandoned pond within the conservation easement shall be filled after the new channel is active. This fill should be a combination of compacted clay soil and Plain Riprap, Class 1. The area should be graded to drain into the new channel and stabilized with seed and mulch. The existing stream outside the conservatian easement shall be plugged every 100' to promote overland flow to the channel.
- When construction is complete the spoil areas shall be graded to drain to the new channel and stabilized with seed and mulch.
- When construction is complete the borrow areas shall be restored to grade to the extent possible. After grading the area shall be stabilized with seed and mulch.
- Locations of the temporary stream crossings are approximate and will be established in the field by the Contractor throughout the course of constructing the project

OUTLET STABILIZATION STRUCTURE DETAIL



TEMPORARY DEWATERING SEDIMENT TRAP DETAIL



Dewatering within excavated areas, if required, shall be performed in accordance with the details shown on this plan. Alternative methods of dewatering may require prior approval of the Engineer.

Contractor is to pump turbid water from the stream to the sediment trap enclosure to provide sediment control during construction of the stream.

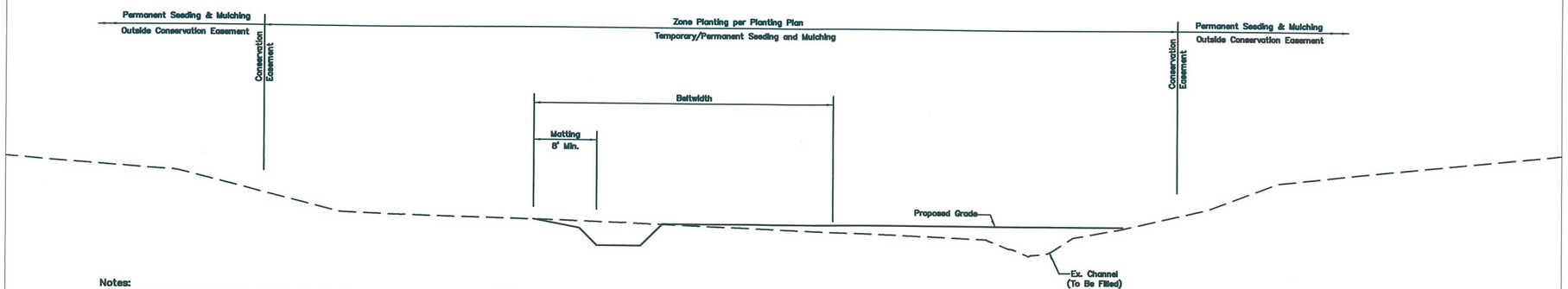
All sedimentation and erosion control devices shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Contractor shall utilize sediment trap enclosure prior to discharge from site for all excavation dewatering activities. Outfall shall be through native ground cover. No untreated stormwater will be released from the site. Accumulated sediment shall be removed and properly disposed of in an area beyond the floodway and properly stabilized, as necessary.

Specific Application:
Do not exceed 23 gallons per minute pumping rate or the seepage capacity of the filter fabric enclosure, whichever is less. Filter fabric shall have an equivalent opening size (EOS) of 40 – 80 sieve (0.3 gal/min/sf maximum). Filter fabric and wire mesh backing shall extend 18" below grade and shall be covered with compacted backfill. Temporary sediment storage shall be provided within the excavated portion of the sediment trap. Excavated side slopes shall not be steeper than 2 horiz :1 vert. Depth of excavation shall be 4–feet below natural grade. Sediment trap shall be re–excavated when the holding area becomes half–full of sediment.

SEEDING TABLE OUTSIDE CONSERVATION EASEMENT

TYPE		APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED:			
Rye (Grain)	*(Secale cereale)*	120 lbs/acre	June–August
PERMANENT SEED:			
Big Bluestem	*(Andropogon gerardii)*	15 lbs/acre of mixture	September – May
Tall Fescue	*(Festuca arundinacea)*		
Kentucky Bluegrass	*(Poa pratensis)*		
Korean Lespedeza	*(Lespedeza stipulacea)*		
Sericea Lespedeza	*(Lespedeza cuneata)*		
Redtop	*(Agrostis gigantea)*		
Indiangrass	*(Sorghastrum nutans)*		

CHANNEL STABILIZATION DETAIL – SECTION B–B



Notes:
- Typical Section B–B is from left to right looking downstream, see sheet 13 for location.
- Matting shall be placed along the outside of the meander bends, see channel reinforcement detail on sheet 10.
- See sheet 12 for a detailed erosion control schedule.
- See plan view on sheet 13 for location of each erosion control feature.
- Matting shall be installed per NCDOT Item 1631.3 and detail, sheet 16.
- Straw mulch shall be applied at a ratio 1–2 tons per acre, and shall be anchored using a mulch anchoring tool or other approved method.

Job No. 2006-1399 | Sheet RP-16/18
Date January, 2008 | Scale Not To Scale

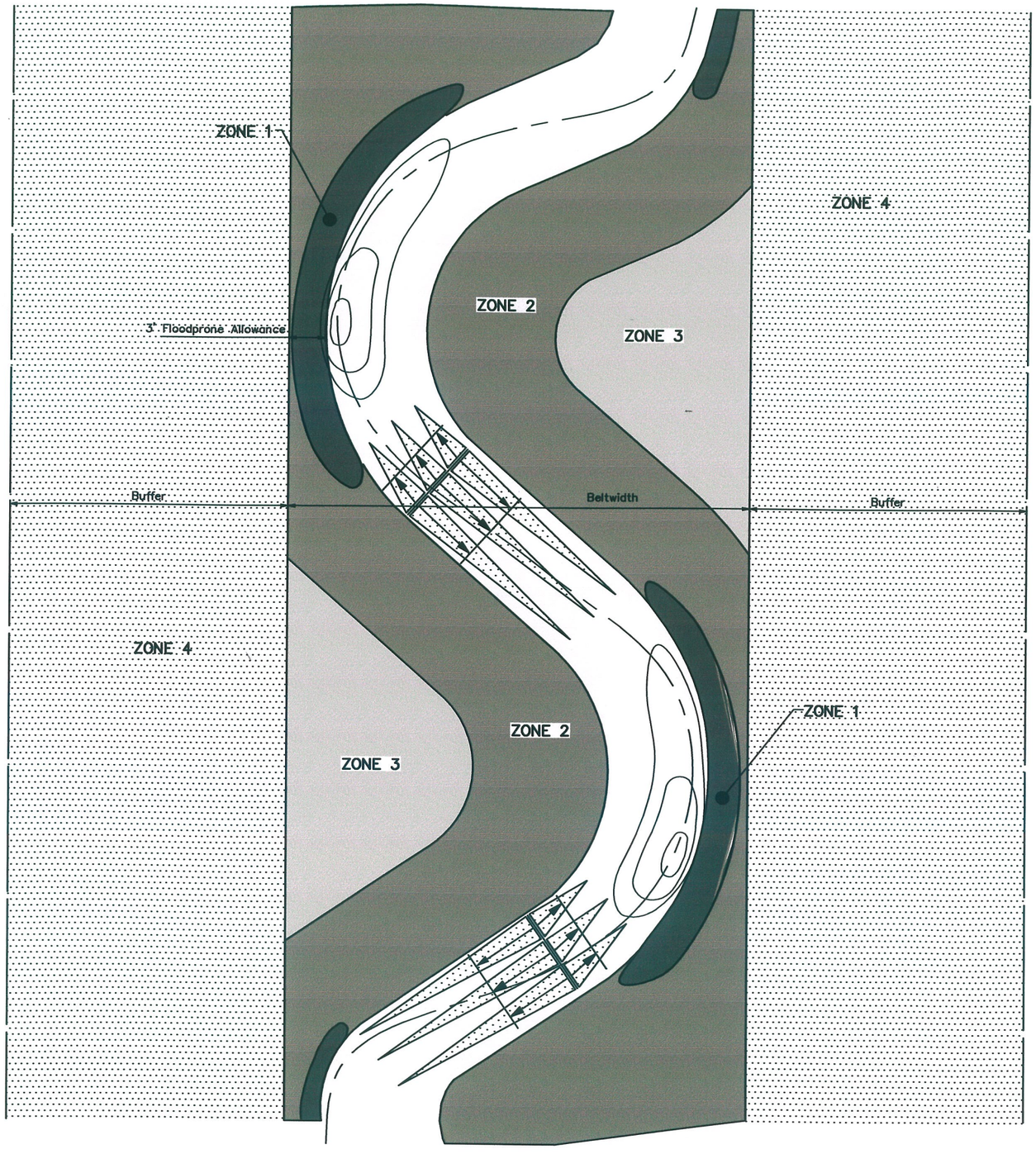
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
EROSION CONTROL DETAILS

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

REVISIONS

MARK	DATE	DESCRIPTION



PLANTING ZONES
Not to Scale

KEY

*Proposed Beaverdam Creek & UT Plantings**

- *Zone 1 - Stream Edge*
  ***Live Branches**, 3x3' centers*

Common Name	Scientific Name
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Black willow	*Salix nigra*
Silky willow	*Salix sericea*
Elderberry	*Sambucus canadensis*

- *Zone 2 - Streamside Shrubs and Trees*
  ***Shrubs,** Bareroot Material - 4x4' centers*

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Tag alder	*Alnus serrulata*
Red chokeberry	*Aronia arbutifolia*
Silky dogwood	*Cornus amomum*
American holly	*Ilex opaca*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*

***Trees,** 1 Gallon Containers - 100 foot spacing*

Common Name	Scientific Name
River birch	*Betula nigra*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Sycamore	*Platanus occidentalis*
Water oak	*Quercus nigra*
Willow oak	*Quercus phellos*
American elm	*Ulmus americana*

- *Zone 3 - Floodplain*
  Bareroot Material - 8x8' centers

Common Name	Scientific Name
Red chokeberry	*Aronia arbutifolia*
Paw paw	*Asimina triloba*
River birch	*Betula nigra*
American hornbeam	*Carpinus caroliniana*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Sycamore	*Platanus occidentalis*
American elm	*Ulmus americana*

- *Zone 4 - 30' Riparian Buffer*
  Bareroot Material - 10x10' centers

Common Name	Scientific Name
Pignut hickory	*Carya glabra*
Flowering dogwood	*Cornus florida*
White ash	*Fraxinus americana*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Eastern hophornbeam	*Ostrya virginiana*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Smooth sumac	*Rhus glabra*
Winged elm	*Ulmus alata*

In addition to planting described above, temporary and permanent seeding will occur in Zones 2, 3 & 4. See seeding table, this sheet.

**Final species selection will be based upon availability.*

Notes

– **The existing wooded portions of Beaverdam Creek and Unnamed Tributary 1 will only contain planting zones 1 and 2. See sheet 18.**

STREAM CORRIDOR SEEDING TABLE		
TYPE	APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: **Rye (Grain)** *(Secale cereale)*	40 lbs/acre	June–August
PERMANENT SEED: **Big Bluestem** *(Andropogon gerardii)* **Broomsedge** *(Andropogon virginicus)* **Deertongue** *(Panicum clandestinum)* **Little Bluestem** *(Schizachyrium scoparium)* **Indiangrass** *(Sorghastrum nutans)*	15 lbs/acre of mixture	September – May
OVERSEED: **Pearl Millet** *(Pennisetum glaucum)*	15 lbs/acre	June–August

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLANTING PLAN

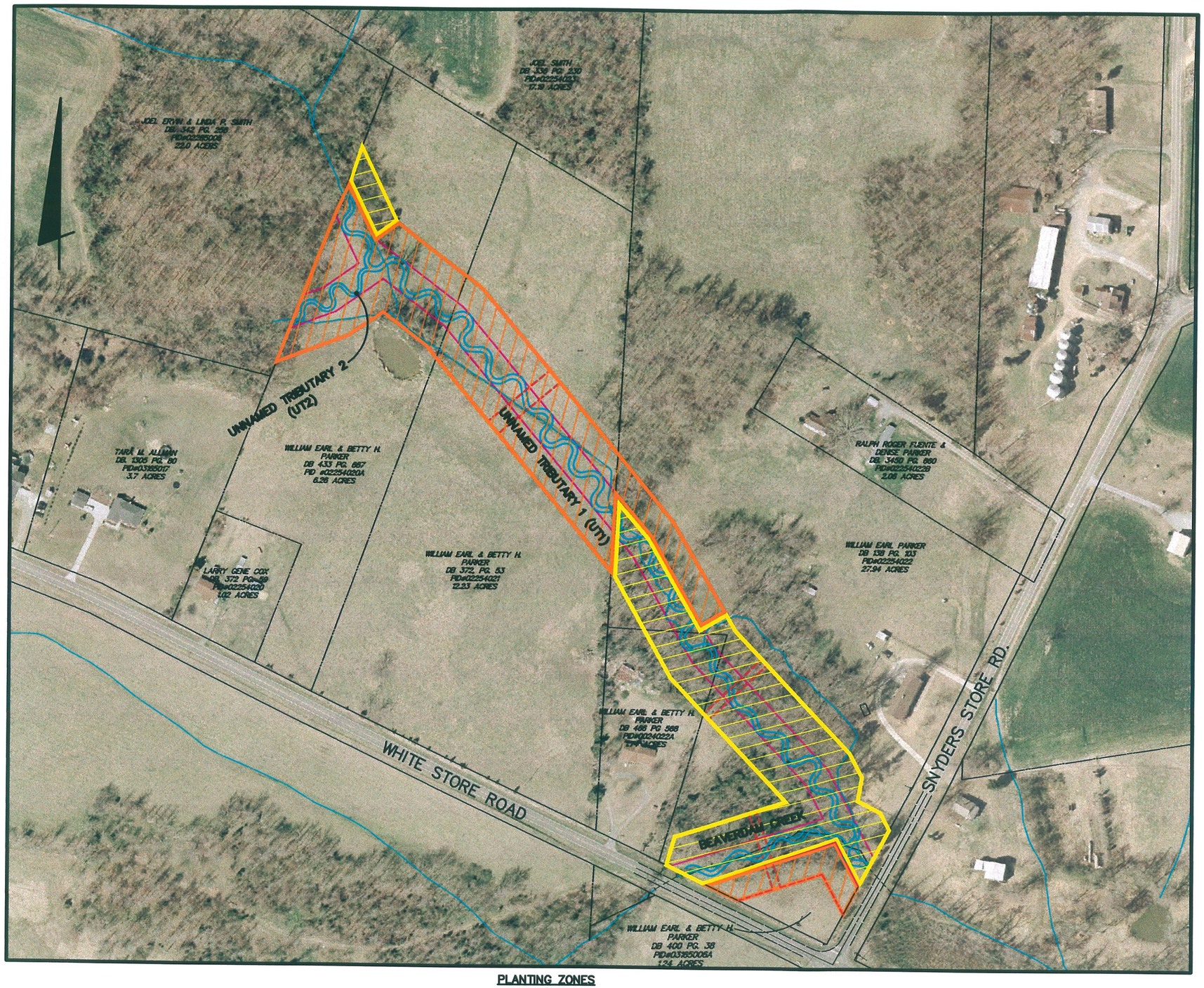
Job No. 2006-1398
Date January, 2008
Scale Not To Scale
Sheet **RP-17/18**

Ecosystem Enhancement Program

EMH&T
Rivers, Mechanicsburg, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

REVISIONS

MARK	DATE	DESCRIPTION



PLANTING ZONES
Scale: 1" = 200'

LEGEND

PLANTING ZONES 1–4

PLANTING ZONES 1 & 2 ONLY

NOTE:
See Planting Plan Zones and Planting List, Sheet 17.

Job No.	Sheet
2006-1399	RP-18/18
Date	Scale
January, 2008	As Noted

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
STREAM RESTORATION PROJECT
PLANTING PLAN

Ecosystem Enhancement Program

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: (614)775.4800

REVISIONS

MARK	DATE	DESCRIPTION

Appendix "2"

Project Site NCDWQ Stream Classification Form

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

Date: 4/10/07	**Project:** Beaverdam	**Latitude:**
Evaluator: S. Peffer	**Site:** Beaverdam Mainstem	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 31	**County:** Union	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 20.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	1	2	(3)
3. In-channel structure: riffle-pool sequence	0	1	(2)	3
4. Soil texture or stream substrate sorting	0	1	(2)	3
5. Active/relic floodplain	0	1	(2)	3
6. Depositional bars or benches	0	(1)	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	(1)	2	3
9[a] Natural levees	0	(1)	2	3
10. Headcuts	0	1	2	(3)
11. Grade controls	0	0.5	1	(1.5)
12. Natural valley or drainageway	0	0.5	(1)	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	(No = 0)		Yes = 3	

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

B. Hydrology (Subtotal = 6)				
14. Groundwater flow/discharge	0	(1)	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	(1)	2	3
16. Leaflitter	1.5	(1)	0.5	0
17. Sediment on plants or debris	0	0.5	(1)	1.5
18. Organic debris lines or piles (Wrack lines)	0	(0.5)	1	1.5
19. Hydric soils (redoxymorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 4.5)				
20[b]. Fibrous roots in channel	3	(2)	1	0
21[b]. Rooted plants in channel	3	(2)	1	0
22. Crayfish	(0)	0.5	1	1.5
23. Bivalves	(0)	1	2	3
24. Fish	0	(0.5)	1	1.5
25. Amphibians	(0)	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	(0)	0.5	1	1.5
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	(0)	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; (Other = 0)			

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

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

Geomorphology of stream is indicative of perennial. Flow upstream is severely impaired by sedimentation.

Sketch:

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

Date: 4/10/07	**Project:** Beaverdam	**Latitude:**
Evaluator: S. Peffer	**Site:** UT1	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 45	**County:** Union	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 27)

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

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

B. Hydrology (Subtotal = 8)

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

C. Biology (Subtotal = 10)

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

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

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

Sketch:

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

Date: 4/10/07	**Project:** Beaverdam	**Latitude:**
Evaluator: S. Peffer	**Site:** UT2	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 32.25	**County:** Union	**Other** *e.g. Quad Name:*

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

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

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

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

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

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

Sketch:

Appendix "3"

Davis Branch Reference Reach, Rosgen Level III Assessment Documentation

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Beaverdam Creek, Reach - Davis Branch Reference Reach

Basin NAME: Yadkin River Drainage AREA: 365.44 acre 0.571 mi^2

Location: Davis Branch Near Marshville, N.C.

Twp: _____ Rge: _____ Sec: _____ Qtr: _____ Lat: 35.0914 Long: 80.334

Observers: Warren E. Knotts, PG & Sean Peffer, Env. Sc. Date: 8/8/2006

Bankfull WIDTH (W_{bkf}) — **12.91** Feet
WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.

Mean DEPTH (d_{bkf}) — **1.21** Feet
Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)

Bankfull Cross Section Area (A_{bkf}) — **15.65** $Feet^2$
AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.

WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) — **10.67** Ft/Ft
Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.

Maximum DEPTH (d_{mrif}) — **1.61** Feet
Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.

Flood-Prone Area WIDTH (W_{fpa}) — **50** Feet
The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or ($2 \times d_{mrif}$)

Entrenchment RATIO (ER) — **3.87** Ft/Ft
The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.

Channel Materials (Particle Size Index) D50 — **69.2** mm
The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.

Water Surface SLOPE (S) — **0.03256** Ft/Ft
Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.

Channel SINUOSITY (K) — **1.19**
Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).

Stream Type **E 3/1b**

For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.

Reference Reach Summary Data Form

Channel Dimension

... and Reference Reach Summary Data

Mean Riffle Depth (d_{bkf})	1.21	feet	Mean Riffle Width (W_{bkf})	12.91	feet	Mean Riffle Area (A_{bkf})	15.65	$feet^2$
Mean Pool Depth (d_{bkfp})	1.46	feet	Mean Pool Width (W_{bkfp})	14.49	feet	Mean Pool Area (A_{bkfp})	21.16	$feet^2$
Ratio Mean Pool Depth/Mean Riffle Depth	1.207	d_{bkfp}/d_{bkf}	Ratio Pool Width/Riffle Width	1.122	W_{bkfp}/W_{bkf}	Ratio Pool Area/ Riffle Area	1.352	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mrif})	1.72	feet	Max Pool Depth (d_{mpool})	2.04	feet	Max riffle depth/Mean riffle depth	1.421	
Max pool depth/Mean riffle depth	1.686					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				4.96	ft/s	Estimation Method	Resistence Eq. (u/u*)	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				77.62	cfs	Drainage Area	0.571	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	99.2	80.1	116.5	feet	Meander Length Ratio (Lm/W_{bkf})	7.684	6.204	9.024
Radius of Curvature (Rc)	29.4	16.4	45.3	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	2.277	1.270	3.509
Belt Width (W_{blt})	38	27.8	53	feet	Meander Width Ratio (W_{blt}/W_{bkf})	2.943	2.153	4.105
Individual Pool Length	21.2	12.04	29.09	feet	Pool Length/Riffle Width	1.642	0.933	2.253
Pool to Pool Spacing	38.56	33.42	43.7	feet	Pool to Pool Spacing/Riffle Width	2.987	2.589	3.385

Channel Profile

Valley Slope (VS)	0.0387	ft/ft	Average Water Surface Slope (S)	0.03256	ft/ft	Sinuosity (VS/S)	1.19	
Stream Length (SL)	1138	feet	Valley Length (VL)	974	feet	Sinuosity (SL/VL)	1.168	
Low Bank Height (LBH)	start 1.33 / end 2.34	feet	Max Riffle Depth	start 1.33 / end 2.34	feet	Bank Height Ratio (LBH/Max Riffle Depth)	start 1 / end 1	

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0520	0.0283	0.0799	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	1.598	0.869	2.453
Run Slope (S_{run})	0.0076	0.0076	0.0076	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	0.232	0.232	0.232
Pool Slope (S_p)	0.0011	0.0010	0.0011	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	0.033	0.032	0.035
Glide Slope (S_g)	0.0166	0.0166	0.0166	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	0.510	0.510	0.510

Feature Midpoint [a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	1.720	1.330	2.340	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	1.421	1.099	1.934
Run Depth (d_{mrun})	1.970	1.640	2.290	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	1.628	1.355	1.893
Pool Depth (d_{mp})	2.040	1.830	2.380	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	1.686	1.512	1.967
Glide Depth (d_{mg})	1.770	1.650	1.890	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	1.463	1.364	1.562

Channel Materials

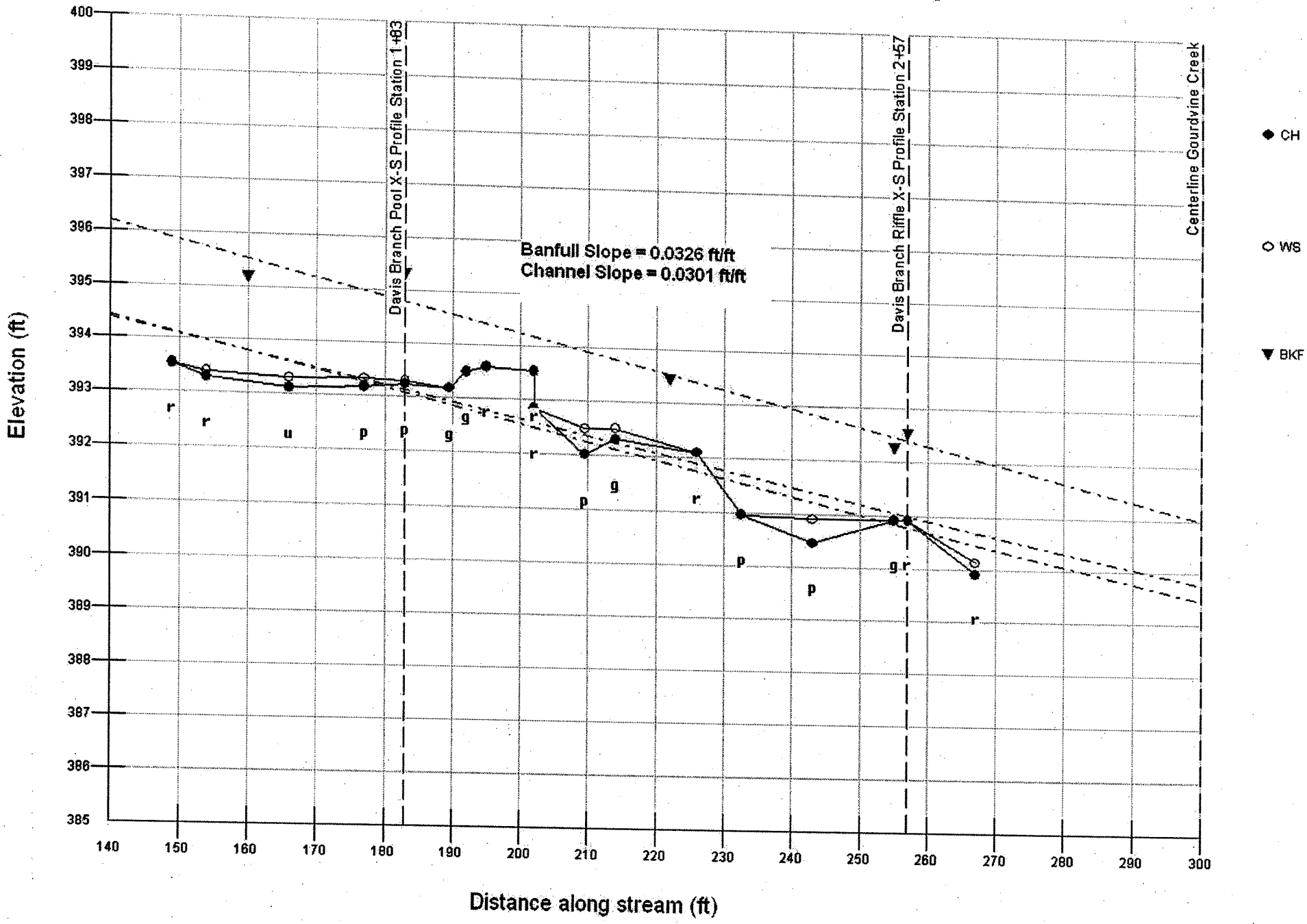
Catagories	Reach [b]	Riffle [c]	Bar	Indices	Reach [b]	Riffle [c]	Bar	
% Silt/Clay		0		D16		28.78		mm
% Sand		0		D35		52.6		mm
% Gravel		45		D50		69.2		mm
% Cobble		50		D84		140.12		mm
% Boulder		5		D95		256		mm
% Bedrock		0		D100		362		mm

a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

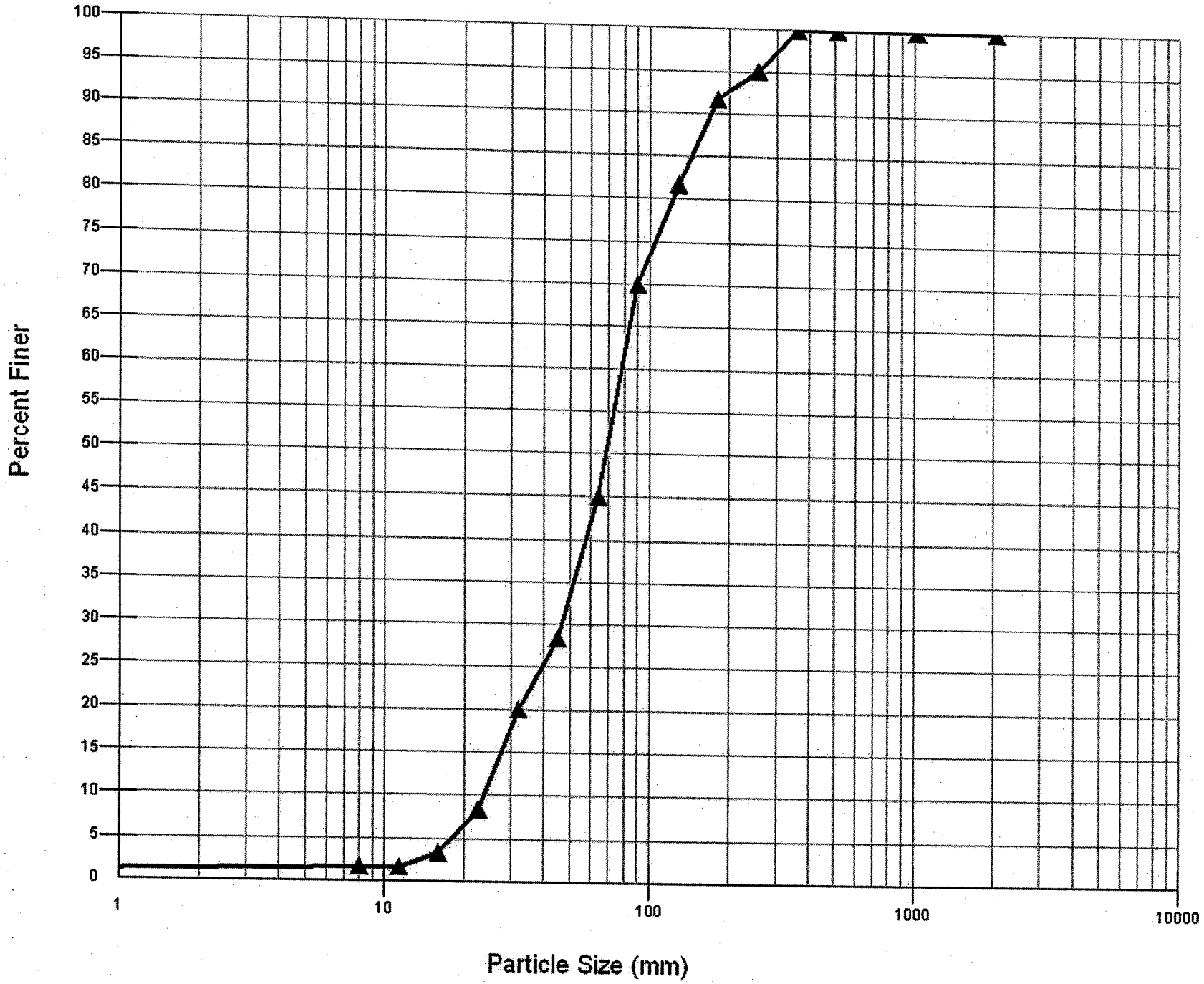
b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.

Davis Branch Reference Reach Longitudinal Profile - August 2006



Davis Branch Reference Reach - Riffle Bed Sample



RIVERMORPH PARTICLE SUMMARY

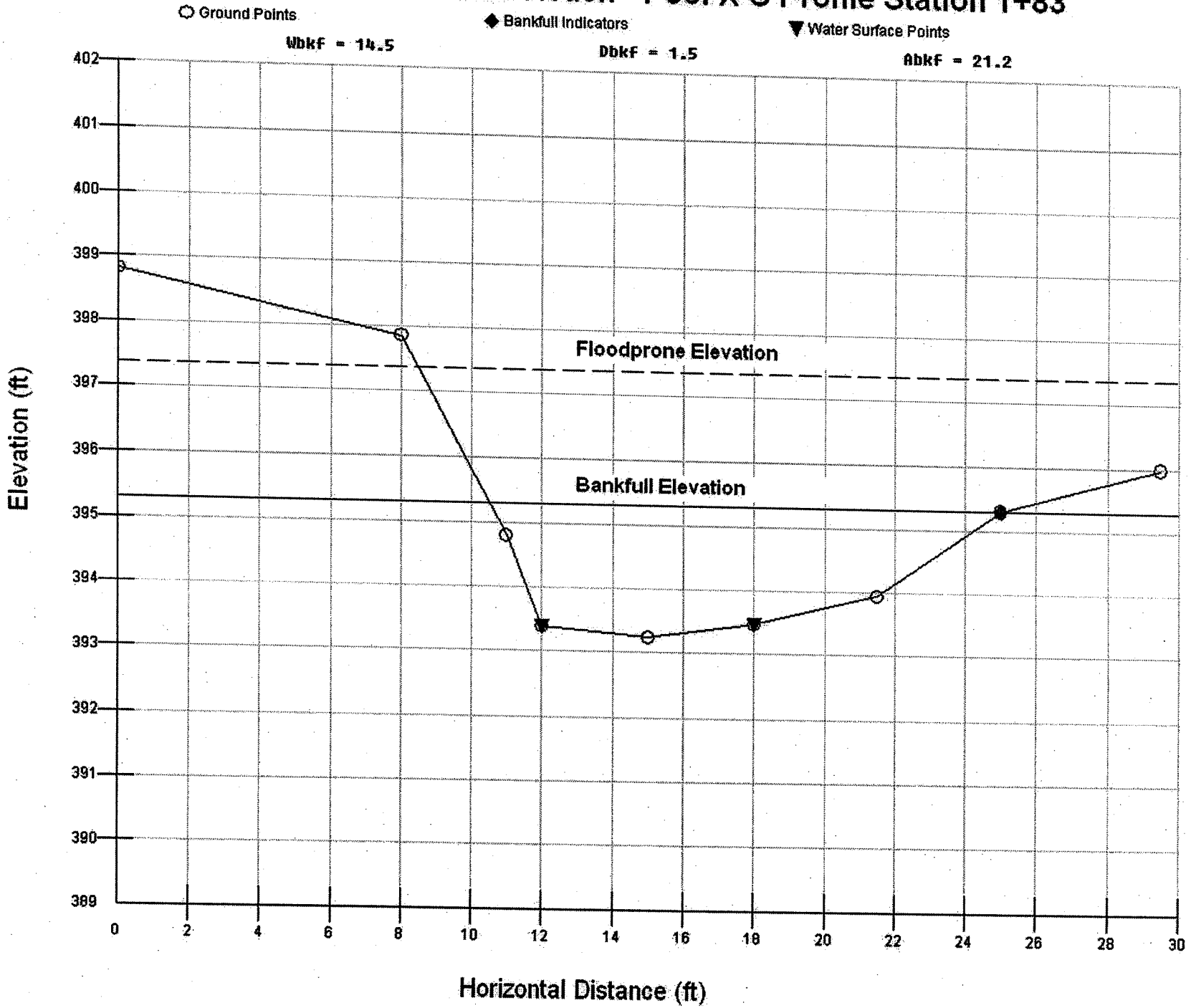
River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach
Sample Name: Riffle Bed Sample
Survey Date: 08/08/06

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	1	1.67	1.67
8.0 - 11.3	0	0.00	1.67
11.3 - 16.0	1	1.67	3.33
16.0 - 22.6	3	5.00	8.33
22.6 - 32.0	7	11.67	20.00
32 - 45	5	8.33	28.33
45 - 64	10	16.67	45.00
64 - 90	15	25.00	70.00
90 - 128	7	11.67	81.67
128 - 180	6	10.00	91.67
180 - 256	2	3.33	95.00
256 - 362	3	5.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	28.78
D35 (mm)	52.6
D50 (mm)	69.2
D84 (mm)	140.12
D95 (mm)	256
D100 (mm)	362
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	45
Cobble (%)	50
Boulder (%)	5
Bedrock (%)	0

Total Particles = 60.

Davis Branch Reference Reach - Pool X-S Profile Station 1+83



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach
Cross Section Name: Davis Branch Pool X-S Profile Station 1+83
Survey Date: 08/08/06

Cross Section Data Entry

BM Elevation: 392.74 ft
Backsight Rod Reading: 10 ft

TAPE	FS	ELEV	NOTE
29.5	6.75	395.99	RB
25	7.44	395.3	BKF
21.5	8.8	393.94	PB
18	9.28	393.46	REW
15	9.51	393.23	TW
12	9.36	393.38	LEW
11	7.94	394.8	ON LB
8	4.89	397.85	LB
0	3.93	398.81	FP

Cross Sectional Geometry

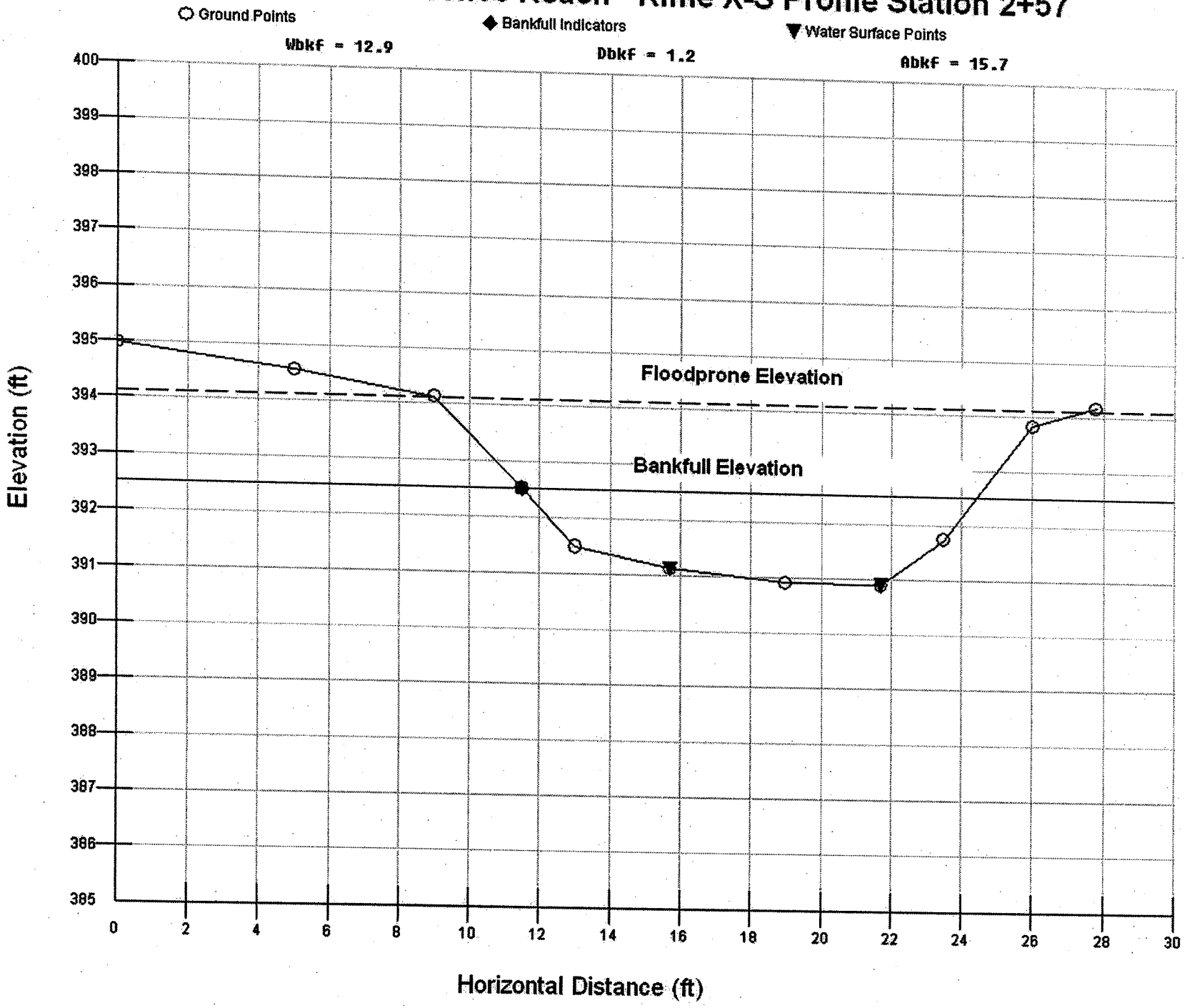
	Channel	Left	Right
Floodprone Elevation (ft)	397.37	-----	-----
Bankfull Elevation (ft)	395.3	-----	-----
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	14.49	-----	-----
Entrenchment Ratio	3.45	-----	-----
Mean Depth (ft)	1.46	-----	-----
Maximum Depth (ft)	2.07	-----	-----
Width/Depth Ratio	9.92	-----	-----
Bankfull Area (sq ft)	21.16	-----	-----
Wetted Perimeter (ft)	15.74	-----	-----
Hydraulic Radius (ft)	1.34	-----	-----
Begin BKF Station	25	-----	-----
End BKF Station	10.51	-----	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.03256	0	0
Shear Stress (lb/sq ft)	2.72		
Movable Particle (mm)	317.6		

Davis Branch Reference Reach - Riffle X-S Profile Station 2+57



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach
Cross Section Name: Davis Branch Riffle X-S Profile Station 2+57
Survey Date: 08/08/06

Cross Section Data Entry

BM Elevation: 390 ft
Backsight Rod Reading: 9.48 ft

TAPE	FS	ELEV	NOTE
27.8	5.3	394.18	FP
26	5.65	393.83	RB
23.5	7.73	391.75	
21.7	8.58	390.9	REW
19	8.56	390.92	TW
15.7	8.34	391.14	LEW
13	7.98	391.5	SB
11.5	6.97	392.51	BKF
9	5.35	394.13	LB
5	4.92	394.56	FP
0	4.51	394.97	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	394.12	-----	-----
Bankfull Elevation (ft)	392.51	-----	-----
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	12.91	-----	-----
Entrenchment Ratio	3.87	-----	-----
Mean Depth (ft)	1.21	-----	-----
Maximum Depth (ft)	1.61	-----	-----
Width/Depth Ratio	10.67	-----	-----
Bankfull Area (sq ft)	15.65	-----	-----
Wetted Perimeter (ft)	13.72	-----	-----
Hydraulic Radius (ft)	1.14	-----	-----
Begin BKF Station	24.41	-----	-----
End BKF Station	11.5	-----	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.03256	0	0
Shear Stress (lb/sq ft)	2.32		
Movable Particle (mm)	282.0		

RIVERMORPH STREAM VISUAL ASSESSMENT PROTOCOL SUMMARY

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach
Survey Date: 08/20/80

Channel Condition:	10
Hydrologic Alteration:	9
Riparian Zone:	10
Bank Stability:	9
Water Appearance:	3
Nutrient Enrichment:	1
Barriers to Fish Movement:	10
Instream Fish Cover:	10
Pools:	7
Invertebrate Habitat:	8
Canopy Cover:	10
Manure Presence:	1
Salinity:	5
Riffle Embeddedness:	10
Macroinvertebrates:	6

Warmwater Fishery

Rating Criteria:
Poor < 6.0
Fair 6.1-7.4
Good 7.5-8.9
Excellent > 9.0

Overall Score (total divided by number scored) = 7.27

Suspected Cause of Observed Problems:
Nutrient loading & bank instability from uncontrolled livestock intrusion upstream.

Recommendations:
Restore stable pattern, profile, dimension & native riparian buffers along impaired reaches; livestock exclusion.

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach
BEHI Name: Pool XS 1+83
Survey Date: 08/08/06

Bankfull Height: 2.07 ft
Bank Height: 4.47 ft
Root Depth: 4 ft
Root Density: 95 %
Bank Angle: 47 Degrees
Surface Protection: 98 %

Bank Material Adjustment: Silt/Clay 0

Bank Stratification Adjustment: None 0

Erosion Loss Curve: Yellowstone

NBS Method #7: Vertical Velocity Near-Bank Shear Stress Method

Velocity at Surface: 4.96 fps	Velocity at Bed: 3.5 fps
Depth: 2.07 ft	Hydraulic Radius: 1.34 ft
Bankfull Slope: 0.03256	Shear Stress: 2.72 lb/sq/ft
NB Shear Stress: 0.97 lb/sq/ft	Shear Ratio: 0.35

BEHI Numerical Rating: 16.1
BEHI Adjective Rating: Low
NBS Numerical Rating: 0.35
NBS Adjective Rating: Very Low
Total Bank Length: 974 ft
Estimated Sediment Loss: 3.23 Cu Yds per Year
Estimated Sediment Loss: 4.2 Tons per Year

RIVERMORPH RAPID BIOASSESSMENT PROTOCOL SUMMARY

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach

Epifaunal Substrate/Avail Cover:	17
Embeddedness:	20
Velocity/Depth Regime:	20
Sediment Deposition:	17
Channel Flow Status:	9
Channel Alteration:	18
Frequency of Riffles:	18
Bank Stability (LB):	9
Bank Stability (RB):	9
Vegetative Protection (LB):	10
Vegetative Protection (RB):	10
Riparian Veg. Zone Width (LB):	8
Riparian Veg. Zone Width (RB):	8

High Gradient Stream
Rating Criteria:
0-50 Poor
51-100 Marginal
101-150 Suboptimal
151-200 Optimal

Score - 173

RIVERMORPH BEHI SUMMARY REPORT

River Name: Beaverdam Creek
Reach Name: Davis Branch Reference Reach

Table 1. Bank Identification Summary

Bank	Name
1	Pool XS 1+83

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	16.1	Low	Very Low	974	3.23	4.2
Totals				974	3.23	4.2

Total Reach Ln: 974 Total Loss (tons/yr) per ft of Reach: 0.0043

Appendix "4"

Project Site Design Calculations, Spreadsheets and Summary Reports

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Beaverdam Creek, Reach - Beaverdam Ck Impaired Mainstem

Basin NAME: Yadkin River Drainage AREA: 162.24 acre 0.2535 mi^2

Location: Davis Branch Near Marshville, N.C.

Twp: _____ Rge: _____ Sec: _____ Qtr: _____ Lat: 34.9278 Long: 80.436

Observers: Warren E. Knotts, PG & Sean Peffer, Env. Sc. Date: 7/17/2007

Bankfull WIDTH (W_{bkf}) — **7.44** Feet
WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.

Mean DEPTH (d_{bkf}) — **0.81** Feet
Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)

Bankfull Cross Section Area (A_{bkf}) — **6.05** $Feet^2$
AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.

WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) — **9.19** Ft/Ft
Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.

Maximum DEPTH (d_{mrif}) — **1.14** Feet
Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.

Flood-Prone Area WIDTH (W_{fpa}) — **27.4** Feet
The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or ($2 \times d_{mrif}$)

Entrenchment RATIO (ER) — **3.68** Ft/Ft
The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.

Channel Materials (Particle Size Index) D50 — **9.5** mm
The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.

Water Surface SLOPE (S) — **0.01691** Ft/Ft
Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.

Channel SINUOSITY (K) — **1.08**
Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).

Stream Type **E 4**

For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.

Reference Reach Summary Data Form

... and Reference Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	0.81	feet	Mean Riffle Width (W_{bkf})	7.44	feet	Mean Riffle Area (A_{bkf})	6.05	$feet^2$
Mean Pool Depth (d_{bkfp})	0.95	feet	Mean Pool Width (W_{bkfp})	9.77	feet	Mean Pool Area (A_{bkfp})	9.29	$feet^2$
Ratio Mean Pool Depth/Mean Riffle Depth	1.173	d_{bkfp}/d_{bkf}	Ratio Pool Width/Riffle Width	1.313	W_{bkfp}/W_{bkf}	Ratio Pool Area/ Riffle Area	1.536	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mrif})	0.84	feet	Max Pool Depth (d_{mpool})	1.29	feet	Max riffle depth/Mean riffle depth	1.037	
Max pool depth/Mean riffle depth	1.593					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				6.17	ft/s	Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				37.3	cfs	Drainage Area	0.2535	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	0	0	0	feet	Meander Length Ratio (Lm/W_{bkf})	0.000	0.000	0.000
Radius of Curvature (Rc)	0	0	0	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	0.000	0.000	0.000
Belt Width (W_{blt})	0	0	0	feet	Meander Width Ratio (W_{blt}/W_{bkf})	0.000	0.000	0.000
Individual Pool Length	19.53	17.17	21.88	feet	Pool Length/Riffle Width	2.625	2.308	2.941
Pool to Pool Spacing	86.3	67.68	104.9	feet	Pool to Pool Spacing/Riffle Width	11.599	9.097	14.101

Channel Profile

Valley Slope (VS)	0.0182	ft/ft	Average Water Surface Slope (S)	0.01691	ft/ft	Sinuosity (VS/S)	1.08	
Stream Length (SL)	0	feet	Valley Length (VL)	0	feet	Sinuosity (SL/VL)	#####	
Low Bank Height (LBH)	start 0 / end 0	feet	Max Riffle Depth	start 0 / end 0	feet	Bank Height Ratio (LBH/Max Riffle Depth)	start ##### / end #####	

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0246	0.0194	0.0328	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	1.457	1.145	1.938
Run Slope (S_{run})	0.0000	0.0000	0.0000	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	0.000	0.000	0.000
Pool Slope (S_p)	0.0014	0.0009	0.0018	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	0.082	0.055	0.108
Glide Slope (S_g)	0.0000	0.0000	0.0000	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	0.000	0.000	0.000

Feature Midpoint [a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	0.840	0.770	0.900	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	1.037	0.951	1.111
Run Depth (d_{mrun})	0.000	0.000	0.000	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	0.000	0.000	0.000
Pool Depth (d_{mp})	1.290	1.130	1.420	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	1.593	1.395	1.753
Glide Depth (d_{mg})	0.000	0.000	0.000	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	0.000	0.000	0.000

Channel Materials

Catagories	Reach[b]	Riffle[c]	Bar
% Silt/Clay	10		
% Sand	0		
% Gravel	90		
% Cobble	0		
% Boulder	0		
% Bedrock	0		

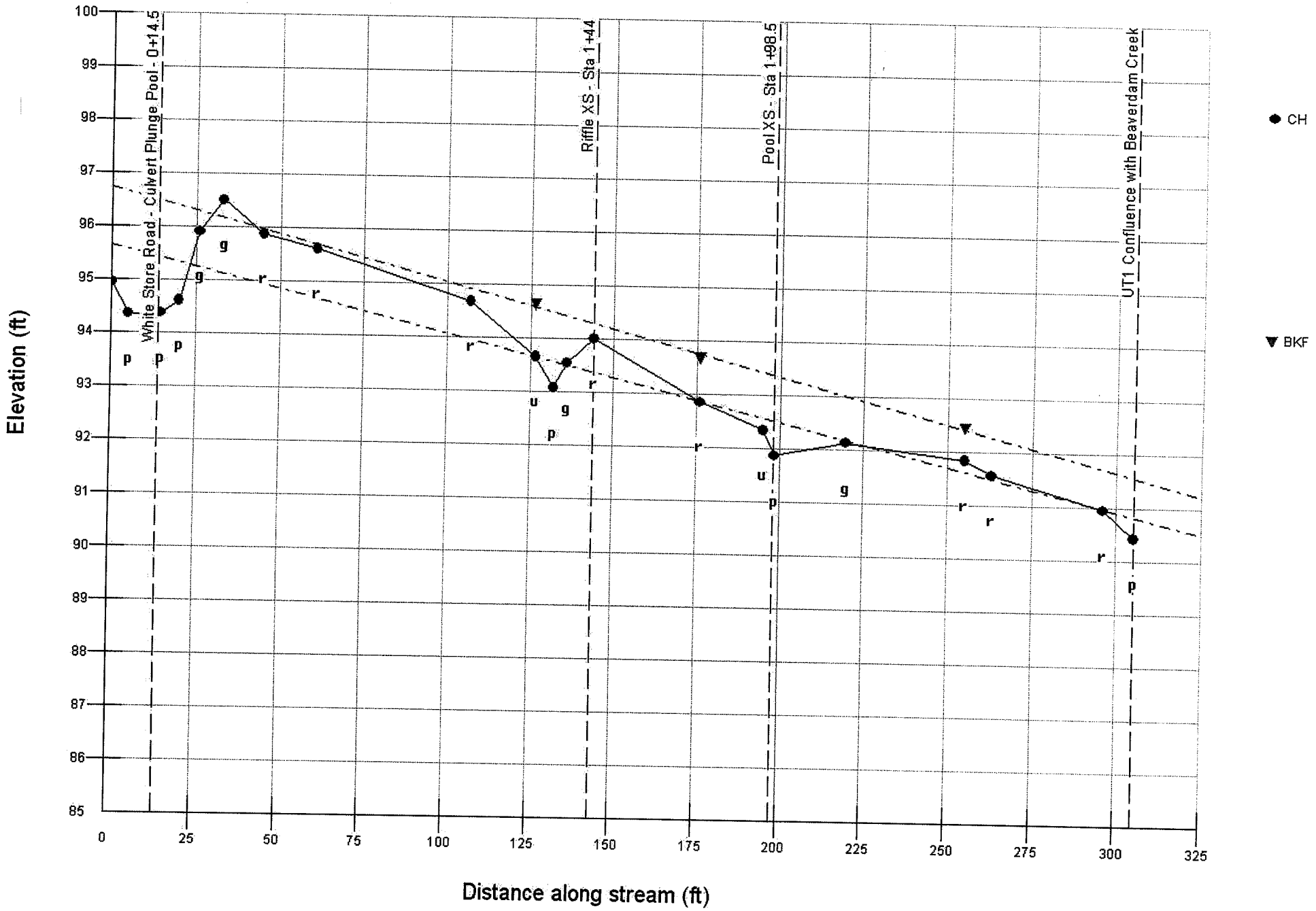
Indices	Reach[b]	Riffle[c]	Bar	
D16	4.15			mm
D35	6.98			mm
D50	9.5			mm
D84	17.15			mm
D95	22.6			mm
D100	45			mm

a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

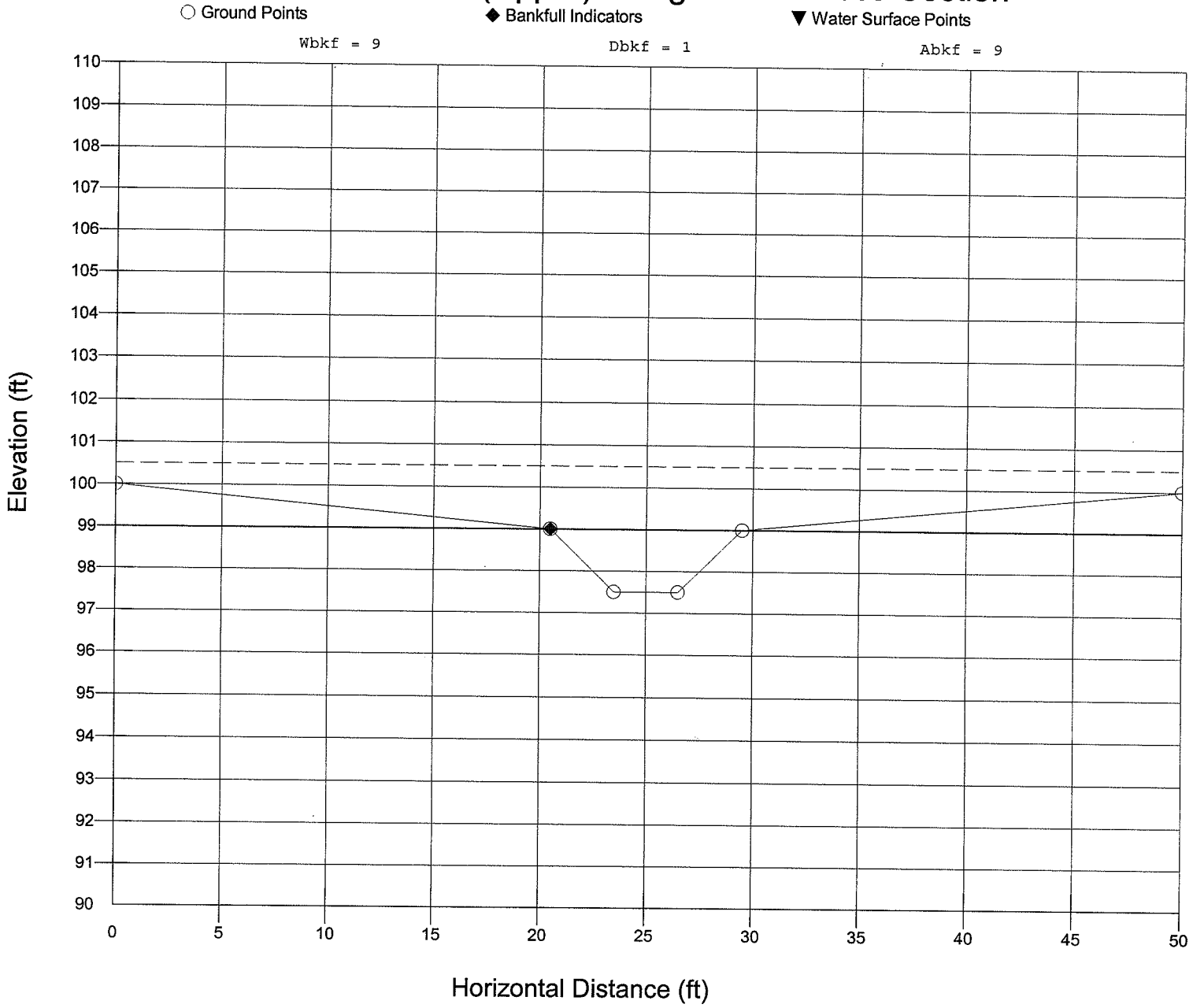
b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.

Beaverdam Creek (Upper) Impaired Mainstem Longitudinal Profile 07/17/07



Beaverdam Creek (Upper) Design Riffle Cross-Section



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
Cross Section Name: Riffle (Upper) Design XS
Survey Date: 09/21/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	0	100	
20.5	1	99	BKF
23.5	2.5	97.5	
26.5	2.5	97.5	
29.5	1	99	
50	0	100	

Cross Sectional Geometry

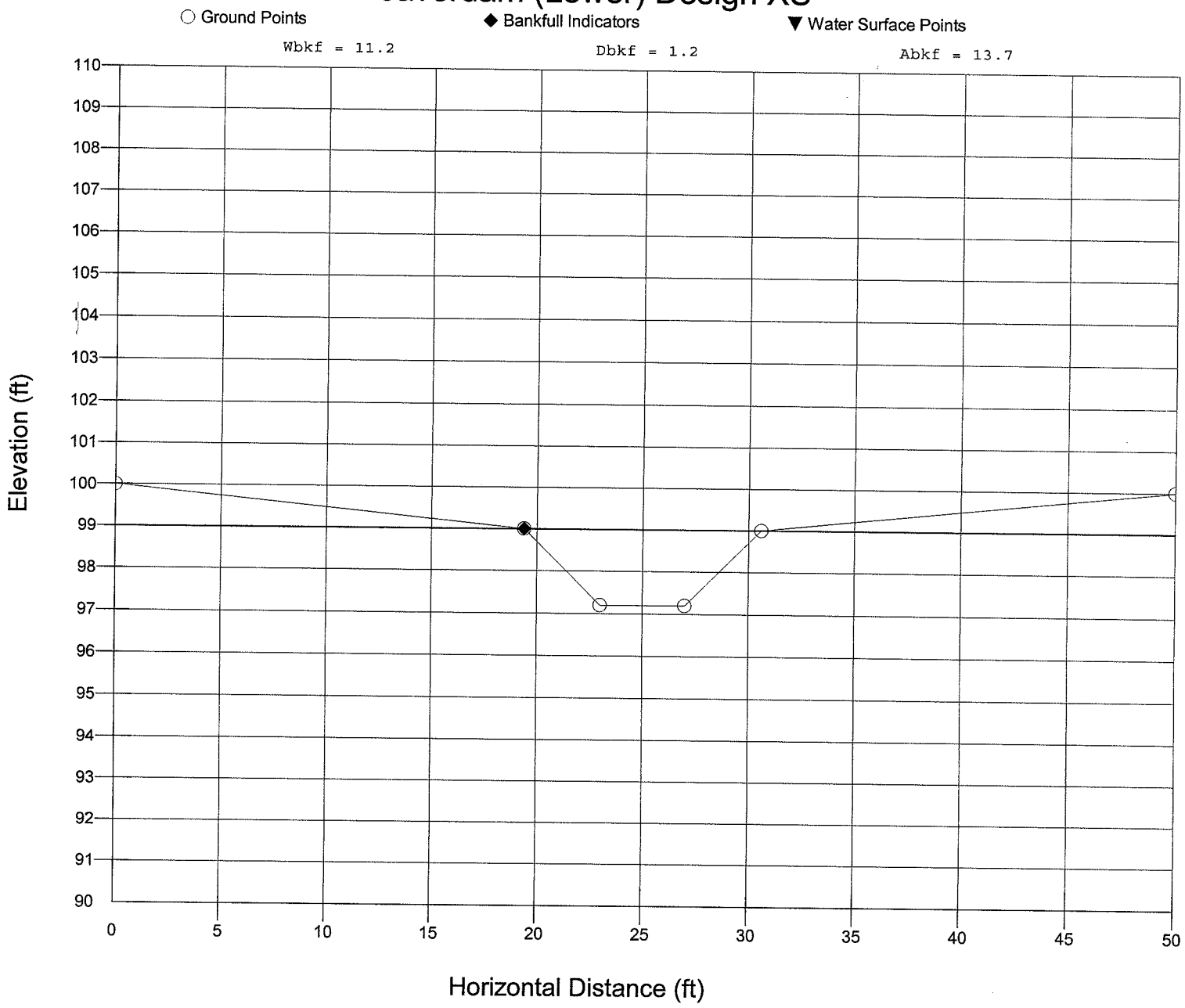
	Channel	Left	Right
Floodprone Elevation (ft)	100.5	100.5	100.5
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	9	4.5	4.5
Entrenchment Ratio	5.56	-----	-----
Mean Depth (ft)	1	1	1
Maximum Depth (ft)	1.5	1.5	1.5
Width/Depth Ratio	9	4.5	4.5
Bankfull Area (sq ft)	9	4.5	4.5
Wetted Perimeter (ft)	9.71	6.35	6.35
Hydraulic Radius (ft)	0.93	0.71	0.71
Begin BKF Station	20.5	20.5	25
End BKF Station	29.5	25	29.5

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.007	0	0
Shear Stress (lb/sq ft)	0.41		
Movable Particle (mm)	78.4		

Beaverdam (Lower) Design XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
Cross Section Name: Beaverdam (Lower) Design XS
Survey Date: 09/24/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	0	100	
19.4	1	99	BKF
23	2.8	97.2	
27	2.8	97.2	TW
30.6	1	99	RB
50	0	100	

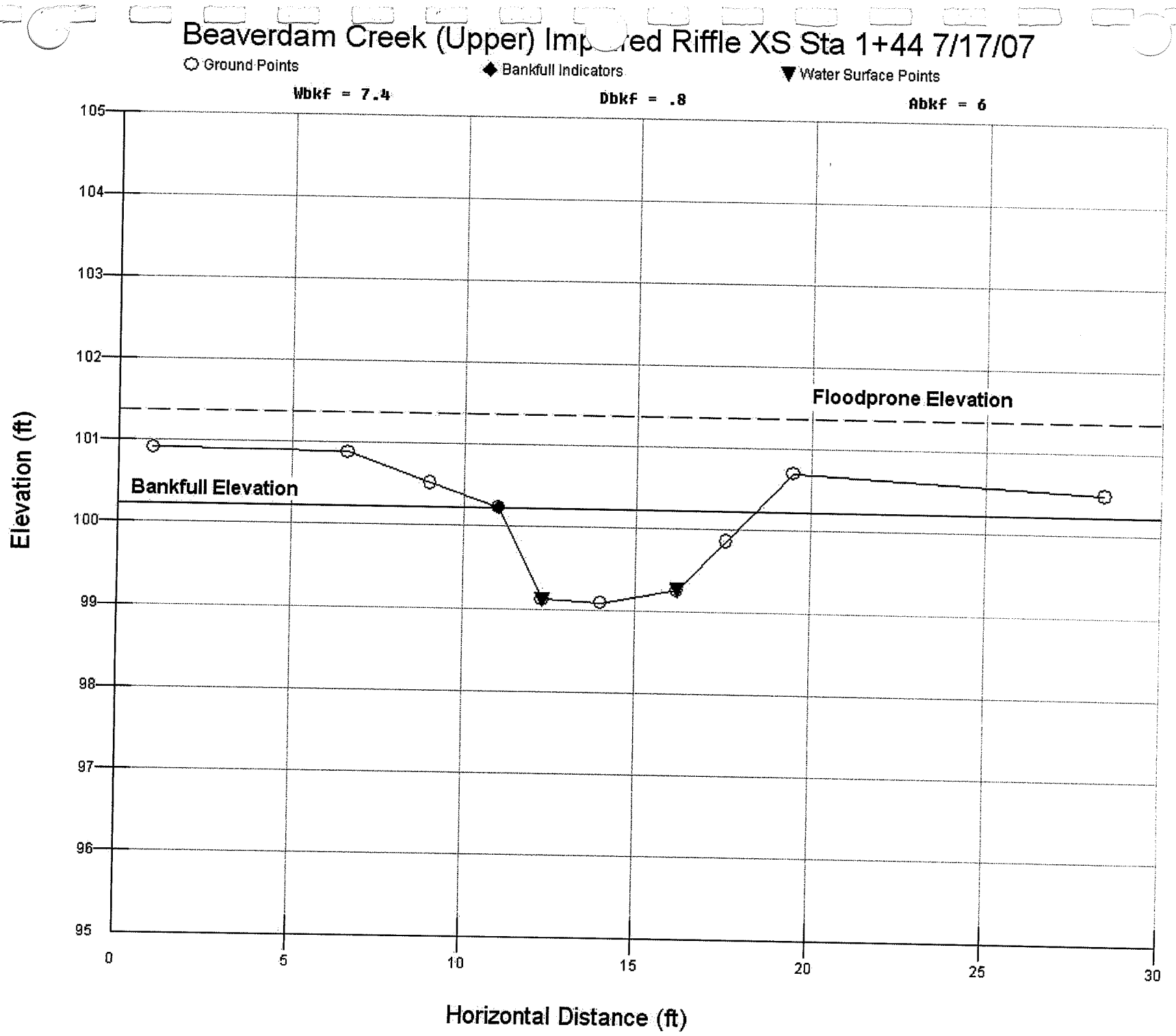
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	100.8	100.8	100.8
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	11.2	5	6.2
Entrenchment Ratio	4.46	-----	-----
Mean Depth (ft)	1.22	1.15	1.28
Maximum Depth (ft)	1.8	1.8	1.8
Width/Depth Ratio	9.18	4.35	4.84
Bankfull Area (sq ft)	13.68	5.76	7.92
Wetted Perimeter (ft)	12.05	7.22	8.42
Hydraulic Radius (ft)	1.14	0.8	0.94
Begin BKF Station	19.4	19.4	24.4
End BKF Station	30.6	24.4	30.6

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0261	0	0
Shear Stress (lb/sq ft)	1.86		
Movable Particle (mm)	239.6		


Beaverdam Creek (Upper) Impaired Riffle XS Sta 1+44 7/17/07
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 7.4
Dbkf = .8
Abkf = 6
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
Horizontal Distance (ft)
105
104
103
102
101
100
99
98
97
96
95
0
5
10
15
20
25
30

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
Cross Section Name: Pool XS - Sta 1+98.5
Survey Date: 07/17/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	5.63	94.37	
4	6.23	93.77	
5.7	5.99	94.01	
9	6.23	93.77	BKF
12	6.54	93.46	
14.3	6.98	93.02	LB
15	8	92	LEW
15.7	8.13	91.87	TW
18.4	8.1	91.9	REW
18.9	5.6	94.4	RB
20.8	5.32	94.68	FP
26.4	5.16	94.84	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	95.67	95.67	95.67
Bankfull Elevation (ft)	93.77	93.77	93.77
Floodprone Width (ft)	26.4	-----	-----
Bankfull Width (ft)	9.77	4.89	4.88
Entrenchment Ratio	2.7	-----	-----
Mean Depth (ft)	0.95	0.28	1.62
Maximum Depth (ft)	1.9	0.67	1.9
Width/Depth Ratio	10.28	17.46	3.01
Bankfull Area (sq ft)	9.29	1.39	7.9
Wetted Perimeter (ft)	11.91	5.61	7.64
Hydraulic Radius (ft)	0.78	0.25	1.03
Begin BKF Station	9	9	13.89
End BKF Station	18.77	13.89	18.77

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.01691	0	0
Shear Stress (lb/sq ft)	0.82		
Movable Particle (mm)	131.7		

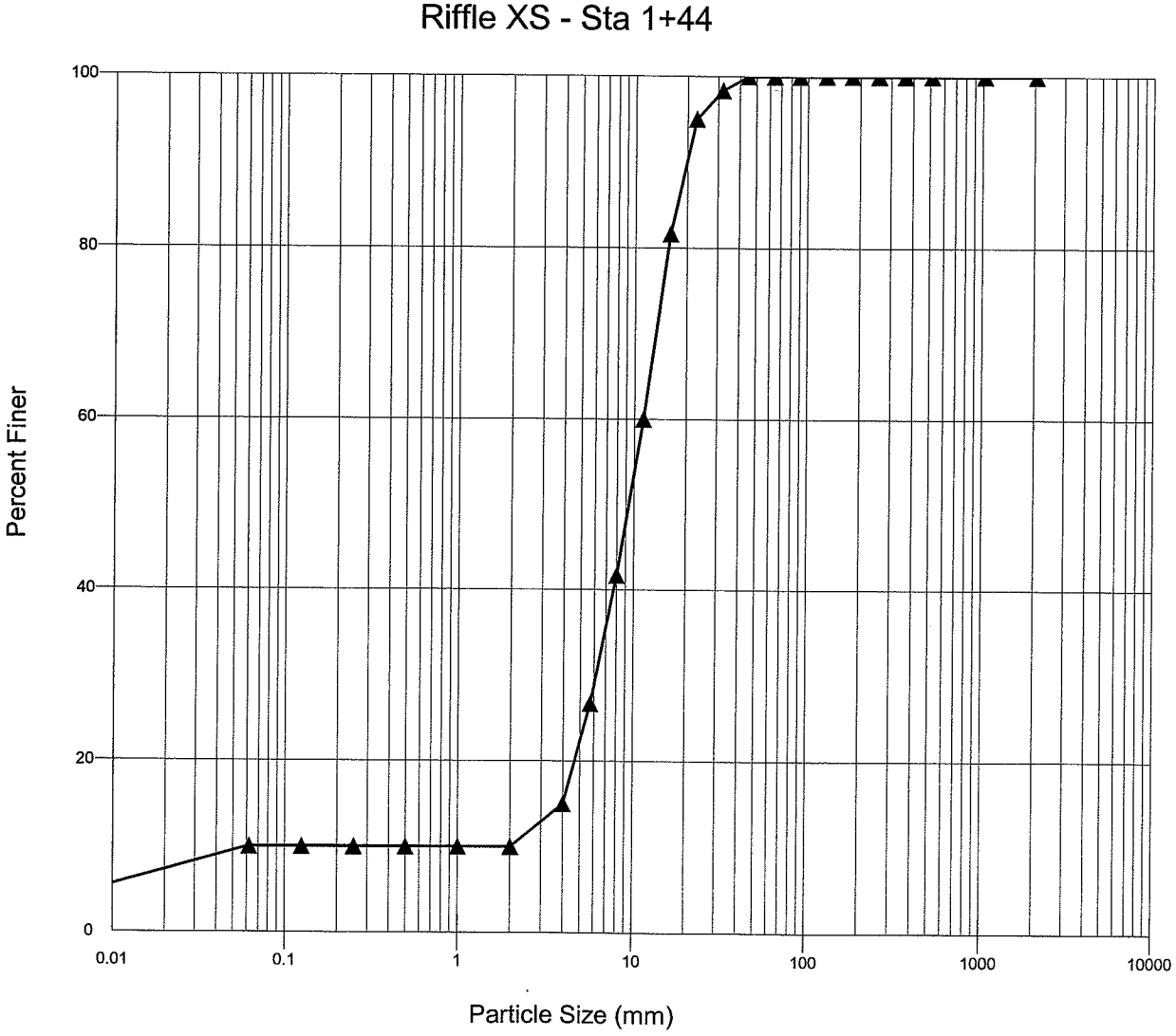
RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
Sample Name: Riffle XS - Sta 1+44
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	6	10.00	10.00
0.062 - 0.125	0	0.00	10.00
0.125 - 0.25	0	0.00	10.00
0.25 - 0.50	0	0.00	10.00
0.50 - 1.0	0	0.00	10.00
1.0 - 2.0	0	0.00	10.00
2.0 - 4.0	3	5.00	15.00
4.0 - 5.7	7	11.67	26.67
5.7 - 8.0	9	15.00	41.67
8.0 - 11.3	11	18.33	60.00
11.3 - 16.0	13	21.67	81.67
16.0 - 22.6	8	13.33	95.00
22.6 - 32.0	2	3.33	98.33
32 - 45	1	1.67	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	4.15
D35 (mm)	6.98
D50 (mm)	9.5
D84 (mm)	17.15
D95 (mm)	22.6
D100 (mm)	45
Silt/Clay (%)	10
Sand (%)	0
Gravel (%)	90
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 60.


Riffle XS - Sta 1+44
Percent Finer
100
80
60
40
20
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)

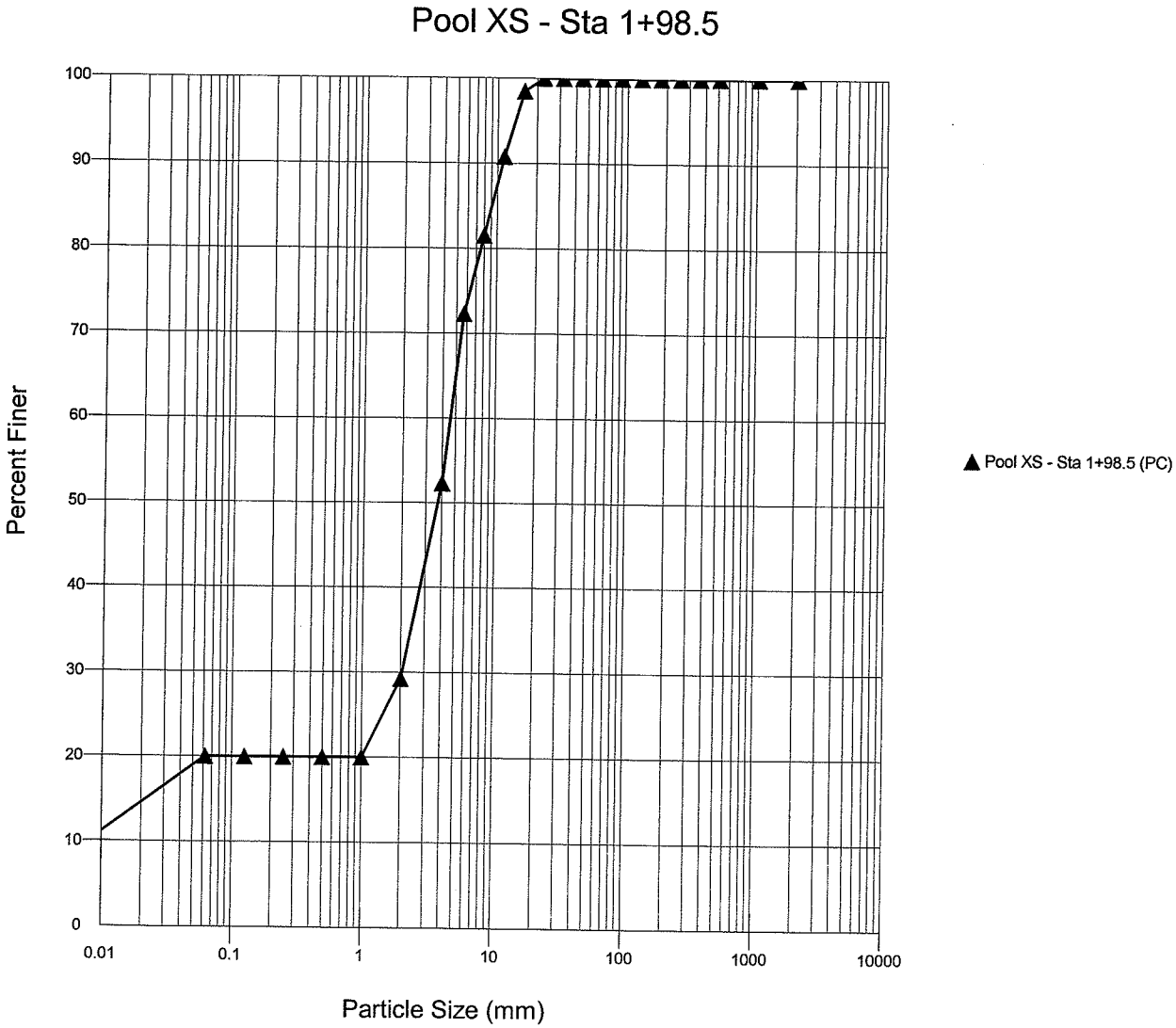
RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
Sample Name: Pool XS - Sta 1+98.5
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	13	20.00	20.00
0.062 - 0.125	0	0.00	20.00
0.125 - 0.25	0	0.00	20.00
0.25 - 0.50	0	0.00	20.00
0.50 - 1.0	0	0.00	20.00
1.0 - 2.0	6	9.23	29.23
2.0 - 4.0	15	23.08	52.31
4.0 - 5.7	13	20.00	72.31
5.7 - 8.0	6	9.23	81.54
8.0 - 11.3	6	9.23	90.77
11.3 - 16.0	5	7.69	98.46
16.0 - 22.6	1	1.54	100.00
22.6 - 32.0	0	0.00	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.05
D35 (mm)	2.5
D50 (mm)	3.8
D84 (mm)	8.88
D95 (mm)	13.89
D100 (mm)	22.6
Silt/Clay (%)	20
Sand (%)	9.23
Gravel (%)	70.77
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 65.


Pool XS - Sta 1+98.5
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)
Pool XS - Sta 1+98.5 (PC)

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem
BEHI Name: XS 1+98.5
Survey Date: 07/17/2007

Bankfull Height: 0.95 ft
Bank Height: 2.97 ft
Root Depth: 0.25 ft
Root Density: 3 %
Bank Angle: 90 Degrees
Surface Protection: 0 %

Bank Material Adjustment: Sand 10

Bank Stratification Adjustment: Yes 3

Erosion Loss Curve: Yellowstone

NBS Method #5: Ratio of Near-Bank Maximum Bankfull Depth to Mean Bankfull Depth

NB Max Depth: 1.9 ft Mean Depth: 0.95 ft
Ratio: 2.00

BEHI Numerical Rating: 59.6
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 2.00
NBS Adjective Rating: High
Total Bank Length: 386 ft
Estimated Sediment Loss: 21.23 Cu Yds per Year
Estimated Sediment Loss: 27.6 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Beaverdam Creek
Reach Name: Beaverdam Ck Impaired Mainstem

Table 1. Bank Identification Summary

Bank	Name
1	XS 1+98.5

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	59.6	Extreme	High	386	21.23	27.6
Totals				386	21.23	27.6

Total Reach Ln: 386 Total Loss (tons/yr) per ft of Reach: 0.0715

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Beaverdam Creek, Reach - UT1 (Lower) Impaired

Basin NAME: _____ Drainage AREA: 151.744 acre 0.2371 mi^2

Location: _____

Twp: _____ Rge: _____ Sec: _____ Qtr: _____ Lat: 34.9278 Long: 80.436

Observers: _____ Date: 9/20/2007

Bankfull WIDTH (W_{bkf}) — **11.22** Feet
WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.

Mean DEPTH (d_{bkf}) — **0.75** Feet
Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section.
($d_{bkf}=A_{bkf}/W_{bkf}$)

Bankfull Cross Section Area (A_{bkf}) — **8.42** $Feet^2$
AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.

WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) — **14.96** Ft/Ft
Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.

Maximum DEPTH (d_{mrif}) — **1.17** Feet
Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.

Flood-Prone Area WIDTH (W_{fpa}) — **30.7** Feet
The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or ($2 \times d_{mrif}$)

Entrenchment RATIO (ER) — **2.74** Ft/Ft
The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.

Channel Materials (Particle Size Index) D50 — **4.57** mm
The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.

Water Surface SLOPE (S) — **0.0058** Ft/Ft
Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.

Channel SINUOSITY (K) — **1.16**
Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).

Stream Type **C 4**

For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.

Reference Reach Summary Data Form

Channel Dimension

... and Reference Reach Summary Data

Mean Riffle Depth (d_{bkf})	1.11	feet	Mean Riffle Width (W_{bkf})	9.27	feet	Mean Riffle Area (A_{bkf})	8.42	$feet^2$
Mean Pool Depth (d_{bkfp})	0	feet	Mean Pool Width (W_{bkfp})	0	feet	Mean Pool Area (A_{bkfp})	0	$feet^2$
Ratio Mean Pool Depth/Mean Riffle Depth	0.000	d_{bkfp}/d_{bkf}	Ratio Pool Width/Riffle Width	0.000	W_{bkfp}/W_{bkf}	Ratio Pool Area/ Riffle Area	0.000	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mrif})	1.54	feet	Max Pool Depth (d_{mpool})	0	feet	Max riffle depth/Mean riffle depth	1.387	
Max pool depth/Mean riffle depth	0					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	3.59	ft/s				Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	30.14	cfs				Drainage Area	0.2371	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	0	0	0	feet	Meander Length Ratio (Lm/W_{bkf})	0.000	0.000	0.000
Radius of Curvature (Rc)	0	0	0	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	0.000	0.000	0.000
Belt Width (W_{blt})	0	0	0	feet	Meander Width Ratio (W_{blt}/W_{bkf})	0.000	0.000	0.000
Individual Pool Length	31.23	24.61	39.38	feet	Pool Length/Riffle Width	3.369	2.655	4.248
Pool to Pool Spacing	54.66	35.38	76.6	feet	Pool to Pool Spacing/Riffle Width	5.896	3.817	8.263

Channel Profile

Valley Slope (VS)	0.0067	ft/ft	Average Water Surface Slope (S)	0.0058	ft/ft	Sinuosity (VS/S)	1.16	
Stream Length (SL)	0	feet	Valley Length (VL)	0	feet	Sinuosity (SL/VL)	#####	
Low Bank Height (LBH)	start 2.06	feet	Max Riffle Depth	start 0	feet	Bank Height Ratio (LBH/Max Riffle Depth)	start #####	
	end 2.68	feet		end 0	feet		end #####	

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0151	0.0117	0.0185	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	2.605	2.024	3.184
Run Slope (S_{run})	0.0000	0.0000	0.0000	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	0.000	0.000	0.000
Pool Slope (S_p)	0.0008	0.0000	0.0013	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	0.129	0.000	0.222
Glide Slope (S_g)	0.0000	0.0000	0.0000	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	0.000	0.000	0.000

Feature Midpoint [a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	1.540	1.170	1.900	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	1.387	1.054	1.712
Run Depth (d_{mrun})	0.000	0.000	0.000	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	0.000	0.000	0.000
Pool Depth (d_{mp})	0.000	0.000	0.000	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	0.000	0.000	0.000
Glide Depth (d_{mg})	0.000	0.000	0.000	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	0.000	0.000	0.000

Channel Materials

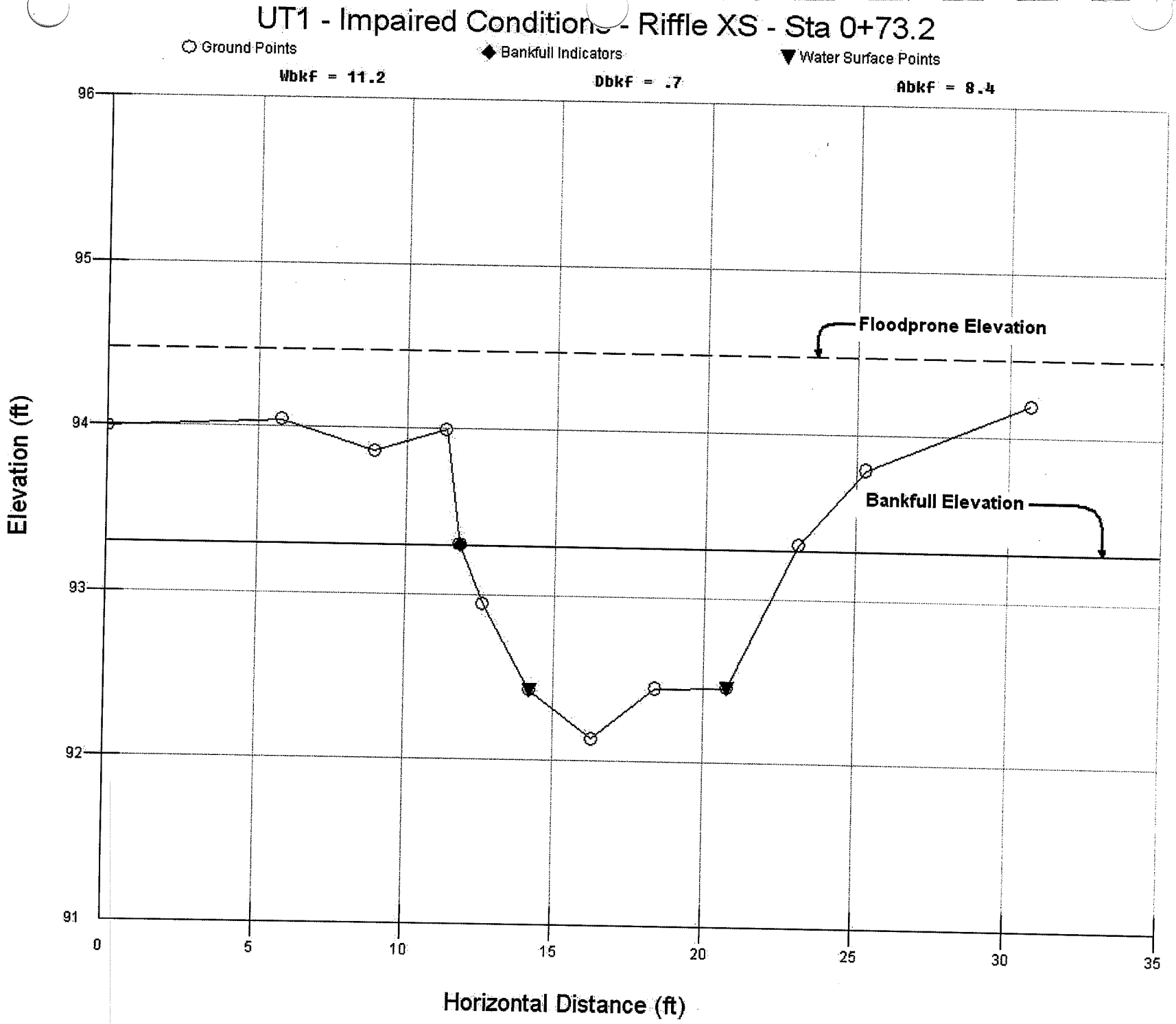
Catagories	Reach [b]	Riffle [c]	Bar
% Silt/Clay	26.27	17.74	
% Sand	3.39	0	
% Gravel	70.34	82.26	
% Cobble	0	0	
% Boulder	0	0	
% Bedrock	0	0	

Indices	Reach [b]	Riffle [c]	Bar	
D16	0.04	0.06		mm
D35	2.7	4.33		mm
D50	4.57	5.46		mm
D84	13.91	16.13		mm
D95	26.76	28.05		mm
D100	64	45		mm

a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.


UT1 - Impaired Conditions - Riffle XS - Sta 0+73.2
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 11.2
Dbkf = .7
Abkf = 8.4
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
96
95
94
93
92
91
0
5
10
15
20
25
30
35
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: Riffle XS - Sta 0+73.2
Survey Date: 07/17/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	6.01	93.99	FP
5.8	5.96	94.04	FP
8.9	6.14	93.86	FP
11.3	6.01	93.99	LB
11.8	6.7	93.3	BKF
12.6	7.06	92.94	
14.2	7.58	92.42	LEW
16.3	7.87	92.13	TW
18.4	7.56	92.44	SB
20.8	7.55	92.45	REW
23.1	6.67	93.33	RB
25.3	6.21	93.79	
30.7	5.81	94.19	FP

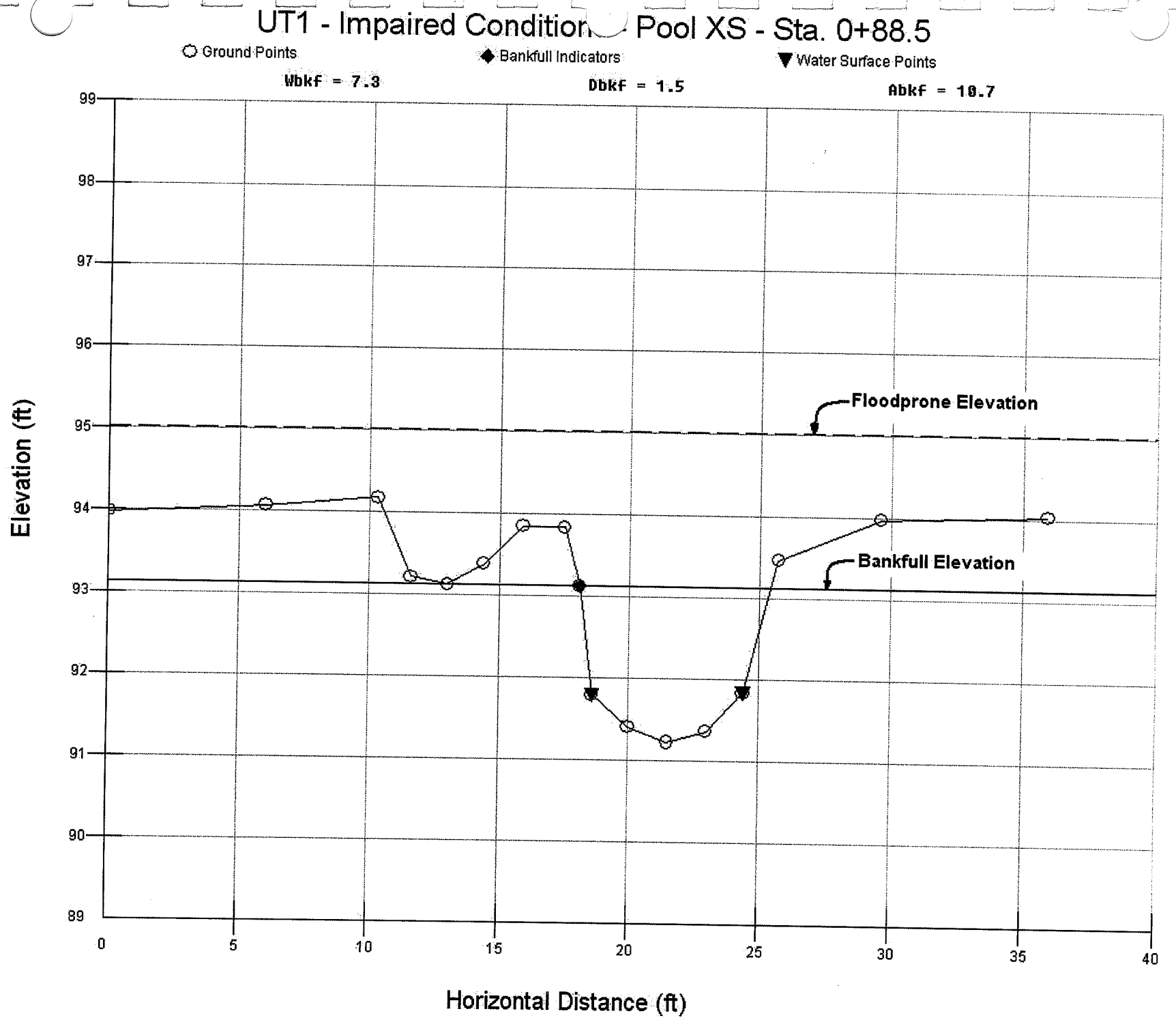
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	94.47	94.47	94.47
Bankfull Elevation (ft)	93.3	93.3	93.3
Floodprone Width (ft)	30.7	-----	-----
Bankfull Width (ft)	11.22	5.62	5.6
Entrenchment Ratio	2.74	-----	-----
Mean Depth (ft)	0.75	0.8	0.7
Maximum Depth (ft)	1.17	1.17	1
Width/Depth Ratio	14.96	7.03	8
Bankfull Area (sq ft)	8.42	4.51	3.91
Wetted Perimeter (ft)	11.58	6.82	6.77
Hydraulic Radius (ft)	0.73	0.66	0.58
Begin BKF Station	11.8	11.8	17.42
End BKF Station	23.02	17.42	23.02

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0058	0	0
Shear Stress (lb/sq ft)	0.26		
Movable Particle (mm)	57.1		


UT1 - Impaired Condition - Pool XS - Sta. 0+88.5
Ground Points
Bankfull Indicators
Water Surface Points
WbkF = 7.3
DbkF = 1.5
AbkF = 10.7
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
Horizontal Distance (ft)
99
98
97
96
95
94
93
92
91
90
89
0
5
10
15
20
25
30
35
40

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: Pool XS - Sta 0+88.5
Survey Date: 07/17/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	6.02	93.98	FP
6	5.93	94.07	FP
10.3	5.82	94.18	FP
11.6	6.79	93.21	FP CH
13	6.88	93.12	FP CH TW
14.4	6.62	93.38	FP CH
15.9	6.15	93.85	FP
17.5	6.16	93.84	LB
18.1	6.88	93.12	BKF
18.6	8.21	91.79	LEW
20	8.6	91.4	SB
21.5	8.78	91.22	SB
23	8.64	91.36	TW
24.4	8.17	91.83	REW
25.7	6.53	93.47	RB
29.6	6.02	93.98	FP
35.9	5.96	94.04	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	95.02	95.02	95.02
Bankfull Elevation (ft)	93.12	93.12	93.12
Floodprone Width (ft)	35.9	-----	-----
Bankfull Width (ft)	7.32	3.66	3.66
Entrenchment Ratio	4.9	-----	-----
Mean Depth (ft)	1.46	1.55	1.38
Maximum Depth (ft)	1.9	1.9	1.88
Width/Depth Ratio	5.01	2.36	2.65
Bankfull Area (sq ft)	10.72	5.67	5.05
Wetted Perimeter (ft)	9.01	6.52	6.24
Hydraulic Radius (ft)	1.19	0.87	0.81
Begin BKF Station	18.1	18.1	21.76
End BKF Station	25.42	21.76	25.42

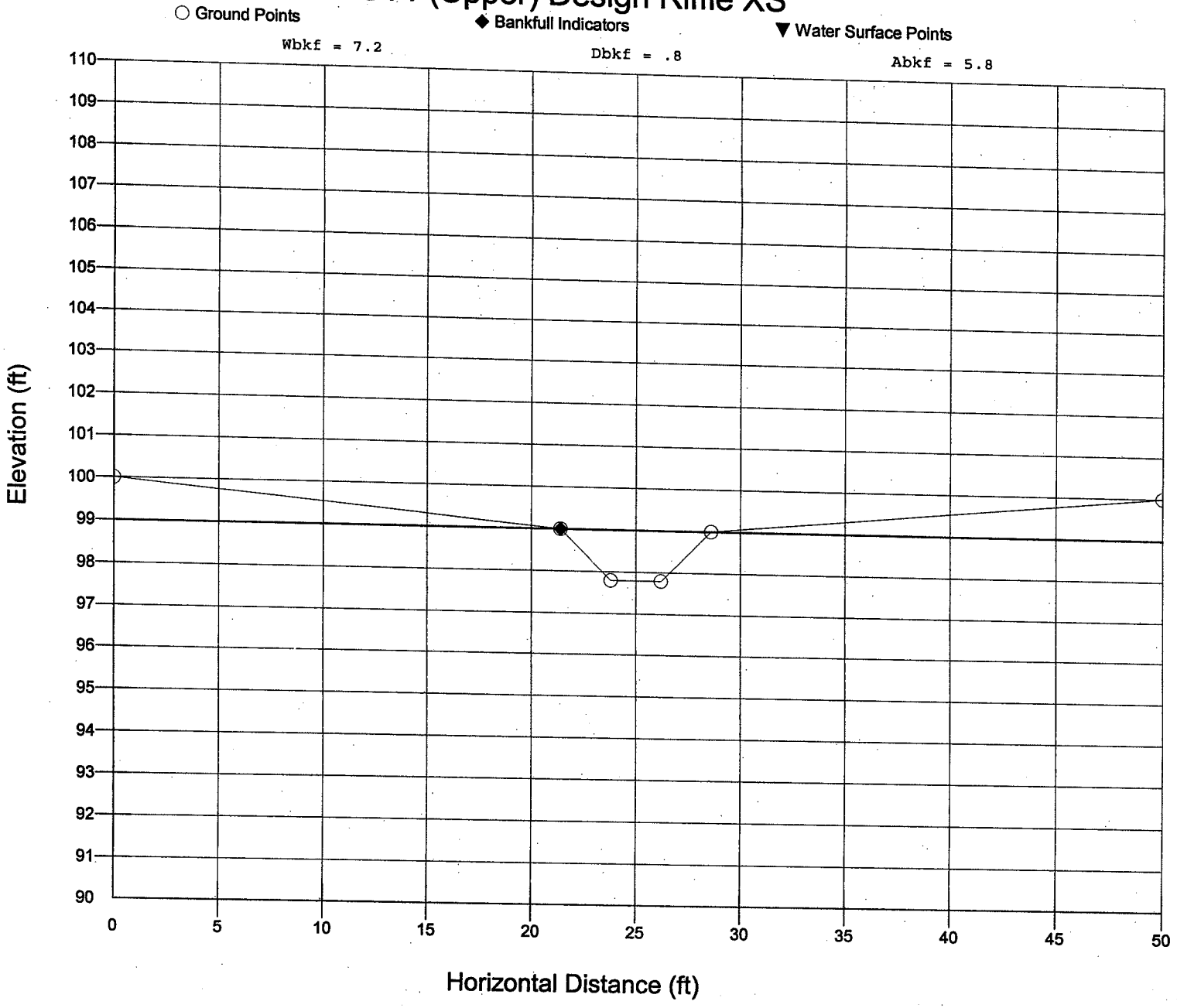
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0058	0	0
Shear Stress (lb/sq ft)	0.43		

Movable Particle (mm)	81.8

UT1 (Upper) Design Riffle XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: UT1 (Upper) Design Riffle XS
Survey Date: 09/24/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	0	100	
21.4	1	99	BKF
23.8	2.2	97.8	
26.2	2.2	97.8	TW
28.6	1	99	RB
50	0	100	

Cross Sectional Geometry

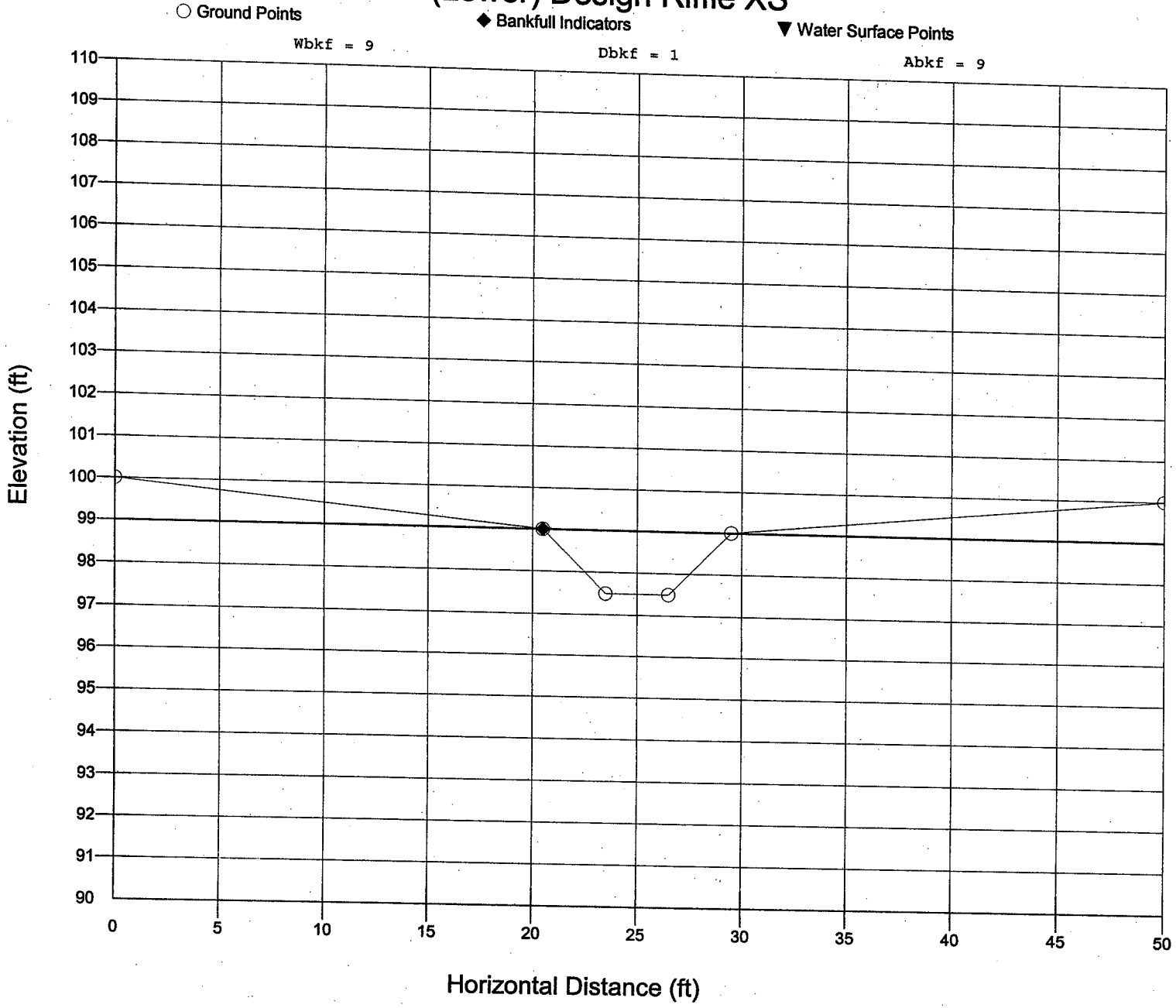
	Channel	Left	Right
Floodprone Elevation (ft)	100.2	100.2	100.2
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	7.2	3.6	3.6
Entrenchment Ratio	6.94	-----	-----
Mean Depth (ft)	0.8	0.8	0.8
Maximum Depth (ft)	1.2	1.2	1.2
Width/Depth Ratio	9	4.5	4.5
Bankfull Area (sq ft)	5.76	2.88	2.88
Wetted Perimeter (ft)	7.77	5.08	5.08
Hydraulic Radius (ft)	0.74	0.57	0.57
Begin BKF Station	21.4	21.4	25
End BKF Station	28.6	25	28.6

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.004	0	0
Shear Stress (lb/sq ft)	0.18		
Movable Particle (mm)	43.9		

UT1 (Lower) Design Riffle XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: UT1 (Lower) Design Riffle XS
Survey Date: 09/24/07

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	100	
20.5	1	99	BKF
23.5	2.5	97.5	
26.5	2.5	97.5	
29.5	1	99	
50	0	100	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	100.5	100.5	100.5
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	9	4.5	4.5
Entrenchment Ratio	5.56	-----	-----
Mean Depth (ft)	1	1	1
Maximum Depth (ft)	1.5	1.5	1.5
Width/Depth Ratio	9	4.5	4.5
Bankfull Area (sq ft)	9	4.5	4.5
Wetted Perimeter (ft)	9.71	6.35	6.35
Hydraulic Radius (ft)	0.93	0.71	0.71
Begin BKF Station	20.5	20.5	25
End BKF Station	29.5	25	29.5

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0047	0	0
Shear Stress (lb/sq ft)	0.27		
Movable Particle (mm)	58.5		

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: Pool XS - Sta 0+88.5
Survey Date: 07/17/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	6.02	93.98	FP
6	5.93	94.07	FP
10.3	5.82	94.18	FP
11.6	6.79	93.21	FP CH
13	6.88	93.12	FP CH TW
14.4	6.62	93.38	FP CH
15.9	6.15	93.85	FP
17.5	6.16	93.84	LB
18.1	6.88	93.12	BKF
18.6	8.21	91.79	LEW
20	8.6	91.4	SB
21.5	8.78	91.22	SB
23	8.64	91.36	TW
24.4	8.17	91.83	REW
25.7	6.53	93.47	RB
29.6	6.02	93.98	FP
35.9	5.96	94.04	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	95.02	95.02	95.02
Bankfull Elevation (ft)	93.12	93.12	93.12
Floodprone Width (ft)	35.9	-----	-----
Bankfull Width (ft)	7.32	3.66	3.66
Entrenchment Ratio	4.9	-----	-----
Mean Depth (ft)	1.46	1.55	1.38
Maximum Depth (ft)	1.9	1.9	1.88
Width/Depth Ratio	5.01	2.36	2.65
Bankfull Area (sq ft)	10.72	5.67	5.05
Wetted Perimeter (ft)	9.01	6.52	6.24
Hydraulic Radius (ft)	1.19	0.87	0.81
Begin BKF Station	18.1	18.1	21.76
End BKF Station	25.42	21.76	25.42

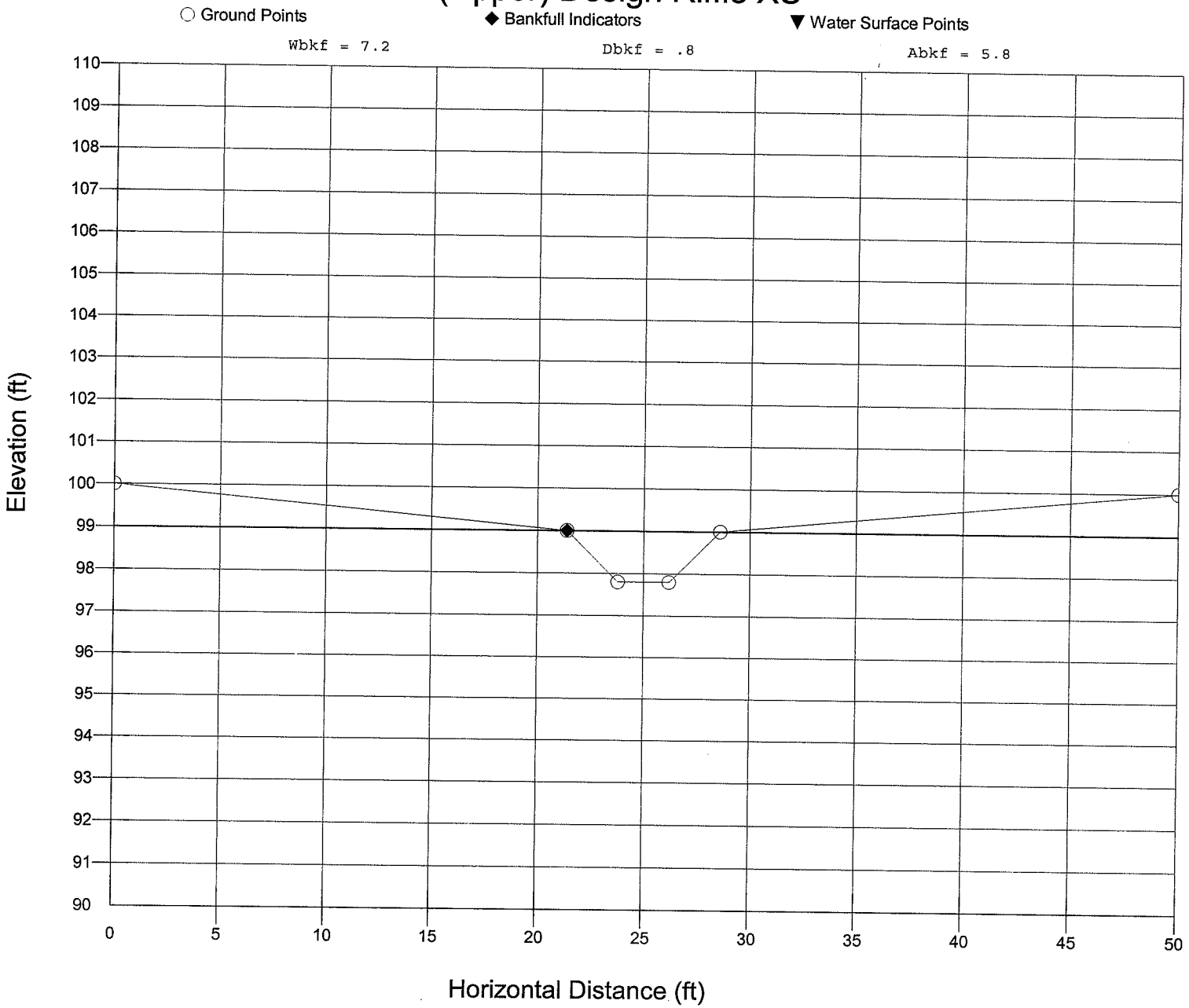
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0058	0	0
Shear Stress (lb/sq ft)	0.43		

Movable Particle (mm)	81.8

UT1 (Upper) Design Riffle XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: UT1 (Upper) Design Riffle XS
Survey Date: 09/24/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	0	100	
21.4	1	99	BKF
23.8	2.2	97.8	
26.2	2.2	97.8	TW
28.6	1	99	RB
50	0	100	

Cross Sectional Geometry

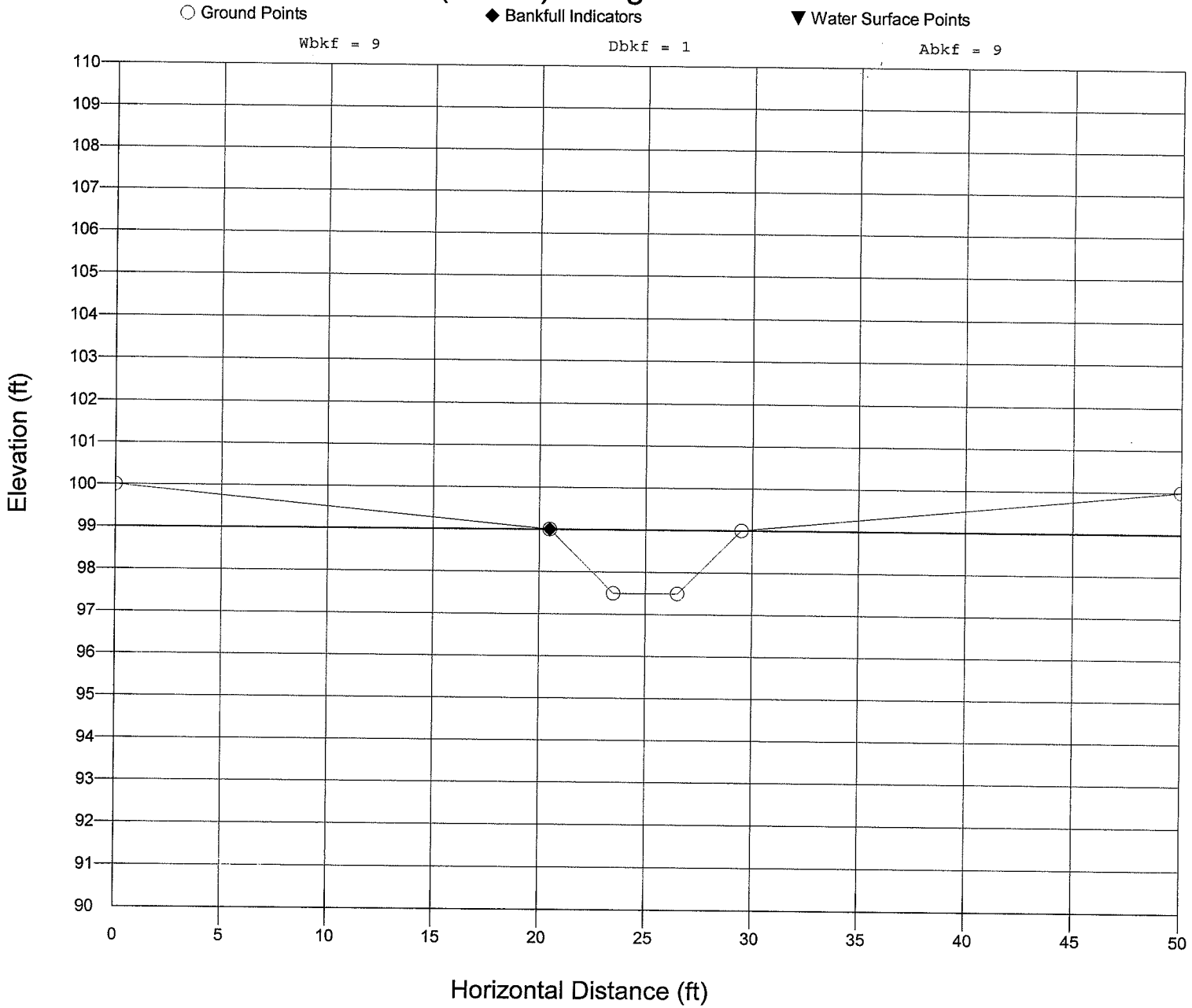
	Channel	Left	Right
Floodprone Elevation (ft)	100.2	100.2	100.2
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	7.2	3.6	3.6
Entrenchment Ratio	6.94	-----	-----
Mean Depth (ft)	0.8	0.8	0.8
Maximum Depth (ft)	1.2	1.2	1.2
Width/Depth Ratio	9	4.5	4.5
Bankfull Area (sq ft)	5.76	2.88	2.88
Wetted Perimeter (ft)	7.77	5.08	5.08
Hydraulic Radius (ft)	0.74	0.57	0.57
Begin BKF Station	21.4	21.4	25
End BKF Station	28.6	25	28.6

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.004	0	0
Shear Stress (lb/sq ft)	0.18		
Movable Particle (mm)	43.9		

UT1 (Lower) Design Riffle XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Cross Section Name: UT1 (Lower) Design Riffle XS
Survey Date: 09/24/07

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	100	
20.5	1	99	BKF
23.5	2.5	97.5	
26.5	2.5	97.5	
29.5	1	99	
50	0	100	

Cross Sectional Geometry

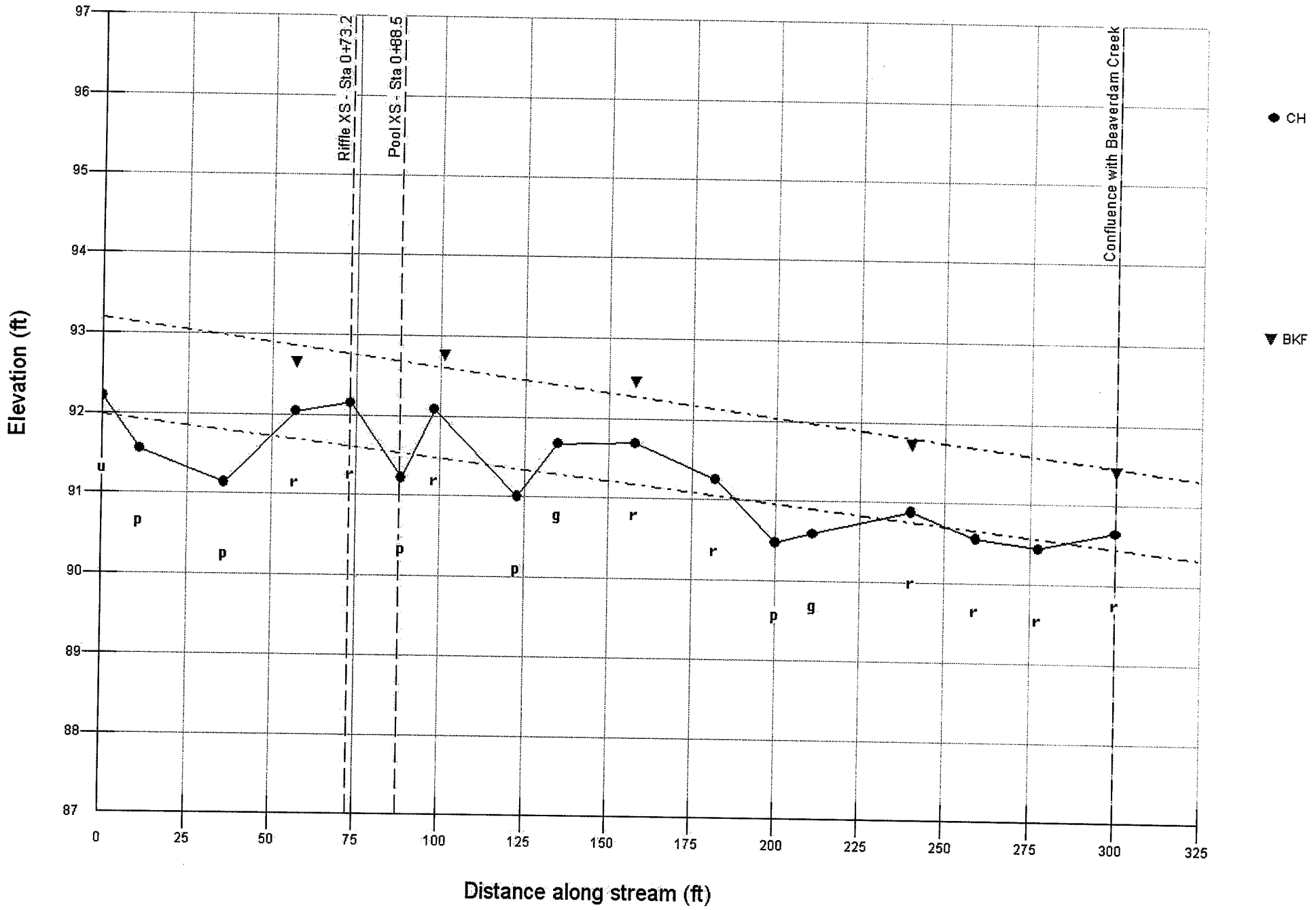
	Channel	Left	Right
Floodprone Elevation (ft)	100.5	100.5	100.5
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	9	4.5	4.5
Entrenchment Ratio	5.56	-----	-----
Mean Depth (ft)	1	1	1
Maximum Depth (ft)	1.5	1.5	1.5
Width/Depth Ratio	9	4.5	4.5
Bankfull Area (sq ft)	9	4.5	4.5
Wetted Perimeter (ft)	9.71	6.35	6.35
Hydraulic Radius (ft)	0.93	0.71	0.71
Begin BKF Station	20.5	20.5	25
End BKF Station	29.5	25	29.5

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0047	0	0
Shear Stress (lb/sq ft)	0.27		
Movable Particle (mm)	58.5		

Beaverdam Creek - UT1 (Lower) Impaired Reach - 07/17/07



RIVERMORPH PROFILE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Profile Name: UT1 Impaired Reach
Survey Date: 07/24/07

Survey Data

DIST	CH	WS	BKF	P1	P2	P3	P4
0	92.21						
11	91.55						
36	91.14						
57	92.04		92.65				
73.2	92.15						
88.5	91.22						
98.2	92.08						
101			92.76				
123	91						
135	91.67						
158	91.69		92.46				
182	91.25						
200	90.47						
211	90.59						
240	90.88		91.72				
259	90.55						
277.5	90.44						
300	90.64		91.42				

Cross Section / Bank Profile Locations

Name	Type	Profile Station
Riffle XS - Sta 0+73.2	Riffle XS	73.2
Pool XS - Sta 0+88.5	Riffle XS	88.5
UT1 (Upper) Design Riffle XS	Riffle XS	0
UT1 (Lower) Design Riffle XS	Riffle XS	0
Confluence with Beaverdam Creek	Other XS	300

Measurements from Graph

Bankfull Slope: 0.0058

Variable	Min	Avg	Max
S riffle	0.01174	0.01511	0.01847
S pool	0	0.00075	0.00129
S run	0	0	0
S glide	0	0	0
P - P	35.38	54.66	76.6
P length	24.61	31.23	39.38
Dmax riffle	0.89	1.02	1.15
Dmax pool	1.46	1.59	1.84
Dmax run	0	0	0
Dmax glide	0	0	0
Low Bank Ht	2.06	2.37	2.68

Length and depth measurements in feet, slopes in ft/ft.

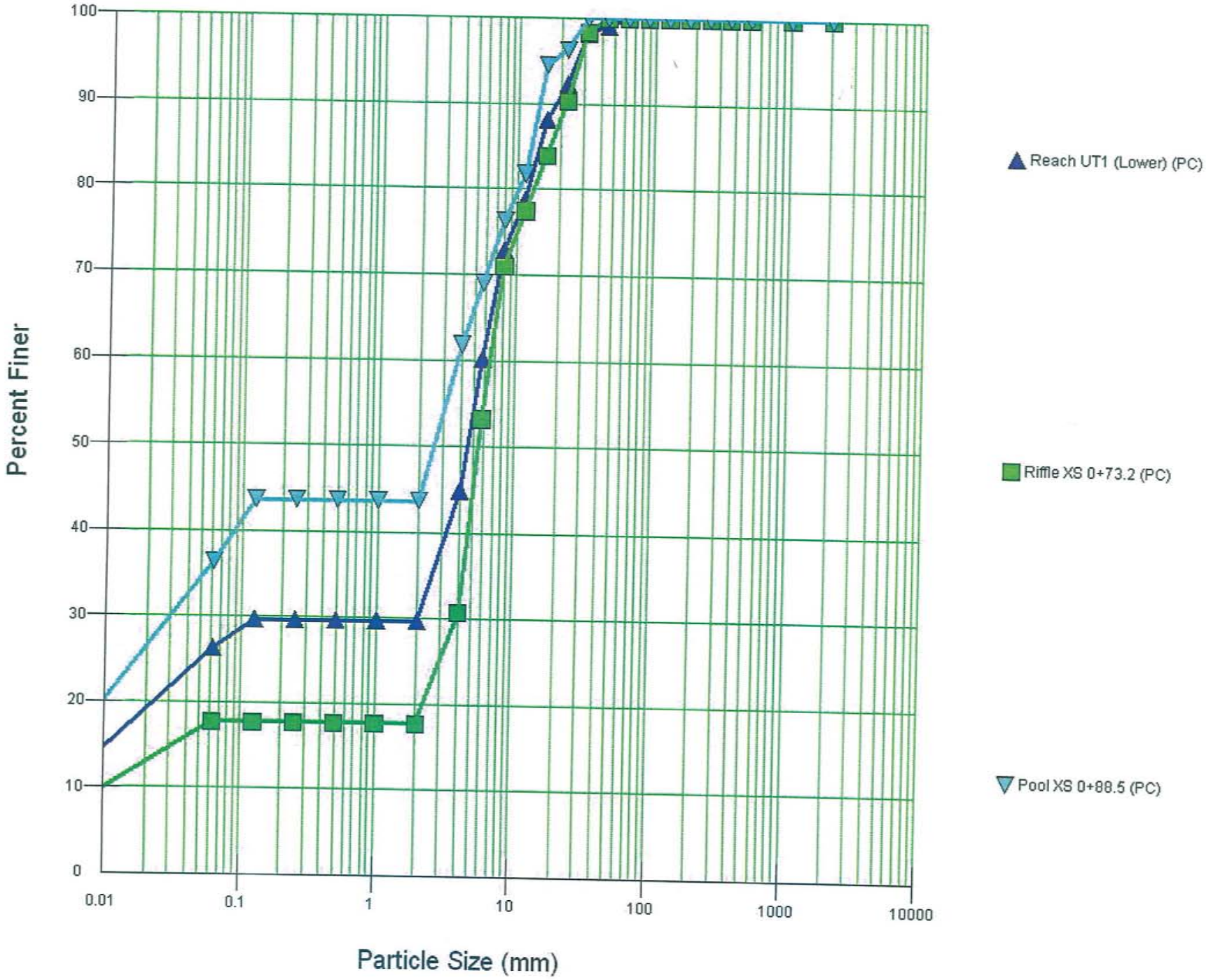
RIVERMORPH PROFILE SUMMARY

Notes

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Profile Name: UT1 Impaired Reach
Survey Date: 07/24/07

DIST	Note
0	U
11	P
36	P
57	R
73.2	Riffle @ XS
88.5	Pool @ XS
98.2	R
101	BKF
123	P
135	G
158	R
182	R
200	P
211	G
240	R
259	R
277.5	R
300	Riffle @ Conf w BDC

Reach Particle Distribution - UT1 (Lower) Altered Conditions 7/17/07



RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Sample Name: Riffle XS 0+73.2
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	11	17.74	17.74
0.062 - 0.125	0	0.00	17.74
0.125 - 0.25	0	0.00	17.74
0.25 - 0.50	0	0.00	17.74
0.50 - 1.0	0	0.00	17.74
1.0 - 2.0	0	0.00	17.74
2.0 - 4.0	8	12.90	30.65
4.0 - 5.7	14	22.58	53.23
5.7 - 8.0	11	17.74	70.97
8.0 - 11.3	4	6.45	77.42
11.3 - 16.0	4	6.45	83.87
16.0 - 22.6	4	6.45	90.32
22.6 - 32.0	5	8.06	98.39
32 - 45	1	1.61	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.06
D35 (mm)	4.33
D50 (mm)	5.46
D84 (mm)	16.13
D95 (mm)	28.05
D100 (mm)	45
Silt/Clay (%)	17.74
Sand (%)	0
Gravel (%)	82.26
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 62.

RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Sample Name: Pool XS 0+88.5
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	20	36.36	36.36
0.062 - 0.125	4	7.27	43.64
0.125 - 0.25	0	0.00	43.64
0.25 - 0.50	0	0.00	43.64
0.50 - 1.0	0	0.00	43.64
1.0 - 2.0	0	0.00	43.64
2.0 - 4.0	10	18.18	61.82
4.0 - 5.7	4	7.27	69.09
5.7 - 8.0	4	7.27	76.36
8.0 - 11.3	3	5.45	81.82
11.3 - 16.0	7	12.73	94.55
16.0 - 22.6	1	1.82	96.36
22.6 - 32.0	2	3.64	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.03
D35 (mm)	0.06
D50 (mm)	2.7
D84 (mm)	12.1
D95 (mm)	17.64
D100 (mm)	32
Silt/Clay (%)	36.36
Sand (%)	7.28
Gravel (%)	56.36
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 55 (need at least 60).

RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
Sample Name: Reach UT1 (Lower)
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	31	26.27	26.27
0.062 - 0.125	4	3.39	29.66
0.125 - 0.25	0	0.00	29.66
0.25 - 0.50	0	0.00	29.66
0.50 - 1.0	0	0.00	29.66
1.0 - 2.0	0	0.00	29.66
2.0 - 4.0	18	15.25	44.92
4.0 - 5.7	18	15.25	60.17
5.7 - 8.0	15	12.71	72.88
8.0 - 11.3	7	5.93	78.81
11.3 - 16.0	11	9.32	88.14
16.0 - 22.6	5	4.24	92.37
22.6 - 32.0	7	5.93	98.31
32 - 45	1	0.85	99.15
45 - 64	1	0.85	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.04
D35 (mm)	2.7
D50 (mm)	4.57
D84 (mm)	13.91
D95 (mm)	26.76
D100 (mm)	64
Silt/Clay (%)	26.27
Sand (%)	3.39
Gravel (%)	70.34
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 118.

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired
BEHI Name: XS 0+88.5
Survey Date: 07/17/2007

Bankfull Height: 1.46 ft
Bank Height: 2.68 ft
Root Depth: 0.25 ft
Root Density: 3 %
Bank Angle: 90 Degrees
Surface Protection: 0 %

Bank Material Adjustment: Sand 10

Bank Stratification Adjustment: Yes 5

Erosion Loss Curve: Yellowstone

NBS Method #5: Ratio of Near-Bank Maximum Bankfull Depth to Mean Bankfull Depth

NB Max Depth: 1.9 ft Mean Depth: 1.46 ft
Ratio: 1.30

BEHI Numerical Rating: 58.6
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 1.30
NBS Adjective Rating: Low
Total Bank Length: 1351 ft
Estimated Sediment Loss: 67.05 Cu Yds per Year
Estimated Sediment Loss: 87.17 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Beaverdam Creek
Reach Name: UT1 (Lower) Impaired

Table 1. Bank Identification Summary

Bank	Name
1	XS 0+88.5

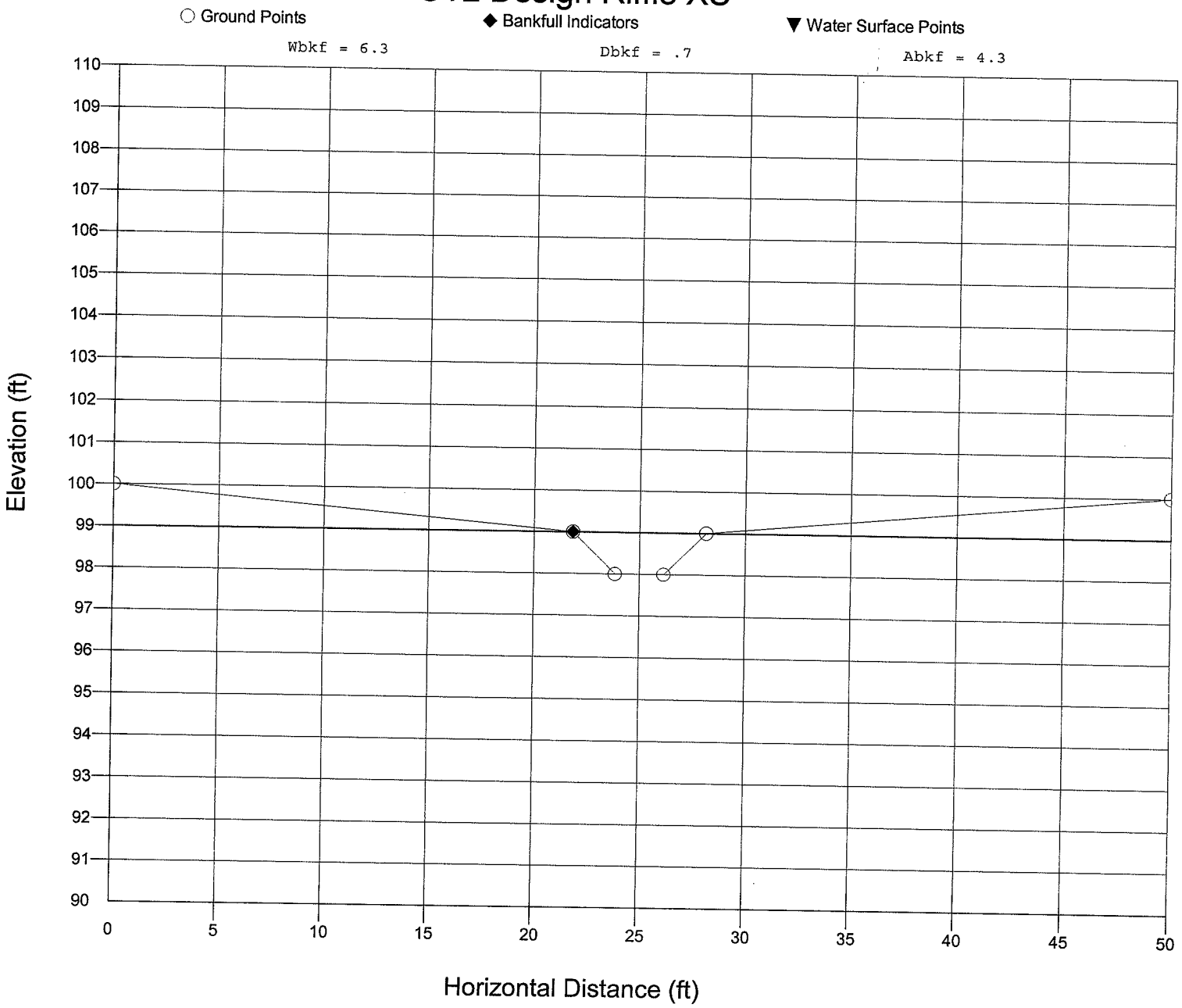
Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	58.6	Extreme	Low	1351	67.05	87.17
Totals				1351	67.05	87.17

Total Reach Ln: 1351 Total Loss (tons/yr) per ft of Reach: 0.0645

Movable Particle (mm)	130.9

UT2 Design Riffle XS



RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Cross Section Name: UT2 Design Riffle XS
Survey Date: 09/25/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	0	100	
21.85	1	99	BKF
23.85	2	98	
26.15	2	98	TW
28.15	1	99	RB
50	0	100	

Cross Sectional Geometry

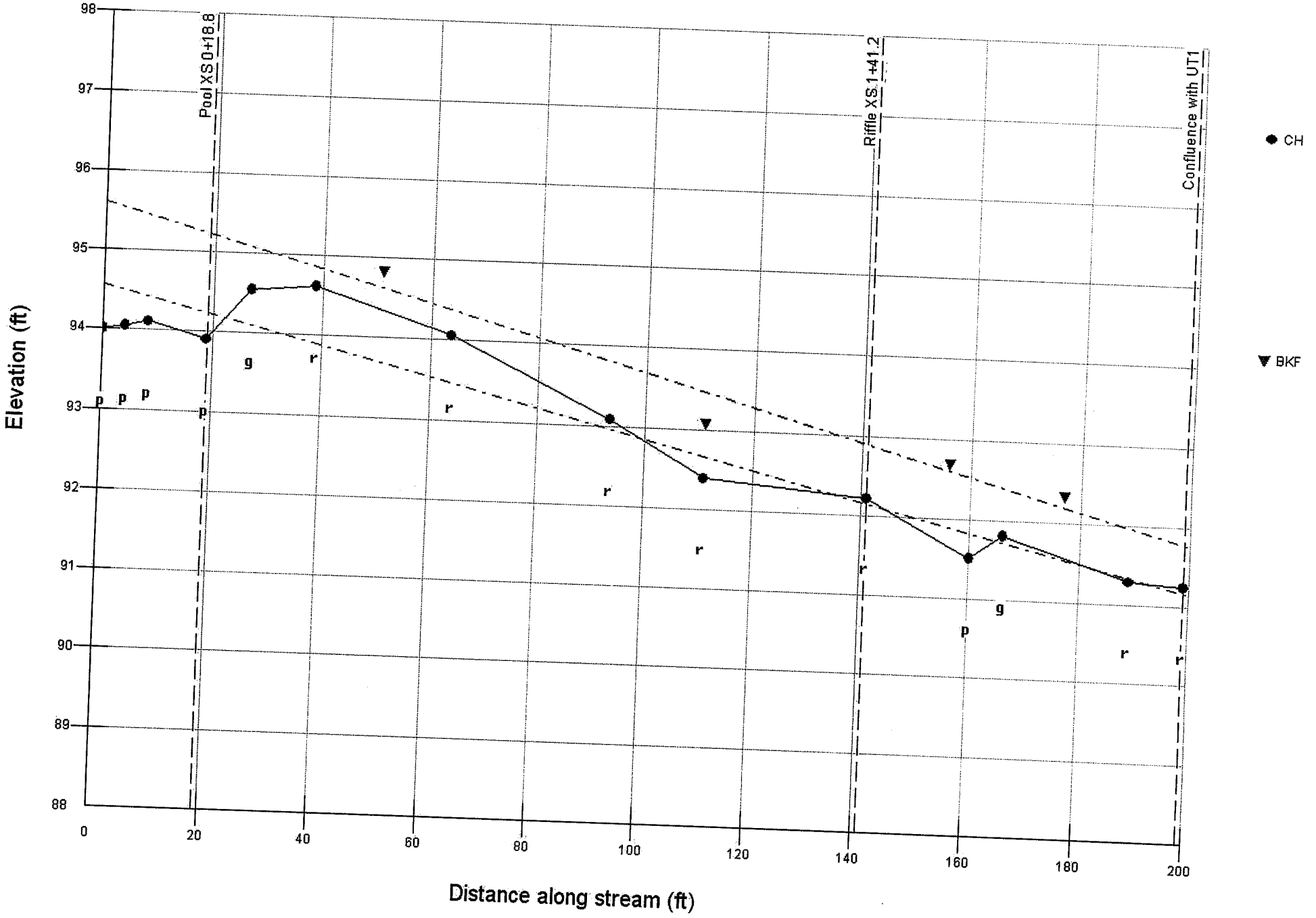
	Channel	Left	Right
Floodprone Elevation (ft)	100	100	100
Bankfull Elevation (ft)	99	99	99
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	6.3	3.15	3.15
Entrenchment Ratio	7.94	-----	-----
Mean Depth (ft)	0.68	0.68	0.68
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	9.26	4.63	4.63
Bankfull Area (sq ft)	4.3	2.15	2.15
Wetted Perimeter (ft)	6.77	4.39	4.39
Hydraulic Radius (ft)	0.63	0.49	0.49
Begin BKF Station	21.85	21.85	25
End BKF Station	28.15	25	28.15

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0054	0	0
Shear Stress (lb/sq ft)	0.21		
Movable Particle (mm)	48.6		

UT2 Impaired Conditions Longitudinal Profile - 7/17/07



River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Profile Name: UT2 Impaired Conditions Profile
Survey Date: 09/20/07

Survey Data

DIST	CH	WS	BKF	P1	P2	P3	P4
0	94						
4	94.04						
8.2	94.1						
18.8	93.9						
26.9	94.54						
38.7	94.61						
51			94.82				
63.8	94.05						
93.5	93.08						
111	92.39		93.07				
141	92.22						
156			92.68				
160	91.51						
166	91.81						
177			92.33				
189	91.29						
199	91.24						

Cross Section / Bank Profile Locations

Name	Type	Profile Station
Pool XS 0+18.8	Pool XS	18.8
Riffle XS 1+41.2	Riffle XS	141.2
UT2 Design Riffle XS	Riffle XS	0
Confluence with UT1	Other XS	199

Measurements from Graph

Bankfull Slope: 0.01924

Variable	Min	Avg	Max
S riffle	0.01731	0.02398	0.03064
S pool	0.00063	0.00075	0.00086
S run	0	0	0
S glide	0	0	0
P - P	141.23	141.23	141.23
P length	24.98	25.94	26.9
Dmax riffle	0.68	0.7	0.72
Dmax pool	1.02	1.18	1.34
Dmax run	0	0	0
Dmax glide	0	0	0
Low Bank Ht	2.1	2.56	3.01

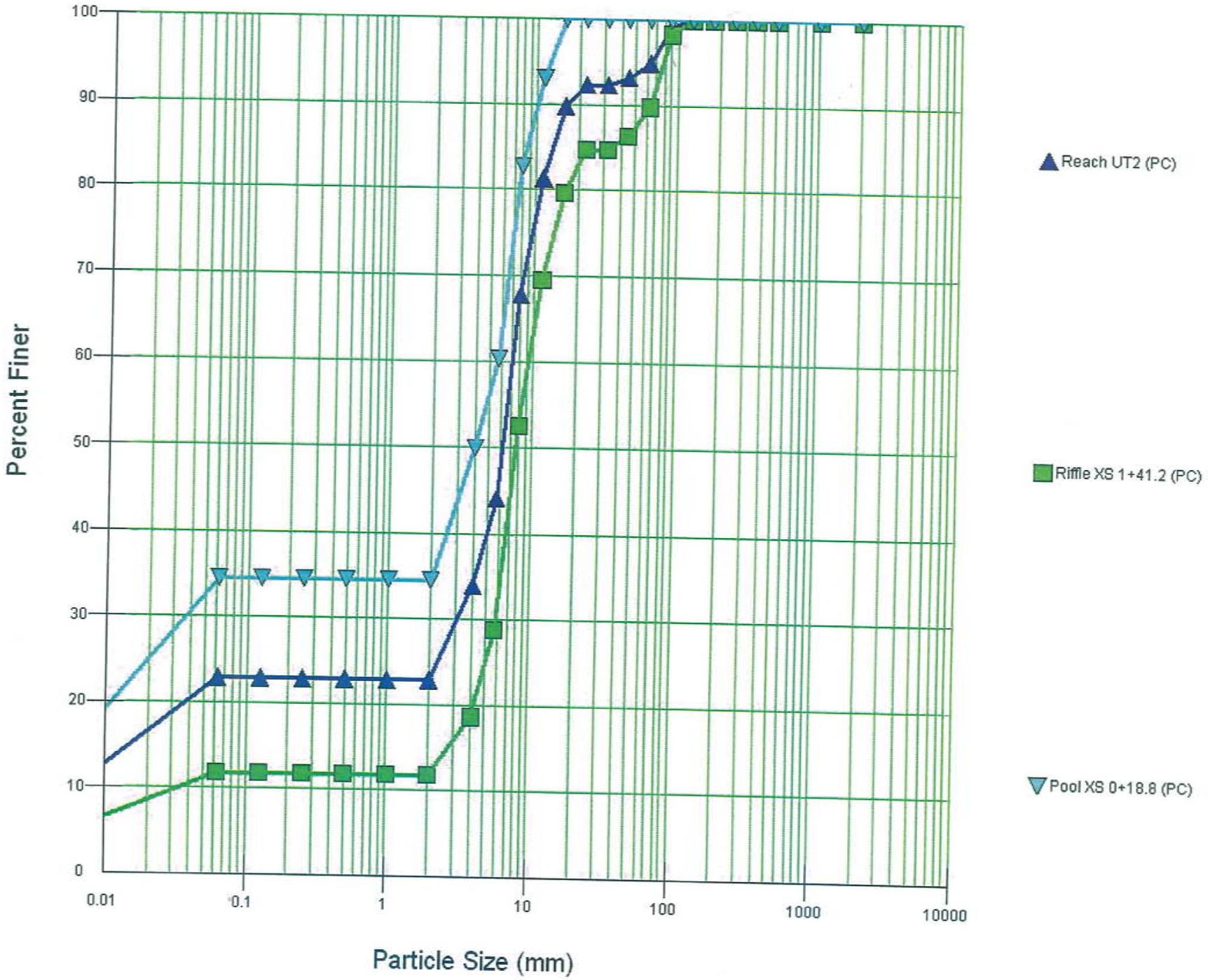
Length and depth measurements in feet, slopes in ft/ft.

Notes

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Profile Name: UT2 Impaired Conditions Profile
Survey Date: 09/20/07

DIST	Note
0	P
4	P
8.2	P
18.8	Pool @ XS
26.9	G
38.7	R
51	BKF
63.8	R
93.5	R
111	R
141	Riffle @ XS
156	BKF
160	P
166	G
177	BKF
189	R
199	Riffle Confluence w UT1

Reach UT2 Particle Distributi... - Altered Conditions 7/17/07



RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Sample Name: Reach UT2
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	27	22.88	22.88
0.062 - 0.125	0	0.00	22.88
0.125 - 0.25	0	0.00	22.88
0.25 - 0.50	0	0.00	22.88
0.50 - 1.0	0	0.00	22.88
1.0 - 2.0	0	0.00	22.88
2.0 - 4.0	13	11.02	33.90
4.0 - 5.7	12	10.17	44.07
5.7 - 8.0	28	23.73	67.80
8.0 - 11.3	16	13.56	81.36
11.3 - 16.0	10	8.47	89.83
16.0 - 22.6	3	2.54	92.37
22.6 - 32.0	0	0.00	92.37
32 - 45	1	0.85	93.22
45 - 64	2	1.69	94.92
64 - 90	5	4.24	99.15
90 - 128	1	0.85	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.04
D35 (mm)	4.18
D50 (mm)	6.27
D84 (mm)	12.76
D95 (mm)	64.49
D100 (mm)	128
Silt/Clay (%)	22.88
Sand (%)	0
Gravel (%)	72.04
Cobble (%)	5.08
Boulder (%)	0
Bedrock (%)	0

Total Particles = 118.

RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Sample Name: Riffle XS 1+41.2
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	7	11.86	11.86
0.062 - 0.125	0	0.00	11.86
0.125 - 0.25	0	0.00	11.86
0.25 - 0.50	0	0.00	11.86
0.50 - 1.0	0	0.00	11.86
1.0 - 2.0	0	0.00	11.86
2.0 - 4.0	4	6.78	18.64
4.0 - 5.7	6	10.17	28.81
5.7 - 8.0	14	23.73	52.54
8.0 - 11.3	10	16.95	69.49
11.3 - 16.0	6	10.17	79.66
16.0 - 22.6	3	5.08	84.75
22.6 - 32.0	0	0.00	84.75
32 - 45	1	1.69	86.44
45 - 64	2	3.39	89.83
64 - 90	5	8.47	98.31
90 - 128	1	1.69	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	3.22
D35 (mm)	6.3
D50 (mm)	7.75
D84 (mm)	21.63
D95 (mm)	79.85
D100 (mm)	128
Silt/Clay (%)	11.86
Sand (%)	0
Gravel (%)	77.97
Cobble (%)	10.17
Boulder (%)	0
Bedrock (%)	0

Total Particles = 59 (need at least 60).

RIVERMORPH PARTICLE SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Sample Name: Pool XS 0+18.8
Survey Date: 07/17/07

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	20	34.48	34.48
0.062 - 0.125	0	0.00	34.48
0.125 - 0.25	0	0.00	34.48
0.25 - 0.50	0	0.00	34.48
0.50 - 1.0	0	0.00	34.48
1.0 - 2.0	0	0.00	34.48
2.0 - 4.0	9	15.52	50.00
4.0 - 5.7	6	10.34	60.34
5.7 - 8.0	13	22.41	82.76
8.0 - 11.3	6	10.34	93.10
11.3 - 16.0	4	6.90	100.00
16.0 - 22.6	0	0.00	100.00
22.6 - 32.0	0	0.00	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.03
D35 (mm)	2.07
D50 (mm)	4
D84 (mm)	8.4
D95 (mm)	12.59
D100 (mm)	16
Silt/Clay (%)	34.48
Sand (%)	0
Gravel (%)	65.52
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 58 (need at least 60).

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Beaverdam Creek, Reach - UT2 Impaired

Basin NAME: _____ Drainage AREA: 48.96 acre 0.0765 mi^2

Location: _____

Twp: _____ Rge: _____ Sec: _____ Qtr: _____ Lat: 34.9278 Long: 80.436

Observers: _____ Date: 8/17/2007

Bankfull WIDTH (W_{bkf}) — **4.91** Feet
WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.

Mean DEPTH (d_{bkf}) — **0.59** Feet
Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)

Bankfull Cross Section Area (A_{bkf}) — **2.88** $Feet^2$
AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.

WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) — **8.32** Ft/Ft
Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.

Maximum DEPTH (d_{mrif}) — **0.99** Feet
Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.

Flood-Prone Area WIDTH (W_{fpa}) — **21.24** Feet
The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or ($2 \times d_{mrif}$)

Entrenchment RATIO (ER) — **4.33** Ft/Ft
The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.

Channel Materials (Particle Size Index) D50 — **6.27** mm
The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.

Water Surface SLOPE (S) — **0.01924** Ft/Ft
Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.

Channel SINUOSITY (K) — **1.01**
Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).

Stream Type **E 4**

For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.

Reference Reach Summary Data Form

... and Reference Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	0.59	feet	Mean Riffle Width (W_{bkf})	4.91	feet	Mean Riffle Area (A_{bkf})	2.88	$feet^2$
Mean Pool Depth (d_{bkfp})	0.73	feet	Mean Pool Width (W_{bkfp})	7.32	feet	Mean Pool Area (A_{bkfp})	5.36	$feet^2$
Ratio Mean Pool Depth/Mean Riffle Depth	1.237	d_{bkfp}/d_{bkf}	Ratio Pool Width/Riffle Width	1.491	W_{bkfp}/W_{bkf}	Ratio Pool Area/ Riffle Area	1.861	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mrif})	0.99	feet	Max Pool Depth (d_{mpool})	1.19	feet	Max riffle depth/Mean riffle depth	1.678	
Max pool depth/Mean riffle depth	2.017					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				4.54	ft/s	Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				13.1	cfs	Drainage Area	0.0765	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	0	0	0	feet	Meander Length Ratio (Lm/W_{bkf})	0.000	0.000	0.000
Radius of Curvature (Rc)	0	0	0	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	0.000	0.000	0.000
Belt Width (W_{blt})	0	0	0	feet	Meander Width Ratio (W_{blt}/W_{bkf})	0.000	0.000	0.000
Individual Pool Length	25.94	24.98	26.9	feet	Pool Length/Riffle Width	5.283	5.088	5.479
Pool to Pool Spacing	141.2	141.2	141.2	feet	Pool to Pool Spacing/Riffle Width	28.764	28.764	28.764

Channel Profile

Valley Slope (VS)	0.0194	ft/ft	Average Water Surface Slope (S)	0.01924	ft/ft	Sinuosity (VS/S)	1.01	
Stream Length (SL)	0	feet	Valley Length (VL)	0	feet	Sinuosity (SL/VL)	#####	
Low Bank Height (LBH)	start 2.1 / end 3.01	feet	Max Riffle Depth	start 0 / end 0	feet	Bank Height Ratio (LBH/Max Riffle Depth)	start ##### / end #####	

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0240	0.0173	0.0306	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	1.246	0.900	1.593
Run Slope (S_{run})	0.0000	0.0000	0.0000	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	0.000	0.000	0.000
Pool Slope (S_p)	0.0008	0.0006	0.0009	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	0.039	0.033	0.045
Glide Slope (S_g)	0.0000	0.0000	0.0000	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	0.000	0.000	0.000

Feature Midpoint [a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	0.990	0.990	0.990	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	1.678	1.678	1.678
Run Depth (d_{mrun})	0.000	0.000	0.000	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	0.000	0.000	0.000
Pool Depth (d_{mp})	1.190	1.190	1.190	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	2.017	2.017	2.017
Glide Depth (d_{mg})	0.000	0.000	0.000	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	0.000	0.000	0.000

Channel Materials

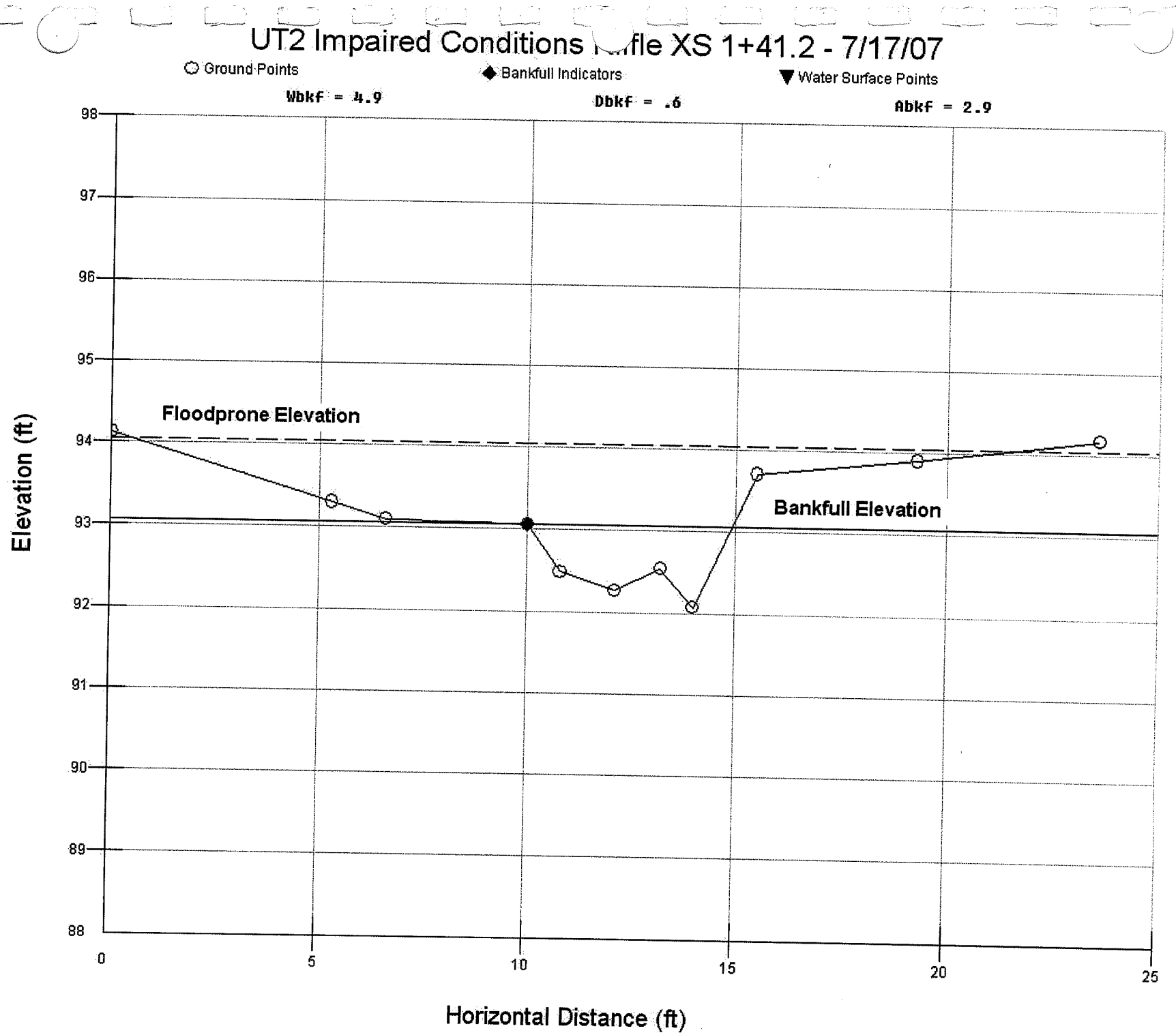
Catagories	Reach[b]	Riffle[c]	Bar
% Silt/Clay	22.88	11.86	
% Sand	0	0	
% Gravel	72.04	77.97	
% Cobble	5.08	10.17	
% Boulder	0	0	
% Bedrock	0	0	

Indices	Reach[b]	Riffle[c]	Bar	
D16	0.04	3.22		mm
D35	4.18	6.3		mm
D50	6.27	7.75		mm
D84	12.76	21.63		mm
D95	64.49	79.85		mm
D100	128	128		mm

a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.


UT2 Impaired Conditions Riffle XS 1+41.2 - 7/17/07
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 4.9
Dbkf = .6
Abkf = 2.9
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
Horizontal Distance (ft)
98
97
96
95
94
93
92
91
90
89
88
0
5
10
15
20
25

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Cross Section Name: Riffle XS 1+41.2
Survey Date: 09/19/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	5.88	94.12	
5.3	6.7	93.3	
6.6	6.9	93.1	LB
10	6.94	93.06	BKF
10.8	7.51	92.49	
12.1	7.73	92.27	
13.2	7.46	92.54	
14	7.93	92.07	TW
15.5	6.29	93.71	RB
19.3	6.1	93.9	FP
23.6	5.83	94.17	

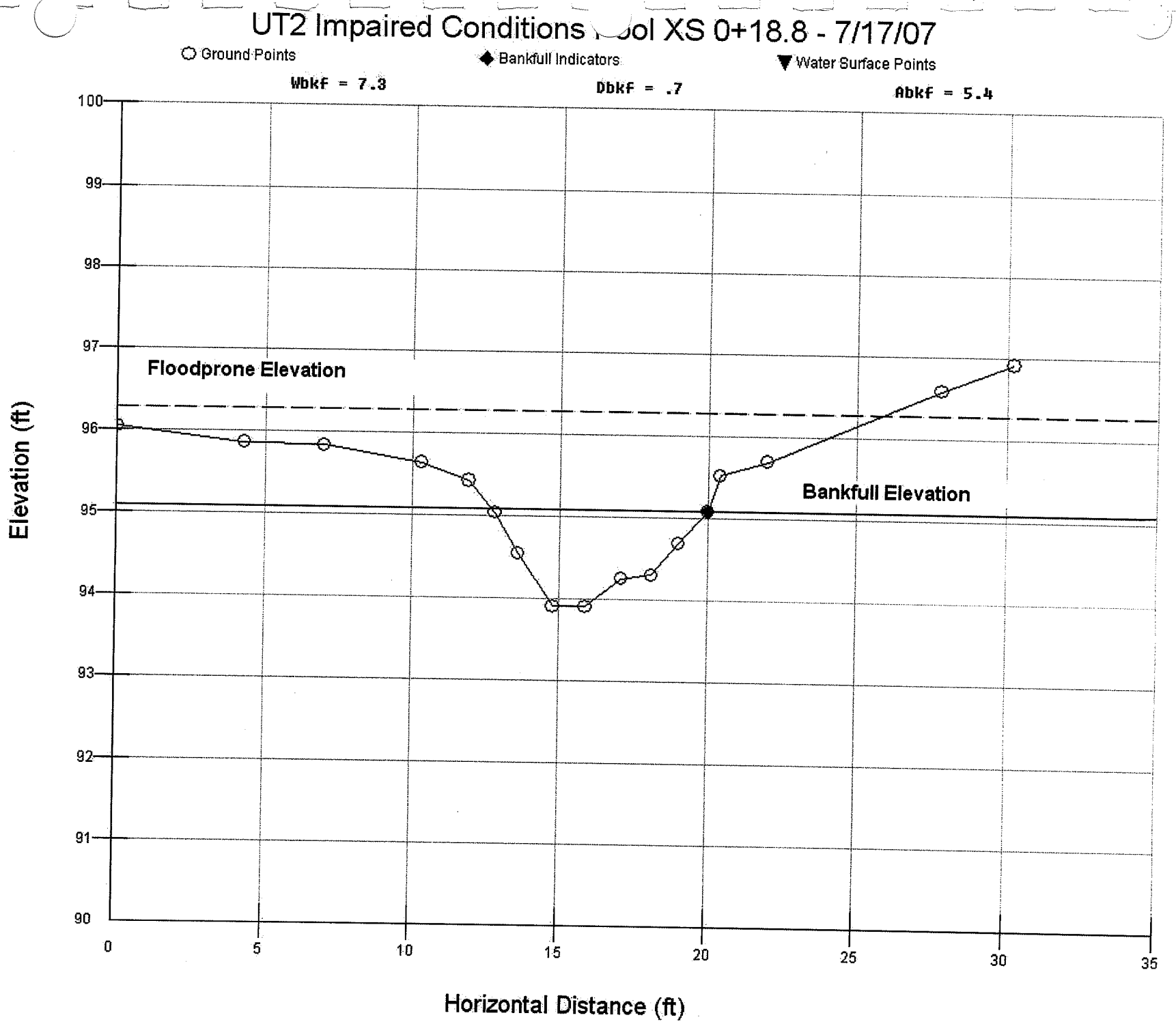
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	94.05	94.05	94.05
Bankfull Elevation (ft)	93.06	93.06	93.06
Floodprone Width (ft)	21.24	-----	-----
Bankfull Width (ft)	4.91	2.45	2.46
Entrenchment Ratio	4.33	-----	-----
Mean Depth (ft)	0.59	0.56	0.62
Maximum Depth (ft)	0.99	0.79	0.99
Width/Depth Ratio	8.32	4.38	3.97
Bankfull Area (sq ft)	2.88	1.37	1.51
Wetted Perimeter (ft)	5.7	3.37	3.75
Hydraulic Radius (ft)	0.51	0.41	0.4
Begin BKF Station	10	10	12.45
End BKF Station	14.91	12.45	14.91

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.01924	0	0
Shear Stress (lb/sq ft)	0.61		
Movable Particle (mm)	106.0		


UT2 Impaired Conditions Pool XS 0+18.8 - 7/17/07
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 7.3
Dbkf = .7
Abkf = 5.4
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
Horizontal Distance (ft)
100
99
98
97
96
95
94
93
92
91
90
0
5
10
15
20
25
30
35

RIVERMORPH CROSS SECTION SUMMARY

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
Cross Section Name: Pool XS 0+18.8
Survey Date: 09/19/07

Cross Section Data Entry

BM Elevation: 95 ft
Backsight Rod Reading: 5 ft

TAPE	FS	ELEV	NOTE
0	3.96	96.04	
4.3	4.14	95.86	
7	4.16	95.84	
10.3	4.36	95.64	LB
11.9	4.57	95.43	
12.8	4.96	95.04	
13.6	5.46	94.54	
14.8	6.1	93.9	
15.9	6.1	93.9	TW
17.1	5.75	94.25	
18.1	5.7	94.3	
19	5.31	94.69	
20	4.91	95.09	BKF
20.4	4.47	95.53	RB
22	4.3	95.7	FP
27.8	3.42	96.58	
30.2	3.09	96.91	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	96.28	96.28	96.28
Bankfull Elevation (ft)	95.09	95.09	95.09
Floodprone Width (ft)	25.82	-----	-----
Bankfull Width (ft)	7.32	3.5	3.82
Entrenchment Ratio	3.53	-----	-----
Mean Depth (ft)	0.73	0.83	0.64
Maximum Depth (ft)	1.19	1.19	1.11
Width/Depth Ratio	10.03	4.22	5.97
Bankfull Area (sq ft)	5.36	2.92	2.45
Wetted Perimeter (ft)	7.84	4.93	5.13
Hydraulic Radius (ft)	0.68	0.59	0.48
Begin BKF Station	12.68	12.68	16.18
End BKF Station	20	16.18	20

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.01924	0	0
Shear Stress (lb/sq ft)	0.82		

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Beaverdam Creek
Reach Name: UT2 Impaired
BEHI Name: XS 0+18.8
Survey Date: 10/01/2007

Bankfull Height: 0.73 ft
Bank Height: 2.14 ft
Root Depth: 0.5 ft
Root Density: 50 %
Bank Angle: 75 Degrees
Surface Protection: 70 %

Bank Material Adjustment: Sand 10

Bank Stratification Adjustment: Yes 3

Erosion Loss Curve: Yellowstone

NBS Method #5: Ratio of Near-Bank Maximum Bankfull Depth to Mean Bankfull Depth

NB Max Depth: 1.19 ft Mean Depth: 0.73 ft
Ratio: 1.63

BEHI Numerical Rating: 46.2
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 1.63
NBS Adjective Rating: Moderate
Total Bank Length: 203 ft
Estimated Sediment Loss: 4.02 Cu Yds per Year
Estimated Sediment Loss: 5.23 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Beaverdam Creek
Reach Name: UT2 Impaired

Table 1. Bank Identification Summary

Bank	Name
1	XS 0+18.8

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	46.2	Extreme	Moderate	203	4.02	5.23
Totals				203	4.02	5.23

Total Reach Ln: 203 Total Loss (tons/yr) per ft of Reach: 0.0258