McCain Site
Randolph County, North Carolina

Stream Restoration Plan

Contract No. EW-02040S

State Project No. 020594001

North Carolina Ecosystem Enhancement Program

June 2005

EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) initiated the McCain Property Stream Restoration Feasibility Study in April 2003 to evaluate the feasibility of restoring a degraded section of an unnamed tributary to Back Creek (UTBC). The purpose of this mitigation project would be to compensate for unavoidable stream and buffer impacts in the Upper Yadkin River Basin resulting from planned NCDOT Transportation Improvement Projects. With the creation of the North Carolina Ecosystem Enhancement Program (EEP), this project was shifted to this new agency for completion.

The project site is part of a 71.54-acre parcel owned by Ms. Sigrid N. McCain that is located approximately one mile southeast of the intersection of Lake Lucas Road (SR 1518) and Spero Road (SR 1504) in Sophia, Randolph County, North Carolina. The property is an active livestock farm, with a portion of the property dedicated to pasture and livestock grazing. The primary land uses on the property include rangeland, agriculture (small grain), and hardwood forest. UTBC is a second-order, perennial stream that drains in a southerly direction across the subject property before joining Back Creek. The 2,475-foot project reach is located within USGS Hydrologic Unit 03040103050050 (Lower Yadkin watershed), in a non-targeted portion of the NC Division of Water Quality (NCDWQ) Sub-basin 03-07-09.

A significant portion of UTBC within the project site has been degraded due to poor grazing management and the removal of riparian vegetation. The stream channel in several locations was historically relocated hard against the valley walls to open of the valley bottom for farming.

Coordination with the landowner was conducted to identify current and planned land use requirements associated with the project site. A Rosgen Level III assessment and qualitative stream stability evaluations were conducted to characterize existing stream conditions and determine the potential for restoration. Further, the presence of conditions or characteristics that have the potential to constrain restoration activities on the project site was evaluated.

A reference reach study of Richland Creek in a nearby watershed and an upstream reach of UTBC were conducted. A rain gage, stream gages and scour chains were installed on the UTBC in the project site to evaluate flows and sediment transport. From sediment transport modeling, a design shear stress was established for the anticipated gradation of the relocated streambed. Based on the reference reach surveys and sound geomorphic principles, the proposed mitigation stream alignment, profile and typical cross sections were developed.

The proposed stream restoration plan is to build a 2,445-foot long meandering stream that falls within the Rosgen stream types Bc4 and C4. Two stream types are necessary because the valley slope changes through the project site. The proposed stream will be relocated off of the existing valley walls into the bottom of the valley. This relocation stream channel was adjusted in profile such that the channel bed will be located in an alluvial gravel layer that has been observed in the valley. The stream channel cross sections were designed to be hydraulically stable with a gravel stream bed. A minimum width 50-foot buffer will be provided on both sides of the proposed channel. This buffer will have 3660-feet of exclusion fence, three stable stream crossings, and a re-vegetation plan. This re-vegetation of the 8.4-acre conservation easement will consist of shrubs on the stream channel banks and woody plantings on the floodplain within the exclusion fencing.

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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) initiated the McCain Property Stream Restoration Feasibility Study in April 2003 to evaluate the feasibility of restoring a degraded section of an unnamed tributary to Back Creek (UTBC). The purpose of this mitigation project would be to compensate for unavoidable stream and buffer impacts in the Yadkin River Basin resulting from planned NCDOT Transportation Improvement Projects. With the creation of the North Carolina Ecosystem Enhancement Program (EEP) this project was shifted to this new agency for completion.

1.1 Project Description

The EEP intends on utilizing the McCain Site in Randolph County for a comprehensive restoration of the stream and its woody corridor across an active cattle-rearing pasture. This restoration plan presents detailed information regarding the existing site and watershed conditions, the morphological design criteria developed from a selected reference reach, and the project design parameters based upon natural channel restoration methodologies.

1.2 Project Goals and Objectives

The goals and objectives of the McCain Site Mitigation Project are to:
- Restore stable channel morphology that is capable of moving the flows and sediment provided by its watershed;
- Reduce sediment-related water quality impacts resulting from lateral bank erosion and bed degradation on the downstream Back Creek and reservoir;
- Improve aquatic habitat diversity through the enhancement of riffle-pool bed variability and the use of in-stream structures;
- Restore vegetative riparian buffers and vegetated channel banks utilizing native plant species; and,
- Provide a fenced corridor with stabilized access for cattle watering.

2.0 PROJECT SITE LOCATION

2.1 General Description

The project site is a 2,475-foot section of perennial stream that is situated on part of a 71.54-acre parcel owned by Ms. Sigrid N. McCain that is located approximately one mile southeast of the intersection of Lake Lucas Road (SR 1518) and Spero Road (SR 1504) in Sophia, Randolph County, North Carolina (Figure 1. Vicinity Map). UTBC is a second-order, perennial stream that drains in a southerly direction across the subject property before joining Back Creek.

The property is an active livestock farm, with a portion of the property dedicated to pasture and livestock grazing. The primary land uses on the property include rangeland, agriculture (small grain), and hardwood forest. There is a large pole barn for storing livestock feed and agricultural machinery. A private residence and two small storage sheds are located in the southwestern portion of the subject property. UTBC and its associated riparian area run along the eastern property boundary.

2.2 USGS and NCDWQ River Basin Designations

The project reach is located within USGS Hydrologic Unit 03040103050050 (Yadkin River Basin), in a non-targeted portion of the NC Division of Water Quality (NCDWQ) Sub-basin 03-07-09.

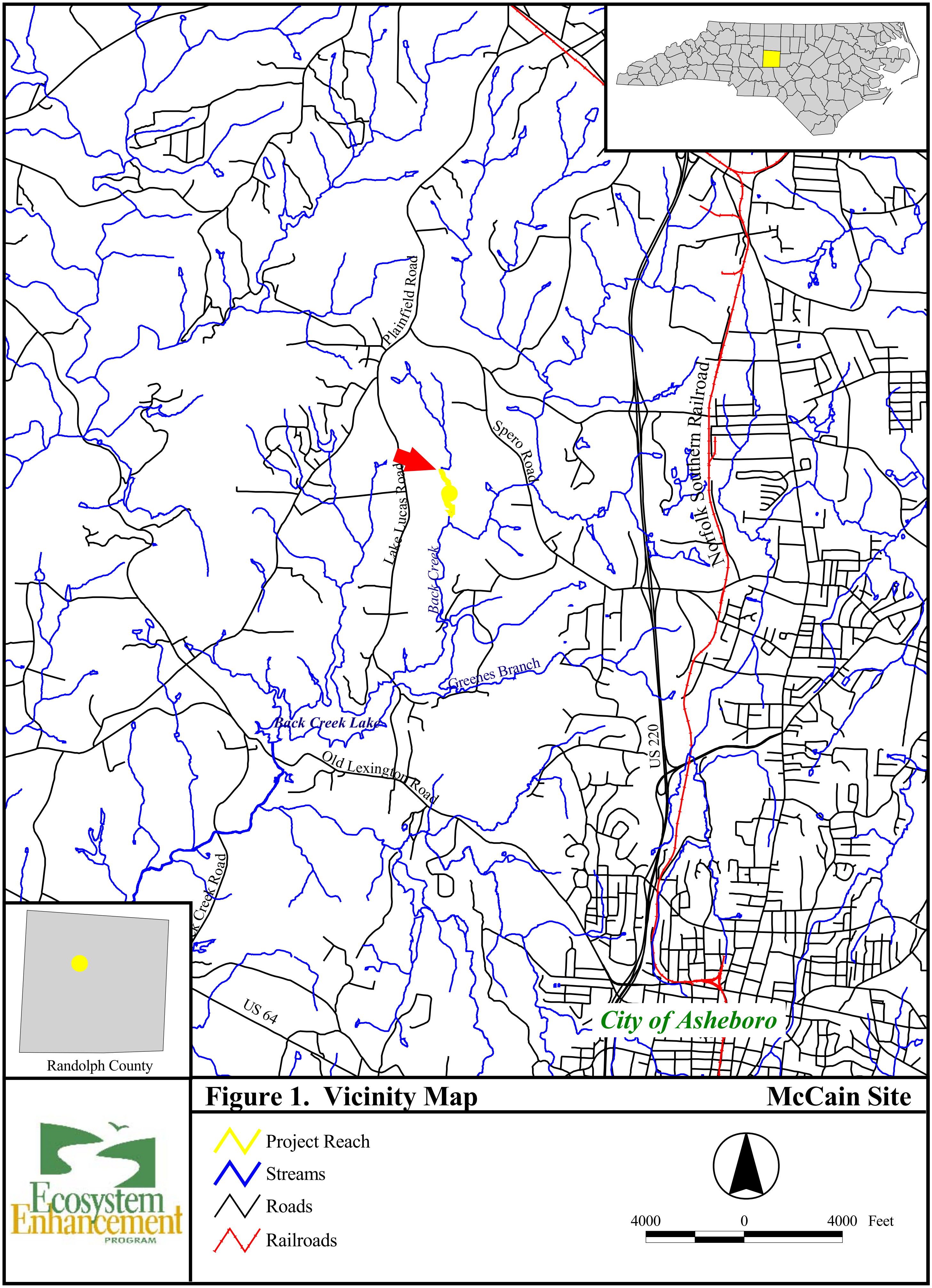


Figure 1. Vicinity Map **McCain Site**

2.3 NCDWQ Surface Water Classification

The NCDWQ assigns surface waters a classification in order to help protect, maintain, and preserve water quality. The unnamed tributary to Back Creek has not been rated by the NCDWQ. However, Back Creek (NCDWQ Stream Index Number 13-2-3-3-(0.3)) from its source to a point one mile downstream of Randolph County SR 1504 is designated a "WS-II HQW" usage classification (NCDENR, 2002). WS-II indicates waters protected as water supplies, which are usually in predominantly undeveloped watersheds and only general permits for discharges are allowed. WS-II waters are also protected for Class C uses, which include fishing, wildlife, fish and aquatic life propagation and survival, agriculture, and secondary recreation that involve human body contact with the water. The "HQW" is a supplemental classification intended to protect water bodies with water quality higher than state standards. WS-II waters are HQW by definition.

3.0 WATERSHED CHARACTERIZATION

3.1 General Description

The project site is located in a rural setting within the Carolina Slate Belt ecoregion of the Piedmont physiographic province. Site topography is characterized as rolling to hilly with elevations ranging from 670 feet above mean sea level (AMSL) near the McCain residence to 530 feet AMSL at the downstream project limits on UTBC. The elevation change along UTBC falls from approximately 550 feet at the upper part of the site to approximately 530 feet at the lower end of the project, a longitudinal valley distance of 1,988 feet (1.0% mean slope).

3.2 Drainage Area

The drainage area contributing to the most downstream extent of the project reach is 0.88 square miles (Figure 2. Project Drainage). The soils types of the watershed are presented in Figure 3 (Soils).

3.3 Land Use and Development Potential

An Anderson Level I classification indicates that the contributing drainage area consists of: forest (67%), agriculture (16%), rangeland (12%), and urban (4%) land use / land cover (Figure 4. Land Use /Land Cover). Due to the rural nature of the area, the potential exists for future development. However, development pressures are currently considered low, and there are currently no obvious signs of development.

3.4 Historical Resources

Historic aerial photographs were obtained from the Randolph County Natural Resources Conservation Service (NRCS) office in order to enhance the assessment of existing site conditions. The intent of the review was to understand the chronology of land disturbance and aid in the evaluation of the site and the development of an appropriate restoration strategy. Aerial photographs of the site were obtained from 1937, 1957, and 1966.

In 1937, the subject property looked very similar to current conditions; no significant differences are discernable at the scale and quality of the photo. The stream valley was cleared at that time, and presumably used for agriculture or pasture. The stream channel appeared to follow the pattern observable today. No changes in either the stream valley or stream channel within the project area were observed in the 1957 or 1966 aerial photographs. Therefore, any alterations to the stream channel occurred before 1937, and there have been no significant changes to the project area since then.

3.5 Cultural and Archaeological Resources

To evaluate the presence of significant cultural resources on the subject property and the potential that the proposed project would impact them, KCI requested a formal review at the North Carolina Department of Cultural Resources, State Historic Preservation Office (SHPO). No historic preservation sites nor sites of archeological importance were noted on the McCain Property (See Appendix A).

3.6 Effect on Natural Resources

Rare, Threatened, or Endangered Species (RTE)
KCI conducted an informal file review at the North Carolina Natural Heritage Program's (NHP) office in order to identify the potential for the presence of rare, threatened, or endangered species within a one-mile radius of the project site. This review did not reveal the presence of any known rare, threatened, or endangered species. Appendix B includes the NHP list of Rare, Threatened, and Endangered Species and Critical Habitats in Randolph County and the state and federal status for each species.

Additionally, KCI requested a formal review by the NHP to identify the presence of rare species, critical habitats, and priority natural areas on the project site and to determine the potential impact of the proposed project on these resources. In a letter dated May 21, 2003, the NHP indicated that there are no records of such resources either at the site or within one mile of the project area.

Wetlands
A review of the Randleman, North Carolina National Wetland Inventory (NWI) Map identified no wetlands within the project study area. Further, no wetlands were identified in the project study area during the field investigation (April 2003).

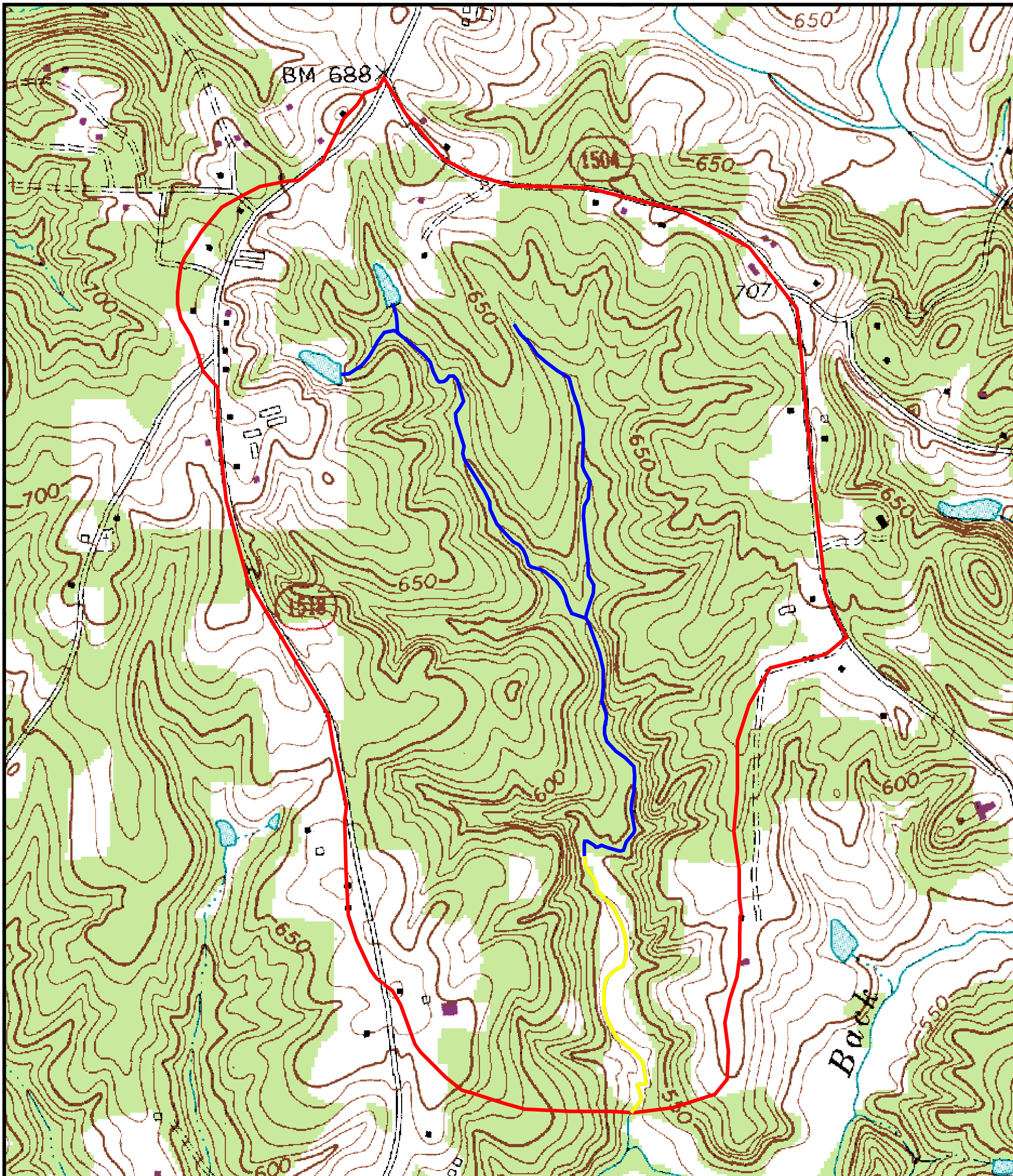


Figure 2. Project Drainage **McCain Site**

Project Reach

Streams

Drainage Area
0.88 sq. miles

900 0 900 Feet

Ecosystem Enhancement PROGRAM

Source: Randleman USGS 7.5' Topographic Quadrangle

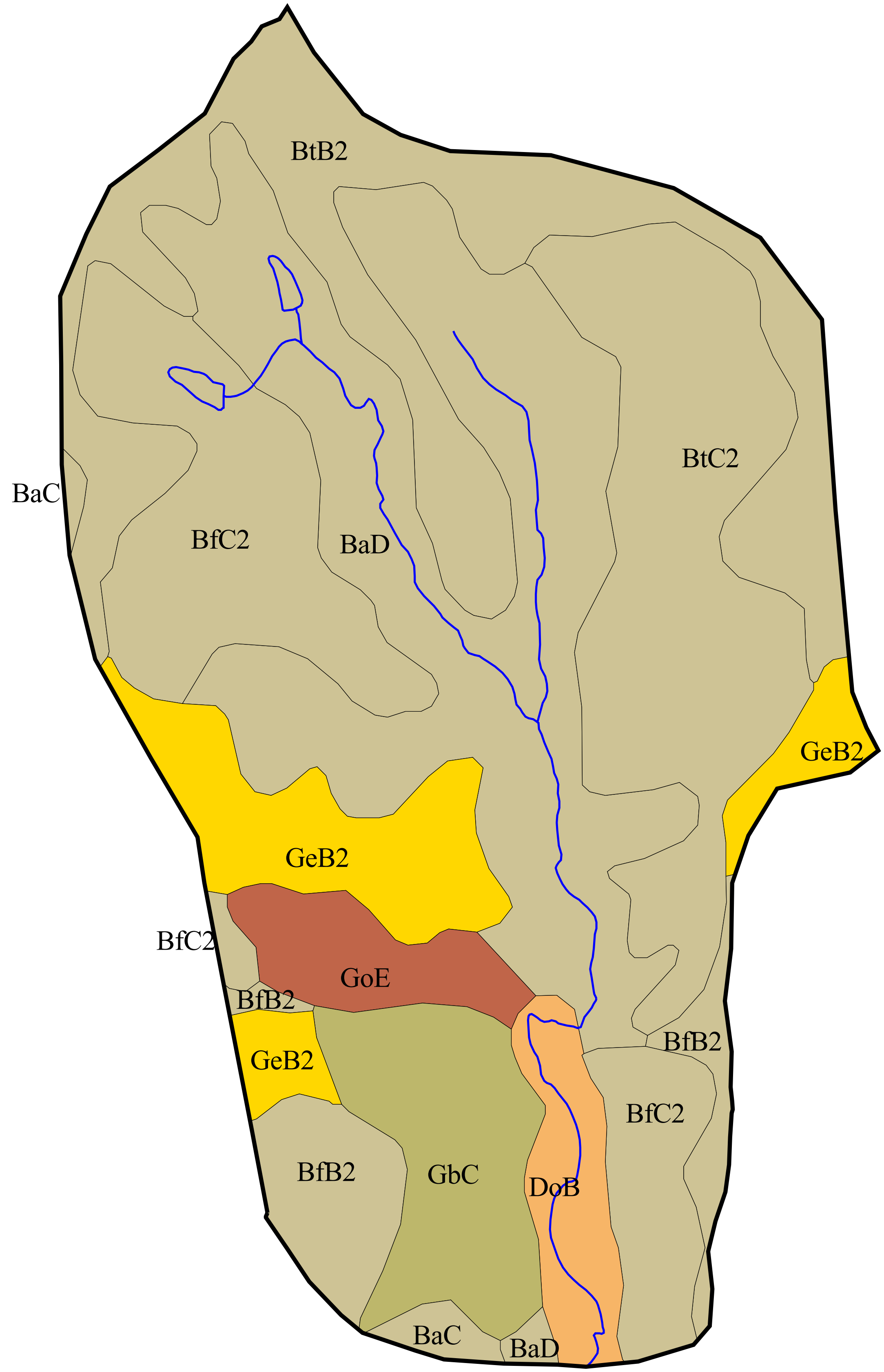


Figure 3. Soils **McCain Site**

Soil Types

- Goldston Very Channery Silt Loam
- Georgeville Silty Clay Loam
- Georgeville Silt Loam
- Dogue Sandy Loam
- Badin-Tatum Complex

Streams

Drainage Area

500 0 500 Feet

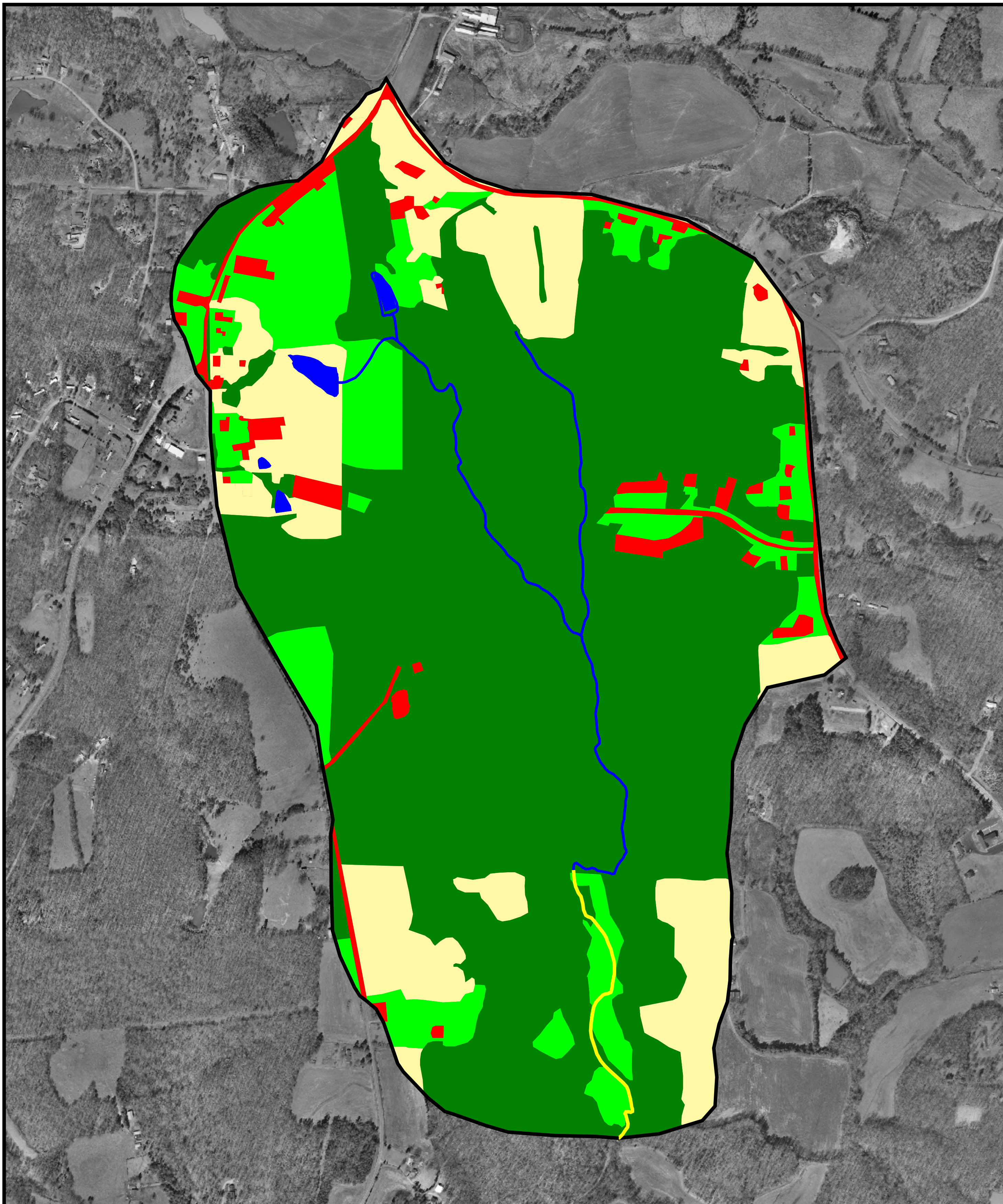


Figure 4. Land Use/Land Cover **McCain Site**

4.0 EXISTING CONDITIONS ASSESSMENT

A site field assessment was conducted in April 2003 to document existing conditions and evaluate the potential for stream and riparian buffer restoration. Observations and collected data are described below, illustrated in Figure 5 Existing Conditions and documented in the site photographs (Appendix C). The site was revisited from April to December 2004 several times to take further measurements, to install a rain gage and stream gages, to sample the stream bed, to survey the immediate upstream reach to compare with a reference reach, and several times to download data and take more sediment samples.

4.1 General Site Description

As the project location can be seen on the Figure 5; the valley has four natural bends, in which the stream channel flows near the low spot in the valley. It appears that in the two western bends of the valley that the stream may have been relocated hard against the valley wall to allow the valley bottom to be actively farmed, then pastured. Such an active relocation was undisputedly found on the upstream adjacent property.

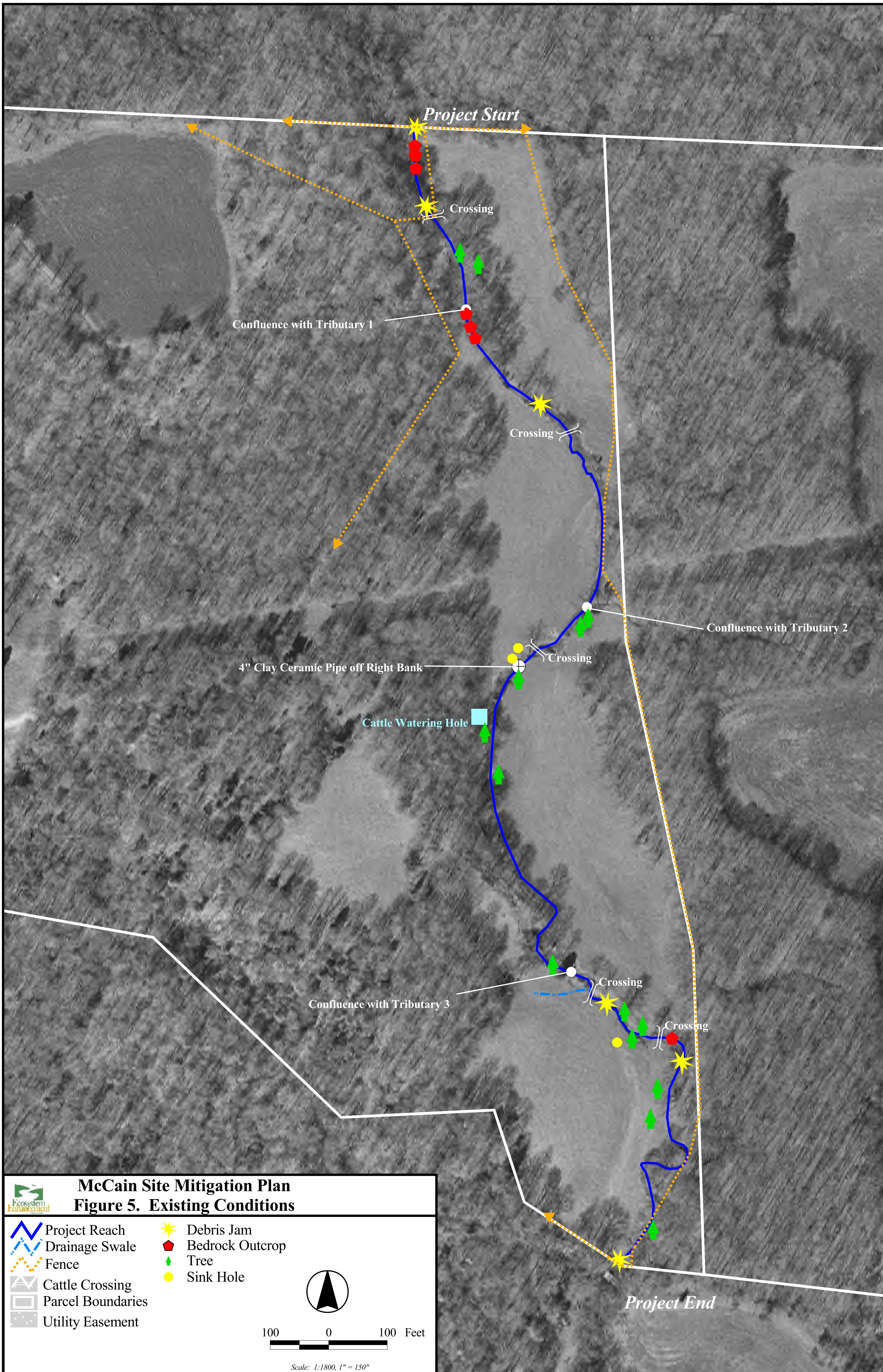
In the two western valley bends, the channel is incised, with this incision extending through the *Dogue* loamy soil and into soils and sediment deposits, which are over 300 years old and predate the *Dogue's* depositional event. The upstream western bend in the valley appears to have eroded through a channery deposit and eroded down to bedrock in places. The downstream western bend in the valley is adjacent to some severe gully erosion caused by cattle taking short cuts to the stream channel. The two eastern bends of the valley are in better condition partly due to fences on the east bank preventing the cattle from climbing the far banks. In the upstream eastern valley bend, the stream does not strike the valley wall but, is never the less, heavily impacted by cattle movement because its low banks allow easy access. The lower eastern valley bend has the only true meandering stretch of stream channel that has exposed some bedrock. This meandering has caused some outer bends to consist of severely eroded valley wall cuts.

The unlimited access to the stream channel by rearing cattle (weaned calves to heifers and young bulls) has resulted in stream banks that have little vegetation and a channel bottom that has been thoroughly mixed and in some places compacted. The three tributaries on the project site also have some erosion problems, partly due to the down cutting of the main valley channel over the last century. The project ends where this meandering valley confluences with the much larger floodplain in the Back Creek valley. The project site is the only place on this un-named tributary to Back Creek where the creek is not bordered by forest. A mile downstream on Back Creek is a small water supply reservoir.

4.2 Geology and Soils

Local geology consists of metamorphic rocks of the Charlotte and Milton Belts overlying metamorphic rocks within the Carolina Slate Belt. These include metamorphosed volcanic rock, metamudstone, meta-sandstone, and metaconglomerates. These metamorphic rocks date from the Cambrian Period to the Late Proterozoic Era (500 to 900 million years ago). Predominant soil types located within the project site include *Dogue sandy loam* and *Goldston very channery silt clay loam* in the stream valley, and *Badin-Tatum complex* in the upland pasture. The predominant soil types within the project watershed include *Badin-Tatum complex* and *Georgeville silty clay loam.*

Dogue sandy loam (DoB) is nearly level, very deep, somewhat poorly drained soil found on floodplains, formed in alluvial deposits. *Dogue* soils are subject to frequent flooding, and have inclusions of hydric soils or wet spots. *Badin-Tatum complex (BfB2, BfC2, BtB2, BtC2*, and *BaD)* soils consist of strongly sloping *Badin* soils and *Tatum* soils on uplands. These soils formed in residuum from Carolina slates and other fine-grained rocks, and are moderately deep to deep and well-drained. *Georgeville silty clay loam (GeB2)* soils are



McCain Site Mitigation Plan
Figure 5. Existing Conditions

gently sloping, very deep, well-drained, eroded soils found on uplands. *Goldston very channery silt clay loam (GoE)* is moderately steep to steep, shallow, well-drained to excessively drained soils found on uplands. These soils formed in residuum from Carolina slates.

4.3 Existing Riparian Buffer and Natural Communities

The existing riparian buffer is a rural cattle rearing pasture, which is largely devoid of natural habitat communities within the fence line. At one location on the project, the east side of the floodplain is fenced and a herbaceous community exists with a mix of wetland and upland species. Trees along the stream are limited to top of bank, interspersed with open areas, with only a few good connections to the woods on the valley slopes. The valley on the upstream adjacent property is entirely forested with good understory and ground level strata.

4.4 Existing Stream Characteristics

4.4.1 Morphological Description

A Rosgen Level III assessment was conducted to gather existing stream dimension, pattern, and profile data and determine the potential for restoration. Channel cross-sections and bed materials were surveyed at four representative locations along UTBC. Data developed from these surveys are summarized below (Table 1) with detailed data provided in Appendix D.

Table 1. Summary of Existing Channel Morphology.

Parameter	**UTBC XS-1**	**UTBC XS-2**	**UTBC XS-3**	**UTBC XS-4**
A_{bkf} (sq ft)	21.30	26.00	25.70	29.30
W_{bkf} (ft)	19.36	21.17	14.63	19.41
W_{fpa} (ft)	34.0	NA	125.0	125.0
d_{mbkf} (ft)	1.72	2.34	3.48	3.34
D_{bkf} (ft)	1.10	1.23	1.76	1.51
W/D ratio	17.6	17.2	8.3	12.9
Entrenchment Ratio	1.76	NA	8.54	6.44
Bank Height Ratio	1.03	1.69	0.99	1.06
Local W. S. Slope (ft/ft)	0.011	0.0002	0.0014	0.0025
Discharge (cfs)	83.93	NA	61.44	87.76
D_{50} (mm)	22	9	0.34	0.2
Stream Type	B4c	---	E5	C5

4.4.2 Channel Evolution Stage

Conceptual channel evolution models are used to describe the sequential changes a stream undergoes after disturbance and predict its most probable stable endpoint (stream type). The Simon Channel Evolution Model (Simon, 1989), commonly used in sand or strongly alluvial systems, cannot be used at the McCain site for two reasons. The un-named tributary to Back Creek is relatively steep and functions primarily as a sediment transport reach with some bedrock control. The floodplain soil, *Dogue*, is a loam soil that primarily becomes wash load when eroded. These two situations prevent the Simon's Stage IV/V from developing. The Simon model is based on the degradation to aggregation stream evolution sequence. However, on the lower UTBC, the backwater conditions from Back Creek have created a transitional reach into the Back Creek floodplain that from all indications appears to be Stage IV/V, however the depositional processes are completely different from that in the Simon Channel Evolution Model.

The stream on the McCain site follows an aggregation to degradation stream evolution model (Schlindwein, 2004). In the late 1700s or early 1800s, the watershed was largely clear of the climax forest and the land utilized for row crops for decades. The steep slopes of the watershed lost their topsoil due to rainfall and erosion quickly. This eroded topsoil ended up being deposited on the original floodplain. The original floodplain may have been gravely and poorly suited to agriculture. The marginal fields of the watershed were abandoned and allowed to reforest. The deposition of eroded topsoil on the floodplain slowed down to the point that the newly deposited *Dogue* soil became attractive bottomland for agriculture. With every spring flood, a new layer of soil deposited on this floodplain (called "made land") that did not need to be fertilized each year to be productive. However, as the thick topsoil was lost from most of the watershed and forest re-established on steep slopes, the sediment delivery to the stream system reduced significantly sometime after the Civil War. This was the end of the aggregation phase of the stream evolution for most watersheds in the Piedmont.

With less sediment from these watersheds, the stream flow became "hungry water" and it gullied through the *Dogue* soil deposits. In any cases this gulling was in direct conflict with the farmer's efforts to crop these bottomlands, the streams were relocated hard against valley walls so that the fertile bottomlands could be utilized. However with the end of "made land", these *Dogue* soils with low levels of organics and clay quickly became unproductive. In many cases these bottomlands were abandoned to reforest or converted to pasturing. The steam types during this evolutionary phase went from being gullies to a wider eroded stream type and possibly stabilized as a meandering stream type.

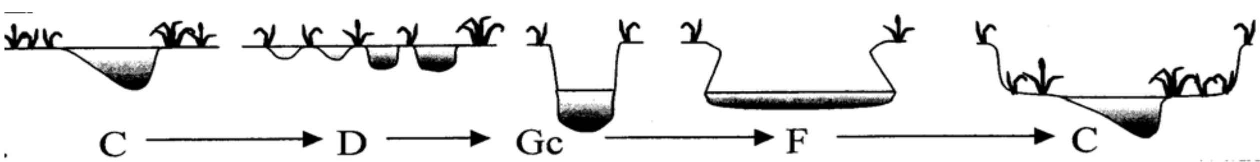


Figure 6. Aggradation –Degradation Stream Evolution Sequence (D. Rosgen)

The sequence of stream types using the Rosgen (1996) classification system is E-C-D-G-F-C, shown in Figure 6. The E-C-D is the aggregation sequence and the G-F-C is the degradation sequence. The E channel type is a low sediment load meandering stream. The C channel type is a meandering riffle and pool sequence with a good sediment load. The D channel type is a shallow braided channel that is choked with sediment. The F channel type is a broad incised channel with long runs and short pools that can be stable in the humid east with woody vegetation on its banks. The C channel type may not develop on bedrock or higher gradient reaches, in this case a Bc channel type that has balanced runs and pools and is not incised can develop.

On the McCain site, the existing stream channel waivers in between the F, C and Bc stream types. All of these stream types can be stable if their banks were allowed to re-vegetate with woody growth. A simple fencing of the stream channel with reforestation would produce a significant improvement in the condition of this stream channel. However, because long sections of this channel have been thrown up against the valley walls, full stabilization would remain elusive. As a consequence, the preferred stable condition of this stream would be a mix of C and Bc stream channel types, relocated away from the valley walls.

4.4.3 Stability Assessment

From an overall site perspective, a number of factors have contributed to the degradation of the project reach. Certain sources of disturbance have occurred historically while others are more recent and ongoing. Historic aerial photography dating to 1937 shows that both the site and the watershed have undergone relatively minor changes in land use over the last 68 years. Therefore, instability created by logging within the watershed or the initial clearing of the site has most likely moved through the stream network and may not be causing significant adjustments in channel geomorphology at the present time. In addition, decreases in the base elevation of Back Creek in response to historical changes in land use or the installation of dams and culverts, may have influenced or be influencing channel morphology of UTBC. However, it is probable that vertical grade control exists between the location of the site and the confluence of UTBC and Back Creek that would prevent a headcut from advancing upstream to the site.

The most significant factors contributing to stream degradation on site, both in the past and present, are the impacts associated with cattle access to the stream and the absence of riparian and bank vegetation. The resulting bank instability has allowed a majority of the project stream to incise, overwiden and straighten to varying degrees and other stream sections to experience overwidening and possibly meander migration. The presence of shallow bedrock contacts on site has prevented the stream from incising further.

To better understand the existing and possible future condition of the project stream, qualitative stability assessments of distinct stream sections were developed based on both the dimensionless ratios (i.e., entrenchment ratio, bank height ratio) calculated from the cross-section data and visual observations.

Section 1 from Station 10+00 to ~14+90 is a transitioning reach. This Type B4c reach is the steepest and most entrenched section of the project stream with a bank height ratio of 1.21, entrenchment ratio of 1.76 and a slope of 0.011. Past disturbance of the stream caused this section to incise to bedrock elevation, overwiden and straighten. At the present time, this section has begun to form a Type C channel within the older, overwidened channel. The overall rate and extent of bank failure for the reach has declined and bar formation is active in a few locations where a meander planform is developing. Bank erosion potential is high in localized areas of meander formation (e.g., the location of XS2), but sediment input from this section is expected to be relatively low. Section 1 also experiences the least disturbance due to cattle access. A combination of the high left bank heights with the proximity of the hill slope to the right bank greatly reduce the amount of physical damage directly caused by the cattle due to hoof shear and trampling. In addition, approximately 145 feet of the upper portion of Section 1 is fenced out of the pasture area.

Towards the downstream end of Section 1, the stream valley widens, channel entrenchment decreases and water surface slope decreases. In contrast to Section 1, the stream in Section 2 is heavily impacted by cattle access and exhibits large variations in width and degree of bank failure, resulting in high sediment input to the stream. In general, Section 2 from Station ~14+90 to 20+05 is experiencing both aggradation and widening. Historically, the channel was probably a Type C4, or possibly a Type C5 at the higher base elevation, that downcut to become slightly entrenched, but not to a sufficient degree to classify as a Type G or Type F stream, and is now becoming significantly wider. The large amount of sediment contributed by the eroding banks is causing channel aggradation that only exacerbates the need for the hydraulically inefficient, overwidened channel to increase bankfull width.

It is important to consider this process of channel evolution where downcutting, widening and aggrading has occurred when evaluating the bed material size distribution of the existing degraded channel in both Sections 1 and 2. The large amount of cobble and boulder-sized material is predominantly due to materials already present in the soil column and weathered bedrock becoming exposed and worked into the bed of the active channel. The presence of these larger size classes is not an indication of the bankfull sediment transport capacity of the existing stream.

Section 3 from Station 20+05 to ~ 34+45 is significantly different from Sections 1 and 2 in that the channel narrows considerably and retains some original meander pattern. The bank height ratio decreases to 1.0 as the stream approaches the location of XS3. Section 3 is widening to a greater degree at the upstream end and experiencing only minor degradation. The downstream reach of Section 3 is only moderately unstable with almost no bed degradation, near vertical outside meander banks and inside meander banks that appear to be aggrading. This reach may be experiencing a slow meander migration as a result of the outside meander banks being destabilized by lack of vegetation. This lower reach of Section 3 also exhibits relatively minor riffle and pool morphology and low water surface slope.

Cross sections 3 and 4 were classified as Type E5 and Type C5, respectively. This section may have been a stable Type E5 that is undergoing moderate bank failure and will stabilize as a Type C5 stream. At the present time, Section 3 seems to be undergoing the least amount of erosion and change in dimension, plan and profile of all the sections of the project stream.

4.5 Constraints

The presence of conditions or characteristics that have the potential to hinder restoration activities on the project site was evaluated. The evaluation focused primarily on the presence of hazardous materials, utilities and restrictive easements, rare/threatened/endangered species (RTE) or critical habitats, cultural resources, and the potential for hydrologic trespass. Existing information regarding project site constraints was acquired and reviewed. In addition, any site conditions that have the potential to restrict the restoration design and implementation were documented during the field investigation. Table 2 summarizes the identified constraints that may hinder the implementation of site restoration activities.

4.5.1 Hazardous Materials

The presence or likely presence of hazardous substances on the subject property and surrounding area under conditions that indicate a past, present or potential release into the ground, groundwater, or surface water was evaluated. The evaluation included a review of public record environmental database information and a visual site inspection.

A report meeting ASTM E1527-00 Standards for records search requirements was obtained summarizing existing federal and state database information regarding known environmental conditions for the subject property and surrounding area. No conditions of environmental concern were identified on the McCain Property or within the specified search radii. The visual site inspection was conducted in April 2003, and there were no potential environmental concerns to the project site or hazardous materials identified. The findings were documented on an Environmental Screening Inspection Form with corresponding photographs.

4.5.2 Utilities and Easements

KCI obtained copies of the property deed dating back to 1936 from the Randolph County Tax Office in April 2003 (Table 3). A power line easement transects the subject property in a southwest-northeast orientation, crossing UTBC at Station 19+70. The documentation for the power line easement was not found in the records at the Randolph County Tax Office. KCI determined that Randolph Electric is the power company that owns the easement (Contact: Ron Gunnell at (336) 625-0981 ext. 342).

Trees will be planted outside of the utility easement. A fall zone will, by default, extend to the edge of the utility easement. The power company will likely retain the rights to maintain “dangerous” trees immediately adjacent to the utility easement, following coordination with the holder of the conservation easement.

There will be no management agreement with the power company. The utility easement will be excluded from the conservation easement for the McCain Mitigation Site.

4.5.3 Hydrologic Trespass

The proposed project reach is entirely contained within the McCain property. The restoration of the project reach is not anticipated to produce hydrologic trespass conditions on any adjacent properties.

Table 2. Summary of Design Constraints

Fatal Flaw/Constraint	Nature of Constraint	Proposed Resolution
Current Land Use (specify)	Livestock grazing, grain agriculture, forest	
Adjacent Property Land Use	Forest, agriculture, low-density residential development	
Landowner Concerns	Cattle access to water	Incorporate stable cattle stream crossings into proposed design to allow access to water and pasture
Deed Restrictions/Easements	Utility easement crosses project site	Exclude utility easement from the conservation easement.
Project contractibility/access	Steep wooded hill slopes around project site	Access along utility easement. Verify whether improvements can be made within the easement (overhead).
Utilities	Overhead power lines cross project site	Preserve access to utility easement for utility maintenance needs
Structures	N/A	
Cultural (historical/archaeological)	SHPO Review – No occurrences (Appendix A).	
Rare, Threatened, and Endangered Species	Natural Heritage Program Findings Letter (Appendix B) indicated no record of occurrences within one-mile radius of the project site.	
Natural Features (soils, bedrock)	Bedrock outcrops in streambed and banks	Accommodate bedrock presence into proposed design
FEMA Regulated Area	Project area within Zone C (area of minimal flooding, with no detailed modeling required)	

Table 3. Property Ownership History

Book	Page	Grantee (buyer)	Grantor (seller)	Date
813	234	Terry W. and Sigrid Nissen McCain	Glenn M. and Mary E. Surratt	10/2/62
584	556	Glenn M. and Mary E. Surratt	Edgar G. and Odelia C. Lineberry	9/19/55
584	555	Edgar G. and Odelia C. Lineberry	T.R. and Kathleen Lineberry	9/17/55
276	259	T.R. Lineberry	Edgar G. Lineberry	3/14/36

5.0 REFERENCE REACH ANALYSIS

A reference reach is a channel with a stable dimension, pattern, and profile within the particular valley morphology. The reference reach is used to develop dimensionless morphological ratios (based on bankfull stage) that can be extrapolated to disturbed/unstable streams to restore a stream of the same type and disposition as the reference stream (Rosgen, 1998). The selection criteria included a stable reach occurring under similar hydrophysiographic, landform, and watershed land use conditions.

The project site occurs in rolling to hilly terrain of the Carolina Slate Belt ecoregion of the Piedmont physiographic province. The project stream runs through a gently sloping valley (average slope of approximately 0.8%) with alternating toe slopes. The project watershed is a small (0.88 square miles), primarily forested watershed with a small percentage of agriculture, pasture, and rural, low-density residential land uses. A reference reach with similar site and watershed conditions was desired.

It was determined that the restored stream will contain sections of two Rosgen stream types – "C3" and "C4." The NCDOT reference reach database was used to select potential reference reaches with similar stream type and slope. The database did not contain any Rosgen "C3" type steams in the piedmont physiographic province, however four potential "C4" reference reaches were visited to determine their use for this project. The reaches are listed below:

- UT to South Fork Cane Creek, Chatham County
- Morgan Creek, Orange County
- Spencer Branch, Montgomery County
- Richland Creek, Moore County

Richland Creek was selected as a reference reach for the McCain Site. In addition, a second suitable reference reach site was located on the project stream (UT to Back Creek), immediately upstream of the project site. Each reference reach is described in Appendix E with the location, description, photographs, and surveyed data.

6.0 RESTORATION DESIGN

The restoration design of the Un-named Tributary to Back Creek (UTBC) is based on a Priority Level 2 approach, as described in "A Geomorphological Approach to Restoration of Incised Rivers", (Rosgen, 1997). For clarity and convenience, definitions of the four restoration priorities are provided in Table 4.

6.1 Stream

The design proposes constructing 2,445 linear feet of meandering channel. The restoration will establish a bankfull channel with a new floodplain, a channel bed at its existing level in an existing gravel layer, and the cross section dimensions necessary to provide stable flow maintenance and sediment transport. The design bankfull stage will equal the floodplain elevation in the new channel (bank height ratio = 1.0). The proposed stream dimension, pattern, and profile will be based on the detailed morphological criteria and hydraulic geometry relationships developed from the reference stream, see Table 5. The establishment of a stable bedform (i.e., riffle-pool sequence, pool spacing) will be addressed in the profiling of the design channel. Refer to Figures 7 through 20 for the proposed channel dimension, pattern and profile.

In-stream structures will be incorporated to reduce the burden of energy dissipation on the channel geometry. J-Vanes (Figure 14: Details) will be used to stabilize the restored channel. These structures are designed to reduce bank erosion and the influence of secondary circulation in the near-bank region of stream bends. The structures further promote efficient sediment transport and produce/enhance in-stream habitat. Coir fiber matting will be used to provide temporary stabilization on the newly graded streambanks. The confluence of tributaries with the restored stream will be stabilized with grade control structures and step sequences where necessary to match the proposed grade of the restored main channel. Excavated materials from the design channel will be used to partially backfill the abandoned channel sections.

The restoration project will also include other non-stream related components:

- Cattle exclusion fencing will be installed along the outer boundary of the restored riparian buffers and a permanent conservation easement will be recorded to protect the site in perpetuity.
- A gate will be provided in the cattle-exclusion fencing and a stabilized stream crossing provided for machinery access to the utility easement.
- Two stabilized stream crossings will be installed to provide cattle and machinery access to isolated pasture areas. Rock fords, fenced on either side to exclude cattle from further accessing the waterway, are recommended measures for these crossings.
- Offline watering devices will be installed at a two locations.

6.2 Riparian Buffers

Native woody and herbaceous species will be used to establish fifty (50) foot wide riparian buffers on both sides of the restored reach. Four hundred thirty-six (436) trees per acre (based on an average 10’ x 10’ spacing) will be planted to achieve a mature survivability of three hundred twenty (320) trees per acre in the riparian zone (DENR, 2001). Plant placement and groupings will be randomized during installation in order to develop a more naturalized appearance in the buffer. Woody vegetation planting will be conducted during dormancy.

Tree and shrub species to be planted may consist of the following:

<u>Trees</u>
American sycamore (*Platanus occidentalis*)
Tulip poplar (*Liriodendron tulipifera*)
Green ash (*Fraxinus pennsylvanica*)
River birch (*Betula nigra*)
Cherrybark oak (*Quercus pagoda*)
Willow oak (*Quercus phellos*)
Water oak (*Quercus nigra*)

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

On the restored stream banks, live stakes will be used in conjunction with the native herbaceous seed mix to provide natural stabilization. Appropriate species identified for live staking include elderberry (*Sambucus canadensis*), silky willow (*Salix sericea*), silky dogwood (*Cornus amomum*), and black willow (*Salix nigra*).

Table 4. Priority Levels of Incised River Restoration.

Description	Methods	Advantages	Disadvantages
Priority 1 Convert G and/or F stream types to C or E at previous elevation with floodplain.	Re-establish channel on previous floodplain using relic channel or construction of new bankfull discharge channel. Design new channel for dimension, pattern, and profile characteristic of stable form. Fill in existing incised channel or with discontinuous oxbow lakes level with new floodplain elevation.	Re-establishment of floodplain and stable channel: 1) reduces bank height and streambank erosion, 2) reduces land loss, 3) raises water table, 4) decreases sediment, 5) improves aquatic and terrestrial habitats, 6) improves land productivity, and 7) improves aesthetics.	1) Floodplain re-establishment could cause flood damage to urban, agricultural, and industrial development. 2) Downstream end of project could require grade control from new to previous channel to prevent head-cutting.
Priority 2 Convert F and/or G stream types to C or E. Re-establishment of floodplain at existing level or higher, but not at original level.	If belt width provides for the minimum meander width ratio for C or E stream types, construct channel in bed of existing channel, convert existing bed to new floodplain. If belt width is too narrow, excavate streambank walls. End-haul material or place in streambed to raise bed elevation and create new floodplain in the deposition.	1) Decreases bank height and streambank erosion, 2) Allows for riparian vegetation to help stabilize banks, 3) Establishes floodplain to help take stress off of channel during flood, 4) Improves aquatic habitat, 5) Prevents wide-scale flooding of original land surface, 6) Reduces sediment, 7) Downstream grade transition for grade control is easier.	1) Does not raise water table back to previous elevation. 2) Shear stress and velocity higher during flood due to narrower floodplain. 3) Upper banks need to be sloped and stabilized to reduce erosion during flood.
Priority 3 Convert to a new stream type without an active floodplain, but containing a floodprone area. Convert G to B stream type, or F to Bc.	Excavation of channel to change stream type involves establishing proper dimension, pattern, and profile. To convert a G to B stream involves an increase in width/depth and entrenchment ratio, shaping upper slopes and stabilizing both bed and banks. A conversion from F to Bc stream type involves a decrease in width/depth ratio and an increase in entrenchment ratio.	1) Reduces the amount of land needed to return the river to a stable form. 2) Developments next to river need not be relocated due to flooding potential. 3) Decreases flood stage for same magnitude flood. 4) Improves aquatic habitat.	1) High cost of materials for bed and streambank stabilization. 2) Does not create the diversity of aquatic habitat. 3) Does not raise water table to previous levels.
Priority 4 Stabilize channel in place.	A long list of stabilization materials and methods have been used to decrease streambed and streambank erosion, including concrete, gabions, boulders, and bioengineering methods.	1) Excavation volumes are reduced. 2) Land needed for restoration is minimal.	1) High cost for stabilization. 2) High risk due to excessive shear stress and velocity. 3) Limited aquatic habitat depending on nature of stabilization methods used.

Source: Rosgen, 1997, "A Geomorphological Approach to Restoration of Incised Rivers".

Table 5. Morphological Design Criteria

McCain Property Stream Restoration				Design Ranges or Target Values	Upstream Reach 10+00 to 12+85	Middle Reach 12+85 to 20+21	Transition Reach 20+21 to 25+51	Lower Reach 25+51 to 34+45	Average Values
SUMMARY		***Stream Type***		B3c/C4					
	*	**W**bkf	(ft)	18.8	18	24	20	18	20
		Dbkf	(ft)	1.1	1.367	1.042	1.28	1.417	1.277
	*	**A**bkf	(sq ft)	21.0	24.6	25	25.6	25.5	25.18
	*	**W**bkf**/D**bkf (W/D)	(ft/ft)	17.0	13.17	23.04	15.63	12.71	16.14
		Dmax	(ft)	2.0	2	1.3	1.7	2	1.75
		Wfpa	(ft)						
		Wfpa**/W**bkf (ER)	(ft/ft)						
	*	**S**ave	(ft/ft)	0.0060	0.006767	0.010447	0.007965	0.006788	0.005246
	*	**K**		1.5					1.254
	*	**D**50	(mm)	26.0					
		D84	(mm)	48.0					
		Vbkf	(ft/sec)	4.8	3.865	3.949	3.918	3.949	3.920
	*	**Q**bkf	(cfs)	100.0	95	99	100	101	
DIMENSION	RIFFLE	**W**bkf	(ft)	18.8	18	24	20	18	20
		Dbkf	(ft)	1.1	1.367	1.042	1.28	1.417	1.277
		Abkf	(sq ft)	21.0	24.6	25	25.6	25.5	25.2
		Dmax	(ft)	2.0	2	1.3	1.7	2	1.75
		Wfpa	(ft)						
		Dtob	(ft)						
		Vbkf	(ft/sec)	4.8	3.865	3.949	3.918	3.949	3.920
		Qbkf	(cfs)	100.0	95	99	100	101	
	RIFFLE RATIOS	**W**bkf**/D**bkf (W/D)	(ft/ft)	17.0	13.17	23.04	15.63	12.71	16.14
		Dmax**/D**bkf	(ft/ft)	1.6	1.463	1.248	1.328	1.411	1.363
		Dtob**/D**max	(ft/ft)						
		Wfpa**/W**bkf (ER)	(ft/ft)						
	POOL	**W**pool	(ft)	28.2	20	24	20	20	21
		Dpool	(ft)	2.2-2.75	3	2.33	2.8	3.33	2.87
		Apool	(sq ft)	62-78	39.5	35.88	36.67	41.64	38.42
	POOL RATIOS	**W**pool**/W**bkf	(ft/ft)	1.5	1.111	1.000	1.000	1.111	1.056
		Dpool**/D**bkf	(ft/ft)	2.0-2.5	2.195	2.236	2.188	2.350	2.242
		Apool**/A**bkf	(ft2/ft2)	2.9-3.6	1.606	1.435	1.432	1.633	1.527
PATTERN		**L**m	(ft)	130-280	190.62	294.34	212	236.34	233.325
		Rc	(ft)	30-60	30-35	50-60	35-40	35-55	30-60
		Wblt	(ft)	100-250					
		K		1.45	1.165	1.201	1.218	1.232	1.254
	RATIOS	**L**m**/W**bkf	(ft/ft)	10 to 14	10.6	12.3	10.6	13.1	11.6
		Rc**/W**bkf	(ft/ft)	1.6-3.2	1.7 to 1.9	2.1 to 2.5	1.8 to 2	1.9 to 3.1	2.16
		Wblt**/W**bkf	(ft/ft)	5-13					
PROFILE		**S**val	(ft/ft)	0.0080	0.0061116	0.0100368	0.007699	0.0063411	0.0065785
		Save	(ft/ft)	0.0060	0.005246	0.008357	0.006321	0.005147	0.005246
		Sriffle	(ft/ft)	.01-.014	0.006767	0.010447	0.007965	0.006768	
		Spool	(ft/ft)		0.002899	0.005208	0.004226	0.002757	
		Lriffle	(ft)	28-75	57.83	88.48	59.4	66.57	68.8
		Lpool	(ft)	56-94	37.48	58.7	46.59	51.6	50
		P to **P**	(ft)	56-188	95.31	147.17	106	118.17	116.66
	RATIOS	**S**riffle**/S**ave	(ft/ft)	2.4-2.8	1.290	1.250	1.260	1.315	1.279
		Spool**/S**ave	(ft/ft)		0.553	0.623	0.669	0.536	0.595
		Lriffle**/W**bkf	(ft/ft)	1.5-4.0	3.213	3.687	2.970	3.698	3.392
		Lpool**/W**bkf	(ft/ft)	3-5	2.082	2.446	2.330	2.867	2.431
		P to **P/W**bkf	(ft/ft)	5-7	5.295	6.132	5.300	6.565	5.823

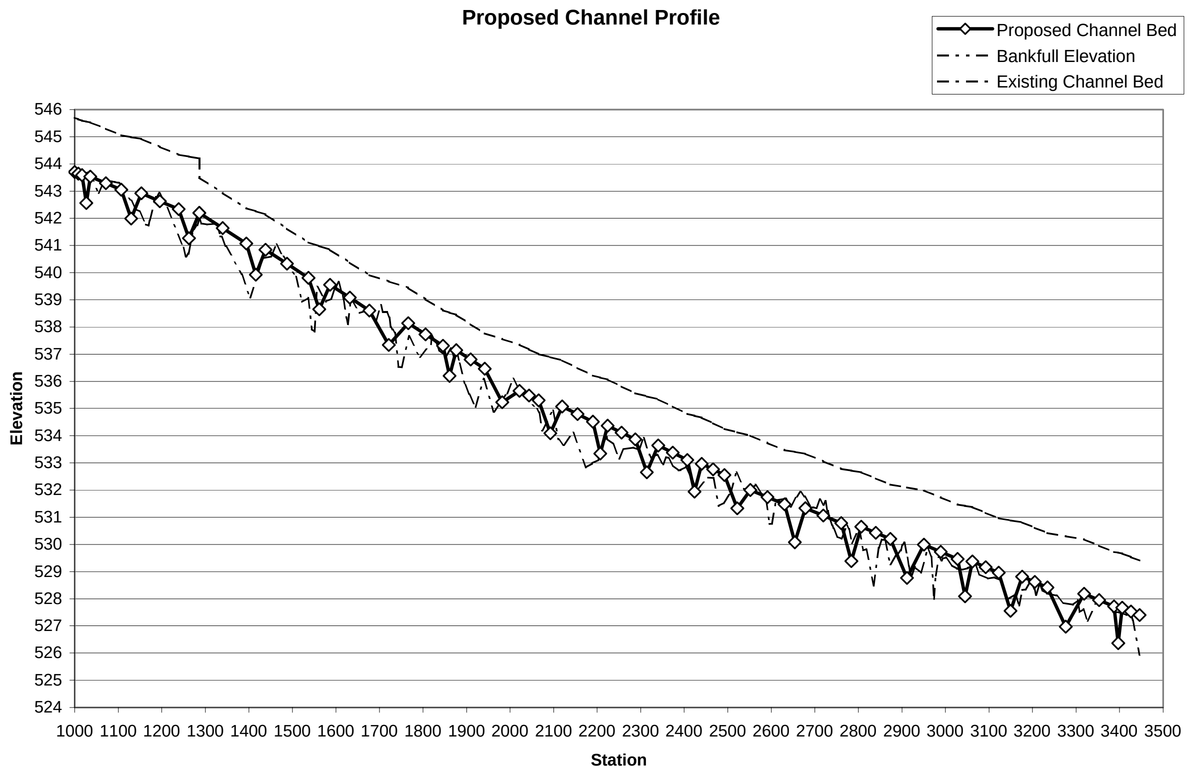


Figure 7. Stream Profile.

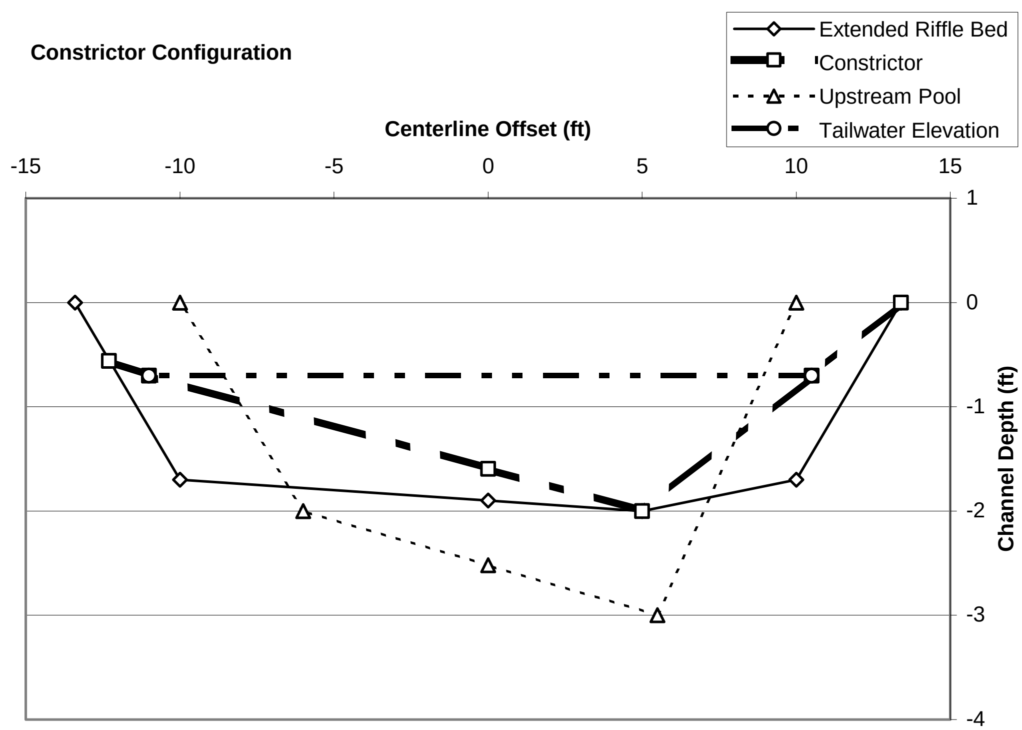


Figure 8. Constrictor Cross Section at Station 12+86 to 13+16.

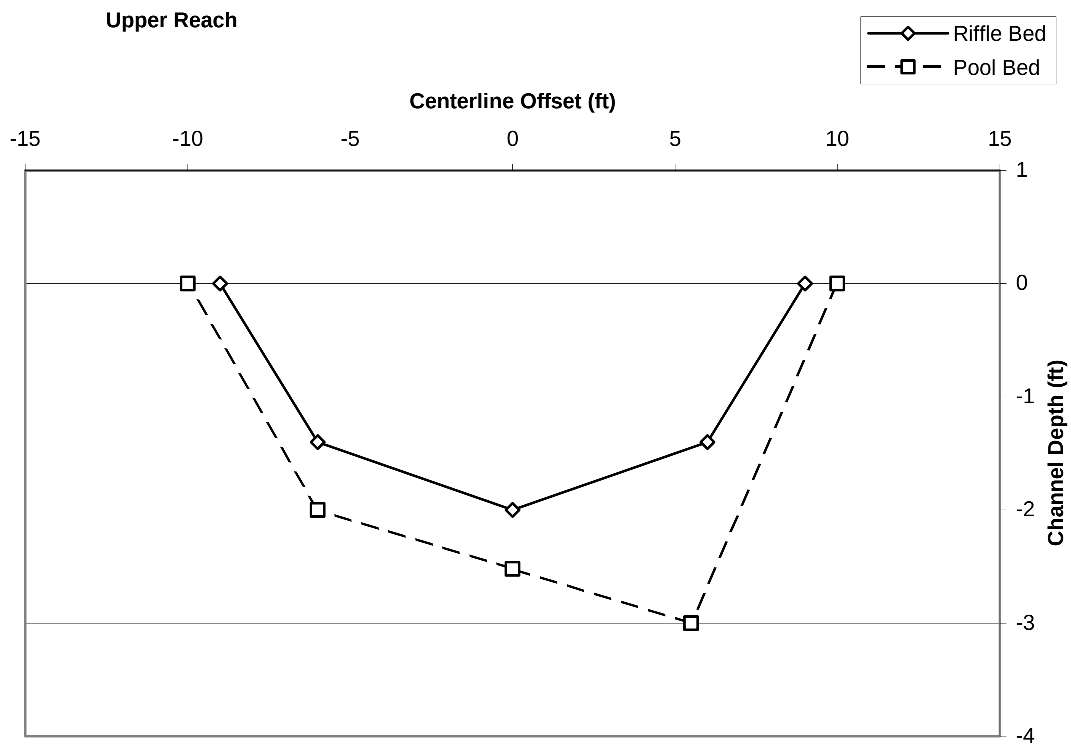


Figure 9. Proposed Cross-sections: Sta. 10+00 to12+86.

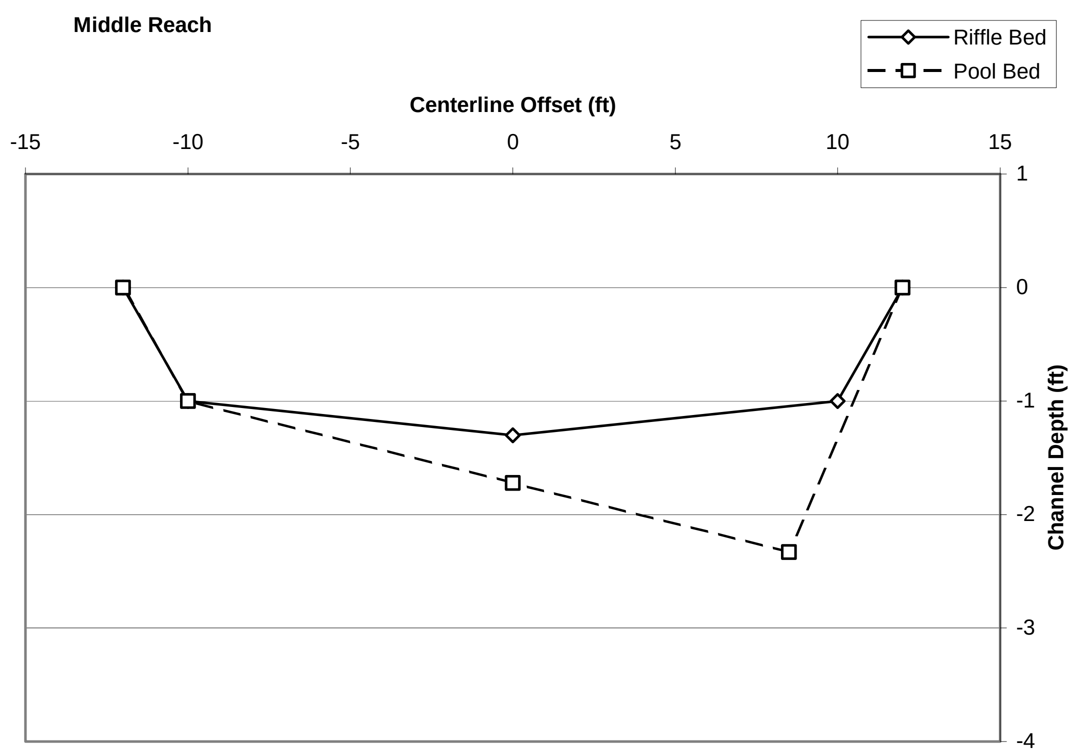


Figure 10. Proposed Cross-sections: Sta. 12+86 to 20+22.

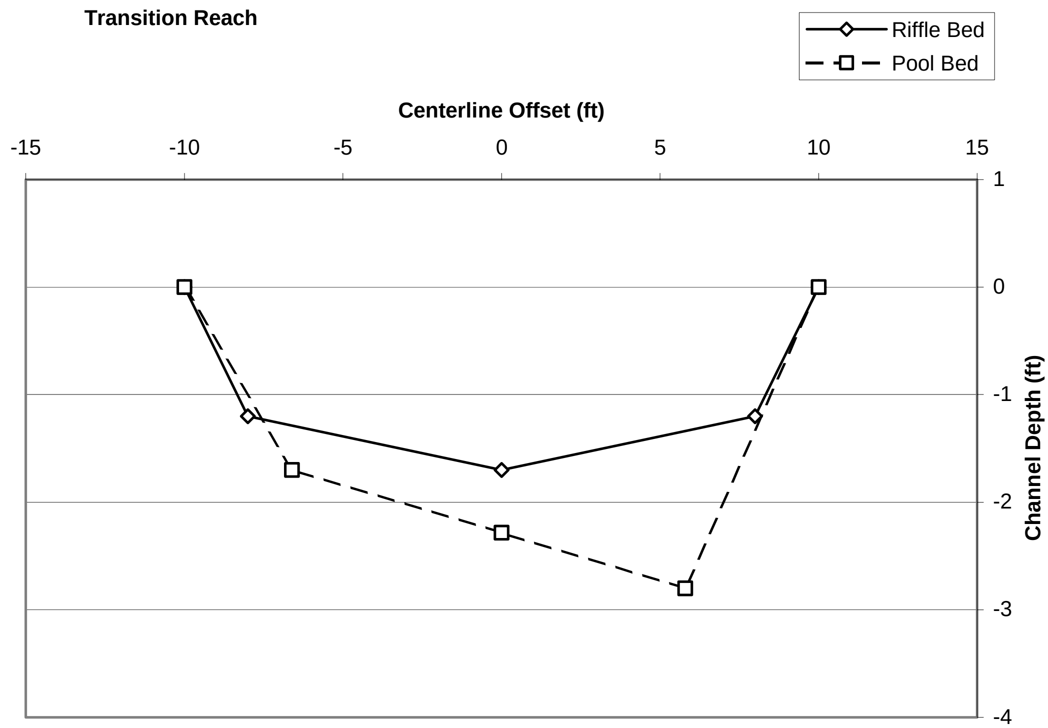


Figure 11. Proposed Cross-sections: Sta. 20+22 to 25+52.

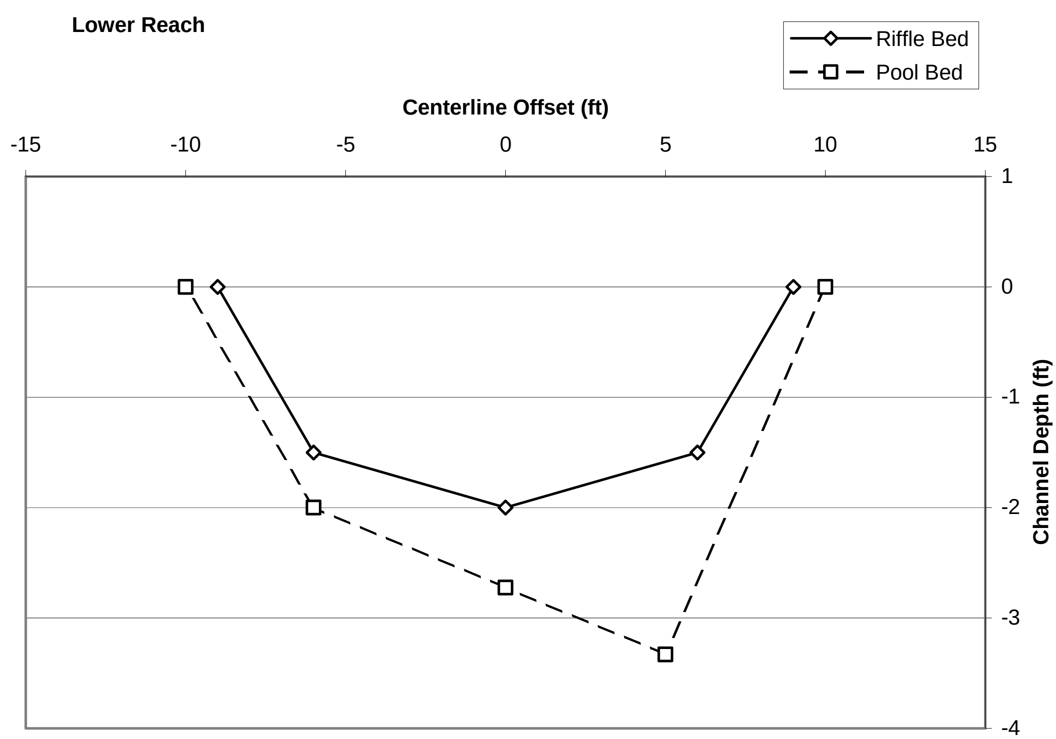


Figure 12. Proposed Cross-sections: Sta. 25+52 to 34+46.

STATE PROJECT: 020594001

STATE	STATE PROJECT NUMBER	SHEET NO.	TOTAL SHEETS
N.C.	020594001	1	8

SYM.	DESCRIPTION	DATE	APPROVED

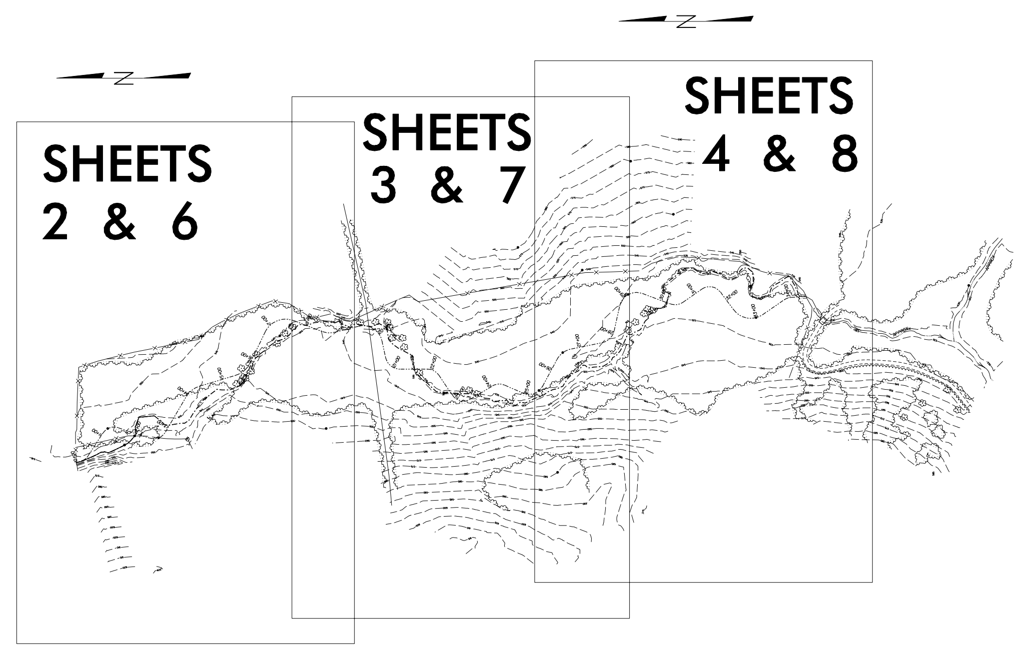
REVISIONS

STATE OF NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

RANDOLPH COUNTY

LOCATION: McCAIN PROPERTY
UN–NAMED TRIBUTARY TO BACK CREEK
SOPHIA, NORTH CAROLINA

TYPE OF WORK: STREAM RESTORATION



SEMI–FINAL DESIGN PLANS

GRAPHIC SCALES

–40 –20 0 40 80
PLANS

–40 –20 0 40 80
PROFILE (HORIZONTAL)

–4 –2 0 4 8
PROFILE (VERTICAL)

PROJECT LENGTH

STREAM RESTORATION LENGTH = 2,445 FEET

Prepared In the Office of:

KCI Associates
of North Carolina, P.A.
SUITE 220 LANDMARK CENTER II, 4601 SIX FORKS RD., RALEIGH NC
ENGINEERS • PLANNERS • ECOLOGISTS

PROJECT START DATE:

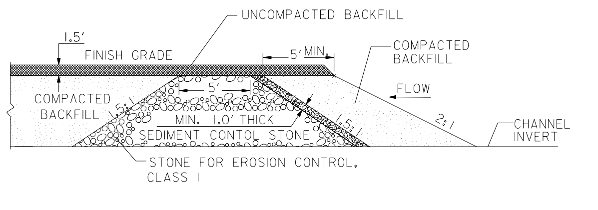
PROJECT ENGINEER

PROJECT ENGINEER

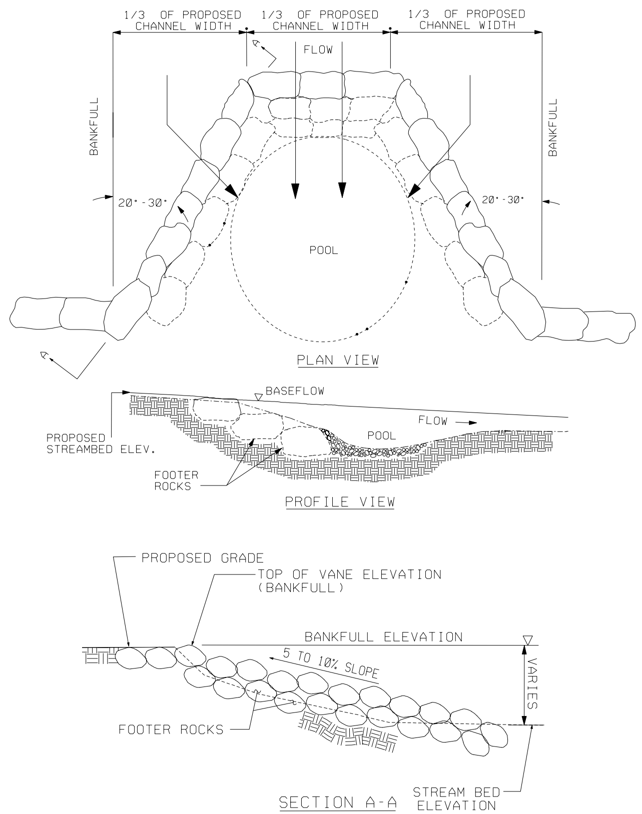
P.E.

SIGNATURE:

Prepared for:

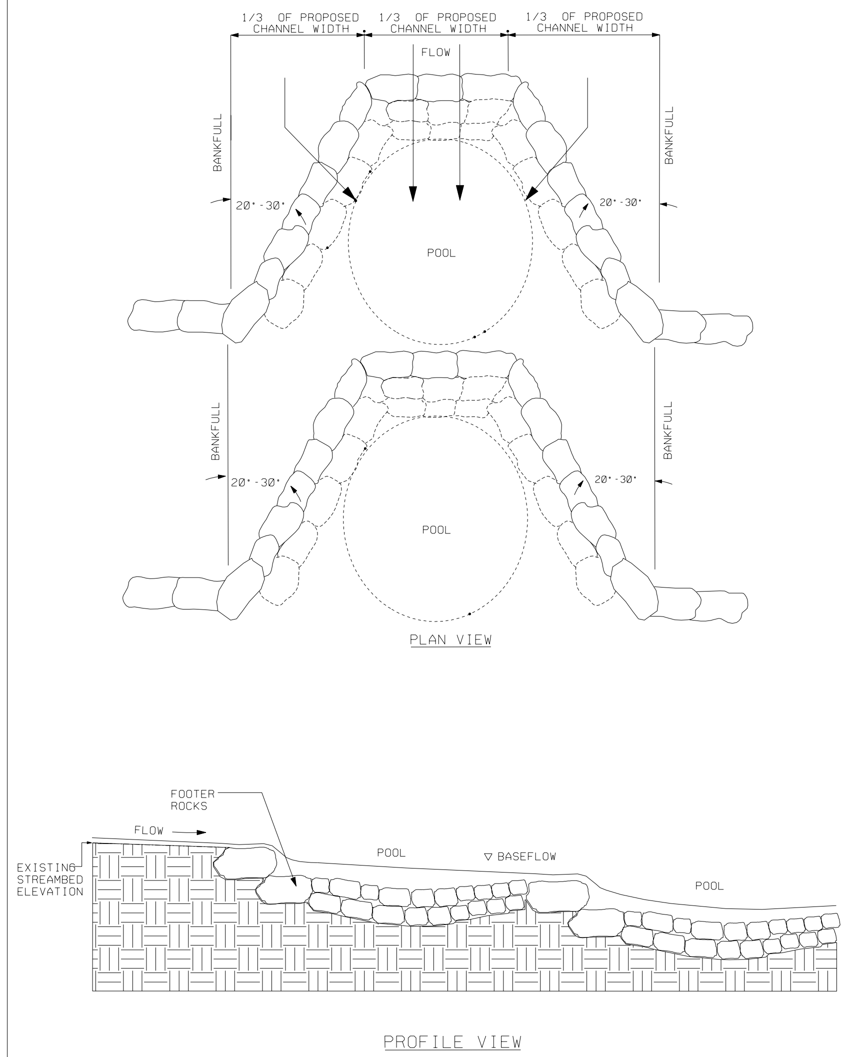


CHANNEL BLOCK
SCALE: NTS



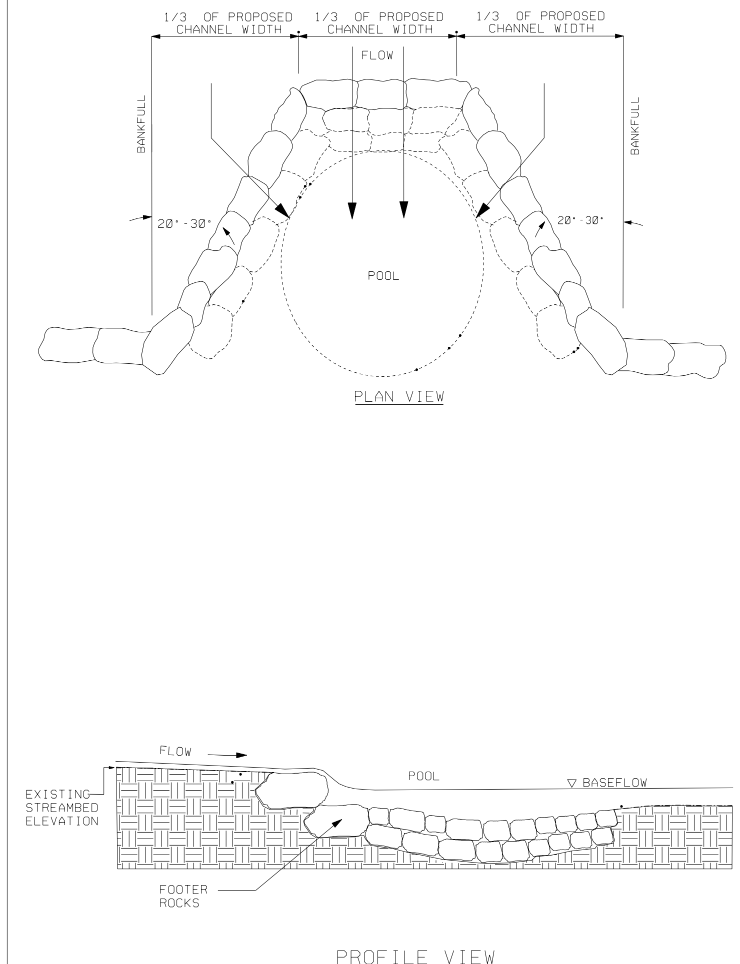
CROSS VANE
SCALE: NTS

*** NOTE: ALL ROCKS OR STONES ARE STONE, BOULDERS



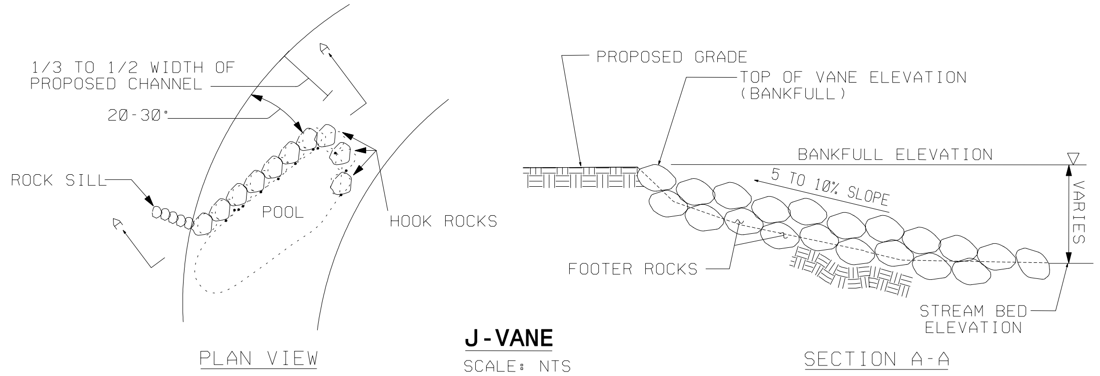
DOUBLE STEP POOL - CROSS VANE
SCALE: NTS

*** NOTE: ALL ROCKS OR STONES ARE STONE BOULDERS OR CLASS II



SINGLE STEP POOL - CROSS VANE
SCALE: NTS

*** NOTE: ALL ROCKS OR STONES ARE STONE BOULDERS OR CLASS II



J-VANE
SCALE: NTS

*** NOTE: ALL ROCKS OR STONES IN THE VANE STRUCTURE ARE STONE, BOULDERS
*** NOTE: GAPS SHOULD BE PLACED ONLY BETWEEN THE HOOK ROCKS

REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

Ecosystem Enhancement PROGRAM

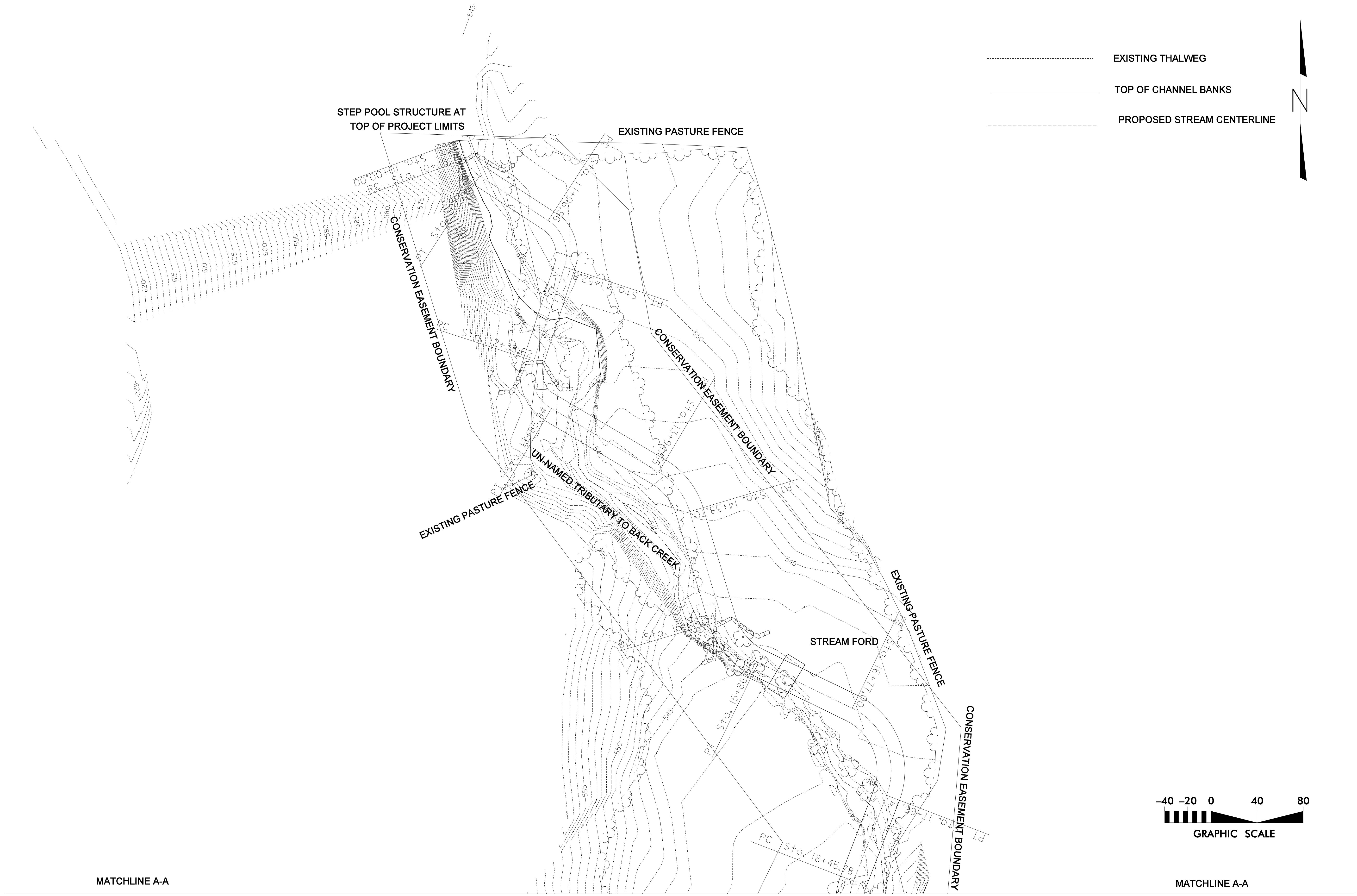
KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

McCAIN PROPERTY - UT TO BACK CREEK STREAM RESTORATION PROJECT
SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA
STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005
SCALE: 1" = 40'

DETAILS

FIGURE 14
SHEET 2 OF 8



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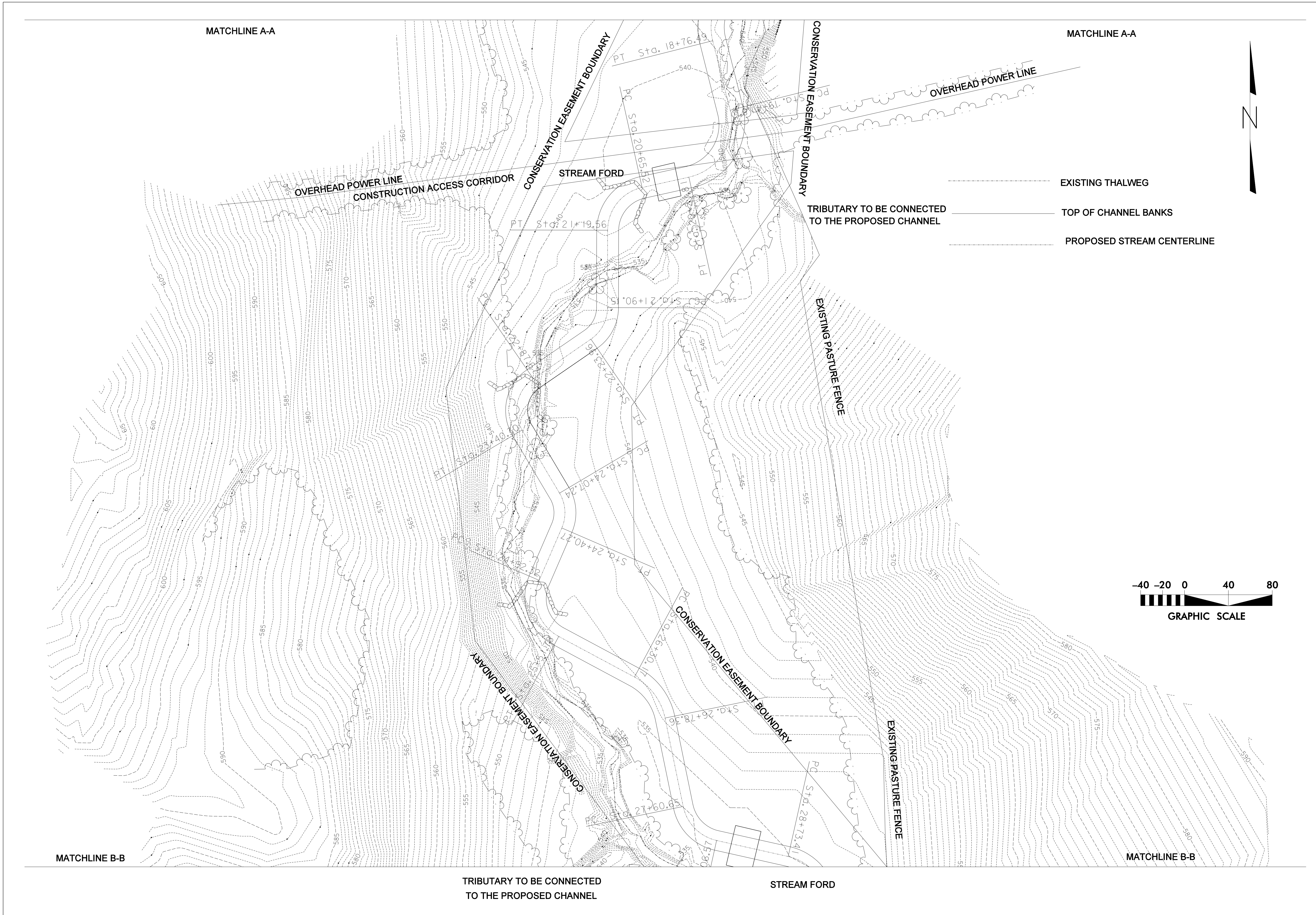
STREAM RESTORATION PROJECT
SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA
STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005
SCALE: 1" = 40'

GRADING PLAN 1

FIGURE 15

SHEET 3 OF 8



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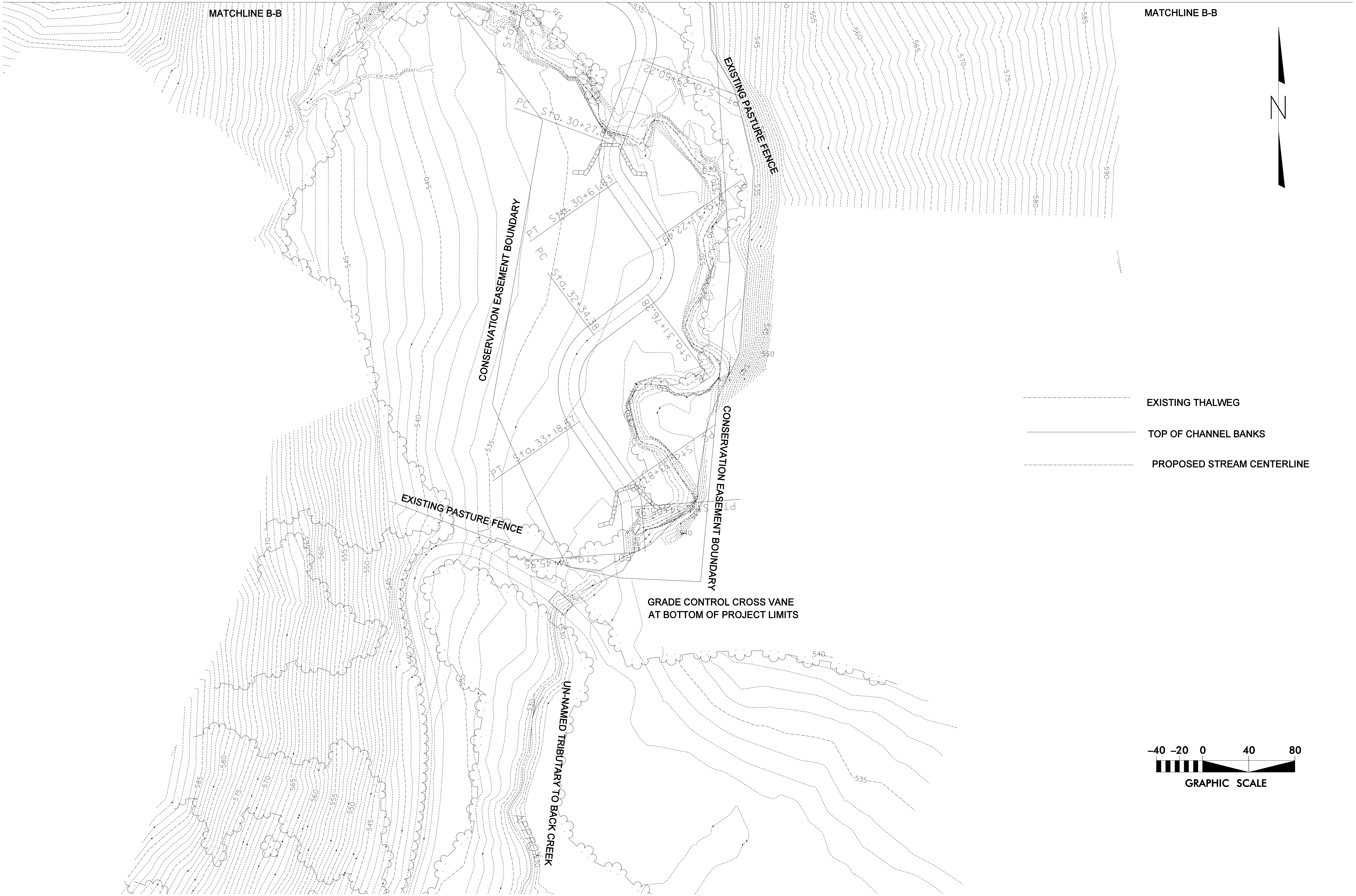
McCAIN PROPERTY - UT TO BACK CREEK
STREAM RESTORATION PROJECT
SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA
STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005
SCALE: 1" = 40'

GRADING PLAN 2

FIGURE 16
SHEET 4 OF 8



SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

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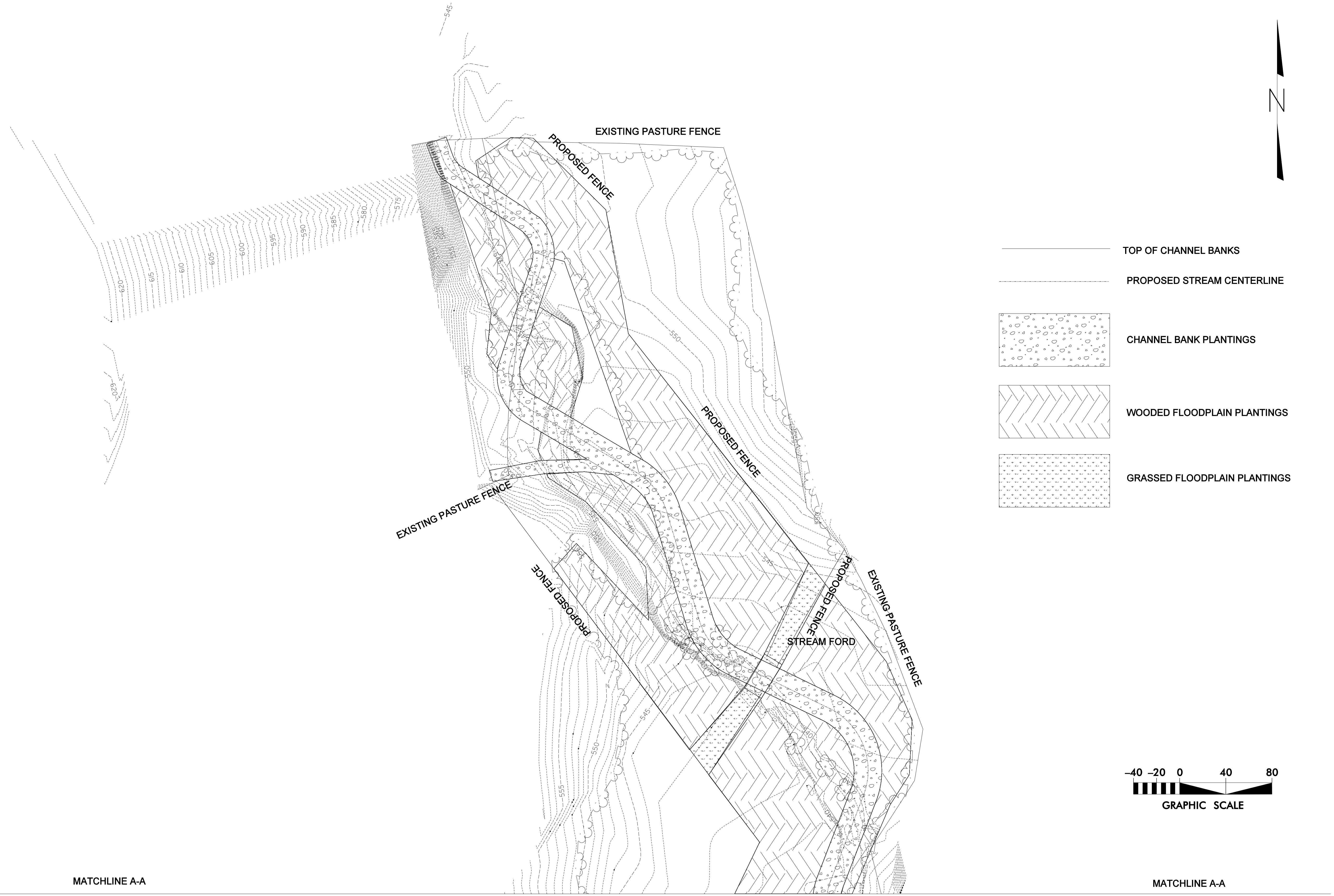
McCAIN PROPERTY - UT TO BACK CREEK
STREAM RESTORATION PROJECT
SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA
STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005
SCALE: 1" = 40'

GRADING
PLAN 3

FIGURE 17
SHEET 5 OF 8



SYM.	DESCRIPTION	DATE	APPROVED

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RALEIGH, NORTH CAROLINA 27609

McCAIN PROPERTY - UT TO BACK CREEK
STREAM RESTORATION PROJECT
SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA

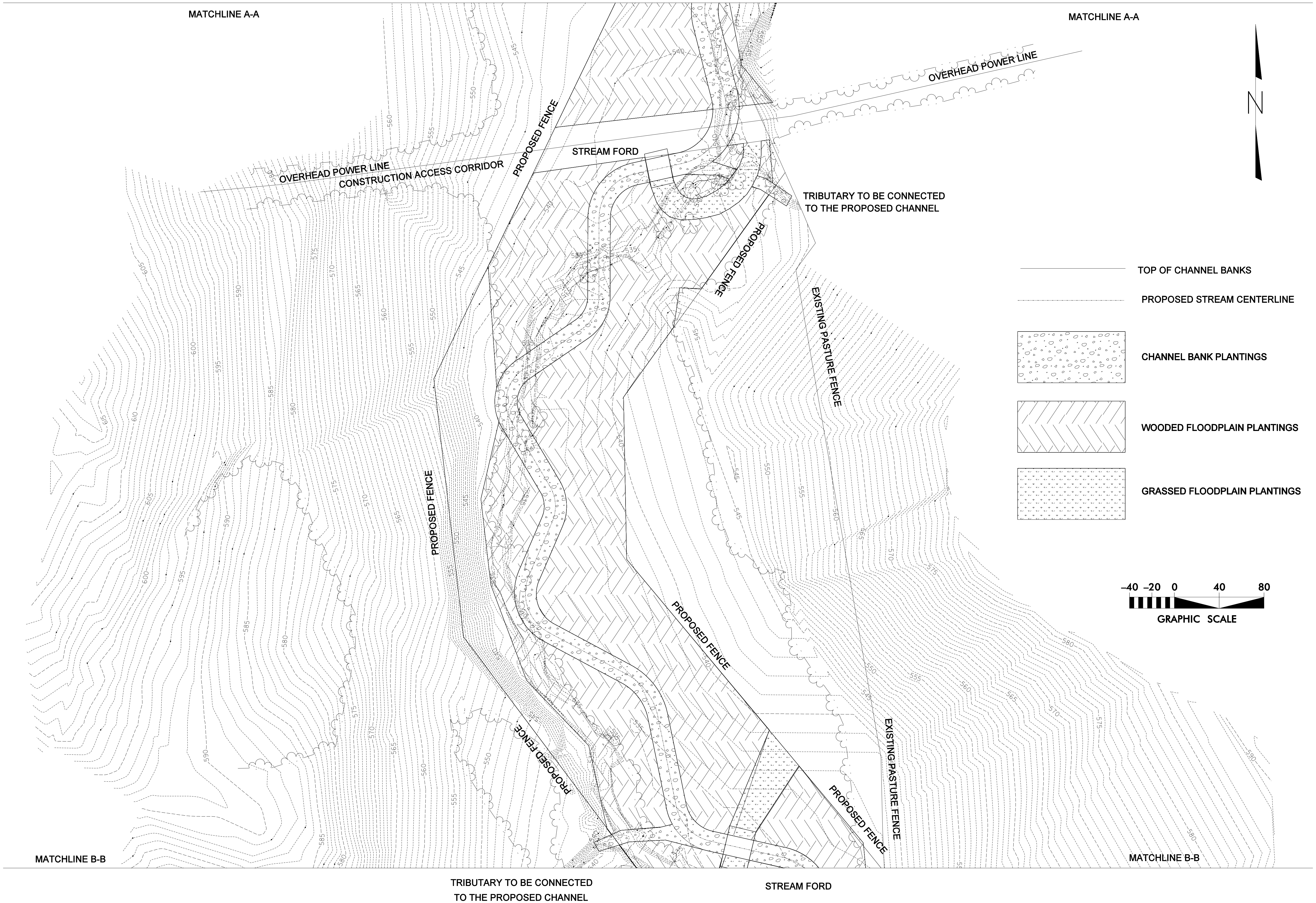
STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005
SCALE: 1" = 40'

LANDSCAPE PLAN 1

FIGURE 18

SHEET 6 OF 8



SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

Ecosystem Enhancement PROGRAM

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

McCAIN PROPERTY - UT TO BACK CREEK STREAM RESTORATION PROJECT

SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA

STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005

SCALE: 1" = 40'

LANDSCAPE PLAN 2

FIGURE 19

SHEET 7 OF 8

TOP OF CHANNEL BANKS

PROPOSED STREAM CENTERLINE

CHANNEL BANK PLANTINGS

WOODED FLOODPLAIN PLANTINGS

GRASSED FLOODPLAIN PLANTINGS

–40 –20 0 40 80

GRAPHIC SCALE

SYM. | DESCRIPTION | DATE | APPROVED

REVISIONS

Ecosystem Enhancement PROGRAM

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

McCAIN PROPERTY - UT TO BACK CREEK STREAM RESTORATION PROJECT

SOPHIA, RANDOLPH COUNTY, NORTH CAROLINA

STATION 10+00.00 TO STATION 34+45

DATE: FEBRUARY, 2005

SCALE: 1" = 40'

PLANTING PLAN 3

FIGURE 20

SHEET 8 OF 8

7.0 SEDIMENT TRANSPORT ANALYSIS

A stable channel is able to move the sediment supplied by its watershed without aggrading or degrading. This ability is evaluated through two parameters: competency and capacity. Competency is the channel's ability to move particles of a certain size, expressed as units of Pascals (Pa) or lbs/ft^2. Capacity is the channel's ability to move a specific volume of sediment (sediment discharge). Sediment discharge is the amount of sediment moving through a cross section over a specified period of time, expressed in dimensionless parameters or as mass or weight units of kg/sec or lbs/sec.

7.1 Competency

Whenever there is any stream flow, there will always be sediment movement. However, there is a threshold level of bedload sediment movement that will result in a noticeable change in the channel bed. The flow associated with this threshold movement is the reference condition that all sediment transport models are based upon. In natural streambeds there are particles of a wide range of sizes. At low, but significant flow levels, only the smallest particles will be moving, with the larger particles resisting the flow of the stream. This is the condition of partial sediment transport. As the stream flow increases, eventually every particle on the streambed will show threshold movement, this is the condition of full sediment transport.

Some streams will routinely reach full sediment transport, such as sand streams, and models such as Ackers & White (1973) are used for these conditions. Some streams will rarely move even the median size particle on the bed (D_{50}), such as cobble-boulder streams, and models such as Andrews (1983, 1994) are used for these conditions. There is a wide range of sand-gravel-cobble streams that have the flow conditions necessary to significantly move particles greater than the D_{50}, but do not reach the full sediment transport condition. This condition is present at the stream channel on the McCain property, and the model used was Wilcock-Crowe (2003), which is actually a "sediment capacity" model (see next section). However, a capacity model must contain an entrainment predictor.

Entrainment is the condition that initiates the movement of a selected particle size in the presence of a mix grade channel bed. If the largest particle that moves during a bankfull event can be identified, then the flow conditions that produced this movement can be determined and this flow condition (the channel competency) is used in the design of the restored stream channel. The preferred method of determining this particle size and flow condition is by direct measurement. However, to stand in a stream channel at bankfull flow with both a flow meter and a sediment sampler is both difficult and extremely unlikely in remote locations. However, a rain gage and stream gages can be installed to measure the stream channel's response to rain events and, in the channel bed, scour chains installed to measure the depth of scour during these events. The bed material above the scour chain can be collected and sieved to determine the material sizes in transport for a known recorded flow event.

The indirect scour chain method was attempted at the McCain site. In addition, the channel was sampled by the pebble count method at several sites for trend analysis and at one scour chain site, the surface and subsurface sediment samples were sieved to compare to the scour chain data. However, the UTBC stream bed has been compacted by cattle and after months of observations, the scour chains never recorded a sediment transport event. Another four sites were sampled for surface and subsurface sediment gradation, including the second scour chain site. Two bar locations were also sampled with the intent of conducting detailed analysis of the sediment data to determine if a design shear stress could be calculated from the Wilcock-Crowe (2003) models.

There are two ways to model streams; first to consider only the largest particle observed in motion (Andrews, 1983) and second to consider all of the bed material observed to be in motion (Andrews, 1994). If the stream channel has a bed of sediment in balance with its flow, then there should be a natural armour layer on the surface, with the subsurface an indication on the annual bedload. An attempt to find a sediment transport balance between the entire surface and subsurface samples was futile. The surface and subsurface had been mixed by the cattle too much to have this balance condition represented in the samples. There was also an attempt to determine if the subsurface could predict the surface D_{50} (and vice versa), which produced encouraging results at two locations. The largest particles found in the surface and subsurface samples were compared to the gradation of the surface samples. This did not produce useful results as the mixing by the cattle had driven large particles into the subsurface (and small particles into the surface that washed away).

The assumption that the subsurface could be an indicator of annual sediment transport was not viable, however a second assumption of balanced streams is that a point bar sample at the so called “1/3, 1/3” location could be an indicator of annual sediment transport. The upstream bar proved to be the wrong kind and the downstream point bar at scour chain site #2 showed a good result when compared to the surface sample at that location. This result compared well to the best of the subsurface modeling. The location of this sediment sample was also well placed for use in the stream restoration design. Scour chain site #2 was well away from the channery deposit at the top end of the site. The surface material in the channel could then represent the gravel layer where the relocated stream channel would be placed.

This model produced an average shear stress condition that would be used in stream design to move the largest particles expected to be in the sediment transport over the expected gradation of the stream channel. This shear stress can be used for the design riffle cross-sections and channel gradient in the various project reaches using the equation:

$$\tau = \gamma R s$$

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

The target shear stress value (converted to a shear-velocity) for the design cross-sections is u* = 0.156 m/s. Supporting sediment transport calculations and rating curves are provided in Appendix F.

7.2 Capacity

A sediment transport capacity analysis was not conducted because the reach on the McCain property is a transport reach. Transport reaches are supply limited and will flush their beds at the end of storms. A realistic sediment transport model cannot be based on a flushed channel bed. The flushed bed cannot predict the movement of the fine materials that make up the bulk of the bedload sediment transport.

8.0 FLOODING ANALYSIS

The Un-named Tributary to Back Creek (UTBC) in Randolph County is not located in a Federal Emergency Management Agency (FEMA) Detailed Flood Study Zone. It is the intent of the restoration design to maintain the 100-year flood elevation at or below the current stages following restoration.

The conversion of an existing, incised stream system to a more open and natural meandering stream will normally reduce flood stages along the project reach. At the downstream end of the project, the stream encounters the floodplain of Back Creek approximately a mile above the Back Creek Lake reservoir. It is not likely that the existing UTBC has any effect on the 100-yr flood stage at this location.

9.0 MONITORING AND EVALUATION

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

9.1 Duration

The first scheduled monitoring will be conducted at the end of the first full growing following project completion. Monitoring shall subsequently be conducted annually for a total period of five (5) years.

9.2 Reporting

Monitoring reports will be prepared and submitted after all monitoring tasks for each monitoring event are completed. Each report will provide the new monitoring data and compare the new data against previous findings. Data tables, cross sections, profiles, photographs and other graphics will be included in the report as necessary. Each report will include a discussion of any significant deviations from the as-built survey and previous annual measurements, as well as evaluations as to whether the changes indicate a stabilizing or de-stabilizing condition.

9.3 Stream Stability

The purpose of monitoring is to evaluate the stability of the restored stream. Following the procedures established in the USDA Forest Service Manual, *Stream Channel Reference Sites* (Harrelson, et.al, 1994) and the methodologies utilized in the Rosgen stream assessment and classification system (Rosgen, 1994 and 1996), data collected will consist of detailed dimension and pattern measurements, a longitudinal profile, and bed materials sampling. Width/depth ratio, entrenchment ratio, low bank height ratio, sinuosity, meander width ratio, radius of curvature (on newly constructed meanders during 1st year monitoring only), pool-to-pool spacing as well as the average, riffle and pool water slopes will be calculated from the collected data. Pebble count data will be plotted by size distribution in order to assess the D50 and D84 size class.

9.3.1 Dimension

Four permanent cross-sections, two riffle and two pool, will be established and used to evaluate stream dimension. At least one riffle and one pool cross-section will be located within the area also surveyed as part of the longitudinal profile. Permanent monuments will be established by either conventional survey or GPS. The cross-section surveys shall provide a detailed measurement of the stream and banks, to include points on the adjacent floodplain, at the top of bank, bankfull, at all breaks in slope, the edge of water, and thalweg. Subsequently, width/depth ratios, entrenchment ratios and bank height ratios will be calculated for each cross-section.

Cross-section measurements should show little change from the as-built cross-sections. If changes do occur, they will be evaluated to determine whether they are minor adjustments associated with settling and increased stability or whether they indicate movement toward an unstable condition.

9.3.2 Pattern
Measurements associated with the restored channel pattern will include belt width, meander length, and radius of curvature (on newly constructed meanders only for the first year). Subsequently, sinuosity, meander width ratio and radius of curvature and meander length/bankfull width ratios will be calculated.

9.3.3 Profile
A longitudinal profile of a representative reach of the restored channel will be surveyed. The profile will extend a minimum of 20 bankfull widths. Measurements will include slopes (average, pool, riffle), as well as calculations of pool-to-pool spacing. Annual measurements should indicate stable bedform features with little change from the as-built survey. The pools should maintain their depth with lower water surface slopes, while the riffles should remain shallower and steeper.

9.3.4 Bed Materials
Pebble counts will be conducted at each riffle cross-section, as well as across the overall study reach (based upon percentage of riffles and pools) for the purpose of classification and to evaluate sediment transport.

9.4 Photograph Reference Points

Photograph reference points (PRP's) will be established to assist in characterizing the site and to allow qualitative evaluation of the site conditions. The location of each photo point will be permanently marked in the field and the bearing/orientation documented to allow for repeated use.

9.4.1 Cross-section Photograph Reference Points
Four (4) photographs will be taken at each permanent cross section, as follows: 1) from the left bank permanent monument/pin showing the right bank, 2) from the right bank permanent monument/pin showing the left bank, 3) from downstream of the cross-section looking upstream, and 4) from upstream of the cross-section looking downstream. The survey tape will be centered in each photograph and the water line will be located near the lower edge. Effort will be made to consistently show the same area in each photograph.

9.4.2 Longitudinal Photograph Reference Points
Ten (10) permanent points will be established longitudinally throughout the project site to allow further photo-documentation of the restored stream channel condition.

9.4.3 Additional Photograph Locations
Additional PRP's will be located, as needed, to document the condition of specific in-stream structures such as J-vanes and cross vanes, as well as infrastructure associated with the stream such as utility and road crossings.

9.5 Bank and Riparian Vegetation Monitoring

Bank and Riparian Vegetation monitoring shall follow the EEP Vegetation Monitoring Protocol, which will be accepted and approved before construction of this project begins.

REFERENCES

Ackers, P. and W.R. White. 1973. Sediment transport: new approach and analysis. Journal of the Hydraulics Division, ASCE, Volume 99, Number HY11, pp. 2041-2060.

Andrews, E.D. (1983) "Entrainment of Gravel from Natural Sorted Riverbed Material," Geological Society of America Bulletin 94, 1225-1231.

Andrews, E.D. (1994) "Marginal Bedload Transport in a Gravel-Bed Stream Channel, Sagehen Creek, California," Water Resources Research, 30 () 2241-2250.

Doll, B.A., D.E. Wise-Frederick, C.M. Buckner, S.D. Wilkerson, W.A. Harman, R.E. Smith, and J. Spooner. 2002. Hydraulic Geometry Relationships for Urban Streams throughout the Piedmont of North Carolina. JAWRA, Volume 38, Number 3, pp. 641-651.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

NCDENR. 2001. "Guidelines for Riparian Buffer Restoration." Division of Water Quality, Wetlands Restoration Program, Raleigh, NC.

NCDENR. 2001. "Interim, Internal Technical Guide: Benthic Macroinvertebrate Monitoring Protocols for Compensatory Stream Restoration Projects." Division of Water Quality, 401 Wetlands Unit, Raleigh, NC.

NCDENR. "Water Quality Stream Classification for Streams in North Carolina." Water Quality Section (http://h2o.enr.state.nc.us/bims/reports/basinsandwaterbodies). September 2002.

NCGS. 1985. Geologic Map of North Carolina

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22: 169-199.

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

Rosgen, D.L. 1997. A geomorphological approach to restoration of incised rivers. In: Wang, S.S.Y., E.J. Langendoen, and F.D. Shields, Jr. (Eds.). Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. pp. 12-22.

Rosgen, D.L. 1998. The Reference Reach – a Blueprint for Natural Channel Design. Proceedings of the Wetland Engineering and River Restoration Conference, Denver, CO, ASCE.

Rosgen, D.L. 2001. "Natural Channel Design Methodology (40 Steps)." Natural Channel Design and River Restoration Short Course, Pagosa Springs, CO – October 2001.

Schafale, M.P. and A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina, 3rd Approximation. North Carolina Natural Heritage Program, NCDEHNR, Division of Parks and Recreation. Raleigh, NC.

Schlindwein, P.A. (2004) "Evolution of Piedmont Floodplains and Stream Channels: Implication for Urban Stream Restoration," *Proceeding of the World Water Resources Congress,* Salt Lake City, UT, EWRI/ASCE

Simon, A. 1989. A model of channel response in distributed alluvial channels. Earth Surface Processes and Landforms. 14(1): 11-26.

USDA. 1971. Soil Survey for Durham County, North Carolina. Natural Resource Conservation Service.

Wilcock, P.R. and Crowe, J.C. (2003). "Surface-Based Transport Model for Mixed-Size Sediment", *Journal of Hydraulic Engineering*, ASCE, 129(2), pp 120-128.

Appendix A

SHPO Documentation

Review Form
Potential Restoration Sites

1. Applicant Information:

Preparer/Company KCI

Address: 4601 Six Forks Rd. ste 220 Raleigh, NC 27609

Phone/Fax/E-mail: 919-783-9214

For North Carolina HPO Use Only

II. Site Information: (Attach copy of USGS map or photocopy of quad on reverse; include I and 2 mile radius around site)

Wetland Restoration Stream Restoration Applicant's Identification #________

Other:________

Address: 2592 Lake Lucas Rd. Sophia, NC 27350

County: Randolph Quad Name: Randleman

III. Identification of Historic Properties:

List sites **by** site number and Status: NR = National Register listed; SL = Study List; DOE = Determination of Eligibility; LID = Local Designation; UA = Unassessed

Archeology

# of recorded sites in immediate area of site: ∅

Architecture

# of recorded sites within 1 mile radius

∅

IV. Additional Information or investigation needed:

No survey rec, provided work w/in banks

__Survey

__Testing of sites ________

Recommended by or on: [illegible] 4/26/05
(Office of State Archaeology)

no PSR

__Photo Reconnaissance

__Balloon Test

Recornrnended by or on:
(Survey & Planning Branch)

V. Recommendations/Final Determination:

__Recommendations for additional work are shown above.

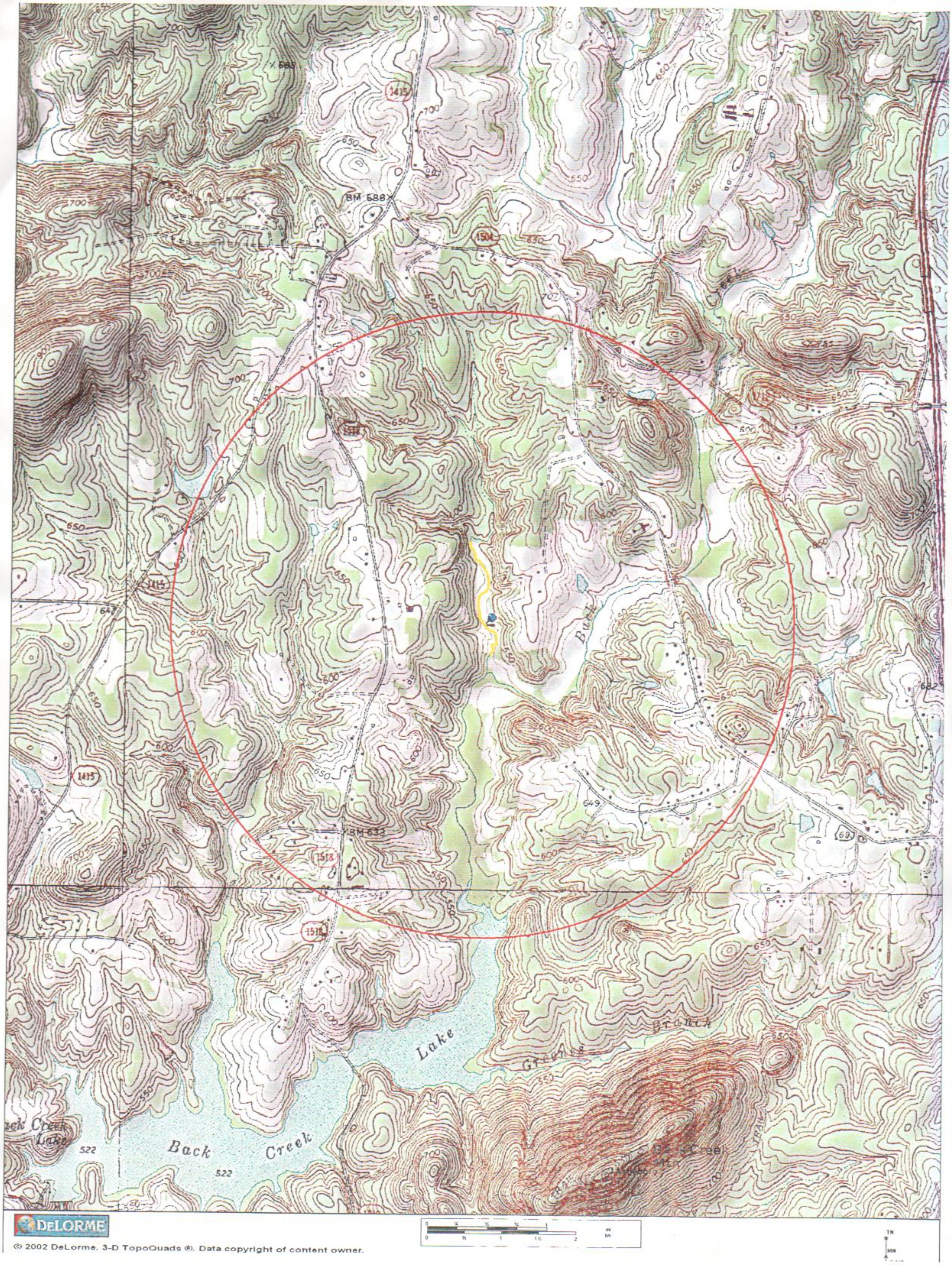
✓ The proposed restoration site will not affect historic properties in the area of potential effect.

Renee Gledhill-Earley

Renee Gledhill-Earley, Environmental Review Coordinator

4-26-05 Date

December 2001



BM 588
BM 633
Back Creek
Lake
Back Creek Lake
Greenes Branch
DeLORME

Appendix B

Natural Heritage Program Findings Letter

NCDENR

North Carolina Department of Environment and Natural Resources
Division of Parks and Recreation

Michael F. Easley, Governor William G. Ross, Jr., Secretary Philip K. McKnelly, Director

May 21, 2003

Ms. Kimberly A. Nimmer
KCI Engineers
Landmark Center I, Suite 200
4601 Six Forks Road
Raleigh, NC 27609

Subject: Stream Restoration Site in Randolph County
KCI Job #:1202084E

Dear Ms. Nimmer:

The Natural Heritage Program has no record of rare species, significant natural communities, or priority natural areas at the site nor within a mile of the project area. Although our maps do not show records of such natural heritage elements in the project area, it does not necessarily mean that they are not present. It may simply mean that the area has not been surveyed. The use of Natural Heritage Program data should not be substituted for actual field surveys, particularly if the project area contains suitable habitat for rare species, significant natural communities, or priority natural areas.

You may wish to check the Natural Heritage Program database website at <www.ncsparks.net/nhp/search.html> for a listing of rare plants and animals and significant natural communities in the county and on the topographic quad map. Please do not hesitate to contact me at 919-715-8687 if you have questions or need further information.

Sincerely,

Harry E. LeGrand, Jr.

Harry E. LeGrand, Jr., Zoologist
Natural Heritage Program

HEL/hel

Rare, Threatened, and Endangered Species and Critical Habitats in Randolph County, NC
NCDENR-Natural Heritage Program

Major Group	Scientific Name	Common Name	State Status	Federal Status	State Rank	Global Rank
Mammal	Condylura cristata pop1	Star-nosed Mole – Coastal Plain population	SC	NA	S2	G5T2Q
Reptile	Crotalus horridus	Timber Rattlesnake	SC	NA	S3	G4
Amphibian	Hemidactylium scutatum	Four-toed salamander	SC	NA	S3	G5
Fish	Notropis Mekistocholas	Cape Fear Shiner	E	E	S1	G1
Mollusk	Alasmidonta undulata	Triangle Floater	T	NA	S2	G4
Mollusk	Alasmidonta varicose	Brook Floater	E	FSC	S1	G3
Mollusk	Fusconaia masoni	Atlantic Pigtoe	E	FSC	S1	G2
Mollusk	Lampsilis cariosa	Yellow Lampmussel	E	FSC	S1	G3G4
Mollusk	Lampsilis radiata conspicua	Carolina Fatmucket	T	NA	S1?	G5T2Q
Mollusk	Strophitus undulates	Squawfoot	T	NA	S2S3	G5
Mollusk	Toxolasma pullus	Savannah Lilliput	E	FSC	S1	G2
Mollusk	Villosa constricta	Notched Rainbow	SC	NA	S3	G3
Mollusk	Villosa delumbis	Eastern Creekshell	SR	NA	S3	G4
Mollusk	Villosa vaughaniana	Carolina Creekshell	E	FSC	S2	G2
Crustacean	Cambarus catagius	Greensboro Burrowing Crayfish	SC	NA	S2	G3
Insect	Gomphus abbreviatus	Spine-crowned Clubtail	SR	NA	S3?	G3G4
Vascular Plant	Amorpha schwerinii	Piedmont Indigo-bush	SR-T	NA	S3	G3
Vascular Plant	Aster georgianus	Georgia Aster	T	C	S2	G2G3
Vascular Plant	Berberis canadensis	American Barberry	SR-T	NA	S2	G3
Vascular Plant	Cardamine dissecta	Dissected Toothwort	SR-P	NA	S2	G4?
Vascular Plant	Helianthus schweinitzii	Schweinitz’s Sunflower	E	E	S2	G2
Vascular Plant	Hexalectris spicata	Crested Coralroot	SR-P	NA	S2	G5
Vascular Plant	Ruellia purshiana	Pursh’s Wild-petunia	SR-O	NA	S2	G3?

Vascular Plant	Schoenoplectus etuberculatus	Canby's Bulrush	SR-P	NA	S3	G3G4
Natural Community	Basic Mesic Forest (Piedmont Subtype)	NA	NA	NA	S2	G5T3
Natural Community	Basic Oak-Hickory Forest	NA	NA	NA	S3	G4
Natural Community	Dry Oak-Hickory Forest	NA	NA	NA	S4	G5
Natural Community	Dry-Mesic Oak-Hickory Forest	NA	NA	NA	S5	G5
Natural Community	Floodplain Pool	NA	NA	NA	S2	G3?
Natural Community	Low Elevation Seep	NA	NA	NA	S3	G4?
Natural Community	Mesic Mixed Hardwood Forest (Piedmont Subtype)	NA	NA	NA	S4	G5T5
Natural Community	Piedmont Monadnock	NA	NA	NA	S4	G5
Natural Community	Piedmont/Coastal Plain Acidic Cliff	NA	NA	NA	S2?	G4
Natural Community	Piedmont/Coastal Plan Heath Bluff	NA	NA	NA	S3	G4?
Natural Community	Piedmont/Low Mountain Alluvial Forest	NA	NA	NA	S5	G5
Natural Community	Rocky Bar and Shore	NA	NA	NA	S5	G5
Natural Community	Upland Depression Swamp Forest	NA	NA	NA	S2	G3
Natural Community	Upland Pool	NA	NA	NA	S1	G1
Natural Community	Xeric Hardpan Forest	NA	NA	NA	S3	G3G4

State Status:
SC – Special Concern
E – Endangered
T – Threatened
SR – Significantly Rare
-T – Throughout
-P – Peripheral
-O – Other

Federal Status:
E – Endangered
FSC – Federal "Species of Concern"
C – Candidate

<u>State Rank:</u>

S1 – Critically imperiled in North Carolina because of extreme rarity or otherwise very vulnerable to extirpation in the state.
S2 – Imperiled in North Carolina because of rarity or otherwise vulnerable to extirpation in the state.
S3 – Rare or uncommon in North Carolina.
S4 – Apparently secure in North Carolina, with many occurrences.
S5 – Demonstrably secure in North Carolina and essentially ineradicable under present conditions.
S? – Unranked, or rank uncertain.

<u>Global Rank:</u>

G1 – Critically imperiled globally because of extreme rarity or otherwise very vulnerable to extinction throughout its range.
G2 – Imperiled globally because of rarity or otherwise vulnerable to extinction throughout its range.
G3 – Either very rare and local throughout its range, or found locally in a restricted area.
G4 – Apparently secure globally, although it may be quite rare in parts of its range (especially at the periphery).
G5 – Demonstrably secure globally, although it may be quite rare in parts of its range (especially at the periphery).
G? – Unranked, or rank uncertain.
G_T_ - Status of subspecies or variety; the G-rank refers to the species as a whole, the T-rank to the subspecies.

Appendix C

Project Site Existing Conditions Data

Photograph 1 – View of UTBC prior to entering project site, looking upstream from Station 10+00 across the McCain property boundary.

Photograph 2 – View looking upstream at top of project site. Logs in stream in upper right of photo mark station 10+00. Scour along the right bank is predominantly into weathered bedrock.


Photograph 3 – Weathered bedrock along right bank and in UTBC streambed (Station 10+20 to 10+35).


Photograph 4 – View downstream at Cross-section 1.

Photograph 5 - Barbed wire fence crossing stream that has caused a debris jam.

Photograph 6 – View downstream at Cross-section 2.

Photograph 7 – Undercut left bank at Cross-section 2, top of bank overhangs ~2.3 feet.

Photograph 8 – View looking downstream of confluence with small unnamed tributary, entering from lower right in photo (~Station 13+25 – 13+50).

Photograph 9 – View looking downstream below confluence of tributary with UTBC. Bedrock along right bank and in stream, steep bank above bedrock on right bank (Station 13+50 to 14+00).

Photograph 10 – View looking downstream, meander pattern of UTBC is visible in the lower right of the photo, moving to the left. Steep, eroding banks occur on the outside meander bank with bar formation on the inside bank.

Photograph 11 – Looking downstream at debris jam across UTBC channel, right bank undercut with exposed roots upstream of jam (Station ~15+50).

Photograph 12 – High-traffic cattle crossing, with boulders along the left bank and in the stream channel (Station ~16+15).

Photograph 13 – Boulder/cobble bar along steep right bank, cattle access in right foreground; small sod island with two small trees near left bank.

Photograph 14 – View downstream toward power line easement, upstream of bend to the right in UTBC.

Photograph 15 – Confluence of UT2 with UTBC along left bank (Station ~19+50). Note transverse boulder/cobble bar extending across channel upstream of confluence. Fence marking property boundary is visible along top of photo.

Photograph 16 – Headcut along Trib 2 at property boundary, approximately 50 feet upstream from confluence with UTBC.


Photograph 17 – View upstream from Station 20+25. Note large gravel and cobble bar along left bank. Steep right bank in foreground; further upstream right bank has been worn down from cattle access.


Photograph 18 – Cattle crossing at near Station 20+50. Cobbles and boulders in stream channel, possibly placed to help stabilize crossing. Banks flattened from cattle access, increasing channel width/depth ratio.

Photograph 19 – Ceramic drainage tile about four inches in diameter at base of right bank (Station ~21+00).

Photograph 20 –Sinkholes in right bank extending approximately 30 feet from top of bank, possibly associated with drainage tile (Station ~21+00).

Photograph 21 – Manmade cattle watering hole, set back approximately 40 feet from right bank (Station ~22+00).

Photograph 22 – View downstream, gravel and cobble bar with grass along left bank. Both banks are relatively steep, though the right bank has more hoof shear. Right floodplain extends approximately 20 feet back from the top of right bank to the toe of slope.


Photograph 23 – View downstream; right bank has significant erosion from cattle access. Large overhanging tree on left bank with roots exposed from undercutting.


Photograph 24 – Confluence of UT3 with UTBC along right bank, significant erosion due to cattle access.


Photograph 25 – Headcut along UT3, approximately 50 feet upstream of confluence with UTBC.


Photograph 26 – Concrete pipe along UT3, above headcut.

Photograph 27 – A portion of the flow in UT3 crosses a field towards the right bank of UTBC. The channel appears to be newly formed, either due to overbank flow or was excavated to redirect flow.

Photograph 28 – View downstream of fallen tree and large debris jam across UTBC.

Photograph 29 – View downstream of left bank bench and gravel bar, erosion of right bank from cattle access.

Photograph 30 – View downstream of channel constricted between large trees on each bank. Bank undercutting has left roots exposed.


Photograph 31 – High-traffic cattle crossing. Note meander bend downstream of cattle crossing, with large tree on each bank.


Photograph 32 – Bedrock in streambed at cattle crossing.


Photograph 33 – Sinkholes in riparian area approximately 30 feet from right bank of UTBC. Maximum depth is approximately two feet.


Photograph 34 – View downstream of series of debris jams. The disruption of flow has caused localized bank erosion and the formation of plunge pools. Fence line approximately 20 feet from left top of bank marks property boundary.

Photograph 35 – Downstream view. Left bank is nearly vertical; right bank is sloped back due to cattle access.

Photograph 36 – Downstream view at Cross-section 3, located at crossover point between two sharp meander bends. Near-vertical right bank and sloping left bank are an indication of down-valley meander migration.


Photograph 37 – Downstream view of Cross-section 4, located on meander with bed morphology that has been significantly disturbed. Channel flow has both run and pool characteristics.


Photograph 38 – Downstream view of UTBC. Unstable banks, undercutting around large tree on right bank has left roots exposed. Further downstream, a large uprooted tree on the right bank has fallen away from stream into riparian area.

Photograph 39 – Debris jam at downstream end of project, caused by barbed wire fence crossing stream at the property boundary.

Photograph 40 – Concrete slab crossing stream channel approximately 20 feet downstream of project boundary.

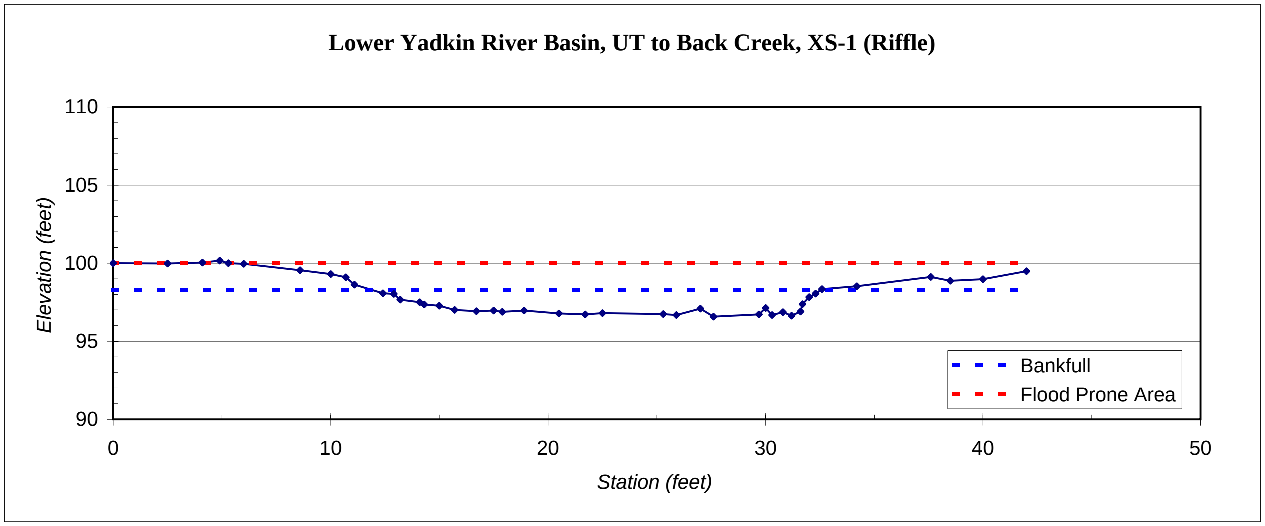
Photograph 41 – View upstream from right bank riparian area at downstream end of project. Overall stream pattern influenced by alternating toe slopes as the stream progresses down valley.

River Basin:	Lower Yadkin
Watershed:	UT to Back Creek
XS ID	XS-1 (Riffle)
Drainage Area (sq mi):	0.74
Date:	April 25, 2003
Field Crew:	KN, DR, KB

Station	**Rod Ht.**	**Elevation**
0	4.55	100.00
2.5	4.57	99.98
4.1	4.51	100.04
4.9	4.39	100.16
5.3	4.56	99.99
6	4.6	99.95
8.6	5.01	99.54
10	5.24	99.31
10.7	5.45	99.10
11.1	5.92	98.63
12.4	6.47	98.08
12.9	6.52	98.03
13.2	6.89	97.66
14.1	7.04	97.51
14.3	7.19	97.36
15	7.28	97.27
15.7	7.55	97
16.7	7.62	96.93
17.5	7.58	96.97
17.9	7.67	96.88
18.9	7.59	96.96
20.5	7.77	96.78
21.7	7.82	96.73
22.5	7.75	96.8
25.3	7.81	96.74
25.9	7.86	96.69
27	7.47	97.08
27.6	7.98	96.57
29.7	7.83	96.72
30	7.42	97.13
30.3	7.86	96.69
30.8	7.69	96.86
31.2	7.91	96.64
31.6	7.64	96.91
31.7	7.18	97.37
32	6.72	97.83
32.3	6.49	98.06
32.6	6.21	98.34
34.2	6.02	98.53
37.6	5.44	99.11
38.5	5.67	98.88
40	5.57	98.98
42	5.07	99.48

SUMMARY DATA	
Bankfull Elevation:	98.29
Bankfull Cross-Sectional Area:	21.30
Bankfull Width:	19.36
Flood Prone Area Elevation:	100.01
Flood Prone Width:	34.00
Max Depth at Bankfull:	1.72
Mean Depth at Bankfull:	1.10
W / D Ratio:	17.6
Entrenchment Ratio:	1.76
Bank Height Ratio:	1.03
Slope (ft/ft):	0.011
Discharge (cfs)	83.93
D_{50} XS1	22
D_{50} Profile 1	35

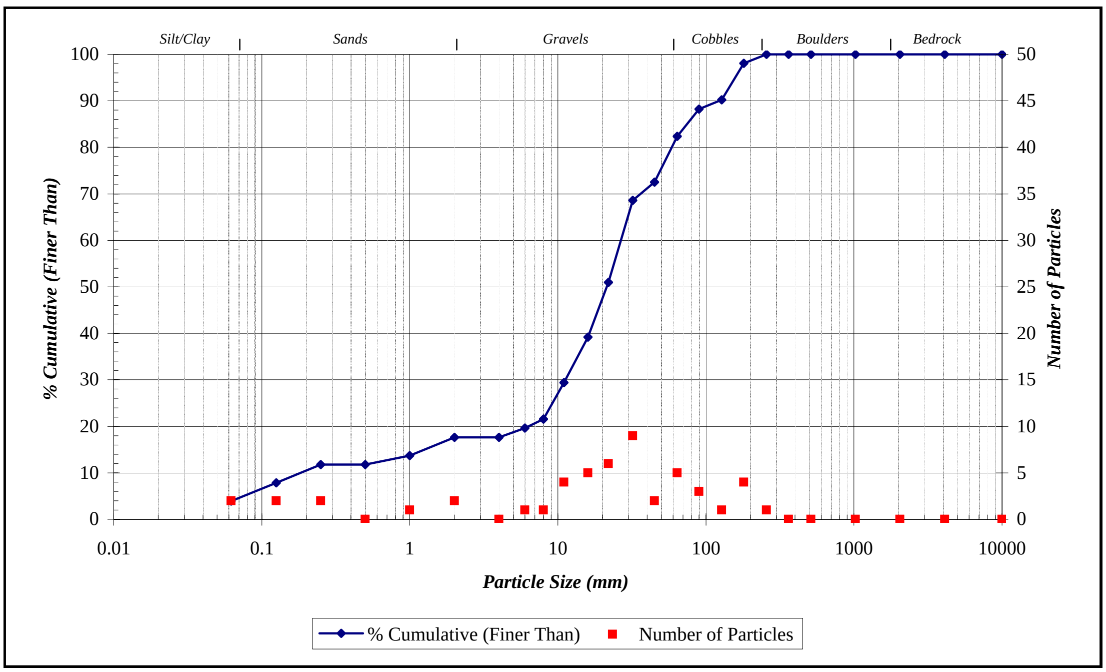
Stream Type:	B4c



McCain Site Restoration Plan
Existing Conditions

Stream:	UT to Back Creek
Location:	Cross-section #1 (Sta 1+33)
Date:	4/25/2003

Particle		Size Range (mm)	Total #	Item %	% Cum.
S/C	Silt/Clay	0 < 0.062	2	4	4
Sand	Very Fine Sand	0.062 < 0.125	2	4	8
	Fine Sand	0.125 < 0.25	2	4	12
	Medium Sand	0.25 < 0.50	0	0	12
	Coarse Sand	0.50 < 1.0	1	2	14
	Very Coarse Sand	1 < 2	2	4	18
Gravel	Very Fine Gravel	2 < 4	0	0	18
	Fine Gravel	4 < 6	1	2	20
	Fine Gravel	6 < 8	1	2	22
	Medium Gravel	8 < 11	4	8	29
	Medium Gravel	11 < 16	5	10	39
	Coarse Gravel	16 < 22	6	12	51
	Coarse Gravel	22 < 32	9	18	69
	Very Coarse Gravel	32 < 45	2	4	73
	Very Coarse Gravel	45 < 64	5	10	82
Cbl	Small Cobble	64 < 90	3	6	88
	Medium Cobble	90 < 128	1	2	90
	Large Cobble	128 < 180	4	8	98
	Very Large Cobble	180 < 256	1	2	100
Bldr	Small Boulder	256 < 362	0	0	100
	Small Boulder	362 < 512	0	0	100
	Medium Boulder	512 < 1024	0	0	100
	Large Boulder	1024 < 2048	0	0	100
	Very Large Boulder	2048 < 4096	0	0	100
Bdrk	Bedrock	Bedrock	0	0	100
		Totals:	51	100	100



Size percent less than (mm)				
D16	D35	D50	D84	D95
1.6	14	22	70	160

Percent by substrate type (%)					
Silt/Clay	Sand	Gravel	Cobble	Boulder	Bedrock
4	14	65	18	0	0

McCain Site Restoration Plan

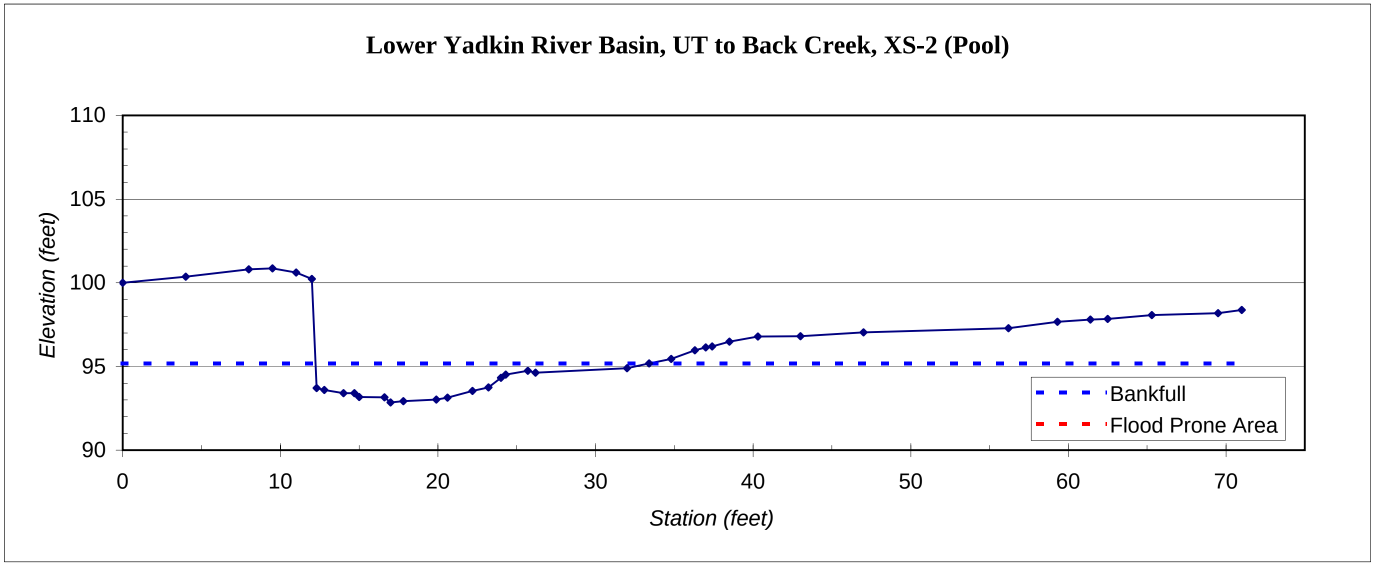
Existing Conditions

River Basin:	Lower Yadkin
Watershed:	UT to Back Creek
XS ID	XS-2 (Pool)
Drainage Area (sq mi):	0.74
Date:	April 24, 2003
Field Crew:	KN, DR, KB

Stream Type:	B4c

Station	Rod Ht.	Elevation
0	2.08	100.00
4	1.71	100.37
8	1.27	100.81
9.5	1.22	100.86
11	1.46	100.62
12	1.86	100.22
12.3	8.38	93.70
12.8	8.48	93.60
14	8.68	93.40
14.7	8.67	93.41
15	8.91	93.17
16.6	8.92	93.16
17	9.24	92.84
17.8	9.16	92.92
19.9	9.05	93.03
20.6	8.95	93.13
22.2	8.55	93.53
23.2	8.34	93.74
24	7.75	94.33
24.3	7.56	94.52
25.7	7.34	94.74
26.2	7.45	94.63
32	7.19	94.89
33.4	6.9	95.18
34.8	6.63	95.45
36.3	6.12	95.96
37	5.95	96.13
37.4	5.89	96.19
38.5	5.59	96.49
40.3	5.29	96.79
43	5.27	96.81
47	5.04	97.04
56.2	4.8	97.28
59.3	4.41	97.67
61.4	4.27	97.81
62.5	4.24	97.84
65.3	4.02	98.06
69.5	3.89	98.19
71	3.7	98.38

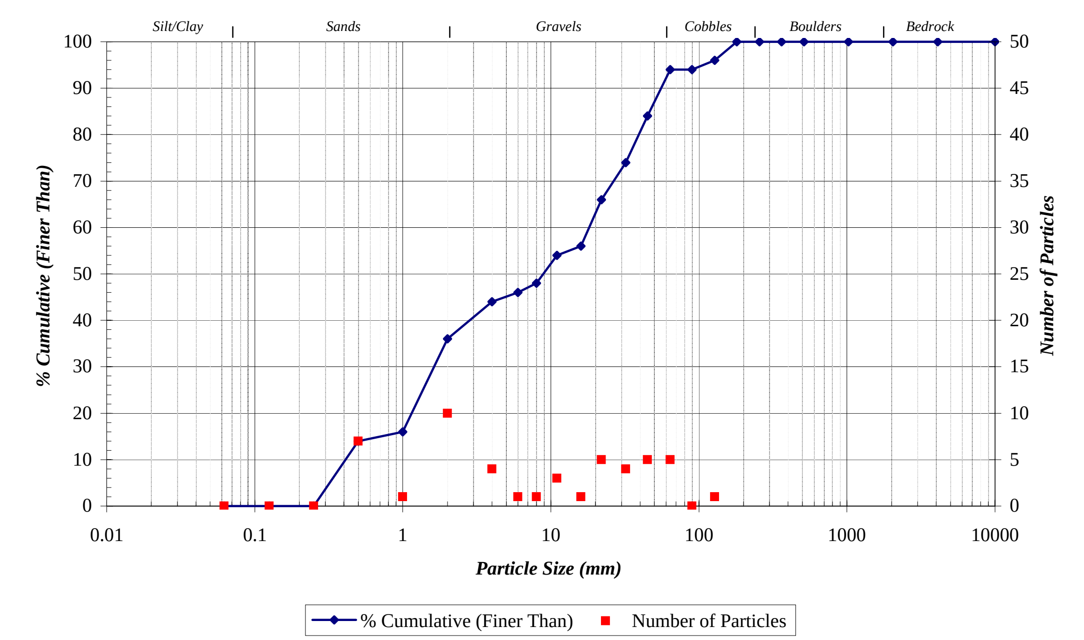
SUMMARY DATA	
Bankfull Elevation:	95.18
Bankfull Cross-Sectional Area:	26.00
Bankfull Width:	21.17
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.34
Mean Depth at Bankfull:	1.23
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA
Slope (ft/ft):	0.0002
Discharge (cfs)	NA
D_{50} XS2	9
D_{50} Profile 1	35



McCain Site Restoration Plan
Existing Conditions

Stream:	UT to Back Creek
Location:	Cross-section #2 (Sta 2+68)
Date:	4/24/2003

Particle		Size Range (mm)	Total #	Item %	% Cum.
S/C	Silt/Clay	0 < 0.062	0	0	0
Sand	Very Fine Sand	0.062 < 0.125	0	0	0
	Fine Sand	0.125 < 0.25	0	0	0
	Medium Sand	0.25 < 0.50	7	14	14
	Coarse Sand	0.50 < 1.0	1	2	16
	Very Coarse Sand	1 < 2	10	20	36
Gravel	Very Fine Gravel	2 < 4	4	8	44
	Fine Gravel	4 < 6	1	2	46
	Fine Gravel	6 < 8	1	2	48
	Medium Gravel	8 < 11	3	6	54
	Medium Gravel	11 < 16	1	2	56
	Coarse Gravel	16 < 22	5	10	66
	Coarse Gravel	22 < 32	4	8	74
	Very Coarse Gravel	32 < 45	5	10	84
	Very Coarse Gravel	45 < 64	5	10	94
Cbl	Small Cobble	64 < 90	0	0	94
	Medium Cobble	90 < 128	1	2	96
	Large Cobble	128 < 180	2	4	100
	Very Large Cobble	180 < 256	0	0	100
Bldr	Small Boulder	256 < 362	0	0	100
	Small Boulder	362 < 512	0	0	100
	Medium Boulder	512 < 1024	0	0	100
	Large Boulder	1024 < 2048	0	0	100
	Very Large Boulder	2048 < 4096	0	0	100
Bdrk	Bedrock	Bedrock	0	0	100
		Totals:	50	100	100



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.9	1.9	9	45	110

Percent by substrate type (%)					
Silt/Clay	Sand	Gravel	Cobble	Boulder	Bedrock
0	36	58	6	0	0

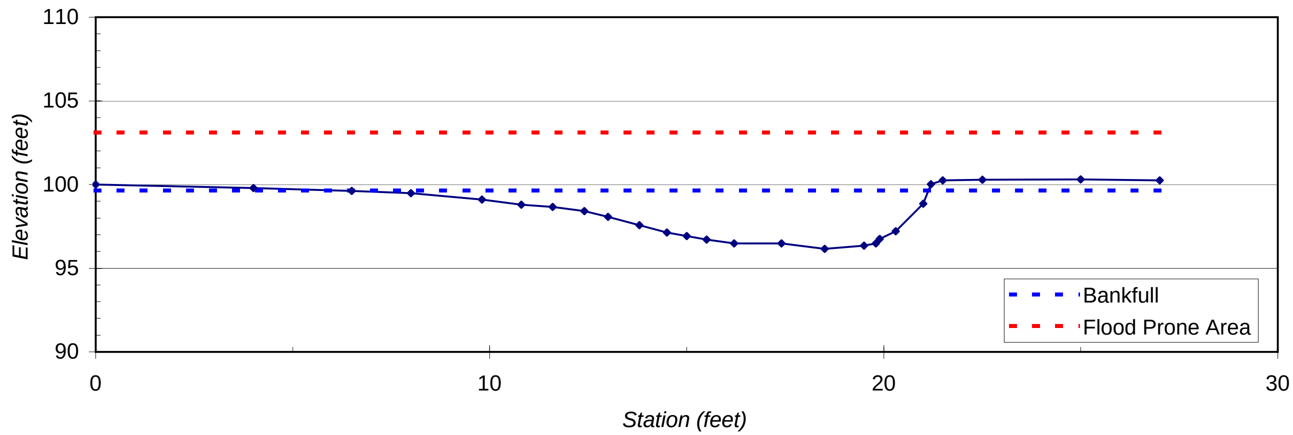
River Basin:	Lower Yadkin
Watershed:	UT to Back Creek
XS ID	XS-3 (Riffle/Run)
Drainage Area (sq mi):	0.87
Date:	April 24, 2003
Field Crew:	KN, DR, KB

Station	Rod Ht.	Elevation
0	5.11	100.00
4	5.32	99.79
6.5	5.5	99.61
8	5.62	99.49
9.8	6	99.11
10.8	6.31	98.80
11.6	6.44	98.67
12.4	6.69	98.42
13	7.05	98.06
13.8	7.53	97.58
14.5	7.97	97.14
15	8.19	96.92
15.5	8.39	96.72
16.2	8.62	96.49
17.4	8.62	96.49
18.5	8.95	96.16
19.5	8.76	96.35
19.8	8.63	96.48
19.9	8.37	96.74
20.3	7.91	97.20
21	6.25	98.86
21.2	5.1	100.01
21.5	4.86	100.25
22.5	4.82	100.29
25	4.81	100.3
27	4.87	100.24

SUMMARY DATA	
Bankfull Elevation:	99.64
Bankfull Cross-Sectional Area:	25.70
Bankfull Width:	14.63
Flood Prone Area Elevation:	103.12
Flood Prone Width:	125.00
Max Depth at Bankfull:	3.48
Mean Depth at Bankfull:	1.76
W / D Ratio:	8.3
Entrenchment Ratio:	8.54
Bank Height Ratio:	0.99
Slope (ft/ft):	0.0014
Discharge (cfs)	61.44
D_{50} XS3	0.34
D_{50} Profile 2	0.2

Stream Type:	E5

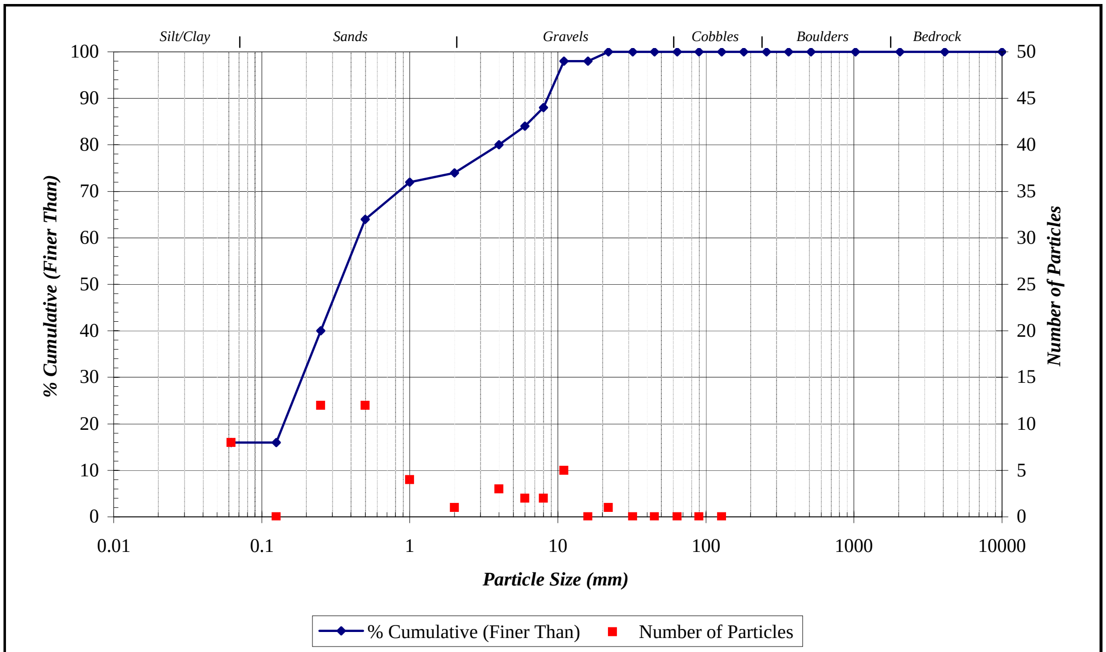
Lower Yadkin River Basin, UT to Back Creek, XS-3 (Riffle/Run)



McCain Site Restoration Plan
Existing Conditions

Stream:	UT to Back Creek
Location:	Cross-section #3 (Sta 21+42)
Date:	4/24/2003

Particle		Size Range (mm)	Total #	Item %	% Cum.
S/C	Silt/Clay	0 < 0.062	8	16	16
Sand	Very Fine Sand	0.062 < 0.125	0	0	16
	Fine Sand	0.125 < 0.25	12	24	40
	Medium Sand	0.25 < 0.50	12	24	64
	Coarse Sand	0.50 < 1.0	4	8	72
	Very Coarse Sand	1 < 2	1	2	74
Gravel	Very Fine Gravel	2 < 4	3	6	80
	Fine Gravel	4 < 6	2	4	84
	Fine Gravel	6 < 8	2	4	88
	Medium Gravel	8 < 11	5	10	98
	Medium Gravel	11 < 16	0	0	98
	Coarse Gravel	16 < 22	1	2	100
	Coarse Gravel	22 < 32	0	0	100
	Very Coarse Gravel	32 < 45	0	0	100
	Very Coarse Gravel	45 < 64	0	0	100
Cbl	Small Cobble	64 < 90	0	0	100
	Medium Cobble	90 < 128	0	0	100
	Large Cobble	128 < 180	0	0	100
	Very Large Cobble	180 < 256	0	0	100
Bldr	Small Boulder	256 < 362	0	0	100
	Small Boulder	362 < 512	0	0	100
	Medium Boulder	512 < 1024	0	0	100
	Large Boulder	1024 < 2048	0	0	100
	Very Large Boulder	2048 < 4096	0	0	100
Bdrk	Bedrock	Bedrock	0	0	100
		Totals:	50	100	100



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.062	0.22	0.34	6	10

Percent by substrate type (%)					
Silt/Clay	Sand	Gravel	Cobble	Boulder	Bedrock
16	58	26	0	0	0

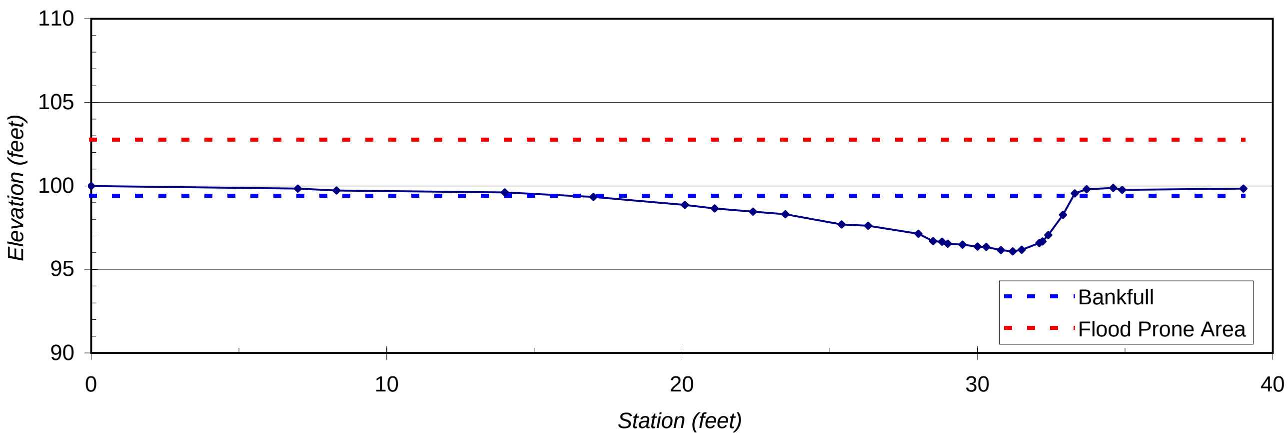
River Basin:	Lower Yadkin
Watershed:	UT to Back Creek
XS ID	XS-4 (Run/Pool)
Drainage Area (sq mi):	0.87
Date:	April 24, 2003
Field Crew:	KN, DR, KB

Station	Rod Ht.	Elevation
0	5.33	100.00
7	5.49	99.84
8.3	5.6	99.73
14	5.72	99.61
17	6	99.33
20.1	6.47	98.86
21.1	6.68	98.65
22.4	6.87	98.46
23.5	7.03	98.30
25.4	7.64	97.69
26.3	7.72	97.61
28	8.19	97.14
28.5	8.64	96.69
28.8	8.67	96.66
29	8.79	96.54
29.5	8.84	96.49
30	8.97	96.36
30.3	8.99	96.34
30.8	9.17	96.16
31.2	9.25	96.08
31.5	9.15	96.18
32.1	8.76	96.57
32.2	8.66	96.67
32.4	8.27	97.06
32.9	7.06	98.27
33.3	5.79	99.54
33.7	5.54	99.79
34.6	5.46	99.87
34.9	5.57	99.76
39	5.5	99.83

SUMMARY DATA	
Bankfull Elevation:	99.42
Bankfull Cross-Sectional Area:	29.30
Bankfull Width:	19.41
Flood Prone Area Elevation:	102.76
Flood Prone Width:	125.00
Max Depth at Bankfull:	3.34
Mean Depth at Bankfull:	1.51
W / D Ratio:	12.9
Entrenchment Ratio:	6.44
Bank Height Ratio:	1.06
Slope (ft/ft):	0.0025
Discharge (cfs)	87.76
D_{50} XS4	0.2
D_{50} Profile 2	0.2

Stream Type:	C5

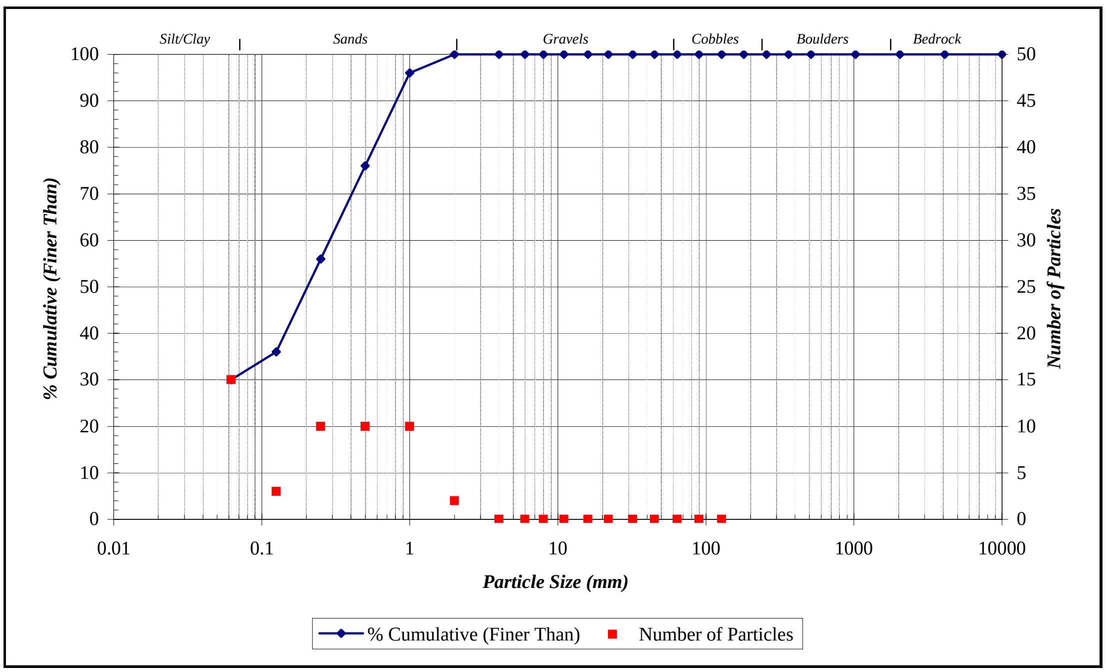
Lower Yadkin River Basin, UT to Back Creek, XS-4 (Run/Pool)



McCain Site Restoration Plan
Existing Conditions

Stream:	UT to Back Creek
Location:	Cross-section #4 (Sta 22+85)
Date:	4/24/2003

Particle		Size Range (mm)	Total #	Item %	% Cum.
S/C	Silt/Clay	0 < 0.062	15	30	30
Sand	Very Fine Sand	0.062 < 0.125	3	6	36
	Fine Sand	0.125 < 0.25	10	20	56
	Medium Sand	0.25 < 0.50	10	20	76
	Coarse Sand	0.50 < 1.0	10	20	96
	Very Coarse Sand	1 < 2	2	4	100
Gravel	Very Fine Gravel	2 < 4	0	0	100
	Fine Gravel	4 < 6	0	0	100
	Fine Gravel	6 < 8	0	0	100
	Medium Gravel	8 < 11	0	0	100
	Medium Gravel	11 < 16	0	0	100
	Coarse Gravel	16 < 22	0	0	100
	Coarse Gravel	22 < 32	0	0	100
	Very Coarse Gravel	32 < 45	0	0	100
	Very Coarse Gravel	45 < 64	0	0	100
Cbl	Small Cobble	64 < 90	0	0	100
	Medium Cobble	90 < 128	0	0	100
	Large Cobble	128 < 180	0	0	100
	Very Large Cobble	180 < 256	0	0	100
Bldr	Small Boulder	256 < 362	0	0	100
	Small Boulder	362 < 512	0	0	100
	Medium Boulder	512 < 1024	0	0	100
	Large Boulder	1024 < 2048	0	0	100
	Very Large Boulder	2048 < 4096	0	0	100
Bdrk	Bedrock	Bedrock	0	0	100
		Totals:	50	100	100



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.062	0.11	0.2	0.65	0.95

Percent by substrate type (%)					
Silt/Clay	Sand	Gravel	Cobble	Boulder	Bedrock
30	70	0	0	0	0

Appendix D

Stream Design & Spreadsheets

Stream Design Strategy

In the layout of the relocated stream design, the natural stability of the planform was of great concern. The two natural ranges for **R**c/**W**bkf and **PP/W**bkf were targeted. However it was only after the second design iteration that these values were attained.

The allocation of the stream drop across the proposed profile had to match the three general reach gradients of the existing profile. After the first design iteration, it became obvious that there was going to be a hydraulic drop issue at the upstream gradient increase and a slope transition would be required at the downstream reduction in stream gradient. Because of concerns over a reduction in bed roughness along the steeper portion of the relocated alignment, the **S**riffle/**S**ave ratio was kept low and the **L**riffle/**L**pool ratio kept high. These two values are expected to adjust as the relocated channel sorts its bed over time. Also the **D**pool/**D**bkf ratio was held within a natural range, which results in the **W**pool/**W**bkf ratio being very low and out of range.

In cross section, the concern over the proposed channel bed roughness resulted to a reduction in both **D**bkf and the **W/D** ratio. As a consequence the **A**bkf was higher and **V**bkf lower than the target values.

The combination of planform, profile and dimension adjustments met the design shear velocity target value, which is an indication that the channel would remain stable once it is taken away from the valley walls and place back into an existing alluvial layer in the bottom of the valley.

At the upstream channel gradient transition, a hydraulic drop will result from the differences in the stream channel **W/D** ratios. To remedy this drop and prevent a headcut from proceeding upstream, a flow constrictor was designed to manage the energy of this water surface drop. The flow environment at the top of the project site is obviously energetic, such that a few step-pool structures may be required at the property line in-lieu-of the first riffle-pool sequence.

Tributaries where possible will be turned into the abandoned stream channel and connections provided to link the abandoned channel to the proposed channel. This will retain the natural bottom of the existing stream channel and provide even greater variety in rearing and refugia habitat. Where the exiting channel alignment and the proposed channel alignment crosses, the abandoned channel will be plugged at its upstream end and partially filled to prevent chute cutoffs from forming. There will also be a couple of very good opportunities to create off-channel oxbow habitat. Where the abandoned channel strikes the valley walls, a bench should be installed of soil such that vegetation can stabilize the exposed high banks.

The design spreadsheets are included on the following pages.

Profile Un-Named Tributary to Back Creek

Point Type	Station (ft)	Reach Type	Reach Length (ft)	Riffle Length (ft)	Fixed Bed Elevation (ft)	Riffle Depth (ft)	Pool Depth (ft)	Hydraulic Slope (ft/ft)	Hydraulic Grade Line Elevation (ft/ft)	Channel Bed Elevation (ft)		Total Riffle Length (ft)	Total Pool Length (ft)	Channel Length (ft)	Hydraulic Drop (ft)	Average Slope (ft/ft)	Riffle Slope (ft/ft)	Pool Slope (ft/ft)	Station (ft)	Riffle Flag	Riffles (#)	Average Riffle Length (ft)	Pool Flag	Pools (#)	Average Pool Length (ft)	Average Pool -Pool Spacing (ft)	Average Design Lm (ft)	ınge of Stable Wbkf PP/5 (ft)	PP/7 (ft)	Design Wbkf (ft)	Design in Range %	Design PP/Wbkf	Design Lm/Wbkf	Rc (ft)	Rc/Wbkf
PT	1000.00				543.70	2			545.70	543.70		173.49	112.45	285.94	1.50	0.005246	0.006767	0.002899	1000.00		3	57.83		3	37.48333	95.31333	190.63	19.06	13.62	18	80%	5.30	10.59		
		riffle	16.79	16.79				0.006767				60.7%	39.3%				129%	55%		1		84%	0		75%	80%									
PC	1016.79					2			545.59	543.59									1016.79	0			0												
		pool	19.28	0.00				0.002899					***UPPER MAJOR REACH***							0			1											30	1.67
PT	1036.07					2			545.53	543.53									1036.07	0			0												
		riffle	70.89	70.89				0.006767					Valley Length:	245.41						1			0												
PC	1106.96					2			545.05	543.05			Sinuosity:	1.165					1106.96	0			0												
		pool	45.85	0.00				0.002899												0			1											35	1.94
PT	1152.81					2			544.92	542.92									1152.81	0			0												
		riffle	85.81	85.81				0.006767												1			0												
PC	1238.62					2			544.34	542.34									1238.62	0			0												
		pool	47.32	0.00				0.002899												0			1											35	1.94
		hydraulic drop			542.2	2			544.20	542.20																									
PT	1285.94				542.20	1.3			543.50	542.20		442.39	293.48	735.87	6.15	0.008357	0.010447	0.005208	1285.94	0	5	88.478	0	5	58.696	147.174	294.35	29.43	21.02	24	35%	6.13	12.26		
		riffle	108.11	108.11				0.010447				60.1%	39.9%				125%	62%		1		129%	0		117%	124%									
PC	1394.05					1.3			542.37	541.07									1394.05	0			0												
		pool	44.02	0.00				0.005208					***MIDDLE MAJOR REACH***							0			1											60	2.50
PT	1438.07					1.3			542.14	540.84									1438.07	0			0												
		riffle	98.87	98.87				0.010447					Valley Length:	612.49						1			0												
PC	1536.94					1.3			541.11	539.81			Sinuosity:	1.201					1536.94	0			0												
		pool	49.61	0.00				0.005208												0			1											60	2.50
PT	1586.55					1.3			540.85	539.55									1586.55	0			0												
		riffle	90.45	90.45				0.010447												1			0												
PC	1677.00					1.3			539.91	538.61									1677.00	0			0												
		pool	89.14	0.00				0.005208												0			1											60	2.50
PT	1766.14					1.3			539.44	538.14									1766.14	0			0												
		riffle	79.64	79.64				0.010447												1			0												
PC	1845.78					1.3			538.61	537.31									1845.78	0			0												
		pool	30.71	0.00				0.005208												0			1											50	2.08
PT	1876.49					1.3			538.45	537.15									1876.49	0			0												
		riffle	65.32	65.32				0.010447												1			0												
PC	1941.81					1.3			537.77	536.47									1941.81	0			0												
		pool	80.00	0.00				0.005208												0			1											50	2.08
PT	2021.81				535.65	1.7			537.35	535.65	537	297.00	232.97	529.97	3.35	0.006321	0.007965	0.004226	2021.81	0	5	59.4	0	5	46.594	105.994	211.99	21.20	15.14	20	80%	5.30	10.60		
		riffle	43.71	43.71				0.007965				56.0%	44.0%				126%	67%		1		86%	0		93%	89%									
PC	2065.52					1.7			537.00	535.30									2065.52	0			0												
		pool	54.04	0.00				0.004226					**Transistion**							0			1											40	2.00
PT	2119.56					1.7			536.77	535.07									2119.56	0			0												
		riffle	70.59	70.59				0.007965					Valley Length:	435.28						1			0												
PC	2190.15					1.7			536.21	534.51			Sinuosity:	1.218					2190.15	0			0												
		pool	33.81	0.00				0.004226												0			1											35	1.75
PT	2223.96					1.7			536.07	534.37									2223.96	0			0												
		riffle	63.71	63.71				0.007965												1			0												
PC	2287.67					1.7			535.56	533.86									2287.67	0			0												
		pool	52.63	0.00				0.004226												0			1											35	1.75
PT	2340.30					1.7			535.34	533.64									2340.30	0			0												
		riffle	66.94	66.94				0.007965												1			0												
PC	2407.24					1.7			534.81	533.11									2407.24	0			0												
		pool	33.03	0.00				0.004226												0			1											35	1.75
PT	2440.27					1.7			534.67	532.97									2440.27	0			0												
		riffle	52.05	52.05				0.007965												1			0												
PC	2492.32					1.7			534.25	532.55									2492.32	0			0												
		pool	59.46	0.00				0.004226												0			1											40	2.00
PT	2551.78				532	2			534.00	532.00		532.54	361.23	893.77	4.60	0.005147	0.006768	0.002757	2551.78	0	8	66.5675	0	7	51.60429	118.1718	236.34	23.63	16.88	18	17%	6.57	13.13		
		riffle	78.39	78.39				0.006768				59.6%	40.4%				132%	54%		1		97%	0		103%	99%									
PC	2630.17					2			533.47	531.47									2630.17	0			0												
		pool	48.19	0.00				0.002757												0			1											55	3.06
PT	2678.36					2			533.34	531.34			***LOWER MAJOR REACH***						2678.36	0			0												
		riffle	82.29	82.29				0.006768												1			0												
PC	2760.65					2			532.78	530.78			Valley Length:	725.63					2760.65	0			0												
		pool	45.92	0.00				0.002757					Sinuosity:	1.232						0			1											40	2.22
PT	2806.57					2			532.65	530.65									2806.57	0			0												
		riffle	66.84	66.84				0.006768												1			0												
PC	2873.41					2			532.20	530.20									2873.41	0			0												
		pool	76.81	0.00				0.002757												0			1											45	2.50
PT	2950.22					2			531.99	529.99									2950.22	0			0												
		riffle	77.67	77.67				0.006768												1			0												
PC	3027.89					2			531.46	529.46									3027.89	0			0												
		pool	33.74	0.00				0.002757												0			1											35	1.94
PT	3061.63					2			531.37	529.37									3061.63	0			0												
		riffle	60.86	60.86				0.006768												1			0												
PC	3122.49					2			530.96	528.96									3122.49	0			0												
		pool	53.79	0.00				0.002757												0			1											35	1.94
PT	3176.28					2			530.81	528.81									3176.28	0			0												
		riffle	58.10	58.10				0.006768												1			0												
PC	3234.38					2			530.42	528.42									3234.38	0			0												
		pool	84.19	0.00				0.002757												0			1											55	3.06
PT	3318.57					2			530.18	528.18									3318.57	0			0												
		riffle	68.82	68.82				0.006768												1			0												
PC	3387.39					2			529.72	527.72									3387.39	0			0												
		pool	18.59	0.00				0.002757												0			1											35	1.94
PT	3405.98					2			529.67	527.67									3405.98	0			0												
		riffle	39.57	39.57				0.006768												1			0												
P	3445.55				527.40	2			529.40	527.40									3445.55																
			sum:	1445.42								1445.42	1000.13	2445.55	16.30	0.005246				21	21	68.8	20	20	50.0	118.8								sum:	43.14
												59.1%	40.9%																					average:	2.16
													Valley Length:	1950.67 ft																					
													Total Sinuosity:	1.254																					
													Ave. Reach Sinuosity	1.203962																					
													St/Sreach	1.04131																					

Lower Reach

Riffle

Manning's n:	0.038		for Rosgen B3 stream type	
Slope	0.006768			
Dmax	2	ft		
Wbkf	18	ft		
Area	25.5	ft2		
Wp	18.75	ft		
Rh	1.36	ft	1.47	Dmax/Rh
Velocity	3.948946	fps		
Qbkf	100.6981	cfs		
			12.71	Wbkf/Dbkf
Dbkf	1.417	ft	1.41	Dmax/Dbkf
Shear-max	0.844641	lbs/ft2		
Shear Vel	0.660194	ft/s	0.20127878	m/s

Pool

Manning's n:	0.050		for pool losses	
Slope	0.002757			
Dpool	3.33	ft	2.35	Dpool/Dbkf
Wpool	20	ft	1.11	Wpool/Wbkf
Area	41.64	ft2	1.63	Apool/Abkf
Wp	21.56	ft		
Rh	1.931354	ft		
Velocity	2.419895	fps		
Qbkf	100.7644	cfs		

	riffle station (ft)	riffle channel depth (ft)	pool station (ft)	pool channel depth (ft)
	9	0	10	0
	6	-1.5	5	-3.33
center line	0	-2	0	-2.725
	-6	-1.5	-6	-2
	-9	0	-10	0

Transition

Riffle

Manning's n	0.039		for Rosgen B3 stream type	
Slope	0.007965		shallower	
Dmax	1.7	ft		
Wbkf	20	ft		
Area	25.6	ft2		
Wp	20.696	ft		
Rh	1.236954	ft	1.37	Dmax/Rh
Velocity	3.918313	fps		
Qbkf	100.3088	cfs		
			15.63	Wbkf/Dbkf
Dbkf	1.280	ft	1.33	Dmax/Dbkf
Shear-max	0.844885	lbs/ft2		
Shear Vel	0.66029	ft/s	0.201307792	m/s

Pool

Manning's n	0.05		for pool losses	
Slope	0.004226			
Dpool	2.8	ft	2.19	Dpool/Dbkf
Wpool	20	ft	1.00	Wpool/Wbkf
Area	36.67	ft2	1.43	Apool/Abkf
Wp	21.3	ft		
Rh	1.721596	ft		
Velocity	2.742211	fps		
Qbkf	100.5569	cfs		

	riffle station (ft)	riffle channel depth (ft)	pool station (ft)	pool channel depth (ft)
	10	0	10	0
	8	-1.2	5.8	-2.8
center line	0	-1.7	0	-2.285
	-8	-1.2	-6.6	-1.7
	-10	0	-10	0

Middle Reach

Riffle

Manning's	0.039		for Rosgen B3 stream type	
Slope	0.010447		shallower	
Dmax	1.3	ft		
Wbkf	24	ft		
Area	25	ft2		
Wp	24.48	ft		
Rh	1.021242	ft	1.27	Dmax/Rh
Velocity	3.949402	fps		
Qbkf	98.73505	cfs		
			23.04	Wbkf/Dbkf
Dbkf	1.042	ft	1.25	Dmax/Dbkf
Shear-max	0.847446	lbs/ft2		
Shear Vel	0.66129	ft/s	0.201612653	m/s

Pool

Manning's	0.050		for pool losses	
Slope	0.005208			
Dpool	2.33	ft	2.24	Dpool/Dbkf
Wpool	24	ft	1.00	Wpool/Wbkf
Area	35.88	ft2	1.44	Apool/Abkf
Wp	24.97	ft		
Rh	1.436924	ft		
Velocity	2.747525	fps		
Qbkf	98.5812	cfs		

	riffle station (ft)	riffle channel depth (ft)	pool station (ft)	pool channel depth (ft)
	12	0	12	0
	10	-1	8.5	-2.33
center line	0	-1.3	0	-1.72
	-10	-1	-10	-1
	-12	0	-12	0

Upper Reach

Riffle

Manning's	0.038		for Rosgen B3 stream type	
Slope	0.006767			
Dmax	2	ft		
Wbkf	18	ft		
Area	24.6	ft2		
Wp	18.68	ft		
Rh	1.316916	ft	1.52	Dmax/Rh
Velocity	3.864878	fps		
Qbkf	95.07599	cfs		
			13.17	Wbkf/Dbkf
Dbkf	1.367	ft	1.46	Dmax/Dbkf
Shear-max	0.844541	lbs/ft2		
Shear Vel	0.660155	ft/s	0.201266789	m/s

Pool

Manning's	0.050		for pool losses	
Slope	0.002899			
Dpool	3	ft	2.20	Dpool/Dbkf
Wpool	20	ft	1.11	Wpool/Wbkf
Area	39.5	ft2	1.61	Apool/Abkf
Wp	21.424	ft		
Rh	1.843727	ft		
Velocity	2.405852	fps		
Qbkf	95.03114	cfs		

	riffle station (ft)	riffle channel depth (ft)	pool station (ft)	pool channel depth (ft)
	9	0	10	0
	6	-1.4	5.5	-3
center line	0	-2	0	-2.52
	-6	-1.4	-6	-2
	-9	0	-10	0

Average Values

0.00799	Slope
1.75	Dmax
20.00	Wbkf
25.18	Abkf
1.41	Dmax/Rh
3.92	Vbkf
1.28	Dbkf
16.14	Wbkf/Dbkf
1.36	Dmax/Dbkf
0.2014	m/s
2.87	Dpool
21.00	Wpool
38.42	Apool
2.24	Dpool/Dbkf
1.06	Wpool/Wbkf
1.53	Apool/Abkf
2.58	Vpool
0.66	Vpool/Vbkf

	extended riffle station (ft)	extended riffle channel depth (ft)	constrictor station (ft)	constrictor channel depth (ft)
	13.4	0	13.4	0
	10	-1.7	10.5	-0.7
	5	-2	5	-2
center line	0	-1.9	0	-1.594
	-10	-1.7	-11	-0.7
	-13.4	0	-12.3	-0.56

Constrictor Design

input squares

channel				
steep gradi	slope	0.010447		
	Kutters n	0.039		
	area		25.000	
	wp		24.480	
	Rh		1.021	
	V		3.949	
	Q		98.736	
	tailwater depth		1.300	
	headwater depth		2.000	
Control	Length		26.800	at head water depth
Side Weirs	coefficient	2.6		
	Length		5.300	
	max depth		0.700	
	local flow		3.228	
Main Weir	coefficient	3.08		
	Length		21.500	at tail water depth
	head		0.700	
	local flow		38.783	
Main Orific	coefficient	0.6		
	Length		21.500	at tail water depth
	head		0.700	
	local flow		56.474	
	Total Flow		98.485	check against high lighted flow

Appendix E

Reference Reach Data

From the survey of the two reference reach locations, the following geometry and flow conditions were calculated. The site location information of these two reference reaches follows:

	Stream		UTBC US of McCain Site			Richland Creek			
	Reach		Reference Reach			Reference			
	Station		0+00 to 7+12						
	Location								
	Description		Composite - 2 Riffle XS and 3 Pool XS						
			Sample/Min	Max	Mean	Sample/Min	Max	Mean	
SUMMARY		*Stream Type*							
	*	**W**bkf	(ft)	10.4	16.1	13.3	14.8	27.1	21.0
		Dbkf	(ft)	0.90	1.20	1.05	0.80	1.50	1.15
	*	**A**bkf	(sq ft)	12.5	14.4	13.5	21.2	22.3	21.8
	*	**W**bkf/**D**bkf (W/D)	(ft/ft)	11.6	13.4	12.6	18.5	18.1	18.2
		Dmax	(ft)	1.40	1.70	1.55	1.90	2.00	1.95
		Wfpa	(ft)	150.0	150.0	150.0	200.0	200.0	200.0
		Wfpa/**W**bkf (ER)	(ft/ft)	14.4	9.3	11.3	13.5	7.4	9.5
	*	**S**ave	(ft/ft)	0.0068	0.0072	0.0070	0.0120		0.0120
	*	**K**		1.70		1.70	1.46		1.46
	*	**D**50	(mm)						70.0
		D84	(mm)						168.0
		Vbkf	(ft/sec)	4.4	5.0	4.7	5.8	6.8	6.3
	*	**Q**bkf	(cfs)	63.1	63.2	63.2	122.6	151.4	137.0

DIMENSION	RIFFLE	**W**bkf	(ft)	10.4	16.1	13.3	14.8	27.1	21.0
		Dbkf	(ft)	0.90	1.20	1.05	0.80	1.50	1.15
		Abkf	(sq ft)	12.5	14.4	13.5	21.2	22.3	21.8
		Dmax	(ft)	1.40	1.70	1.55	1.90	2.00	1.95
		Wfpa	(ft)	150.0	150.0	150.0	200.0	200.0	200.0
		Dtob	(ft)	2.2	3.6	2.9	3.4	3.7	3.6
		Vbkf	(ft/sec)	4.4	5.0	4.7	5.8	6.8	6.3
		Qbkf	(cfs)	63.1	63.2	63.2	122.6	151.4	137.0
	RATIOS	**W**bkf/**D**bkf (W/D)	(ft/ft)	11.6	13.4	12.6	18.5	18.1	18.2
		Dmax/**D**bkf	(ft/ft)	1.56	1.42	1.48	2.38	1.33	1.70
		Dtob/**D**max	(ft/ft)	1.57	2.12	1.87	1.79	1.85	1.82
		Wfpa/**W**bkf (ER)	(ft/ft)	14.4	9.3	11.3	13.5	7.4	9.5
	POOL	**W**pool	(ft)	10.1	16.0	14.0			15.2
		Dpool	(ft)	1.80	2.50	2.17			3.10
		Apool	(sq ft)	10.4	19.3	15.9			36.5
	RATIOS	**W**pool/**W**bkf	(ft/ft)	0.97	0.99	1.06			0.73
		Dpool/**D**bkf	(ft/ft)	2.00	2.08	2.07			2.09
		Apool/**A**bkf	(ft2/ft2)	0.81	1.11	1.04			1.70
PATTERN		**L**m	(ft)	70.0	120.0	97.5	148.0	108.0	128.0
		Rc	(ft)	14.5	25.9	18.6	16.3	26.8	22.8
		Wblt	(ft)	135.0		135.0	75.0		75.0
		K		1.70		1.70	1.46		1.46
	RATIOS	**L**m/**W**bkf	(ft/ft)	6.73	7.45	7.36	10.00	3.99	6.11
		Rc/**W**bkf	(ft/ft)	1.39	1.61	1.41	1.10	0.99	1.09
		Wblt/**W**bkf	(ft/ft)	12.98		10.19	5.07		3.58
PROFILE		**S**val	(ft/ft)	0.0070	0.0075	0.0073	0.0126		0.0126
		Save	(ft/ft)	0.0068	0.0072	0.0070	0.0120		0.0120
		Sriffle	(ft/ft)	0.0100	0.0410	0.0199	0.0030	0.0756	0.0289
		Spool	(ft/ft)	0.0000	0.0013	0.0003	0.0009	0.0074	0.0027
		Lriffle	(ft)	9.0	108.0	40.7	16.0	103.0	46.0
		Lpool	(ft)	31.0	108.0	53.4	28.0	89.0	47.6
		P to **P**	(ft)	43.5	181.0	80.3	38.0	147.0	92.3
	RATIOS	**S**riffle/**S**ave	(ft/ft)			2.8429			2.4122
		Spool/**S**ave	(ft/ft)	0.0000	0.1806	0.0429	0.0758		0.2290
		Lriffle/**W**bkf	(ft/ft)	0.87	6.71	3.07	1.08	3.80	2.20
		Lpool/**W**bkf	(ft/ft)	2.98	6.71	4.03	1.89	3.28	2.27
		P to **P**/**W**bkf	(ft/ft)	4.18	11.24	6.06	2.57	5.42	4.40
MATERIALS		**D**50-reach	(mm)	23	54	39			70
		D84-reach	(mm)	84	114	99			168
		D50-riffle	(mm)				79		
		D84-riffle	(mm)				155		
		D50-pool	(mm)				60		
		D84-pool	(mm)				181		

Memorandum

Re: McCain Mitigation Site Reference Reaches

Date: May 21, 2004

<u>Introduction/Overview</u>

As part of the Mitigation Planning effort for the McCain Site in Randolph County, North Carolina, a suitable reference reach was needed to develop dimensionless geomorphic ratios for use in the stream restoration design. The selection criteria included a stable reach occurring under similar hydrophysiographic, landform, and watershed land use conditions.

The project site occurs in rolling to hilly terrain of the Carolina Slate Belt ecoregion of the Piedmont physiographic province. The project stream runs through a gently sloping valley (average slope of approximately 0.8%) with alternating toe slopes. The project watershed is a small (0.88 square miles), primarily forested watershed with a small percentage of agriculture, pasture, and rural, low-density residential land uses. A reference reach with similar site and watershed conditions was desired.

It was determined that the restored stream will contain sections of two Rosgen stream types – "C3" and "C4." The NCDOT reference reach database was used to select potential reference reaches with similar stream type and slope. The database did not contain any Rosgen "C3" type steams in the piedmont physiographic province, however four potential "C4" reference reaches were visited to determine their use for this project. The reaches are listed below:

- UT to South Fork Cane Creek, Chatham County
- Morgan Creek, Orange County
- Spencer Branch, Montgomery County
- Richland Creek, Moore County

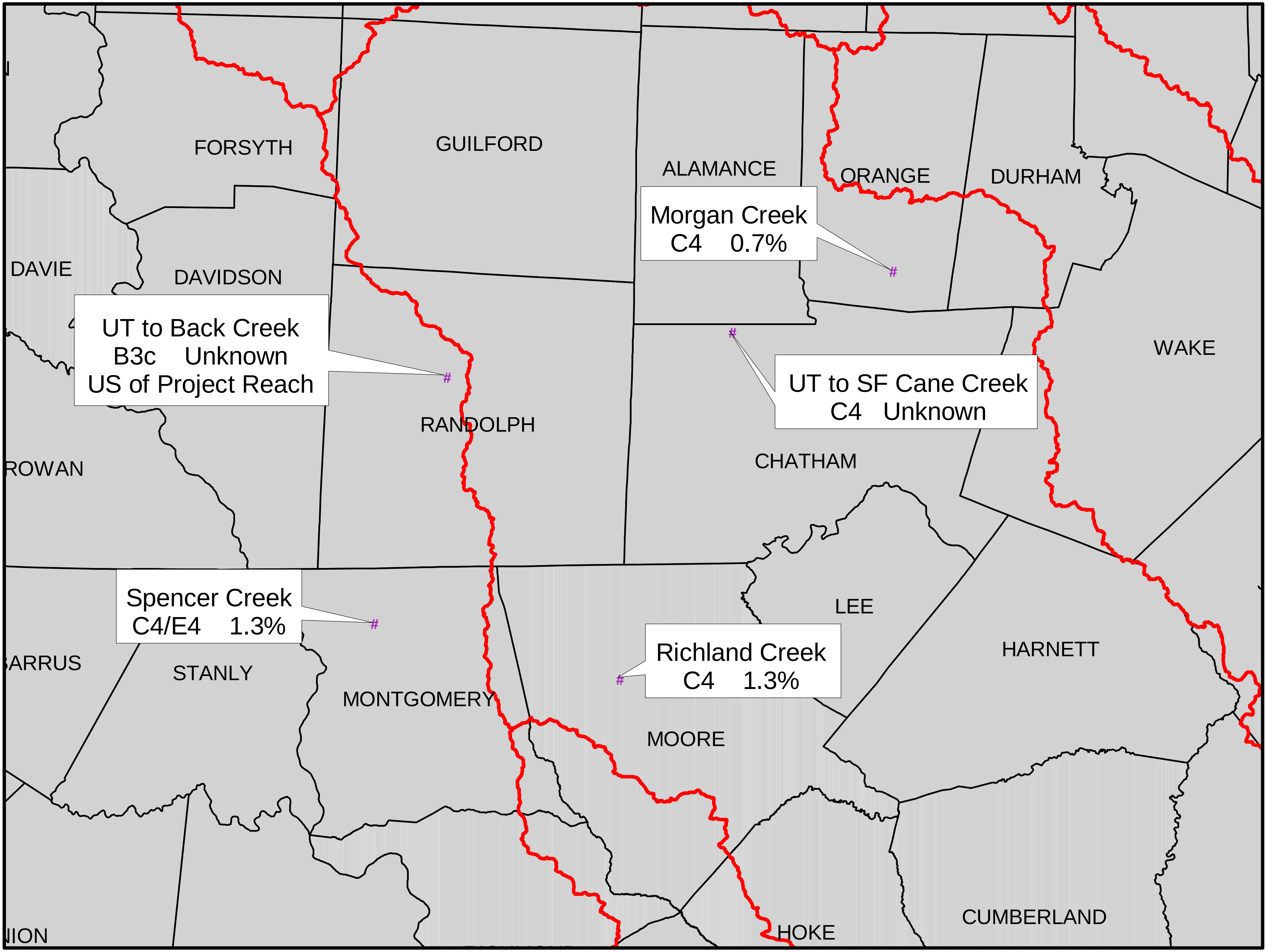
Richland Creek was selected as a reference reach for the McCain Site. In addition, a second suitable reference reach site was located on the project stream (UT to Back Creek), immediately upstream of the project site. Each reference reach is described below with the location, description, and surveyed data.

Stream	UTBC US of McCain Site
Reach	Reference Reach
Station	0+00 to 7+12
Location	
Description	omposite - 2 Riffle XS and 3 Pool X

Stream	Richland Creek
Reach	Reference
Station	
Location	
Description	

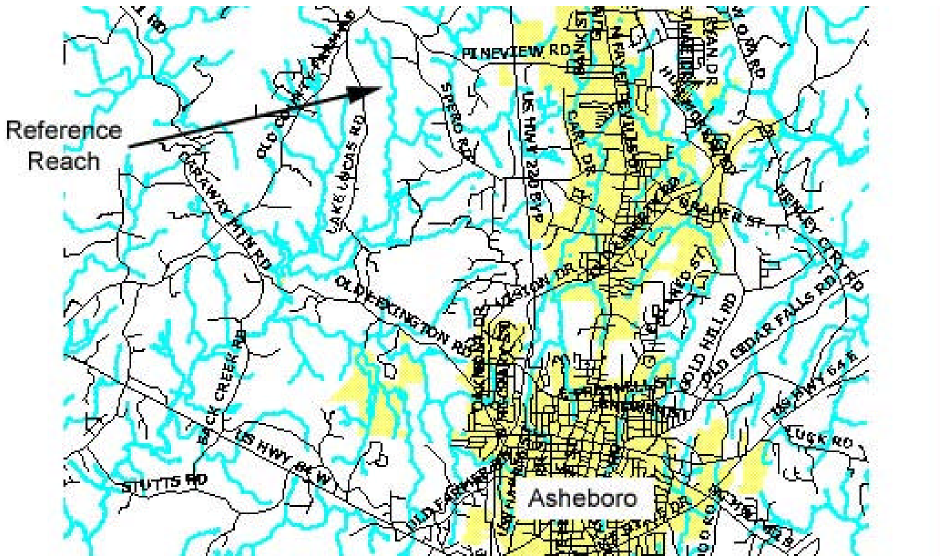
Stream	Design
Reach	Ratios
Station	
Location	
Description	

Section			Parameter	Units	Sample/Min	Max	Mean		Sample/Min	Max	Mean		Design	
SUMMARY			*Stream Type*				C4/E4				C3/C4		B3c/C4	
SUMMARY		*	Wbkf	(ft)	10.4	16.1	13.3		14.8	27.1	21.0		18.8	
SUMMARY			Dbkf	(ft)	0.9	1.2	1.1		0.8	1.5	1.2		1.1	
SUMMARY		*	Abkf	(sq ft)	12.5	14.4	13.5		21.2	22.3	21.8		21.0	
SUMMARY		*	Wbkf/Dbkf (W/D)	(ft/ft)	11.6	13.4	12.6		18.5	18.1	18.2		17.0	
SUMMARY			Dmax	(ft)	1.4	1.7	1.6		1.9	2.0	2.0		2.0	
SUMMARY			Wfpa	(ft)	150.0	150.0	150.0		200.0	200.0	200.0			
SUMMARY			Wfpa/Wbkf (ER)	(ft/ft)	14.4	9.3	11.3		13.5	7.4	9.5			
SUMMARY		*	Save	(ft/ft)	0.0	0.0	0.0		0.0		0.0		0.6	
SUMMARY		*	K		1.7		1.7		1.5		1.5		1.5	
SUMMARY		*	D50	(mm)							70.0			
SUMMARY			D84	(mm)							168.0			
SUMMARY			Vbkf	(ft/sec)			4.7		5.8	6.8	6.3		4.8	
SUMMARY		*	Qbkf	(cfs)			63.2		122.6	151.4	137.0		100.0	
			Drainage Area	(mi2)			0.7				0.9		0.9	
								Regional				Regional		Regional
DIMENSION	RIFFLE		Wbkf	(ft)	10.4	16.1	13.3	Curve	14.8	27.1	21.0	Curve	18.8	Curve
DIMENSION	RIFFLE		Dbkf	(ft)	0.9	1.2	1.1		0.8	1.5	1.2		1.1	
DIMENSION	RIFFLE		Abkf	(sq ft)	12.5	14.4	13.5	16.0-16.5	21.2	22.3	21.8	20.0-20.5	21.0	19.7-20.2
DIMENSION	RIFFLE							(8-32) 95%				(10-40) 95%		(10-40) 95%
DIMENSION	RIFFLE		Dmax	(ft)	1.4	1.7	1.6	Confidence Interval	1.9	2.0	2.0	Confidence Interval	2.0	Confidence Interval
DIMENSION	RIFFLE		Wfpa	(ft)	150.0	150.0	150.0		200.0	200.0	200.0			
DIMENSION	RIFFLE		Dtob	(ft)	2.2	3.6	2.9		3.4	3.7	3.6			
DIMENSION	RIFFLE		Vbkf	(ft/sec)			4.7		5.8	6.8	6.3		4.8	
DIMENSION	RIFFLE		Qbkf	(cfs)			63.2	45-67	122.6	151.4	137.0	61-85	100.0	59-84
DIMENSION	RIFFLE							(22-200) 95%				(28-250) 95%		(28-250) 95%
DIMENSION	RIFFLE	RATIOS	Wbkf/Dbkf (W/D)	(ft/ft)	11.6	13.4	12.6	Confidence Interval	18.5	18.1	18.2	Confidence Interval	17.0	Confidence Interval
DIMENSION	RIFFLE	RATIOS	Dmax/Dbkf	(ft/ft)	1.6	1.4	1.5		2.4	1.3	1.7		1.6	
DIMENSION	RIFFLE	RATIOS	Dtob/Dmax	(ft/ft)	1.6	2.1	1.9		1.8	1.9	1.8			
DIMENSION	RIFFLE	RATIOS	Wfpa/Wbkf (ER)	(ft/ft)	14.4	9.3	11.3		13.5	7.4	9.5			
DIMENSION	POOL		Wpool	(ft)	10.1	16.0	14.0				15.2		28.2	
DIMENSION	POOL		Dpool	(ft)	1.0	1.5	1.3				2.4		2.2-2.75	
DIMENSION	POOL		Apool	(sq ft)	10.4	19.3	15.9				3.1		62-78	
DIMENSION	POOL	RATIOS	Wpool/Wbkf	(ft/ft)	1.0	1.0	1.1				0.7		1.5	
DIMENSION	POOL	RATIOS	Dpool/Dbkf	(ft/ft)	1.1	1.3	1.2				2.1		2.0-2.5	
DIMENSION	POOL	RATIOS	Apool/Abkf	(ft2/ft2)	0.8	1.1	1.0				0.7		2.9-3.6	
PATTERN			Lm	(ft)	70.0	120.0	97.5		148.0	108.0	128.0		130-280	
PATTERN			Rc	(ft)	14.5	25.9	18.6		16.3	26.8	22.8		30-60	
PATTERN			Wblt	(ft)	135.0		135.0		75.0		75.0		100-250	
PATTERN			K		1.7		1.7		1.5		1.5		1.45	
PATTERN		RATIOS	Lm/Wbkf	(ft/ft)	6.7	7.5	7.4		10.0	4.0	6.1		38183.0	
PATTERN		RATIOS	Rc/Wbkf	(ft/ft)	1.4	1.6	1.4		1.1	1.0	1.1		1.6-3.2	
PATTERN		RATIOS	Wblt/Wbkf	(ft/ft)	13.0		10.2		5.1		3.6		5-13	
PROFILE			Sval	(ft/ft)	0.0070	0.0075	0.0073		0.0126		0.0126		0.8	
PROFILE			Save	(ft/ft)	0.0068	0.0072	0.0070		0.0120		0.0120		0.6	
PROFILE			Sriffle	(ft/ft)	0.0100	0.0410	0.0199		0.0030	0.0756	0.0289		1.0-1.4	
PROFILE			Spool	(ft/ft)	0.0000	0.0013	0.0003		0.0009	0.0074	0.0027		0.0	
PROFILE			Lriffle	(ft)	9.0	108.0	40.7		16.0	103.0	46.0		28-75	
PROFILE			Lpool	(ft)	31.0	108.0	53.4		28.0	89.0	47.6		56-94	
PROFILE			P to P	(ft)	43.5	181.0	80.3		38.0	147.0	92.3		56-188	
PROFILE		RATIOS	Sriffle/Save	(ft/ft)			2.8429				2.4122		2.4-2.8	
PROFILE		RATIOS	Spool/Save	(ft/ft)	0.0000	0.1806	0.0429		0.0758		0.2290		0.0	
PROFILE		RATIOS	Lriffle/Wbkf	(ft/ft)	0.9	6.7	3.1		1.1	3.8	2.2		1.5-4.0	
PROFILE		RATIOS	Lpool/Wbkf	(ft/ft)	3.0	6.7	4.0		1.9	3.3	2.3		3-5	
PROFILE		RATIOS	P to P/Wbkf	(ft/ft)	4.2	11.2	6.1		2.6	5.4	4.4		3-10	
MATERIALS			D50-reach	(mm)	23	54	39				70		0.2-35, 18.4	
MATERIALS			D84-reach	(mm)	84	114	99				168		4-175, 16.8	
MATERIALS			D50-riffle	(mm)					79				0.34-22	
MATERIALS			D84-riffle	(mm)					155				6-70	
MATERIALS			D50-pool	(mm)					60				0.2-9	
MATERIALS			D84-pool	(mm)					181				0.65-45	


FORSYTH
GUILFORD
ALAMANCE
ORANGE
DURHAM
Morgan Creek
C4 0.7%
DAVIE
DAVIDSON
UT to Back Creek
B3c Unknown
US of Project Reach
WAKE
UT to SF Cane Creek
C4 Unknown
RANDOLPH
ROWAN
CHATHAM
Spencer Creek
C4/E4 1.3%
LEE
Richland Creek
C4 1.3%
HARNETT
ARRUS
STANLY
MONTGOMERY
MOORE
CUMBERLAND
IION
HOKE

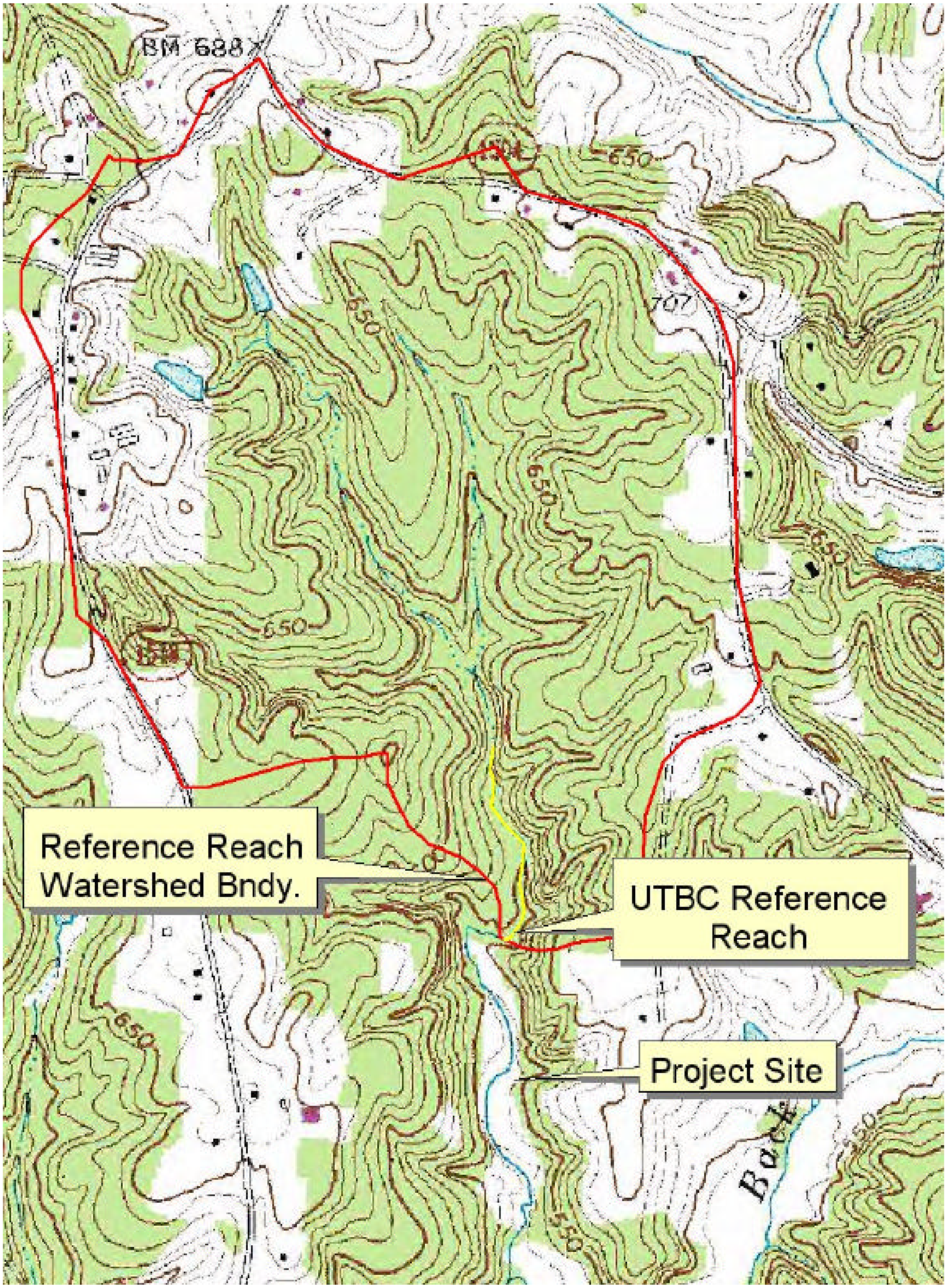
UT to Back Creek (UTBC), Randolph County

The UTBC reference site is located in Randolph County, northwest of the City of Asheboro. The reference reach is located off of Lake Lucas Road, upstream of the McCain property on a parcel owned by Mr. Ray Thomas of Climax, NC. This 712-foot reach is a moderate to high sinuosity channel within a mature forested tract. UTBC, through the reference reach, has an average slope of 0.7% and was classified as a Rosgen "E4/C4" stream type. Maps showing the vicinity and site, as well as the reference reach survey summary is shown on the following pages.



The UT to Back Creek reference reach is located northwest of Asheboro in Randolph County.

The 712-foot reach is located upstream of the project site.



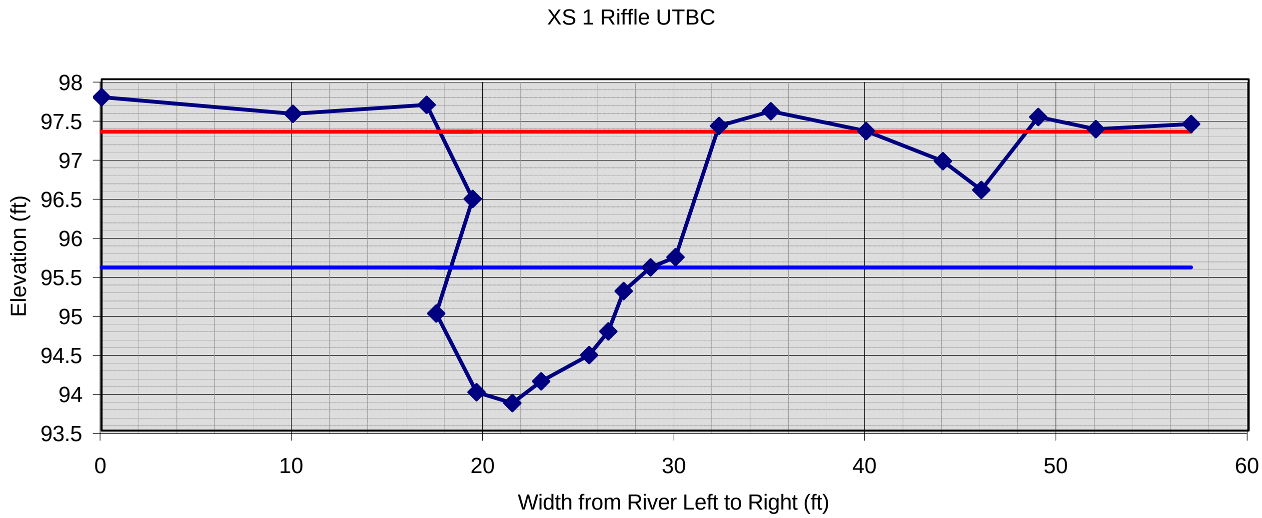
USGS Quad map showing the UTBC reference reach drainage area.


UT to Back Creek, cross-section 3, riffle, looking downstream


UT to Back Creek, cross-section 4, pool, looking downstream


UT to Back Creek, cross-section 5, pool, looking downstream

Cross Section



section:	XS 1
	Riffle
stream:	UTBC
location:	Profile Station 0+27
description:	Setup 1 (Riffle)
height of instrument (ft):	100.00

notes	omit pt.	distance (ft)	FS (ft)	elevation
Terrace	☐	0	2.23	97.77
	☐	10	2.44	97.56
LTOB	☐	17	2.33	97.67
	☐	19.4	3.53	96.47
Undercut	☐	17.5	5	95
LEW	☐	19.6	6.01	93.99
TW	☐	21.5	6.15	93.85
	☐	23	5.87	94.13
REW/WS	☐	25.5	5.53	94.47
Bench	☐	26.5	5.23	94.77
Bench	☐	27.3	4.71	95.29
BKF	☐	28.7	4.41	95.59
	☐	30	4.28	95.72
RTOB	☐	32.3	2.6	97.4
Terrace	☐	35	2.41	97.59
	☐	40	2.66	97.34
	☐	44	3.05	96.95
Swale TW	☐	46	3.42	96.58
	☐	49	2.48	97.52
	☐	52	2.64	97.36
RBKP	☐	57	2.57	97.43
	☐			
	☐			
	☐			
	☐			

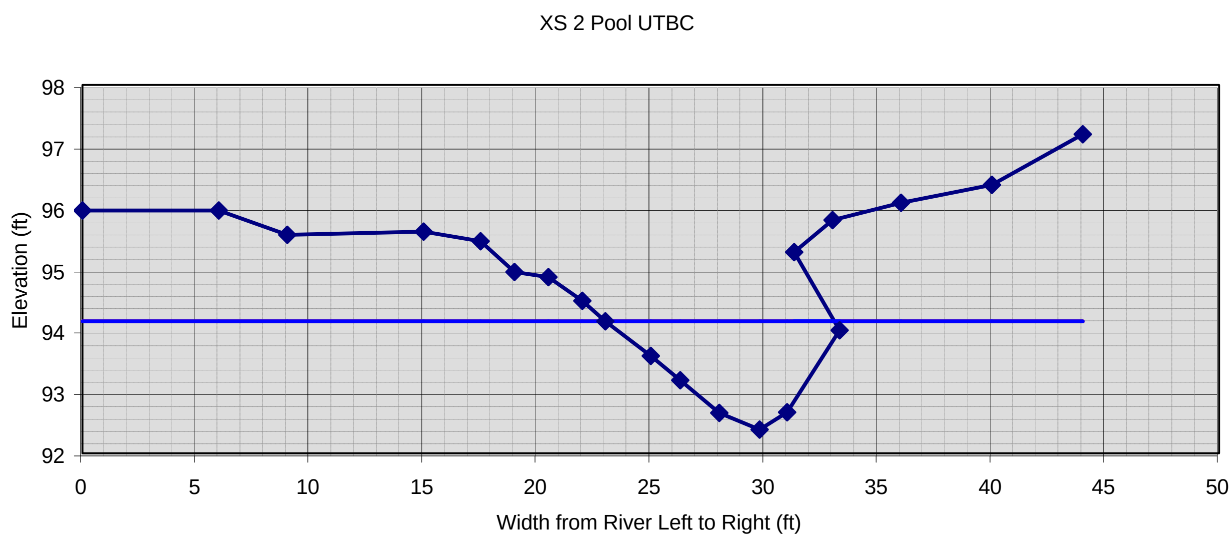
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
4.41	2.6	150.0	1.44	0.035
95.59	97.4			

dimensions			
12.5	x-section area	1.2	d mean
10.4	width	12.7	wet P
1.7	d max	1.0	hyd radi
3.6	bank ht	8.7	w/d ratio
150.0	W flood prone area	14.4	ent ratio

hydraulics	
5.0	velocity (ft/sec)
63.1	discharge rate, Q (cfs)
0.89	shear stress ((lbs/ft sq)
0.68	shear velocity (ft/sec)
5.433	unit stream power (lbs/ft/sec)
0.66	Froude number
7.5	friction factor u/u*
57.3	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Cross Section



section:	XS 2
	Pool
stream:	UTBC
location:	Profile Station 1+08.2
description:	Setup 2 (Pool)
height of instrument (ft):	100.00

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBKP		0	4.05	95.95
		6	4.05	95.95
		9	4.44	95.56
		15	4.39	95.61
LTOB		17.5	4.55	95.45
		19	5.05	94.95
		20.5	5.13	94.87
		22	5.52	94.48
BKF		23	5.85	94.15
		25	6.41	93.59
LEW/WS		26.3	6.81	93.19
		28	7.34	92.66
TW		29.8	7.61	92.39
REW		31	7.33	92.67
Undercut		33.3	6	94
		31.3	4.72	95.28
RTOB		33	4.2	95.8
		36	3.92	96.08
		40	3.63	96.37
BRBKP		44	2.8	97.2

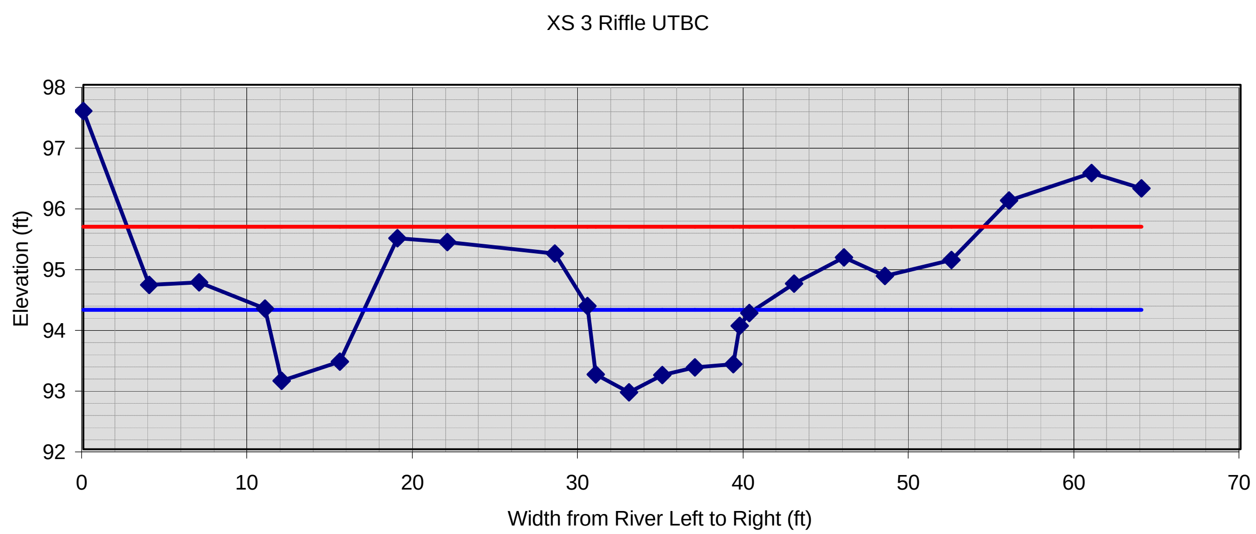
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.85	4.55		0.05	
94.15	95.45			

dimensions			
10.4	x-section area	1.0	d mean
10.1	width	11.2	wet P
1.8	d max	0.9	hyd radi
3.1	bank ht	~~9.8~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.03	shear stress ((lbs/ft sq)
0.12	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
2.3	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
~~0.0~~	relative roughness	~~0.0~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	XS 3
	Riffle
stream:	UTBC
location:	Profile Station 2+75
description:	Setup 3 (Riffle)
height of instrument (ft):	100.00

notes	omit pt.	distance (ft)	FS (ft)	elevation
Hillside	☐	0	2.43	97.57
TOS	☐	4	5.3	94.7
	☐	7	5.25	94.75
LTOB-SC	☐	11	5.68	94.32
LEW-SC	☐	12	6.87	93.13
REW-SC	☐	15.5	6.56	93.44
RTOB-SC	☐	19	4.53	95.47
	☐	22	4.59	95.41
LTOB	☐	28.5	4.78	95.22
BKF	☐	30.5	5.64	94.36
LEW	☐	31	6.77	93.23
TW	☐	33	7.06	92.94
	☐	35	6.78	93.22
	☐	37	6.65	93.35
REW	☐	39.3	6.6	93.4
	☐	39.7	5.97	94.03
BKF	☐	40.3	5.76	94.24
	☐	43	5.27	94.73
RTOB	☐	46	4.84	95.16
Swale	☐	48.5	5.15	94.85
	☐	52.5	4.88	95.12
	☐	56	3.9	96.1
	☐	61	3.45	96.55
RBKP	☐	64	3.7	96.3
	☐			

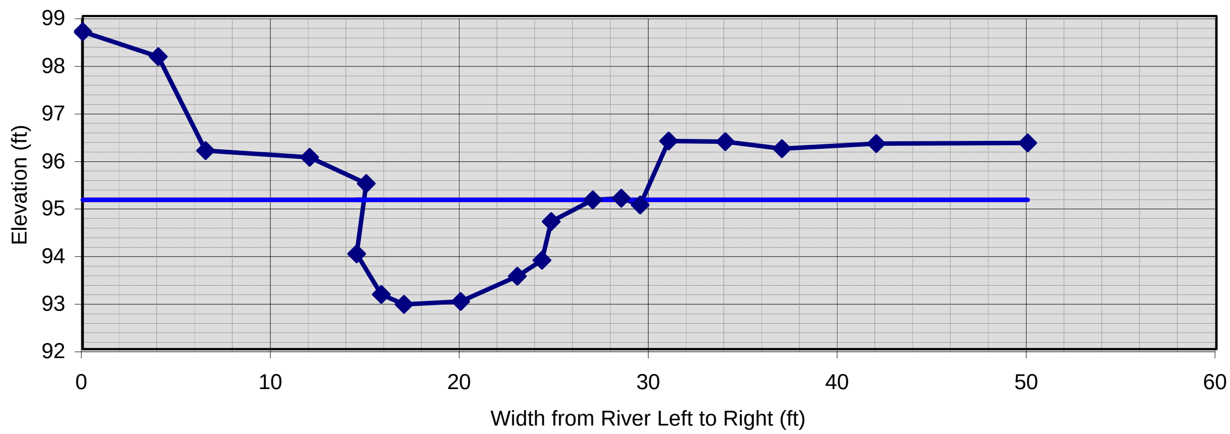
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.7	4.84	150.0	1.44	0.035
94.3	95.16			

dimensions			
14.4	x-section area	0.9	d mean
16.1	width	18.0	wet P
1.4	d max	0.8	hyd radi
2.2	bank ht	17.9	w/d ratio
150.0	W flood prone area	9.3	ent ratio

hydraulics	
4.4	velocity (ft/sec)
63.2	discharge rate, Q (cfs)
0.72	shear stress ((lbs/ft sq)
0.61	shear velocity (ft/sec)
3.534	unit stream power (lbs/ft/sec)
0.67	Froude number
7.2	friction factor u/u*
45.9	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Cross Section



section:	**XS 4**
	Pool
stream:	**UTBC**
location:	**Profile Station 4+85.5**
description:	**Setup 4 (Straight Pool)**
height of instrument (ft):	**100.00**

notes	omit pt.	distance (ft)	FS (ft)	elevation
TOS	☐	**0**	**1.33**	98.67
	☐	**4**	**1.85**	98.15
LBOB	☐	**6.5**	**3.83**	96.17
LTOB	☐	**12**	**3.97**	96.03
	☐	**15**	**4.52**	95.48
Undercut	☐	**14.5**	**6**	94
LEW	☐	**15.8**	**6.85**	93.15
	☐	**17**	**7.06**	92.94
	☐	**20**	**7**	93
	☐	**23**	**6.47**	93.53
REW/WS	☐	**24.3**	**6.13**	93.87
	☐	**24.8**	**5.32**	94.68
BKF	☐	**27**	**4.86**	95.14
	☐	**28.5**	**4.83**	95.17
	☐	**29.5**	**4.97**	95.03
RTOB	☐	**31**	**3.63**	96.37
	☐	**34**	**3.64**	96.36
	☐	**37**	**3.79**	96.21
	☐	**42**	**3.68**	96.32
RBKP	☐	**50**	**3.67**	96.33
	☐			
	☐			
	☐			
	☐			

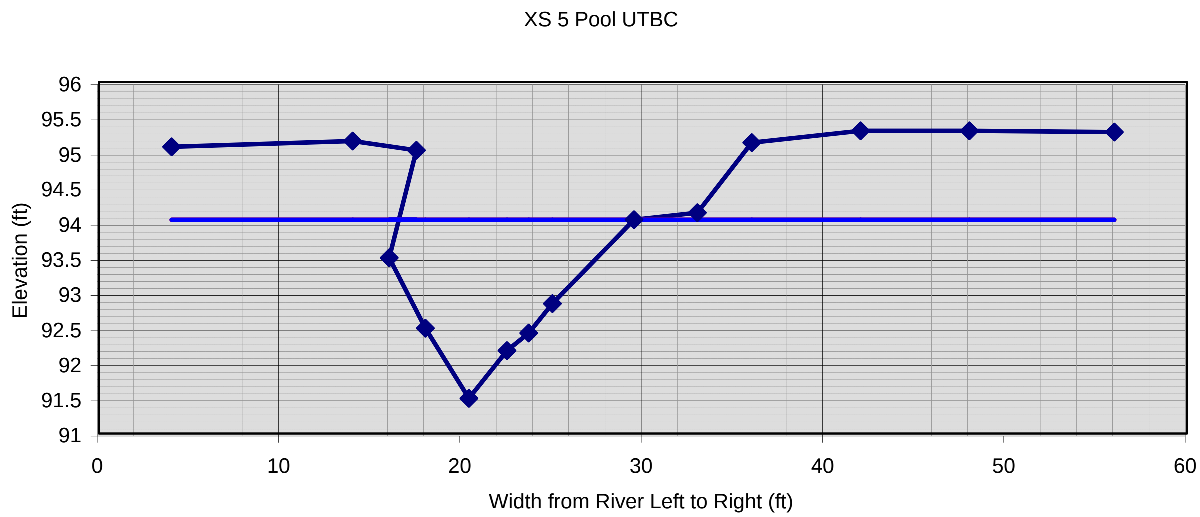
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
4.86	**3.97**	~~**150.0**~~	**0.05**	
95.14	96.03			

dimensions			
19.3	x-section area	1.5	d mean
13.0	width	15.5	wet P
2.2	d max	1.2	hyd radi
3.1	bank ht	~~8.8~~	w/d ratio
~~150.0~~	W flood prone area	~~11.5~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.04	shear stress ((lbs/ft sq)
0.14	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
3.0	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
~~0.0~~	relative roughness	~~0.0~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	**XS 5**
	Pool
stream:	**UTBC**
location:	**Profile Station 5+82**
description:	**Setup 5 (Pool)**
height of instrument (ft):	**100.00**

notes	omit pt.	distance (ft)	FS (ft)	elevation
	☐	**4**	**4.92**	95.08
	☐	**14**	**4.84**	95.16
LTOB	☐	**17.5**	**4.97**	95.03
Undercut	☐	**16**	**6.5**	93.5
LEW/WS	☐	**18**	**7.5**	92.5
TW	☐	**20.4**	**8.5**	91.5
	☐	**22.5**	**7.82**	92.18
REW	☐	**23.7**	**7.57**	92.43
	☐	**25**	**7.15**	92.85
BKF	☐	**29.5**	**5.96**	94.04
Bench	☐	**33**	**5.86**	94.14
RTOB	☐	**36**	**4.86**	95.14
Terrace	☐	**42**	**4.69**	95.31
Terrace	☐	**48**	**4.69**	95.31
Terrace	☐	**56**	**4.71**	95.29
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			

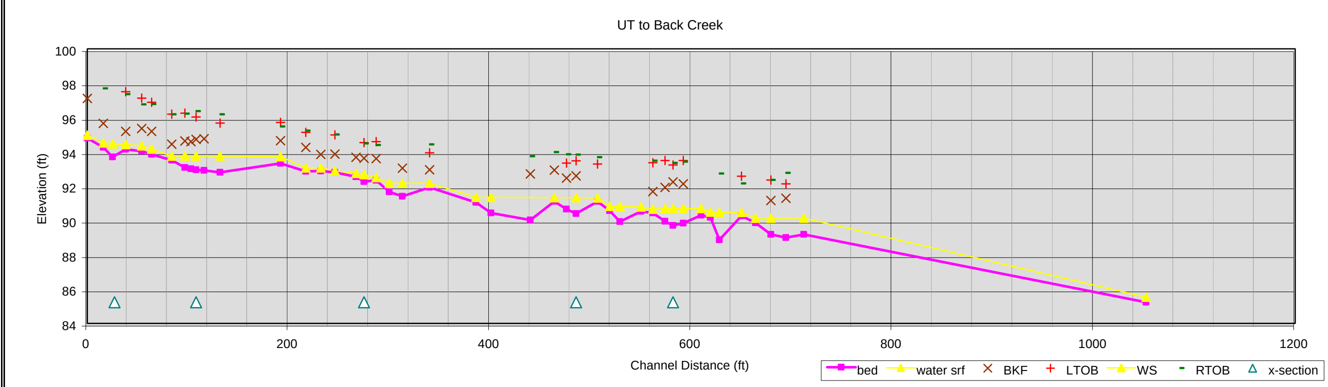
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.96	**4.97**	~~**150.0**~~	**0**	
94.04	95.03			

dimensions			
18.0	x-section area	1.4	d mean
13.0	width	15.0	wet P
2.5	d max	1.2	hyd radi
3.5	bank ht	~~9.3~~	w/d ratio
~~150.0~~	W flood prone area	~~11.6~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
~~0.0~~	relative roughness	~~0.0~~	fric. factor
~~0.000~~	Manning's n from channel material		

Longitudinal Profile	Hints	Stream:	UT to Back Creek	Location:	US of Project Site
		Watershed:	Back Creek	Date:	



100 :Elevation BM

notes	cross section	station		BS	HI	FS TP	FS bed	depth water	FS WS	FS BKF	FS LTOB	FS RTOB	AZ azimuth	ELEV bed	ELEV water srf	ELEV WS	ELEV BKF	ELEV LTOB	ELEV RTOB
					100														
HOR		0			100		5.21		5.03	2.89				94.79		94.97	97.11		
HOP		16			100		5.75		5.48	4.34		2.32	225	94.25		94.52	95.66		97.68
MP		25			100		6.31		5.53				225	93.69		94.47			
Riffle	XS 1	27			100								225						
Glide		38			100		5.86		5.58	4.81	2.49	2.65	225	94.14		94.42	95.19	97.51	97.35
Riffle		54			100		5.96		5.65	4.64	2.88	3.25	225	94.04		94.35	95.36	97.12	96.75
Riffle		64			100		6.15		5.83	4.81	3.11	3.23	225	93.85		94.17	95.19	96.89	96.77
TP 1					100	4.97													
				5.54	100.57										#N/A	#N/A	#N/A	#N/A	#N/A
TR		84			100.57		7.06		6.81	6.13	4.38	4.4	225	93.51		93.76	94.44	96.19	96.17
Run		97			100.57		7.49		6.81	5.94	4.31	4.35		93.08		93.76	94.63	96.26	96.22
Pool		103			100.57		7.57			5.98				93			94.59		
Pool	XS 2	108			100.57		7.61		6.81	5.85	4.55	4.2		92.96		93.76	94.72	96.02	96.37
MP		116			100.57		7.65			5.81			135	92.92			94.76		
Pool		132			100.57		7.77		6.82		4.89	4.39	135	92.8		93.75		95.68	96.18
TP 2					100.57	6.87													
				5.62	99.32										#N/A	#N/A	#N/A	#N/A	#N/A
Glide		192			99.32		5.99		5.61	4.67	3.61	3.86	180	93.33		93.71	94.65	95.71	95.46
TR		217			99.32		6.47		6.25	5.06	4.18	4.09	180	92.85		93.07	94.26	95.14	95.23
HOR/BR		232			99.32		6.44		6.25	5.47			180	92.88		93.07	93.85		
BR		246			99.32		6.52		6.43	5.45	4.34	4.31	157.5	92.8		92.89	93.87	94.98	95.01
Riffle		267			99.32		6.77		6.58	5.65			157.5	92.55		92.74	93.67		
Riffle	XS 3	275			99.32		7.06		6.65	5.7	4.78	4.84	180	92.26		92.67	93.62	94.54	94.48
Riffle		287			99.32		6.99		6.81	5.71	4.72	4.94	180	92.33		92.51	93.61	94.6	94.38
rossover Bar		300			99.32		7.66		7.16				180	91.66		92.16			
HOR		313			99.32		7.91		7.16	6.28			180	91.41		92.16	93.04		
HOR		340			99.32		7.4		7.16	6.36	5.38	4.89	180	91.92		92.16	92.96	93.94	94.43
TP 3					99.32	7.48													
				5.61	97.45										#N/A	#N/A	#N/A	#N/A	#N/A
HOP		386			97.45		6.41		6.1				225	91.04		91.35			
Pool		401			97.45		7.02		6.11				225	90.43		91.34			
Pool		440			97.45		7.43			4.74		3.72	225	90.02			92.71		93.73
Pool		464			97.45		6.35		6.12	4.52		3.48	225	91.1		91.33	92.93		93.97
		476			97.45		6.8			4.98	4.11	3.6	225	90.65			92.47	93.34	93.85
Pool	XS 4	485.5			97.45		7.06		6.13	4.86	3.97	3.63	225	90.39		91.32	92.59	93.48	93.82
HOR		507			97.45		6.35		6.14		4.17	3.78	202.5	91.1		91.31		93.28	93.67
HOP		519			97.45		6.88		6.63				202.5	90.57		90.82			
Pool		529			97.45		7.52		6.64				180	89.93		90.81			
		550			97.45		6.93		6.67				180	90.52		90.78			
HOP		562			97.45		7.02		6.79		4.08		225	90.43		90.66		93.37	
TP 4					97.45	6.47													
				7.22	98.2										#N/A	#N/A	#N/A	#N/A	#N/A
		562			98.2					6.51		4.72	225				91.69		93.48
Pool		574			98.2		8.25		7.5	6.27	4.71		225	89.95		90.7	91.93	93.49	
Pool	XS 5	582			98.2		8.5		7.5	5.96	4.97	4.86	225	89.7		90.7	92.24	93.23	93.34
Pool		592			98.2		8.36		7.5	6.07	4.71	4.78	315	89.84		90.7	92.13	93.49	93.42
HOR		610			98.2		7.9		7.5				315	90.3		90.7			
HOP		619			98.2		8.02		7.71				315	90.18		90.49			
MP		628			98.2		9.33		7.72			5.48	315	88.87		90.48			92.72
HOR		650			98.2		7.94		7.72		5.63	6.05	315	90.26		90.48		92.57	92.15
HOP		664			98.2		8.34		8.07				315	89.86		90.13			
Pool		679			98.2		9.01		8.07	7.04	5.85	5.85	270	89.19		90.13	91.16	92.35	92.35
Pool		694			98.2		9.2			6.91	6.07	5.43	270	89			91.29	92.13	92.77
Glide		712			98.2		9.02		8.07				270	89.18		90.13			
TP 4					98.2	7.22													
				7.41	98.39										#N/A	#N/A	#N/A	#N/A	#N/A
Cain Site - HOR		1052			98.39		13.15		12.86				270	85.24		85.53			
For Pattern		1100			98.39								180						
					98.39														

Pebble Count of Channel Reach

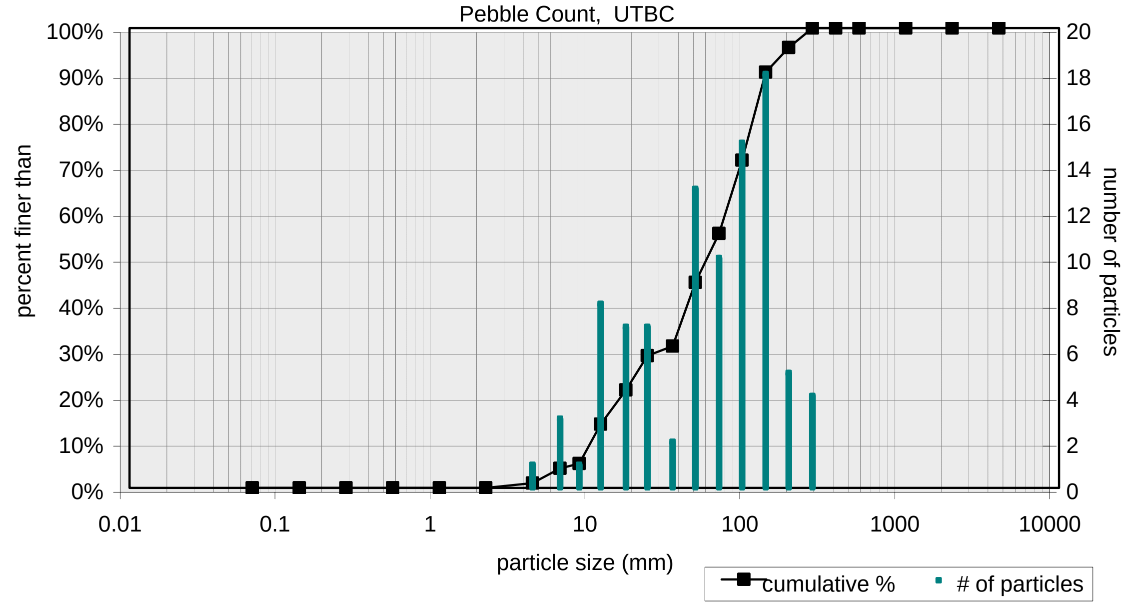
Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	**1**
fine gravel	4	6	**3**
fine gravel	6	8	**1**
medium gravel	8	11	**8**
medium gravel	11	16	**7**
coarse gravel	16	22	**7**
coarse gravel	22	32	**2**
very coarse gravel	32	45	**13**
very coarse gravel	45	64	**10**
small cobble	64	90	**15**
medium cobble	90	128	**18**
large cobble	128	180	**5**
very large cobble	180	256	**4**
small boulder	256	362	
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
	total particle count:		94
bedrock			**6**
clay hardpan			
detritus/wood			
artificial			
	total count:		100

##

Pebble Count,
UTBC

Profile Station 0+00 to 1+32

Note: **Composite Sample - 70% Riffle; 30% Pool**



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	12.269	35.45	53.7	79	114	172	3.2	37.4	3.0

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	0%	0%	52%	42%	0%	6%	0%	0%	0%

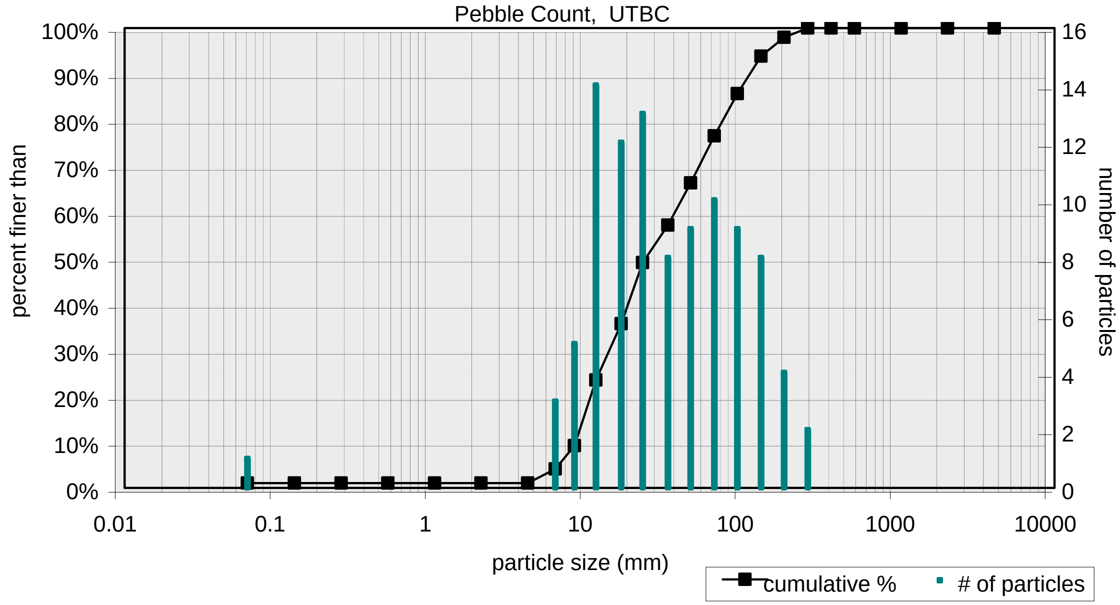
Pebble Count of Channel Reach

Pebble Count,
UTBC

Profile Station 1+92 to 7+12

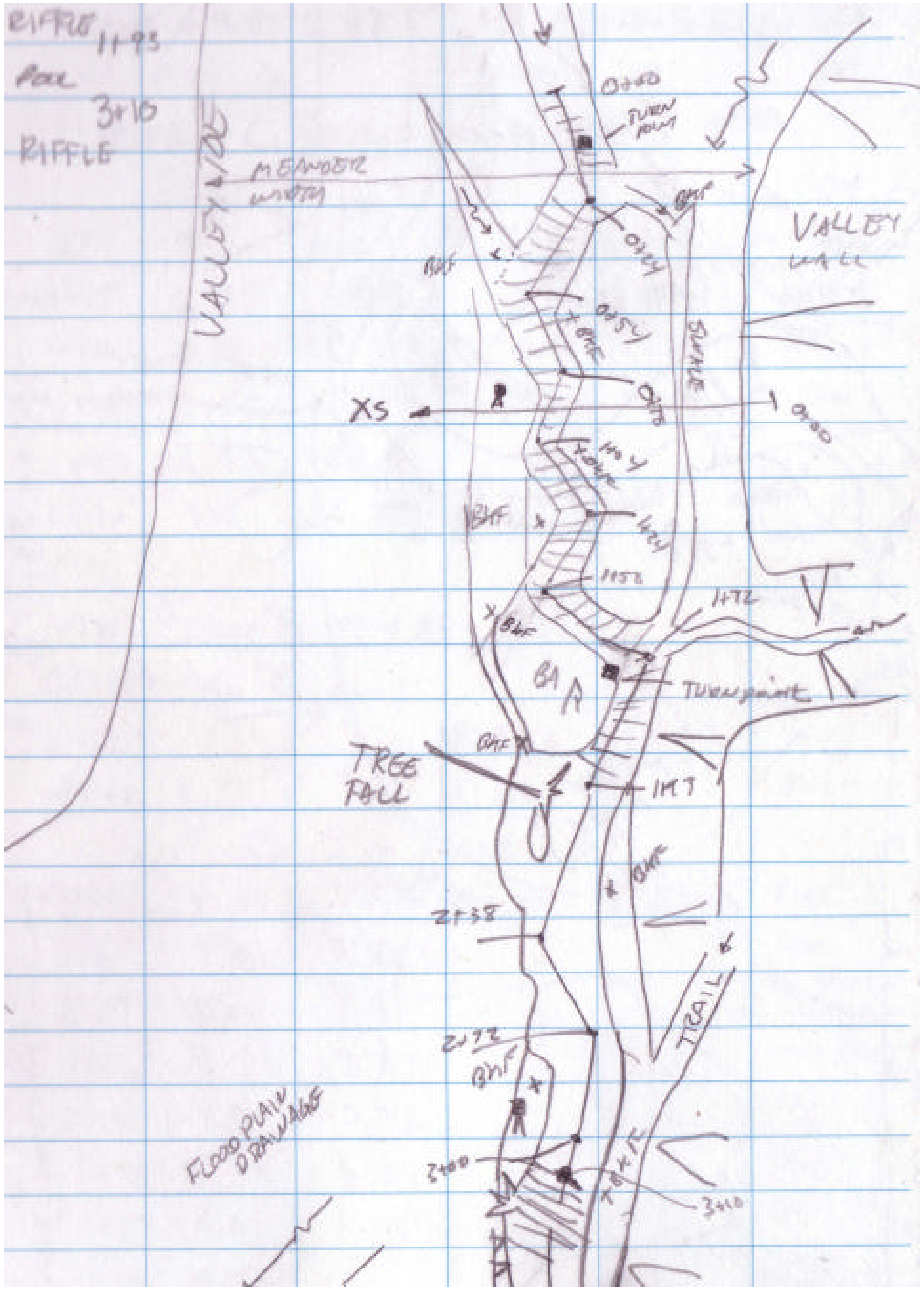
Note: **Composite Sample - 50% Riffle; 50% Pool**

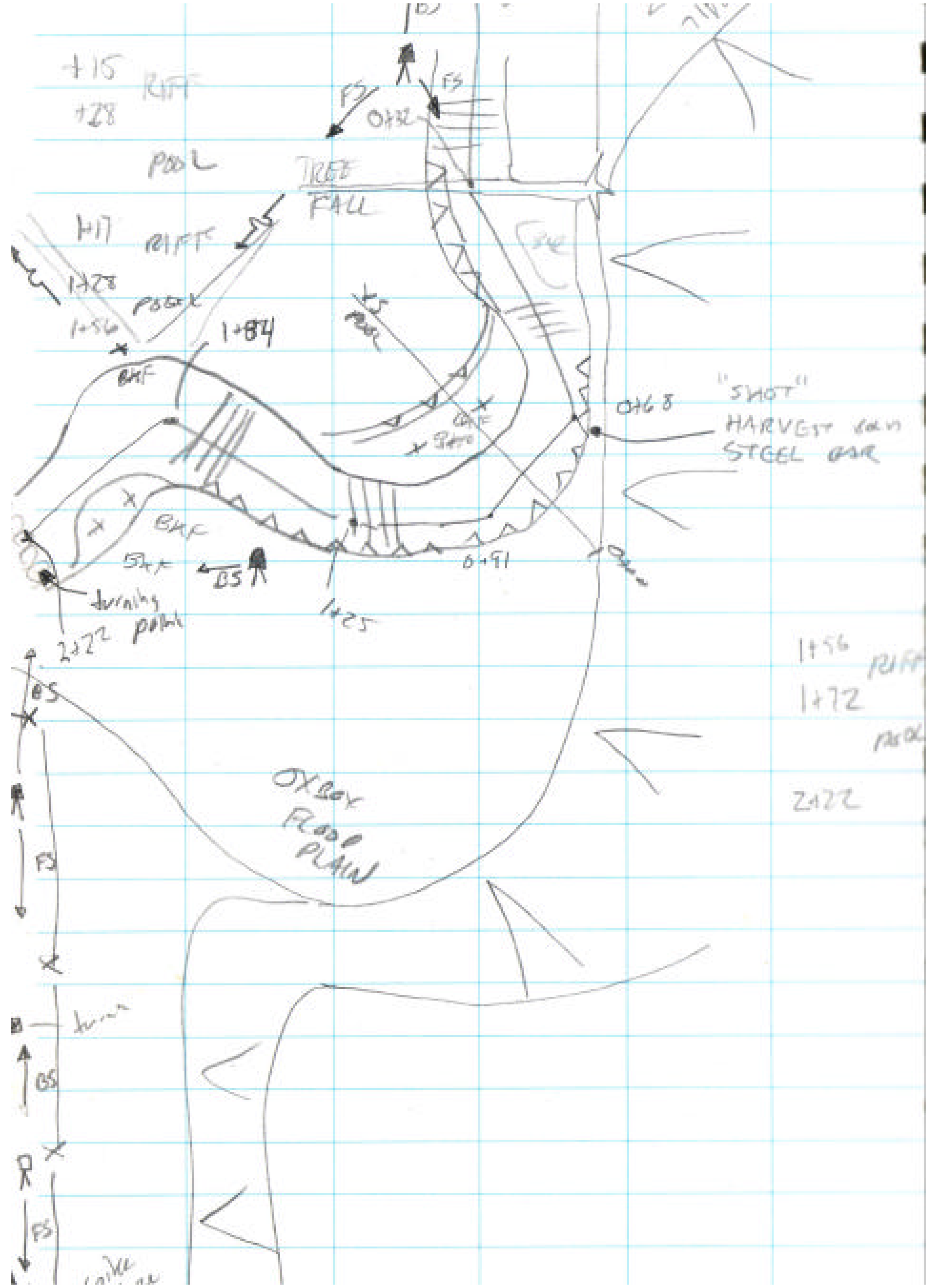
Material	Size Range (mm)		Count	
silt/clay	0	0.062	**1**	##
very fine sand	0.062	0.13		##
fine sand	0.13	0.25		##
medium sand	0.25	0.5		##
coarse sand	0.5	1		##
very coarse sand	1	2		##
very fine gravel	2	4		##
fine gravel	4	6	**3**	##
fine gravel	6	8	**5**	##
medium gravel	8	11	**14**	##
medium gravel	11	16	**12**	##
coarse gravel	16	22	**13**	##
coarse gravel	22	32	**8**	##
very coarse gravel	32	45	**9**	##
very coarse gravel	45	64	**10**	##
small cobble	64	90	**9**	##
medium cobble	90	128	**8**	##
large cobble	128	180	**4**	##
very large cobble	180	256	**2**	##
small boulder	256	362		##
small boulder	362	512		##
medium boulder	512	1024		##
large boulder	1024	2048		##
very large boulder	2048	4096		##
	total particle count:		98	
bedrock			**2**	
clay hardpan				
detritus/wood				
artificial				
	total count:		100	



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	9.313	15.65	23.1	43	84	141	3.1	28.0	3.0

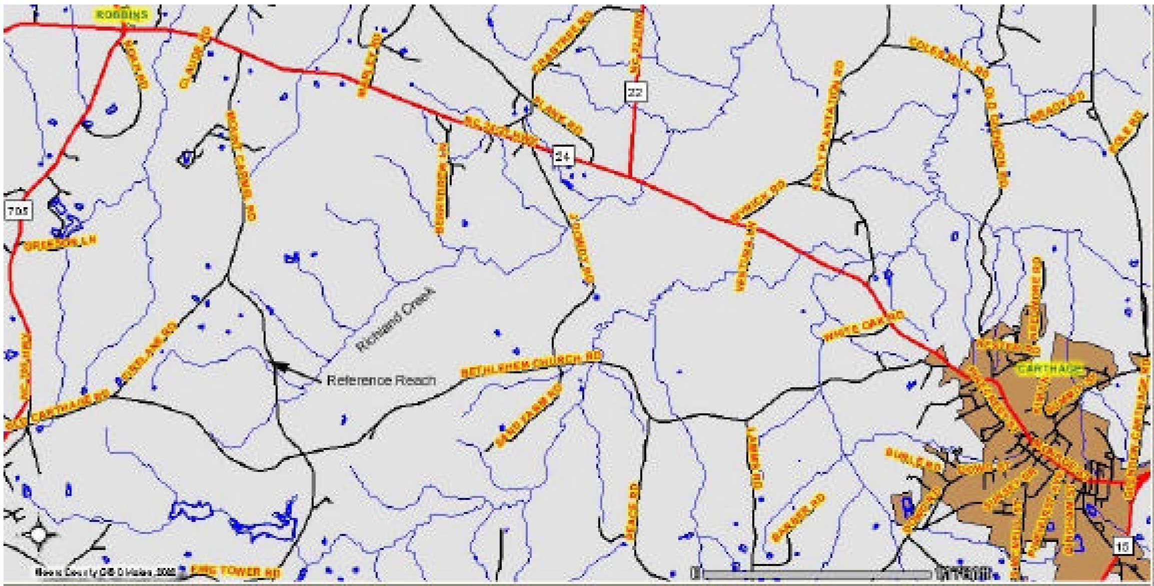
based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	1%	0%	74%	23%	0%	2%	0%	0%	0%


RIFFLE 1+93
POOL
3+10
RIFFLE
VALLEY WALL
MEANDER WIDTH
0+00
TURN POINT
BKF
VALLEY WALL
XS
0+00
SWALE
BKF
1+53
1+72
BAR
TURN point
TREE FALL
BKF
1+47
2+38
2+72
BKF
3+00
3+10
TRAIL
FLOOD PLAIN DRAINAGE


1+15 RIFF
1+28
POOL
FS
0+32
TREE FALL
1+17 RIFF
1+28 POOL
1+56
1+84
XS
BKF
0+68
"SHOT" HARVEST bar STEEL BAR
BKF
BS
turning point
2+22 point
1+25
0+91
1+56 RIFF
1+72
POOL
2+22
OXBOW FLOOD PLAIN
BS
FS
turn

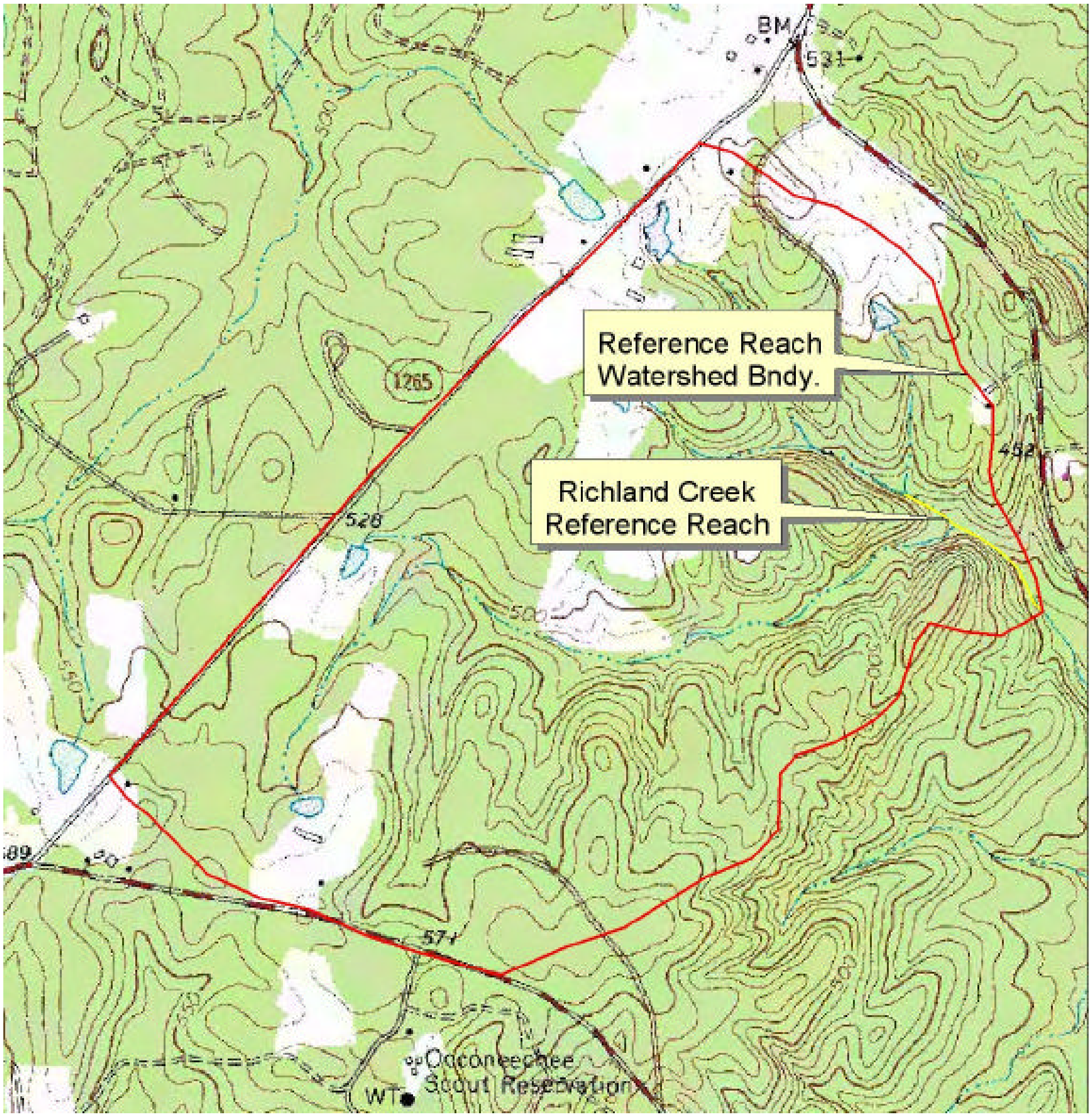
Richland Creek, Moore County

The Richland Creek reference reach is located in Moore County, west of the town of Carthage and upstream (west) of Mount Carmel Road on the Occoneechee Scout Reservation. This 525-foot reach is a moderate sinuosity channel occurring within a late-stage successional forested tract. Richland Creek, through the reference reach, has an average slope of 1.2% and was classified as a Rosgen "C3/C4" stream type. Maps showing the vicinity and site, as well as the reference reach survey summary is shown on the following pages.



The Richland Creek reference reach is located west of Carthage in Moore County.

The 525-foot reach is located upstream of Mount Carmel Road in a forested tract on the Occoneechee Scout Reservation.



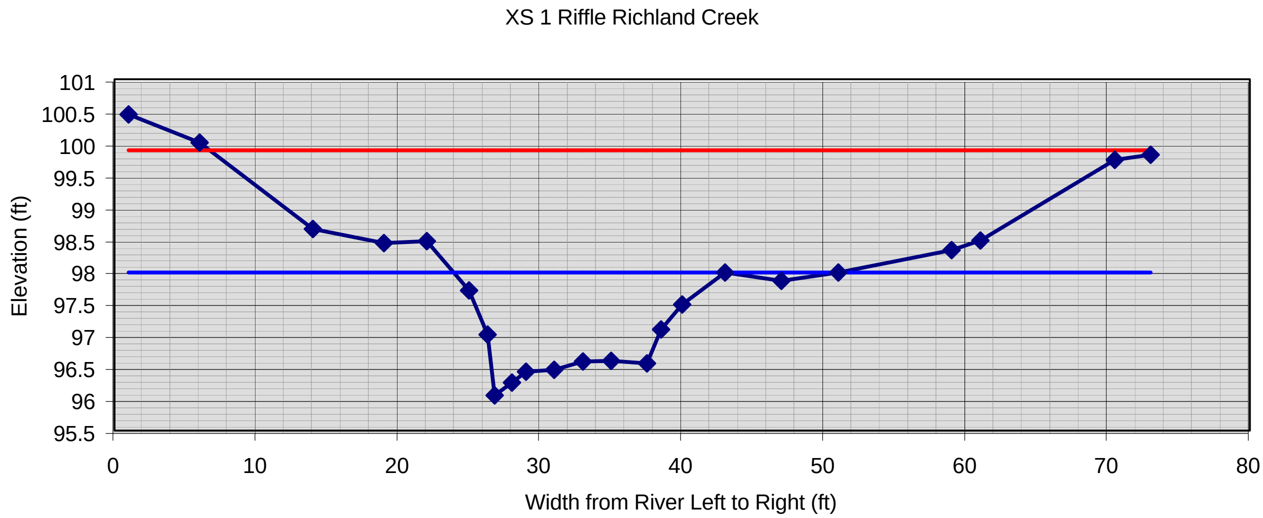
USGS Quad map showing the Richland Creek reference reach drainage area.

Richland Creek, cross-section 1, riffle, looking downstream

Richland Creek, cross-section 2, pool, looking downstream

Richland Creek, cross-section 3, riffle, looking downstream

Cross Section



section:	**XS 1**
	Riffle
stream:	**Richland Creek**
location:	**Profile Station 1+55**
description:	**Setup 2 (Riffle)**
height of instrument (ft):	**102.20**

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBKP	☐	1	1.75	100.45
LTOB	☐	6	2.19	100.01
	☐	14	3.54	98.66
	☐	19	3.76	98.44
	☐	22	3.73	98.47
	☐	25	4.51	97.69
	☐	26.3	5.2	97
LEW/TW	☐	26.8	6.15	96.05
	☐	28	5.95	96.25
	☐	29	5.78	96.42
	☐	31	5.75	96.45
	☐	33	5.62	96.58
	☐	35	5.61	96.59
REW/WS	☐	37.5	5.65	96.55
	☐	38.5	5.12	97.08
BKF?	☐	40	4.73	97.47
Low Bench	☐	43	4.23	97.97
Low Bench	☐	47	4.36	97.84
Low Bench	☐	51	4.23	97.97
Low Bench	☐	59	3.87	98.33
RBOB	☐	61	3.72	98.48
RTOB	☐	70.5	2.46	99.74
Terrace	☐	73	2.38	99.82
	☐			
	☐			

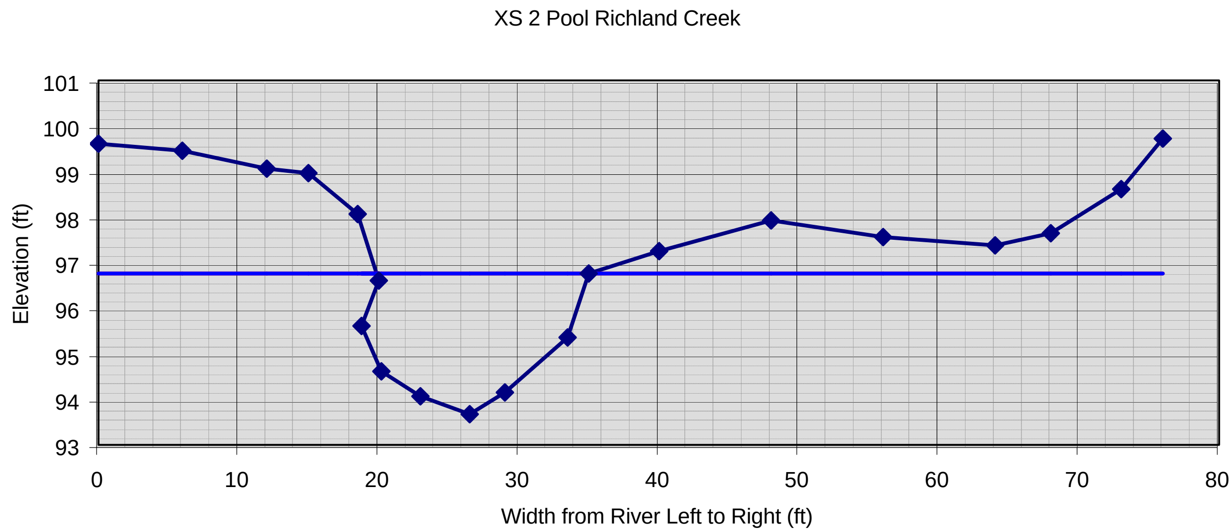
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
4.23	2.46	200.0	2.69	0.035
97.97	99.74			

dimensions			
21.2	x-section area	0.8	d mean
27.1	width	28.1	wet P
1.9	d max	0.8	hyd radi
3.7	bank ht	34.5	w/d ratio
200.0	W flood prone area	7.4	ent ratio

hydraulics	
5.8	velocity (ft/sec)
122.6	discharge rate, Q (cfs)
1.27	shear stress ((lbs/ft sq)
0.81	shear velocity (ft/sec)
7.598	unit stream power (lbs/ft/sec)
1.32	Froude number
7.1	friction factor u/u*
115.0	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Cross Section



section:	XS 2
	Pool
stream:	Richland Creek
location:	Profile Station 2+33
description:	Setup 2 (Pool)
height of instrument (ft):	102.20

notes	omit pt.	distance (ft)	FS (ft)	elevation
Terrace	☐	0	2.59	99.61
	☐	6	2.75	99.45
	☐	12	3.14	99.06
	☐	15	3.24	98.96
LTOB	☐	18.5	4.14	98.06
	☐	20	5.59	96.61
Undercut	☐	18.8	6.59	95.61
LEW	☐	20.2	7.59	94.61
	☐	23	8.13	94.07
TW	☐	26.5	8.53	93.67
	☐	29	8.05	94.15
REW/WS	☐	33.5	6.84	95.36
BKF	☐	35	5.44	96.76
Floodplain	☐	40	4.95	97.25
RTOB	☐	48	4.27	97.93
Terrace	☐	56	4.64	97.56
Terrace	☐	64	4.82	97.38
TS	☐	68	4.55	97.65
Hillside	☐	73	3.58	98.62
	☐	76	2.48	99.72
	☐			
	☐			
	☐			
	☐			
	☐			

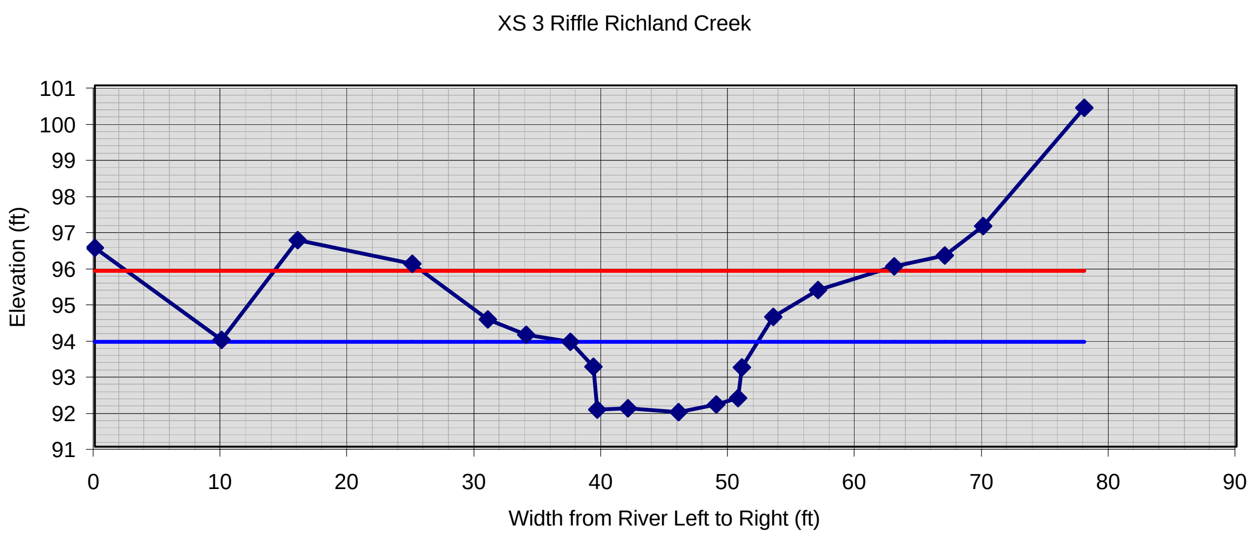
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.44	4.27		0.09	
96.76	97.93			

dimensions			
35.6	x-section area	2.4	d mean
15.2	width	19.1	wet P
3.1	d max	1.9	hyd radi
4.3	bank ht	~~6.4~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.10	shear stress ((lbs/ft sq)
0.23	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
6.8	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
~~0.0~~	relative roughness	~~0.0~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	XS 3
	Riffle
stream:	Richland Creek
location:	Profile Station 4+71
description:	Setup 4 (Riffle)
height of instrument (ft):	101.28

notes	omit pt.	distance (ft)	FS (ft)	elevation
FP/ Terrac	☐	0	4.77	96.51
Terrace hig	☐	10	7.32	93.96
	☐	16	4.57	96.71
LTOB	☐	25	5.22	96.06
Bot Bank	☐	31	6.75	94.53
Bench	☐	34	7.19	94.09
LBKF	☐	37.5	7.37	93.91
	☐	39.3	8.07	93.21
LEW	☐	39.6	9.25	92.03
	☐	42	9.22	92.06
Profile Tap	☐	46	9.33	91.95
	☐	49	9.12	92.16
REW	☐	50.7	8.93	92.35
	☐	51	8.09	93.19
	☐	53.5	6.69	94.59
RTOB	☐	57	5.94	95.34
	☐	63	5.29	95.99
Top slope	☐	67	4.99	96.29
	☐	70	4.17	97.11
Hillside	☐	78	0.9	100.38
	☐			
	☐			
	☐			
	☐			
	☐			

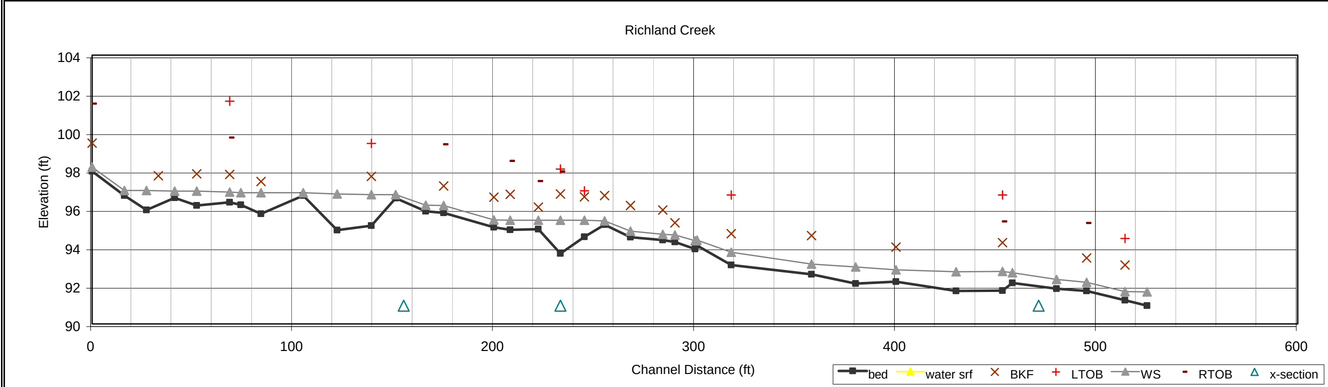
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.37	5.94	150.0	1.73	0.035
93.91	95.34			

dimensions			
22.3	x-section area	1.5	d mean
14.8	width	16.6	wet P
2.0	d max	1.3	hyd radi
3.4	bank ht	9.8	w/d ratio
150.0	W flood prone area	10.1	ent ratio

hydraulics	
6.8	velocity (ft/sec)
151.4	discharge rate, Q (cfs)
1.45	shear stress ((lbs/ft sq)
0.86	shear velocity (ft/sec)
11.053	unit stream power (lbs/ft/sec)
0.95	Froude number
7.9	friction factor u/u*
~~149.0~~	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Longitudinal Profile	Hints	Stream:	Richland Creek	Location:	
		Watershed:	Richland Creek	Date:	



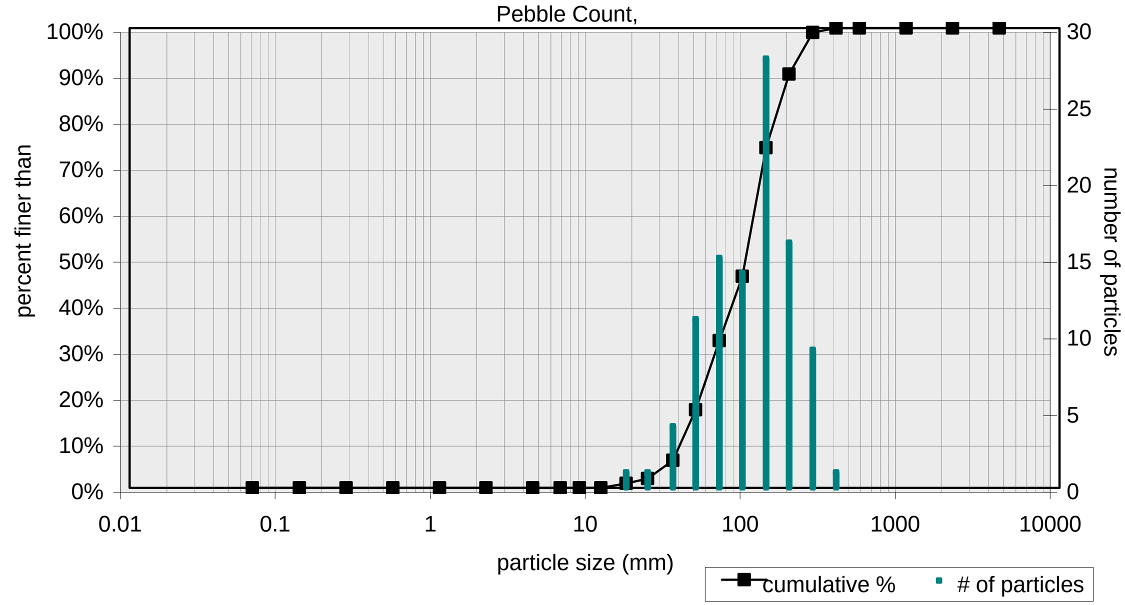
105.28 :Elevation BM

notes	cross section	station		BS	HI	FS TP	FS bed	depth water	FS WS	FS BKF	FS LTOB	FS RTOB	AZ azimuth	ELEV bed	ELEV water srf	ELEV WS	ELEV BKF	ELEV LTOB	ELEV RTOB
					105.28														
HOR		0			105.28		7.33		7.12	5.86		3.81		97.95		98.16	99.42		101.47
HOP		16			105.28		8.6		8.33					96.68		96.95			
MP		27			105.28		9.35		8.33					95.93		96.95			
		33			105.28					7.56							97.72		
Glide		41			105.28		8.71		8.37					96.57		96.91			
Glide		52			105.28		9.11		8.37	7.47				96.17		96.91	97.81		
HOR		68.5			105.28		8.95		8.42	7.49	3.68	5.58		96.33		96.86	97.79	101.6	99.7
Hop		74			105.28		9.08		8.44					96.2		96.84			
Pool		84			105.28		9.54		8.44	7.86				95.74		96.84	97.42		
HOP/BR		105			105.28		8.6		8.45					96.68		96.83			
Pool		122			105.28		10.39		8.51					94.89		96.77			
Pool		139			105.28		10.16		8.55	7.59	5.88			95.12		96.73	97.69	99.4	
HOR		151			105.28		8.73		8.54					96.55		96.74			
Riffle	XS 1	155			105.28														
TR		166			105.28		9.41		9.1					95.87		96.18			
Run		175			105.28		9.49		9.12	8.09		5.93		95.79		96.16	97.19		99.35
HOP		200			105.28		10.24		9.86	8.68				95.04		95.42	96.6		
TP 1					105.28	9.54													
				6.46	102.2										#N/A	#N/A	#N/A	#N/A	#N/A
Run		208			102.2		7.3		6.8	5.45		3.71		94.9		95.4	96.75		98.49
HOP		222			102.2		7.26		6.8	6.11		4.76		94.94		95.4	96.09		97.44
MP	XS 2	233			102.2		8.53		6.8	5.44	4.14	4.27		93.67		95.4	96.76	98.06	97.93
Glide		245			102.2		7.66		6.8	5.59	5.26			94.54		95.4	96.61	96.94	
HOR		255			102.2		7.04		6.83	5.51				95.16		95.37	96.69		
Riffle		268			102.2		7.68		7.36	6.03				94.52		94.84	96.17		
		284			102.2		7.84		7.54	6.26				94.36		94.66	95.94		
Run		290			102.2		7.94		7.57	6.93				94.26		94.63	95.27		
		300			102.2		8.3		7.86					93.9		94.34			
TP 2					102.2	7.2													
				4.66	99.66										#N/A	#N/A	#N/A	#N/A	#N/A
Riffle		301			99.66		5.58		5.3					94.08		94.36			
Pool		318			99.66		6.59		5.93	4.96	2.95			93.07		93.73	94.7	96.71	
iffle/Run/BR		358			99.66		7.07		6.54	5.06				92.59		93.12	94.6		
Pool		380			99.66		7.56		6.7					92.1		92.96			
Riffle		400			99.66		7.46		6.85	5.66				92.2		92.81	94		
HOP		430			99.66		7.94		6.94					91.72		92.72			
Pool		453			99.66		7.92		6.92	5.43	2.95	4.32		91.74		92.74	94.23	96.71	95.34
HOR		458			99.66		7.53		7					92.13		92.66			
Riffle	XS 3	471			99.66														
Riffle		480			99.66		7.82		7.34					91.84		92.32			
Riffle		495			99.66		7.95		7.49	6.22		4.41		91.71		92.17	93.44		95.25
TR		514			99.66		8.42		7.97	6.6	5.21			91.24		91.69	93.06	94.45	
Small Bend		525			99.66		8.71		7.99					90.95		91.67			
					99.66	6.81													
				8.43	101.28										#N/A	#N/A	#N/A	#N/A	#N/A
					101.28														

Pebble Count of Channel Reach Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	**1**
coarse gravel	16	22	**1**
coarse gravel	22	32	**4**
very coarse gravel	32	45	**11**
very coarse gravel	45	64	**15**
small cobble	64	90	**14**
medium cobble	90	128	**28**
large cobble	128	180	**16**
very large cobble	180	256	**9**
small boulder	256	362	**1**
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
		total particle count:	100
bedrock			
clay hardpan			
detritus/wood			
artificial			
		total count:	100

Note: **Richland Creek XS 1**



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	43.627	68.85	94.6	114	158	219	1.9	83.1	1.9

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	0%	0%	32%	67%	1%	0%	0%	0%	0%

Pebble Count of Channel Reach

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	**3**
very coarse sand	1	2	**4**
very fine gravel	2	4	**5**
fine gravel	4	6	**5**
fine gravel	6	8	**4**
medium gravel	8	11	**5**
medium gravel	11	16	**3**
coarse gravel	16	22	**3**
coarse gravel	22	32	**7**
very coarse gravel	32	45	**1**
very coarse gravel	45	64	**8**
small cobble	64	90	**7**
medium cobble	90	128	**14**
large cobble	128	180	**9**
very large cobble	180	256	**11**
small boulder	256	362	**3**
small boulder	362	512	**1**
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
		total particle count:	93
bedrock			**10**
clay hardpan			
detritus/wood			
artificial			
		total count:	103

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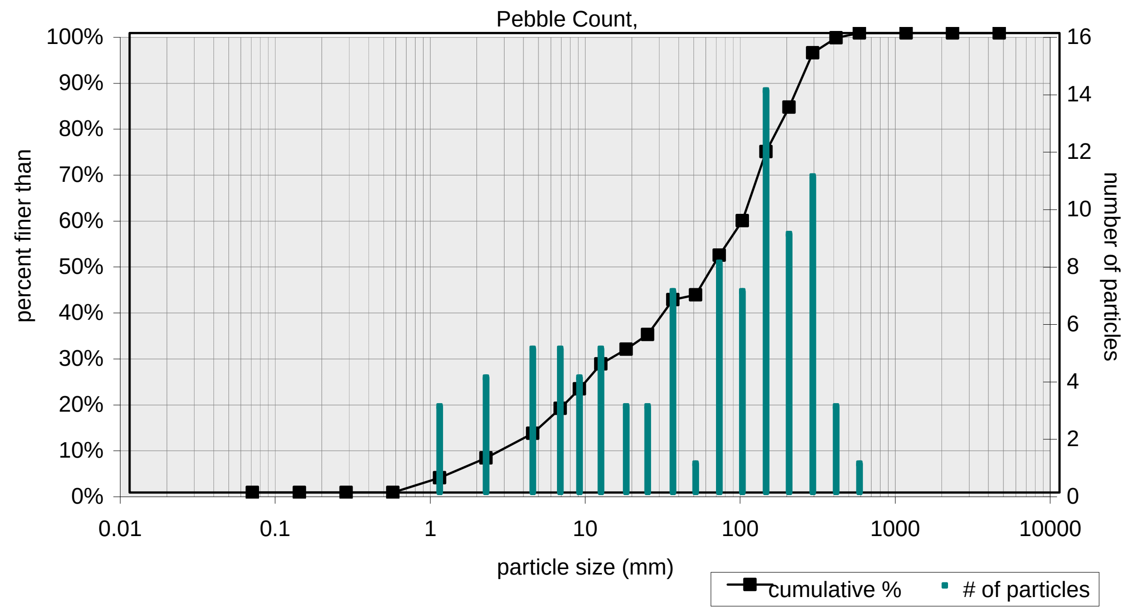
Pebble Count,

Note: **Richland Creek XS 2**



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	5.052	22.66	59.9	103	181	251	7.4	30.2	6.0

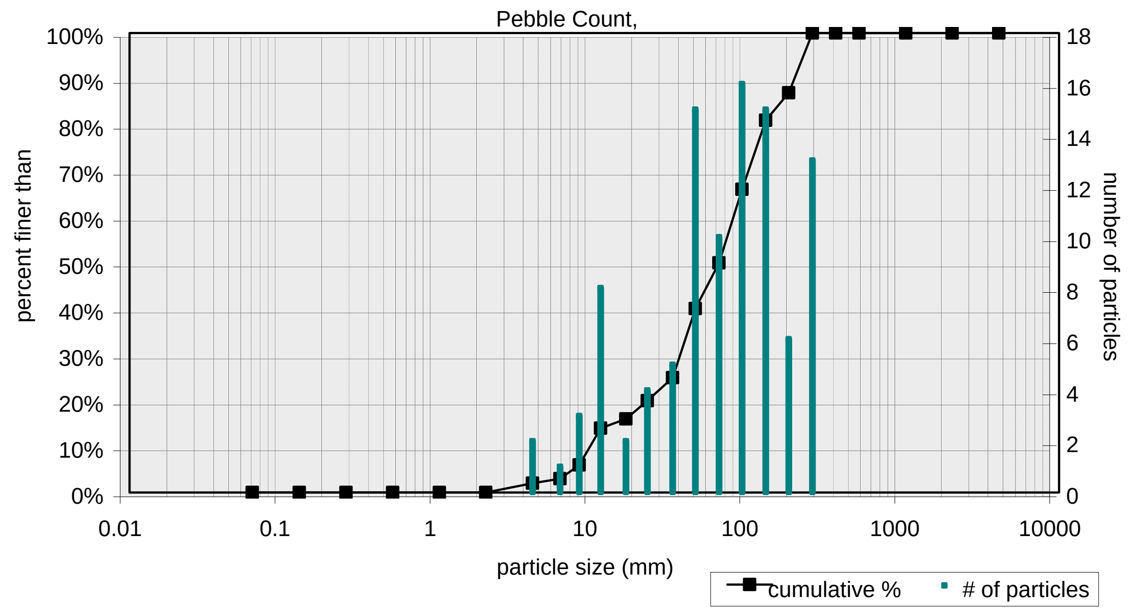
based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	0%	7%	40%	40%	4%	10%	0%	0%	0%

Pebble Count of Channel Reach

Pebble Count,

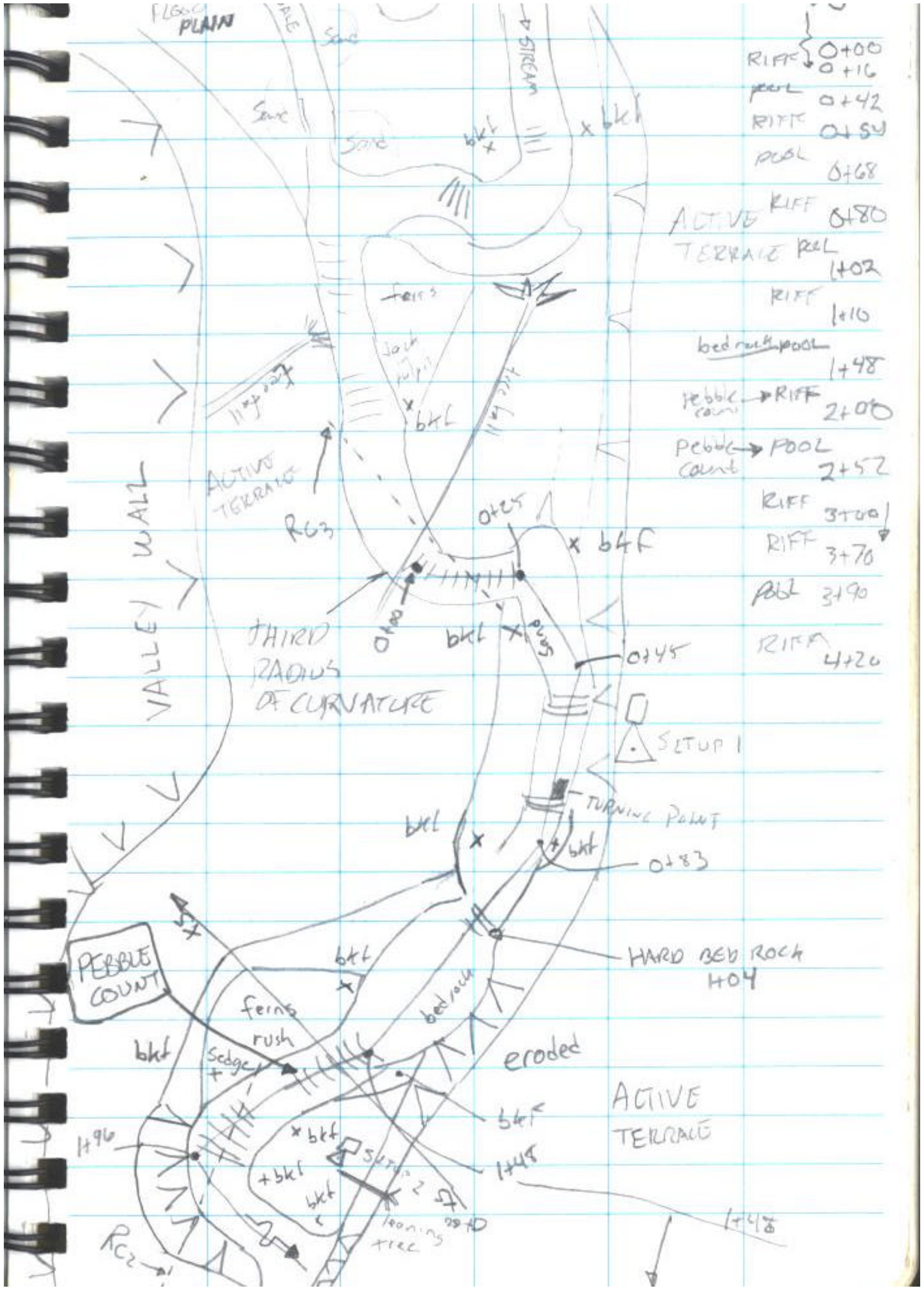
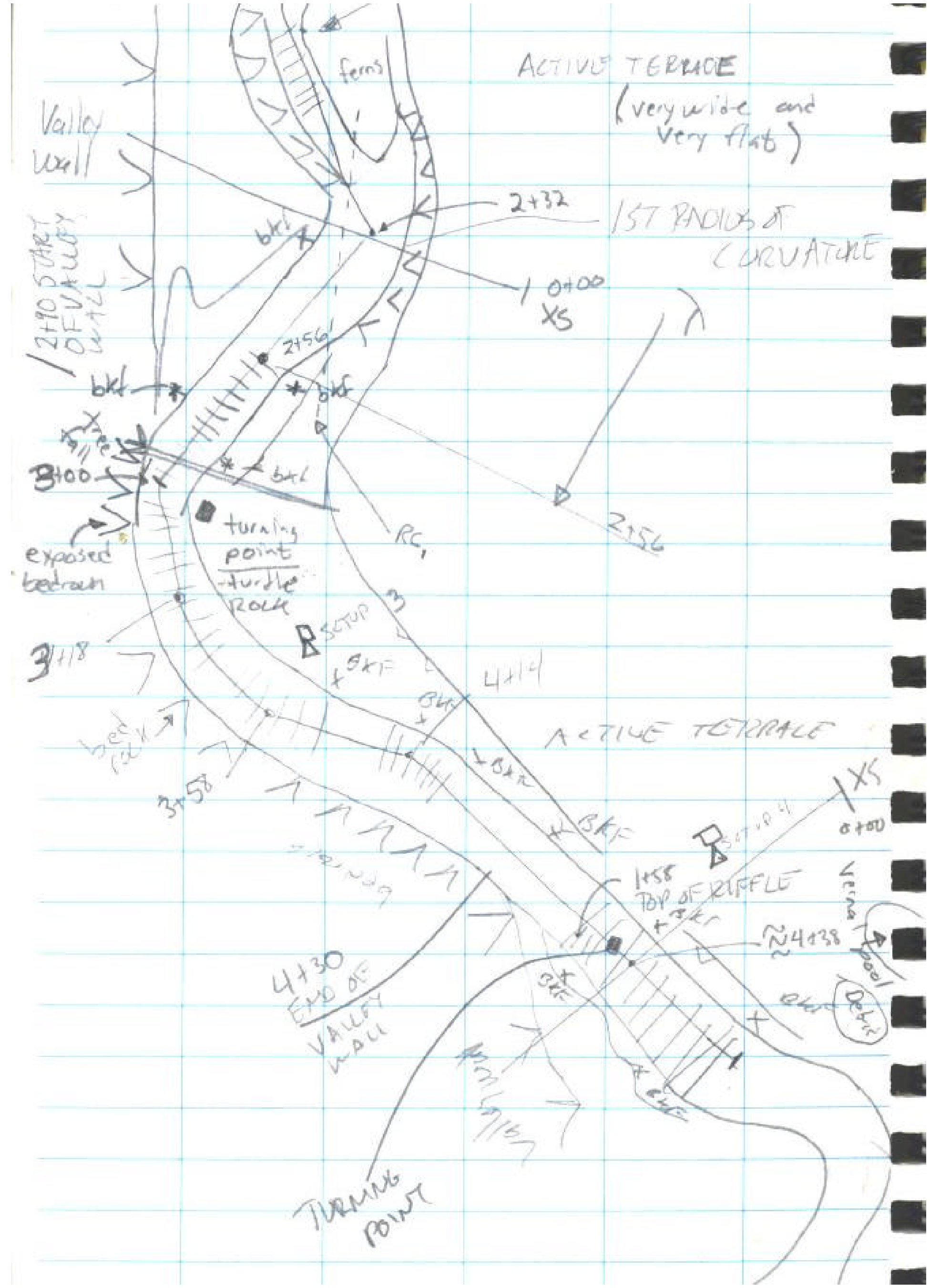
Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	**2**
fine gravel	4	6	**1**
fine gravel	6	8	**3**
medium gravel	8	11	**8**
medium gravel	11	16	**2**
coarse gravel	16	22	**4**
coarse gravel	22	32	**5**
very coarse gravel	32	45	**15**
very coarse gravel	45	64	**10**
small cobble	64	90	**16**
medium cobble	90	128	**15**
large cobble	128	180	**6**
very large cobble	180	256	**13**
small boulder	256	362	
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
		total particle count:	100
bedrock			
clay hardpan			
detritus/wood			
artificial			
		total count:	100

Note: **Richland Creek XS 3**



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	16.000	40.17	64.0	88	152	224	3.2	49.3	3.1

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	0%	0%	50%	50%	0%	0%	0%	0%	0%


FLOOD PLAIN
STREAM
RIFF 0+00 0+16
pool 0+42
RIFF 0+54
POOL 0+68
RIFF 0+80
POOL 1+02
RIFF 1+10
bedrock pool 1+48
pebble count RIFF 2+00
Pebble count POOL 2+52
RIFF 3+00
RIFF 3+70
POOL 3+90
RIFF 4+20
ACTIVE TERRACE
ferns
ACTIVE TERRACE
RC3
VALLEY WALL
THIRD RADIUS OF CURVATURE
0+25
0+00
x bkf
bkf
0+45
SETUP 1
TURNING POINT
0+83
HARD BED ROCK
4+04
PEBBLE COUNT
ferns
rush
sedge
bedrock
eroded
ACTIVE TERRACE
bkf
1+48
1+96
leaning tree
RC2

ferns
ACTIVE TERRACE (very wide and very flat)
Valley wall
2+32
1ST RADIUS OF CURVATURE
0+00 XS
2+90 START OF VALLEY WALL
2+56
bkf
3+00
exposed bedrock
turning point
turtle Rock
RC1
2+56
SETUP 3
3+18
4+14
ACTIVE TERRACE
3+58
XS
0+00
SETUP 4
1+58 TOP OF RIFFLE
~4+38
pool
Debris
4+30 END OF VALLEY WALL
TURNING POINT

Appendix F

Sediment Transport Data

Sediment Sampling and Entrainment at the Un-named Tributary to Back Creek

Four pebble counts were taken in the project reaches and two pebble counts taken in the upstream reference reach. Five bed samples were taken in the project reaches, both surface & subsurface at each location. Two bar samples were taken; one side and one point. Two scour chains, a rain gage and two flow gages were installed.

Observations

From the pebble counts, there are variations in the channel bed, with a noticeable trend to finer beds in the downstream direction. This would make sense for a watershed and geological point of view. The upper reaches are dominated by channery deposits from tributaries that the existing channel has cut through. The lower reach is close to the Back Creek confluence and would be dominated by backwater effects from the main channel, as the Back Creek Lake reservoir is just downstream.

Of the channel bed samples, the one at XS3 (SC2) does not follow the trend of downstream fining in the subsurface sample. XS3 has all the indications of a cattle trod streambed. The armour ratio between the surface and subsurface sample is very low. This occurs when the cattle hooves mix the channel bed, which leads to the loss of fines from the subsurface. There are insignificant differences between these two samples, and these samples do not fall within the trend of the other three bed samples or the four pebble counts. The channel samples from SC1 also show sign of being heavily trodded. Having only two sample immediately showing significant cattle damage is actually quite amazing considering the heard at the project site.

The bed samples have several significant trends. First there is a downstream fining. Second, the D84 of the subsurface sample is close to the D50 of the surface sample indicating that the D50 of the channel bed should be mobilized during bankfull events. The armour ratio of the three bed samples range from 2.1 to 2.8 (increasing downsteam) which is another indication that the channel bed surface is active at bankfull flows. An active bed is one where the subsurface is a good indication of the bedload sediment transport in the stream system. Third, while there are decent amounts of sand in the subsurface, ranging from 11% to 25%, there is no indication in the pebble counts or bed surface bulk samples of any sand at all. However, all of the bar samples have high sand content, ranging from 29% to 66%. Therefore the channel bed does not record the sand transport that is obvious in the system.

There are two broad methods of sediment transport analysis developed by Gilbert in 1914, first to look at the entire channel bed in sediment transport modeling, or to look at the competency of the channel to move the largest observed in sediment transport.

When four of the channel bed samples are subjected to entire bed sediment transport modeling, there are several indicators that the surface and subsurface are not in balance. Such widespread inconsistencies point to the fact that all of the sample locations are effected by cattle trodding. The two scour chain sites, looked the most alluvial and easiest to install a chain. However by being the most alluvial, the cattle trodding had the highest impacts. The less alluvial sites were more armoured and less likely to be mixed. However, the mixing that did occur was enough to unbalance the surface and subsurface samples. This natural balance was examined in two ways, first: could the surface and subsurface samples cross predict sediment transport rates with shear stress, and second: could the surface and subsurface samples predict the other's D50 with shear stress.

When the channel samples were modeled for the sediment transport rates, only two spots show reasonable results that however had shallower flow depths than had been expected. When the modeling was examined for the D50 balance most results were absurdly high or low and the best results were at the same two spots as before and they produced deeper flow depths than the previous analysis.

The sediment transport analysis based on the entrainment of the largest particles thought to be in motion was attempted in three ways. First scour chains were installed at two sites, however the channel beds seem to have mixed and then compacted by the cattle. After several bankfull events, there still had not been any scour and redeposit at these two locations. No sampling could be performed this way.

When the channel bed samples were examined directly, the largest particles in the channel were all outside of the valid range of any of Andrew's (1983, 1994) equations. When the Wilcock-Crowe (2003) equation was used, it consistently produced shear result indicating that out of bank flow events are required to move these particle sizes.

Finally when the bar samples were compared to the channel beds, only the point bar sample had reasonable results. Upstream at XS1, the bar sample was 2/3rds sand and the channel bed was extremely narrowly sorted. This is an indication of extreme local turbulence washing the channel bed into a narrow gradation range and suspending the sand into the flow. The side bar sample would then be more representative of the local wash load and not the bed load, so it could not be used. Downstream at XS3, the point bar sample was somewhat unique in the channel system because there were very few well-developed point bars. When the D84 of the point bar was compared to the channel bed D50 it produced a flow depth that matched the reference reach and regional curve expectation.

Conclusions

Because of the trampled condition of SC1 & XS3, these sampled subsurfaces cannot be used in any meaningful way in a sediment transport analysis.

Because of the absence of sand in the surface bulk samples, a full range sediment transport analysis is not possible from these samples. These samples may be used in an entrainment type calculation of the largest particle in motion. However, the recent methods of Dave Rosgen (to perform these calculations using Andrews equations) do not fit the data set from the McCain property very well.

The fact that sand is missing in the streambed is an indication that this tributary primarily acts as a transport reach. It is likely that this project site is supply limited for the sand fraction. Meaning that the upstream supply of sand will cut off before the project's reaches' capability of transport this sand. As a consequence, the channel bed will wash clean of sand and store this last of the sand transport in the shallow pool locations as the stream flow recedes after each bankfull flow event. Because this stream acts so much like a transport channel, the channel bed does not truly represent a regime channel, therefore it's not surprising that the sediment transport parameters will fall outside of normal alluvial stream channel characteristics.

The entrainment calculation is based on assessing the largest particle known to be transported during bankfull events. However these particle sizes are much larger than the D50 of the channel bed. Therefore, the use of "near equal mobility" functions, like Andrew's (1983, 1994) equations, are not possible because the data exceeds the 1.3 x D50 upper size limitation of these equations. Only XS1 comes close to the published valid range for Andrew's equation and this location sowed signs of extreme turbulence. For the data range of the McCain site, a "near no-hiding" function, like the Wilcock-Crowe (2003) equations, are appropriate.

The "near no-hiding" reference shear stress for mobility from the Wilcock-Crowe function is:

$$\tau_{ri} = \tau_{rs50}\left(\frac{D_i}{D_{s50}}\right)^{0.67}$$

where:

$$\tau^*_{rm} = 0.036$$

for a gravel bed.

$$\tau_{rs50} = \tau^*_{rm}(\rho_s - \rho)gD_{s50}$$

Based on the bar samples at XS3, a point shear velocity of 0.201 m/s (0.66 fps)was selected for the channel design. When this shear velocity was combined with a design Q of around 2.834 m^3/s (100 cfs), four reaches with differing channel gradients produced cross sectional geometry that fit well with the range of geometry observed in the reference reach. When the hydraulic radius and average channel gradient from the two steepest reaches was examined, the design point shear stress was converted back to an average shear stress of 0.1565 m/s. This agreed amazing well with the average shear stress of 0.1566 m/s from the entrainment calculations, shown below.

Andrews, E.D. (1983). "Entrainment of Gravel from Natural Sorted Riverbed Material," Geologic Society of America Bulletin 94, 1225-1231.

Andrews, E.D. (1994). "Marginal Bedload in a Gravel-Bed Stream, Sage Hen Creek, California," Water Resources Research, 30, 2241-2250

Wilcock, P.R. and Crowe, J.C. (2003). "Surface-Based Transport Model for Mixed-Size Sediment", *Journal of Hydraulic Engineering*, ASCE, 129(2), pp 120-128.

McCain Sediment Entrainment Calculations

Reach 1			Reach 2		
Riffle/Bar			Riffle/Bar		
D50=	45.9	Riffle D50	D50=	25.9	Riffle D50
D84=	90.0	Riffle D84	D84=	83.0	Riffle D84
D^50=	23.1	Bar D50	D^50=		Bar D50
Di=	63.5	Bar Largest	Di=		Bar Largest
Di2=	38.1	Bar 2nd Largest	Di2=		Bar 2nd Largest
Pavement/Subpavement			Pavement/Subpavement		
D50=	40.6	Pavement D50	D50=	25.2	Pavement D50
D84=	49.3	Pavement D84	D84=	43.4	Pavement D84
D^50=	19.3	Subpavement D50	D^50=	10.5	Subpavement D50
Di=	57.2	Subpavement Largest	Di=	57.2	Subpavement Largest
Di2=	47.6	Subpavement 2nd Largest	Di2=	44.5	Subpavement 2nd Largest

Ratio of largest to surface D50			Ratio of largest to surface D50		
	1.38	Bar Largest		0.00	Bar Largest
	0.83	Bar 2nd Largest		0.00	Bar 2nd Largest
	1.25	Subpavement Largest		2.21	Subpavement Largest
	1.04	Subpavement 2nd Largest		1.72	Subpavement 2nd Largest
	0.0360	Tc*, 50		0.0360	Tc*, 50
Pa	42.9566	Tc,50	Pa	24.2391	Tc,50
Shear Stress Levels			Shear Stress Levels		
Pa	47.7343	Bar Largest	Pa	0.0000	Bar Largest
Pa	41.1279	Bar 2nd Largest	Pa	0.0000	Bar 2nd Largest
Pa	45.8893	Subpavement Largest	Pa	34.9408	Subpavement Largest
Pa	43.3812	Subpavement 2nd Largest	Pa	29.7961	Subpavement 2nd Largest
lbs/ft2	1.00	Bar Largest	lbs/ft2	0.00	Bar Largest
lbs/ft2	0.86	Bar 2nd Largest	lbs/ft2	0.00	Bar 2nd Largest
lbs/ft2	0.96	Subpavement Largest	lbs/ft2	0.73	Subpavement Largest
lbs/ft2	0.91	Subpavement 2nd Largest	lbs/ft2	0.62	Subpavement 2nd Largest

McCain Sediment Entrainment Calculations

Reach 3			Reach 4		
Riffle/Bar			Riffle/Bar		
D50=	***25.4***	Riffle D50	D50=	***11.6***	Riffle D50
D84=	***47.9***	Riffle D84	D84=	***43.0***	Riffle D84
D^50=	***9.2***	Bar D50	D^50=		Bar D50
Di=	***63.5***	Bar Largest	Di=		Bar Largest
Di2=	***38.1***	Bar 2nd Largest	Di2=		Bar 2nd Largest
Pavement/Subpavement			Pavement/Subpavement		
D50=	***25.4***	Pavement D50	D50=	***17.4***	Pavement D50
D84=	***47.9***	Pavement D84	D84=	***26.3***	Pavement D84
D^50=	***19.6***	Subpavement D50	D^50=	***6.1***	Subpavement D50
Di=	***50.8***	Subpavement Largest	Di=	***38.1***	Subpavement Largest
Di2=	***38.1***	Subpavement 2nd Largest	Di2=	***38.1***	Subpavement 2nd Largest

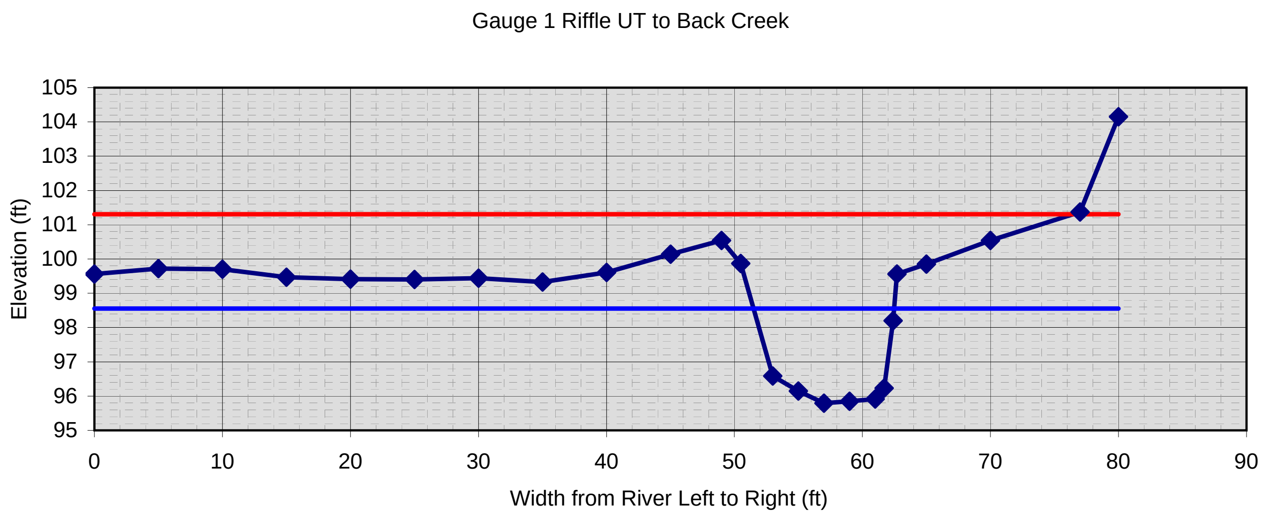
Ratio of largest to surface D50			Ratio of largest to surface D50		
	2.50	Bar Largest		***0.00***	Bar Largest
	1.50	Bar 2nd Largest		***0.00***	Bar 2nd Largest
	2.00	Subpavement Largest		***3.28***	Subpavement Largest
	1.50	Subpavement 2nd Largest		***3.28***	Subpavement 2nd Largest
	0.0360	Tc*, 50		***0.0360***	Tc*, 50
Pa	***23.7712***	Tc,50	Pa	***10.8561***	Tc,50
Shear Stress Levels			Shear Stress Levels		
Pa	***37.7385***	Bar Largest	Pa	***0.0000***	Bar Largest
Pa	***27.3403***	Bar 2nd Largest	Pa	***0.0000***	Bar 2nd Largest
Pa	***32.0142***	Subpavement Largest	Pa	***21.9185***	Subpavement Largest
Pa	***27.3403***	Subpavement 2nd Largest	Pa	***21.9185***	Subpavement 2nd Largest
lbs/ft2	***0.79***	Bar Largest	lbs/ft2	***0.00***	Bar Largest
lbs/ft2	***0.57***	Bar 2nd Largest	lbs/ft2	***0.00***	Bar 2nd Largest
lbs/ft2	***0.67***	Subpavement Largest	lbs/ft2	***0.46***	Subpavement Largest
lbs/ft2	***0.57***	Subpavement 2nd Largest	lbs/ft2	***0.46***	Subpavement 2nd Largest

McCain Sediment Entrainment Calculations

Reach 3		
Riffle/Bar		
D50=	***25.4***	Riffle D50
D84=	***47.9***	Riffle D84
D^50=	***9.2***	Bar D50
Di=	***63.5***	Bar Largest
Di2=	***38.1***	Bar 2nd Largest
Pavement/Subpavement		
D50=	***25.4***	Pavement D50
D84=	***47.9***	Pavement D84
D^50=	***19.6***	Subpavement D50
Di=	***50.8***	Subpavement Largest
Di2=	***38.1***	Subpavement 2nd Largest

Point Bar Comparison		
	28.4	D84 point bar
mm	***28.4***	
Pa	***24.5258***	
lbs/ft2	***0.512***	
m/s	***0.1566***	u*
ft/s	***0.5137***	
slope	***0.38%***	average
m	***0.66***	depth
ft	***2.16***	

Cross Section



section:	Gauge 1
	Riffle
stream:	UT to Back Creek
location:	about 2 feet US of Gauge 1
description:	BS on Lower R Spike is 5.95
height of instrument (ft):	105.95

notes	omit pt.	distance (ft)	FS (ft)	elevation
Lbkp	☐	0	6.39	99.56
	☐	5	6.23	99.72
	☐	10	6.25	99.7
	☐	15	6.48	99.47
	☐	20	6.54	99.41
	☐	25	6.55	99.4
	☐	30	6.51	99.44
	☐	35	6.62	99.33
	☐	40	6.34	99.61
	☐	45	5.81	100.14
LTOB	☐	49	5.41	100.54
	☐	50.5	6.08	99.87
LEW/WS	☐	53	9.36	96.59
	☐	55	9.8	96.15
	☐	57	10.16	95.79
	☐	59	10.1	95.85
	☐	61	10.04	95.91
REW	☐	61.7	9.72	96.23
	☐	62.4	7.75	98.2
RTOB	☐	62.7	6.39	99.56
	☐	65	6.1	99.85
	☐	70	5.41	100.54
Toe of Slop	☐	77	4.58	101.37
Slope	☐	80	1.8	104.15
	☐			

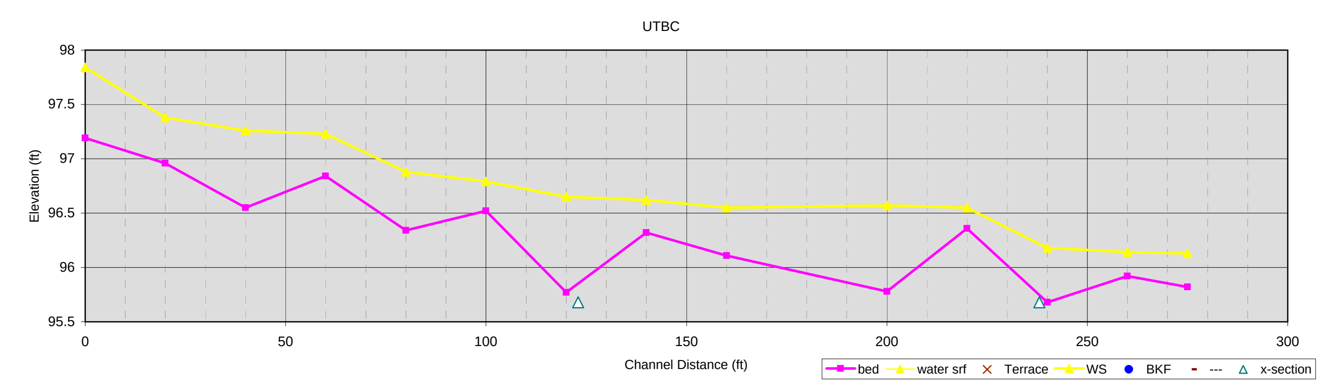
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.4	6.39	100.0	0.5	0.03
98.55	99.56			

dimensions			
24.5	x-section area	2.2	d mean
11.0	width	13.8	wet P
2.8	d max	1.8	hyd radi
3.8	bank ht	4.9	w/d ratio
100.0	W flood prone area	9.1	ent ratio

hydraulics	
5.1	velocity (ft/sec)
125.8	discharge rate, Q (cfs)
0.55	shear stress ((lbs/ft sq)
0.53	shear velocity (ft/sec)
3.576	unit stream power (lbs/ft/sec)
0.37	Froude number
9.6	friction factor u/u*
34.4	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

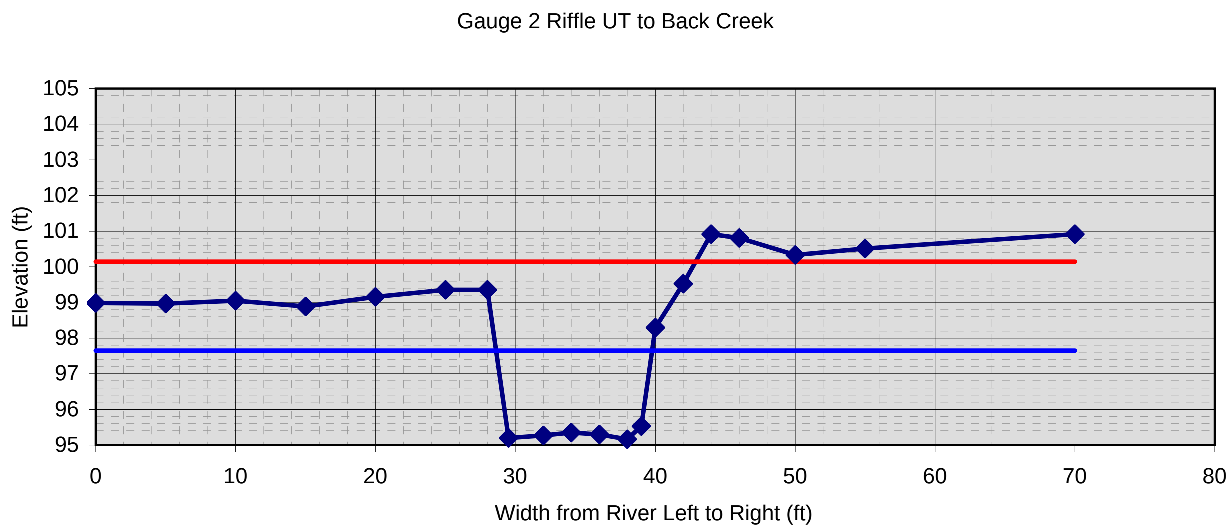
Longitudinal Profile	Hints	Stream:	UTBC	Location:	Gauge 1
		Watershed:	Back Creek	Date:	



100 :Elevation BM

notes	cross section	station		BS 5.95	HI 105.95	FS TP	FS bed	depth water	FS BKF	FS Terrace	FS WS	FS	AZ azimuth	ELEV bed	ELEV water srf	ELEV BKF	ELEV Terrace	ELEV WS	ELEV ---
		0			105.95		8.76				8.11			97.19				97.84	
		20			105.95		8.99				8.57			96.96				97.38	
		40			105.95		9.4				8.69			96.55				97.26	
		60			105.95		9.11				8.72			96.84				97.23	
		80			105.95		9.61				9.07			96.34				96.88	
		100			105.95		9.43				9.16			96.52				96.79	
		120			105.95		10.18				9.3			95.77				96.65	
XS Tape		121.5			105.95														
	Gauge 1	123			105.95														
		140			105.95		9.63				9.33			96.32				96.62	
		160			105.95		9.84				9.4			96.11				96.55	
		200			105.95		10.17				9.38			95.78				96.57	
		220			105.95		9.59				9.4			96.36				96.55	
	Chain	238			105.95														
		240			105.95		10.27				9.77			95.68				96.18	
		260			105.95		10.03				9.81			95.92				96.14	
		275			105.95		10.13				9.82			95.82				96.13	

Cross Section



section:	Gauge 2
	Riffle
stream:	UT to Back Creek
location:	about 1 feet US of Gauge 2
description:	BS on Lower RR Spike is 5.95
height of instrument (ft):	105.95

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBKP	☐	0	6.96	98.99
	☐	5	6.98	98.97
	☐	10	6.9	99.05
	☐	15	7.06	98.89
	☐	20	6.79	99.16
	☐	25	6.6	99.35
LTOB	☐	28	6.6	99.35
LEW	☐	29.5	10.75	95.2
	☐	32	10.68	95.27
	☐	34	10.6	95.35
	☐	36	10.65	95.3
	☐	38	10.79	95.16
REW	☐	39	10.42	95.53
	☐	40	7.66	98.29
	☐	42	6.43	99.52
RTOB	☐	44	5.03	100.92
	☐	46	5.14	100.81
	☐	50	5.62	100.33
	☐	55	5.44	100.51
	☐	70	5.03	100.92
	☐			
	☐			
	☐			
	☐			
	☐			

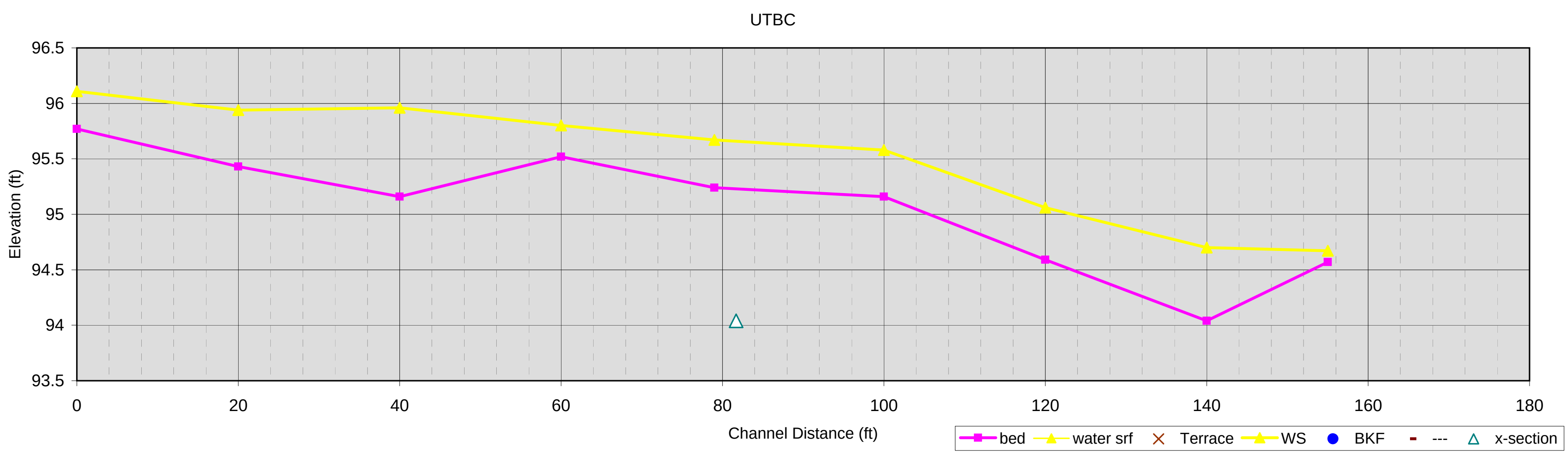
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
8.3	6.6	200.0	0.6	0.03
97.65	99.35			

dimensions			
24.4	x-section area	2.2	d mean
11.2	width	14.4	wet P
2.5	d max	1.7	hyd radi
4.2	bank ht	5.1	w/d ratio
200.0	W flood prone area	17.9	ent ratio

hydraulics	
5.4	velocity (ft/sec)
133.0	discharge rate, Q (cfs)
0.63	shear stress ((lbs/ft sq)
0.57	shear velocity (ft/sec)
4.463	unit stream power (lbs/ft/sec)
0.42	Froude number
9.5	friction factor u/u*
39.9	threshold grain size (mm)

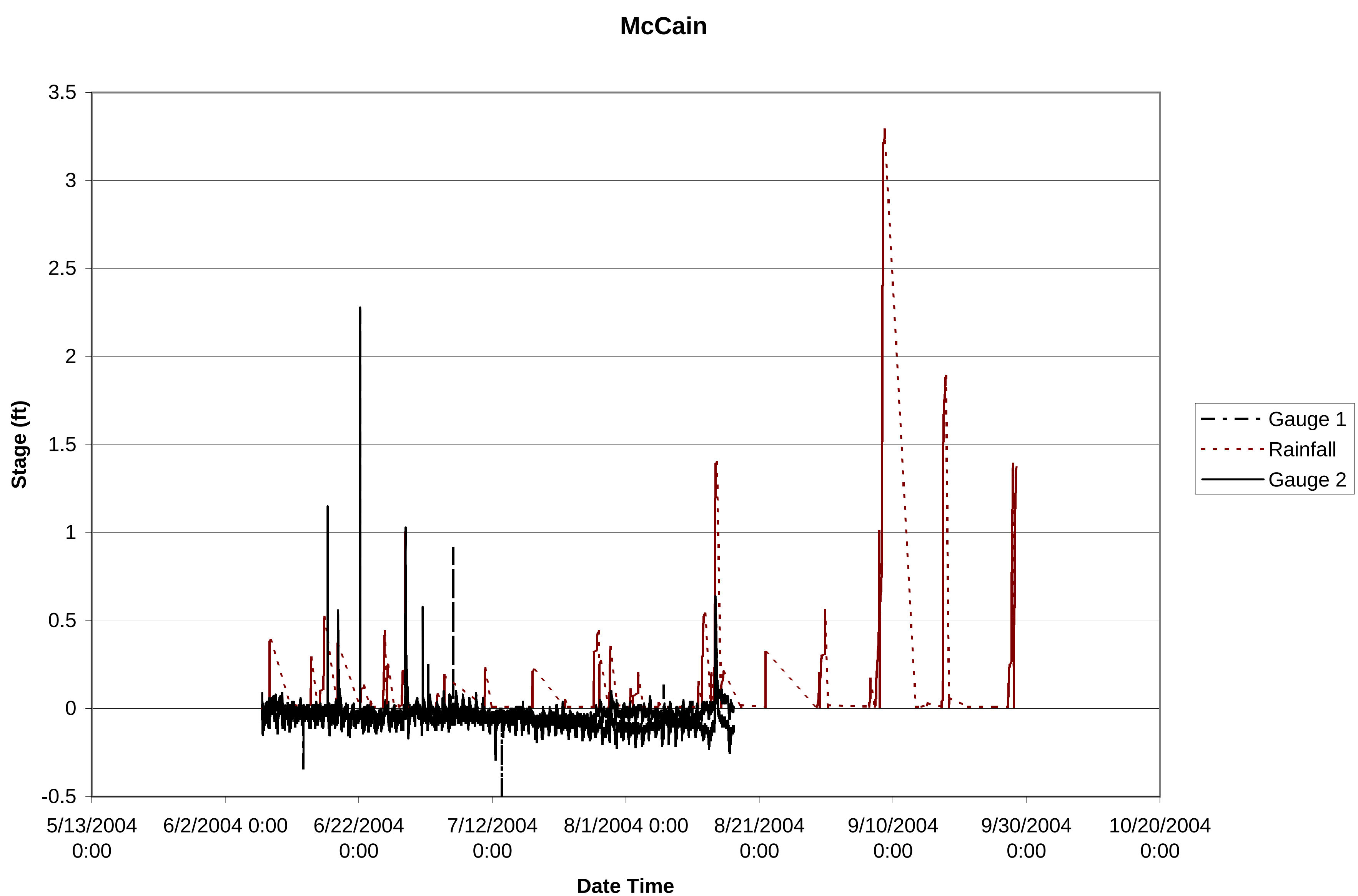
check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Longitudinal Profile	Hints	Stream:	UTBC	Location:	Gauge 2
		Watershed:	Back Creek	Date:	

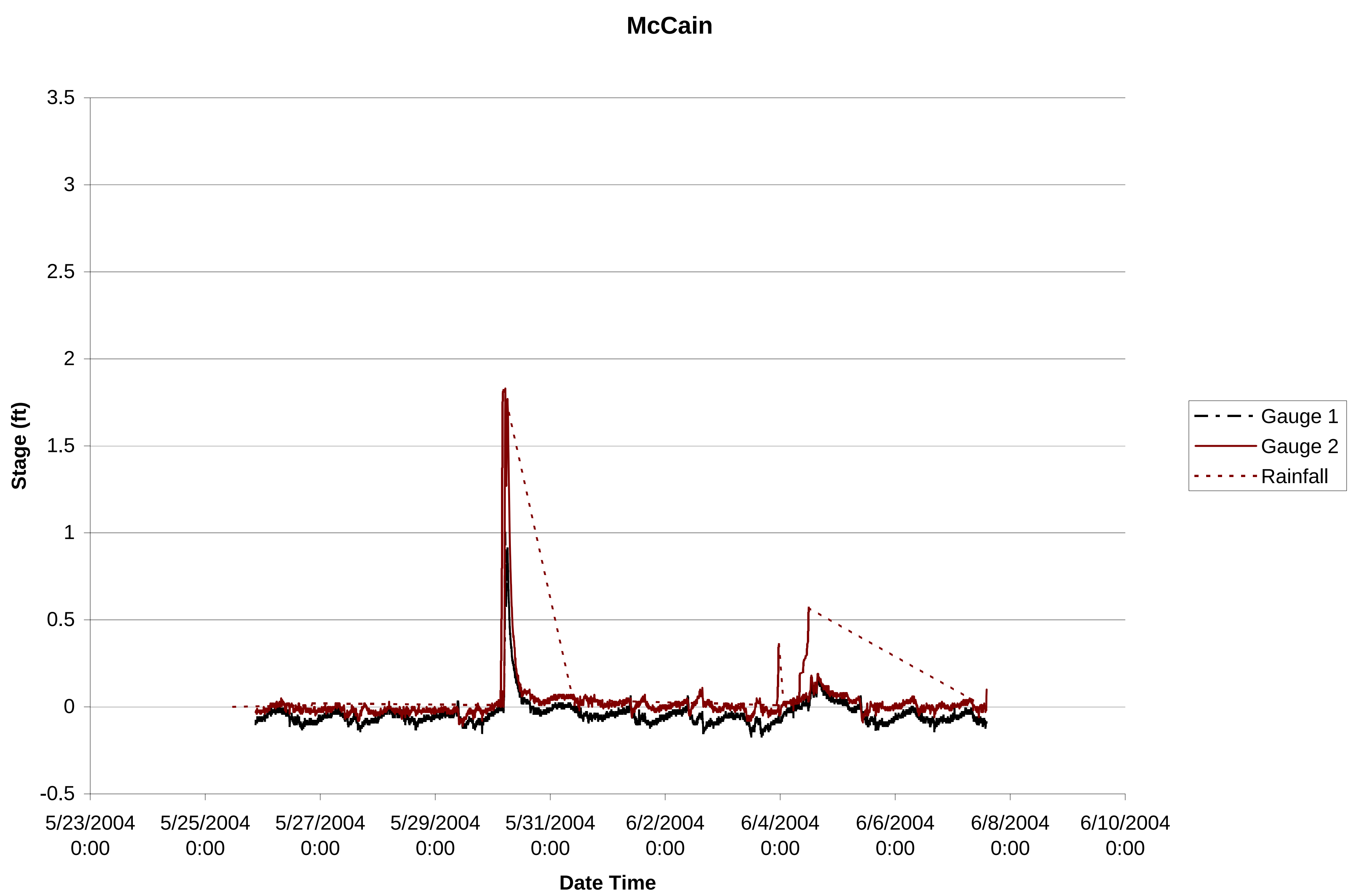


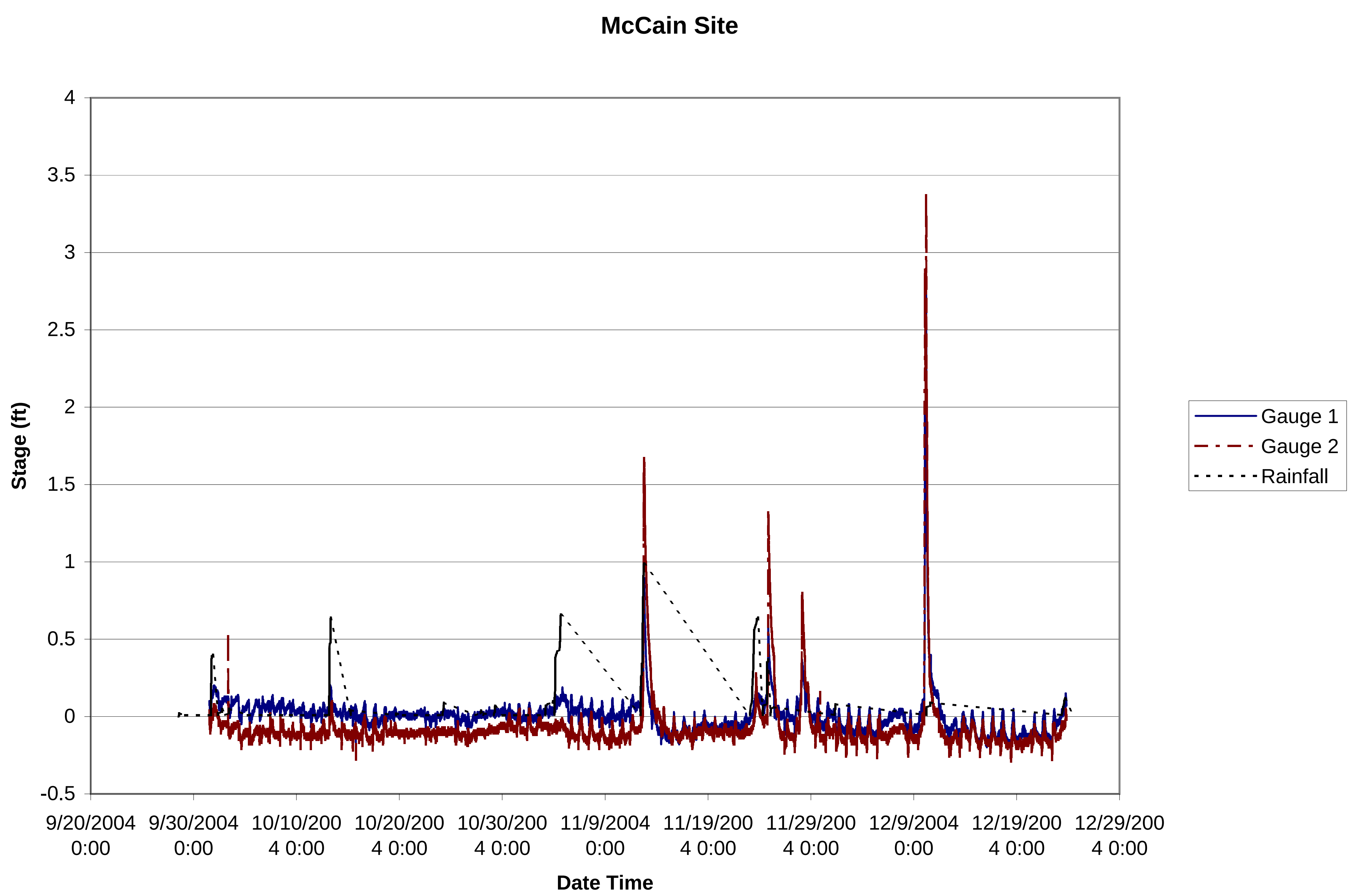
100 :Elevation BM

notes	cross section	station		BS	HI	FS TP	FS bed	depth water	FS BKF	FS Terrace	FS WS	FS	AZ azimuth	ELEV bed	ELEV water srf	ELEV BKF	ELEV Terrace	ELEV WS	ELEV ---
				5.95	105.95														
		0			105.95		10.18				9.84			95.77				96.11	
		20			105.95		10.52				10.01			95.43				95.94	
		40			105.95		10.79				9.99			95.16				95.96	
Trib RB		44			105.95														
		60			105.95		10.43				10.15			95.52				95.8	
		79			105.95		10.71				10.28			95.24				95.67	
XS Tape		81			105.95														
	Gauge 2	81.7			105.95														
		100			105.95		10.79				10.37			95.16				95.58	
attle Crossing		105			105.95														
		120			105.95		11.36				10.89			94.59				95.06	
art Debris Jam		125			105.95														
d Debris Jam		135			105.95														
		140			105.95		11.91				11.25			94.04				94.7	
		155			105.95		11.38				11.28			94.57				94.67	

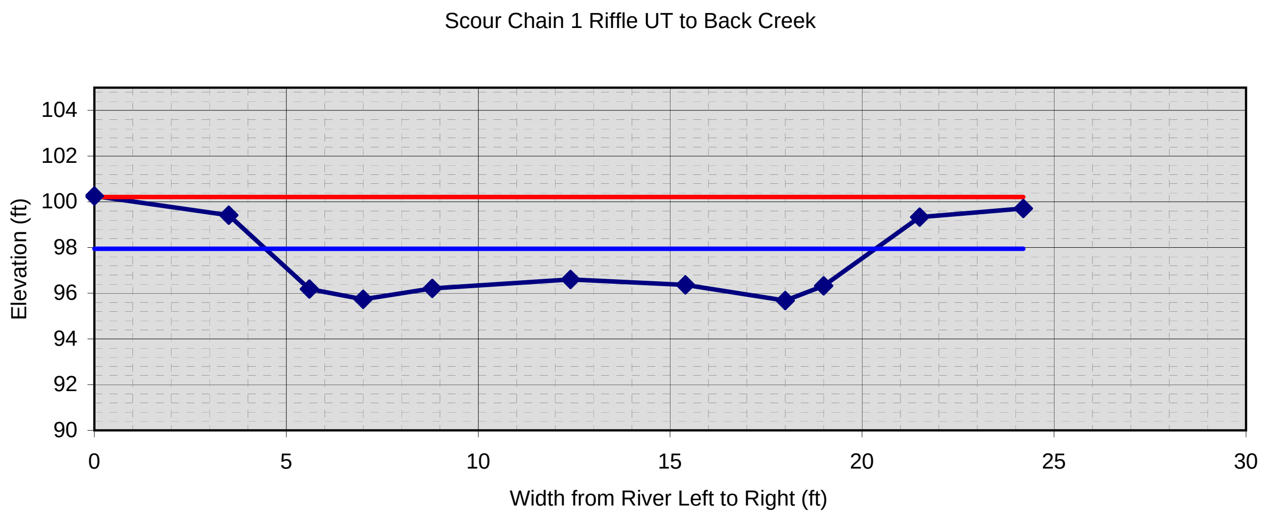


McCain
Stage (ft)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
5/13/2004 0:00
6/2/2004 0:00
6/22/2004 0:00
7/12/2004 0:00
8/1/2004 0:00
8/21/2004 0:00
9/10/2004 0:00
9/30/2004 0:00
10/20/2004 0:00
Date Time
Gauge 1
Rainfall
Gauge 2


McCain
Stage (ft)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
5/23/2004 0:00
5/25/2004 0:00
5/27/2004 0:00
5/29/2004 0:00
5/31/2004 0:00
6/2/2004 0:00
6/4/2004 0:00
6/6/2004 0:00
6/8/2004 0:00
6/10/2004 0:00
Date Time
Gauge 1
Gauge 2
Rainfall


McCain Site
Stage (ft)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
9/20/2004 0:00
9/30/2004 0:00
10/10/200 4 0:00
10/20/200 4 0:00
10/30/200 4 0:00
11/9/2004 0:00
11/19/200 4 0:00
11/29/200 4 0:00
12/9/2004 0:00
12/19/200 4 0:00
12/29/200 4 0:00
Date Time
Gauge 1
Gauge 2
Rainfall

Cross Section



section:	Scour Chain 1
	Riffle
stream:	UT to Back Creek
location:	BS on lower RR Spike is 5.95
description:	Permanent Scour Chain XS
height of instrument (ft):	105.95

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBKP Top		0	5.7	100.25
LTOB		3.5	6.54	99.41
LEW		5.6	9.77	96.18
TW		7	10.21	95.74
EW		8.8	9.74	96.21
Chain		12.4	9.35	96.6
EW		15.4	9.58	96.37
		18	10.27	95.68
REW		19	9.62	96.33
RTOB		21.5	6.62	99.33
RBKP Top		24.2	6.24	99.71

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
8	6.62			
97.95	99.33			

dimensions

25.4	x-section area	1.6	d mean
15.9	width	18.1	wet P
2.3	d max	1.4	hyd radi
3.7	bank ht	10.0	w/d ratio
0.0	W flood prone area	0.0	ent ratio

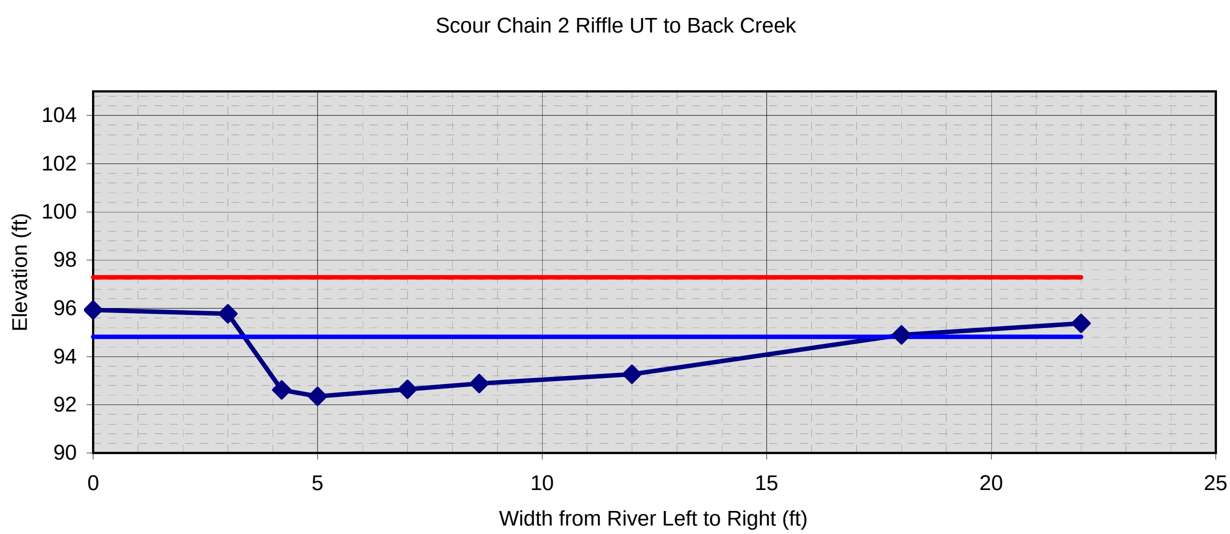
hydraulics

0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material

	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Cross Section



section:	Scour Chain 2
	Riffle
stream:	UT to Back Creek
location:	BS on lower RR Spike is 3.32
description:	Permanent Scour Chain XS
height of instrument (ft):	103.32

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBKP Top	☐	0	7.39	95.93
LTOB	☐	3	7.54	95.78
LEW	☐	4.2	10.7	92.62
	☐	5	10.97	92.35
REW/WS	☐	7	10.68	92.64
Chain	☐	8.6	10.44	92.88
RBOB	☐	12	10.05	93.27
	☐	18	8.42	94.9
RBKP Top	☐	22	7.95	95.37

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
8.5	7.54			
94.82	95.78			

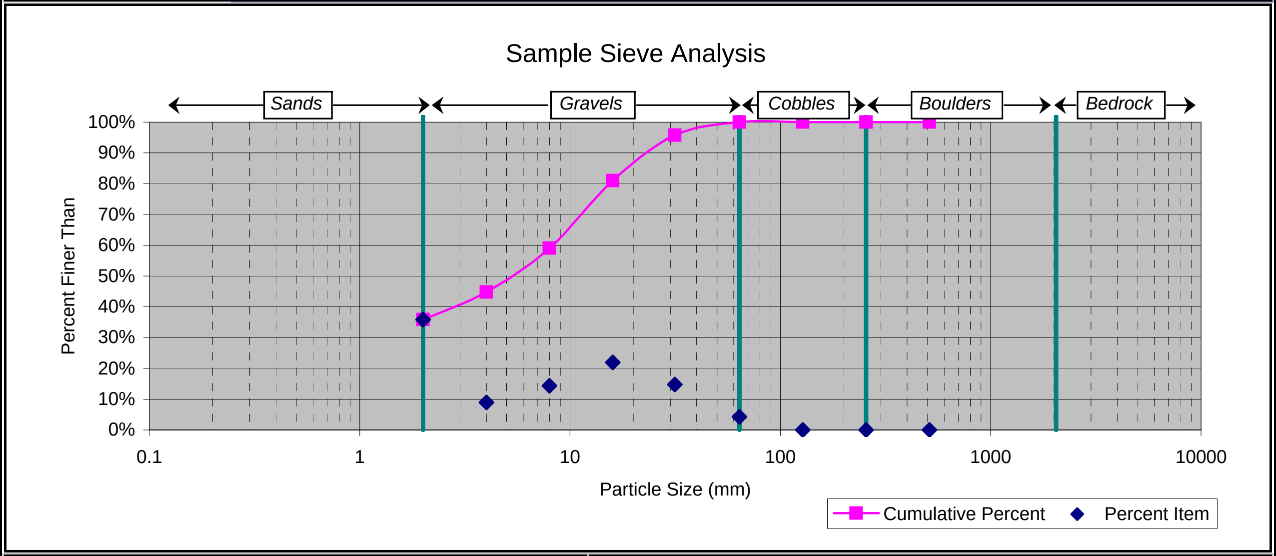
dimensions			
21.1	x-section area	1.5	d mean
14.3	width	16.2	wet P
2.5	d max	1.3	hyd radi
3.4	bank ht	9.8	w/d ratio
0.0	W flood prone area	0.0	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	123.9	35.9%	35.9%
4.0	30.8	8.9%	44.8%
8.0	49.4	14.3%	59.1%
16.0	75.8	21.9%	81.0%
31.5	50.9	14.7%	95.7%
64.0	14.7	4.3%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	345.5	100%	

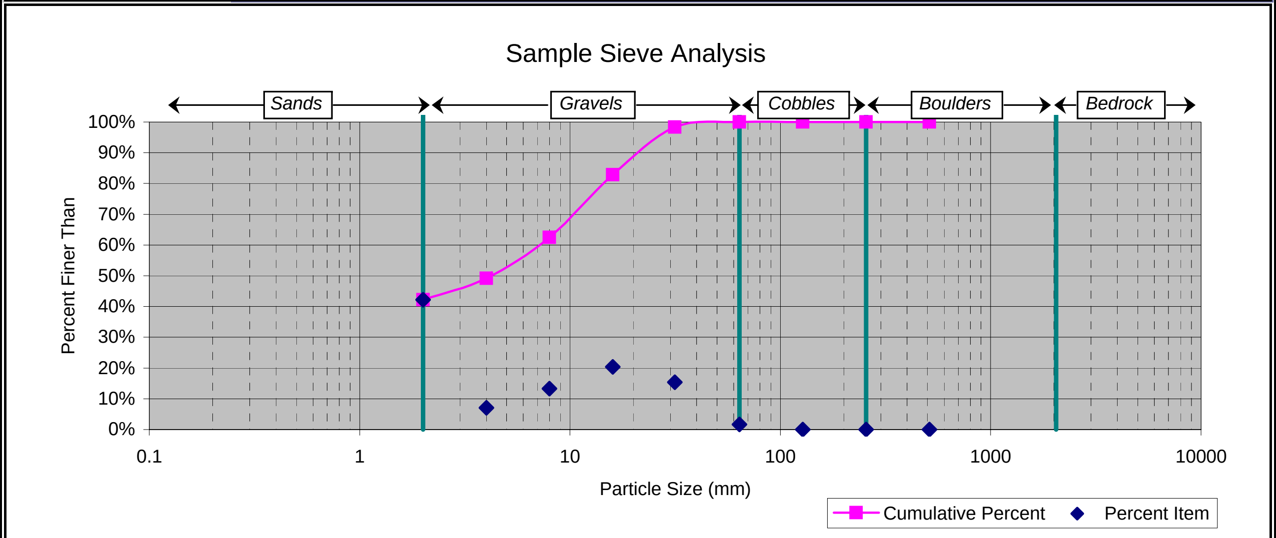
Stream:	UTBC
Watershed:	Back Creek
Location:	Scour Chain #1
Note:	Surface Sample of Riffle



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
5.2	5.2	5.2	18.4	30.4	0%	36%	64%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	91.8	42.2%	42.2%
4.0	15.3	7.0%	49.2%
8.0	28.9	13.3%	62.5%
16.0	44.4	20.4%	82.9%
31.5	33.6	15.4%	98.3%
64.0	3.7	1.7%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	217.7	100%	

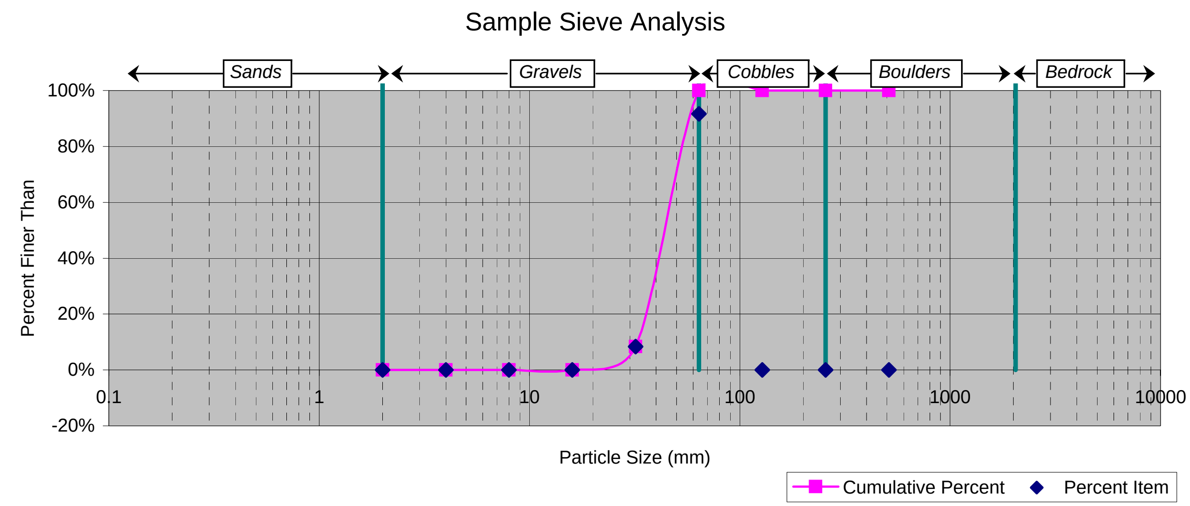
Stream:	UTBC
Watershed:	Back Creek
Location:	Scour Chain #1
Note:	Subsurface Sample at Riffle



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
4.2	4.2	4.2	16.8	27.3	0%	42%	58%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	0	0.0%	0.0%
4.0	0.0	0.0%	0.0%
8.0	0.0	0.0%	0.0%
16.0	0.0	0.0%	0.0%
32.0	2.5	8.3%	8.3%
64.0	27.5	91.7%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	30.0	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #1
Note:	Surface Sample

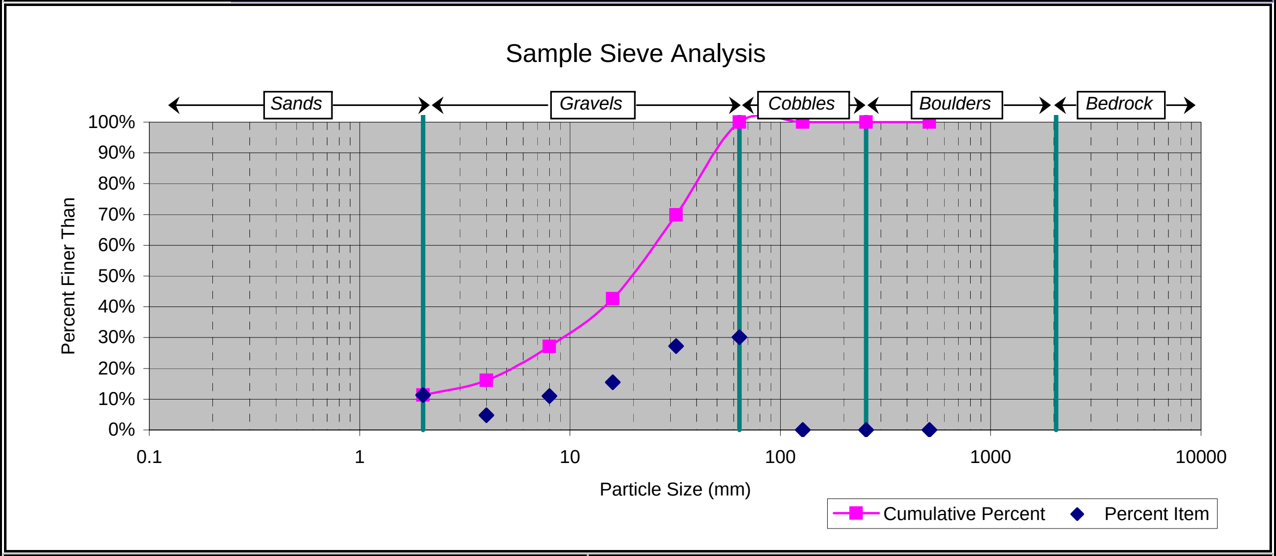


Size percent less than (mm)				
D16	D35	D50	D84	D95
33.9	39.1	43.9	56.7	61.6

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
0%	0%	100%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	36	11.4%	11.4%
4.0	15.1	4.8%	16.1%
8.0	35.0	11.0%	27.2%
16.0	49.0	15.5%	42.6%
32.0	86.5	27.3%	69.9%
64.0	95.5	30.1%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	317.1	100%	

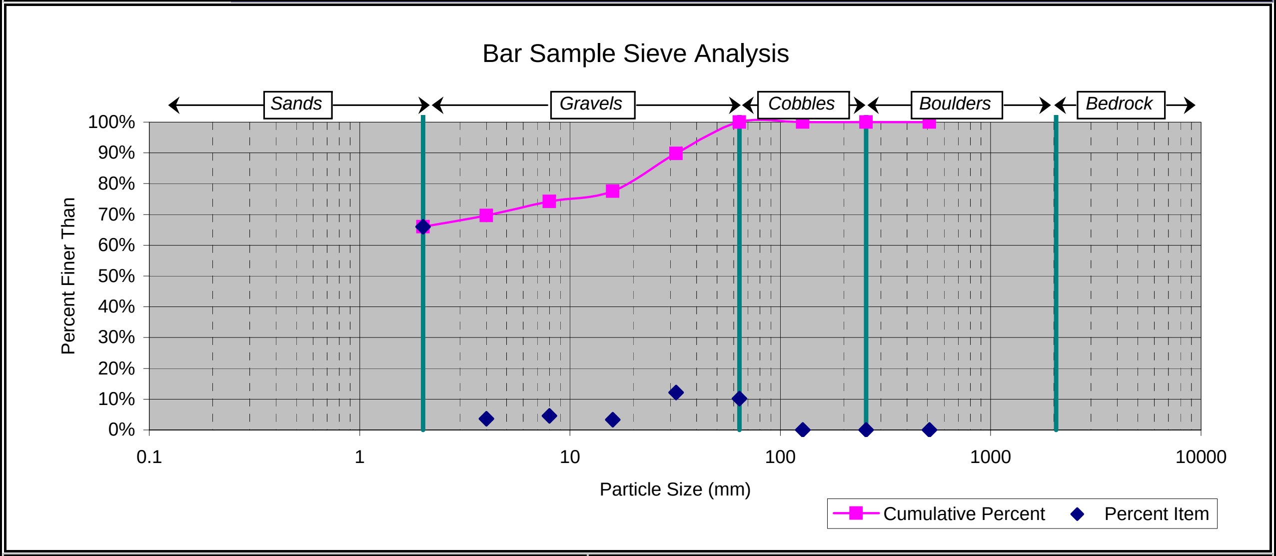
Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #1
Note:	Subsurface Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
3.9	11.4	19.3	44.3	57.0	0%	11%	89%	0%	---	---

Bar Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	100	66.0%	66.0%
4.0	5.5	3.6%	69.6%
8.0	7.0	4.6%	74.3%
16.0	5.0	3.3%	77.6%
32.0	18.5	12.2%	89.8%
64.0	15.5	10.2%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	151.5	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #1
Note:	Side Bar Sample

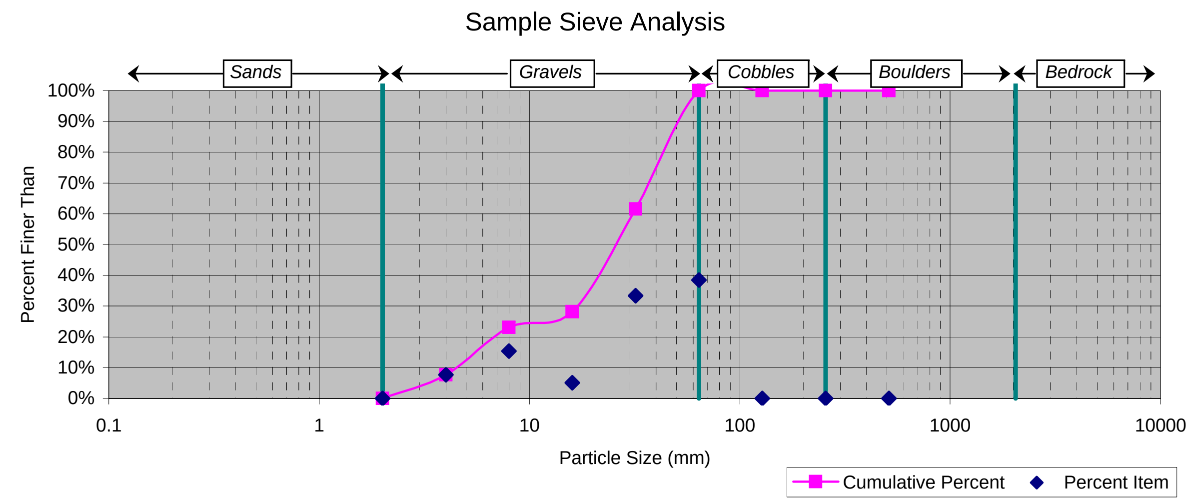


Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
23.1	23.1	23.1	23.1	45.6	0%	66%	34%	0%	---	---

Sample Sieve Analysis

Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	0	0.0%	0.0%
4.0	1.5	7.7%	7.7%
8.0	3.0	15.4%	23.1%
16.0	1.0	5.1%	28.2%
32.0	6.5	33.3%	61.5%
64.0	7.5	38.5%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	19.5	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #2
Note:	Surface Sample

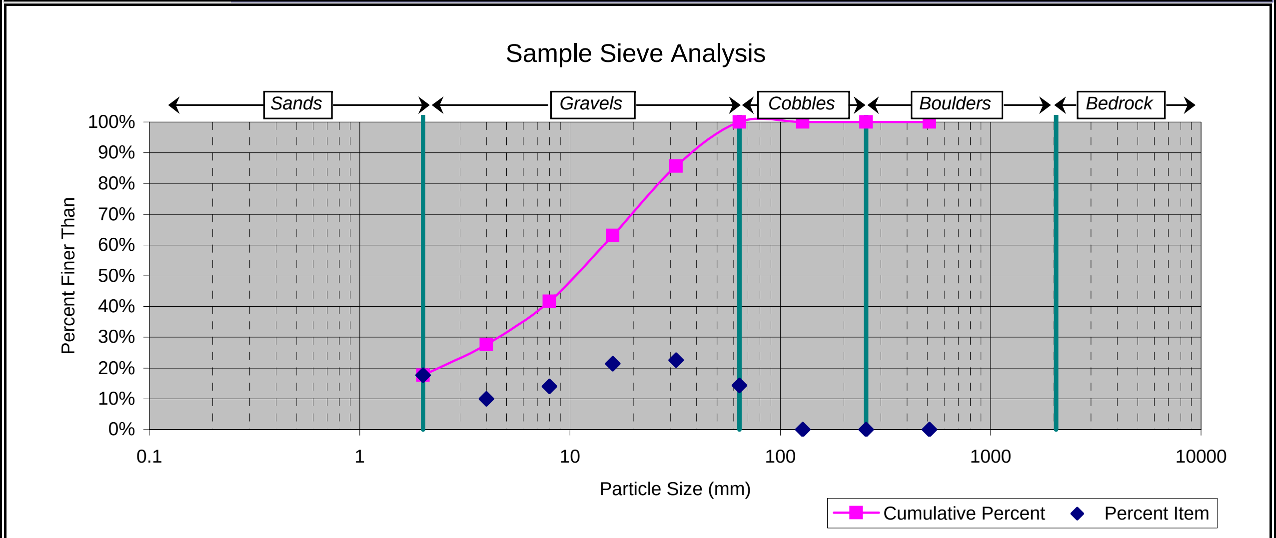


Size percent less than (mm)				
D16	D35	D50	D84	D95
5.8	18.4	25.2	48.0	58.5

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
0%	0%	100%	0%	---	---

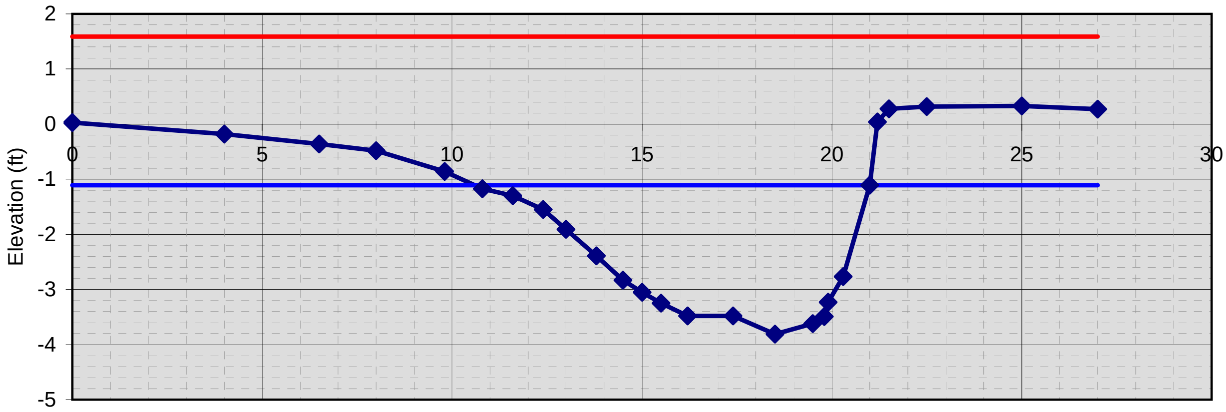
Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	24	17.7%	17.7%
4.0	13.5	10.0%	27.7%
8.0	19.0	14.0%	41.7%
16.0	29.0	21.4%	63.1%
32.0	30.5	22.5%	85.6%
64.0	19.5	14.4%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	135.5	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #2
Note:	Subsurface Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
5.7	5.7	10.5	30.5	50.3	0%	18%	82%	0%	---	---

Cross Section



section:	XS-3
	Riffle
stream:	UT to Back Creek
location:	Randolph County
description:	McCain Property
height of instrument (ft):	5.14

notes	omit pt.	distance (ft)	FS (ft)	elevation
LB pin	☐	0	5.11	0.03
slope brk	☐	4	5.32	-0.18
LTOB	☐	6.5	5.5	-0.36
slope brk	☐	8	5.62	-0.48
LBKFL?	☐	9.8	6	-0.86
slope brk	☐	10.8	6.31	-1.17
slope brk	☐	11.6	6.44	-1.3
slope brk	☐	12.4	6.69	-1.55
slope brk	☐	13	7.05	-1.91
slope brk	☐	13.8	7.53	-2.39
slope brk	☐	14.5	7.97	-2.83
slope brk	☐	15	8.19	-3.05
LEOW	☐	15.5	8.39	-3.25
streambed	☐	16.2	8.62	-3.48
	☐	17.4	8.62	-3.48
thalweg	☐	18.5	8.95	-3.81
	☐	19.5	8.76	-3.62
	☐	19.8	8.63	-3.49
REOW	☐	19.9	8.37	-3.23
slope brk	☐	20.3	7.91	-2.77
RBKFL?	☐	21	6.25	-1.11
slope brk	☐	21.2	5.1	0.04
RTOB	☐	21.5	4.86	0.28
	☐	22.5	4.82	0.32
	☐	25	4.81	0.33
RB pin	☐	27	4.87	0.27
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.25	5.5	125.0		
-1.11	-0.36			

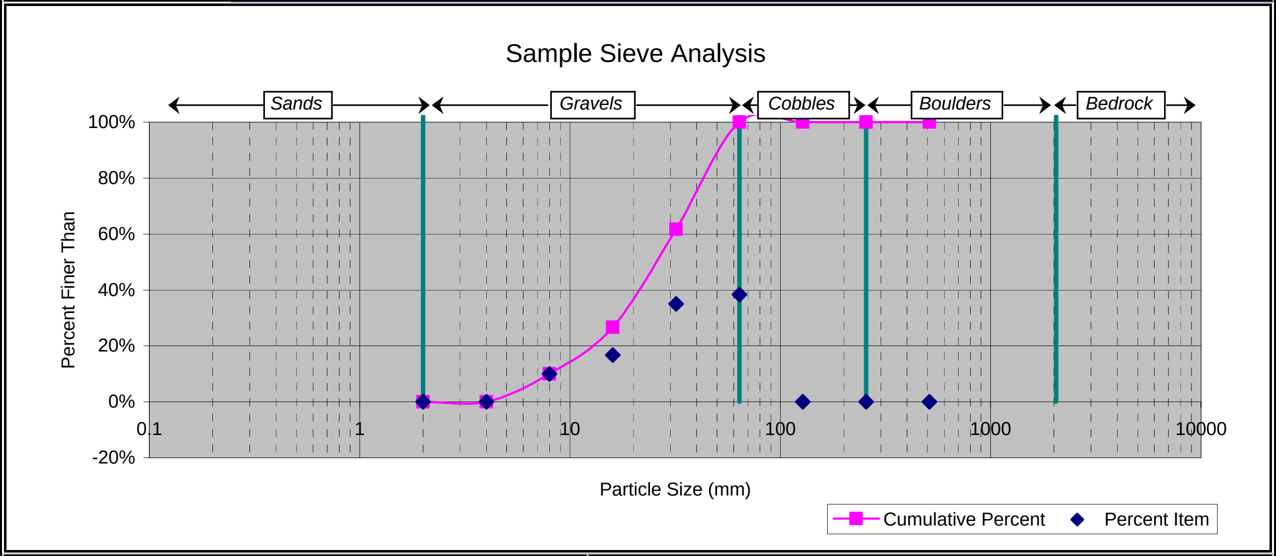
dimensions			
16.7	x-section area	1.6	d mean
10.4	width	12.5	wet P
2.7	d max	1.3	hyd radi
3.5	bank ht	6.5	w/d ratio
125.0	W flood prone area	12.0	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material			
	measured D84 (mm)		
0.0	relative roughness	0.0	fric. factor
0.000	Manning's n from channel material		

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	0	0.0%	0.0%
4.0	0.0	0.0%	0.0%
8.0	3.0	10.0%	10.0%
16.0	5.0	16.7%	26.7%
32.0	10.5	35.0%	61.7%
64.0	11.5	38.3%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	30.0	100%	

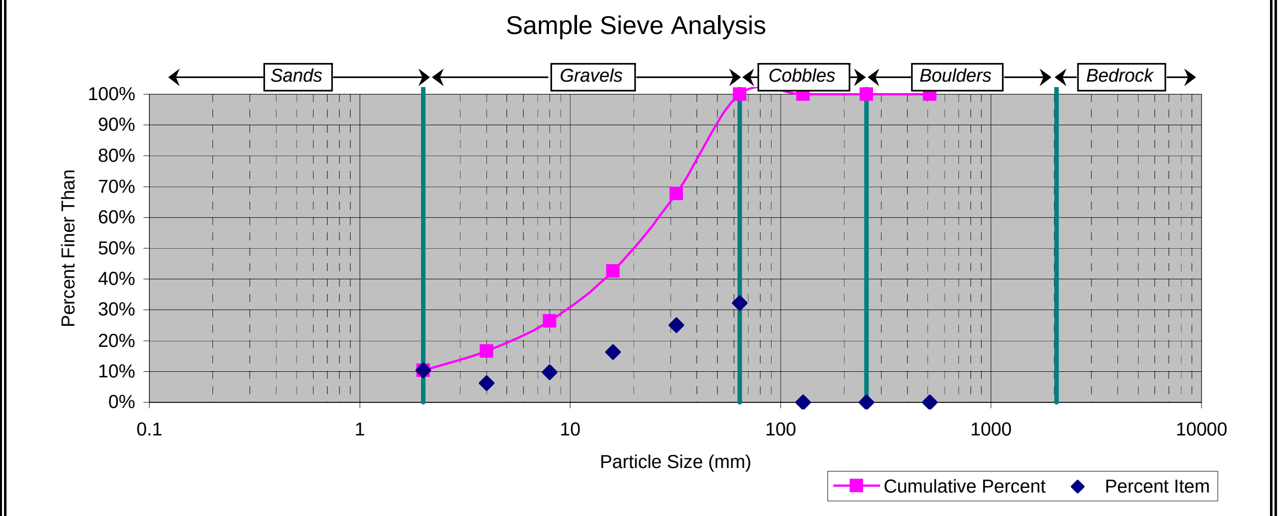
Stream: UTBC
Watershed: Back Creek
Location: Sample Site #3 - Scour Chain #2
Note: Surface Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
10.3	18.9	25.4	47.9	58.5	0%	0%	100%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	16	10.4%	10.4%
4.0	9.5	6.2%	16.6%
8.0	15.0	9.8%	26.4%
16.0	25.0	16.3%	42.7%
32.0	38.5	25.1%	67.8%
64.0	49.5	32.2%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	153.5	100%	

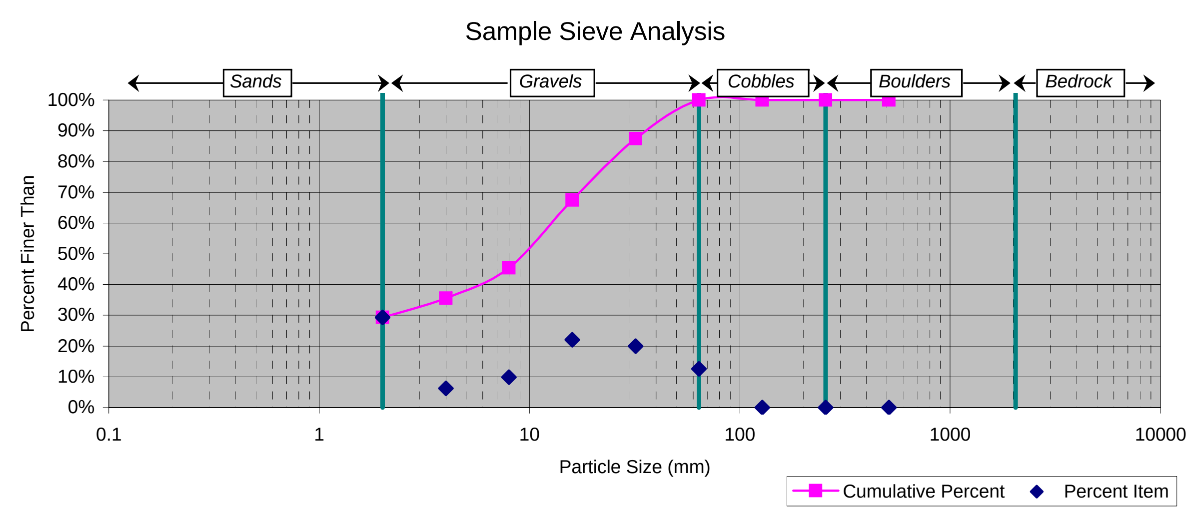
Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #3 - Scour Chain #2
Note:	Subsurface Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
3.7	11.5	19.6	45.4	57.5	0%	10%	90%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	92	29.3%	29.3%
4.0	19.5	6.2%	35.6%
8.0	31.0	9.9%	45.5%
16.0	69.0	22.0%	67.5%
32.0	62.5	19.9%	87.4%
64.0	39.5	12.6%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	313.5	100%	

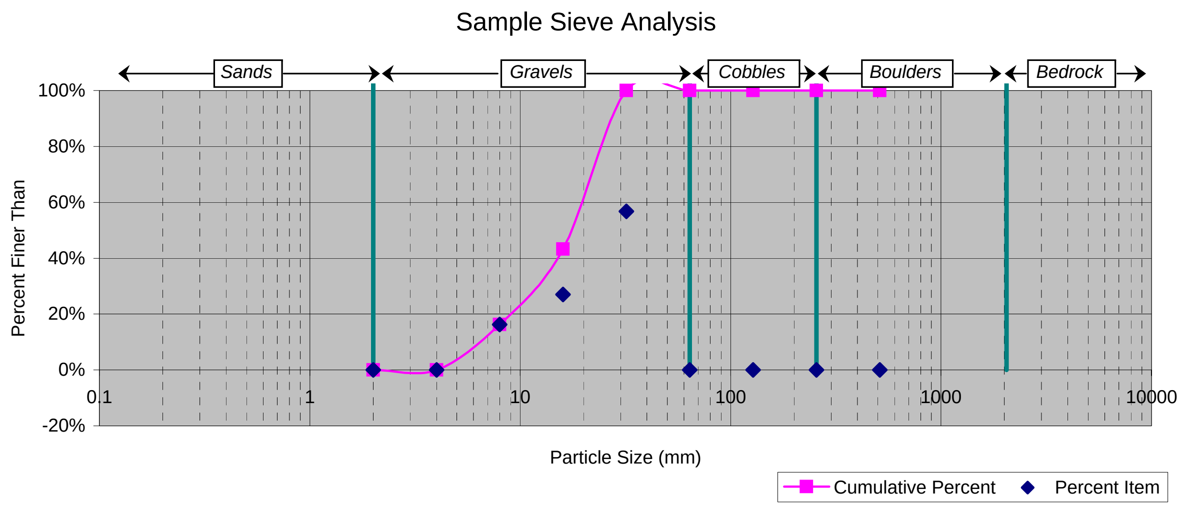
Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #3 - Scour Chain #2
Note:	Point Bar Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
3.8	3.8	9.2	28.4	48.6	0%	29%	71%	0%	---	---

Sample Sieve Analysis			
Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	0	0.0%	0.0%
4.0	0.0	0.0%	0.0%
8.0	3.0	16.2%	16.2%
16.0	5.0	27.0%	43.2%
32.0	10.5	56.8%	100.0%
64.0	0.0	0.0%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	18.5	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #4
Note:	Surface Sample

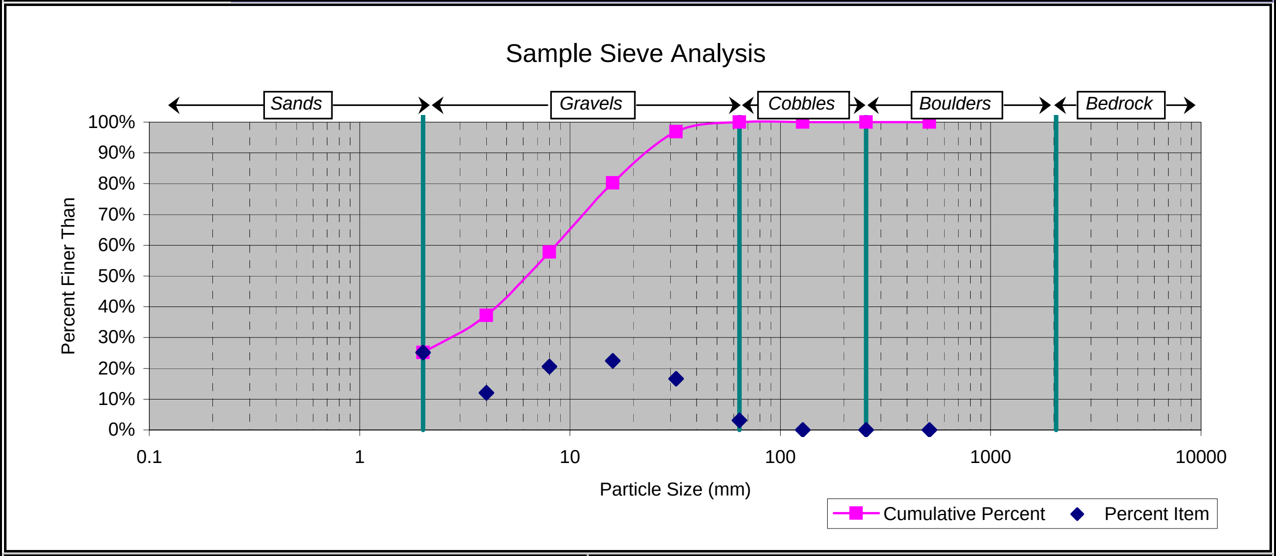


Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
7.9	13.0	17.4	26.3	30.1	0%	0%	100%	0%	---	---

Sample Sieve Analysis

Smallest Sieve Passed (mm)	Weight (oz)	% Item	Percent Finer Than
2.0	28	25.1%	25.1%
4.0	13.5	12.1%	37.2%
8.0	23.0	20.6%	57.8%
16.0	25.0	22.4%	80.3%
32.0	18.5	16.6%	96.9%
64.0	3.5	3.1%	100.0%
128.0	0.0	0.0%	100.0%
256.0	0.0	0.0%	100.0%
512.0	0.0	0.0%	100.0%
Total:	111.5	100%	

Stream:	UTBC
Watershed:	Back Creek
Location:	Sample Site #4
Note:	Subsurface Sample



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
3.5	3.5	6.1	18.7	29.6	0%	25%	75%	0%	---	---