# BAILEY FORK WETLAND AND STREAM RESTORATION PROJECT (DRAFT)

## ANNUAL MONITORING REPORT FOR 2009 (YEAR 4)

**Project Number D04006-3**

**Submitted to:**

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## 1.0 SUMMARY

This Annual Report details the monitoring activities during the 2009 growing season (Monitoring Year 4) on the Bailey Fork Wetland and Stream Restoration Site ("Site"). Construction of the Site, including planting of trees, was completed in April 2006. In accordance with the Restoration Plan for the Site, 21 vegetation monitoring plots, 13 permanent cross-sections, 3 longitudinal profile surveys, and 8 hydrologic monitoring gauges (4 automated and 4 manual) were installed and/or assessed across the restoration site. The 2009 data represent results from the fourth year of vegetation and hydrologic monitoring for wetlands and streams.

The design for the Bailey Fork Site involved the restoration of a "Piedmont/ Low Mountain alluvial forest" and associated riverine wetlands described by Schafale and Weakley (1990). Prior to restoration, wetland, stream, and buffer functions on the Site were impaired as a result of agricultural conversion. Streams flowing through the Site were channelized many years ago to reduce flooding and provide drainage for adjacent farm fields. After construction, it was determined that 12.1 acres of riverine wetlands and 6,097 linear feet of stream were restored, and 5.3 acres of riverine wetlands and 9,765 linear feet of stream were enhanced.

Weather station data from the Morganton Weather Station (Morganton, NC UCAN: 14224, COOP: 315838) were used in conjunction with a manual rain gauge located on the Site to document precipitation amounts. The on-site manual gauge is used to validate observations made at the automated station. According to the Morganton weather station data, total rainfall during the Year 4 monitoring period was above the normal average from January 2009 through November 2009. For this period, the Morganton measured rainfall to be 3.07 inches above the historic average.

A total of 21 monitoring plots, each 100 square meters (10m x 10m) in size, were used to document survivability of the woody vegetation planted at the Site. Vegetation monitoring documented the average number of surviving stems per acre on site to be 546, which is a survival rate of greater than 79 percent based on the initial planting count of 687 stems per acre. Surviving planted vegetation ranged from 200 stems per acre to 720 stems per acre. A lower survival rate in Plot 9 was documented and the surrounding area will require supplemental planting with 4-year old stems in early 2010. Overall, the Site is also on track to meet the final success criteria of 260 trees per acre by the end of Year 5 as specified in the Restoration Plan for the Site.

The Year 4 cross-sectional monitoring data document that there has been some adjustment to stream dimension since construction. The Year 4 longitudinal profiles showed that some pools have filled slightly due to accumulated sediment. The on-site crest gauges documented the occurrence of at least one bankfull flow event at two of the three crest gauges during Year 4 of the post-construction monitoring period. The bankfull measurements collected during monitoring through Year 4, document that all three restored reaches have met the success criteria for bankfull events for the project. Overall, monitoring indicates that the Site is on track to achieve the stream morphology success criteria specified in the site Restoration Plan

During 2009, all eight on-site wells recorded a hydroperiod of greater than 7 percent during the growing season. Hydrologic data collected from the reference site, an existing wetland system, indicates that the reference site experienced hydroperiods considerably less than the hydroperiods recorded by all eight wells at the restoration site. Overall monitoring data indicates

that the Site is on track to achieve the hydrologic success criteria specified in the Restoration Plan.

The Site exhibited excellent riffle pool sequencing, pattern, and habitat diversity for benthic macroinvertebrates. It is anticipated that continued improvements in biotic indices and an increase in Dominance in Common (DIC) will be seen in future monitoring reports as communities continue to re-establish.

In summary, the Site remains on track to achieve the hydrologic, vegetative and stream success criteria specified in the Restoration Plan for the Site.

## 2.0 PROJECT BACKGROUND

The Site is located in Burke County, North Carolina (Figure 1). The project is within cataloging unit 03050101. The Site has recently been used for pasture and hay production. In the past, the Site was used for row crop agriculture and pasture. Ditches were installed to increase arable land and improve drainage when the land was under agricultural production. The streams on the Site were channelized and riparian vegetation was cleared in most locations. Wetland and stream functions on the Site had been severely impacted as a result of these land use changes.

The project involved the restoration of 12.1 acres of riverine wetlands, enhancement of 5.3 acres of riverine wetlands, restoration of 6,097 LF of stream, and enhancement of 9,765 LF of stream. Figures 2(a), 2(b), 2(c), and 2(d) summarize the restoration and enhancement zones on the project site. A total of 61 acres of stream, wetland, and riparian buffer are protected through a permanent conservation easement.

### 2.1 Project Location

The Site is located approximately two miles southwest of the town of Morganton, along Hopewell Road. The Site is divided into two parts by Hopewell Road and I-40. The monitoring entrance for the northern half of the Site is located at a farm gate on the north side of Hopewell Road immediately east of the Bailey Fork bridge crossing. The monitoring entrance for the southern half of the Site is located south of I-40. The entrance is at the end of Flint Avenue which is accessed from Hopewell Road south of the I-40 overpass.

### 2.2 Mitigation Goals and Objectives

The specific goals for the Bailey Fork Restoration Project were as follows:

- Restore 6,097 LF of stream channel
- Enhance 9,765 LF of stream channel
- Restore 12.1 acres of riparian wetlands
- Enhance of 5.3 acres of existing, riverine wetlands
- Exclude cattle from stream, wetland and riparian buffer areas
- Develop an ecosystem-based restoration design
- Improve habitat functions
- Realize water quality benefits.

### 2.3 Project Description and Restoration Approach

For analysis and design purposes, the on-site streams were divided into four reaches. The reaches were numbered sequentially, moving from south to north, with unnamed tributaries carrying a "UT" designation. UT1 is a second order stream that begins offsite, flows into the project area from the southwest, and ends at its confluence with Bailey Fork. UT2 is a first order stream that begins offsite, flows into the project area from the west, and ends at its confluence with UT1. UT3 is a second order stream that begins offsite, flows into the project area from the south, and ends at its confluence with the main stem of Bailey Fork. Bailey Fork flows into the project area from the south and ends at the confluence with Silver Creek. The drainage area of the three tributaries ranges from 0.25 square miles ($mi^2$) to 0.92 $mi^2$, while the drainage area at

the downstream end of Bailey Fork is 8.3 $mi^2$. All four reaches were classified as incised and straightened E5 channels prior to restoration activities. Design information is shown in Table 1.

**Table 1. Design Approach for Bailey Fork Restoration Site**

| Bailey Fork Restoration Site: EEP Contract No. D04006-3 | | | | |
|---|---|---|---|---|
| **Project Segment or Reach ID** | **Mitigation Type *** | **Approach**** | **Linear Footage or Acreage** | **Stream and Wetland Mitigation Units** |
| Reach UT1 | R | P1 | 1,948 LF | 1,948 |
| Reach UT2 | R | P1 | 923 LF | 923 |
| Reach UT3 | R | P1 | 3,226 LF | 3,226 |
| Reach UT3 | EII | SS | 135 LF | 54 |
| Reach Bailey Fork | EII | SS | 9,630 LF | 3,852 |
| Riverine Wetland | R | - | 12.1 ac | 12.1 |
| Riverine Wetland | E | - | 5.3 ac | 2.7 |

* R = Restoration EII = Enhancement II

** P1 = Priority I SS = Stabilization

Wetland functions on the Site had been severely impaired by agricultural conversion. Streams flowing through the Site were channelized many years ago to reduce flooding and provide drainage for adjacent farm fields. As a result, nearly all wetland functions within the project area were destroyed.

The design for the restored streams involved the construction of new, meandering channels across the agricultural fields. Reaches UT1, UT2, and UT3 were restored to Rosgen "C5" channels with design dimensions based on nearby reference reaches. The enhancement areas along Bailey Fork and UT3 were accomplished through the use of stabilizing in-stream structures in highly eroded areas and additional buffer planting. Wetland restoration of the prior-converted farm fields on the Site involved grading areas of the farm fields and raising the local water table to restore a natural flooding regime. The streams through the Site were restored to a stable dimension, pattern, and profile, such that riparian wetland functions were restored to the adjacent hydric soil areas. Drainage ditches within the restoration areas were filled to decrease surface and subsurface drainage and raise the local water table. Total stream length across the Bailey Fork Restoration Project was increased from approximately 14,076 LF to 15,862 LF.

The designs allow stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on stream banks. In-stream structures were used to control streambed grade, reduce stream bank stress, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root wads, log vanes, log weirs, and rock vanes, which promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles or rock cross vanes were installed to provide long-term stability. Stream banks were stabilized using a combination of erosion control matting, bare-root planting, and transplants. Transplants provide living root mass to increase stream bank stability

and create holding areas for fish and aquatic biota. Native vegetation was planted across the Site, and the entire restoration site is protected through a permanent conservation easement.

## 2.4 Project History and Background

The chronology of the Bailey Fork Mitigation Project is presented in Table 2. The contact information for all designers, contractors, and relevant suppliers is shown in Table 3. Relevant project background information is presented in Table 4.

**Table 2. Project Activity and Reporting History**

**Bailey Fork Wetland and Stream Restoration Project: EEP Contract No. D04006-3**

| Activity or Report | Scheduled Completion | Data Collection Complete | Actual Completion or Delivery |
|---|---|---|---|
| Restoration Plan Prepared | N/A | N/A | Apr-05 |
| Restoration Plan Amended | N/A | N/A | Apr-05 |
| Restoration Plan Approved | N/A | N/A | Apr-06 |
| Final Design – (at least 90% complete) | N/A | N/A | N/A |
| Construction Begins | Oct-05 | N/A | Nov-05 |
| Temporary S&E mix applied to entire project area | Mar-06 | N/A | Apr-06 |
| Permanent seed mix applied to entire project area | Mar-06 | N/A | Apr-06 |
| Planting of live stakes | Mar-06 | N/A | Apr-06 |
| Planting of bare root trees | Mar-06 | N/A | Apr-06 |
| End of Construction | Mar-06 | N/A | Apr-06 |
| Survey of As-built conditions (Year 0 Monitoring-baseline) | Mar-06 | Apr-06 | Apr-06 |
| Year 1 Monitoring | Dec-06 | Nov-06 | Dec-06 |
| Year 2 Monitoring | Dec-07 | Nov-07 | Dec-07 |
| Year 3 Monitoring | Oct-08 | Nov-08 | Dec-08 |
| Year 4 Monitoring | Oct-09 | Nov-09 | Dec-09 |
| Year 5 Monitoring | Scheduled Oct-10 | Scheduled Nov-10 | Scheduled Nov-10 |

**Table 3. Project Contacts**

| Bailey Fork Restoration Site: EEP Contract No. D04006-3 | |
|---|---|
| **Full Service Delivery Contractor** | |
| EBX Neuse-I, LLC | 909 Capability Drive, Suite 3100<br>Raleigh, NC 27606<br>Contact:<br>Norton Webster, Tel. 919-829-9909 |
| **Designer** | |
| Michael Baker Engineering, Inc. | 8000 Regency Parkway, Suite 200<br>Cary, NC 27518<br>Contact:<br>Eng. Kevin Tweedy, Tel. 919-463-5488 |
| **Construction Contractor** | |
| River Works, Inc. | 8000 Regency Parkway, Suite 200<br>Cary, NC 27518<br>Contact:<br>Will Pedersen, Tel. 919-459-9001 |
| **Planting Contractor** | |
| River Works, Inc. | 8000 Regency Parkway, Suite 200<br>Cary, NC 27518<br>Contact:<br>Will Pedersen, Tel. 919-459-9001 |
| **Seeding Contractor** | |
| River Works, Inc. | 8000 Regency Parkway, Suite 200<br>Cary, NC 27518<br>Contact:<br>Will Pedersen, Tel. 919-459-9001 |
| Seed Mix Sources | Mellow Marsh Farm, 919-742-1200 |
| Nursery Stock Suppliers | International Paper, 1-888-888-7159 |
| **Monitoring Performers** | |
| Michael Baker Engineering, Inc. | 8000 Regency Parkway, Suite 200<br>Cary, NC 27518 |
| Stream Monitoring Point of Contact: | Eng. Kevin Tweedy, Tel. 919-463-5488 |
| Wetland Monitoring Point of Contact: | Eng. Kevin Tweedy, Tel. 919-463-5488 |
| Wetland and Natural Resource Consultants, Inc. | 3674 Pine Swamp Rd.<br>Sparta, NC 28675 |
| Vegetation Monitoring Point of Contact: | Chris Huysman, Tel. 336-406-0906 |

**Table 4. Project Background**

| Bailey Fork Restoration Site: EEP Contract No. D04006-3 | |
|---|---|
| Project County: | Burke County, NC |
| Drainage Area: | |
| Reach: Bailey Fork | 8.3 $mi^2$ |
| Reach: UT1 | 0.81$mi^2$ |
| Reach: UT2 | 0.24$mi^2$ |
| Reach: UT3 | 0.92 $mi^2$ |
| Estimated Drainage Percent Impervious Cover: | |
| Reach: Bailey Fork | < 5% |
| Reach: UT1 | < 5% |
| Reach: UT2 | < 5% |
| Reach: UT3 | < 5% |
| Stream Order: | |
| Bailey Fork | 2 |
| UT1 | 1 |
| UT2 | 1 |
| UT3 | 1 |
| Physiographic Region | Piedmont |
| Ecoregion | Northern Inner Piedmont |
| Rosgen Classification of As-Built | C5 |
| Cowardin Classification | Riverine, Upper Perennial, Unconsolidated Bottom |
| Dominant Soil Types | Refer to Section 3.1 for Soil Descriptions |
| Bailey Fork | AaA, CvA |
| UT1 | FaC2, HaA, UnB |
| UT2 | FaC2, HaA, UnB |
| UT3 | FaC2, HaA, UnB |
| Reference site ID | (Remnant channel - Bailey Fork) |
| USGS HUC for Project and Reference sites | 3050101040020 |
| NCDWQ Sub-basin for Project and Reference | 03-08-31 |
| NCDWQ classification for Project and Reference | WS-IV |
| Any portion of any project segment 303d listed? | No |
| Any portion of any project segment upstream of a 303d listed segment? | No |
| Reasons for 303d listing or stressor? | N/A |
| % of project easement fenced | 100% |

## 2.5 Project Plan

Plans depicting the as-built conditions of the major project elements, location of permanent monitoring cross-sections, locations of hydrologic monitoring stations, and locations of permanent vegetation monitoring plots are presented in Figure 2(a), 2(b), 2(c) and 2(d) of this report.

## 3.0 VEGETATION MONITORING

### 3.1 Soil Data

The soil data for the project site are presented in Table 5.

**Table 5. Project Soil Types and Descriptions**

**Bailey Fork Restoration Site: EEP Contract No. D04006-3**

| Soil Name | Location | Description |
|---|---|---|
| Arkaqua** | Main Channel and Floodplain | Arkaqua series consists of somewhat poorly drained soils that formed in loamy alluvium along nearly level floodplains and creeks. Runoff is slow, and permeability is moderate. Soil texture within the profile ranges from loam to clay loam to sandy loam to sandy clay loam. |
| Colvard CvA | Main Channel and Floodplain | Colvard series consists of very deep, well drained soils that formed in loamy alluvium on floodplains. These soils are occasionally flooded, well drained, and have slow surface runoff and moderately rapid permeability. The surface layer and subsurface layers are loamy sands in texture. |
| Fairview FaC2 | Floodplain | Fairview soil type occurs on nearly level floodplains along creeks and rivers in pastureland. It has a very deep soil profile and moderate permeability. The surface layer and subsurface layers are clay loams in texture, with an increase in clay content starting at about one foot below the surface. |
| Hatboro* HaA | Floodplain | Hatboro series consists of a very deep soil profile that is poorly drained with moderate permeability. The series primarily consists of silt loams with underlying layers of sandy clay loam. These soils are generally found on floodplains in pastures and woodlands. |
| Unison UnB | Floodplain | Unison soil type occurs on mountain foot slopes or stream terraces. It generally has a very deep soil profile, is well drained, and is moderately permeable. Uses include cultivated crops, pasture, orchards, and mixed hardwood forests. |

Notes:
Source: From Burke County Soil Survey, USDA-NRCS, http://efotg.nrcs.usda.gov
* Hydric "A" soil type
** Hydric "B" soil type

### 3.2 Description of Vegetation Monitoring

As a final stage of construction, the stream margins and riparian area of the Bailey Fork wetland and stream restoration site were planted with bare root trees, live stakes, and a seed mixture of permanent ground cover for herbaceous vegetation. The woody vegetation was planted randomly six to eight feet apart from the top of the stream banks to the outer edge of the project's re-vegetation limits. The tree species planted at the Site are shown in Table 6. The seed mix of herbaceous species applied to the project's riparian area included soft rush (*Juncus effusus*), bentgrass (*Agrostis alba),* Virginia wild rye (*Elymus virginicus),* switch grass (*Panicum virgatum),* gamagrass, (*Tripsicum dactyloides),* smartweed (*Polygonum pennsylvanicum),* little bluestem (*Schizachyrium scoparium),* devil's beggars tick (*Bidens frondosa),* lanceleaf tickseed

(*Coreopsis lanceolata),* deertounge (*Panicum clandestinum),* big bluestem (*Andropogon gerardii),* and Indian grass (*Sorghastrum nutans).*

This seed mixture was broadcast on the Site at a rate of 15 pounds per acre. All planting was completed in April 2006.

The area surrounding Plot 1 and the area surrounding Plots 12 and 13, which were previously flooded by a beaver impoundment, and were replanted in the spring of 2008 and new vegetation monitoring plots were established.

**Table 6. Tree Species Planted in the Bailey Fork Restoration Area**

| Bailey Fork Restoration Site: EEP Contract No. D04006-3 | | | |
|---|---|---|---|
| **ID** | **Scientific Name** | **Common Name** | **FAC Status** |
| **1** | *Betula nigra* | River Birch | FACW |
| **2** | *Fraxinus pennsylvanica* | Green Ash | FACW |
| **3** | *Platanus occidentalis* | Sycamore | FACW- |
| **4** | *Quercus phellos* | Willow oak | FACW- |
| **5** | *Quercus rubra* | Red oak | FACU |
| **6** | *Quercus michauxii* | Swamp chestnut oak | FACW- |
| **7** | *Liriodendron tulipifera* | Tulip poplar | FACW |
| **8** | *Celtis laevigata* | Sugarberry | FACW |
| **9** | *Diospyros virginiana* | Persimmon | FAC |
| **10** | *Nyssa sylvatica* | Blackgum | FAC |

At the time of planting, vegetation plots labeled 1 through 21 were established on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.025 acre in size, or 10 meters x 10 meters. All of the planted stems inside the plot were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future.

### 3.3 Vegetation Success Criteria

As specified in the approved Restoration Plan for the site, data from vegetation monitoring plots should display a surviving tree density of at least 320 trees per acre at the end of Year 3 of monitoring, and a surviving tree density of at least 260, five-year-old trees per acre at the end of Year 5 of the monitoring period. Although the select native canopy species planted throughout the Site are the target woody vegetation cover, up to 20 percent of the Site's established woody vegetation at the end of the monitoring period may be comprised of invaders.

### 3.4 Results of Vegetative Monitoring

Table 7 presents stem counts of surviving individuals found at each of the monitoring stations at the end of Year 4 of the post-construction monitoring period. Trees within each monitoring plot are flagged regularly to prevent planted trees from losing their identifying marks due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure accurate annual stem counts and calculations of tree survivability. Volunteer individuals found

within the plots are also flagged during this process. Flags are used to tag trees because they do not interfere with the growth of the tree.

Volunteer woody species were observed in some of the vegetation plots, but were deemed too small to tally. If these trees persist into the next growing season, they will be flagged and added to the overall stems per acre assessment of the site. Sweetgum (*Liquidambar styraciflua*) is the most common volunteer, though red maple (*Acer rubrum*), river birch (*Betula nigra*), and black walnut (*Juglans nigra*) were also observed.

The Year 4 monitoring data reflects that with the exception of Plot 9, the Site is on track for meeting the final success criteria of 260 trees per acre by end of Year 5.

Vegetation monitoring efforts have documented the average number of stems per acre on site to be 546, which is a survival rate of greater than 79 percent based on the initial planting count of 687 stems per acre. The lower survival rate in Plot 9 has been documented and the surrounding surviving planted vegetation ranged from 200 stems per acre to 720 stems per acre. A low survival rate was documented in Plot 9 and the area surrounding Plot 9 will be supplemental planted with 4-year old stems in early 2010. Overall, the Site is on track to meet the vegetative success criteria specified in the Restoration Plan.

### 3.5 Vegetation Observations

After construction of the mitigation project, a permanent ground cover seed mixture of Virginia wild rye (*Elymus virginicus*), switch grass (*Panicum virgatum*), and fox sedge (*Carex vulpinoidea*) was broadcast on the Site at a rate of 15 pounds per acre. These species are present on the restored site. Hydrophytic herbaceous vegetation, including rush (*Juncus effusus*), spike-rush (*Eleocharis obtusa*), boxseed (*Ludwigia* sp.), and sedge (*Carex* sp.), are observed across the Site, particularly in areas of periodic inundation. The presence of these herbaceous wetland plants helps to confirm the presence of wetland hydrology on the Site.

There are quite a few weedy species occurring on the site, though none at present seem to be posing any problems for the woody or herbaceous hydrophytic vegetation. Commonly seen weedy vegetation includes various pasture grasses, ragweed (*Ambrosia artemisiifolia*), goldenrod (*Solidago spp*.), horseweed (*Conyza spp*.), milkweed, and beggarticks (*Bidens spp.).* Any threatening weedy vegetation found in the future will be documented and discussed in trimester reports.

### 3.6 Vegetation Photos

Photographs of the Site showing the on-site vegetation are included in Appendix A of this report.

**Table 7. Year 4 (2009) Stem Counts for Each Species Arranged by Plot**

**Bailey Fork Restoration Site: EEP Contract No. D04006-3**

| Tree Species | Plots | | | | | | | | | | | | | | | | | | | | | Initial Totals | Year 1 Totals | Year 2 Totals | Year 3 Totals | Year 4 Totals | Year 4 % Survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | | | | | | |
| *Betula nigra* | 4 | | | | | | | | | | | 6 | 4 | 1 | 7 | 4 | 5 | 14 | 2 | 6 | | 44 | 50 | 46 | 49 | 53 | 79% |
| *Fraxinus pennsylvanica* | | | 2 | 2 | | | | | | | | 4 | 5 | 5 | | 8 | 4 | | 5 | 8 | 6 | 48 | 56 | 47 | 54 | 49 | |
| *Platanus occidentalis* | 3 | | 1 | 9 | 10 | 4 | 8 | | | 9 | | 6 | 4 | | 5 | | | 4 | 2 | 2 | 1 | 54 | 59 | 59 | 68 | 68 | |
| *Quercus phellos* | 3 | | 4 | | | 3 | | 2 | 1 | | 3 | | 1 | | | | | | | | | 10 | 14 | 11 | 17 | 17 | |
| *Quercus rubra* | | 1 | 3 | | 1 | 1 | 2 | | | | 4 | | | | | | | | | | 2 | 1 | 20 | 18 | 19 | 14 | |
| *Quercus michauxii* | | | | | | | 5 | 2 | | | | | | | | | | | | | | 9 | 11 | 8 | 11 | 7 | |
| *Liriodendron tulipiferra* | 2 | 4 | | 2 | | | | 1 | | 6 | 8 | | | | | | | | 1 | | | 38 | 35 | 22 | 24 | 24 | |
| *Celtis laevigata* | | 5 | | | | | | | 3 | | | | | 5 | 2 | 1 | 3 | | 3 | | 4 | 49 | 38 | 33 | 33 | 26 | |
| *Diospyros virginiana* | | | 6 | 4 | 2 | 2 | | | | | | | | | | | | | | | | 0 | 7 | 15 | 15 | 14 | |
| *Nyssa sylvatica* | | 4 | 1 | | 1 | 3 | | 2 | 1 | | | | 2 | | | | | | | | | 26 | 38 | 23 | 20 | 14 | |
| **Stems per plot** | 12 | 14 | 17 | 17 | 14 | 13 | 15 | 7 | 5 | 15 | 15 | 16 | 16 | 11 | 14 | 13 | 12 | 18 | 13 | 16 | 13 | 362 | 328 | 282 | 310 | 286 | |
| **Stems per acre** | 480 | 560 | 680 | 680 | 560 | 520 | 600 | 280 | 200 | 600 | 600 | 640 | 640 | 440 | 560 | 520 | 480 | 720 | 520 | 640 | 520 | 687 | 624 | 537 | 590 | 546 | |

## 4.0 STREAM MONITORING

### 4.1 Description of Stream Monitoring

To document the stated success criteria, the following monitoring program was instituted following construction completion on the Site:

*Bankfull Events*: Three crest gauges were installed on the Site to document bankfull events. The gauges are checked each month to record the highest out-of-bank flow event that occurred since the last inspection. Crest gauge 1 is located on UT1 near station 25+00 (Figure 2(c)). Crest gauge 2 is located on UT2 near station 17+00 (Figure 2(c)). Crest gauge 3 is located on UT3 near station 31+00 (Figure 2(d)).

*Cross-sections*: Two permanent cross-sections were installed per 1,000 LF of stream restoration work, with one of the locations being a riffle cross-section and one location being a pool cross-section. A total of 13 permanent cross-sections were established across the Site. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. Permanent cross-section pins were surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg. Riffle cross-sections are classified using the Rosgen stream classification system. Permanent cross-sections for 2009 (Year 4) were surveyed in October 2009.

*Longitudinal Profiles*: A complete longitudinal profile was surveyed following construction completion to record as-built conditions. The profile was conducted for the entire length of the restored channels (UT1, UT2, and UT3). Measurements included thalweg, water surface, bankfull, and top of low bank. Each measurement was taken at the head of the feature (e.g., riffle, pool, glide). In addition, maximum pool depths were recorded. All surveys were tied to a single, permanent benchmark. A longitudinal survey of 3,000 LF of restored stream length was completed in November 2007, October 2008 and October 2009.

*Photograph Reference Stations*: Photographs are used to visually document restoration success. A total of 52 reference stations were established to document conditions at the constructed grade control structures across the Site, and additional photograph stations were established at each of the 13 permanent cross-sections and hydrologic monitoring stations. The Global Positioning System (GPS) coordinates of each photograph station were noted as additional references to ensure the same photograph location is used throughout the monitoring period. Reference photographs are taken at least once per year.

Each stream bank is photographed at each permanent cross-section photograph station. For each stream bank photo, the photograph view line follows a survey tape placed across the channel, perpendicular to flow (representing the cross-section line). The photograph is framed so that the survey tape is centered in the photograph (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame. A photograph log of the Site is included in Appendix A of this report.

### 4.2 Stream Restoration Success Criteria

The approved Restoration Plan requires the following criteria be met to achieve stream restoration success:

*Bankfull Events*: Two bankfull flow events must be documented within the five-year monitoring period. The two bankfull events must occur in separate years.

*Cross-sections:* There should be little change in as-built cross-sections. If changes to channel cross-sections take place, they should be minor changes representing a move to increasing stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for "C" type channels.

*Longitudinal Profiles:* The longitudinal profiles should show that the bedform features are remaining stable (not aggrading or degrading). The pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed in "C" type channels.

*Photograph Reference Stations*: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Photographs should indicate the absence of developing bars within the channel, no excessive bank erosion or increase in channel depth over time, and maturation of riparian vegetation.

## 4.3 Bankfull Discharge Monitoring Results

During 2009, the on-site crest gauge documented the occurrence of at least one bankfull flow event at two of the three crest gauges during Year 4 of the post-construction monitoring period, as shown in Table 8. Inspection of conditions during site visits revealed visual evidence of out-of-bank flows, confirming the crest gauge readings. The largest on-site stream flow documented by the crest gauges during Year 4 of monitoring was approximately 0.9 feet (10.8 inches) at crest gauge 3 on UT3. The bankfull measurements collected during Year 4 and the measurements collected during Year 1, Year 2 and Year 3 of monitoring show that all three restored reaches have met the success criteria for bankfull events on the project. However, crest gauge monitoring will continue until Year 5 to continually document bankfull flow events within the restored channel.

**Table 8. Verification of Bankfull Events**

| **Bailey Fork Restoration Site: EEP Contract No. D04006-3** | | |
|---|---|---|
| Date of Data Collection | Method of Data Collection | Measurement (ft) |
| 3/31/2009 | Crest Gauge 2 UT2 | 0.25 |
| 3/31/2009 | Crest Gauge 3 UT3 | 0.9 |

## 4.4 Stream Monitoring Data and Photos

A photograph log of the project showing selected photograph point locations and crest gauge photographs are included in Appendix A of this report. Data and photographs from each permanent cross-section are included in Appendix B of this report.

## 4.5 Stream Stability Assessment

Table 9 presents a summary of the results obtained from the visual inspection of in-stream structures performed during Year 4 of post-construction monitoring. The percentages noted are a general overall field evaluation of the how the features were performing at the time of the photograph point survey. According to the visual assessment, all features of UT2 and UT3 were performing as designed. The step pool at station 29+00 on UT1 has experienced some minor piping and bank stability is becoming a localized concern, this area will be further assessed further in 2010 and will be repaired if deemed necessary.

**Table 9. Categorical Stream Feature Visual Stability Assessment**

**Bailey Fork Mitigation Site: EEP Contract No. D04006-3**

| Feature | Performance Percentage | | | | | |
|---|---|---|---|---|---|---|
| | Initial | MY-01 | MY-02 | MY-03 | MY-04 | MY-05 |
| Riffles | 100% | 100% | 95% | 95% | 95% | |
| Pools | 100% | 100% | 95% | 100% | 100% | |
| Thalweg | 100% | 100% | 100% | 100% | 100% | |
| Meanders | 100% | 100% | 100% | 100% | 100% | |
| Bed General | 100% | 100% | 100% | 100% | 100% | |
| Vanes / J Hooks etc. | 100% | 100% | 100% | 95% | 95% | |
| Wads and Boulders | 100% | 100% | 100% | 100% | 100% | |

## 4.6 Stream Stability Baseline

The quantitative pre-construction, reference reach, and design data used to determine mitigation approach and prepare the construction plans for the project are summarized in Appendix C. The as-built baseline data that determines stream stability during the project's post-construction monitoring period are also summarized in Appendix D.

## 4.7 Longitudinal Profile Results

The Year 4 longitudinal profile was completed in October 2009 and was compared to data collected during the as-built condition survey and with Year 3 monitoring data. The longitudinal profile is presented in Appendix B. During Year 4 monitoring, approximately 3,400 LF of channel were surveyed.

During Year 4 of monitoring 1,215 feet of UT1 were surveyed. According to the Year 4 longitudinal profile of UT1, pools from stations 17+50 to 26+55 have accumulated some sediment since as-built conditions and Year 3 monitoring; however, the pools remain significantly deeper than the riffles and are functioning as designed. The longitudinal profile in this same section shows that the riffles and structures have maintained the same elevations as as-built conditions. Riffles located in UT1 from stations 26+55 through 28+24 have also remained stable during Year 4 monitoring.

The constructed riffle and rock step-pool sequence located at stations 28+25 through 29+65 is installed on the lower end of UT1. This section of UT1 was installed to step down the elevation of the UT1 thalweg to match the existing channel at the confluence with Bailey Fork. During Year 4 of

monitoring, the thalweg in this section of UT1 has shifted below the as-built elevation; however, the thalweg has remained relatively stable since Year 3. Minor piping has been noted above a rock step within the rock step-pool sequence on UT1. In this same localized area one stream bank has experienced some slight erosion. At this time, repair of the area does not appear necessary, but observation of the area will continue into 2010. During Year 4 of monitoring, 930 feet of UT2 were surveyed. The longitudinal profile of UT2 shows that from stations 10+00 to 13+00, the streambed has become elevated due to deposition of bed material from upstream. This material has not resulted in stream instability, but has rather acted to increase the average slope from stations 10+00 to 13+00 to approximately the same average slope as the remainder of the channel. This is seen as a positive evolution of the channel, as a section of essentially backwatered channel from 11+00 to 13+00 has now evolved to a section of free-flowing channel with a steeper slope. Also within UT2, stations 13+00 to 15+00 have accumulated some sediment, but the bed elevations are similar to those documented in Year 3. All stations downstream of 15+00 are relatively similar to the as-built conditions.

During Year 4 of monitoring 1,250 feet of UT3 was surveyed. The Year 4 longitudinal profile of UT3 shows that many pools have accumulated some sediment since as-built conditions; however, riffles and the in-channel structures are holding grade and have not accumulated sediment. Due to the above average rainfall amounts observed during 2009, it is concluded that large storm events have caused higher amounts of sediment from upstream to be deposited in the pools. This deposition of sediment in UT3 during 2009 has likely exceeded the scouring potential normally seen during past monitoring years. While pool depths have decreased, pools are still prevalent throughout the reach and channel stability has not been affected by the accumulated sediment.

All of the longitudinal profiles from Year 4 monitoring showed some changes in the restored reaches. These changes do not appear to pose a threat to the stability of the channels.

### 4.8 Cross-Section Monitoring Results

Year 4 cross-section monitoring data for stream stability were collected during September and October of 2009. The Year 4 data were compared to baseline stream geometry data collected in April 2006 (as-built conditions), Year 1 monitoring data collected in October 2006, Year 2 monitoring data collected in November 2007 and Year 3 monitoring data collected in October 2008.

The 13 permanent cross-sections along the restored channels (7 located across riffles and 6 located across pools) were re-surveyed to document stream dimension at the end of monitoring Year 4. Data from each of these cross-sections are summarized in Appendix B and D. The cross-sections show that there have been minor adjustments to stream dimension since construction in April 2006.

Pool cross-sections 2, 4, and 6 are located on UT3, cross-section 10 is located on UT2 and cross-section 8 and 13 are located on UT1. The pool cross-sections are located at the apex of meander bends.

Survey data from UT3 pool cross-sections 2, 4 and 6 indicate that all pools, except the pool in cross-section 4, have experienced some dimensional changes since as-built conditions. However, UT3 cross-sections 2 and 6 have remained relatively stable since monitoring years 2 through 4. Survey data from UT2 pool cross-section 10, indicate that the pool has experienced since as-built conditions, but this accumulation of material is considered a positive evolutionary step and dimension has changed little since Year 2. Survey data from UT1 pool cross-sections 8 and 13 indicate that the channel is evolving to a stable dimension with the same general trends seen for UT2.

Riffle cross-sections 1, 3, 5 and 7 are located on UT3, cross-section 11 is located on UT2 and cross-section 9 and 12 are located on UT1. Survey data from UT3 riffle cross-sections 1, 3 indicate that all riffles on UT3 have remained stable since as-built conditions. Survey data from UT2 riffle cross-section 11, indicate that the riffle has relatively stable since as-built conditions. Survey data from UT1 riffle cross-sections 9 and 12 indicate that both riffles have experienced moderate dimensional changes since as-built conditions. It is likely that cross-sections 9 and 12 are undergoing a natural shift towards more stable conditions within UT1. It is noted that the channel dimensions of cross-section 12 have fluctuated each monitoring year since construction, but has never scoured deeper than the as-built condition, and such fluctuations are common for streams with a sandy bed material.

In-stream structures installed within the restored stream include: constructed riffles, rock cross vanes, a rock step-pool, log vanes, log weirs, and root wads. A constructed riffle and a rock step-pool were installed on the lower end of UT1, and a constructed riffle was installed at the lower end of UT3 to step down the elevation of the restored stream beds to match the existing channel inverts at the confluences of the restored channels and Bailey Fork.

Visual observations of these structures throughout Year 4 have indicated that the rock structures are functioning as designed and holding their elevation grade. However, minor piping has been noted above a rock step within the rock step-pool sequence on UT1. In this same localized area, one stream bank has experienced some slight erosion. At this time, repair of the area does not appear necessary, and observation of the area will continue into 2010.

It was also noted that two rock cross vanes on Bailey Fork Creek at approximate stations 17+00 and 28+50 have been impacted by past beaver activity. During a site visit in early November 2008 (Year 3), two beaver dams were observed across the rock inverts on top of the cross vanes. At that time, water was flowing around the sides of both dams and over the arms of the structures. These beaver dams were not present in October 2009 (Year 4). However, the area will be monitored for further beaver activity going forward. Photos from October 2009 of these cross vanes are provided in the photo log in Appendix A.

Log vanes placed in meander pool areas have provided scour to keep pools deep and provide cover for fish. Log weirs placed in riffle areas have maintained riffle elevations and provided downstream scour holes which provide habitat. Root wads placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms.

Photographs of the channel were taken throughout the monitoring season to document the evolution of the restored stream geometry (see Appendix A). Herbaceous vegetation is dense along the edges of the restored stream, making it difficult in some areas to photograph the stream channel.

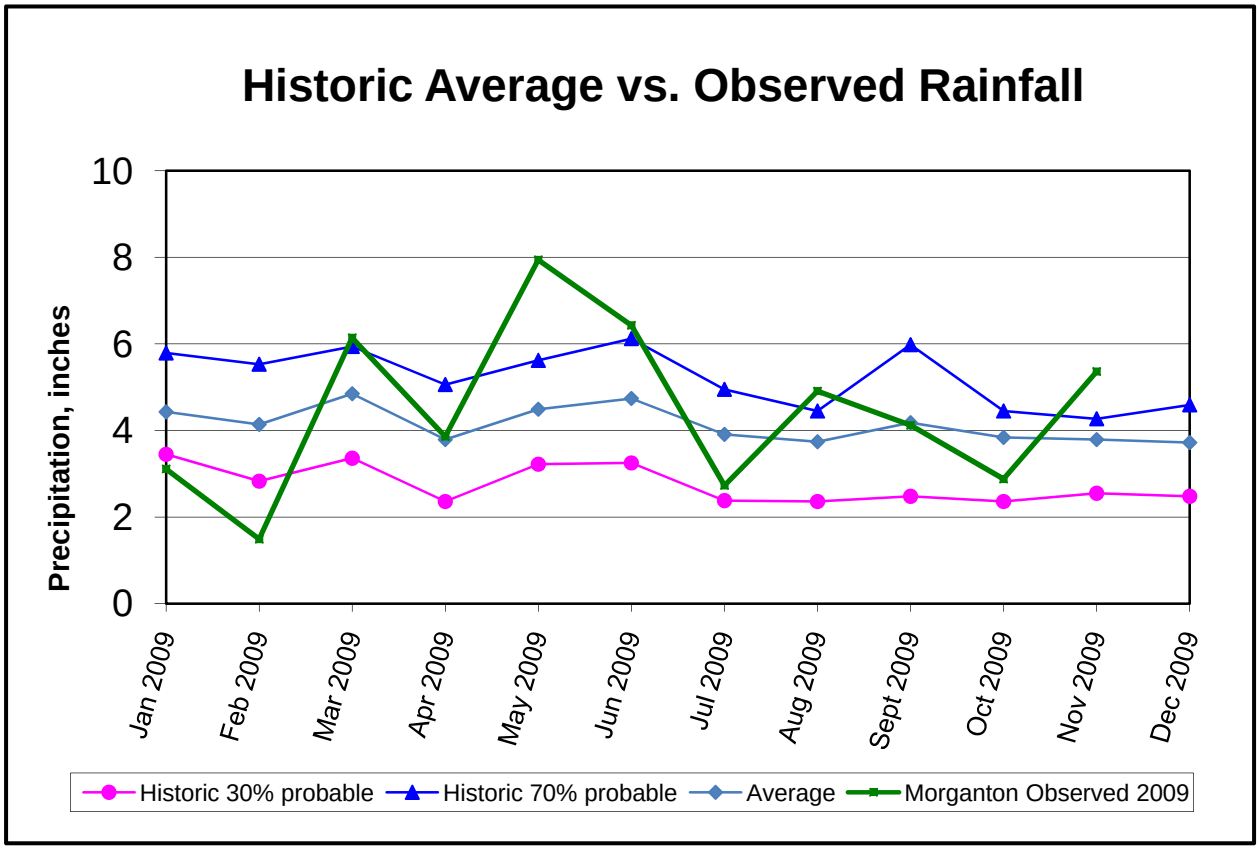
## 5.0 HYDROLOGY

Weather station data from the Morganton Weather Station (Morganton, NC UCAN: 14224, COOP: 315838) were used in conjunction with a manual rain gauge located on the Site to document precipitation amounts. The on-site manual gauge is used to validate observations made at the automated station. According to the Morganton weather station data, total rainfall during the Year 4 monitoring period was above the normal average from January 2009 through November 2009. For this period, the Morganton station measured rainfall to be 3.07 inches above the historic average. Above average to average rainfall occurred during the months of March, April, May, June, August, September and November. Below average rainfall occurred during January, February, July and October (see Table 10 and Figure 3).

**Table 10. Comparison of Historic Rainfall to Observed Rainfall (inches)**
**Bailey Fork Mitigation Site: EEP Contract No. D04006-3**

| Month | Average | 30% | 70% | Observed 2009 Precipitation |
|---|---|---|---|---|
| January | 4.43 | 3.45 | 5.79 | 3.11 |
| February | 4.14 | 2.83 | 5.53 | 1.49 |
| March | 4.85 | 3.36 | 5.94 | 6.14 |
| April | 3.79 | 2.36 | 5.06 | 3.86 |
| May | 4.49 | 3.22 | 5.62 | 7.94 |
| June | 4.74 | 3.25 | 6.12 | 6.43 |
| July | 3.91 | 2.38 | 4.95 | 2.73 |
| August | 3.74 | 2.36 | 4.45 | 4.91 |
| September | 4.18 | 2.48 | 5.98 | 4.12 |
| October | 3.84 | 2.03 | 4.76 | 2.88 |
| November | 3.79 | 2.55 | 4.27 | 5.36 |
| December | 3.72 | 2.48 | 4.59 | NA |
| **Total:** | 49.62 | -- | -- | 48.97 (through November 2009) |

**Figure 3. Historic Average vs. Observed Rainfall**




The Bailey Fork Restoration Plan specified that eight monitoring wells (four automated and four manual) would be established across the restored site. A total of eight wells (four automated and four manual) were installed during early-March 2006 to document water table hydrology in all required monitoring locations. All wells are located in the restored wetland areas adjacent to UT3, and the locations of monitoring wells are shown on the as-built plan sheets. Hydrologic monitoring results are shown in Table 11. A photograph log of the wetland well monitoring stations is included in Appendix A of this report.

During 2009, all eight on-site wells recorded hydroperiods of greater than 7 percent during the growing season. Hydrologic data collected from the reference site, an existing wetland system, indicates that the reference site experienced hydroperiods considerably less than the hydroperiods recorded by all eight wells at the restoration site.

**Table 11**
Hydrologic Monitoring Results for 2009 (Year 4)
**Bailey Fork Mitigation Site: EEP Contract No. D04006-3**

| Monitoring Station | Most Consecutive Days Meeting Criteria[1] | Cumulative Days Meeting Criteria[2] | Number of Instances Meeting Criteria[3] |
|---|---|---|---|
| AW1 | 26 (12.5%) | 100 (48.1%) | 7 |
| AW2 | 24 (11.5%) | 92 (44.2%) | 8 |
| AW3 | 84 (40.4%) | 119 (57.2%) | 4 |
| AW4 | 52 (25.0%) | 67 (32.2%) | 3 |
| MW1[4] | 24 (11.5%) | 92 (44.2%) | 8 |
| MW2[4] | 24 (11.5%) | 92 (44.2%) | 8 |
| MW3[5] | 84 (40.4%) | 119 (57.2%) | 4 |
| MW4[6] | 52 (25.0%) | 67 (32.2%) | 3 |
| REF1 | 7 (3.4%) | 47 (22.6%) | 11 |
| REF2 | 5 (2.4%) | 23 (11.1%) | 6 |

[1] Indicates the most consecutive number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[2] Indicates the cumulative number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[3] Indicates the number of instances within the monitored growing season when the water table rose to less than 12 inches from the soil surface.

[4] Groundwater gauge MW1 and MW2 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW2.

[5] Groundwater gauge MW3 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW3.

[6] Groundwater gauge MW4 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW4.

# 6.0 BENTHIC MACROINVERTEBRATE MONITORING

## 6.1 Description of Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate monitoring was conducted in accordance with the Bailey Fork Restoration Plan. Because of seasonal fluctuations in populations, macroinvertebrate sampling must be consistently conducted in the same season. Year 3 benthic sampling for the Site was conducted during winter of 2009. This report summarizes the benthic samples collected during the third year post-construction monitoring phase.

The sampling methodology followed the Qual 4 method listed in NCDWQ's Standard Operating Procedures for Benthic Macroinvertebrates (2006). Field sampling was conducted by Christine Miller and Ian Eckardt of Baker. Laboratory identification of collected species was conducted by Pennington & Associates, Inc.

Benthic macroinvertebrate samples were collected at Site 1 of the Bailey Fork project on January 17, 2009, Site 3 on March 16, and Sites 2 and 4 on March 19. Sites 1 and 3 were located within the restoration area on UT1 to Bailey Fork and UT3 to Bailey Fork, respectively. Site 2 was an off-site reference site located upstream of Site 1. Site 4 was an off-site reference site located on UT3 south of Hopewell Road upstream of Site 3. Figure 4 in Appendix E illustrates the sampling site locations.

Benthic macroinvertebrates were collected to assess quantity and quality of life in the stream. In particular, specimens belonging to the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT Species) are useful as an index of water quality. These groups are generally the least tolerant to water pollution and therefore are very useful indicators of water quality. Sampling for these three orders is referred to as EPT sampling.

Habitat assessments using NCDWQ's protocols were also conducted at each site. Physical and chemical measurements including water temperature, dissolved oxygen concentration, pH, and specific conductivity were recorded at each site. The habitat assessment field data sheets are presented in Appendix E.

## 6.2 Benthic Macroinvertebrate Sampling Results

A comparison between the pre- and post-construction monitoring results is presented in Table 12 in Appendix E with complete laboratory results also provided in Appendix E.

## 6.3 Benthic Macroinvertebrate Sampling Discussion

Site 2, the reference site for Site 1, exhibited an abundance of taxa in Year 3 post-construction. Overall taxa richness was nearly double that observed during pre-construction monitoring. EPT richness decreased from Year 2 to Year 3. Although EPT richness dropped when compared to pre-construction values the EPT biotic index was lower than that recorded during pre-construction monitoring which indicates that the species present were less tolerant than in pre-construction. The total biotic index for Site 2 remained slightly above the pre-construction value. The higher total index could be attributed to the decrease in overall shredder taxa observed during the recent post-construction monitoring. Despite the increase in the total biotic index at Site 2, the decrease in EPT biotic index suggests that the communities are stable and that water quality is adequate to support intolerant species.

The Year 3 post-construction monitoring at Site 1, which underwent complete restoration, revealed similar total taxa and EPT taxa richness to that of the pre-construction sampling. Although taxa richness has remained steady throughout the post-construction monitoring the EPT biotic index has decreased each year. This indicates that the EPT species recolonizing at Site 1 are less tolerant which suggests that water quality is improving. Year 3 post-construction shredder taxa remain slightly below that observed during pre-construction monitoring. These organisms feed on partially decomposed organic matter such as sticks and leaf packs, a rare habitat (see Section 6.4). The decrease in sensitive species and lack of shredders are common responses after a major disturbance to habitat such as the in-stream construction techniques implemented on Site 1. It is anticipated that as the project matures, shredder populations will increase as more habitat in the form of snags, logs, and leaf packs become available.

Currently Site 1 has 13% Dominance in Common (DIC) compared to the reference site, which indicates that 13% of the dominant communities at the reference site are dominant at Site 1. In Year 2 post-construction conditions, Site 1 had a DIC of 86%. Although the DIC has decreased the sites still share several species. The difference lies in the abundance of these species. For example, in Year 2 *Pycnopsyche* sp., which has a low tolerance value of 2.5, was common at both Site 1 and 2. In Year 3 *Pycnopsyche* sp. was present but rare at Site 1 and common at Site 2. The difference in DIC may be the result of when sampling was conducted. Although both samples were collected in the winter, Site 1 was monitored on January 27, 2009 and Site 2 was visited on March 19, 2009.

Site 4 was the reference reach for Site 3. The third year of post construction monitoring showed a significant increase in total taxa and EPT taxa richness at Site 4. Both values were above the pre-construction values. The overall and EPT biotic index were similar to the pre-construction values. During Year 2, Site 4 had very low taxa richness which could have been attributed to the extreme drought conditions experienced across western North Carolina during 2007. Three times as many taxa were collected during Year 3 sampling.

Site 3 appears to be recovering well from backwater conditions caused by a beaver dam during Year 2 of post-construction monitoring. The stagnant water conditions likely caused the decrease in total and EPT taxa richness noted in Year 2 of post construction. Year 3 total and EPT taxa richness have significantly increased. The increase suggests that available habitat has improved. During Year 2 monitoring fine sediment deposition was observed at Site 3. It appears that the stream has been able to transport the fine sediment downstream thereby creating more habitat opportunities for macroinvertebrates. The total biotic index was below that of the pre-construction conditions while the EPT biotic index was slightly above. Currently Site 3 has 17% DIC with the reference site, up from 0% after Year 2 of post construction. It is anticipated that Site 3 will continue to improve as the project matures. Improvements in biotic indices and an increase in DIC are likely as communities reestablish.

## 6.4 Habitat Assessment Results and Discussion

Site 1 received an 81 on the Habitat Assessment Field Data Sheet. The site exhibited excellent riffle pool sequencing and pattern. Riffles were mostly gravel and cobbles, slightly embedded with sand, and the pool bottoms were sandy. The riparian buffer at Site 1 could be classified as fallow field with immature hardwood saplings scattered throughout. Although herbaceous plants dominate the stream corridor, tree saplings are beginning to develop. Portions of the stream banks are well shaded by tag alders and willows. These streamside shrubs are supplying a small

amount of organic debris to the channel and organic habitats such as sticks and leaf packs were present but minimal at Site 1. The lack of organic habitats is still likely the cause for the decrease in shredder communities from pre-construction monitoring to post-construction monitoring. It is anticipated that as the riparian buffer grows in, the shredders from the upstream reference site (Site 2) will begin to colonize the restoration reach.

Site 2, the reference reach for Site 1, received a habitat assessment score of 75. The reach exhibited riffle pool sequencing with moderate bank erosion on alternating banks. The riparian buffer was mature and intact along most of the reach. Rocks, sticks, leaf packs, snags and undercut banks were all present along this reach. The ecological habitat observed during this monitoring cycle appears to be very similar to the pre-construction conditions.

The habitat assessment score of Site 3 increased from 67 during Year 2 to 83 in Year 3 post-construction monitoring. The increase in habitat assessment score reflects an improvement in available habitat and a decrease in sedimentation. During Year 2 the site experienced backwater conditions due to a downstream beaver dam. As a result, fine sediment covered portions of the bed and banks in the vicinity of Site 3. During Year 3, the beaver dam was removed and the excess sediment was flushed downstream thereby increasing available habitat and allowing greater opportunity for re-colonization. In-stream habitat was diverse with rocks and root mats abundant. The site also exhibited excellent riffle pool sequencing and pattern once the beaver dam was removed.

The habitat score for Site 4, the reference reach for Site 3, increased slightly from 63 in Year 2 to 69 for Year 3 post construction monitoring. The riparian zone is mix of mature forest and fallow field. Portions of the left floodplain have been impacted by a maintained power line easement. In-stream habitats included rocks, sticks, leaf packs, logs, and undercut banks. Pool bottoms were sandy. The reach had areas of severe bank erosion. Despite the low habitat assessment score, this reach continues to have a very low EPT biotic index, indicating that the water quality is high enough to support intolerant species

The restoration of pattern and dimension as well as the addition of several root wads, vanes, and armored riffles has enhanced the overall in-stream habitat throughout the restoration sites, while the reference reaches appeared ecologically stable. The habitat scores at Sites 1 and 3 increased from the scores collected in Year 2 of post construction. The planted riparian vegetation has had minimal effect on in-stream habitat at Sites 1 and 3 however future contributions from planted riparian vegetation will be evident as the woody plant species mature. Contributions will include in-stream habitat structures such as sticks and leaf packs.

The physical and chemical measurements of water temperature, pH, and specific conductivity at all sites were relatively normal for Piedmont streams.

### 6.5 Photograph Log

The photograph log is attached as Appendix E. Photos P-1 and P-2 show the stable, well defined riffle pool sequence at Site 1. Site 1 lacks a mature forested canopy; however young woody vegetation is present along the banks. Photos P-3 and P-4 show the mature canopy with breaks for light penetration at Site 2. Site 3 is shown in P-5 and P-6. The site lacks a canopy so the stream receives full sunlight with little to no shade. Fenced out cattle are visible in the background of P-6. P-7 and P-8 are upstream and downstream views of Site 4. These photos

show the extreme bank erosion affecting the right bank of the stream. Despite the erosion, the varied habitat types are visible, including rocks, logs, undercut banks, and leafpacks.

## 7.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

*Vegetation Monitoring.* For the 21 monitoring plots, surviving planted stems ranged from 200 stems per acre to 720 stems per acre. The plots displayed an overall average of 546 stems per acre which is a survival rate of greater than 79 percent based on the initial planting count of 687 stems per acre. Surviving planted vegetation ranged from 200 stems per acre to 720 stems per acre. Overall, the Site is on track to meet the final success criteria of 260 trees per acre by the end of Year 5 as specified in the Restoration Plan for the Site. The area surrounding Plot 9 will require supplemental planting with 4-year old stems in 2010.

Overall, the Site is on track to achieve the vegetative success criteria specified in the Restoration Plan for the Site.

*Stream Monitoring.* The entire length of the restored stream channel was inspected during Year 4 of the monitoring period to assess stream performance.

Stream cross-sectional data document that there has been some adjustment to stream dimension since construction, but the adjustments are considered typical for newly restored stream systems and not an indicator of instability.

The Year 4 longitudinal profiles showed that some pools have aggraded slightly due to accumulated sediment. Due to the above average rainfall amounts observed during 2009, it is concluded that large storm events have caused higher amounts of sediment to be deposited in the restored pools. The deposition of sediment in UT3 during 2009 has exceeded the scouring potential normally seen during past monitoring years. While pool depths have decreased, pools are still prevalent throughout the reach and channel stability has not been affected by the accumulated sediment. It is likely that these sediments are present in the pools due to off-site deposition into the upstream portions of the restored streams system. All of the longitudinal profiles during Year 3 of monitoring showed some changes in the restored reaches. These changes do not appear to pose a significant threat to the stability of the channels

It was also noted that two rock cross vanes on Bailey Fork Creek at approximate stations 17+00 and 28+50 have been impacted by beaver activity. During a site visit in early November 2008 (Year 3), two beaver dams were observed across the rock inverts on top of the cross vanes. These beaver dams were not present in October 2009. The area will continue to be observed for further beaver activity.

The on-site crest gauges documented the occurrence of at least one bankfull flow event at two of the three crest gauges during Year 4 of the post-construction monitoring period. The bankfull measurements collected during monitoring in Years 1 through 4 documents that all three restored reaches have met the success criteria for bankfull events for the project.

Overall, the Site is on track to achieve the stream success criteria specified in the Restoration Plan for the Site.

*Hydrologic Monitoring.* During 2009, all eight on-site wells recorded a hydroperiod of greater than 7 percent saturation during the growing season. Hydrologic data collected from the reference site, an existing wetland system, indicates that the reference site

experienced hydroperiods considerably less than the hydroperiod recorded by all eight wells at the restoration site.

Overall, the Site is on track to achieve the hydrologic success criteria specified in the Restoration Plan for the Site.

*Benthic Monitoring.* The Site exhibited excellent riffle pool sequencing, pattern, and habitat diversity during Year 3 of benthic macroinvertebrate monitoring. Site 1 on UT2, which underwent complete restoration, revealed similar total taxa and EPT taxa richness to that of the pre-construction sampling. Although taxa richness has remained steady throughout the post-construction monitoring the EPT biotic index has decreased each year. This indicates that the EPT species re-colonizing at Site 1 are less tolerant which suggests that water quality is improving. Year 3 post-construction shredder taxa remain slightly below that observed during pre-construction monitoring. These organisms feed on partially decomposed organic matter such as sticks and leaf packs, a rare habitat on UT2. The decrease in sensitive species and lack of shredders are common responses after a major disturbance to habitat such as the in-stream construction techniques implemented on Site 1. It is anticipated that as the project matures, shredder populations will increase as more habitat in the form of snags, logs, and leaf packs become available.

Year 3 total and EPT taxa richness on UT3 have significantly increased. The increase suggests that available habitat is improving. During Year 2 monitoring fine sediment deposition was observed at Site 3. The total biotic index was below that of the pre-construction conditions while the EPT biotic index was slightly above. Currently Site 3 has 17% DIC with the reference site, up from 0% after Year 2 of post construction. It is anticipated that Site 3 will continue to improve as the project matures.

It is anticipated that continued improvements in biotic indices and an increase in DIC will be seen in future monitoring reports as communities continue to re-establish. The physical and chemical measurements of water temperature, percent dissolved oxygen, dissolved oxygen concentration, pH, and specific conductivity at all sites were relatively normal for Piedmont streams.

In summary, the Site remains on track to achieve the hydrologic, vegetative and stream success criteria specified in the Restoration Plan for the Site and monitoring will continue in 2009.

## 8.0 WILDLIFE OBSERVATIONS

Observations of deer and raccoon tracks are common on the Bailey Fork Site. During certain times of the year, frogs, turtles and fish have been observed.

## 9.0 REFERENCES

NCDWQ's Standard Operating Procedures for Benthic Macroinvertebrates (2006)

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

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

USDA, NC Agricultural Experiment Station, *Soil Survey of Burke County, North Carolina*, 2006.

# FIGURES

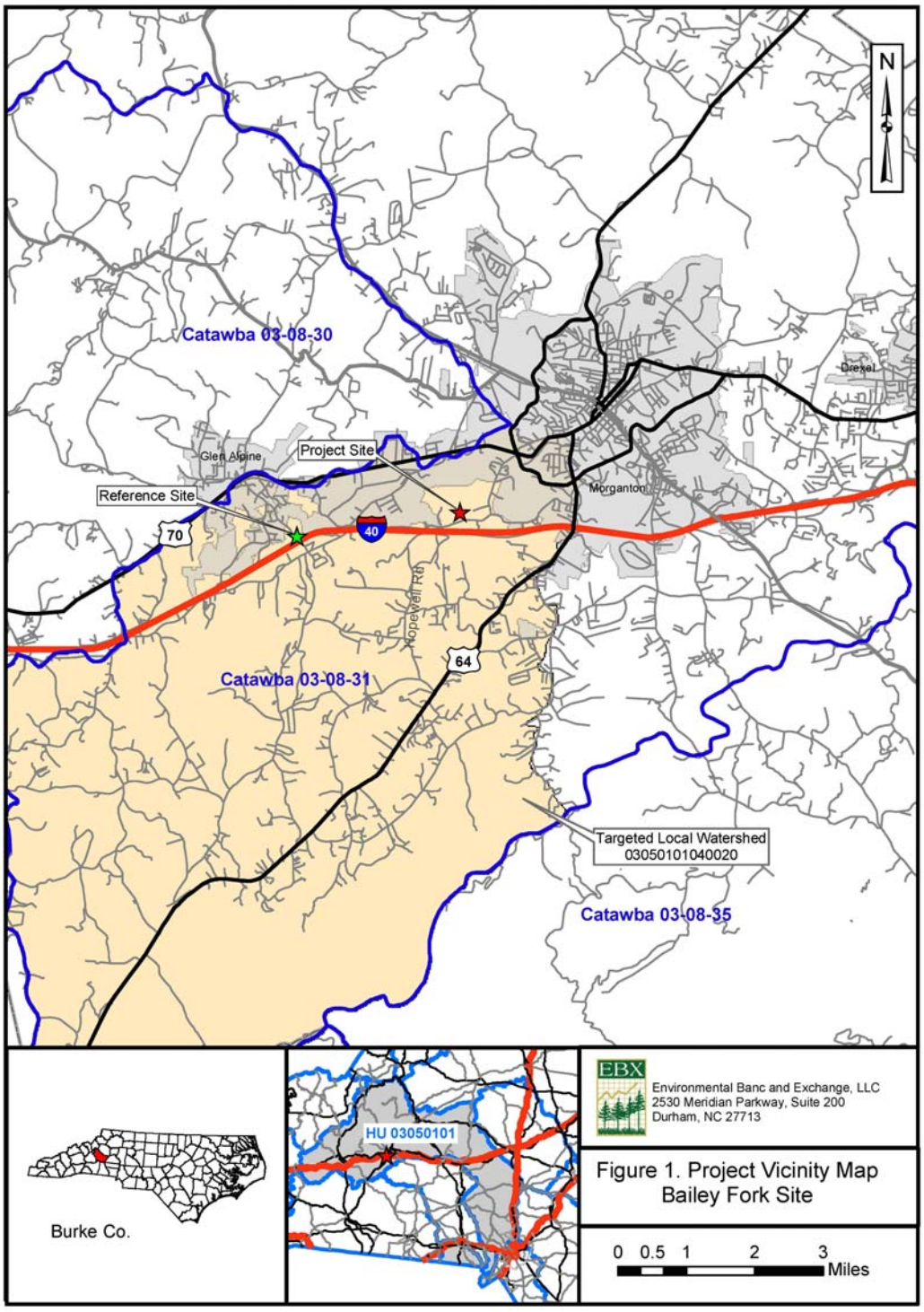



**Figure 1. Location of Bailey Fork Stream Mitigation Site.**

2/26/03

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|---|---|
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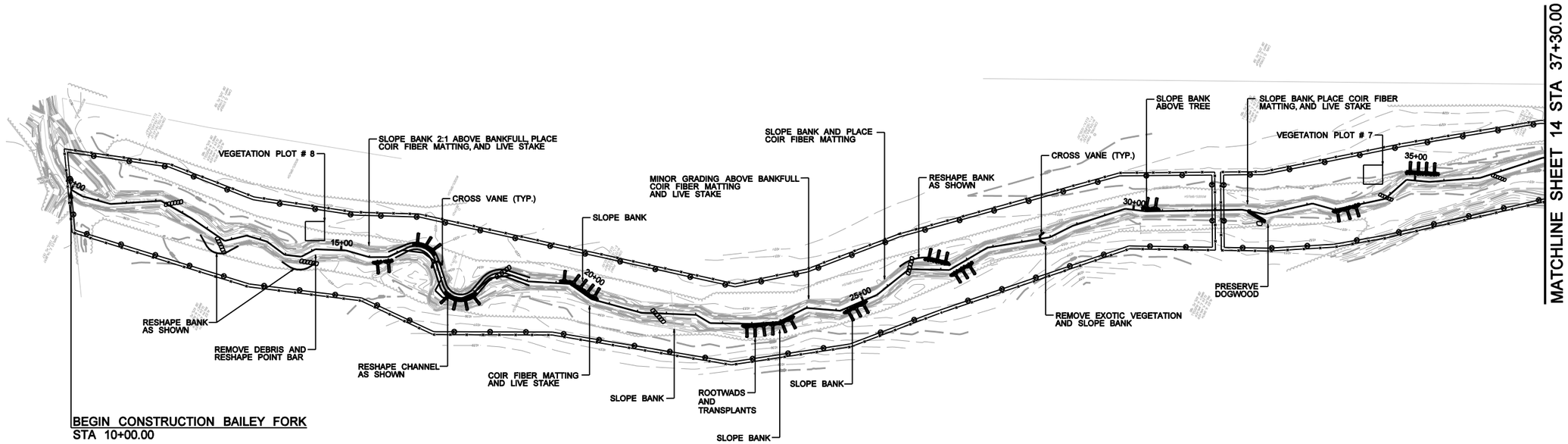


FIGURE: 2A

PLAN VIEW

100 50 0 100 200
SCALE (FT)

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Fax: 919-463-5490

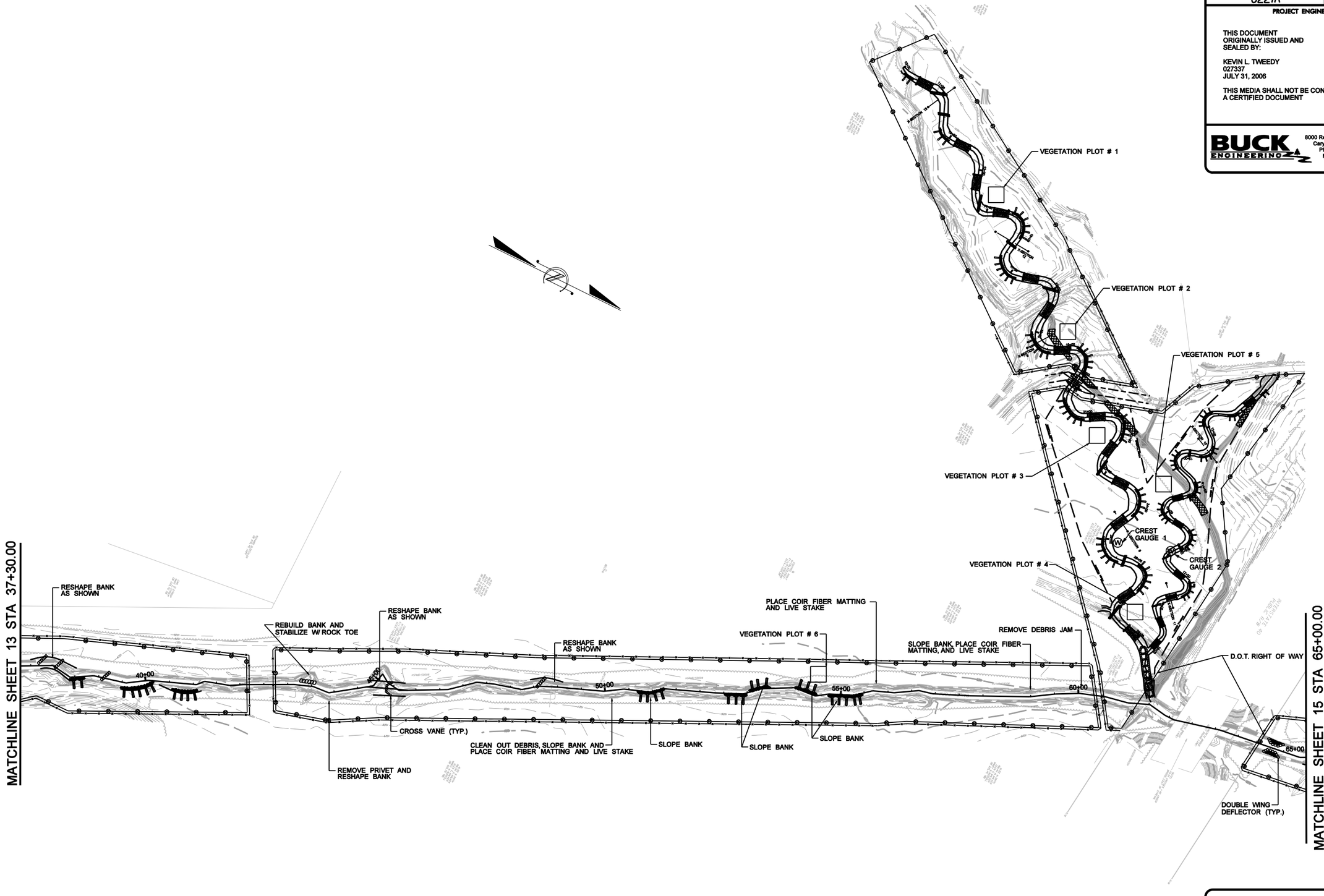


FIGURE: 2B
CROSS SECTION NUMBERING CHANGED 11-20-07

PLAN VIEW

100 50 0 100 200
SCALE (FT)

K:\26_2007\0221R\Design\As-built\0221R_AB_EBX_psh_14.dgn

2/26/03

| BUCK PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| 0221R | 15 |

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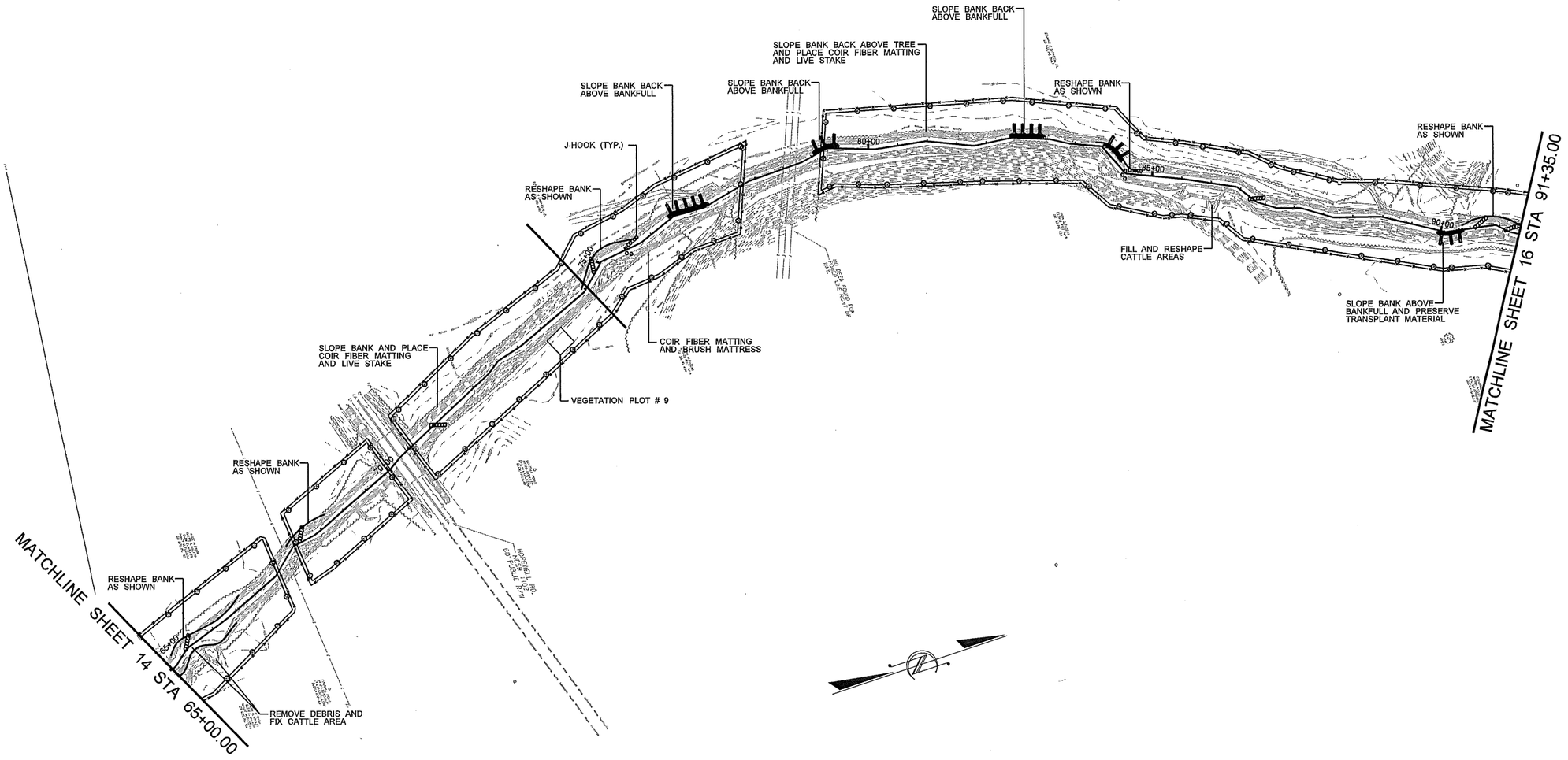


FIGURE: 2C

PLAN VIEW

100 50 0 100 200
SCALE (FT)

3/10/2010
R:\0221R_Design\As-built\0221R_AB_EBX_psh_15.dgn
Symons

2/26/03

| BUCK PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| 0221R | 16 |

PROJECT ENGINEER

THIS DOCUMENT
ORIGINALLY ISSUED AND
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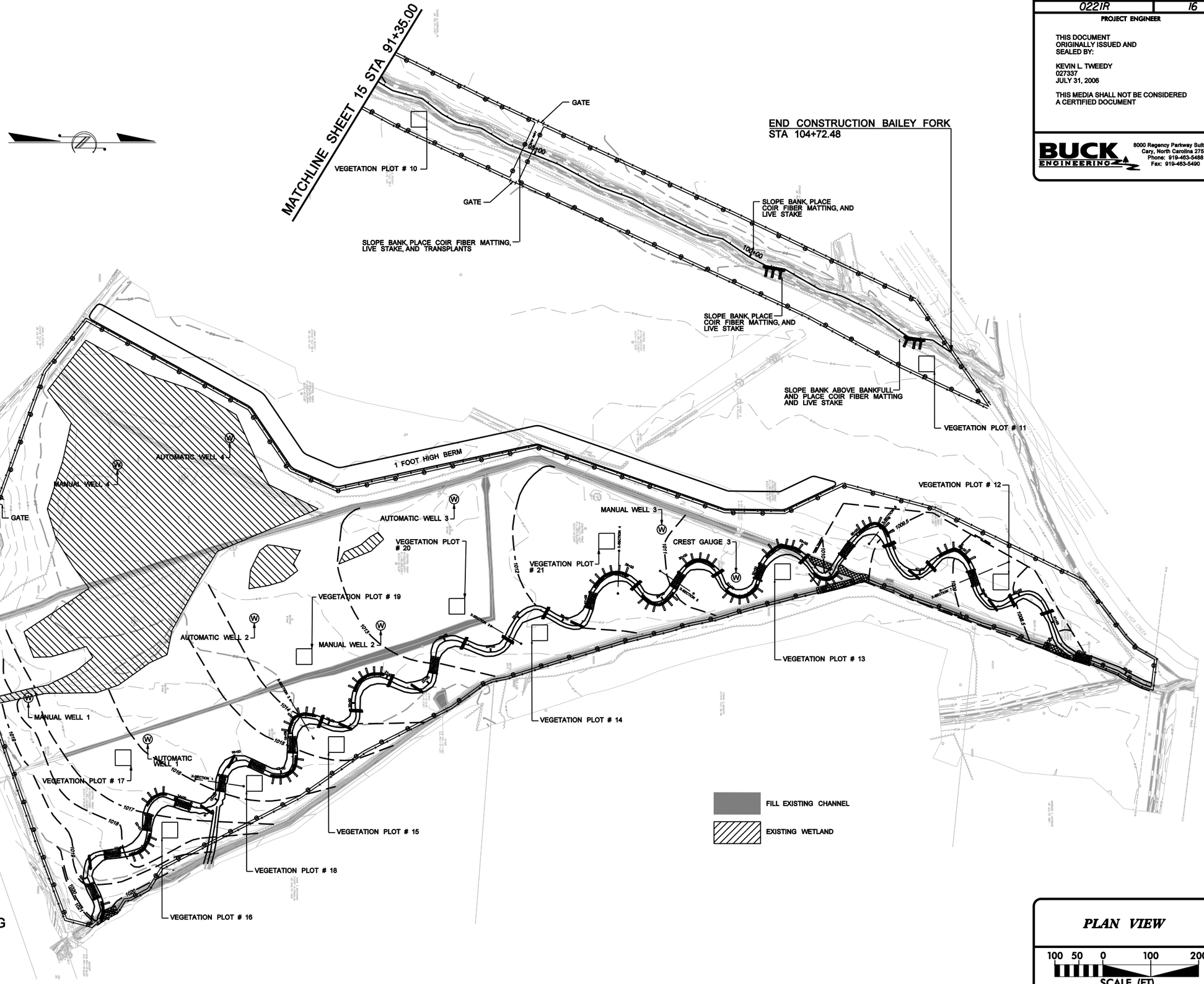



FIGURE: 2D
CROSS SECTION NUMBERING
CHANGED 11-20-07

PLAN VIEW

100 50 0 100 200
SCALE (FT)

IK/26/2007
R:\0221R\Design\As-built\0221R_AB_EBX_psh_16.dgn

# APPENDIX A

# PHOTO LOG

# VEGETATION PHOTOS

**Bailey Fork Vegetation Plot Photos**


Bailey Fork Vegetation Plot 1


Bailey Fork Vegetation Plot 2

Bailey Fork Vegetation Plot 3

Bailey Fork Vegetation Plot 4

Bailey Fork Vegetation Plot 5

Bailey Fork Vegetation Plot 6

Bailey Fork Vegetation Plot 7

Bailey Fork Vegetation Plot 8

Bailey Fork Vegetation Plot 9

Bailey Fork Vegetation Plot 10

Bailey Fork Vegetation Plot 11

Bailey Fork Vegetation Plot 12

Bailey Fork Vegetation Plot 13

Bailey Fork Vegetation Plot 14

Bailey Fork Vegetation Plot 15

Bailey Fork Vegetation Plot 16

Bailey Fork Vegetation Plot 17

Bailey Fork Vegetation Plot 18

Bailey Fork Vegetation Plot 19

Bailey Fork Vegetation Plot 20

Bailey Fork Vegetation Plot 21

# STREAM PHOTOS AND WETLAND PHOTOS

UT1 Photo Point 1

UT1 Photo Point 2

UT1 Photo Point 3

UT1 Photo Point 5

UT1 Photo Point 7

UT1 Photo Point 10

UT1 Photo Point 13

UT1 Photo Point 17

UT1 Photo Point 19

UT2 Photo Point 1

UT2 Photo Point 3

UT2 Photo Point 6

UT2 Photo Point 8

UT2 Photo Point 12

UT3 Photo Point 1

UT3 Photo Point 4

UT3 Photo Point 8

UT3 Photo Point 10

UT3 Photo Point 12

UT3 Photo Point 15

UT3 Photo Point 18

UT3 Photo Point 19

UT3 Photo Point 22

UT3 Photo Point 24

UT3 Photo Point 25

UT3 Photo Point 26

Bailey Fork Cross Vane 1

Bailey Fork Cross Vane 2


Crest Gauge UT3 03/31/09


Crest Gauge UT2 03/31/09

Auto Well 1 - East

Auto Well 1 - North

Auto Well 1 – South

Auto Well 1 - West

Auto Well 2 - East

Auto Well 2 - North

Auto Well 2 - South

Auto Well 2 - West

Auto Well 3 - East

Auto Well 3 - North

Auto Well 3 - South

Auto Well 3 - West


Auto Well 4 - East


Auto Well 4 - North


Auto Well 4 - South


Auto Well 4 - West

Manual Well 1 - East

Manual Well 1 - North

Manual Well 1 - South

Manual Well 1 - West

Manual Well 2 - East

Manual Well 2 - North

Manual Well 2 - South

Manual Well 2 - West

Manual Well 3 - East

Manual Well 3 - North

Manual Well 3 - South

Manual Well 3 - West

Manual Well 4 - East

Manual Well 4 - North

Manual Well 4 - South

Manual Well 4 - West


Bailey Fork Reference Well 1 - East


Bailey Fork Reference Well 1 - North


Bailey Fork Reference Well 1 - South

Bailey Fork Reference Well 1 - West


Bailey Fork Reference Well 1 - East

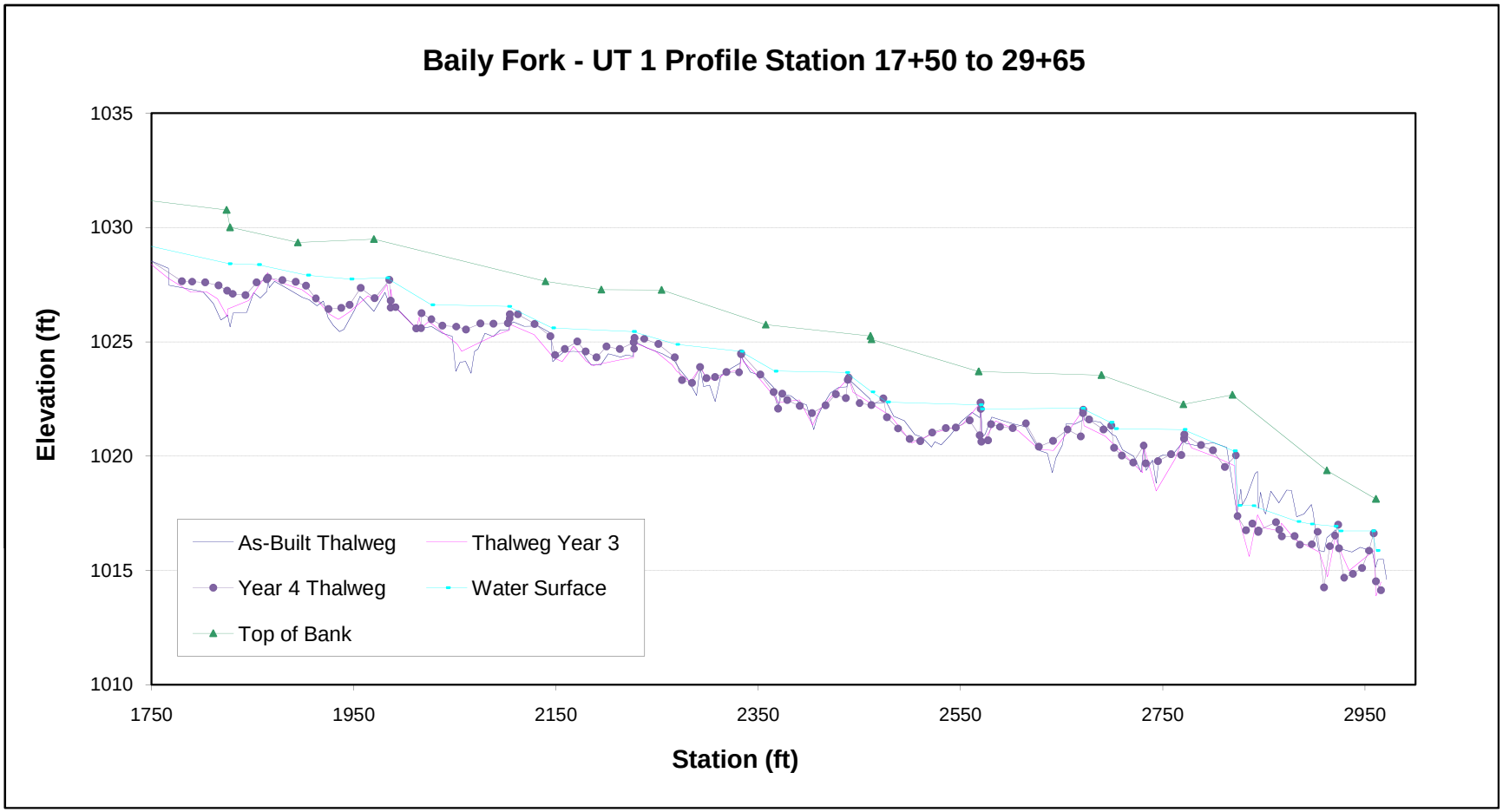
Bailey Fork Reference Well 1 - North

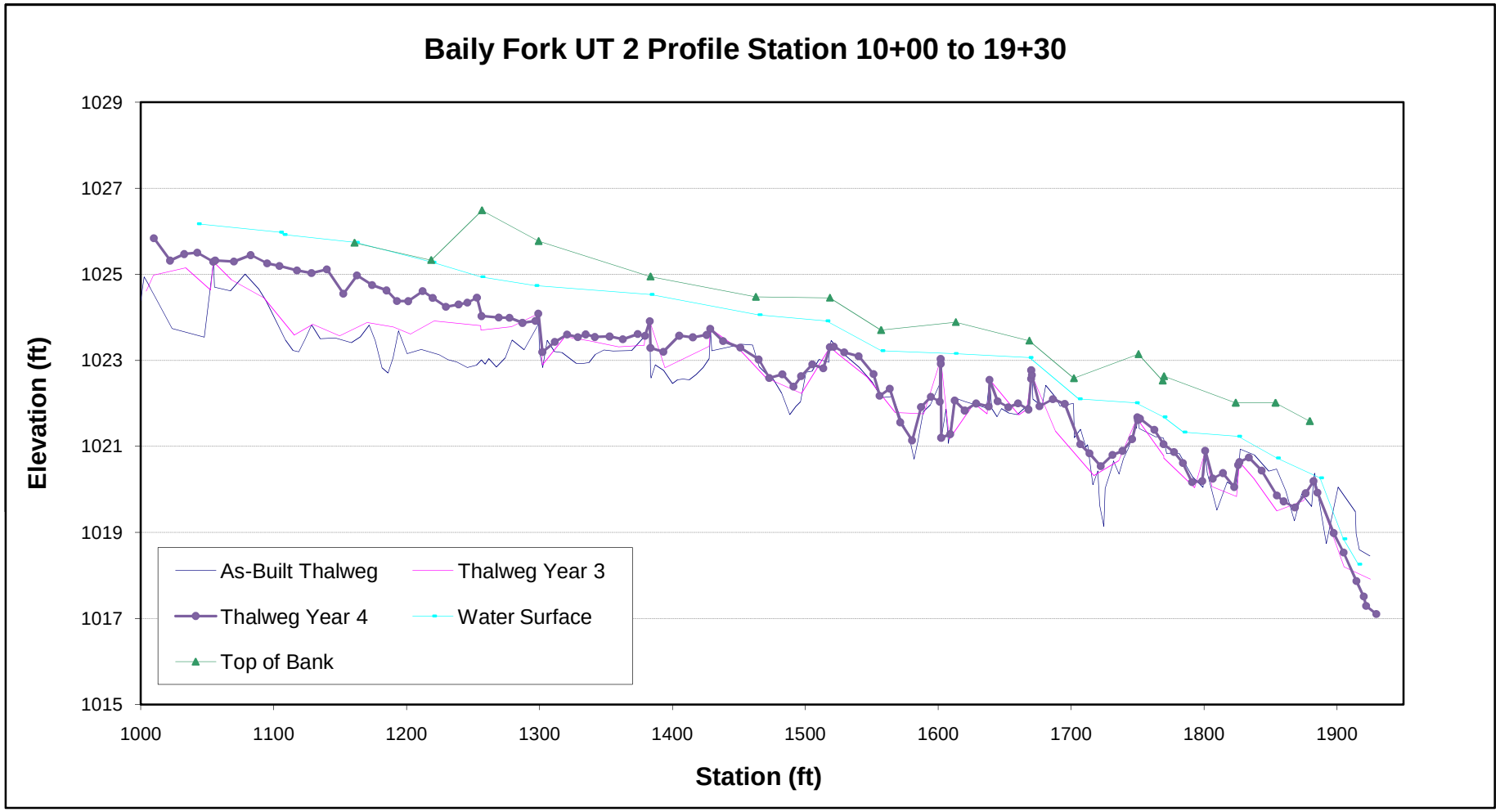
Bailey Fork Reference Well 1 - South

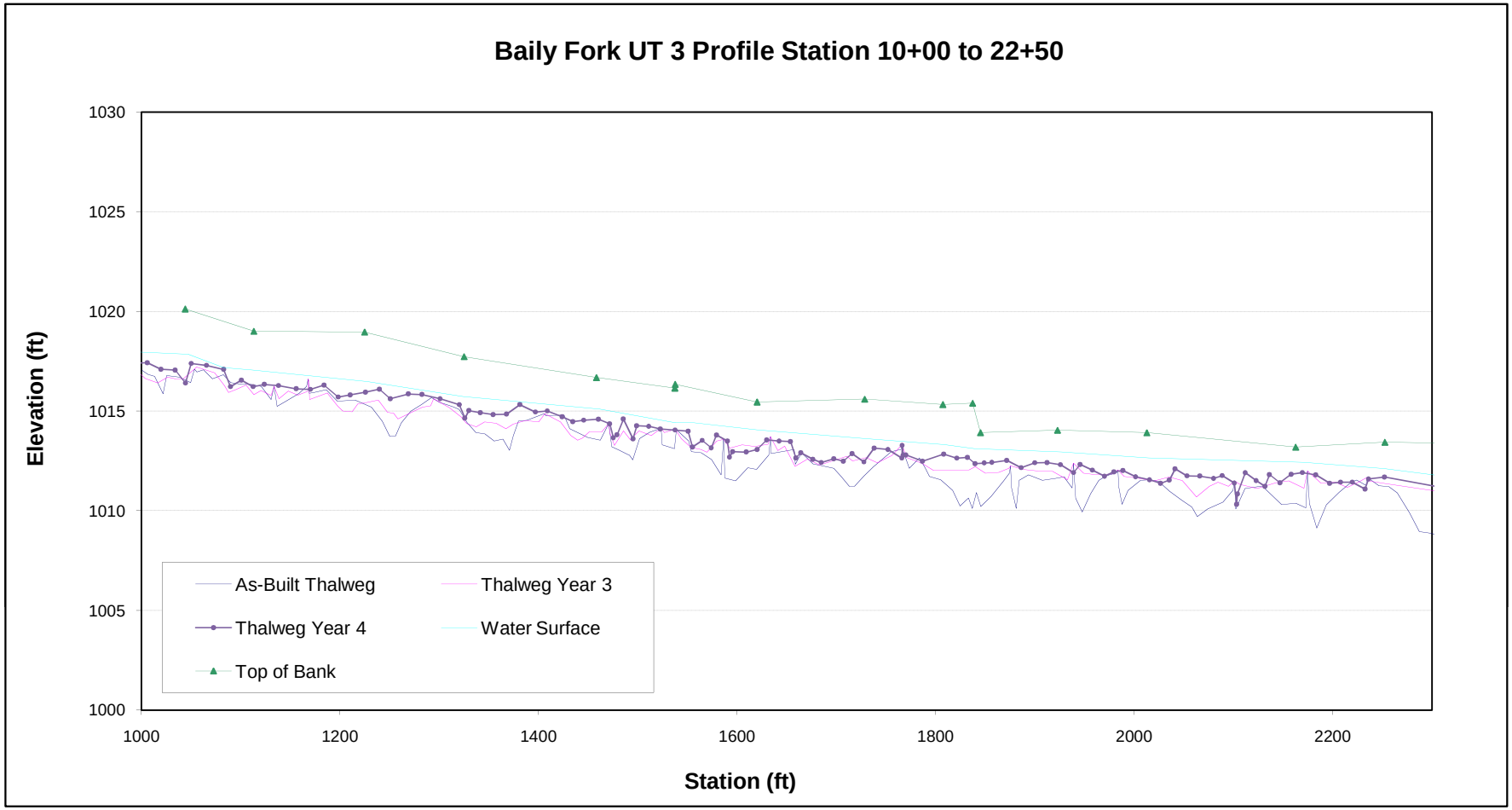
Bailey Fork Reference Well 1 - West

# APPENDIX B

# STREAM MONITORING DATA


Baily Fork - UT 1 Profile Station 17+50 to 29+65
Elevation (ft)
1035
1030
1025
1020
1015
1010
1750
1950
2150
2350
2550
2750
2950
Station (ft)
As-Built Thalweg
Thalweg Year 3
Year 4 Thalweg
Water Surface
Top of Bank


Baily Fork UT 2 Profile Station 10+00 to 19+30
Elevation (ft)
1029
1027
1025
1023
1021
1019
1017
1015
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Station (ft)
As-Built Thalweg
Thalweg Year 3
Thalweg Year 4
Water Surface
Top of Bank


Baily Fork UT 3 Profile Station 10+00 to 22+50
Elevation (ft)
1030
1025
1020
1015
1010
1005
1000
1000
1200
1400
1600
1800
2000
2200
Station (ft)
As-Built Thalweg
Thalweg Year 3
Thalweg Year 4
Water Surface
Top of Bank

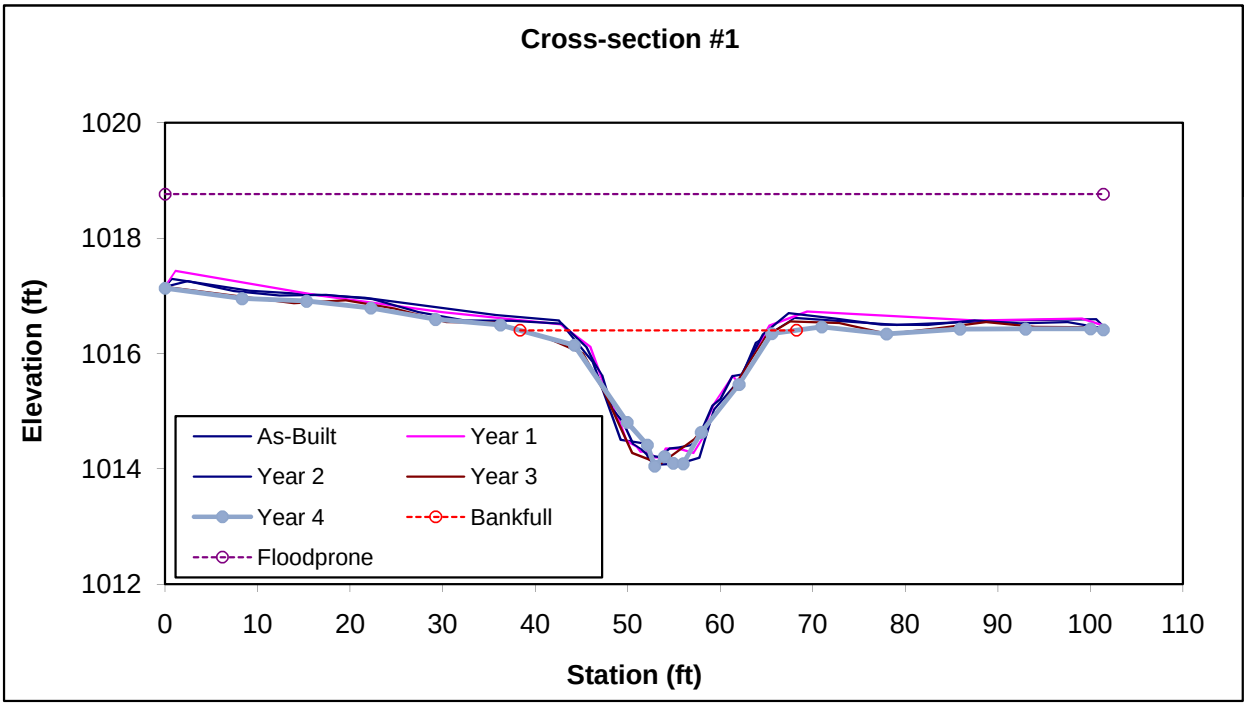
## Permanent Cross-section #1 UT3

(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 30 | 29.85 | 1.01 | 2.36 | 29.66 | 1 | 3.4 | 1016.4 | 1016.34 |



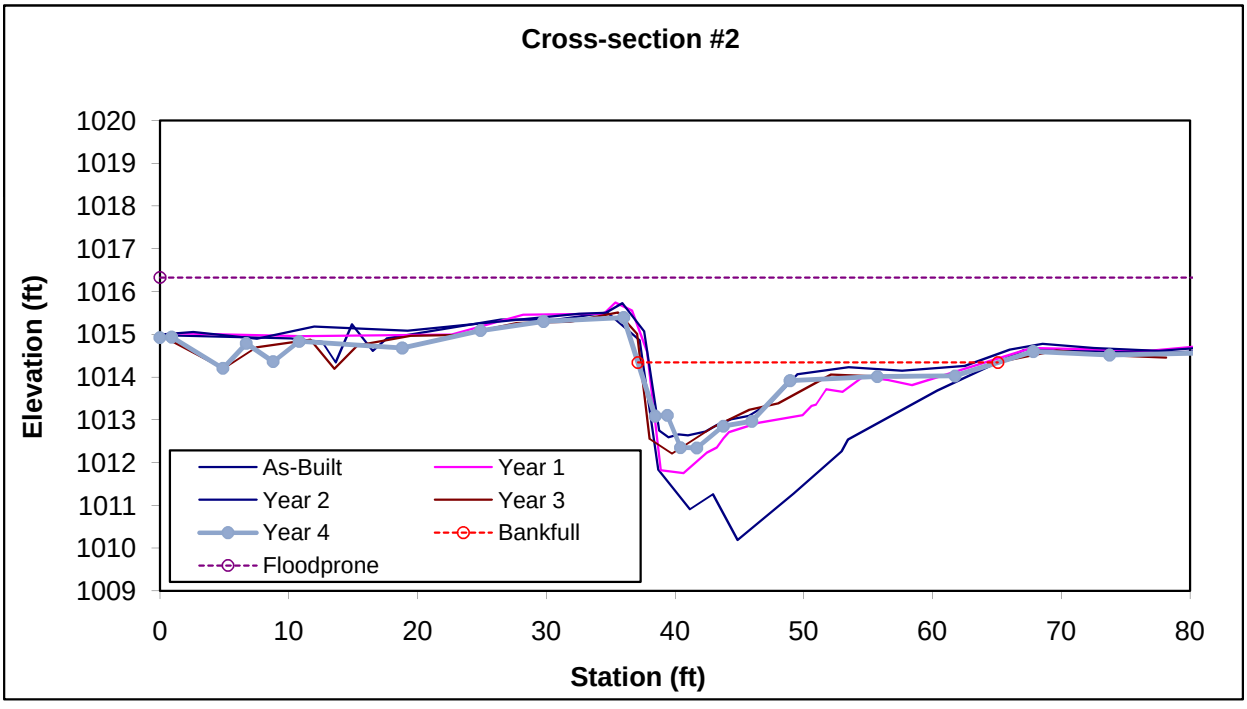
## Permanent Cross-section #2 UT3

(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 20.6 | 27.94 | 0.74 | 1.99 | 37.92 | 1.1 | 3.3 | 1014.34 | 1014.6 |



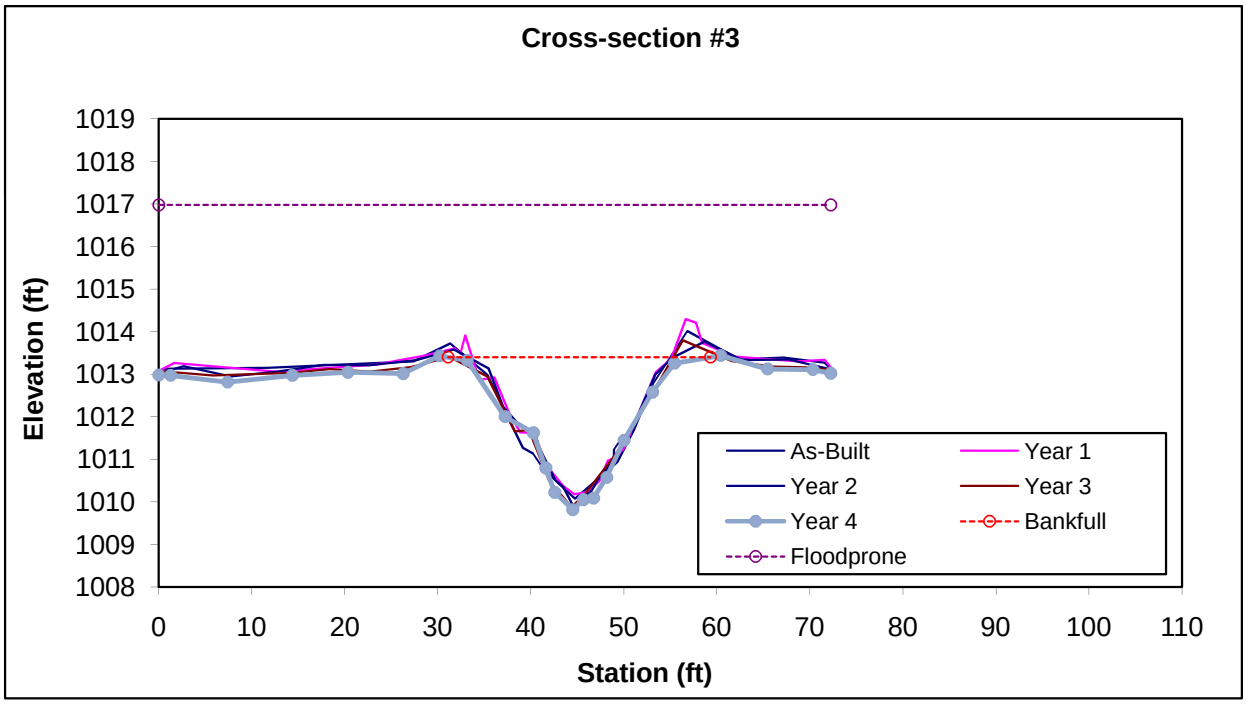
## Permanent Cross-section #3 UT3

(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 42.1 | 28.18 | 1.5 | 3.58 | 18.84 | 1 | 2.6 | 1013.4 | 1013.26 |



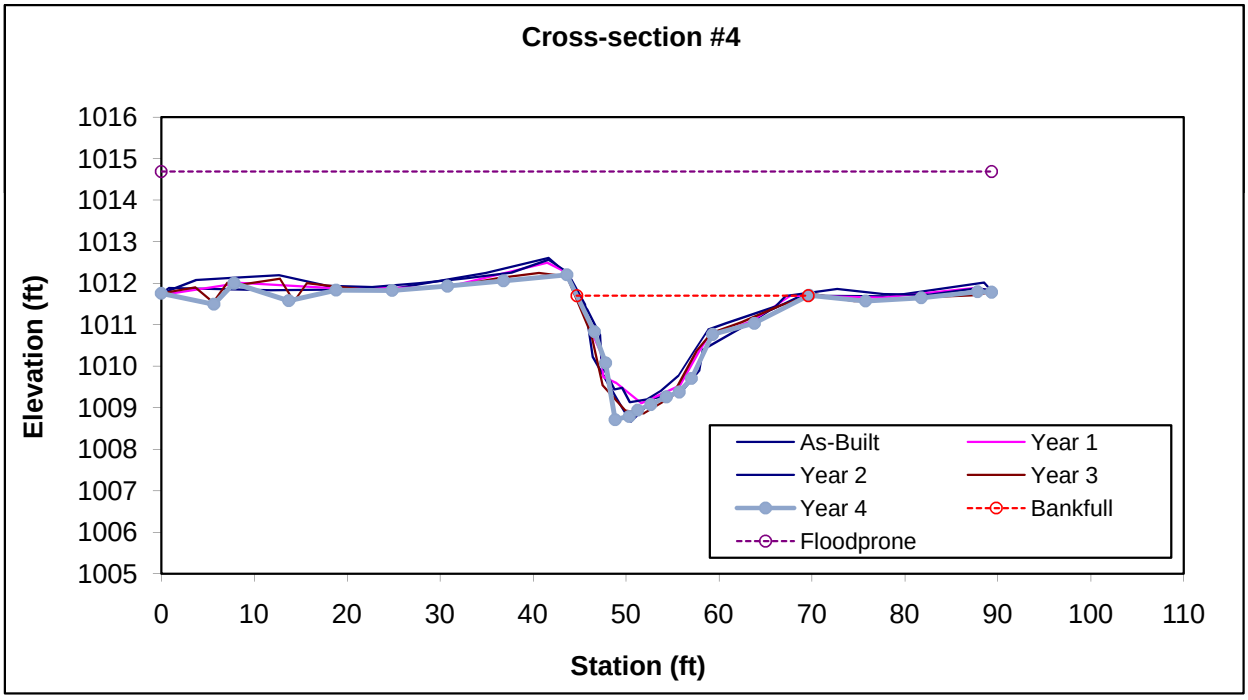
## Permanent Cross-section #4 UT3

(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 34.7 | 24.89 | 1.4 | 2.99 | 17.83 | 1 | 3.6 | 1011.7 | 1011.71 |

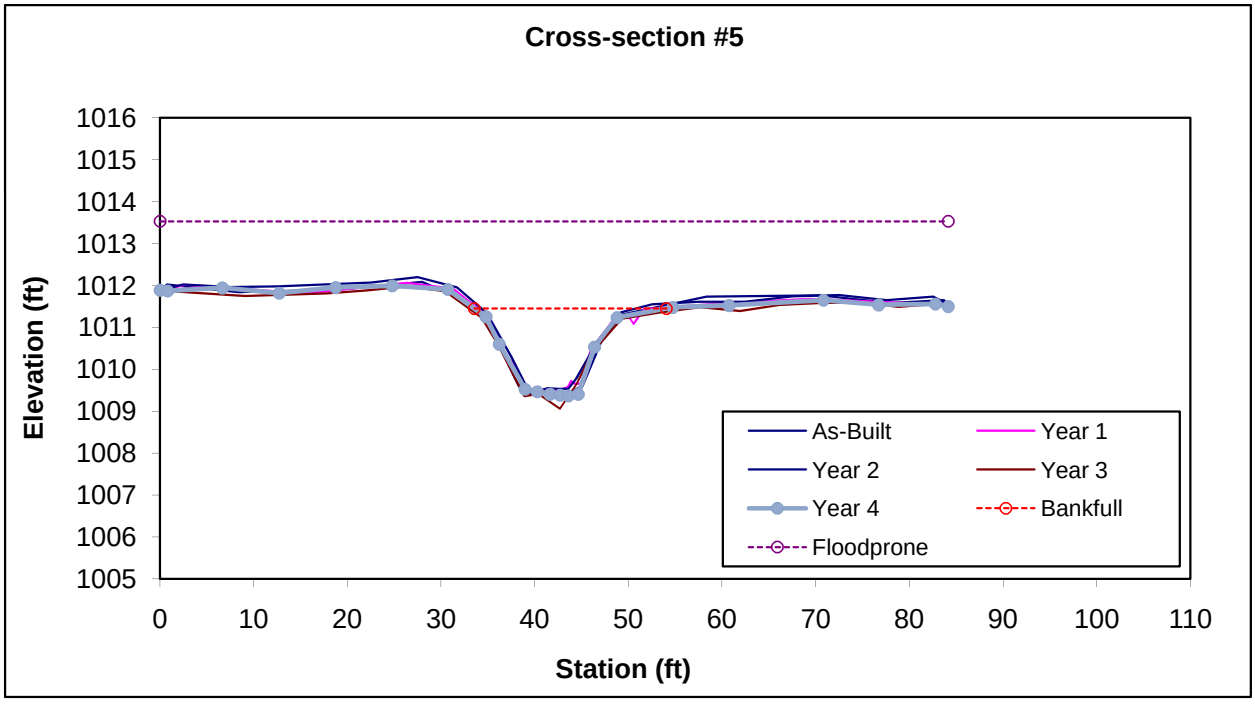


## Permanent Cross-section #5 UT3
(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 20.6 | 20.47 | 1.01 | 2.08 | 20.32 | 1 | 4.1 | 1011.45 | 1011.48 |

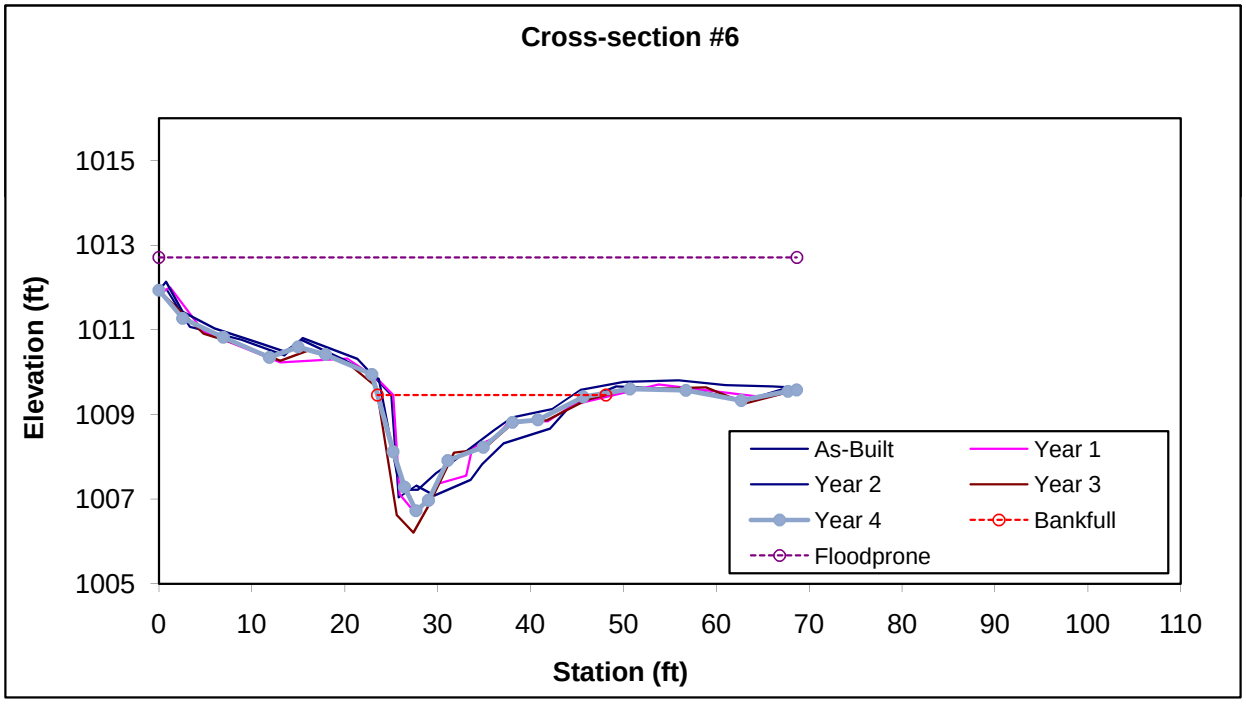


## Permanent Cross-section #6 UT3
(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 25.5 | 23.29 | 1.1 | 2.73 | 21.27 | 1 | 2.9 | 1009.46 | 1009.42 |

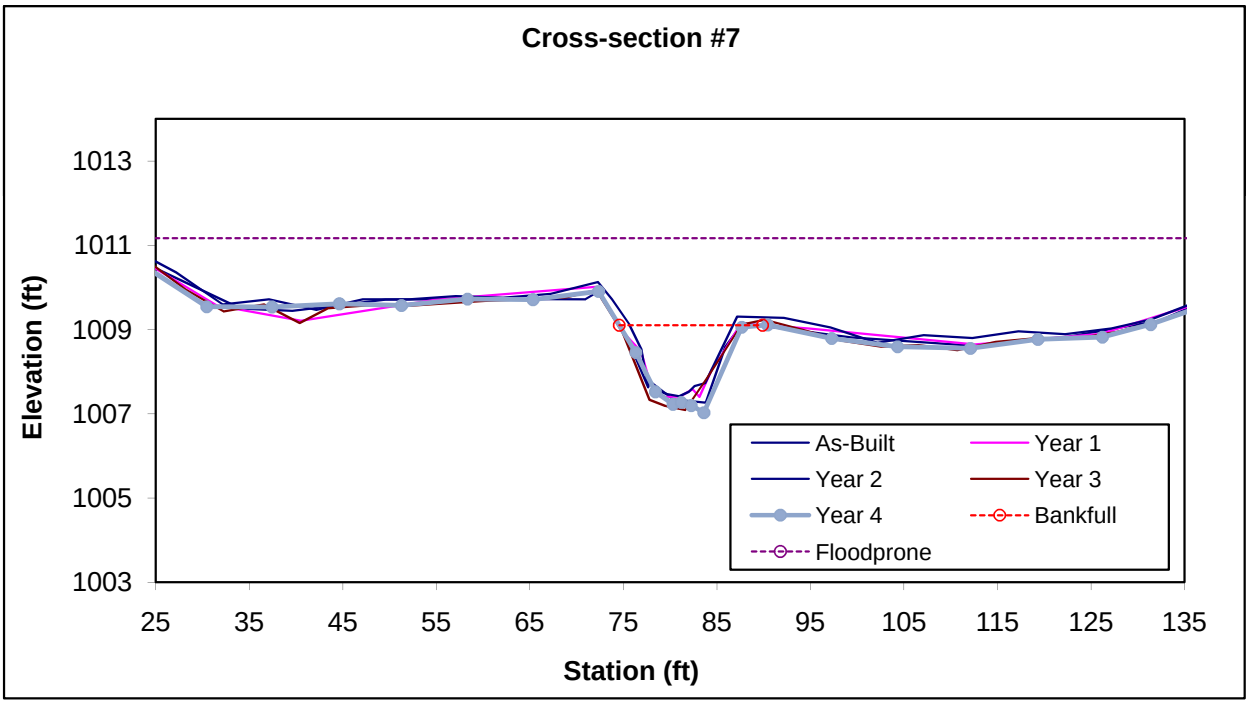


## Permanent Cross-section #7 UT3
(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 16.8 | 15.3 | 1.1 | 2.07 | 13.95 | 1 | 8.7 | 1009.1 | 1009.05 |

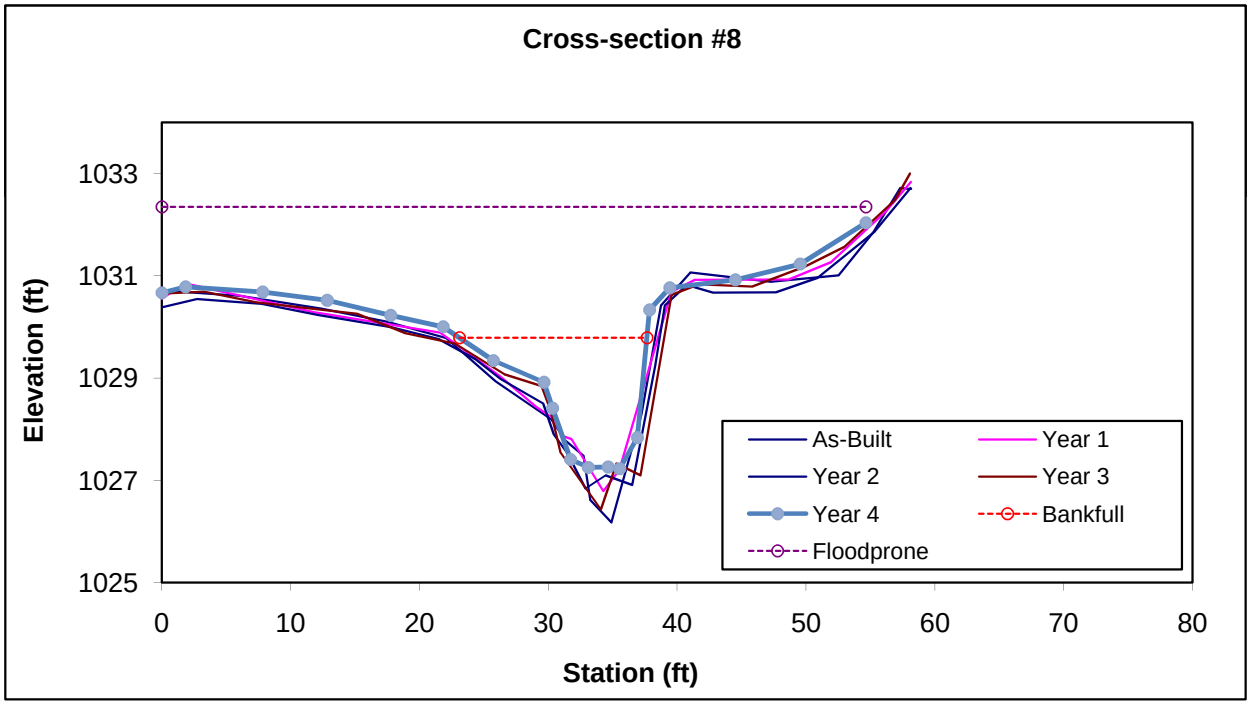


## Permanent Cross-section #8 UT1
(Year 4 Data - Collected October 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 19.9 | 14.55 | 1.37 | 2.56 | 10.62 | 1.1 | 3.8 | 1029.79 | 1030 |



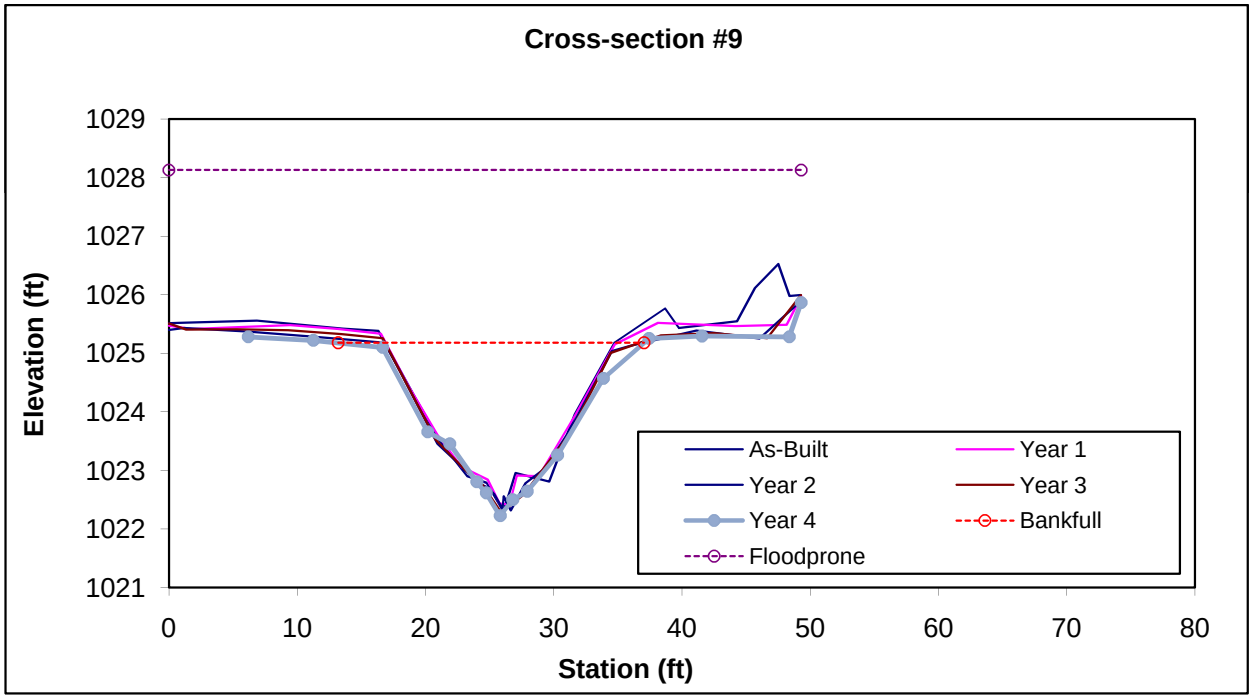
## Permanent Cross-section #9 UT1

(Year 4 Data - Collected September 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 31.3 | 23.83 | 1.31 | 2.95 | 18.12 | 1 | 1.8 | 1025.18 | 1025.1 |



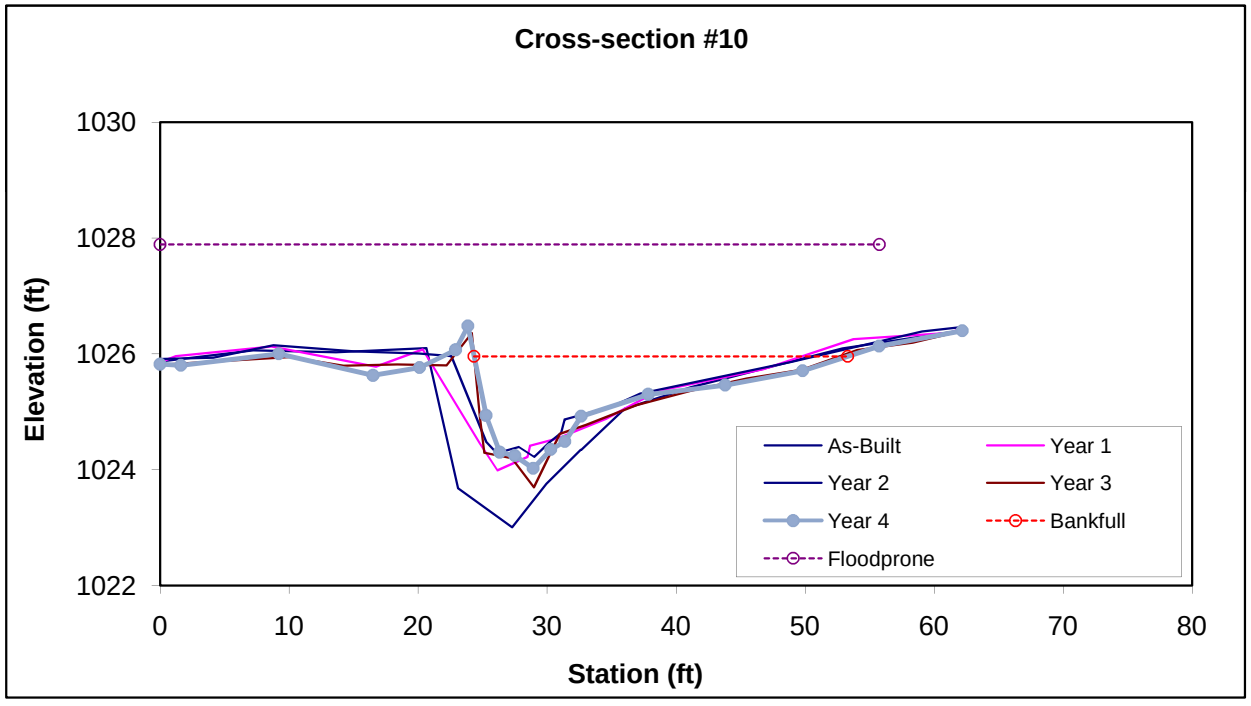
## Permanent Cross-section #10 UT2

(Year 4 Data - Collected September 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 22.7 | 28.96 | 0.78 | 1.93 | 37 | 1.1 | 1.9 | 1025.96 | 1026.14 |



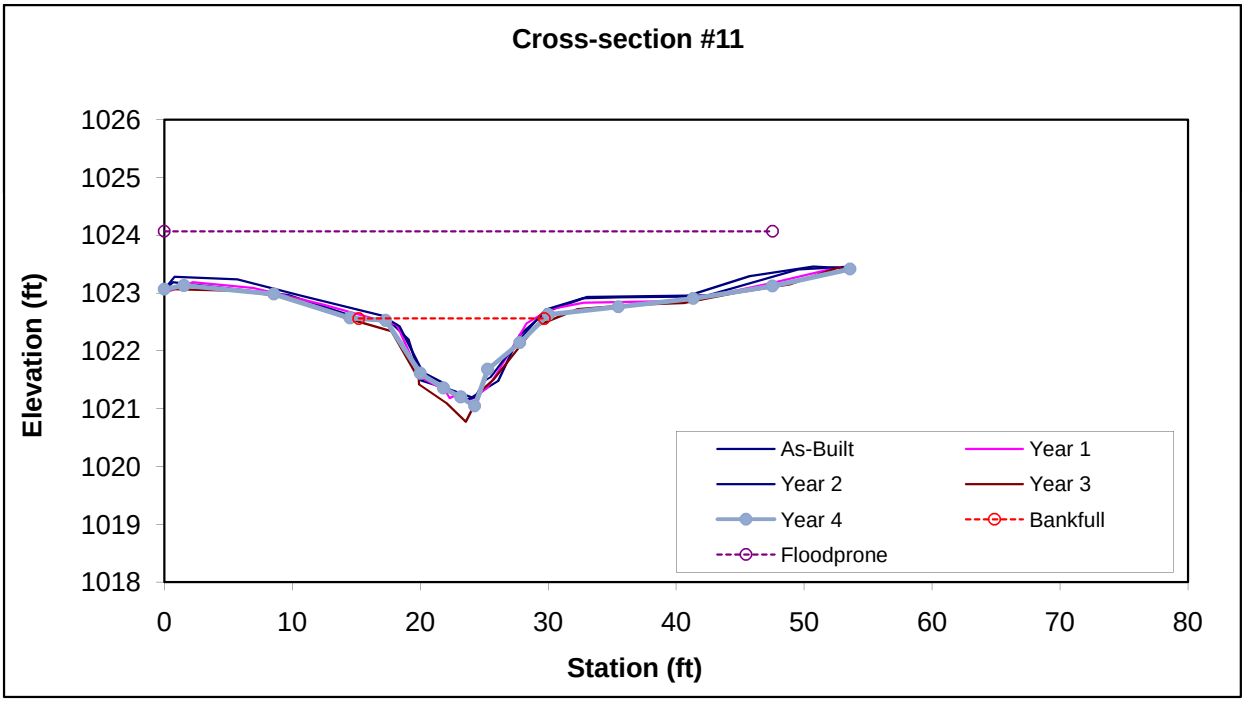
## Permanent Cross-section #11 UT2

(Year 4 Data - Collected September 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 9.8 | 14.5 | 0.68 | 1.51 | 21.38 | 1 | 3.3 | 1022.56 | 1022.53 |



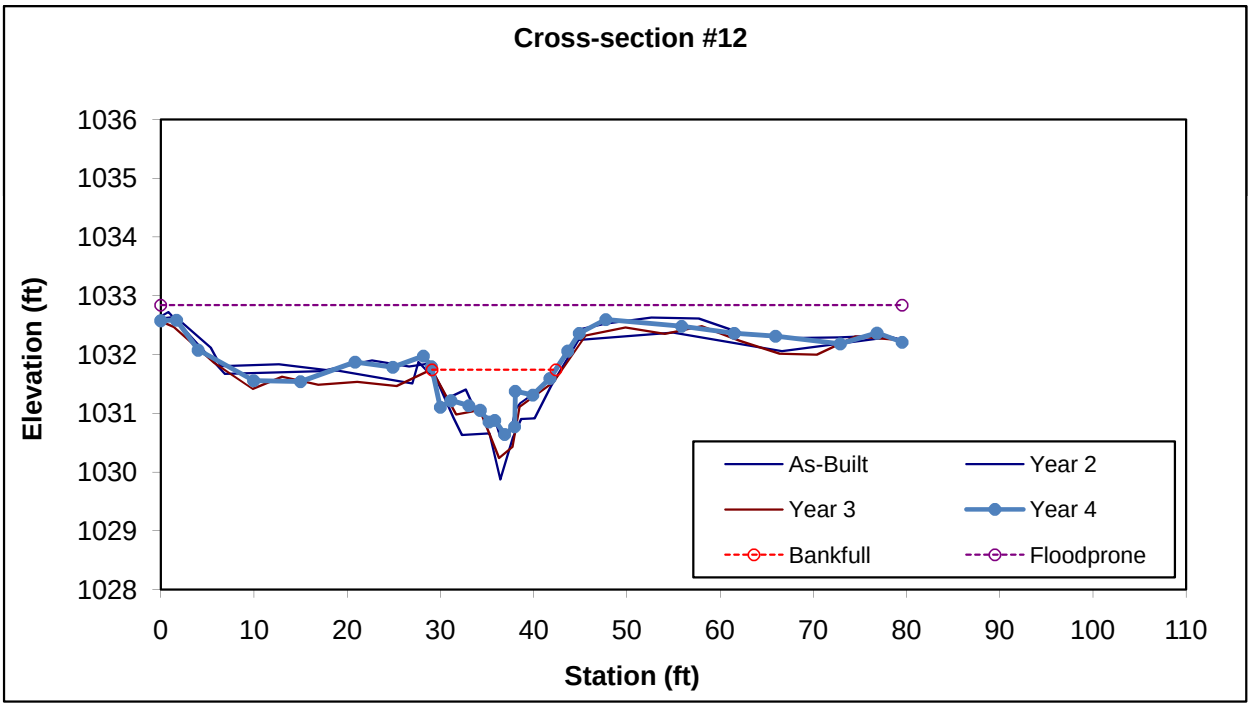
## Permanent Cross-section #12 UT1

(Year 4 Data - Collected September 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 7.6 | 13.25 | 0.57 | 1.1 | 23.08 | 1.2 | 6 | 1031.74 | 1031.98 |



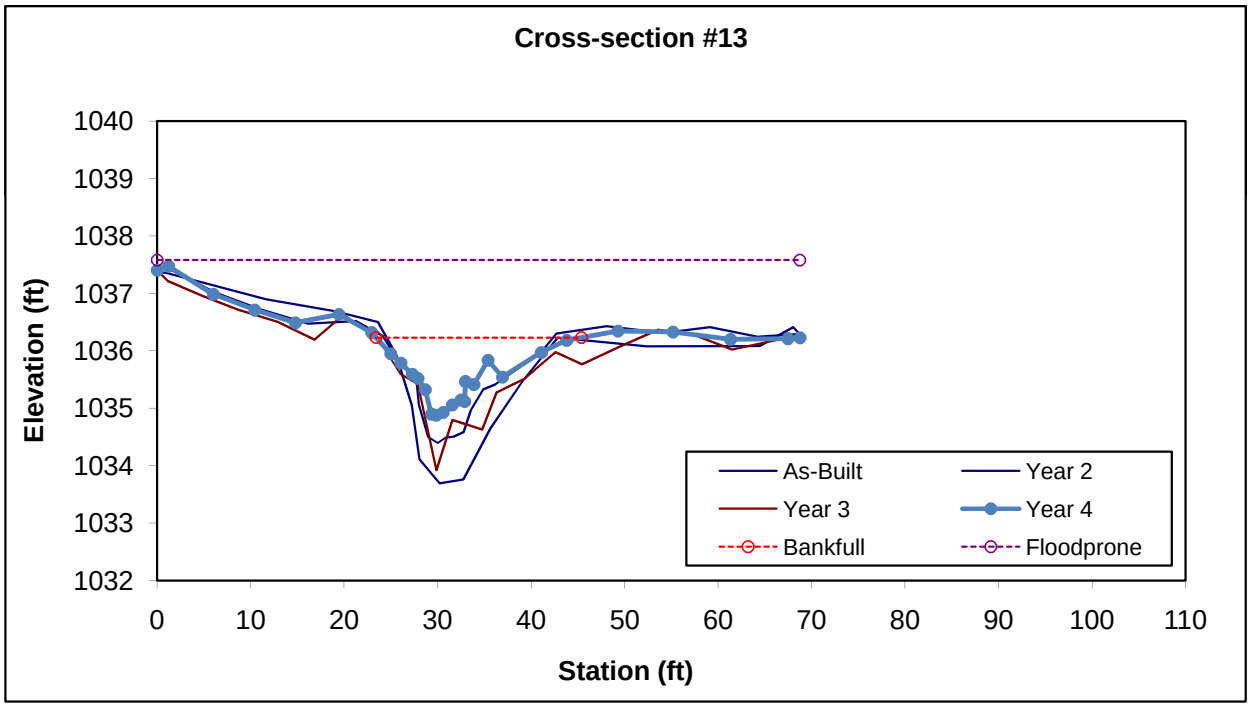
## Permanent Cross-section #13 UT1

(Year 4 Data - Collected September 2009)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 12.4 | 21.95 | 0.56 | 1.35 | 38.91 | 0.7 | 3.1 | 1036.23 | 1035.84 |



# APPENDIX C

# BASELINE STREAM SUMMARY FOR RESTORATION REACHES

**Baseline Stream Summary for Restoration Reaches**

| Bailey Fork Creek Mitigation Site: EEP Contract No. D04006-3 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reach UT1** | | | | | | | | | | | | | | | | | |
| **Parameter** | **USGS Gauge** | | **Regional Curve Interval** | | | **Pre-Existing Condition** | | | **Reference Reach(es) Data** | | | **Design** | | | **As-Built** | | |
| **Dimension - Riffle** | Jacob | Norwood | LL | UL | Eq. | Min | Mean | Max | Min | Mean | Max | Min | Med | Max | Min | Mean | Max |
| Bankfull Width (ft) | 61.3 | 32 | 6.7 | 25 | 10.9 | 9.2 | 10.0 | 10.9 | ----- | ----- | ----- | ----- | 14.9 | ----- | 15.7 | 17.7 | 19.8 |
| Floodprone Width (ft) | 96.3 | ----- | ----- | ----- | ----- | 12.9 | 35.9 | 58.9 | ----- | ----- | ----- | 130.0 | 185.0 | 240.0 | 80.0 | 105.4 | 130.7 |
| Bankfull Mean Depth (ft) | 4.7 | 3.1 | 0.9 | 2.4 | 1.4 | 1.2 | 1.6 | 2.0 | ----- | ----- | ----- | ----- | 1.2 | ----- | 0.9 | 1.3 | 1.7 |
| Bankfull Max Depth (ft) | 5.8 | ----- | ----- | ----- | ----- | 2.0 | 2.4 | 2.9 | ----- | ----- | ----- | ----- | 1.8 | ----- | 2.0 | 2.5 | 3.1 |
| Bankfull Cross-sectional Area (ft2) | 290 | 99 | 9 | 37 | 18.6 | 10.9 | 16.3 | 21.6 | ----- | ----- | ----- | ----- | 18.5 | ----- | 14.0 | 23.3 | 32.7 |
| Width/Depth Ratio | 13 | 10.3 | ----- | ----- | ----- | 5.5 | 6.6 | 7.8 | 5.1 | 7.1 | 9.1 | ----- | 12.0 | ----- | 17.0 | 17.4 | 17.7 |
| Entrenchment Ratio | 1.6 | ----- | ----- | ----- | ----- | 1.4 | 3.4 | 5.4 | ----- | 23.5 | ----- | 8.7 | 12.4 | 16.1 | 5.1 | 5.9 | 6.6 |
| Bank Height Ratio | 1.3 | ----- | ----- | ----- | ----- | 1.0 | 1.5 | 2.0 | ----- | 1.2 | ----- | ----- | 1.0 | ----- | 1.0 | 1.1 | 1.3 |
| Bankfull Velocity (fps) | 3.9 | 2.6 | ----- | ----- | ----- | ----- | 4.8 | ----- | ----- | 5.8 | ----- | ----- | 3.9 | ----- | ----- | 3.9 | ----- |
| **Pattern** | | | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 52 | 85.5 | 119 | 51 | 67 | 84 |
| Radius of Curvature (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 30 | 37.5 | 45 | 28 | 32 | 37 |
| Meander Wavelength (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 104 | 134 | 164 | 130 | 150 | 162 |
| Meander Width Ratio | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 2.42 | 5.46 | 8.5 | 3.5 | 5.75 | 8 | 2.9 | 3.8 | 4.7 |
| **Profile** | | | | | | | | | | | | | | | | | |
| Riffle Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 18 | 45 | 59 | 10 | 45 | 60 |
| Riffle Slope (ft/ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 0.016 | 0.0235 | 0.031 | 0.016 | 0.0235 | 0.031 |
| Pool Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 19 | 50.8 | 69.7 | 19 | 40 | 63 |
| Pool Spacing (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 52 | 67 | 82 | 65 | 75 | 80 |
| **Substrate and Transport Parameters** | | | | | | | | | | | | | | | | | |
| d16 / d35 / d50 / d84 / d95 | ----- | ----- | ----- | ----- | ----- | 0.25 / 0.46 / 0.86 / 9.05 / 14.98 | | | ----- | ----- | ----- | | N/A | | | Not Collected | |
| Reach Shear Stress (competency) lb/f2 | ----- | ----- | ----- | ----- | ----- | ----- | 0.98 | ----- | ----- | ----- | ----- | ----- | 0.66 | ----- | ----- | 0.64 | ----- |
| Stream Power (transport capacity) W/m2 | ----- | ----- | ----- | ----- | ----- | ----- | 93.5 | ----- | ----- | ----- | ----- | ----- | 43.7 | ----- | ----- | 39.6 | ----- |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | | | |
| Channel length (ft) | 850 | ----- | ----- | ----- | ----- | ----- | 1,638 | ----- | ----- | ----- | ----- | ----- | 1,920 | ----- | ----- | 1,948 | ----- |
| Drainage Area (SM) | 25.7 | 7.2 | ----- | ----- | ----- | ----- | 0.8 | ----- | 0.39 | 0.945 | 1.5 | ----- | 0.8 | ----- | ----- | 0.8 | ----- |
| Rosgen Classification | C4 | E | ----- | ----- | ----- | ----- | E5/G5 | ----- | E5 | ----- | E4/5 | ----- | C5 | ----- | ----- | C5 | ----- |
| Bankfull Discharge (cfs) | 1140 | 254 | 18 | 220 | 76.47 | ----- | 72 | ----- | ----- | 119 | ----- | ----- | 72 | ----- | ----- | 72 | ----- |
| Sinuosity | 1.06 | ----- | ----- | ----- | ----- | ----- | 1.1 | ----- | 1.24 | 1.52 | 1.8 | ----- | 1.3 | ----- | ----- | 1.4 | ----- |
| BF slope (ft/ft) | 0.0025 | 0.0008 | ----- | ----- | ----- | ----- | 0.013 | ----- | ----- | ----- | ----- | ----- | 0.010 | ----- | ----- | 0.010 | ----- |

| Reach UT2 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **USGS Gauge** | | **Regional Curve Interval** | | | **Pre-Existing Condition** | | | **Reference Reach(es) Data** | | | **Design** | | | **As-built** | | |
| **Dimension - Riffle** | Jacob | Norwood | LL | UL | Eq. | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max |
| Bankfull Width (ft) | 61.3 | 32.0 | 4.0 | 17.0 | 6.4 | ----- | 5.1 | ----- | ----- | ----- | ----- | ----- | 9.9 | ----- | ----- | 13.8 | ----- |
| Floodprone Width (ft) | 96.3 | ----- | ----- | ----- | ----- | ----- | 10.0 | ----- | ----- | ----- | ----- | 60.0 | 140.0 | 220.0 | ----- | 53.6 | ----- |
| Bankfull Mean Depth (ft) | 4.7 | 3.1 | 0.5 | 1.7 | 1.0 | ----- | 1.6 | ----- | ----- | ----- | ----- | ----- | 0.8 | ----- | ----- | 0.7 | ----- |
| Bankfull Max Depth (ft) | 5.8 | ----- | ----- | ----- | ----- | ----- | 1.9 | ----- | ----- | ----- | ----- | ----- | 1.2 | ----- | ----- | 1.4 | ----- |
| Bankfull Cross-sectional Area (ft2) | 290.0 | 99.0 | 3.8 | 17.0 | 8.2 | ----- | 8.0 | ----- | ----- | ----- | ----- | ----- | 8.2 | ----- | ----- | 9.7 | ----- |
| Width/Depth Ratio | 13.0 | 10.3 | ----- | ----- | ----- | ----- | 3.3 | ----- | 5.1 | 7.1 | 9.1 | ----- | 12.0 | ----- | ----- | 19.7 | ----- |
| Entrenchment Ratio | 1.6 | ----- | ----- | ----- | ----- | ----- | 2.0 | ----- | ----- | 23.5 | ----- | 6.1 | 14.2 | 22.2 | ----- | 3.9 | ----- |
| Bank Height Ratio | 1.3 | ----- | ----- | ----- | ----- | ----- | 2.5 | ----- | ----- | 1.2 | ----- | ----- | 1.0 | ----- | ----- | 1.0 | ----- |
| Bankfull Velocity (fps) | 3.9 | 2.6 | ----- | ----- | ----- | ----- | 2.2 | ----- | ----- | 5.8 | ----- | ----- | 2.2 | ----- | ----- | 1.9 | ----- |
| **Pattern** | | | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 35 | 57 | 79 | 54 | 64 | 72 |
| Radius of Curvature (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 20 | 25 | 30 | 19 | 21 | 24 |
| Meander Wavelength (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 69 | 89 | 109 | 83 | 99 | 111 |
| Meander Width Ratio | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 2.42 | 5.46 | 8.5 | 3.5 | 5.75 | 8 | 3.9 | 4.6 | 5.2 |
| **Profile** | | | | | | | | | | | | | | | | | |
| Riffle Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 22 | 27 | 36 | 22 | 27 | 32 |
| Riffle Slope (ft/ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 0.003 | 0.013 | 0.022 | 0.003 | 0.013 | 0.022 |
| Pool Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 21 | 44 | 58 | 21 | 47 | 64 |
| Pool Spacing (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 35 | 45 | 55 | 41.6 | 49.285 | 55.73 |
| **Substrate and Transport Parameters** | | | | | | | | | | | | | | | | | |
| d16 / d35 / d50 / d84 / d95 | ----- | ----- | ----- | ----- | ----- | 0.23 / 0.39 / 0.61 / 2.67 / 5.90 | | | ----- | ----- | ----- | | N/A | | | Not Collected | |
| Reach Shear Stress (competency) lb/f2 | ----- | ----- | ----- | ----- | ----- | ----- | 0.32 | ----- | ----- | ----- | ----- | ----- | 0.25 | ----- | ----- | 0.21 | ----- |
| Stream Power (transport capacity) W/m2 | ----- | ----- | ----- | ----- | ----- | ----- | 19.3 | ----- | ----- | ----- | ----- | ----- | 9.6 | ----- | ----- | 6.6 | ----- |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | | | |
| Channel length (ft) | 850 | ----- | ----- | ----- | ----- | ----- | 270 | ----- | ----- | ----- | ----- | ----- | 870 | ----- | ----- | 923 | ----- |
| Drainage Area (SM) | 25.7 | 7.2 | ----- | ----- | ----- | ----- | 0.24 | ----- | 0.39 | 0.945 | 1.5 | ----- | 0.24 | ----- | ----- | 0.24 | ----- |
| Rosgen Classification | C4 | E | ----- | ----- | ----- | ----- | E5 | ----- | E5 | | E4/5 | ----- | C5 | ----- | ----- | C5 | ----- |
| Bankfull Discharge (cfs) | 1140 | 254 | 10 | 100 | 32 | ----- | 18 | ----- | | 119 | | ----- | 18 | ----- | ----- | 18 | ----- |
| Sinuosity | 1.06 | ----- | ----- | ----- | ----- | ----- | 1.0 | ----- | 1.2 | 1.5 | 1.8 | ----- | 1.4 | ----- | ----- | 1.4 | ----- |
| BF slope (ft/ft) | 0.0025 | 0.0008 | ----- | ----- | ----- | ----- | 0.005 | ----- | ----- | ----- | ----- | ----- | 0.006 | ----- | ----- | 0.005 | ----- |

| Reach UT3 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **USGS Gauge** | | **Regional Curve Interval** | | | **Pre-Existing Condition** | | | **Reference Reach(es) Data** | | | **Design** | | | **As-built** | | |
| **Dimension - Riffle** | Jacob | Norwood | LL | UL | Eq. | Min | Mean | Max | Min | Mean | Max | Min | Med | Max | Min | Mean | Max |
| Bankfull Width (ft) | 61.3 | 32.0 | 6.8 | 26.0 | 11.5 | 9.2 | 10.0 | 10.8 | ----- | ----- | ----- | ----- | 16.7 | ----- | 13.3 | 24.4 | 26.8 |
| Floodprone Width (ft) | 96.3 | ----- | ----- | ----- | ----- | 40.0 | 60.0 | 80.0 | ----- | ----- | ----- | 80.0 | 280.0 | 480.0 | 72.3 | 96.9 | 129.7 |
| Bankfull Mean Depth (ft) | 4.7 | 3.1 | 0.9 | 2.5 | 1.5 | 1.9 | 2.1 | 2.2 | ----- | ----- | ----- | ----- | 1.2 | ----- | 1.0 | 1.2 | 1.4 |
| Bankfull Max Depth (ft) | 5.8 | ----- | ----- | ----- | ----- | 2.9 | 3.0 | 3.1 | ----- | ----- | ----- | ----- | 1.7 | ----- | 1.9 | 2.2 | 2.5 |
| Bankfull Cross-sectional Area (ft2) | 290.0 | 99.0 | 10.0 | 40.0 | 20.3 | 19.8 | 20.3 | 20.7 | ----- | ----- | ----- | ----- | 20.0 | ----- | 15.9 | 24.5 | 34.1 |
| Width/Depth Ratio | 13.0 | 10.3 | ----- | ----- | ----- | 4.3 | 5.0 | 5.6 | 5.1 | 7.1 | 9.1 | ----- | 14.0 | ----- | 11.1 | 17.2 | 26.6 |
| Entrenchment Ratio | 1.6 | ----- | ----- | ----- | ----- | 3.4 | 5.1 | 6.8 | ----- | 23.5 | ----- | 4.8 | 16.8 | 28.7 | 3.2 | 6.5 | 9.8 |
| Bank Height Ratio | 1.3 | ----- | ----- | ----- | ----- | 1.3 | 1.6 | 1.9 | ----- | 1.2 | ----- | ----- | 1.0 | ----- | ----- | 1.0 | ----- |
| Bankfull Velocity (fps) | 3.9 | 2.6 | ----- | ----- | ----- | 2.7 | 2.7 | 2.6 | ----- | 5.8 | ----- | ----- | 2.7 | ----- | 3.4 | 2.2 | 1.6 |
| **Pattern** | | | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 59 | 96.5 | 134 | 85 | 91 | 120 |
| Radius of Curvature (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 33 | 41.5 | 50 | 27 | 37 | 43 |
| Meander Wavelength (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 117 | 150.5 | 184 | 172 | 179 | 200 |
| Meander Width Ratio | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 2.42 | 5.46 | 8.5 | 3.5 | 5.75 | 8 | 3.5 | 3.7 | 4.9 |
| **Profile** | | | | | | | | | | | | | | | | | |
| Riffle Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 26 | 75 | 91 | 26 | 50 | 63 |
| Riffle Slope (ft/ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 0.004 | ----- | ----- | 0.004 | ----- |
| Pool Length (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 26 | 49 | 69 | 26 | 75 | 98 |
| Pool Spacing (ft) | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 59 | 75.5 | 92 | 86 | 90 | 100 |
| **Substrate and Transport Parameters** | | | | | | | | | | | | | | | | | |
| d16 / d35 / d50 / d84 / d95 | ----- | ----- | ----- | ----- | ----- | 0.24 / 0.34 / 0.44 / 1.38 / 3.40 | | | ----- | ----- | ----- | | N/A | | | Not Collected | |
| Reach Shear Stress (competency) lb/f2 | ----- | ----- | ----- | ----- | ----- | ----- | 0.4 | ----- | ----- | ----- | ----- | ----- | 0.3 | ----- | ----- | 0.3 | ----- |
| Stream Power (transport capacity) W/m2 | ----- | ----- | ----- | ----- | ----- | ----- | 25.0 | ----- | ----- | ----- | ----- | ----- | 14.7 | ----- | ----- | 9.5 | ----- |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | | | |
| Channel length (ft) | 850 | ----- | ----- | ----- | ----- | ----- | 2,513 | ----- | ----- | ----- | ----- | ----- | 3,227 | ----- | ----- | 3,226 | ----- |
| Drainage Area (SM) | 25.7 | 7.2 | ----- | ----- | ----- | ----- | 0.92 | ----- | 0.39 | 0.945 | 1.5 | ----- | 0.92 | ----- | ----- | 0.92 | ----- |
| Rosgen Classification | C4 | E | ----- | ----- | ----- | ----- | E5 | ----- | E5 | ----- | E4/5 | ----- | C5 | ----- | ----- | C5 | ----- |
| Bankfull Discharge (cfs) | 1140 | 254 | 29 | 250 | 83.83 | ----- | 54 | ----- | ----- | 119 | ----- | ----- | 54 | ----- | ----- | 54 | ----- |
| Sinuosity | 1.06 | ----- | ----- | ----- | ----- | ----- | 1.1 | ----- | 1.24 | 1.52 | 1.8 | ----- | 1.4 | ----- | ----- | 1.4 | ----- |
| BF slope (ft/ft) | 0.0025 | 0.0008 | ----- | ----- | ----- | ----- | 0.002 | ----- | ----- | ----- | ----- | ----- | 0.004 | ----- | ----- | 0.004 | ----- |

# APPENDIX D

# MORPHOLOGY AND HYDRAULIC MONITORING SUMMARY

**Morphology and Hydraulic Monitoring Summary - Year 4 Monitoring**

**Bailey Fork Restoration Site: EEP Contract No. D04006-3**

**Reach: UT1**

| I. Cross-Section Parameters | Cross-section 8 Pool | | | | | Cross-section 9 Riffle | | | | | Cross-section 12 Riffle | | | | | Cross-section 13 Pool | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 |
| **Dimension** | | | | | | | | | | | | | | | | | | | | |
| BF Width (ft) | 16.29 | 17.55 | 18.35 | 14.55 | | 22.25 | 20.2 | 19.9 | 23.83 | | 15.25 | 13.9 | 13.99 | 13.25 | | 20.19 | 18.07 | 28.18 | 21.95 | |
| Floodprone Width (ft) | - | - | - | 54.65 | | - | - | - | - | | - | - | - | - | | - | - | - | - | |
| BF Cross-sectional Area (ft2 ) | 22.4 | 25.7 | 25.9 | 19.93 | | 32 | 29.5 | 29.9 | 31.32 | | 12.0 | 8.5 | 9.5 | 7.6 | | 21.3 | 16.2 | 21.8 | 12.38 | |
| BF Mean Depth (ft) | 1.37 | 1.47 | 1.41 | 1.37 | | 1.44 | 1.46 | 1.5 | 1.31 | | 0.79 | 0.61 | 1.5 | 0.57 | | 1.06 | 0.9 | 0.77 | .056 | |
| BF Max Depth (ft) | 2.99 | 2.94 | 3.36 | 2.56 | | 2.96 | 2.87 | 2.89 | 2.95 | | 1.79 | 1.24 | 20.67 | 1.1 | | 2.56 | 1.84 | 2.31 | 1.35 | |
| Width/Depth Ratio | 11.87 | 11.97 | 13.01 | 10.62 | | 15.48 | 13.83 | 13.25 | 18.12 | | 19.32 | 22.81 | 20.67 | 23.08 | | 19.1 | 20.15 | 36.39 | 38.91 | |
| Entrenchment Ratio | 3.6 | 3.3 | 3.2 | 3.76 | | 2.2 | 2.4 | 2.5 | 1.81 | | 5.2 | 5.7 | 5.7 | 6 | | 3.4 | 3.8 | 2.4 | 0.71 | |
| Wetted Perimeter (ft) | - | - | - | - | | - | - | - | - | | - | - | - | - | | - | - | - | - | |
| Hydraulic Radius (ft) | - | - | - | - | | - | - | - | - | | - | - | - | - | | - | - | - | - | |
| **Substrate** | | | | | | | | | | | | | | | | | | | | |
| d50 (mm) | | | | | | | | | | | | | | | | | | | | |
| d84 (mm) | | | | | | | | | | | | | | | | | | | | |

| II. Reachwide Parameters | MY-1 (2006) | | | MY-2 (2007) | | | MY-3 (2008) | | | MY-4 (2009) | | | MY-5 (2010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med |
| **Pattern** | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | | | - | 52 | 85 | - | | | - | | | | | | |
| Radius of Curvature (ft) | | | - | 33 | 41 | - | | | - | | | | | | |
| Meander Wavelength (ft) | | | - | 130 | 136 | - | | | - | | | | | | |
| Meander Width Ratio | | | - | 7.40 | 9.78 | - | | | - | | | | | | |
| **Profile** | | | | | | | | | | | | | | | |
| Riffle Length (ft) | | | - | | | - | | | - | | | | | | |
| Riffle Slope (ft/ft) | | | - | | | - | | | - | | | | | | |
| Pool Length (ft) | | | - | | | - | | | - | | | | | | |
| Pool Spacing (ft) | | | - | | | - | | | - | | | | | | |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | |
| Valley Length (ft) | | | - | | | | | | | | | | | | |
| Channel Length (ft) | | | 1,948 | | | 1,948 | | | 1,948 | | | | | | |
| Sinuosity | | | 1.4 | | | 1.4 | | | 1.38 | | | | | | |
| Water Surface Slope (ft/ft) | | | - | | | - | | | 0.0108 | | | | | | |
| BF Slope (ft/ft) | | | 0.0142 | | | 0.0142 | | | 0.0149 | | | | | | |
| Rosgen Classification | | | C5 | | | C5 | | | C5 | | | | | | |

| Reach: UT2 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **I. Cross-Section Parameters** | Cross-section 10 Pool | | | | | Cross-section 11 Riffle | | | | | | | | | | |
| | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | | | | | | |
| **Dimension** | | | | | | | | | | | | | | | | |
| BF Width (ft) | 29.75 | 28.26 | 28.35 | 28.35 | | 12.41 | 11.69 | 16.13 | 16.21 | | | | | | | |
| Floodprone Width (ft) | - | - | - | | | - | - | - | - | | | | | | | |
| BF Cross-sectional Area (ft2 ) | 26.2 | 21.3 | 24.7 | 24.74 | | 9.6 | 9.0 | 11.9 | 11.98 | | | | | | | |
| BF Mean Depth (ft) | 0.88 | 0.75 | 0.87 | 0.87 | | 0.78 | 0.77 | 0.74 | 0.74 | | | | | | | |
| BF Max Depth (ft) | 2.01 | 1.74 | 2.26 | 2.26 | | 1.42 | 1.4 | 1.78 | 1.8 | | | | | | | |
| Width/Depth Ratio | 33.81 | 37.57 | 32.5 | 32.5 | | 15.98 | 15.13 | 21.79 | 21.92 | | | | | | | |
| Entrenchment Ratio | 2.1 | 2.2 | 2 | 1.99 | | 4.3 | 4.6 | 3 | 2.95 | | | | | | | |
| Wetted Perimeter (ft) | - | - | - | | | - | - | - | - | | | | | | | |
| Hydraulic Radius (ft) | - | - | - | | | - | - | - | - | | | | | | | |
| **Substrate** | | | | | | | | | | | | | | | | |
| d50 (mm) | | | | | | | | | | | | | | | | |
| d84 (mm) | | | | | | | | | | | | | | | | |

| **II. Reachwide Parameters** | MY-1 (2006) | | | MY-2 (2007) | | | MY-3 (2008) | | | MY-4 (2009) | | | MY-5 (2010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med |
| **Pattern** | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | | | - | 50 | 55 | - | | | - | | | | | | |
| Radius of Curvature (ft) | | | - | 22 | 26 | - | | | - | | | | | | |
| Meander Wavelength (ft) | | | - | 90 | 100 | - | | | - | | | | | | |
| Meander Width Ratio | | | - | 7.69 | 8.55 | - | | | - | | | | | | |
| **Profile** | | | | | | | | | | | | | | | |
| Riffle length (ft) | | | - | | | - | | | - | | | | | | |
| Riffle Slope (ft/ft) | | | - | | | - | | | - | | | | | | |
| Pool Length (ft) | | | - | | | - | | | - | | | | | | |
| Pool Spacing (ft) | | | - | | | - | | | - | | | | | | |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | |
| Valley Length (ft) | | | - | | | - | | | - | | | | | | |
| Channel Length (ft) | | | 923 | | | 923 | | | 923 | | | | | | |
| Sinuosity | | | 1.4 | | | 1.4 | | | 1.46 | | | | | | |
| Water Surface Slope (ft/ft) | | | - | | | - | | | .0082 | | | | | | |
| BF Slope (ft/ft) | | | 0.005 | | | 0.005 | | | 0.005 | | | | | | |
| Rosgen Classification | | | C5 | | | C5 | | | C5 | | | | | | |

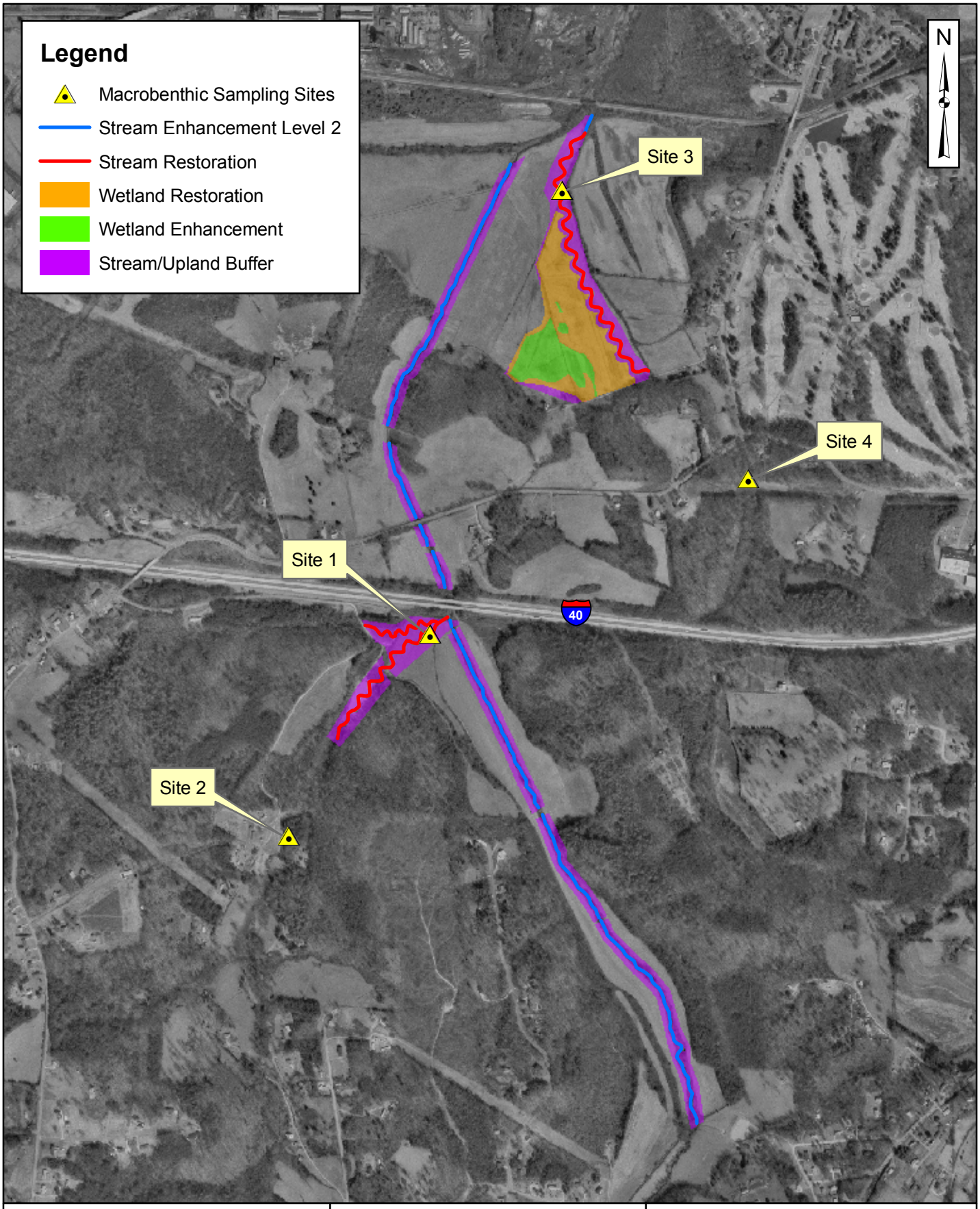
| Reach: UT3 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **I. Cross-Section Parameters** | Cross-section 1 Riffle | | | | | Cross-section 2 Pool | | | | | Cross-section 3 Riffle | | | | | Cross-section 4 Pool | | | | |
| | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 |
| **Dimension** | | | | | | | | | | | | | | | | | | | | |
| BF Width (ft) | 22.4 | 22.89 | 30.72 | 29.85 | | 26.14 | 25.27 | 27.5 | 27.94 | | 22.48 | 23.88 | 23.99 | 28.18 | | 22.62 | 22.84 | 25.46 | 24.89 | |
| Floodprone Width (ft) | 4.58 | - | - | - | | 5.16 | - | - | | | - | - | - | | | - | - | - | | |
| BF Cross-sectional Area (ft2 ) | 29.40 | 29.3 | 33.3 | 30.05 | | 27.7 | 16.5 | 21.9 | 20.58 | | 45.1 | 40.1 | 40.6 | 42.15 | | 30 | 28.5 | 33.8 | 34.73 | |
| BF Mean Depth (ft) | 1.31 | 1.28 | 1.08 | 1.01 | | 1.06 | 0.65 | 0.79 | 0.74 | | 2.01 | 1.68 | 1.69 | 1.5 | | 1.32 | 1.25 | 1.33 | 1.4 | |
| BF Max Depth (ft) | 2.29 | 2.3 | 2.42 | 2.36 | | 2.58 | 1.75 | 2.13 | 1.99 | | 3.54 | 3.66 | 3.52 | 3.58 | | 2.54 | 2.57 | 2.84 | 2.99 | |
| Width/Depth Ratio | 17.1 | 17.2 | 28.37 | 29.66 | | 24.65 | 38.62 | 35.14 | 37.92 | | 11.21 | 14.24 | 14.16 | 18.84 | | 17.08 | 18.27 | 19.16 | 17.83 | |
| Entrenchment Ratio | >4.5 | >4.4 | 3.3 | 3.4 | | >3.6 | >3.7 | 3.4 | 3.33 | | >3.2 | >3.0 | 3 | 2.56 | | 3.9 | 3.9 | 3.5 | 3.59 | |
| Wetted Perimeter (ft) | - | - | - | - | | - | - | - | | | - | - | - | - | | - | - | - | - | |
| Hydraulic Radius (ft) | - | - | - | - | | - | - | - | | | - | - | - | - | | - | - | - | - | |
| **Substrate** | | | | | | | | | | | | | | | | | | | | |
| d50 (mm) | | | | | | | | | | | | | | | | | | | | |
| d84 (mm) | | | | | | | | | | | | | | | | | | | | |

| **II. Reachwide Parameters** | MY-1 (2006) | | | MY-2 (2007) | | | MY-3 (2008) | | | MY-4 (2009) | | | MY-5 (2010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med | Min | Max | Med |
| **Pattern** | | | | | | | | | | | | | | | |
| Channel Beltwidth (ft) | | | - | 70 | 90 | - | | | - | | | | | | |
| Radius of Curvature (ft) | | | - | 28 | 45 | - | | | - | | | | | | |
| Meander Wavelength (ft) | | | - | 160 | 180 | - | | | - | | | | | | |
| Meander Width Ratio | | | - | 6.70 | 16 | - | | | - | | | | | | |
| **Profile** | | | | | | | | | | | | | | | |
| Riffle length (ft) | | | - | | | - | | | - | | | | | | |
| Riffle Slope (ft/ft) | | | - | | | - | | | - | | | | | | |
| Pool Length (ft) | | | - | | | - | | | - | | | | | | |
| Pool Spacing (ft) | | | - | | | - | | | - | | | | | | |
| **Additional Reach Parameters** | | | | | | | | | | | | | | | |
| Valley Length (ft) | | | - | | | - | | | | | | | | | |
| Channel Length (ft) | | | 3226 | | | 3226 | | | 3226 | | | 3226 | | | |
| Sinuosity | | | 1.4 | | | 1.4 | | | 1.51 | | | 1.51 | | | |
| Water Surface Slope (ft/ft) | | | - | | | - | | | .0035 | | | .0035 | | | |
| BF Slope (ft/ft) | | | 0.0049 | | | 0.0049 | | | .0053 | | | .0053 | | | |
| Rosgen Classification | | | C5 | | | C5 | | | C5 | | | C5 | | | |

| Reach: UT3 Continued | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **I. Cross-Section Parameters** | Cross-section 5 Riffle | | | | | Cross-section 6 Pool | | | | | Cross-section 7 Riffle | | | | | |
| | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | MY1 | MY2 | MY3 | MY4 | MY5 | |
| **Dimension** | | | | | | | | | | | | | | | | |
| BF Width (ft) | 33.77 | 17.59 | 23.63 | 20.47 | | 23.85 | 20.57 | 24.56 | 23.29 | | 13.09 | 11.25 | 13.9 | 15.3 | | |
| Floodprone Width (ft) | 4.34 | - | - | - | | 5.66 | - | - | - | | 3.48 | - | - | - | | |
| BF Cross-sectional Area (ft2 ) | 24.6 | 19 | 22.4 | 20.63 | | 26.6 | 22.3 | 29.8 | 25.51 | | 14.3 | 13.0 | 16.8 | 16.78 | | |
| BF Mean Depth (ft) | 0.73 | 1.08 | 0.95 | 1.01 | | 1.12 | 1.09 | 1.21 | 1.1 | | 1.09 | 1.16 | 1.21 | 1.1 | | |
| BF Max Depth (ft) | 2.17 | 2.07 | 2.39 | 2.08 | | 2.83 | 2.24 | 3.25 | 2.73 | | 1.74 | 1.73 | 2.05 | 2.07 | | |
| Width/Depth Ratio | 46.36 | 16.28 | 24.96 | 20.32 | | 21.36 | 18.95 | 20.27 | 21.27 | | 12 | 9.72 | 11.49 | 13.95 | | |
| Entrenchment Ratio | 2.5 | 4.8 | 3.6 | 4.11 | | 2.9 | 3.2 | 2.8 | 2.95 | | 9.7 | 11 | 9.5 | 8.71 | | |
| Wetted Perimeter (ft) | - | - | - | - | | - | - | - | - | | - | - | - | - | | |
| Hydraulic Radius (ft) | - | - | - | - | | - | - | - | - | | - | - | - | - | | |
| **Substrate** | | | | | | | | | | | | | | | | |
| d50 (mm) | | | | | | | | | | | | | | | | |
| d84 (mm) | | | | | | | | | | | | | | | | |

# APPENDIX E

# BENTHIC MACROINVERTEBRATE MONITORING DATA




Environmental Banc and Exchange, LLC
2530 Meridian Parkway, Suite 200
Durham, NC 27713

0 500 1,000 2,000 Feet

Figure 4.
Benthic Macroinvertebrate Sampling Sites
Bailey Fork Site

**Table 12**
**Summary of Pre-Restoration vs. Post-Restoration Benthic Macroinvertebrate Sampling Data**

| | Site 1 | | | | Site 2 | | | | Site 3 | | | | Site 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | UT1 to Bailey Fork (Restoration) | | | | UT1 to Bailey Fork (Reference) | | | | UT3 to Silver Creek (Restoration) | | | | UT3 to Silver Creek (Reference) | | | |
| | Pre | Year 1 | Year 2 | Year 3 | Pre | Year 1 | Year 2 | Year 3 | Pre | Year 1 | Year 2 | Year 3 | Pre | Year 1 | Year 2 | Year 3 |
| | 1/3/2005 | 1/10/2007 | 1/8/2008 | 1/27/2009 | 1/4/2005 | 1/17/2007 | 1/8/2008 | 3/19/2009 | 1/3/2005 | 1/9/2007 | 1/23/2008 | 3/16/2009 | 1/5/2005 | 1/10/2007 | 1/23/2008 | 3/19/2009 |
| Total Taxa Richness | 30 | 35 | 33 | 34 | 26 | 34 | 20 | 43 | 10 | 26 | 19 | 35 | 20 | 14 | 9 | 31 |
| EPT Taxa Richness | 14 | 15 | 18 | 14 | 16 | 20 | 13 | 9 | 1 | 4 | 2 | 9 | 9 | 5 | 3 | 10 |
| Total Biotic Index | 4.27 | 6.33 | 5.1 | 5.28 | 4.09 | 4.3 | 5.04 | 4.83 | 7.8 | 7.87 | 7.96 | 7.02 | 4.18 | 5.75 | 4.53 | 4.39 |
| EPT Biotic Index | 3.71 | 4.95 | 4.63 | 4.49 | 3.41 | 3.65 | 4.98 | 2.57 | 6.2 | 6.55 | 6.15 | 6.65 | 2.74 | 2.81 | 3.3 | 2.8 |
| Dominance in Common (%) | n/a | 40 | 86 | 19 | n/a | n/a | n/a | n/a | n/a | 50 | 0 | 17 | n/a | n/a | n/a | n/a |
| Total Shredder/Scraper Index | 6/4 | 4/3 | 3/5 | 3/5 | 7/3 | 5/3 | 2/5 | 5/6 | 0/1 | 6/3 | 1/1 | 3/1 | 3/2 | 2/2 | 2/0 | 3/5 |
| EPT Shredder/Scraper Index | 3/3 | 1/2 | 2/4 | 2/4 | 4/2 | 2/2 | 1/3 | 1/3 | 0/0 | 0/1 | 0/0 | 0/1 | 1/2 | 0/1 | 0/0 | 1/3 |
| Habitat Assessment Rating | 51 | 82 | 73 | 81 | 65 | 70 | 72 | 75 | 37 | 74 | 67 | 83 | 53 | 51 | 63 | 69 |
| Water Temperature (˚C) | n/a | 8 | 10.3 | 5.9 | n/a | 8.4 | 7.9 | 14.6 | n/a | 6.7 | 6.6 | 10.4 | n/a | 6.6 | 7.9 | 10.6 |
| % Dissolved Oxygen (DO) | n/a | 42.7 | n/a | n/a | n/a | 32.1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 51.7 | n/a | n/a |
| DO Concentration (mg/l) | n/a | 5.05 | n/a | n/a | n/a | 3.76 | 11.35 | n/a | n/a | 4.7 | 13.59 | n/a | n/a | 6.35 | 10.79 | n/a |
| pH | n/a | 6.04 | 7.8 | 7.35 | n/a | 5.97 | 7.8 | 6.93 | n/a | 5.93 | 7.4 | 7.06 | n/a | 5.95 | 7.02 | 7.12 |
| Conductivity (µmhos/cm) | n/a | 40 | 50 | 50 | n/a | 50 | 80 | 40 | n/a | 60 | 80 | 60 | n/a | 70 | 80 | 60 |

| SPECIES | Tolerance Values | Functional Feeding Group | Site 1 UT1 to Bailey Fork | Site 2 UT1 to Bailey Fork Reference | Site 3 UT3 to Silver Creek | Site 4 UT3 to Silver Creek Reference |
|---|---|---|---|---|---|---|
| | | | 1/27/2009 | 3/19/2009 | 3/16/2009 | 3/19/2009 |
| **PLATYHELMINTHES** | | | | | | |
| **Turbellaria** | | | | R | | |
| **MOLLUSCA** | | | | | | |
| **Gastropoda** | | | | | | |
| **Mesogastropoda** | | | | | | |
| Pleuroceridae | | | | | | |
| *Elimia sp.* | **2.5** | **SC** | C | A | | A |
| **Basommatophora** | | | | | | |
| Physidae | | | | | | |
| *Physella sp.* | **8.8** | **CG** | R | | A | |
| **ANNELIDA** | | | | | | |
| **Oligochaeta** | | | | | | |
| **Tubificida** | | | | | | |
| Enchytraeidae | **9.8** | **CG** | | | | |
| Lumbricidae | | | | | | R |
| Naididae | **8** | **CG** | | C | R | |
| *Nais sp.* | **8.9** | **CG** | | A | | |
| *Nais behningi* | **8.9** | **CG** | R | R | | |
| *Slavina appendiculata* | **7.1** | **CG** | | R | | |
| Tubificidae w.h.c. | **7.1** | **CG** | R | R | R | |
| Tubificidae w.o.h.c. | **7.1** | **CG** | | | R | |
| *Limnodrilus hoffmeisteri* | **9.5** | **CG** | | | R | |
| **Lumbriculida** | | | | | | |
| Lumbriculidae | **7** | **CG** | | R | | |
| **ARTHROPODA** | | | | | | |
| **Crustacea** | | | | | | |
| **Cyclopoida** | | | | | C | |
| **Isopoda** | | | | | | |
| Asellidae | | **SH** | | | | |
| *Caecidotea sp.* | **9.1** | **CG** | C | | | |
| **Insecta** | | | | | | |
| **Collembola** | | | | | R | |
| **Ephemeroptera** | | | | | | |
| Ameletidae | | | | | | |
| *Ameletus sp.* | | | | | A | |
| Baetidae | | | | | | |
| *Centroptilum sp.* | **6.6** | **CG** | C | | A | |
| Caenidae | | **CG** | | | | |
| *Caenis sp.* | **7.4** | **CG** | | | R | |
| Ephemerellidae | | | | | | |
| *Ephemerella sp.* | **2** | **SC** | A | A | | R |
| *Eurylophella sp.* | **4.3** | **SC** | | C | | R |
| Ephemeridae | | **CG** | | | | |
| *Ephemera sp.* | **2** | **CG** | R | R | | |
| *Hexagenia sp.* | **4.9** | **CG** | | | | R |
| Heptageniidae | | | | | | |
| *Maccaffertium (Stenonema) sp.* | **4** | **SC** | A | | R | R |
| *Stenacron sp.* | **4** | **SC** | R | | | |

| SPECIES | Tolerance Values | Functional Feeding Group | Site 1 UT1 to Bailey Fork | Site 2 UT1 to Bailey Fork Reference | Site 3 UT3 to Silver Creek | Site 4 UT3 to Silver Creek Reference |
|---|---|---|---|---|---|---|
| | | | 1/27/2009 | 3/19/2009 | 3/16/2009 | 3/19/2009 |
| Leptophlebiidae | | **CG** | | | | |
| *Leptophlebia sp.* | **6.2** | **CG** | R | R | R | |
| **Odonata** | | | | | | |
| Aeshnidae | | **P** | | | | |
| *Boyeria vinosa* | **5.9** | **P** | | R | R | |
| Calopterygidae | | **P** | | | | |
| *Calopteryx maculata* | **7.8** | **P** | | C | | |
| *Calopteryx sp.* | **7.8** | **P** | | | | R |
| Coenagrionidae | | **P** | | | R | |
| *Argia sp.* | **8.2** | **P** | | | R | |
| *Ischnura sp.* | **9.5** | | | | R | |
| Cordulegastridae | | **P** | | | | |
| *Cordulegaster sp.* | **5.7** | **P** | | C | | R |
| Gomphidae | | | | | | |
| *Gomphus sp.* | **5.8** | **P** | | R | | |
| *Lanthus sp.* | **1.8** | **P** | | | | R |
| *Ophiogomphus sp.* | **5.5** | **P** | | R | | |
| *Stylogomphus albistylus* | **4.7** | **P** | | R | | R |
| **Plecoptera** | | | | | | |
| Nemouridae | | | | | | |
| *Prostoia sp.* | **5.8** | | C | | | |
| Perlidae | | | | | | R |
| *Eccoptura xanthenes* | **3.7** | **P** | | C | | R |
| Perlodidae | | | | | | |
| *Isoperla sp.* | **2** | **P** | | | R | C |
| **Hemiptera** | | | | | | |
| Veliidae | | **P** | | | | |
| *Microvelia sp.* | | **P** | | R | | |
| **Megaloptera** | | | | | | |
| Corydalidae | | | | | | |
| *Nigronia fasciatus* | **5.6** | **P** | | | | R |
| **Trichoptera** | | | | | | |
| Calamoceratidae | | **SH** | | | | |
| *Heteroplectron americanum* | **3.2** | **-** | | | | |
| Hydropsychidae | | | R | | | |
| *Cheumatopsyche sp.* | **6.2** | **FC** | A | | R | |
| *Diplectrona modesta* | **2.2** | **FC** | | A | | C |
| *Hydropsyche betteni gp.* | **7.8** | **FC** | C | | A | |
| *Hydropsyche sp.* | **5** | **FC** | R | | | |
| Lepidostomatidae | | **SH** | | | | |
| *Lepidostoma sp.* | **0.9** | **FC** | | R | | |
| Limnephilidae | | | | | | |
| *Ironoquia sp.* | **3** | | | | R | R |
| *Pycnopsyche sp.* | **2.5** | **SH** | R | C | | C |
| Phryganeidae | | **SH** | | | | |
| *Ptilostomis sp.* | **6.4** | **SH** | R | | | |
| Uenoidae | | | | | | |
| *Neophylax sp.* | **2.2** | **SC** | C | R | | |

| SPECIES | Tolerance Values | Functional Feeding Group | Site 1 UT1 to Bailey Fork | Site 2 UT1 to Bailey Fork Reference | Site 3 UT3 to Silver Creek | Site 4 UT3 to Silver Creek Reference |
|---|---|---|---|---|---|---|
| | | | 1/27/2009 | 3/19/2009 | 3/16/2009 | 3/19/2009 |
| **Coleoptera** | | | | | | |
| Curculionidae | | | | | R | |
| Dryopidae | | | | | | |
| *Helichus sp.* | **4.6** | **SC** | | R | | |
| Dytiscidae | | | | | | |
| *Neoporus sp.* | **8.6** | | R | | | |
| Elmidae | | | | | | |
| *Oulimnius latiusculus* | **1.8** | **CG** | | C | | |
| *Stenelmis sp.* | **5.1** | **SC** | | R | | C |
| Haliplidae | | | | | | |
| *Peltodytes sp.* | **8.7** | **SH** | | | R | |
| Hydrophilidae | | **P** | | | | |
| *Hydrochus sp.* | **6.6** | **SH** | | | R | |
| Ptilodactylidae | | **SH** | | | | |
| *Anchytarsus bicolor* | **3.6** | **SH** | | A | | R |
| **Diptera** | | | | | | |
| Ceratopogonidae | | **P** | R | R | | |
| Chironomidae | | | | | | |
| *Ablabesmyia mallochi* | **7.2** | **P** | R | | | |
| *Brillia flavifrons* | **5.2** | **SH** | R | | R | |
| *Cardiocladius obscurus* | **5.9** | **P** | | | R | |
| *Conchapelopia sp.* | **8.4** | **P** | | R | A | R |
| *Corynoneura sp.* | **6** | **CG** | R | R | | |
| *Cricotopus sp.* | **7** | **CG** | R | R | R | |
| *Dicrotendipes neomodestus* | **8.1** | **CG** | R | | C | |
| *Diplocladius cultriger* | **7.4** | **CG** | C | | | |
| *Nanocladius distinctus* | **7.1** | **CG** | | | R | |
| *Orthocladius sp.* | **6** | **CG** | A | | A | |
| *Paralauterborniella nigrohalteralis* | **4.8** | **CG** | | | | R |
| *Parametriocnemus sp.* | **3.7** | **CG** | R | R | C | C |
| *Polypedilum fallax* | **6.4** | **SH** | | R | | |
| *Polypedilum illinoense* | **9** | **SH** | | C | | |
| *Procladius sp.* | **9.1** | **P** | | | R | |
| *Pseudorthocladius sp.* | **1.5** | **CG** | | R | | |
| *Rheocricotopus robacki* | **7.3** | **CG** | R | | | |
| *Rheotanytartsus exiguus gp.* | **5.9** | | R | | | |
| Tanypodinae | | | | | | R |
| *Tanytarsus sp.* | **6.8** | **FC** | | | | C |
| *Tvetenia paucunca* | **3.7** | **CG** | R | | R | |
| Dixidae | | **CG** | | | | |
| *Dixa sp.* | **2.6** | **CG** | | C | | C |
| *Dixella sp.* | | | | | | C |
| Simuliidae | | | | | | |
| *Simulium sp.* | **6** | **FC** | C | R | | R |
| *Prosimulium sp.* | **6** | **FC** | R | | | |
| Tabanidae | | **PI** | | | | |
| *Chrysops sp.* | **6.7** | **PI** | | R | R | |
| Tipulidae | | | | | | |

| SPECIES | Tolerance Values | Functional Feeding Group | Site 1 UT1 to Bailey Fork | Site 2 UT1 to Bailey Fork Reference | Site 3 UT3 to Silver Creek | Site 4 UT3 to Silver Creek Reference |
|---|---|---|---|---|---|---|
| | | | 1/27/2009 | 3/19/2009 | 3/16/2009 | 3/19/2009 |
| *Antocha sp.* | **4.3** | **CG** | | | C | |
| *Dicranota sp.* | **0** | **P** | | | | C |
| *Hexatoma sp.* | **4.3** | **P** | | R | | C |
| *Pseudolimnophila sp.* | **7.2** | **P** | | C | | R |
| *Ptychoptera sp.* | | | | R | | |
| *Tipula sp.* | **7.3** | **SH** | | A | | A |

3/06 Revision 6

**Habitat Assessment Field Data Sheet**
**Mountain/ Piedmont Streams**

**Biological Assessment Unit, DWQ** TOTAL SCORE 81

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

**Stream** Bailey Fork Location/road: Site 1 (Road Name _____) County Burke

**Date** 1-27-09 CC# _____ Basin Catawba Subbasin 11-34-8-3

Observer(s) JJE CDM Type of Study: ☐ Fish ☒ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☐ MT ☒ P ☐ Slate Belt ☐ Triassic Basin

**Water Quality:** Temperature 5.9 °C DO 95.4 % sat Conductivity (corr.) 50 µS/cm pH 7.35

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.**

Visible Land Use: 15 %Forest _____ %Residential _____ %Active Pasture _____ % Active Crops
80 %Fallow Fields _____ % Commercial _____ %Industrial 5 %Other - Describe: Intermittent

Watershed land use : ☐Forest ☐Agriculture ☐Urban ☐ Animal operations upstream

**Width:** (meters) Stream 3-5' Channel (at top of bank) 6-10' **Stream Depth:** (meters) Avg 0.5 Max 1.5-2
☐ Width variable ☐ Large river >25m wide

**Bank Height** (from deepest part of riffle to top of bank-first flat surface you stand on): (meters) 1.5

**Bank Angle:** 30-80 ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

☐ Channelized Ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N, ☒Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
**Flow conditions** : ☐High ☒Normal ☐Low
**Turbidity**: ☒Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes);
**Good potential for Wetlands Restoration Project?? ☐ YES ☒NO Details** Already restored

**Channel Flow Status**

Useful especially under abnormal or low flow conditions.

| | |
|---|---|
| A. Water reaches base of both lower banks, minimal channel substrate exposed | ☒ |
| B. Water fills >75% of available channel, or <25% of channel substrate is exposed | ☐ |
| C. Water fills 25-75% of available channel, many logs/snags exposed | ☐ |
| D. Root mats out of water | ☐ |
| E. Very little water in channel, mostly present as standing pools | ☐ |

**Weather Conditions:** Light Rain, 37° **Photos:** ☐N ☒Y ☒Digital ☐35mm

**Remarks:** Restoration site south of Interstate 40

**I. Channel Modification**

| | Score |
|---|---|
| A. channel natural, frequent bends | (5) |
| B. channel natural, infrequent bends (channelization could be old) | 4 |
| C. some channelization present | 3 |
| D. more extensive channelization, >40% of stream disrupted | 2 |
| E. no bends, completely channelized or rip rapped or gabioned, etc | 0 |

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☒Banks of uniform shape/height

Remarks_____ Subtotal 5

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

A Rocks __ Macrophytes R Sticks and leafpacks R-C Snags and logs A Undercut banks or root mats

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

| | >70% Score | 40-70% Score | 20-40% Score | <20% Score |
|---|---|---|---|---|
| 4 or 5 types present | 20 | 16 | 12 | 8 |
| 3 types present | 19 | (15) | 11 | 7 |
| 2 types present | 18 | 14 | 10 | 6 |
| 1 type present | 17 | 13 | 9 | 5 |
| No types present | 0 | | | |

☐ No woody vegetation in riparian zone Remarks_____ Subtotal 15

**III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder)** Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

| | Score |
|---|---|
| **A. substrate with good mix of gravel, cobble and boulders** | |
| 1. embeddedness <20% (very little sand, usually only behind large boulders) | 15 |
| 2. embeddedness 20-40% | 12 |
| 3. embeddedness 40-80% | 8 |
| 4. embeddedness >80% | 3 |
| **B. substrate gravel and cobble** | |
| 1. embeddedness <20% | 14 |
| 2. embeddedness 20-40% | (11) |
| 3. embeddedness 40-80% | 6 |
| 4. embeddedness >80% | 2 |
| **C. substrate mostly gravel** | |
| 1. embeddedness <50% | 8 |
| 2. embeddedness >50% | 4 |
| **D. substrate homogeneous** | |
| 1. substrate nearly all bedrock | 3 |
| 2. substrate nearly all sand | 3 |
| 3. substrate nearly all detritus | 2 |
| 4. substrate nearly all silt/ clay | 1 |

Remarks_____ Subtotal 11

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

| | Score |
|---|---|
| **A. Pools present** | |
| 1. Pools Frequent (>30% of 200m area surveyed) | |
| a. variety of pool sizes | 10 |
| b. pools about the same size (indicates pools filling in) | (8) |
| 2. Pools Infrequent (<30% of the 200m area surveyed) | |
| a. variety of pool sizes | 6 |
| b. pools about the same size | 4 |
| **B. Pools absent** | 0 |

Subtotal 8

☐ Pool bottom boulder-cobble=hard ☒ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks Pools are fairly same size due to fact that they are man-made

Page Total 39

**V. Riffle Habitats**

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

| | Riffles **Frequent** Score | Riffles **Infrequent** Score |
|---|---|---|
| A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.... | (16) | 12 |
| B. riffle as wide as stream but riffle length is not 2X stream width ..... | 14 | 7 |
| C. riffle not as wide as stream and riffle length is not 2X stream width ..... | 10 | 3 |
| **D. riffles absent**..... | 0 | |

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream

Subtotal 16

**VI. Bank Stability and Vegetation**

| FACE UPSTREAM | Left Bank Score | Rt. Bank Score |
|---|---|---|
| **A. Banks stable** | | |
| 1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion. | (7) | (7) |
| **B. Erosion areas present** | | |
| 1. diverse **trees**, shrubs, grass; plants healthy with good root systems..... | 6 | 6 |
| 2. few trees or small trees and **shrubs**; vegetation appears generally healthy..... | 5 | 5 |
| 3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding..... | 3 | 3 |
| 4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow.. | 2 | 2 |
| 5. little or no bank vegetation, mass erosion and bank failure evident..... | 0 | 0 |

Total 14

Remarks_____

**VII. Light Penetration** Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

| | Score |
|---|---|
| A. Stream with **good** canopy with some breaks for light penetration ..... | 10 |
| B. Stream with **full canopy** - breaks for light penetration absent..... | 8 |
| C. Stream with **partial** canopy - sunlight and shading are essentially equal..... | 7 |
| D. Stream with **minimal** canopy - full sun in all but a few areas..... | (2) |
| **E. No canopy** and no shading..... | 0 |

Remarks_____ Subtotal 2

**VIII. Riparian Vegetative Zone Width**

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

| FACE UPSTREAM<br>Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc) | Lft. Bank Score | Rt. Bank Score |
|---|---|---|
| A. Riparian zone **intact** (no breaks) | | |
| 1. width > 18 meters..... | (5) | (5) |
| 2. width 12-18 meters..... | 4 | 4 |
| 3. width 6-12 meters..... | 3 | 3 |
| 4. width < 6 meters..... | 2 | 2 |
| B. Riparian zone **not intact** (breaks) | | |
| 1. breaks rare | | |
| a. width > 18 meters..... | 4 | 4 |
| b. width 12-18 meters..... | 3 | 3 |
| c. width 6-12 meters..... | 2 | 2 |
| d. width < 6 meters..... | 1 | 1 |
| 2. breaks common | | |
| a. width > 18 meters..... | 3 | 3 |
| b. width 12-18 meters..... | 2 | 2 |
| c. width 6-12 meters..... | 1 | 1 |
| d. width < 6 meters..... | 0 | 0 |

Remarks Buffer well over 18 meters w/ conservation easement

Total 10

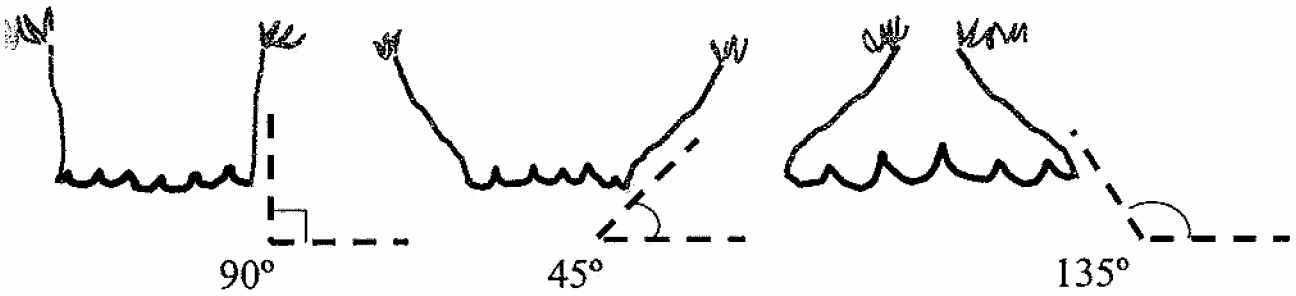
Page Total 42

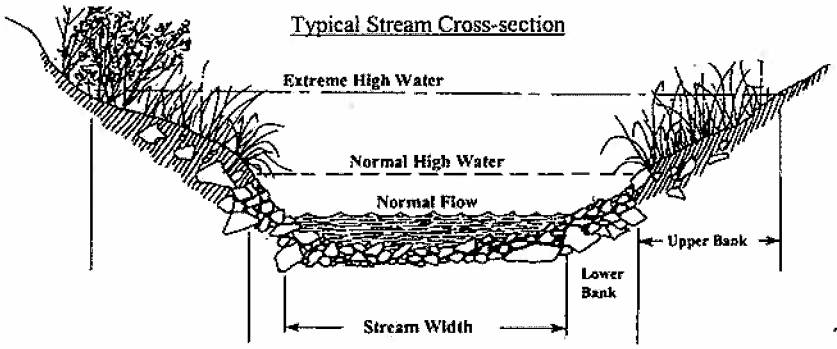
☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream.

**TOTAL SCORE** 81

**Supplement for Habitat Assessment Field Data Sheet**

Diagram to determine bank angle:




This side is 45° bank angle.

Site Sketch:

Other comments:_____

_____

_____

_____

_____

**Habitat Assessment Field Data Sheet**
**Mountain/ Piedmont Streams**

**Biological Assessment Unit, DWQ** **TOTAL SCORE** 75

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

**Stream** Bailey Fork Location/road: Site 2 (Road Name Flint Rd) County Burke

**Date** 3-19-09 **CC#** _____ Basin Catawba Subbasin 11-34-8-3

Observer(s) CDM ISE Type of Study: ☐ Fish ☒ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☐ MT ☒ P ☐ Slate Belt ☐ Triassic Basin

**Water Quality:** Temperature 14.6 °C DO 9.36 (91%) mg/l Conductivity (corr.) 40 µS/cm pH 6.93

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.**

Visible Land Use: 50 %Forest 25 %Residential _____ %Active Pasture _____ % Active Crops
_____ %Fallow Fields _____ % Commercial _____ %Industrial 25 %Other - Describe: Recently cut forest

Watershed land use : ☑ Forest ☑ Agriculture ☐ Urban ☐ Animal operations upstream

**Width**: (meters) Stream 2 Channel (at top of bank) 4 **Stream Depth**: (m) Avg 0.3 Max 0.75
☐ Width variable ☐ Large river >25m wide

**Bank Height** (from deepest part of riffle to top of bank-first flat surface you stand on): (m) 1.5

**Bank Angle**: 30-70 ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

☐ Channelized Ditch
☐ Deeply incised-steep, straight banks ☐ Both banks undercut at bend ☐ Channel filled in with sediment
☐ Recent overbank deposits ☑ Bar development ☐ Buried structures ☐ Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐ Green tinge ☐ Sewage smell
Manmade Stabilization: ☑ N ☐ Y: ☐ Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐ Berm/levee
**Flow conditions** : ☐ High ☑ Normal ☐ Low
**Turbidity**: ☑ Clear ☐ Slightly Turbid ☐ Turbid ☐ Tannic ☐ Milky ☐ Colored (from dyes)
**Good potential for Wetlands Restoration Project??** ☐ **YES** ☐ **NO Details** _____

**Channel Flow Status**

Useful especially under abnormal or low flow conditions.

| | |
|---|---|
| A. Water reaches base of both lower banks, minimal channel substrate exposed | ☑ |
| B. Water fills >75% of available channel, or <25% of channel substrate is exposed | ☐ |
| C. Water fills 25-75% of available channel, many logs/snags exposed | ☐ |
| D. Root mats out of water | ☐ |
| E. Very little water in channel, mostly present as standing pools | ☐ |

**Weather Conditions:** Party Cloudy, 70° **Photos:** ☐ N ☑ Y ☐ Digital ☑ 35mm

**Remarks:** Eco-reference site for Bailey Fork & Silver Creek Sites

Site 2

**I. Channel Modification**

| | Score |
|---|---|
| A. channel natural, frequent bends | (5) |
| B. channel natural, infrequent bends (channelization could be old) | 4 |
| C. some channelization present | 3 |
| D. more extensive channelization, >40% of stream disrupted | 2 |
| E. no bends, completely channelized or rip rapped or gabioned, etc | 0 |

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height

Remarks _____ Subtotal 5

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

C **Rocks** R **Macrophytes** C **Sticks and leafpacks** R-C **Snags and logs** A **Undercut banks or root mats**

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

| | >70% Score | 40-70% Score | 20-40% Score | <20% Score |
|---|---|---|---|---|
| 4 or 5 types present | 20 | 16 | 12 | 8 |
| 3 types present | 19 | (15) | 11 | 7 |
| 2 types present | 18 | 14 | 10 | 6 |
| 1 type present | 17 | 13 | 9 | 5 |
| No types present | 0 | | | |

☐ No woody vegetation in riparian zone Remarks _____ Subtotal 15

**III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder)** Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

| **A. substrate with good mix of gravel, cobble and boulders** | Score |
|---|---|
| 1. embeddedness <20% (very little sand, usually only behind large boulders) | 15 |
| 2. embeddedness 20-40% | 12 |
| 3. embeddedness 40-80% | 8 |
| 4. embeddedness >80% | 3 |
| **B. substrate gravel and cobble** | |
| 1. embeddedness <20% | 14 |
| 2. embeddedness 20-40% | 11 |
| 3. embeddedness 40-80% | (6) |
| 4. embeddedness >80% | 2 |
| **C. substrate mostly gravel** | |
| 1. embeddedness <50% | 8 |
| 2. embeddedness >50% | 4 |
| **D. substrate homogeneous** | |
| 1. substrate nearly all bedrock | 3 |
| 2. substrate nearly all sand | 3 |
| 3. substrate nearly all detritus | 2 |
| 4. substrate nearly all silt/ clay | 1 |

Remarks _____ Subtotal 6

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

| **A. Pools present** | Score |
|---|---|
| 1. Pools Frequent (>30% of 200m area surveyed) | |
| a. variety of pool sizes | 10 |
| b. pools about the same size (indicates pools filling in) | (8) |
| 2. Pools Infrequent (<30% of the 200m area surveyed) | |
| a. variety of pool sizes | 6 |
| b. pools about the same size | 4 |
| **B. Pools absent** | 0 |

Subtotal 8

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks _____

Page Total 34

Site 2

**V. Riffle Habitats**

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

| | Riffles **Frequent** Score | Riffles **Infrequent** Score |
|---|---|---|
| A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.... | (16) | 12 |
| B. riffle as wide as stream but riffle length is not 2X stream width ..... | 14 | 7 |
| C. riffle not as wide as stream and riffle length is not 2X stream width ..... | 10 | 3 |
| **D. riffles absent**..... | 0 | |

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream

Subtotal 16

**VI. Bank Stability and Vegetation**

| FACE UPSTREAM | Left Bank Score | Rt. Bank Score |
|---|---|---|
| **A. Banks stable** | | |
| 1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion.. | 7 | 7 |
| **B. Erosion areas present** | | |
| 1. diverse **trees**, shrubs, grass; plants healthy with good root systems..... | 6 | 6 |
| 2. few trees or small trees and **shrubs**; vegetation appears generally healthy..... | (5) | (5) |
| 3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding..... | 3 | 3 |
| 4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow.. | 2 | 2 |
| 5. little or no bank vegetation, mass erosion and bank failure evident..... | 0 | 0 |

Total 10

Remarks_____

**VII. Light Penetration** Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

| | Score |
|---|---|
| A. Stream with **good** canopy with some breaks for light penetration ..... | (10) |
| B. Stream with **full canopy** - breaks for light penetration absent..... | 8 |
| C. Stream with **partial** canopy - sunlight and shading are essentially equal..... | 7 |
| D. Stream with **minimal** canopy - full sun in all but a few areas..... | 2 |
| E. **No canopy** and no shading..... | 0 |

Remarks_____ Subtotal 10

**VIII. Riparian Vegetative Zone Width**

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

| FACE UPSTREAM<br>Dominant vegetation: ☑Trees ☑Shrubs ☑Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc) | Lft. Bank Score | Rt. Bank Score |
|---|---|---|
| A. Riparian zone **intact** (no breaks) | | |
| 1. width > 18 meters..... | 5 | 5 |
| 2. width 12-18 meters..... | 4 | 4 |
| 3. width 6-12 meters..... | 3 | 3 |
| 4. width < 6 meters..... | 2 | 2 |
| B. Riparian zone **not intact** (breaks) | | |
| 1. breaks rare | | |
| a. width > 18 meters..... | 4 | (4) |
| b. width 12-18 meters..... | 3 | 3 |
| c. width 6-12 meters..... | 2 | 2 |
| d. width < 6 meters..... | 1 | 1 |
| 2. breaks common | | |
| a. width > 18 meters..... | 3 | 3 |
| b. width 12-18 meters..... | 2 | 2 |
| c. width 6-12 meters..... | (1) | 1 |
| d. width < 6 meters..... | 0 | 0 |

Remarks_____ Total 5

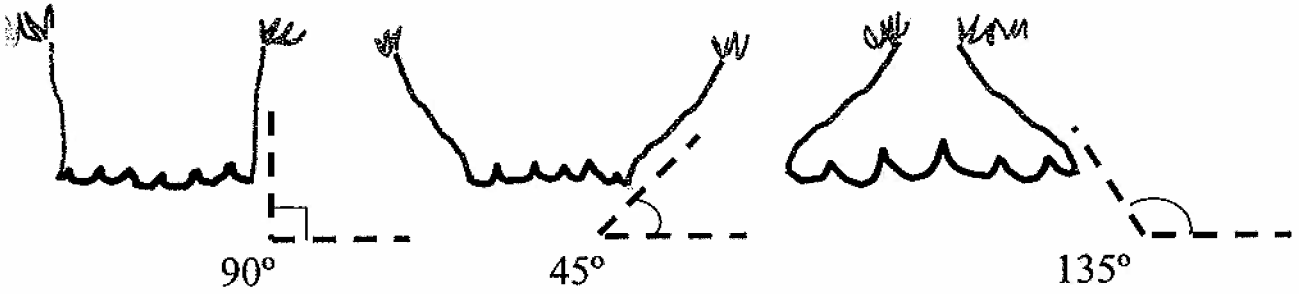
Page Total 41

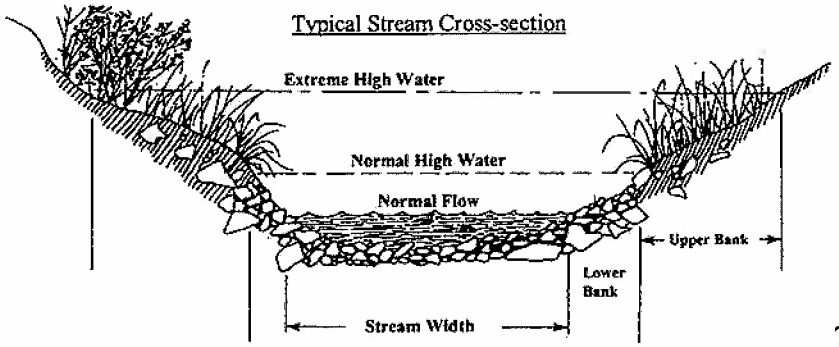
☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE**_____

Site 2

**Supplement for Habitat Assessment Field Data Sheet**

Diagram to determine bank angle:




This side is 45° bank angle.

Site Sketch:

Other comments: _____

3/06 Revision 6

**Habitat Assessment Field Data Sheet**
**Mountain/ Piedmont Streams**

**Biological Assessment Unit, DWQ** **TOTAL SCORE** 83

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

**Stream** Bailey Fork Location/road: Site 3 (Road Name Hopewell) County Burke

**Date** 3-16-09 **CC#** _____ Basin Catawba Subbasin 11-34-8-3

Observer(s) IJE CDM Type of Study: ☐ Fish ☑ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☐ MT ☑ P ☐ Slate Belt ☐ Triassic Basin

**Water Quality:** Temperature 10.4 °C DO 92.1 mg/l Conductivity (corr.) 60 µS/cm pH 7.06

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.**

Visible Land Use: _____%Forest _____%Residential 25 %Active Pasture _____% Active Crops
75 %Fallow Fields _____% Commercial _____%Industrial _____%Other - Describe: _____

Watershed land use : ☐Forest ☒Agriculture ☐Urban ☐ Animal operations upstream

**Width:** (meters) Stream 9ft Channel (at top of bank) 12-15' **Stream Depth:** (m) Avg 1.5 Max 3.5
☐ Width variable ☐ Large river >25m wide

**Bank Height** (from deepest part of riffle to top of bank-first flat surface you stand on): (m) 2.5

**Bank Angle:** 30 ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

☐ Channelized Ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
**Flow conditions** : ☑High ☐Normal ☐Low
**Turbidity:** ☐Clear ☐ Slightly Turbid ☑Turbid ☐Tannic ☐Milky ☐Colored (from dyes)
**Good potential for Wetlands Restoration Project?? ☐ YES ☒NO Details** Already constructed project site

**Channel Flow Status**
Useful especially under abnormal or low flow conditions.

| | |
|---|---|
| A. Water reaches base of both lower banks, minimal channel substrate exposed | ☑ |
| B. Water fills >75% of available channel, or <25% of channel substrate is exposed | ☐ |
| C. Water fills 25-75% of available channel, many logs/snags exposed | ☐ |
| D. Root mats out of water | ☐ |
| E. Very little water in channel, mostly present as standing pools | ☐ |

**Weather Conditions:** Overcast, Light Rain 40° **Photos:** ☐N ☑Y ☑Digital ☐35mm

**Remarks:** The appears elevated due to recent / on going rainfall

**I. Channel Modification**

| | Score |
|---|---|
| A. channel natural, frequent bends | (5) |
| B. channel natural, infrequent bends (channelization could be old) | 4 |
| C. some channelization present | 3 |
| D. more extensive channelization, >40% of stream disrupted | 2 |
| E. no bends, completely channelized or rip rapped or gabioned, etc | 0 |

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☑Banks of uniform shape/height

Remarks Restored stream channel Subtotal 5

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

A **Rocks** R **Macrophytes** R-C **Sticks and leafpacks** R **Snags and logs** A **Undercut banks or root mats**

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

| | >70% Score | 40-70% Score | 20-40% Score | <20% Score |
|---|---|---|---|---|
| 4 or 5 types present | 20 | 16 | 12 | 8 |
| 3 types present | 19 | (15) | 11 | 7 |
| 2 types present | 18 | 14 | 10 | 6 |
| 1 type present | 17 | 13 | 9 | 5 |
| No types present | 0 | | | |

☐ No woody vegetation in riparian zone Remarks Difficult to estimate instream habitat b/c water surface is cleared; its likely recent rains have flushed leaf packs. Subtotal 15

**III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder)** Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

| | Score |
|---|---|
| **A. substrate with good mix of gravel, cobble and boulders** | |
| 1. embeddedness <20% (very little sand, usually only behind large boulders) | 15 |
| 2. embeddedness 20-40% | 12 |
| 3. embeddedness 40-80% | 8 |
| 4. embeddedness >80% | 3 |
| **B. substrate gravel and cobble** | |
| 1. embeddedness <20% | 14 |
| 2. embeddedness 20-40% | (11) |
| 3. embeddedness 40-80% | 6 |
| 4. embeddedness >80% | 2 |
| **C. substrate mostly gravel** | |
| 1. embeddedness <50% | 8 |
| 2. embeddedness >50% | 4 |
| **D. substrate homogeneous** | |
| 1. substrate nearly all bedrock | 3 |
| 2. substrate nearly all sand | 3 |
| 3. substrate nearly all detritus | 2 |
| 4. substrate nearly all silt/ clay | 1 |

Remarks Subtotal 11

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

| | Score |
|---|---|
| **A. Pools present** | |
| 1. Pools Frequent (>30% of 200m area surveyed) | |
| a. variety of pool sizes | (10) |
| b. pools about the same size (indicates pools filling in) | 8 |
| 2. Pools Infrequent (<30% of the 200m area surveyed) | |
| a. variety of pool sizes | 6 |
| b. pools about the same size | 4 |
| **B. Pools absent** | 0 |

Subtotal 10

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☑ Silt bottom ☐ Some pools over wader depth

Remarks

Page Total 41

**V. Riffle Habitats**

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

| | Riffles **Frequent** Score | Riffles **Infrequent** Score |
|---|---|---|
| A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.... | (16) | 12 |
| B. riffle as wide as stream but riffle length is not 2X stream width ..... | 14 | 7 |
| C. riffle not as wide as stream and riffle length is not 2X stream width ..... | 10 | 3 |
| **D. riffles absent**..... | 0 | |

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream Subtotal 16

**VI. Bank Stability and Vegetation**

| FACE UPSTREAM | Left Bank Score | Rt. Bank Score |
|---|---|---|
| **A. Banks stable** | | |
| 1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion. | (7) | (7) |
| **B. Erosion areas present** | | |
| 1. diverse **trees**, shrubs, grass; plants healthy with good root systems..... | 6 | 6 |
| 2. few trees or small trees and **shrubs**; vegetation appears generally healthy..... | 5 | 5 |
| 3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding..... | 3 | 3 |
| 4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow.. | 2 | 2 |
| 5. little or no bank vegetation, mass erosion and bank failure evident..... | 0 | 0 |
| | | Total 14 |

Remarks Vegetation is well established along streambanks

**VII. Light Penetration** Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

| | Score |
|---|---|
| A. Stream with **good** canopy with some breaks for light penetration ..... | 10 |
| B. Stream with **full canopy** - breaks for light penetration absent..... | 8 |
| C. Stream with **partial** canopy - sunlight and shading are essentially equal..... | 7 |
| D. Stream with **minimal** canopy - full sun in all but a few areas..... | (2) |
| E. **No canopy** and no shading..... | 0 |

Remarks Tall grasses & small trees provide minimal shade Subtotal 2

**VIII. Riparian Vegetative Zone Width**

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

| FACE UPSTREAM<br>Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc) | Lft. Bank Score | Rt. Bank Score |
|---|---|---|
| A. Riparian zone **intact** (no breaks) | | |
| 1. width > 18 meters..... | (5) | (5) |
| 2. width 12-18 meters..... | 4 | 4 |
| 3. width 6-12 meters..... | 3 | 3 |
| 4. width < 6 meters..... | 2 | 2 |
| B. Riparian zone **not intact** (breaks) | | |
| 1. breaks rare | | |
| a. width > 18 meters..... | 4 | 4 |
| b. width 12-18 meters..... | 3 | 3 |
| c. width 6-12 meters..... | 2 | 2 |
| d. width < 6 meters..... | 1 | 1 |
| 2. breaks common | | |
| a. width > 18 meters..... | 3 | 3 |
| b. width 12-18 meters..... | 2 | 2 |
| c. width 6-12 meters..... | 1 | 1 |
| d. width < 6 meters..... | 0 | 0 |
| | | Total 10 |

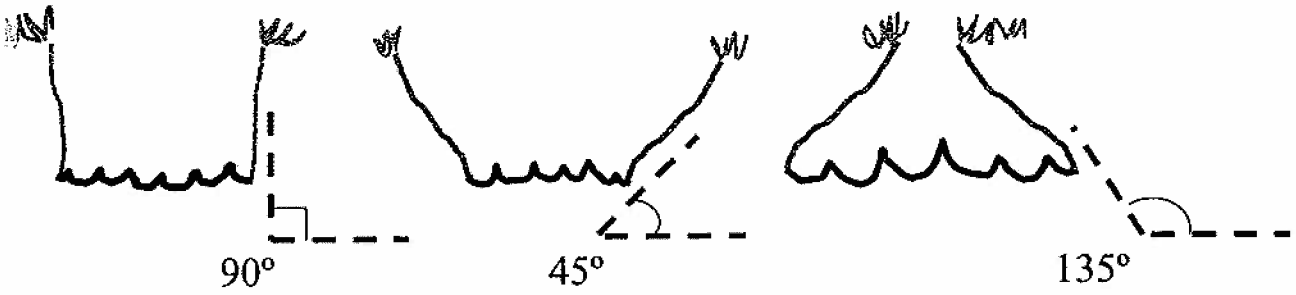
Remarks

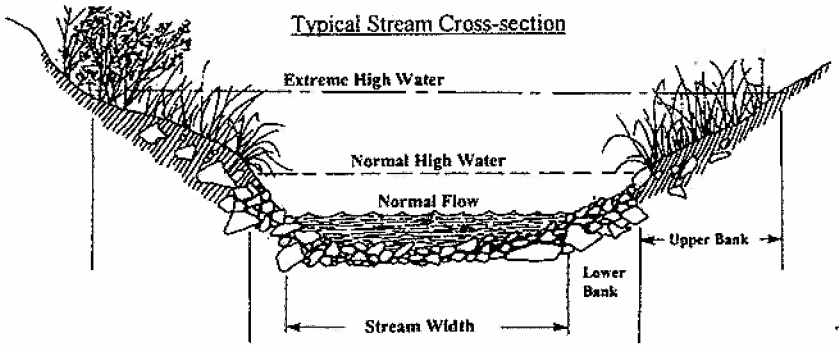
Page Total 42

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE**

**Supplement for Habitat Assessment Field Data Sheet**

Diagram to determine bank angle:




This side is 45° bank angle.

Site Sketch:

Other comments:_____

_____

_____

_____

_____

3/06 Revision 6

**Habitat Assessment Field Data Sheet**
**Mountain/ Piedmont Streams**

**Biological Assessment Unit, DWQ** **TOTAL SCORE** 69

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

**Stream** Bailey Fork Location/road: Site 4 (Road Name U/S of Hopewell Rd) County Burke

**Date** 3-19-09 **CC#** _____ Basin Catawba Subbasin 11-34-8-3

Observer(s) JJE COM Type of Study: ☐ Fish ☑ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☐ MT ☑ P ☐ Slate Belt ☐ Triassic Basin

**Water Quality:** Temperature 10.6 °C DO 93.0 (10.23) mg/l Conductivity (corr.) 60 µS/cm pH 7.12

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.**

Visible Land Use: 70 %Forest 20 %Residential _____ %Active Pasture _____ % Active Crops
_____ %Fallow Fields _____ % Commercial _____ %Industrial 10 %Other - Describe: Cleared forest

Watershed land use : ☑ Forest ☑ Agriculture ☐ Urban ☐ Animal operations upstream

**Width:** (meters) Stream 1.5 Channel (at top of bank) 4.5 **Stream Depth:** (m) Avg 0.5 Max 1
☐ Width variable ☐ Large river >25m wide

**Bank Height** (from deepest part of riffle to top of bank-first flat surface you stand on): (m)_____

**Bank Angle:** 90°+ ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

☐ Channelized Ditch
☑ Deeply incised-steep, straight banks ☐ Both banks undercut at bend ☐ Channel filled in with sediment
☐ Recent overbank deposits ☑ Bar development ☐ Buried structures ☐ Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐ Green tinge ☐ Sewage smell
Manmade Stabilization: ☑ N ☐ Y: ☐ Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐ Berm/levee
**Flow conditions** : ☐ High ☑ Normal ☐ Low
**Turbidity:** ☑ Clear ☐ Slightly Turbid ☐ Turbid ☐ Tannic ☐ Milky ☐ Colored (from dyes)
**Good potential for Wetlands Restoration Project??** ☐ **YES** ☑ **NO Details** Highly incised

**Channel Flow Status**
Useful especially under abnormal or low flow conditions.

| | |
|---|---|
| A. Water reaches base of both lower banks, minimal channel substrate exposed | ☑ |
| B. Water fills >75% of available channel, or <25% of channel substrate is exposed | ☐ |
| C. Water fills 25-75% of available channel, many logs/snags exposed | ☐ |
| D. Root mats out of water | ☐ |
| E. Very little water in channel, mostly present as standing pools | ☐ |

**Weather Conditions:** Partly Cloudy 60's **Photos:** ☐ N ☑ Y ☑ Digital ☐ 35mm

**Remarks:** _____

* Several salamanders
** Couple crawfish
*** Minnow

**I. Channel Modification**

| | Score |
|---|---|
| A. channel natural, frequent bends | (5) |
| B. channel natural, infrequent bends (channelization could be old) | 4 |
| C. some channelization present | 3 |
| D. more extensive channelization, >40% of stream disrupted | 2 |
| E. no bends, completely channelized or rip rapped or gabioned, etc | 0 |

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height

Remarks _____ Subtotal 5

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

C **Rocks** R **Macrophytes** C **Sticks and leafpacks** C **Snags and logs** R **Undercut banks or root mats**

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

| | >70% Score | 40-70% Score | 20-40% Score | <20% Score |
|---|---|---|---|---|
| 4 or 5 types present | 20 | 16 | 12 | 8 |
| 3 types present | 19 | 15 | (11) | 7 |
| 2 types present | 18 | 14 | 10 | 6 |
| 1 type present | 17 | 13 | 9 | 5 |
| No types present | 0 | | | |

☐ No woody vegetation in riparian zone Remarks Many areas of raw banks greatly diminish available habitat. J Subtotal 11

**III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder)** Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

| **A. substrate with good mix of gravel, cobble and boulders** | **Score** |
|---|---|
| 1. embeddedness <20% (very little sand, usually only behind large boulders) | 15 |
| 2. embeddedness 20-40% | 12 |
| 3. embeddedness 40-80% | 8 |
| 4. embeddedness >80% | 3 |
| **B. substrate gravel and cobble** | |
| 1. embeddedness <20% | 14 |
| 2. embeddedness 20-40% | (11) |
| 3. embeddedness 40-80% | 6 |
| 4. embeddedness >80% | 2 |
| **C. substrate mostly gravel** | |
| 1. embeddedness <50% | 8 |
| 2. embeddedness >50% | 4 |
| **D. substrate homogeneous** | |
| 1. substrate nearly all bedrock | 3 |
| 2. substrate nearly all sand | 3 |
| 3. substrate nearly all detritus | 2 |
| 4. substrate nearly all silt/ clay | 1 |

Remarks _____ Subtotal 11

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

| **A. Pools present** | Score |
|---|---|
| 1. Pools Frequent (>30% of 200m area surveyed) | |
| a. variety of pool sizes | (10) |
| b. pools about the same size (indicates pools filling in) | 8 |
| 2. Pools Infrequent (<30% of the 200m area surveyed) | |
| a. variety of pool sizes | 6 |
| b. pools about the same size | 4 |
| **B. Pools absent** | 0 |

Subtotal 10

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks _____

Page Total 37

**V. Riffle Habitats**

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

| | Riffles **Frequent** Score | Riffles **Infrequent** Score |
|---|---|---|
| A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.... | 16 | (12) |
| B. riffle as wide as stream but riffle length is not 2X stream width ..... | 14 | 7 |
| C. riffle not as wide as stream and riffle length is not 2X stream width ..... | 10 | 3 |
| **D. riffles absent**..... | 0 | |

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream Subtotal 12

**VI. Bank Stability and Vegetation**

| FACE UPSTREAM | Left Bank Score | Rt. Bank Score |
|---|---|---|
| **A. Banks stable** | | |
| 1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion.. | 7 | 7 |
| **B. Erosion areas present** | | |
| 1. diverse **trees**, shrubs, grass; plants healthy with good root systems..... | 6 | 6 |
| 2. few trees or small trees and **shrubs**; vegetation appears generally healthy..... | 5 | 5 |
| 3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding..... | 3 | 3 |
| 4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow.. | (2) | 2 |
| 5. little or no bank vegetation, mass erosion and bank failure evident..... | 0 | (0) |
| | | Total 7 |

Remarks_____

**VII. Light Penetration** Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

| | Score |
|---|---|
| A. Stream with **good** canopy with some breaks for light penetration ..... | (10) |
| B. Stream with **full canopy** - breaks for light penetration absent..... | 8 |
| C. Stream with **partial** canopy - sunlight and shading are essentially equal..... | 7 |
| D. Stream with **minimal** canopy - full sun in all but a few areas..... | 2 |
| E. **No canopy** and no shading..... | 0 |

Remarks_____ Subtotal 10

**VIII. Riparian Vegetative Zone Width**

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

| FACE UPSTREAM | Lft. Bank Score | Rt. Bank Score |
|---|---|---|
| Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc) | | |
| A. Riparian zone **intact** (no breaks) | | |
| 1. width > 18 meters..... | 5 | (5) |
| 2. width 12-18 meters..... | 4 | 4 |
| 3. width 6-12 meters..... | 3 | 3 |
| 4. width < 6 meters..... | 2 | 2 |
| B. Riparian zone **not intact** (breaks) | | |
| 1. breaks rare | | |
| a. width > 18 meters..... | 4 | 4 |
| b. width 12-18 meters..... | (3) | 3 |
| c. width 6-12 meters..... | 2 | 2 |
| d. width < 6 meters..... | 1 | 1 |
| 2. breaks common | | |
| a. width > 18 meters..... | 3 | 3 |
| b. width 12-18 meters..... | 2 | 2 |
| c. width 6-12 meters..... | 1 | 1 |
| d. width < 6 meters..... | 0 | 0 |

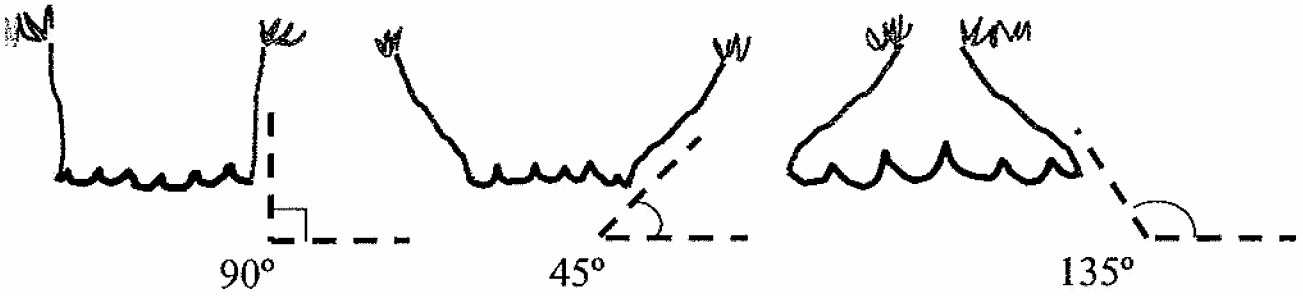
Remarks Portion of left floodplain has been recently cleared Total 8

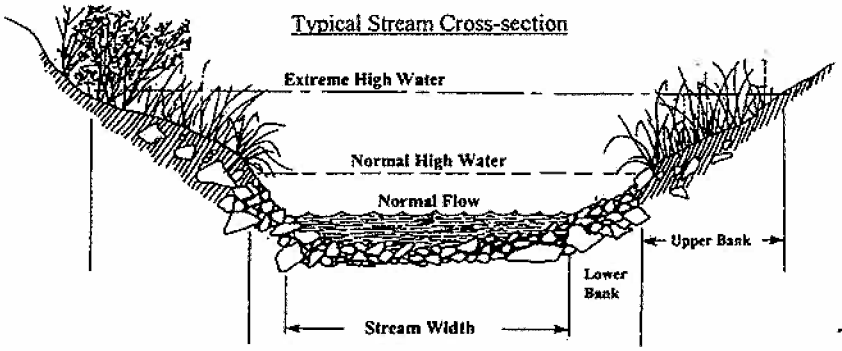
Page Total 32

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE** 69

**Supplement for Habitat Assessment Field Data Sheet**

Diagram to determine bank angle:




This side is 45° bank angle.

Site Sketch:

Other comments:_____

_____

_____

_____

_____


P1 Site 1 – Facing upstream


P2 Site 1 – Facing downstream


P3 Site 2 – Facing upstream


P4 Site 2 – Facing downstream

P5 Site 3 – Facing upstream

P6 Site 3 – Facing downstream


P7 Site 4 – Facing upstream


P8 Site 4 – Facing downstream