South Muddy Creek Stream Restoration Project
Year 1 Monitoring Report

McDowell County, North Carolina

NCEEP Project Number – 737

Project Info:	Monitoring Year: 1 of 5 Year of Data Collection: 2012 Year of Completed Construction: 2011 NCEEP Project Manager: Paul Wiesner Submission Date: November 30th, 2012
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Ecosystem Enhancement PROGRAM

South Muddy Creek Stream Restoration Project
Year 1 Monitoring Report

McDowell County, North Carolina

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Appendices

1.0 EXECUTIVE SUMMARY

The South Muddy Creek Restoration Project (Project) was restored by Michael Baker Engineering, Inc. (Baker) through an on-call design and construction services contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents and presents Year 1 monitoring data as required during the five-year monitoring period.

The specific goals for the South Muddy Creek Restoration Project were as follows:

- Create geomorphically stable conditions on the Project site,
- Improve and restore hydrologic connections between the streams and their floodplains,
- Improve water quality in the South Muddy Creek watershed, and
- Improve aquatic and terrestrial habitat along the Project corridor.

To accomplish these goals the following objectives were implemented:

- Excavate a wide floodplain bench and construct a new channel with stable dimension and pattern,
- Restore channel access the floodplain during bankfull or larger storm events to increase hydrologic connections and alleviate erosive shear stresses,
- Incorporate bedform diversity with varied in-stream structures to provide a variety of aquatic habitats,
- Treat the floodplain for invasive species vegetation, and
- Reestablish a riparian buffer with native vegetation to improve terrestrial habitat and eliminate excessive sedimentation from erosion.

The Project site is located approximately nine miles southeast of Marion in McDowell County, North Carolina, as shown in Figure 1 in Appendix A. The Project is situated in the Catawba River Basin, within the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-30 and United States Geologic Survey (USGS) hydrologic unit 03050101040-020. Directions to the Project site can be found in Figure 1 of Appendix A.

South Muddy Creek lies within the Piedmont physiographic province. Its watershed is predominately forested, supporting some isolated rural residential housing, chicken farms, agricultural lands, nurseries, and several small rural residential developments. In the early 1960's the McDowell County Natural Resource Conservation Service (NRCS) constructed a flood control structure within South Muddy Creek approximately three miles upstream from the Project area. This structure controls flows from approximately 12.4 square miles of the watershed and is located on privately-owned land that is maintained by the NRCS.

The land surrounding the Project site has been used predominantly for crop cultivation and the stream channel has been impacted from past channelization; the channel became disconnected from its floodplain by channel incision over time and excessive shear stress forces on the bed and banks had caused erosion. The Project involved the restoration of 2,787 linear feet (LF) of stream along South Muddy Creek at Sain Road using a Rosgen Priority 2 restoration approach. The Priority 2 channel design approach entailed the excavation of bankfull benches to alleviate shear stress on stream banks, re-establishment of channel pattern to dissipate flow velocities in meander bends while creating in-stream habitat with riffle-pool sequences and the strategic placement of in-stream structures. Approximately 14.1 acres of associated riparian buffer were restored/enhanced throughout the Project area and a conservation easement consisting of 17.1 acres will protect and preserve all stream reaches and riparian buffers in perpetuity.

Table 6a in Appendix B summarizes the vegetation condition of the Project site. The planted acreage performance categories were functioning at 100% with no bare areas or low stem density areas to report.

Invasive areas of concern were observed and documented accordingly in Table 6a and as vegetation problem areas (VPAs) in Figure 2 and Table 6b (Appendix B). Ten discrete areas of invasive species were documented throughout the site and totaled approximately 1 acre, or 5.7% of the total easement acreage. A more detailed summary of the results for the vegetation condition assessment can be found in Appendix B which includes a technical memorandum, current condition planview (CCPV) figures, supporting data tables, and photo logs; the contents of Appendix B was submitted to NCEEP in June 2012 and served as the interim visual site assessment report.

The success criteria or survival threshold for all 12 vegetation monitoring plots were attained and are summarized in Tables 7 and 9 of Appendix C. The average density of total planted stems or tract mean (including volunteers), based on data collected from the 12 monitoring plots during Year 1 monitoring, is 725 stems per acre; this further indicates that the Project site is on track for meeting the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5. It should be noted that most vegetation plots exhibiting a lower planted stem density count are offset by the presence of thriving volunteer species, thereby boosting or increasing the stem density for a given plot and the tract in general upon inclusion of volunteers for total stems per acre.

Table 5a in Appendix B indicates the South Muddy Creek site was geomorphically stable overall and performing at 100% for the majority of parameters evaluated within the lateral/vertical stability and in-stream structure performance categories. The four sub-categories receiving scores of less than 100% correspond to the three stream problem areas (SPAs) documented and summarized in Table 5b (Appendix B). The three SPAs were characterized by localized areas of bank scour and were all located upstream of the Sain Road bridge. A more detailed summary of the results for the visual stream stability assessment can be found in Appendix B which includes a technical memorandum, CCPV figures, supporting data tables, and photo logs.

The four permanent cross-sections in Appendix D show that there has been little adjustment to stream dimension within the Project reach since construction. In general, riffles appeared to have narrowed in width slightly while pools appeared to have slightly increased in (maximum) depth. The longitudinal profile indicates that the bed features are generally stable and that grade control structures (constructed riffles and j-hooks) continue to help maintain the overall profile desired. Pool lengths and depths appear to have been maintained with minor localized adjustments. Aggradation is evident within the downstream limits of the Project reach profile, primarily along the meander bend beginning at station 36+00 where the maximum depth of the pool has aggraded approximately two feet. The maintenance or stability of pools (from scour) throughout the remainder of the Project reach upstream as indicated by the profile, and the shift from finer to coarser bed load material as indicated by the pebble count data, suggests that this aggraded area is localized and may be due to the transport and deposition of finer particles from further upstream (where the sediment sample was collected). The bed load material analysis shown in Figure 5 of Appendix D illustrates this stable transition whereby larger pebbles are making up a greater percentage of the bed material since construction was completed and the baseline condition pebble count was conducted prior to the apparent flush of fines downstream. Scour within the aggraded meander bend, from larger, subsequent storm flows, should flush the aggraded material downstream and help to re-establish a deeper pool over time. The site was found to have had at least two bankfull events based on crest gauge readings. Information on these events is provided in Table 12 of Appendix E.

Summary information/data related to the occurrence of items such as beaver or encroachment, and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report (formerly Mitigation Plan) and in the Mitigation Plan (formerly Restoration Plan) documents available on EEP's website. *It should be noted that the Baseline Monitoring Report and Mitigation Plan for this Project includes the summary of constructed design approaches for South Fork Hoppers Creek (EEP Project No. 92251), a nearby project site that was designed and constructed in conjunction with the South Muddy Creek project as part of the same EEP on-call design and construction*

services contract. All raw data supporting the tables and figures in the appendices is available from EEP upon request.

2.0 METHODOLOGY

The five-year monitoring plan for the Project site includes criteria to evaluate the success of the vegetation and stream components of the project. The methodology and report template used to evaluate these two components adheres to the EEP monitoring guidance document dated November 7, 2011, which will continue to serve as the template for subsequent monitoring years. The specific locations of monitoring features, such as vegetation plots, permanent cross-sections, reference photo stations and crest gauges, are shown on the CCPV sheets found in Figure 2 of Appendix B.

The majority of Year 1 monitoring data was collected in May 2012 and September 2012. All visual site assessment data contained in Appendix B was collected on May 18th except for the vegetation plot data and corresponding plot photos which were collected on May 24th. All stream survey (channel dimension and profile) and sediment data were collected between September 10th and 12th. Stream survey data was collected using a Topcon GRS-1 network Rover GPS unit which collects point data with an accuracy of less than one tenth of a foot.

2.1 Stream Assessment

Geomorphic monitoring of restored stream reaches is being conducted for five years to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include channel dimension (cross-sections), profile (longitudinal survey), bed composition, bank and channel stability, bankfull flows, and reference sites documented by photographs. A crest gauge, as well as high flow marks, will be used to document the occurrence of bankfull events. The methods used and any related success criteria are described below for each parameter. For monitoring stream success criteria, 4 permanent cross-sections, 1 crest gauge, and 20 photo identification points were installed.

2.1.1 Morphologic Parameters and Channel Stability

2.1.1.1 Dimension

Four permanent cross-sections were installed throughout the entire project area. Cross-sections selected for monitoring were located in representative riffle and pool facets and each cross-section was marked on both banks with permanent pins to establish the exact transect used. The two pairs of riffle and pool cross-sections are all located upstream of the Sain Road bridge crossing. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at major breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections were classified using the Rosgen Stream Classification System (Rosgen, 1994), and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

There should be little change in as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sectional data is presented in Figure 3 of Appendix D.

2.1.1.2 Longitudinal Profile

One longitudinal profile was surveyed for the entire project length of the Project reach and is provided in Figure 4 of Appendix D. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, and the top of low bank. All measurements were taken at the head of each feature (e.g., riffle, run, pool, glide) and the maximum pool depth. Elevations of grade control structures were also included in the longitudinal profiles surveyed. Surveys were tied to a permanent benchmark.

The pools should remain relatively deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type as well as other design information.

2.1.1.3 Substrate and Sediment Transport

Bed load material analysis consists of a pebble count taken in the same constructed riffle (at cross-section X4) during annual geomorphic surveys of the Project site. This sample, combined with evidence provided by changes in cross-section and profile data will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes. Bed material distribution data is located in Figure 5 of Appendix D.

2.1.2 Hydrology

2.1.2.1 Streams

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. One crest gauge was installed on the floodplain at the bankfull elevation along the left top of bank at station 22+00. The bottom of the crest gauge coincides with the top of bank (bankfull) elevation. The crest gauges record the highest watermark between site visits, and are checked at each site visit to determine if a bankfull event has occurred. Photographs are used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented at the crest gauge within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years or until the monitoring period ends. If two bankfull events have not been documented at the end of 5 years the Interagency Review Team (IRT) will have to decide on an appropriate course of action.

2.1.3 Photographic Documentation of Site

Photographs will be used to document restoration success visually. Reference stations were photographed during the as-built survey; this will be repeated for at least five years following construction. Reference photos are taken once a year, from a height of approximately five to six feet. Permanent markers will ensure that the same locations (and view directions) are utilized during each monitoring period. Selected site photographs are shown in Appendix B.

2.1.3.1 Lateral Reference Photos

Reference photo transects were taken of the right and left banks at each permanent cross-section. A survey tape was captured in most photographs which represents the cross-section line located perpendicular to the channel flow. The water line was located in the lower edge of the frame in order

to document bank and riparian conditions. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.3.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored streams are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Lateral and structure photographs are used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function, and stability, and effectiveness of erosion control measures subjectively. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.1.4 Visual Stream Morphological Stability Assessment

The visual stream morphological stability assessment involves the qualitative evaluation of lateral and vertical channel stability, and the integrity and overall performance of in-stream structures throughout the Project reach as a whole. Habitat parameters, such as riffle embeddedness and pool depth maintenance, are also measured and scored. The entire project reach was walked, noting geomorphic conditions of the stream bed profile (riffle/pool facets), both stream banks, and engineered in-stream structures. Photos were taken at every stream photo reference station as discussed in the previous section, and in locations of potential SPAs which were documented in the field for subsequent mapping on the CCPV figures. A more detailed summary of the methodology and results for the visual stream stability assessment can be found in Appendix B which includes a technical memorandum, supporting data tables, and SPA photos.

2.2 Vegetation Assessment

Successful restoration of the vegetation on a mitigation site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, twelve vegetation monitoring quadrants were installed across the Project site. The total number of quadrants was calculated using the CVS-NCEEP Entry Tool Database version 2.2.7 (CVS-NCEEP, 2007). The size of individual quadrants varies from 100-square meters for tree species to 1-square meter for herbaceous vegetation. Level 1 CVS vegetation monitoring will occur in spring, after leaf-out has occurred, or in the fall prior to leaf fall. At the end of the first growing season during baseline surveys, species composition, density, and survival were evaluated. Individual quadrant data provided during subsequent monitoring events will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

The interim measure of vegetative success for the site is the survival of at least 320, 3-year old, planted trees per acre at the end of Year 3 of the monitoring period. The final vegetative success criteria is the survival of 260, 5-year old, planted trees per acre at the end of Year 5 of the monitoring period.

Photographs are used to visually document vegetation success in sample plots. Reference photos of tree and herbaceous condition within plots are taken at least once per year. As part of the visual site assessment conducted on May 18th, 2012, the vegetation condition of planted vegetation along stream banks, floodplains, and terraces were qualitatively evaluated for performance; this also included the documentation of invasive species and potential VPAs which were recorded in the field for subsequent mapping on the CCPV figures. A

more detailed summary of the methodology and results for the vegetation condition assessment can be found in Appendix B which includes a technical memorandum, supporting data tables, and photo logs.

3.0 REFERENCES

Carolina Vegetation Survey (CVS) and NC Ecosystem Enhancement Program (NCEEP). 2007. CVS-NCEEP Data Entry Tool v. 2.2.7. University of North Carolina, Raleigh, NC.

Lee, M., Peet R., Roberts, S., Wentworth, T. 2007. CVS-NCEEP Protocol for Recording Vegetation, Version 4.1.

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

APPENDIX A

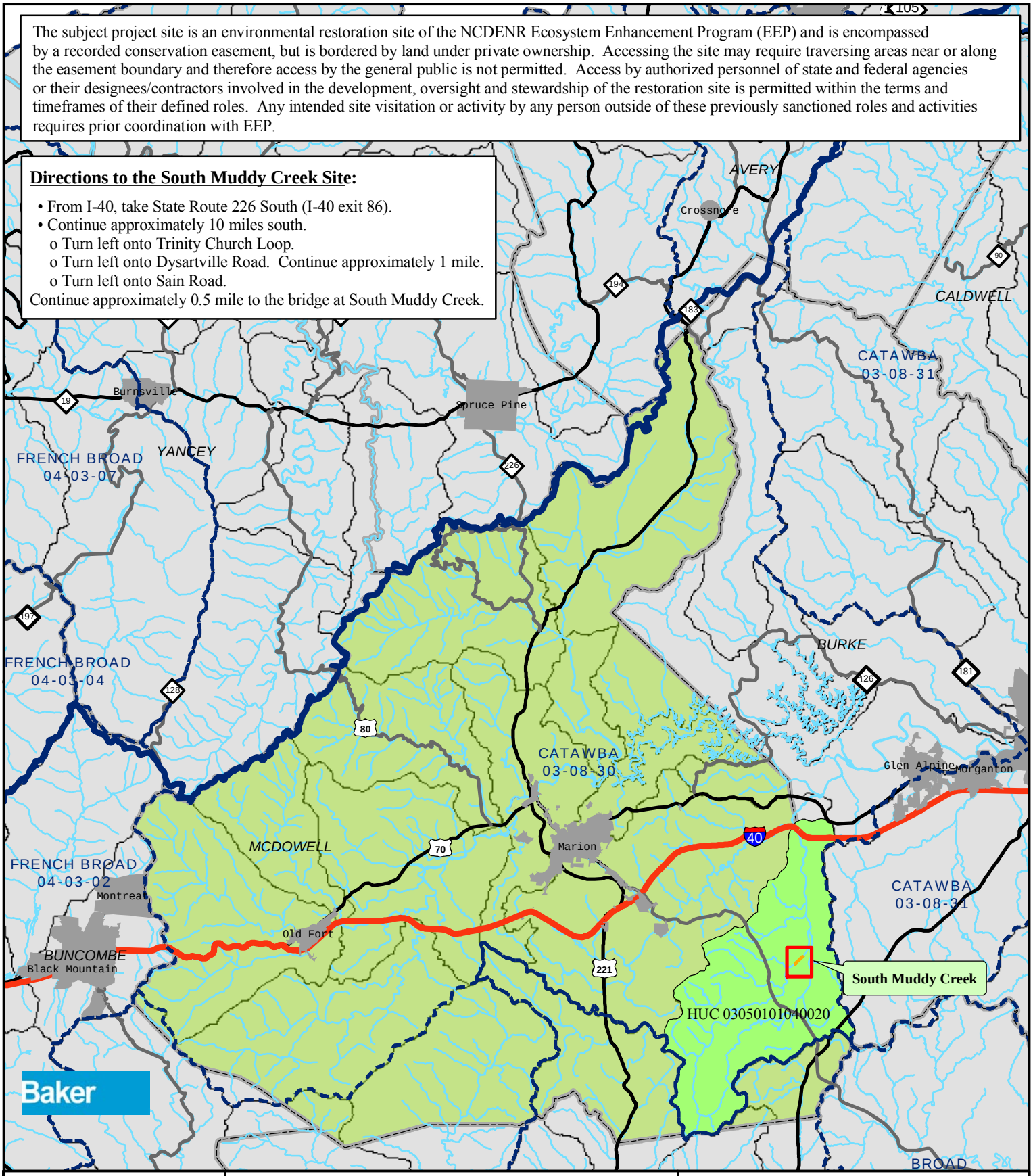
PROJECT VICINITY MAP AND BACKGROUND TABLES

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with EEP.

Directions to the South Muddy Creek Site:

- From I-40, take State Route 226 South (I-40 exit 86).
- Continue approximately 10 miles south.
  - o Turn left onto Trinity Church Loop.
  - o Turn left onto Dysartville Road. Continue approximately 1 mile.
  - o Turn left onto Sain Road.

Continue approximately 0.5 mile to the bridge at South Muddy Creek.



Map Vicinity

McDowell County, NC

Figure 1. Vicinity Map

South Muddy Creek Stream Restoration Project

McDowell County, NC

NCEEP Project No.: 737

November 2012

LEGEND:

- Project Area
- NCDWQ Sub-basin
- USGS Hydrologic Unit
- Counties

0 2.5 5 Miles

Table 1. Project Components
South Muddy Creek Mitigation Plan: EEP Project No. 737

Project Segment or Reach ID	Existing Feet/Acres*	Mitigation Type	Approach	Linear Footage or Acreage*	Stationing	Comment
South Muddy Creek	2,593	R	P2	2,787	10+00 - 38+77**	Installed in-stream structures to protect the stream bank from erosion and to provide aquatic habitat. Priority 2 was implemented to connect the channel to a newly evacated floodplain bench.

* Existing reach breaks and design reach breaks varied based on initial geomorphic differences and design requirements.

** Stationing includes 20 ft. of farm crossing above Sain Rd. and 70 ft. of Sain Rd. bridge crossing, but is not reflected in the reach length.

Component Summations

Restoration Level	Stream (LF)	Riparian Wetland (Ac)		Non-Ripar (Ac)	Upland (Ac)
		Riverine	Non-Riverine		
Restoration	2,787	-	-	-	-
Enhancement		-	-	-	-
Enhancement I	-				
Enhancement II	-				
Creation		-	-	-	-
Preservation	-	-	-	-	-
HQ Preservation	-	-	-	-	-
		-	-		
Totals	2,787	-		-	-

Table 2. Project Activity and Reporting History
South Muddy Creek Mitigation Plan: EEP Project No.737

Elapsed Time Since Grading/Planting Complete: 1 year 8 Months
Number of Reporting Years: 1

Activity or Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Restoration Plan Prepared	N/A	N/A	Jul-07
Restoration Plan Amended	N/A	N/A	Jan-08
Restoration Plan Approved	N/A	N/A	Aug-08
Final Design – (at least 90% complete)	N/A	N/A	Jun-09
Construction Begins	Jun-10	N/A	Jun-10
Temporary S&E mix applied to entire project area	N/A	N/A	N/A
Permanent seed mix applied to entire project area	Nov-10	N/A	Jan-11
Planting of live stakes	Mar-11	N/A	Mar-11
Planting of bare root trees	Mar-11	N/A	Mar-11
End of Construction	Mar-11	N/A	Jun-11
Survey of As-built conditions (Year 0 Monitoring-baseline)	Nov-10	N/A	Jun-11
Year 1 Monitoring	Dec-12	Sep-12	Nov-12
Year 2 Monitoring	Dec-13	N/A	N/A
Year 3 Monitoring	Dec-14	N/A	N/A
Year 4 Monitoring	Dec-15	N/A	N/A
Year 5 Monitoring	Dec-16	N/A	N/A

Table 3. Project Contacts Table South Muddy Creek Mitigation Plan: EEP Project No. 737	
Designer	
Michael Baker Engineering, Inc.	5550 Seventy-Seven Center Dr., Ste.320 Charlotte, NC 28217 Contact: Scott Hunt, Tel. 919-459-9003
Construction Contractor	
Carolina Environmental Contracting, Inc.	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Planting Contractor	
Carolina Environmental Contracting, Inc.	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Seeding Contractor	
Carolina Environmental Contracting, Inc. 12/11/2012	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Seed Mix Sources	Green Resources, Tel. 336-855-6363
Nursery Stock Suppliers	Foggy Mountain Nursery, Tel. 336-384-5323
Profession Land Surveyor	
Turner Land Survey, PLLC.	3201 Glenridge Drive Raleigh, NC 27604 Contact:
Profession Land Surveyor	David Turner, Tel. 919-875-1378
As-Built Plan Set Production	Lissa Turner, Tel. 919-875-1378
Monitoring Performers	
Michael Baker Engineering, Inc.	797 Haywood Road, Suite 201 Asheville, NC 28806 Contact:
Stream Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1408
Vegetation Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1409
Wetland Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1409

Table 4. Project Attribute Table South Muddy Creek Mitigation Plan: EEP Project No. 737	
Project County	McDowell County, NC
Physiographic Region	Piedmont
Ecoregion	Inner Piedmont Belt
Project River Basin	Catawba
USGS HUC for Project and Reference sites	Project: 03050101040020; References: 03040103050 -090 (Spencer Creek), -080 (Barnes Creek); 03030002060 -070 (Morgan Creek); 03020201080 -020 (Sal's Branch)
NCDWQ Sub-basin for Project and Reference	Project: 03-08-30; References: 03-07-09 (Spencer Creek and Barnes Creek); 03-06-06 (Morgan Creek); 03-04-02 (Sal's Branch)
Within extent of EEP Watershed Plan ?	Muddy Creek Local Watershed Plan (LWP), 2003
WRC Class (Warm, Cool, Cold)	Warm
% of project easement fenced or demarcated	100%
Beaver activity observed during design phase ?	None
Restoration Component Attribute Table	
	South Muddy
Drainage area (sq. mi.)	18.8
Stream order	4th
Restored length	2,787
Perennial or Intermittent	Perennial
Watershed type (Rural, Urban, Developing etc.)	Rural
Watershed LULC Distribution (e.g.)	
Developed Low-Medium Intensity	3.7
Ag-Cultivated Crops	0.6
Ag-Pasture/Hay	10.5
Forested	77.4
Other (Open water, Grassland, Etc.)	7.8
Watershed impervious cover (%)	U
NCDWQ AU/Index number	03-08-30
NCDWQ classification	C
303d listed ?	No
Upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor	N/A
Total acreage of easment	17.1
Total planted arceage as part of the restoration	14.1
Rosgen classification of pre-existing	G4c
Rosgen classification of As-built	C4
Valley type	Alluvial
Valley slope	0.0017 ft/ft
Valley side slope range (e.g. 2-3%)	U
Valley toe slope range (e.g. 2-3%)	U
Cowardin classification	Riverine, Upper Perennial, Unconsolidated Bottom, Cobble-Gravel
Trout waters designation	No
Species of concern, endangered etc.? (Y?N)	No
Dominant soil series and characteristics	
Series	IoA
Depth	10
Clay %	18
K	0.15
T	5

APPENDIX B

VISUAL ASSESSMENT DATA

Site Assessment Report – Monitoring Year 1

South Muddy Creek Stream Restoration Project
McDowell County, North Carolina
June 2012

Submitted To: NCDENR - Ecosystem Enhancement Program
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NCDENR Contract ID No. 004522

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1. Introduction

1.1 Purpose

This report summarizes overall stream and vegetation conditions as part of an interim site assessment conducted in conjunction with the Year 1 monitoring services for the South Muddy Creek Stream Restoration Project site located in McDowell County, NC. This site assessment will be included as part of a more comprehensive annual monitoring report to be completed and submitted later this year (fall 2012). The report describes project objectives, discusses the assessment methodology, summarizes assessment results, and documents potential stream and vegetation problem areas (SPAs and VPAs respectively).

1.2 Objectives

The objectives of the site assessment were to:

- provide a general overview of stream morphological stability;
- provide a general overview of vegetation conditions;
- identify and document potential SPAs and VPAs.

1.3 Supporting Data

Supporting data and information are provided following the narrative portion of this report and include:

- current condition plan view (CCPV) figures (Figure 2, sheets 1 and 2);
- visual stream morphology stability assessment table (Table 5a);
- SPA inventory table (Table 5b);
- vegetation condition assessment table (Table 6a);
- VPA inventory table (Table 6b);
- stream station photos;
- SPA photos;
- vegetation monitoring plot photos;
- VPA photos.

2 Methodology

The methodology used for assessing overall stream and vegetation conditions at the South Muddy Creek Stream Restoration Project site adhered to the most recent NCEEP monitoring guidance documents (dated November 7, 2011). The site assessment was comprised of two components, a visual stream morphology stability assessment and a vegetation condition assessment, both of which are described in more detail in the following sections of this report. The assessment was strictly qualitative except for that of the vegetation monitoring plot counts, which were conducted in order to determine whether or not the success criteria

were met per plot for illustrative purposes on the CCPV figures. All other vegetation monitoring plot data (tables) will be included in Appendix C of the Year 1 annual monitoring report to be submitted later this year.

The South Muddy Creek Stream Restoration Project site was evaluated as one project reach for each of the two components (SPA and VPA). This was done since the stream and riparian corridor are contained within one contiguous section along the mainstem of South Muddy Creek; site conditions appeared uniform allowing for an assessment as one reach and the project was assessed as one reach for the Final Baseline Monitoring Document/As-Built Report. Baker performed the visual site assessment on May 18th, 2012 and collected vegetation monitoring plot data on May 24th, 2012.

2.1 Visual Stream Morphology Stability Assessment

The visual stream morphology stability assessment involved the evaluation of lateral and vertical channel stability, and the integrity and overall performance of in-stream structures throughout the project reach as a whole. Habitat parameters, such as riffle embeddedness and pool depth maintenance, were also measured and scored. The entire 2,787 linear foot reach was walked, noting geomorphic conditions of the stream bed profile (riffle/pool facets), both stream banks, and engineered in-stream structures. Photos were taken at every existing stream photo point station (from the as-built) and in locations of potential SPAs which were recorded in the field for subsequent mapping on the CCPV figures.

2.2 Vegetation Condition Assessment

The vegetation condition assessment involved the evaluation of vegetation within the 17.1 acre conservation easement and included assessing the performance of planted vegetation along stream banks, floodplains, and terraces as well as the documentation of invasive species. The assessment of planted vegetation was confined to the 14.1 acres of riparian buffer planting zones within the easement boundary as part of the restoration design whereas invasive vegetation and encroachment areas of invasive species were evaluated for the entire 17.1 acre easement boundary. Vegetation plot data was collected as part of this assessment to determine the success criteria for illustrative purposes on the CCPV figures. Photos were recorded at each vegetation monitoring plot and in locations of potential VPAs throughout the easement, such as areas exhibiting sparse or slow growth/vigor, low stem density, and areas of invasive vegetation concern.

2.3 Post-processing of Field Data

The post-processing of field data consisted of the download and organization of photos into respective photo logs (stream and vegetation), creating the CCPV figures in GIS and AutoCAD using the field-mapped SPAs and VPAs, populating the SPA and VPA tables, and finally scoring the performance of the reach in terms of stream morphology stability and vegetation condition using assessment forms provided by NCEEP.

3 Summary of Results

3.1 Visual Stream Morphology Stability Assessment

Table 5a summarizes the performance of the South Muddy Creek Stream Restoration Project reach in terms of lateral (stream bank) and vertical (channel bed) stability while evaluating the functionality and integrity of in-stream structures. Engineered in-stream structures evaluated for the assessment of this project reach consisted of constructed riffles, rock/log j-hooks, log vanes, root wads, geolifts, and brush mattresses. Constructed riffles were justified for inclusion in the evaluation of structures since they are the predominant grade control structure used throughout the site; however, they were only assessed for the 'overall integrity' and 'grade control' parameter categories in Table 5a.

As Table 5a indicates, the South Muddy Creek site was geomorphically stable overall and performing at 100% as the design intended for the majority of parameters evaluated within the lateral/vertical stability and in-stream structure performance categories. The four sub-categories receiving scores of less than 100% corresponded to the three SPAs that were documented and summarized in Table 5b.

The three SPAs were characterized by localized areas of bank scour and were all located upstream of the Sain Road bridge. SPA1 consists of a short length of brush mattress compromised by an undercut bank between station 21+20 and 21+30; it is located along the right bank at the beginning of a meander bend. The brush mattress (and a portion of the staked and matted bank) appears to be separating from the right bank and overhanging from a combination of poor soil compaction and scour along the toe of bank. The brush originally installed behind the matting to armor the bank has washed away leaving the bank exposed and vulnerable to subsequent erosion. The scour could potentially be a result of the lack of centering of the thalweg immediately upstream of the meander bend where a riffle transitions to a run, and was noted accordingly in Table 5a. The bank protection provided by the remaining length of brush mattress along the right bank may become compromised and less effective over time if SPA1 is not stabilized and the scour (and instability) is allowed to continue to migrate further downstream by undermining the brush.

SPA2 and SPA3 consist of scoured portions of the left bank located within the first constructed riffle section upstream of the Sain Road bridge. Bank scour along these two adjacent problem areas appears to be caused by the lack of centering of the thalweg immediately downstream of the upstream meander bend. As a result, some velocity vectors within the riffle have been redirected toward the left bank instead of being centered in the riffle, thereby increasing near bank stress and causing the bank to erode. Bank erosion within SPA2 is moderate but more severe than that of SPA3 due to a deeper near bank third and thus higher near bank stress as the thalweg is located closer the toe of bank; the stream bank of SPA3 is vertical, exposed and devoid of vegetation and matted protection. SPA2 exhibits mild erosion but maintains a low bank angle and some surface protection in the form of existing matting, herbaceous vegetative cover, and scattered riprap material along the toe.

3.2 Vegetation Condition Assessment

Table 6a summarizes the vegetation condition of the South Muddy Creek Stream Restoration site. The planted acreage performance categories were functioning at 100% with no bare areas, low stem density areas, or areas of poor growth rates/vigor to report. The success criteria or survival threshold for all 12 vegetation monitoring plots were attained. Invasive areas of concern were observed and documented accordingly in Table 6a and as VPAs in Figure 2 and Table 6b.

Ten discrete areas of invasive species were documented throughout the site and totaled approximately 1 acre, or 5.7% of the total easement acreage. This resulted in 8 VPAs since two adjacent pairs of mapped polygons, exhibiting uniform invasive species compositions conditions, were combined into two individual VPAs.

The largest VPA and most critical in warranting treatment is VPA6, which is located in the right terrace downstream of the Sain Road bridge, and is comprised of kudzu (*Pueraria lobata*). Kudzu is considered by NCEEP to be a 'high concern' invasive vine because of its potential to proliferate rapidly and out-compete other native species planted within the easement buffer. It was difficult discerning the source of the kudzu but may be originating from the existing tree cluster on the terrace where other invasive species, such as privet (*Ligustrum sinense*) and multiflora rose (*Rosa multiflora*), were documented for VPA5. VPA6 occupies a large width of the right terrace between the top of terrace and the easement boundary fence line and was observed extending down the terrace slopes toward the right floodplain bench.

VPA2 represents the second largest VPA and consists of trumpet creeper vines (*Campsis radicans*) located in and around vegetation monitoring plots 4 and 5. These areas were previously identified in the Final Baseline Monitoring Document/As-Built Report as areas of concern and were recently scheduled for treatment and removal prior to this assessment. The vines look as though they may have been treated but new growth was observed and are still persisting.

VPA3, VPA4, and VPA5 comprise the next largest VPAs and are characterized as existing tree stands containing persisting invasive vegetation. Privet and multiflora rose was observed in all three VPAs while Japanese honeysuckle (*Lonicera japonica*) was only documented in VPA4. Existing tree stands precluded from removal during construction (that originally contained invasive species) can often be a source of invasive vegetation even after treatment since the soil matrix is undisturbed leaving roots and seeds intact. These areas were previously treated but were exhibiting new growth and are still persisting.

VPA1, VPA7, and VPA8 represent the smallest VPAs and are part of existing tree stands located around the periphery of the easement. These areas appear to have been previously treated but are also still persisting with new growth.

As an update to additional areas of concern reported in the Final Baseline Monitoring Document/As-Built Report, there were no signs of kudzu in the right floodplain upstream of

the Sain Road bridge; this area was previously scheduled for treatment and removal of kudzu prior to the assessment. No mimosa trees were observed encroaching into the easement along the right terrace from the nursery immediately bordering the easement. However, Canadian thistle (*Cirsium arvense*) was observed flourishing in the nursery in close proximity to the easement boundary fence line in the right terrace just upstream of the Sain Road bridge, and should continue to be monitored to minimize encroachment and invasion of the site.

CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

ASBUILT CHANNEL

FENCE

X–# CROSS SECTION

PHOTO ID POINT

VP VEGETATION PLOT

VEGETATION PROBLEM AREA (VPA)
INVASIVE SPECIES PRESENT

VEGETATION PLOT MEETING CRITERIA
(ALL PLOTS CURRENTLY MEETING CRITERIA)

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA (SPA)
UNDERCUT BANKS

STREAM PROBLEM AREA (SPA)
BANKS WITH EVIDENT SCOUR/EROSION

STREAM PROBLEM AREA (SPA)
BANK SLUMPING/CALVING/COLLAPSE
(NO AREAS EXHIBITING PROBLEM)

VEG PLOT CRITERIA ATTAINMENT		
VEG PLOT ID	SURVIVAL THRESHOLD MET?	TOTAL/PLANTED STEM COUNT
1	Y	567/486
2	Y	2023/809
3	Y	769/809
4	Y	647/728
5	Y	850/688
6	Y	850/486

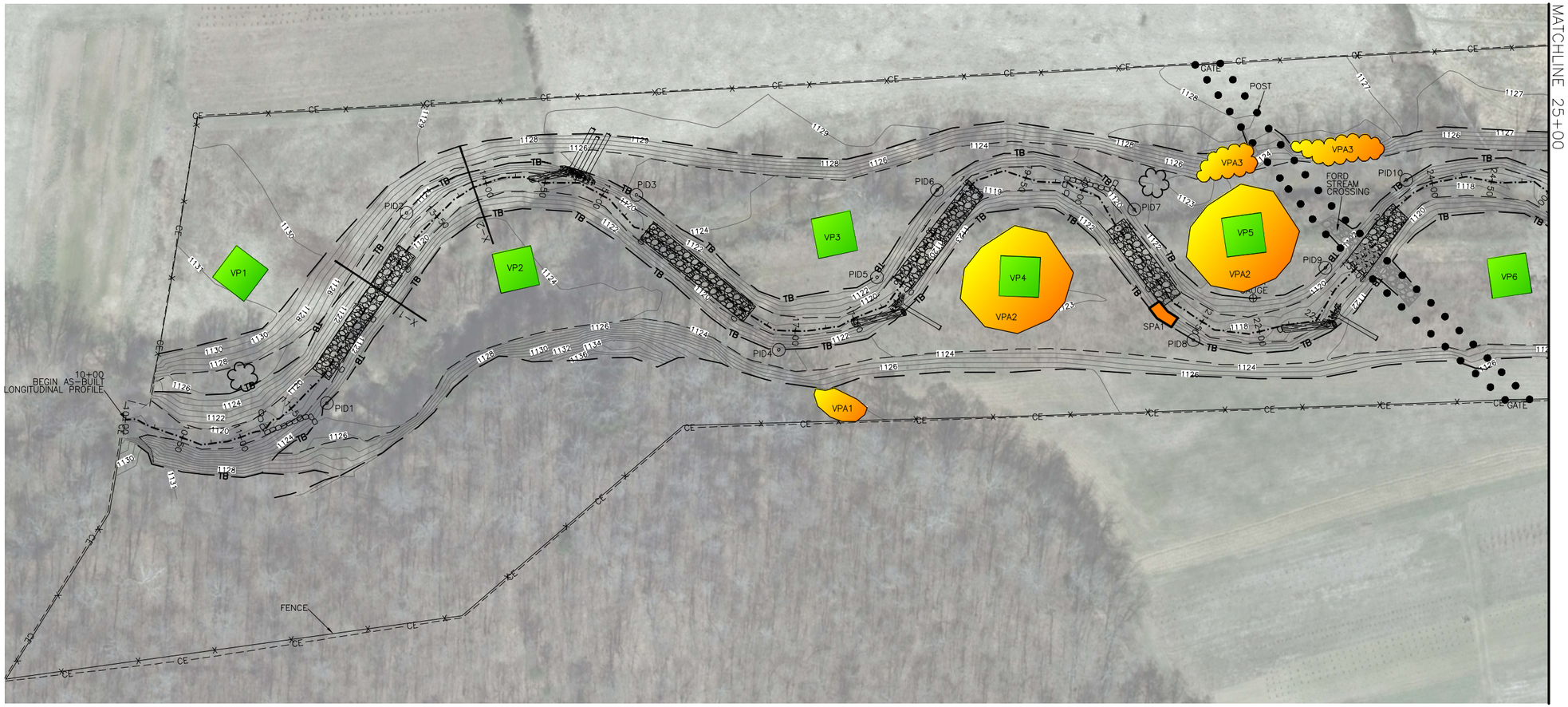

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

50 0 50 100

SOUTH MUDDY CREEK
CURRENT CONDITION PLAN VIEW
YEAR 1 MONITORING
STA. 10+00–25+00

Michael Baker Engineering Inc.
NC Engineering License F-1084
797 Haywood Road, Suite 201
Asheville, North Carolina 28806
Phone: 828.350.1408
Fax: 828.350.1409

Baker

SOUTH MUDDY CREEK
STREAM RESTORATION PROJECT
MCDOWELL COUNTY, NORTH CAROLINA

Ecosystem Enhancement

Prepared for:
Ecosystem Enhancement Program
2728 Capitol Blvd, Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No.	737
Baker Project No.	128221
Date:	11/27/12
DESIGNED:	---
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	1 of 5
Sheet:	1 of 2

CE CONSERVATION EASEMENT

ASBUILT CENTERLINE

TB ASBUILT TOP OF BANK

ASBUILT CHANNEL

FENCE

X–# CROSS SECTION

PHOTO ID POINT

VP VEGETATION PLOT

VEGETATION PROBLEM AREA (VPA)
INVASIVE SPECIES PRESENT

VEGETATION PLOT MEETING CRITERIA
(ALL PLOTS CURRENTLY MEETING CRITERIA)

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA (SPA)
UNDERCUT BANKS

STREAM PROBLEM AREA (SPA)
BANKS WITH EVIDENT SCOUR/EROSION

STREAM PROBLEM AREA (SPA)
BANK SLUMPING/CALVING/COLLAPSE
(NO AREAS EXHIBITING PROBLEM)

VEG PLOT CRITERIA ATTAINMENT

VEG PLOT ID	SURVIVAL THRESHOLD MET?	TOTAL/PLANTED STEM COUNT
7	Y	607/526
8	Y	486/688
9	Y	405/445
10	Y	567/688
11	Y	445/445
12	Y	486/728

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

50 0 50 100

SOUTH MUDDY CREEK
CURRENT CONDITION PLAN VIEW
YEAR 1 MONITORING
STA. 25+00–38+77

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SOUTH MUDDY CREEK
STREAM RESTORATION PROJECT
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737

Baker Project No.
128221

Date:
11/27/12

DESIGNED: ---
DRAWN: MDR
APPROVED: MMC

Monitoring Year:
1 of 5

Sheet:
2 of 2

Table 5a. **Visual Stream Morphology Stability Assessment**

Reach ID **South Muddy Creek**

Assessed Length (LF) **2787**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number per As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Veg.	Footage with Stabilizing Woody Veg.	Adjusted % for Stabilizing Woody Veg.
1. Bed	**1. Vertical Stability**	1. Aggradation			0	0	100%			
		2. Degradation			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate	11	11			100%			
	3. Meander Pool Condition	1. Depth	12	12			100%			
		2. Length	12	12			100%			
	4. Thalweg position	1. Thalweg centering at upstream of meander bend (Run)	11	12			92%			
		2. Thalweg centering at downstream of meander (Glide)	10	11			91%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			2	60	99%	0	0	99%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely			1	10	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	3	70	99%	0	0	99%
3. Engineering Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs	37	38			97%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	11	11			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms	9	9			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%	27	27			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth	9	9			100%			

Table 5b. Stream Problem Areas South Muddy Creek Restoration Project: Project No. 737			
South Muddy Creek (2,787 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Bank Scour	21+20 to 21+30	Right bank (including brush mattress and matting) separating and beginning to slump at beginning of outer meander bend from a combination of poor compaction and scour along the toe of bank.	SPA1
	27+90 to 28+10	Localized scour along left bank resulting in raw, vertical bank, devoid of vegetation and matted protection. Cause appears to be localized eddying within the riffle.	SPA2
	28+40 to 28+80	Localized scour along left bank from what appears to be localized eddying within the riffle.	SPA3

Table 6a. **Vegetation Condition Assessment**

Reach ID **South Muddy Creek**

Planted Acreage **14.1**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres	NA	0	0.00	0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	NA	0	0.00	0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	NA	0	0.00	0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage **17.1**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000 SF	see figure	10	0.97	5.7%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	NA	0	0.00	0.0%

Table 6b. Vegetation Problem Areas South Muddy Creek Restoration Project: Project No. 737			
South Muddy Creek			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Invasive/Exotic Populations	17+25 (right terrace)	*Rosa multiflora* : persisting after treatment	VPA1
	18+00 to 21+00 (right flood bench)	*Campsis radicans* persisting after treatment	VPA2
	20+50 to 23+00 (left flood bench)		
	21+75 to 23+75 (left terrace slope)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA3
	25+50 to 28+50 (left terrace slope)	*Rosa multiflora, Ligustrum sinense,* and *Lonicera japonica* : persisting after treatment within existing tree stand	VPA4
	35+00 to 36+50 (right terrace)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA5
	35+00 to 37+25 (right terrace)	*Pueraria lobata* : persisting after treatment within existing tree stand, terrace, and terrace slope	VPA6
	38+75 (downstream project limits along right bank/terrace)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA7
	38+75 (downstream project limits along left bank/terrace)	*Lonicera japonica* : persisting after treatment within existing tree stand/potential encroachment from outside	VPA8

South Muddy Creek
Stream Station Photos

South Muddy Creek PID 1 – J-Hook near upstream end of project

South Muddy Creek PID 2 –Constructed Riffle,

South Muddy Creek PID 3 – Log Vane in Meander

South Muddy Creek PID 4 – Constructed Riffle

South Muddy Creek PID 5 – Log Vane in Meander

South Muddy Creek PID 6 – Constructed Riffle

South Muddy Creek PID 7 – J-Hook in Meander

South Muddy Creek PID 8 – Constructed Riffle

South Muddy Creek PID 9 – Log Vane in Meander

South Muddy Creek PID 10 – Stream Crossing

South Muddy Creek PID 11 – Constructed Riffle

South Muddy Creek PID 12 – Log Vane and Root Wad in Meander

South Muddy Creek PID 13 – Constructed Riffle

South Muddy Creek PID 14 – Immediately upstream of Sain Road crossing

South Muddy Creek PID 15 – Constructed Riffle downstream of Sain Road crossing

South Muddy Creek PID 16

South Muddy Creek PID 17 – Log Vane in Meander

South Muddy Creek PID 18 – Constructed Riffle

South Muddy Creek PID 19

South Muddy Creek PID 20 – J-Hook near downstream end of project

South Muddy Creek
Stream Problem Area (SPA) Photos

SPA1 – Right bank separating/overhanging from poor compaction and scour along toe of bank (looking upstream)

SPA2 – Localized scour along left bank from eddying within the riffle (looking downstream)

SPA3 – Localized scour along left bank from eddying within the riffle (looking upstream)

South Muddy Creek
Vegetation Plot Photos

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

Notes:
1. Herbaceous plot located in foreground of each photo.

5/24/2012 - Photo 1: Veg Plot 1

5/24/2012 - Photo 2: Veg Plot 1: Herbaceous Plot

5/24/2012 - Photo 3: Veg Plot 2

5/24/2012 - Photo 4: Veg Plot 2: Herbaceous Plot

5/24/2012 - Photo 5: Veg Plot 3

5/24/2012 - Photo 6: Veg Plot 3: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo 7: Veg Plot 4

5/24/2012 - Photo 8: Veg Plot 4: Herbaceous Plot

5/24/2012 - Photo 9: Veg Plot 5

5/24/2012 - Photo 10: Veg Plot 5: Herbaceous Plot

5/24/2012 - Photo Point 11: Veg Plot 6

5/24/2012 - Photo Point 12: Veg Plot 6: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo Point 13: Veg Plot 7

5/24/2012 - Photo Point 14: Veg Plot 7: Herbaceous Plot

5/24/2012 - Photo Point 15: Veg Plot 8

5/24/2012 - Photo Point 16: Veg Plot 8: Herbaceous Plot

5/24/2012 - Photo Point 17: Veg Plot 9

5/24/2012 - Photo Point 18: Veg Plot 9: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo Point 19: Veg Plot 10

5/24/2012 - Photo Point 20: Veg Plot 10: Herbaceous Plot

5/24/2012 - Photo Point 21: Veg Plot 11

5/24/2012 - Photo Point 22: Veg Plot 11: Herbaceous Plot

5/24/2012 - Photo Point 23: Veg Plot 12

5/24/2012 - Photo Point 24: Veg Plot 12: Herbaceous Plot

South Muddy Creek
Vegetation Problem Area (VPA) Photos

VPA1 – Multiflora Rose

VPA2 – Trumpet vine persisting after treatment

VPA3 – Multiflora Rose and Chinese Privet

VPA4 – Multiflora Rose, Chinese Privet, Honeysuckle

VPA5 - Multiflora Rose and Chinese Privet

VPA6 – Kudzu persisting after treatment

VPA7 - Multiflora Rose and Chinese Privet

VPA8 – Japanese Honeysuckle

APPENDIX C

VEGETATION PLOT DATA

Table 7. Vegetation Plot Criteria Attainment South Muddy Creek Mitigation Plan: EEP Project No. 737			
Vegetation Plot ID	**Vegetation Survival Threshold Met?**	**Total/Planted Stem Count***	**Tract Mean**
1	Y	567/486	725
2	Y	2023/809	
3	Y	769/809	
4	Y	647/728	
5	Y	850/688	
6	Y	850/486	
7	Y	607/526	
8	Y	486/688	
9	Y	405/445	
10	Y	567/688	
11	Y	445/445	
12	Y	486/728	
Note: *Total/Planted Stem Count reflects the changes in stem density based on the density of stems at the time of the As-Built Survey (Planted) and the current total density of planted stems including volunteers (Total).			

Table 8. CVS Vegetation Plot Metadata South Muddy Creek Mitigation Plan: EEP Project No. 737	
Report Prepared By	Carmen Horne-McIntyre
Date Prepared	6/6/2012 12:18
Database name	cvs-eep-entrytool-v2.2.7_South Muddy_Hoppers.mdb
Database location	L:\Monitoring\Monitoring Guidance\Vegetation\CVS EEP Entrytool V2.2.7
Computer name	ASHEWCMCINTYR
File size	28475392
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY	
Project Code	92251
Project Name	South Muddy Cr. Stream Restoration
Description	This mitigation project consists of 7,389 LF of stream restoration and preservation efforts on South Muddy Creek and South Fork Hoppers (including 1 unnamed tributary) at the Melton Farm.
River Basin	Catawba
Length(ft)	7389
Stream-to-edge width (ft)	120
Area (sq m)	164733.86
Required Plots (calculated)	24
Sampled Plots	12

Table 9. CVS Stem Count Total and Planted by Plot and Species (with Annual Means)
South Muddy Creek Mitigation Plan: EEP Project No. 737

Tree Species	Common Name	Type	Current Data (MY1 2012)																						Annual Means									
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9		Plot 10		Plot 11		Plot 12		Current Mean		AB (2011)		MY2 (2013)		MY3 (2014)		MY4 (2015)		MY5 (2016)	
			P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Betula nigra	River Birch	Tree	1	1	2	2			5	3	5	1	1	0	5	4	2	2					3	3			3	2	3	3								
Celtis laevigata	Sugarberry	Shrub	3	2	1	1	4	1			2	1	0	1	1	1	1	1	0	1							2	1	2	2								
Diospyros virginiana	Persimmon	Tree			0	3					0	3				1			0	3			0	1	0	3	0	3	2	2								
Fraxinus pennsylvanica	Green Ash	Tree			4	4	2	1	1	1	2	2			1	2	1	0	4	4	5	5			2	2	2	3	2	2								
Juglans nigra	Black Walnut	Tree									1	1	2	1	2	2							1	1			2	1	2	2								
Liriodendron tulipfera	Tulip Poplar	Tree	4	3	6	5	5	5	5	5	2	1	3	2					3	2			1	1	4	1	4	3	4	4								
Nyssa sylvatica	Blackgum	Tree							1	1																	1	1	1	1								
Platanus occidentalis	Sycamore	Tree	1	0	4	4	7	7	3	3	3	5			2	2	4	4	1	0	4	4	4	4	9	5	4	3	4	4								
Quercus pagoda	Cherrybark Oak	Tree									0	3															0	3	0	0								
Quercus palustris	Pin Oak	Tree	3	0			2	0	2	2	2	0	3	3	1		3	1	2	0	1	0	1	0	3	1	2	1	2	2								
Quercus phellos	Willow Oak	Tree					0	4							1	1			1	0			1	0			1	1	1	1								
Quercus rubra	N. Red Oak	Shrub	0	2	3	0			1	0			3	2			6	2			7	5					3	2	4	4								
Volunteers																																						
Acer rubrum	Red Maple	Tree																																				
Diospyros virginiana	Persimmon	Tree																						1				1										
Juglans nigra	Black Walnut	Tree		2								4																3										
Liriodendron tulipfera	Tulip Poplar	Tree		2		5				1						1		2										2										
Platanus occidentalis	Sycamore	Tree		1		25		1						12														10										
Quercus rubra	N. Red Oak	Tree		1		1										1												1										
	Plot area (acres)		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025													
	Species Count		5	6	6	7	5	5	7	6	7	8	5	6	7	9	6	6	5	4	4	3	6	5	4	5	6	6	6	6								
	Planted Stems/Plot		12	8	20	19	20	18	18	15	17	17	12	9	13	13	17	10	11	10	17	14	11	10	18	12	16	13	16	16								
P=Planted	Total Stems/Plot		12	14	20	50	20	19	18	16	17	21	12	21	13	15	17	12	11	10	17	14	11	11	18	12	16	18	16	16								
T=Total	Planted Stems Per Acre		486	324	809	769	809	728	728	607	688	688	486	364	526	526	688	405	445	405	688	567	445	405	728	486	627	523	627	627								
	Total Stems Per Acre (including volunteers)		567		2023		769		647		850		850		607		486		405		567		445		486		725		627	627								

Notes: CVS Level 1 Survey performed. In most cases, the volunteers observed were less than 10 cm in height. The information presented is purely for providing information about the species of trees that may occupy the riparian area that were not planted. In Plot 2, multiple sycamore seedlings noted; counting stopped at 25.

APPENDIX D

STREAM SURVEY DATA

South Muddy Creek

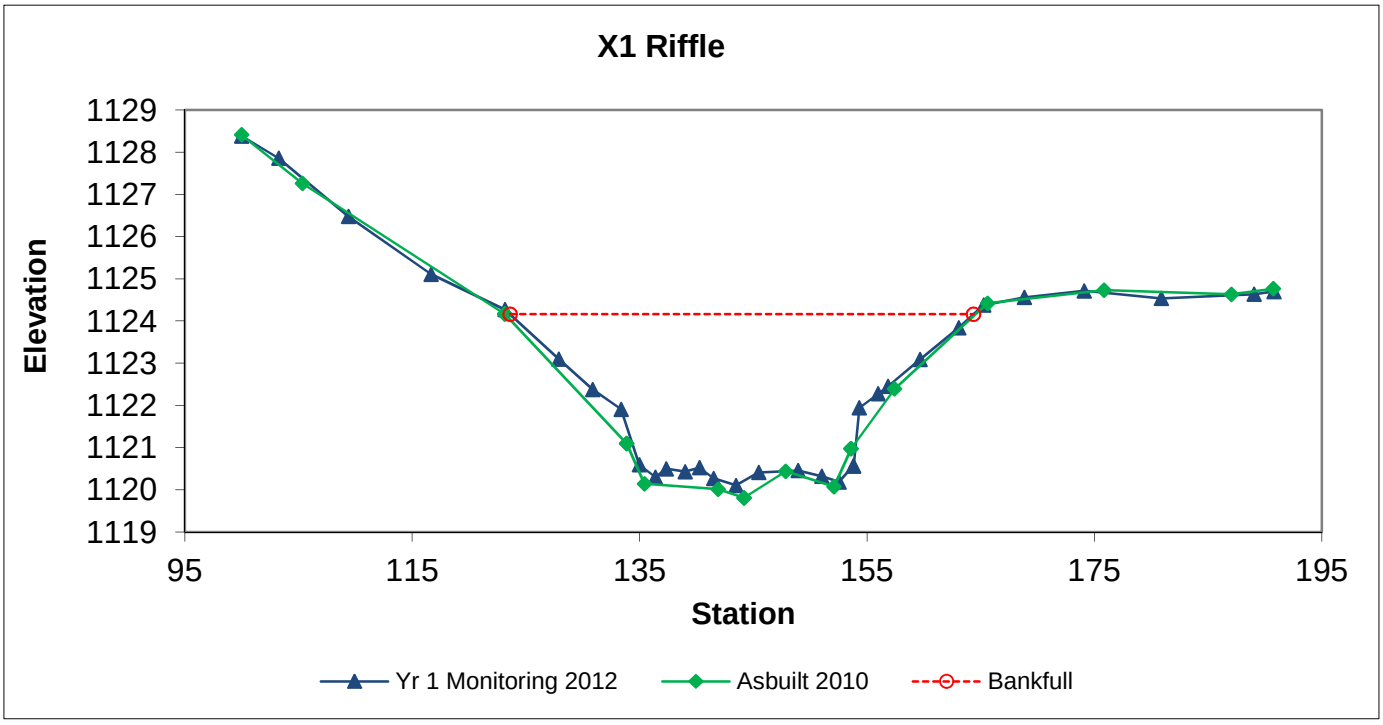
Permanent Cross Section X1

(Year 1 Monitoring - September 2012)

LEFT BANK

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	100.5	40.78	2.46	4.06	16.54	1.1	2.2	1124.16	1124.72



South Muddy Creek

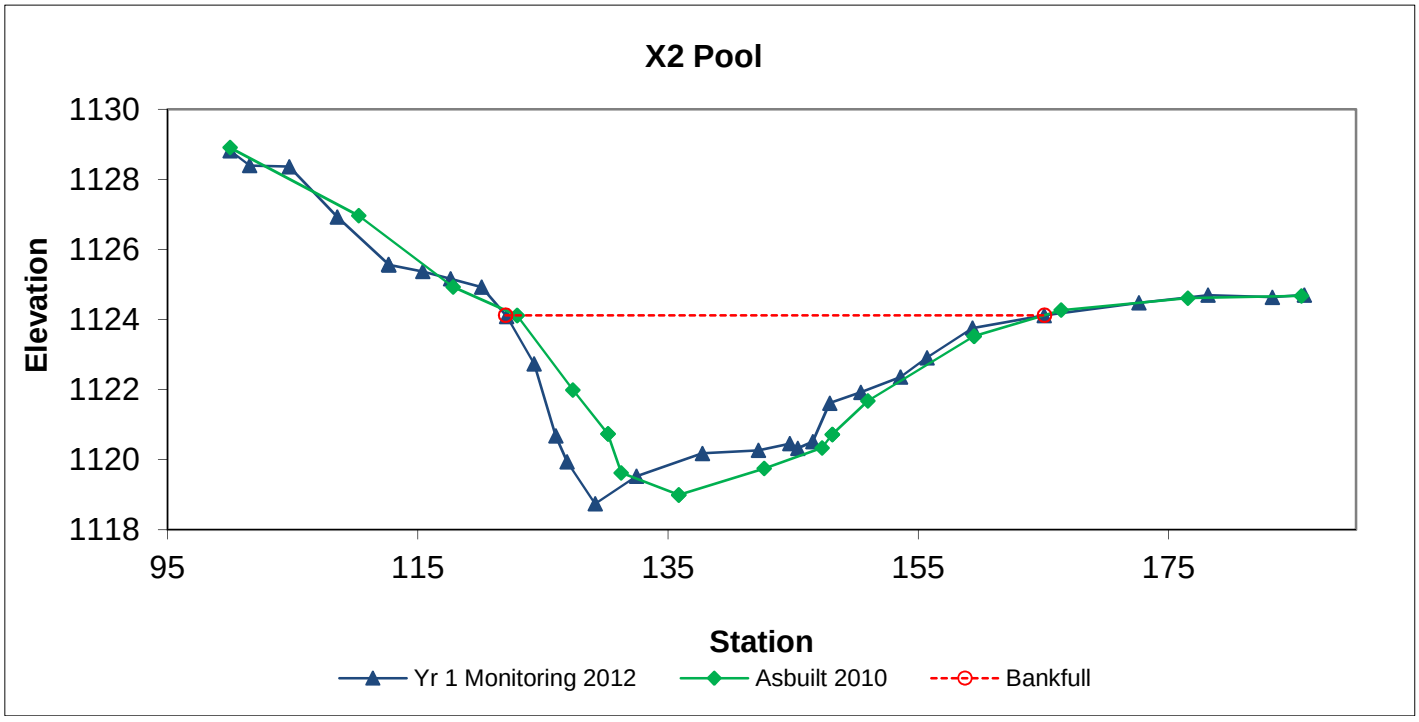
Permanent Cross Section X2

(Year 1 Monitoring - September 2012)

LEFT BANK

RIGHT BANK

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		115.8	43.06	2.69	5.38	16.01	1.1	2	1124.12	1124.7



South Muddy Creek

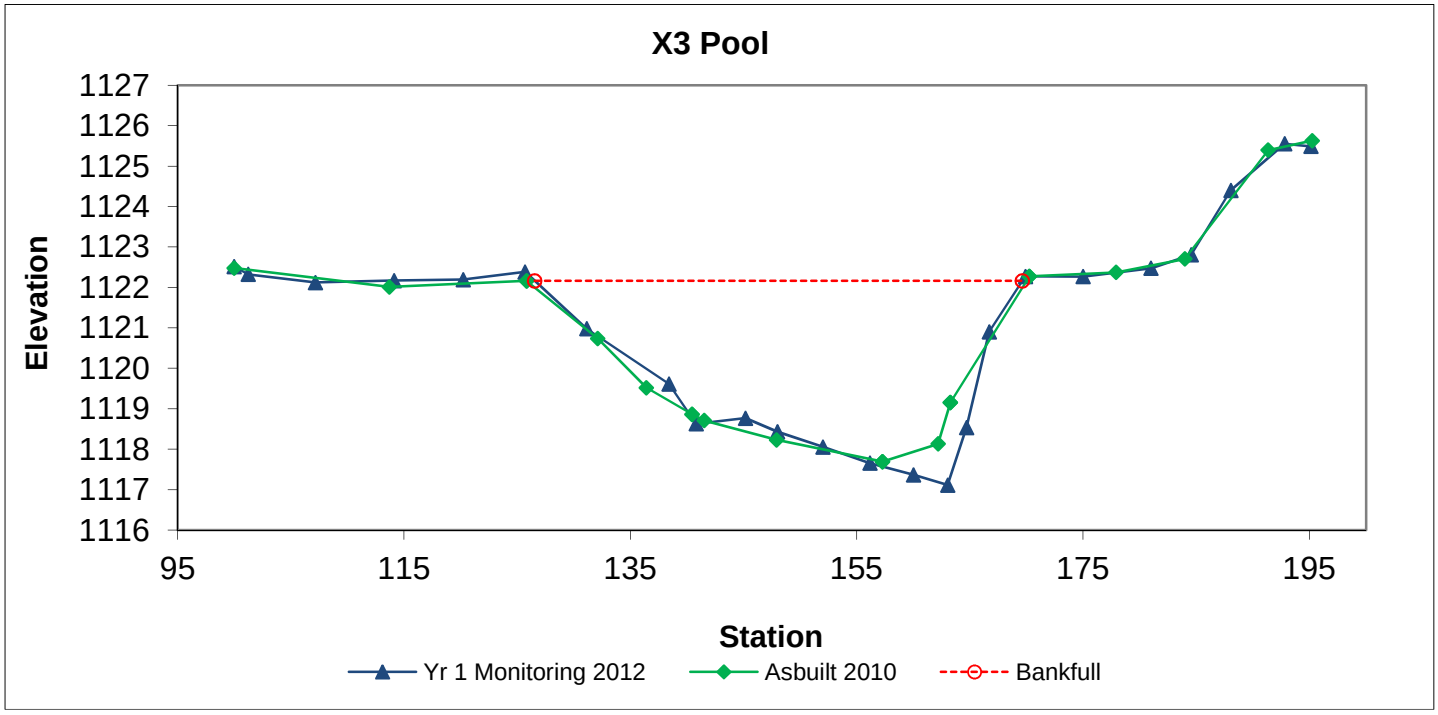
Permanent Cross Section X3

(Year 1 Monitoring - September 2012)

LEFT BANK

RIGHT BANK

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		129	43.08	2.99	5.05	14.39	1	2.2	1122.2	1122.27



South Muddy Creek

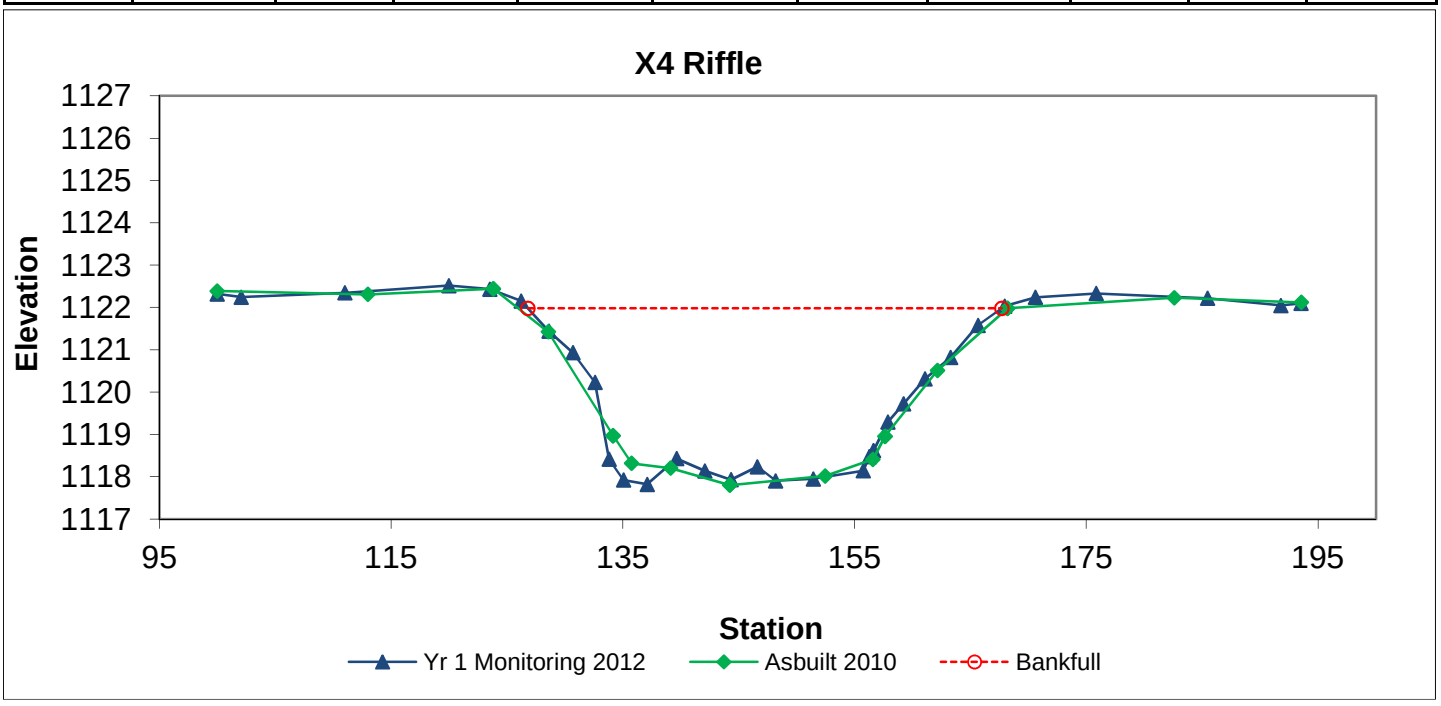
Permanent Cross Section X4

(Year 1 Monitoring - September 2012)

LEFT BANK

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	113.3	40.89	2.77	4.16	14.75	1	2.3	1121.98	1122.03



South Muddy Creek
Profile Chart
Year 1 Monitoring - September 2012

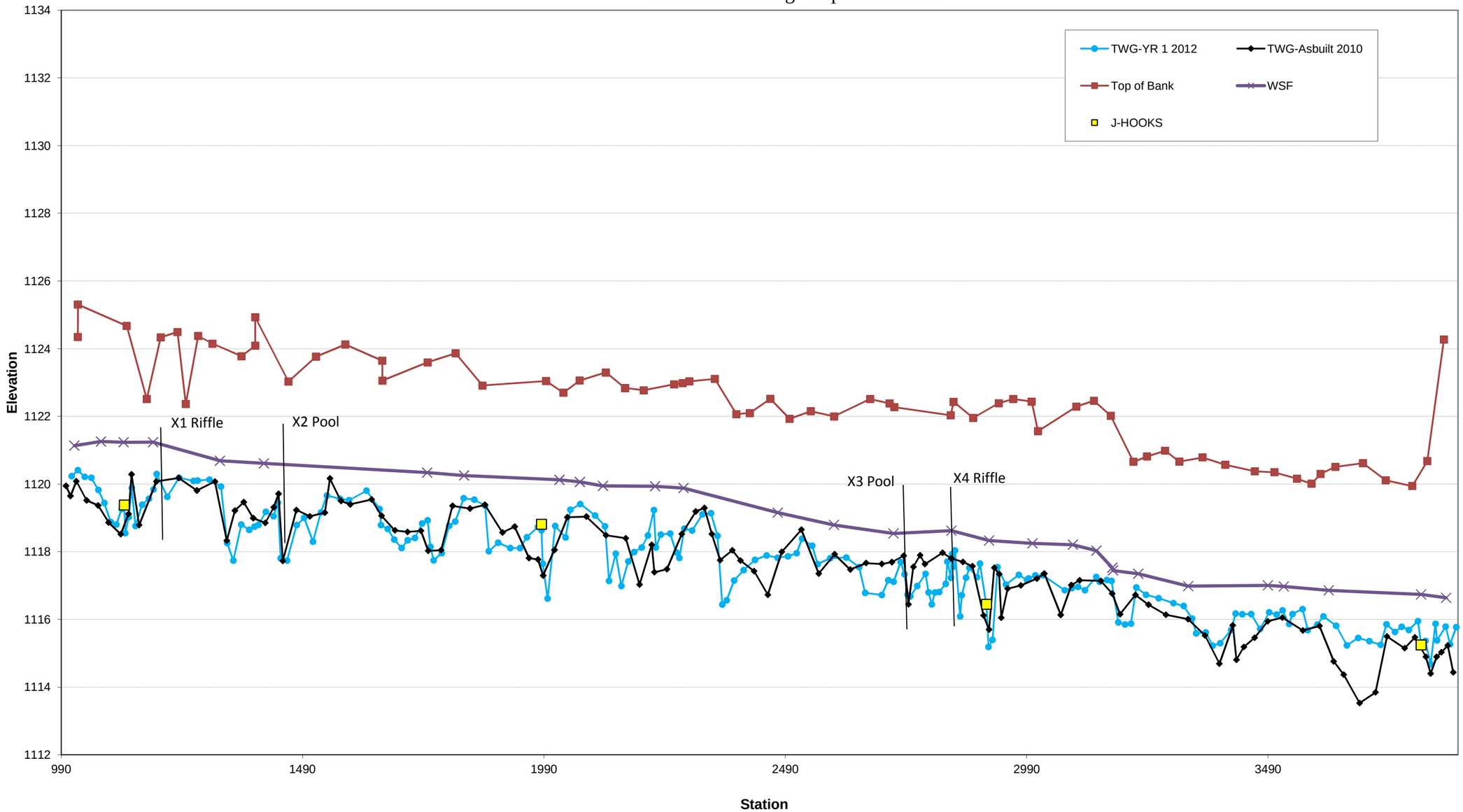
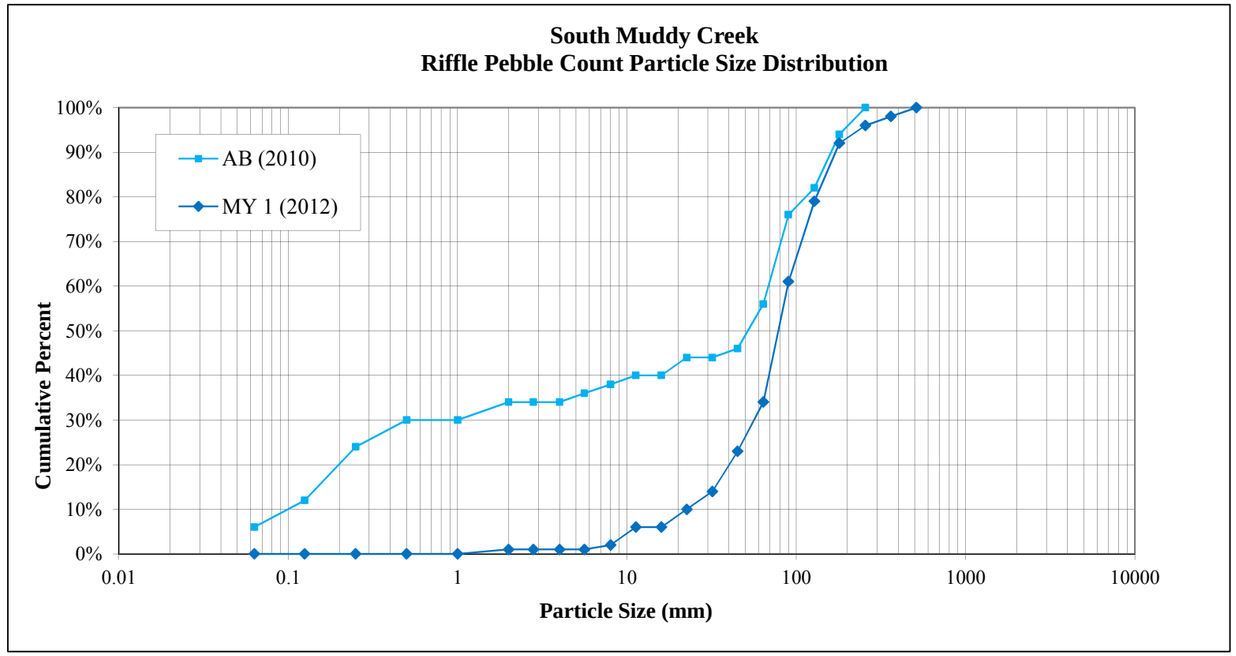


Figure 5. Riffle Pebble Count Size Class Distribution with Annual Overlays

BAKER PROJECT NO.	128221
SITE OR PROJECT:	South Muddy Creek Stream Restoration Project
REACH/LOCATION:	South Muddy Creek - Cross-section 4 (Riffle)
DATE COLLECTED:	9/12/2012
FIELD COLLECTION BY:	mw re
DATA ENTRY BY:	mw re

			PARTICLE CLASS COUNT	Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Class %	% Cum
SILT/CLAY	Silt / Clay	< .063			0%
SAND	Very Fine	.063 - .125			0%
	Fine	.125 - .25			0%
	Medium	.25 - .50			0%
	Coarse	.50 - 1.0			0%
	Very Coarse	1.0 - 2.0	1	1%	1%
GRAVEL	Very Fine	2.0 - 2.8			1%
	Very Fine	2.8 - 4.0			1%
	Fine	4.0 - 5.6			1%
	Fine	5.6 - 8.0	1	1%	2%
	Medium	8.0 - 11.0	4	4%	6%
	Medium	11.0 - 16.0			6%
	Coarse	16.0 - 22.6	4	4%	10%
	Coarse	22.6 - 32	4	4%	14%
	Very Coarse	32 - 45	9	9%	23%
	Very Coarse	45 - 64	11	11%	34%
COBBLE	Small	64 - 90	27	27%	61%
	Small	90 - 128	18	18%	79%
	Large	128 - 180	13	13%	92%
	Large	180 - 256	4	4%	96%
BOULDER	Small	256 - 362	2	2%	98%
	Small	362 - 512	2	2%	100%
	Medium	512 - 1024			
	Large-Very Large	1024 - 2048			
BEDROCK	Bedrock	> 2048			
		Total	100	100%	100%

Cummulative	
Channel materials (mm)	
D_{16} =	34.5
D_{35} =	64.8
D_{50} =	78.3
D_{84} =	145.9
D_{95} =	234.4
D_{100} =	362 - 512



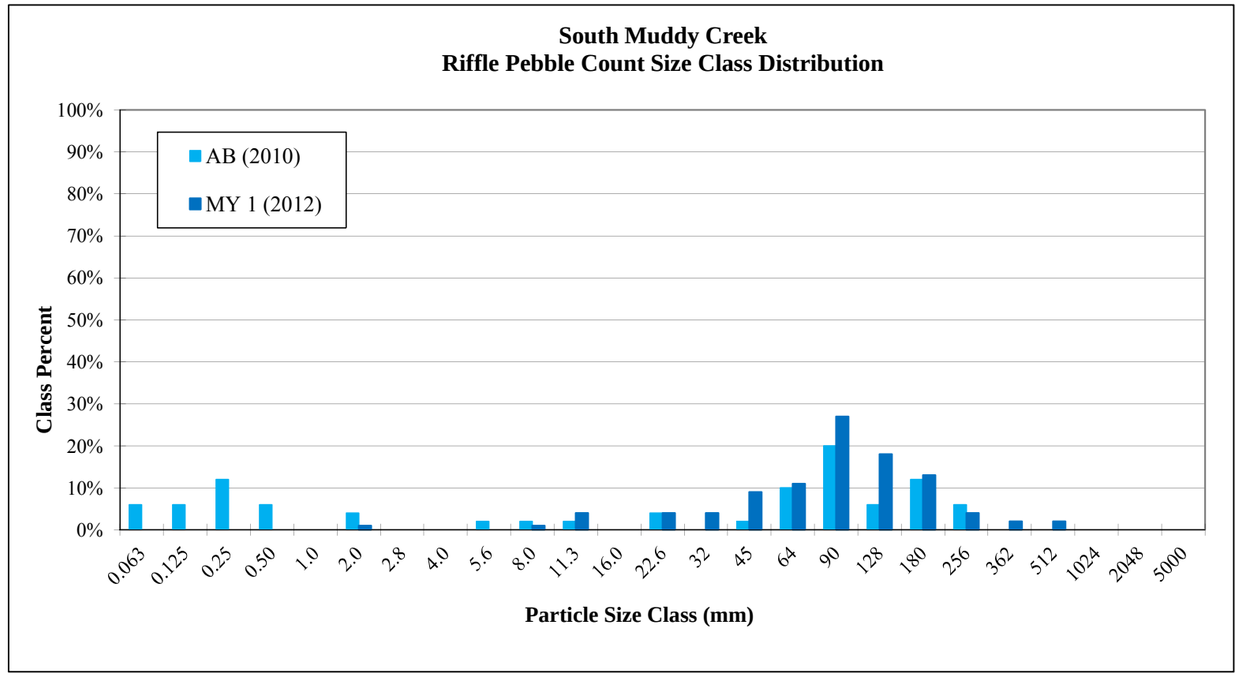


Table 10. Baseline Stream Summary
South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

Parameter	USGS Gauge	Regional Curve Interval (Harman et al, 1999)[1]			Pre-Existing Condition						Reference Reach(es) Data												Design						Monitoring Baseline (As-built)					
											Morgan Creek						Barnes Creek																	
		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
Dimension and Substrate - Riffle																																		
BF Width (ft)	-----	23.0	80.0	42.0	24.1	32.3	-----	51.2	-----	5	33.2	-----	-----	33.5	-----	2	60.7	-----	-----	69	-----	2	-----	43.2	-----	-----	-----	1	41.4	-----	-----	42.2	-----	2
Floodprone Width (ft)	-----	-----	-----	-----	29.6	44.8	-----	72.7	-----	5	77.5	-----	-----	86.8	-----	2	219	-----	-----	220	-----	2	-----	210+	-----	-----	-----	1	90.7	-----	-----	93.6	-----	2
BF Mean Depth (ft)	-----	2.3	5.8	3.8	1.9	2.7	-----	3.0	-----	5	2.3	-----	-----	2.4	-----	2	2.9	-----	-----	3.8	-----	2	-----	3.0	-----	-----	-----	1	2.7	-----	-----	2.8	-----	2
BF Max Depth (ft)	-----	-----	-----	-----	3.3	3.6	-----	4.0	-----	5	2.8	-----	-----	2.9	-----	2	3.9	-----	-----	5.2	-----	2	-----	4.2	-----	-----	-----	1	4.2	-----	-----	4.4	-----	2
BF Cross-sectional Area (ft²)	-----	80.0	300.0	157.6	72.8	83.8	-----	97.2	-----	5	75.1	-----	-----	79.8	-----	2	199	-----	-----	288	-----	2	-----	128.5	-----	-----	-----	1	110.8	-----	-----	115.9	-----	2
Width/Depth Ratio	-----	-----	-----	-----	8.1	12.9	-----	26.9	-----	5	14.1	-----	-----	14.7	-----	2	16	-----	-----	23.8	-----	2	-----	14.4	-----	-----	-----	1	15.4	-----	-----	15.5	-----	2
Entrenchment Ratio	-----	-----	-----	-----	1.1	1.4	-----	1.7	-----	5	2.3	-----	-----	2.6	-----	2	3.2	-----	-----	3.6	-----	2	-----	4.9+	-----	-----	-----	1	2.2	-----	-----	2.2	-----	2
Bank Height Ratio	-----	-----	-----	-----	2.4	2.8	-----	2.8	-----	5+	-----	1.0	-----	-----	-----	2	-----	-----	-----	-----	-----	-----	-----	1.0	-----	-----	-----	1	1.0	-----	-----	1.0	-----	2
d50 (mm)	-----	-----	-----	-----	-----	4.0	-----	-----	-----	1	-----	3.0	-----	-----	-----	1	-----	60	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pattern																																		
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	128.0	-----	-----	209.0	-----	9	143.0	168.3	164.0	244.0	32.2	8
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	84.0	-----	-----	138.0	-----	9	96.0	121.2	114.0	152.0	18.9	9
Rc:Bankfull width (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.9	-----	-----	3.2	-----	9	2.3	2.9	2.7	3.6	0.5	9
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	345.0	-----	-----	506.0	-----	6	387.0	400.8	396.5	418.0	12.9	6
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.0	-----	-----	4.8	-----	9	3.4	4.0	3.9	5.8	0.8	8
Profile																																		
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	61	80	88	122	23	3
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.003	0.004	-----	0.006	-----	3	0.01	-----	-----	0.02	-----	2		-----	-----	-----	-----		0.0034	-----	-----	0.0054	-----	7	0.000	0.006	0.005	0.011	0.004	3
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	80	163	-----	240	-----	4	46	-----	-----	277	-----	2		-----	-----	-----	-----		154.0	-----	-----	327.0	-----	10	167	272	257	335	53	3
Pool Max Depth (ft)	-----	-----	-----	-----	3.8	4.8	-----	5.8	-----	4	-----	4.1	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	6.2	-----	-----	10.3	-----	11		-----	-----	-----	-----	-----
Pool Volume (ft³)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Substrate and Transport Parameters																																		
Ri% / Ru% / P% / G% / S%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
SC% / Sa% / G% / B% / Be%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----			<0.06 / 0.2 / 4 / 25 / 44						N/A / 1.2 / 3 / 77 / 800						0.4 / 11 / 60 / 512 / >2048						-----	-----	-----	-----	-----	-----			0.15 / 5 / 52 / 135 / 190			
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	0.18	-----	-----	0.3	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.28	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	95.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	90.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	10.8	-----	-----	24	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	12.6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																																		
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	-----	18.8	-----	-----	-----	-----	-----	8.4	-----	-----	-----	-----	-----	23.0	-----	-----	-----	-----	-----	18.8	-----	-----	-----	-----	-----	18.8	-----	-----
Impervious cover estimate (%)	-----	-----	-----	-----		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rosgen Classification	-----	-----	-----	-----	-----	G4c	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C5	-----	-----	-----	-----
BF Velocity (fps)	-----	-----	-----	-----	4.1	-----	-----	5.5	-----	5	-----	7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.1	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----
BF Discharge (cfs)	-----	290.0	2000.0	741.1	-----	400	-----	-----	-----	-----	-----	524.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	400.0	-----	-----	-----	-----	-----	340.0	-----	-----	-----	-----
Valley Length	-----	-----	-----	-----		2446	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2409	-----	-----	-----	-----
Channel length (ft)	-----	-----	-----	-----	-----	2593	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2842	-----	-----	-----	-----	-----	2787	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	1.06	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.20	-----	-----	-----	-----	-----	1.18	-----	-----	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	-----	-----	-----		0.0016	-----	-----	-----	-----	-----	0.0070	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.0017	-----	-----	-----	-----	-----	0.0016	-----	-----	-----	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bankfull Floodplain Area (acres)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BEHI VL% / L% / M% / H% / VH% / E%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel Stability or Habitat Metric	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Biological or Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

* Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. Wildland Hydrology. AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

Table 11a. Cross-section Morphology Data Table

South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

	Cross-section 1 (Riffle)						Cross-section 2 (Pool)						Cross-section 3 (Pool)						Cross-section 4 (Riffle)					
Dimension and substrate	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
Based on fixed baseline bankfull elevation																								
Record Elevation (Datum) Used (ft)	1124.2	1124.2					1124.1	1124.1					1122.2	1122.2					1122.0	1122.0				
BF Width (ft)	41.4	40.8					42.1	43.1					44.2	43.1					42.2	40.9				
BF Mean Depth (ft)	2.7	2.5					2.8	2.7					2.9	3.0					2.8	2.8				
Width/Depth Ratio	15.5	16.5					15.3	16.0					15.4	14.4					15.4	14.8				
BF Cross-sectional Area (ft²)	110.8	100.5					115.8	115.8					126.5	129.0					115.9	113.3				
BF Max Depth (ft)	4.4	4.1					5.1	5.4					4.5	5.1					4.2	4.2				
Width of Floodprone Area (ft)	90.7	89.8					85.6	85.9					95.3	95.1					93.6	93.5				
Entrenchment Ratio	2.2	2.2					N/A	N/A					N/A	N/A					2.2	2.3				
Bank Height Ratio	1.0	1.0					1.0	1.1					1.0	1.0					1.0	1.0				
Wetted Perimeter (ft)	46.8	45.7					47.6	48.4					49.9	49.1					47.7	46.4				
Hydraulic Radius (ft)	2.4	2.2					2.4	2.4					2.5	2.6					2.4	2.4				

Table 11b. Baseline Stream Summary
South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

Parameter	Monitoring Baseline (As-built)						MY-1						MY-2						MY-3						MY-4						MY-5					
Dimension and Substrate - Riffle	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
BF Width (ft)	41.4	-----	-----	42.2	-----	2	40.8	-----	-----	40.9	-----	2																								
Floodprone Width (ft)	90.7	-----	-----	93.6	-----	2	89.8	-----	-----	93.5	-----	2																								
BF Mean Depth (ft)	2.7	-----	-----	2.8	-----	2	2.5	-----	-----	2.8	-----	2																								
BF Max Depth (ft)	4.2	-----	-----	4.4	-----	2	4.1	-----	-----	4.2	-----	2																								
BF Cross-sectional Area (ft^2)	110.8	-----	-----	115.9	-----	2	100.5	-----	-----	113.3	-----	2																								
Width/Depth Ratio	15.4	-----	-----	15.5	-----	2	14.8	-----	-----	16.5	-----	2																								
Entrenchment Ratio	2.2	-----	-----	2.2	-----	2	2.2	-----	-----	2.3	-----	2																								
Bank Height Ratio	1.0	-----	-----	1.0	-----	2	1.0	-----	-----	1.0	-----	2																								
Pattern																																				
Channel Beltwidth (ft)	143.0	168.3	164.0	244.0	32.2	8																														
Radius of Curvature (ft)	96.0	121.2	114.0	152.0	18.9	9																														
Rc:Bankfull width (ft/ft)	2.3	2.9	2.7	3.6	0.5	9																														
Meander Wavelength (ft)	387.0	400.8	396.5	418.0	12.9	6																														
Meander Width Ratio	3.4	4.0	3.9	5.8	0.8	8																														
Profile																																				
Riffle Length (ft)	61	80	88	122	23	3	72	101	98	133	30.610456	3																								
Riffle Slope (ft/ft)	0.000	0.006	0.005	0.011	0.004	3	0.002	0.005	0.005	0.009	0.004	3																								
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Pool Spacing (ft)	167	272	257	335	53	3	209	251	253	290	41	3																								
Pool Max Depth (ft)		-----	-----		-----	-----		-----	-----		-----	-----																								
Substrate and Transport Parameters																																				
d16 / d35 / d50 / d84 / d95			0.15 / 5 / 52 / 135 / 190						34.5 / 64.8/78.3 / 145.9 / 234.4																													
Reach Shear Stress (competency) lb/f	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Stream Power (transport capacity) W/m^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Additional Reach Parameters																																				
Drainage Area (SM)	-----	-----	-----	18.8	-----	-----	-----	-----	-----	18.8	-----	-----																								
Rosgen Classification	-----	C5	-----	-----	-----	-----	-----	C5	-----	-----	-----	-----																								
BF Velocity (fps)	-----	3.0	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----																								
BF Discharge (cfs)	-----	340.0	-----	-----	-----	-----	-----	318.0	-----	-----	-----	-----																								
Valley Length	-----	2409	-----	-----	-----	-----	-----	2409	-----	-----	-----	-----																								
Channel length (ft)	-----	2787	-----	-----	-----	-----	-----	2787	-----	-----	-----	-----																								
Sinuosity	-----	1.18	-----	-----	-----	-----	-----	1.18	-----	-----	-----	-----																								
Water Surface Slope (Channel) (ft/ft)	-----	0.0016	-----	-----	-----	-----	-----	0.0016	-----	-----	-----	-----																								
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								

APPENDIX E

HYDROLOGIC DATA

Table 12. Verification of Bankfull or Greater than Bankfull Events
South Muddy Creek Mitigation Plan: EEP Project No. 737

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (feet above bankfull)
May 18, 2012	September 2010 (crest gauge installation for asbuilt) - May 18th, 2012*	Gauge measurement	0.17
August 1, 2012	May 18th - August 1st 2012*	Gauge measurement	0.08

* Date of event(s) occurred sometime between the date range specified.

APPENDIX A

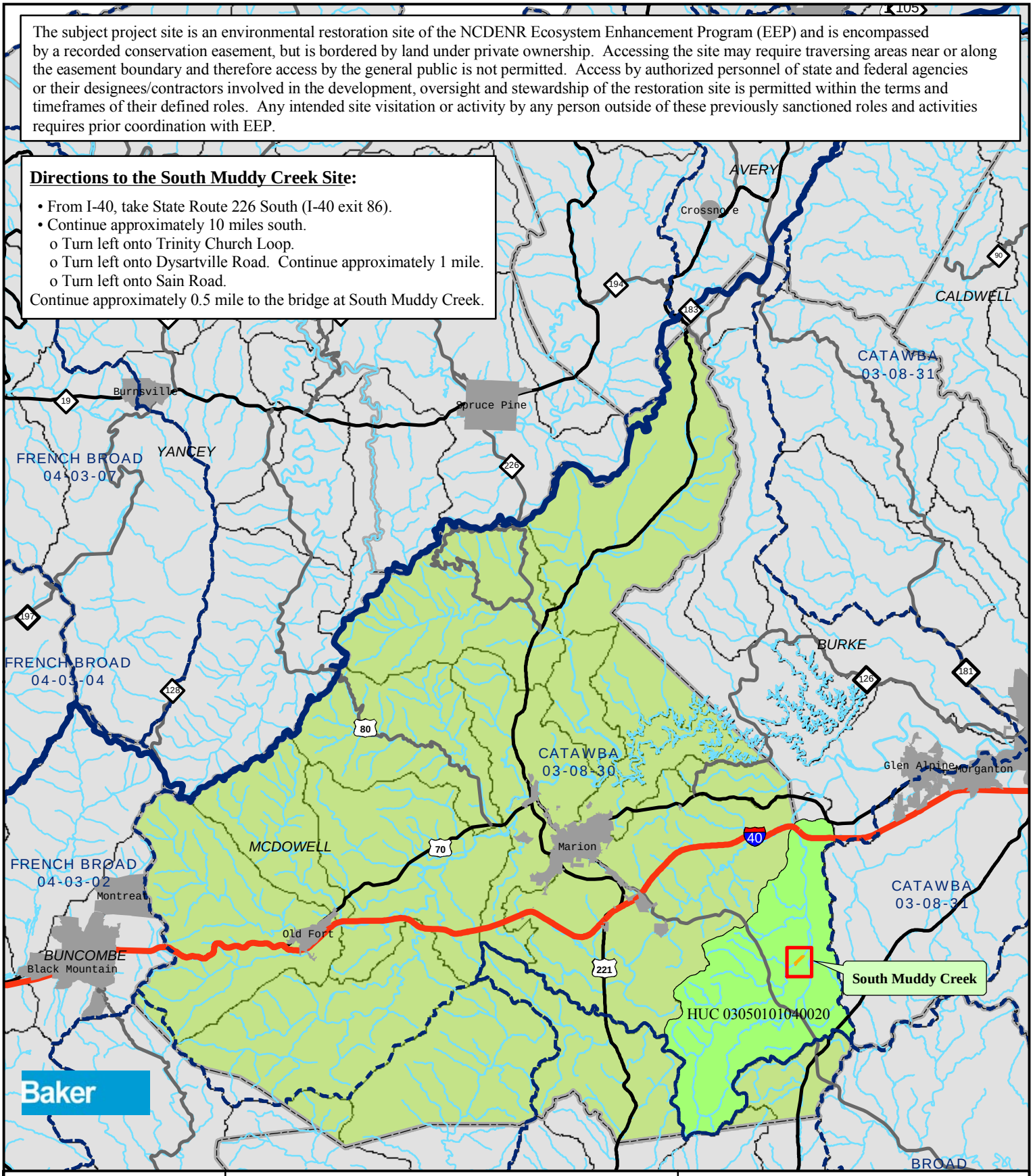
PROJECT VICINITY MAP AND BACKGROUND TABLES

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with EEP.

Directions to the South Muddy Creek Site:

- From I-40, take State Route 226 South (I-40 exit 86).
- Continue approximately 10 miles south.
  - o Turn left onto Trinity Church Loop.
  - o Turn left onto Dysartville Road. Continue approximately 1 mile.
  - o Turn left onto Sain Road.

Continue approximately 0.5 mile to the bridge at South Muddy Creek.



Map Vicinity

McDowell County, NC

Figure 1. Vicinity Map

South Muddy Creek Stream Restoration Project

McDowell County, NC

NCEEP Project No.: 737

November 2012

LEGEND:

- Project Area
- NCDWQ Sub-basin
- USGS Hydrologic Unit
- Counties

0 2.5 5 Miles

Table 1. Project Components
South Muddy Creek Mitigation Plan: EEP Project No. 737

Project Segment or Reach ID	Existing Feet/Acres*	Mitigation Type	Approach	Linear Footage or Acreage*	Stationing	Comment
South Muddy Creek	2,593	R	P2	2,787	10+00 - 38+77**	Installed in-stream structures to protect the stream bank from erosion and to provide aquatic habitat. Priority 2 was implemented to connect the channel to a newly evacated floodplain bench.

* Existing reach breaks and design reach breaks varied based on initial geomorphic differences and design requirements.

** Stationing includes 20 ft. of farm crossing above Sain Rd. and 70 ft. of Sain Rd. bridge crossing, but is not reflected in the reach length.

Component Summations

Restoration Level	Stream (LF)	Riparian Wetland (Ac)		Non-Ripar (Ac)	Upland (Ac)
		Riverine	Non-Riverine		
Restoration	2,787	-	-	-	-
Enhancement		-	-	-	-
Enhancement I	-				
Enhancement II	-				
Creation		-	-	-	-
Preservation	-	-	-	-	-
HQ Preservation	-	-	-	-	-
		-	-		
Totals	2,787	-		-	-

Table 2. Project Activity and Reporting History
South Muddy Creek Mitigation Plan: EEP Project No.737

Elapsed Time Since Grading/Planting Complete: 1 year 8 Months
Number of Reporting Years: 1

Activity or Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Restoration Plan Prepared	N/A	N/A	Jul-07
Restoration Plan Amended	N/A	N/A	Jan-08
Restoration Plan Approved	N/A	N/A	Aug-08
Final Design – (at least 90% complete)	N/A	N/A	Jun-09
Construction Begins	Jun-10	N/A	Jun-10
Temporary S&E mix applied to entire project area	N/A	N/A	N/A
Permanent seed mix applied to entire project area	Nov-10	N/A	Jan-11
Planting of live stakes	Mar-11	N/A	Mar-11
Planting of bare root trees	Mar-11	N/A	Mar-11
End of Construction	Mar-11	N/A	Jun-11
Survey of As-built conditions (Year 0 Monitoring-baseline)	Nov-10	N/A	Jun-11
Year 1 Monitoring	Dec-12	Sep-12	Nov-12
Year 2 Monitoring	Dec-13	N/A	N/A
Year 3 Monitoring	Dec-14	N/A	N/A
Year 4 Monitoring	Dec-15	N/A	N/A
Year 5 Monitoring	Dec-16	N/A	N/A

Table 3. Project Contacts Table South Muddy Creek Mitigation Plan: EEP Project No. 737	
Designer	
Michael Baker Engineering, Inc.	5550 Seventy-Seven Center Dr., Ste.320 Charlotte, NC 28217 Contact: Scott Hunt, Tel. 919-459-9003
Construction Contractor	
Carolina Environmental Contracting, Inc.	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Planting Contractor	
Carolina Environmental Contracting, Inc.	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Seeding Contractor	
Carolina Environmental Contracting, Inc. 12/11/2012	150 Pine Ridge Road Mount Airy, NC 27030 Contact: Stephen James, Tel. 919-921-1116
Seed Mix Sources	Green Resources, Tel. 336-855-6363
Nursery Stock Suppliers	Foggy Mountain Nursery, Tel. 336-384-5323
Profession Land Surveyor	
Turner Land Survey, PLLC.	3201 Glenridge Drive Raleigh, NC 27604 Contact:
Profession Land Surveyor	David Turner, Tel. 919-875-1378
As-Built Plan Set Production	Lissa Turner, Tel. 919-875-1378
Monitoring Performers	
Michael Baker Engineering, Inc.	797 Haywood Road, Suite 201 Asheville, NC 28806 Contact:
Stream Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1408
Vegetation Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1409
Wetland Monitoring Point of Contact:	Carmen McIntyre, Tel. 828-350-1409

Table 4. Project Attribute Table South Muddy Creek Mitigation Plan: EEP Project No. 737	
Project County	McDowell County, NC
Physiographic Region	Piedmont
Ecoregion	Inner Piedmont Belt
Project River Basin	Catawba
USGS HUC for Project and Reference sites	Project: 03050101040020; References: 03040103050 -090 (Spencer Creek), -080 (Barnes Creek); 03030002060 -070 (Morgan Creek); 03020201080 -020 (Sal's Branch)
NCDWQ Sub-basin for Project and Reference	Project: 03-08-30; References: 03-07-09 (Spencer Creek and Barnes Creek); 03-06-06 (Morgan Creek); 03-04-02 (Sal's Branch)
Within extent of EEP Watershed Plan ?	Muddy Creek Local Watershed Plan (LWP), 2003
WRC Class (Warm, Cool, Cold)	Warm
% of project easement fenced or demarcated	100%
Beaver activity observed during design phase ?	None
Restoration Component Attribute Table	
	South Muddy
Drainage area (sq. mi.)	18.8
Stream order	4th
Restored length	2,787
Perennial or Intermittent	Perennial
Watershed type (Rural, Urban, Developing etc.)	Rural
Watershed LULC Distribution (e.g.)	
Developed Low-Medium Intensity	3.7
Ag-Cultivated Crops	0.6
Ag-Pasture/Hay	10.5
Forested	77.4
Other (Open water, Grassland, Etc.)	7.8
Watershed impervious cover (%)	U
NCDWQ AU/Index number	03-08-30
NCDWQ classification	C
303d listed ?	No
Upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor	N/A
Total acreage of easment	17.1
Total planted arceage as part of the restoration	14.1
Rosgen classification of pre-existing	G4c
Rosgen classification of As-built	C4
Valley type	Alluvial
Valley slope	0.0017 ft/ft
Valley side slope range (e.g. 2-3%)	U
Valley toe slope range (e.g. 2-3%)	U
Cowardin classification	Riverine, Upper Perennial, Unconsolidated Bottom, Cobble-Gravel
Trout waters designation	No
Species of concern, endangered etc.? (Y?N)	No
Dominant soil series and characteristics	
Series	IoA
Depth	10
Clay %	18
K	0.15
T	5

APPENDIX B

VISUAL ASSESSMENT DATA

Site Assessment Report – Monitoring Year 1

South Muddy Creek Stream Restoration Project
McDowell County, North Carolina
June 2012

Submitted To: NCDENR - Ecosystem Enhancement Program
1625 Mail Service Center
Raleigh, NC 27699
NCDENR Contract ID No. 004522

Submitted By: Michael Baker Engineering, Inc.
797 Haywood Avenue, Suite 201
Asheville, NC 28806
License: F-1084, Baker Project No. 128221

1. Introduction

1.1 Purpose

This report summarizes overall stream and vegetation conditions as part of an interim site assessment conducted in conjunction with the Year 1 monitoring services for the South Muddy Creek Stream Restoration Project site located in McDowell County, NC. This site assessment will be included as part of a more comprehensive annual monitoring report to be completed and submitted later this year (fall 2012). The report describes project objectives, discusses the assessment methodology, summarizes assessment results, and documents potential stream and vegetation problem areas (SPAs and VPAs respectively).

1.2 Objectives

The objectives of the site assessment were to:

- provide a general overview of stream morphological stability;
- provide a general overview of vegetation conditions;
- identify and document potential SPAs and VPAs.

1.3 Supporting Data

Supporting data and information are provided following the narrative portion of this report and include:

- current condition plan view (CCPV) figures (Figure 2, sheets 1 and 2);
- visual stream morphology stability assessment table (Table 5a);
- SPA inventory table (Table 5b);
- vegetation condition assessment table (Table 6a);
- VPA inventory table (Table 6b);
- stream station photos;
- SPA photos;
- vegetation monitoring plot photos;
- VPA photos.

2 Methodology

The methodology used for assessing overall stream and vegetation conditions at the South Muddy Creek Stream Restoration Project site adhered to the most recent NCEEP monitoring guidance documents (dated November 7, 2011). The site assessment was comprised of two components, a visual stream morphology stability assessment and a vegetation condition assessment, both of which are described in more detail in the following sections of this report. The assessment was strictly qualitative except for that of the vegetation monitoring plot counts, which were conducted in order to determine whether or not the success criteria

were met per plot for illustrative purposes on the CCPV figures. All other vegetation monitoring plot data (tables) will be included in Appendix C of the Year 1 annual monitoring report to be submitted later this year.

The South Muddy Creek Stream Restoration Project site was evaluated as one project reach for each of the two components (SPA and VPA). This was done since the stream and riparian corridor are contained within one contiguous section along the mainstem of South Muddy Creek; site conditions appeared uniform allowing for an assessment as one reach and the project was assessed as one reach for the Final Baseline Monitoring Document/As-Built Report. Baker performed the visual site assessment on May 18th, 2012 and collected vegetation monitoring plot data on May 24th, 2012.

2.1 Visual Stream Morphology Stability Assessment

The visual stream morphology stability assessment involved the evaluation of lateral and vertical channel stability, and the integrity and overall performance of in-stream structures throughout the project reach as a whole. Habitat parameters, such as riffle embeddedness and pool depth maintenance, were also measured and scored. The entire 2,787 linear foot reach was walked, noting geomorphic conditions of the stream bed profile (riffle/pool facets), both stream banks, and engineered in-stream structures. Photos were taken at every existing stream photo point station (from the as-built) and in locations of potential SPAs which were recorded in the field for subsequent mapping on the CCPV figures.

2.2 Vegetation Condition Assessment

The vegetation condition assessment involved the evaluation of vegetation within the 17.1 acre conservation easement and included assessing the performance of planted vegetation along stream banks, floodplains, and terraces as well as the documentation of invasive species. The assessment of planted vegetation was confined to the 14.1 acres of riparian buffer planting zones within the easement boundary as part of the restoration design whereas invasive vegetation and encroachment areas of invasive species were evaluated for the entire 17.1 acre easement boundary. Vegetation plot data was collected as part of this assessment to determine the success criteria for illustrative purposes on the CCPV figures. Photos were recorded at each vegetation monitoring plot and in locations of potential VPAs throughout the easement, such as areas exhibiting sparse or slow growth/vigor, low stem density, and areas of invasive vegetation concern.

2.3 Post-processing of Field Data

The post-processing of field data consisted of the download and organization of photos into respective photo logs (stream and vegetation), creating the CCPV figures in GIS and AutoCAD using the field-mapped SPAs and VPAs, populating the SPA and VPA tables, and finally scoring the performance of the reach in terms of stream morphology stability and vegetation condition using assessment forms provided by NCEEP.

3 Summary of Results

3.1 Visual Stream Morphology Stability Assessment

Table 5a summarizes the performance of the South Muddy Creek Stream Restoration Project reach in terms of lateral (stream bank) and vertical (channel bed) stability while evaluating the functionality and integrity of in-stream structures. Engineered in-stream structures evaluated for the assessment of this project reach consisted of constructed riffles, rock/log j-hooks, log vanes, root wads, geolifts, and brush mattresses. Constructed riffles were justified for inclusion in the evaluation of structures since they are the predominant grade control structure used throughout the site; however, they were only assessed for the 'overall integrity' and 'grade control' parameter categories in Table 5a.

As Table 5a indicates, the South Muddy Creek site was geomorphically stable overall and performing at 100% as the design intended for the majority of parameters evaluated within the lateral/vertical stability and in-stream structure performance categories. The four sub-categories receiving scores of less than 100% corresponded to the three SPAs that were documented and summarized in Table 5b.

The three SPAs were characterized by localized areas of bank scour and were all located upstream of the Sain Road bridge. SPA1 consists of a short length of brush mattress compromised by an undercut bank between station 21+20 and 21+30; it is located along the right bank at the beginning of a meander bend. The brush mattress (and a portion of the staked and matted bank) appears to be separating from the right bank and overhanging from a combination of poor soil compaction and scour along the toe of bank. The brush originally installed behind the matting to armor the bank has washed away leaving the bank exposed and vulnerable to subsequent erosion. The scour could potentially be a result of the lack of centering of the thalweg immediately upstream of the meander bend where a riffle transitions to a run, and was noted accordingly in Table 5a. The bank protection provided by the remaining length of brush mattress along the right bank may become compromised and less effective over time if SPA1 is not stabilized and the scour (and instability) is allowed to continue to migrate further downstream by undermining the brush.

SPA2 and SPA3 consist of scoured portions of the left bank located within the first constructed riffle section upstream of the Sain Road bridge. Bank scour along these two adjacent problem areas appears to be caused by the lack of centering of the thalweg immediately downstream of the upstream meander bend. As a result, some velocity vectors within the riffle have been redirected toward the left bank instead of being centered in the riffle, thereby increasing near bank stress and causing the bank to erode. Bank erosion within SPA2 is moderate but more severe than that of SPA3 due to a deeper near bank third and thus higher near bank stress as the thalweg is located closer the toe of bank; the stream bank of SPA3 is vertical, exposed and devoid of vegetation and matted protection. SPA2 exhibits mild erosion but maintains a low bank angle and some surface protection in the form of existing matting, herbaceous vegetative cover, and scattered riprap material along the toe.

3.2 Vegetation Condition Assessment

Table 6a summarizes the vegetation condition of the South Muddy Creek Stream Restoration site. The planted acreage performance categories were functioning at 100% with no bare areas, low stem density areas, or areas of poor growth rates/vigor to report. The success criteria or survival threshold for all 12 vegetation monitoring plots were attained. Invasive areas of concern were observed and documented accordingly in Table 6a and as VPAs in Figure 2 and Table 6b.

Ten discrete areas of invasive species were documented throughout the site and totaled approximately 1 acre, or 5.7% of the total easement acreage. This resulted in 8 VPAs since two adjacent pairs of mapped polygons, exhibiting uniform invasive species compositions conditions, were combined into two individual VPAs.

The largest VPA and most critical in warranting treatment is VPA6, which is located in the right terrace downstream of the Sain Road bridge, and is comprised of kudzu (*Pueraria lobata*). Kudzu is considered by NCEEP to be a 'high concern' invasive vine because of its potential to proliferate rapidly and out-compete other native species planted within the easement buffer. It was difficult discerning the source of the kudzu but may be originating from the existing tree cluster on the terrace where other invasive species, such as privet (*Ligustrum sinense*) and multiflora rose (*Rosa multiflora*), were documented for VPA5. VPA6 occupies a large width of the right terrace between the top of terrace and the easement boundary fence line and was observed extending down the terrace slopes toward the right floodplain bench.

VPA2 represents the second largest VPA and consists of trumpet creeper vines (*Campsis radicans*) located in and around vegetation monitoring plots 4 and 5. These areas were previously identified in the Final Baseline Monitoring Document/As-Built Report as areas of concern and were recently scheduled for treatment and removal prior to this assessment. The vines look as though they may have been treated but new growth was observed and are still persisting.

VPA3, VPA4, and VPA5 comprise the next largest VPAs and are characterized as existing tree stands containing persisting invasive vegetation. Privet and multiflora rose was observed in all three VPAs while Japanese honeysuckle (*Lonicera japonica*) was only documented in VPA4. Existing tree stands precluded from removal during construction (that originally contained invasive species) can often be a source of invasive vegetation even after treatment since the soil matrix is undisturbed leaving roots and seeds intact. These areas were previously treated but were exhibiting new growth and are still persisting.

VPA1, VPA7, and VPA8 represent the smallest VPAs and are part of existing tree stands located around the periphery of the easement. These areas appear to have been previously treated but are also still persisting with new growth.

As an update to additional areas of concern reported in the Final Baseline Monitoring Document/As-Built Report, there were no signs of kudzu in the right floodplain upstream of

the Sain Road bridge; this area was previously scheduled for treatment and removal of kudzu prior to the assessment. No mimosa trees were observed encroaching into the easement along the right terrace from the nursery immediately bordering the easement. However, Canadian thistle (*Cirsium arvense*) was observed flourishing in the nursery in close proximity to the easement boundary fence line in the right terrace just upstream of the Sain Road bridge, and should continue to be monitored to minimize encroachment and invasion of the site.

CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

ASBUILT CHANNEL

FENCE

X–# CROSS SECTION

PHOTO ID POINT

VP VEGETATION PLOT

VEGETATION PROBLEM AREA (VPA)
INVASIVE SPECIES PRESENT

VEGETATION PLOT MEETING CRITERIA
(ALL PLOTS CURRENTLY MEETING CRITERIA)

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA (SPA)
UNDERCUT BANKS

STREAM PROBLEM AREA (SPA)
BANKS WITH EVIDENT SCOUR/EROSION

STREAM PROBLEM AREA (SPA)
BANK SLUMPING/CALVING/COLLAPSE
(NO AREAS EXHIBITING PROBLEM)

VEG PLOT CRITERIA ATTAINMENT		
VEG PLOT ID	SURVIVAL THRESHOLD MET?	TOTAL/PLANTED STEM COUNT
1	Y	567/486
2	Y	2023/809
3	Y	769/809
4	Y	647/728
5	Y	850/688
6	Y	850/486

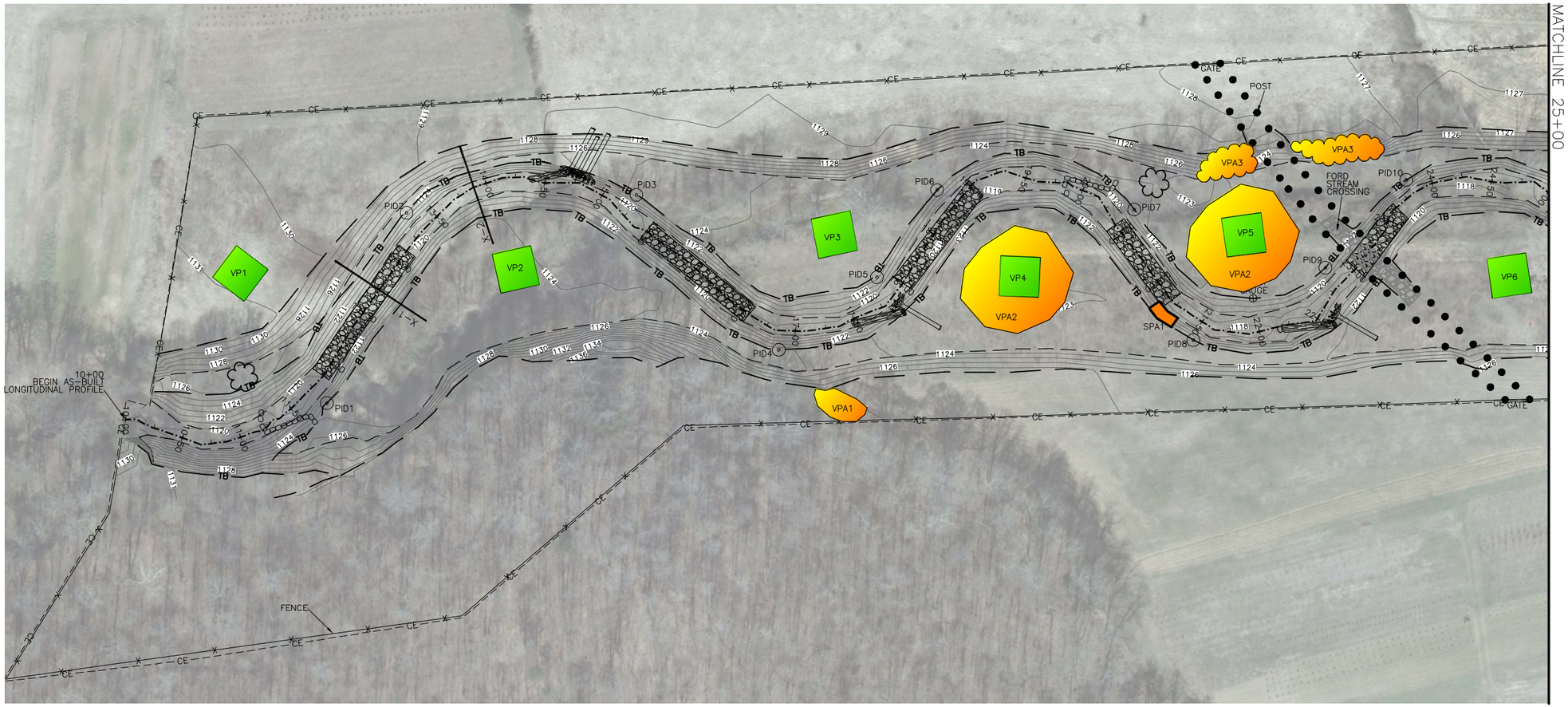


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

50 0 50 100

SOUTH MUDDY CREEK
CURRENT CONDITION PLAN VIEW
YEAR 1 MONITORING
STA. 10+00–25+00

Michael Baker Engineering Inc.
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Baker

SOUTH MUDDY CREEK
STREAM RESTORATION PROJECT
MCDOWELL COUNTY, NORTH CAROLINA

Ecosystem Enhancement

Prepared for:
Ecosystem Enhancement Program
2728 Capitol Blvd, Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No.	737
Baker Project No.	128221
Date:	11/27/12
DESIGNED:	---
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	1 of 5
Sheet:	1 of 2

CE CONSERVATION EASEMENT

ASBUILT CENTERLINE

TB ASBUILT TOP OF BANK

ASBUILT CHANNEL

FENCE

X–# CROSS SECTION

PHOTO ID POINT

VP VEGETATION PLOT

VEGETATION PROBLEM AREA (VPA)
INVASIVE SPECIES PRESENT

VEGETATION PLOT MEETING CRITERIA
(ALL PLOTS CURRENTLY MEETING CRITERIA)

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA (SPA)
UNDERCUT BANKS

STREAM PROBLEM AREA (SPA)
BANKS WITH EVIDENT SCOUR/EROSION

STREAM PROBLEM AREA (SPA)
BANK SLUMPING/CALVING/COLLAPSE
(NO AREAS EXHIBITING PROBLEM)

VEG PLOT CRITERIA ATTAINMENT

VEG PLOT ID	SURVIVAL THRESHOLD MET?	TOTAL/PLANTED STEM COUNT
7	Y	607/526
8	Y	486/688
9	Y	405/445
10	Y	567/688
11	Y	445/445
12	Y	486/728

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

50 0 50 100

SOUTH MUDDY CREEK
CURRENT CONDITION PLAN VIEW
YEAR 1 MONITORING
STA. 25+00–38+77

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SOUTH MUDDY CREEK
STREAM RESTORATION PROJECT
MCDOWELL COUNTY, NORTH CAROLINA

Ecosystem Enhancement

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EEP Project No.
737

Baker Project No.
128221

Date:
11/27/12

DESIGNED: ---
DRAWN: MDR
APPROVED: MMC

Monitoring Year:
1 of 5

Sheet:
2 of 2

Table 5a. **Visual Stream Morphology Stability Assessment**

Reach ID **South Muddy Creek**

Assessed Length (LF) **2787**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number per As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Veg.	Footage with Stabilizing Woody Veg.	Adjusted % for Stabilizing Woody Veg.
1. Bed	**1. Vertical Stability**	1. Aggradation			0	0	100%			
		2. Degradation			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate	11	11			100%			
	3. Meander Pool Condition	1. Depth	12	12			100%			
		2. Length	12	12			100%			
	4. Thalweg position	1. Thalweg centering at upstream of meander bend (Run)	11	12			92%			
		2. Thalweg centering at downstream of meander (Glide)	10	11			91%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			2	60	99%	0	0	99%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely			1	10	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	3	70	99%	0	0	99%
3. Engineering Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs	37	38			97%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	11	11			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms	9	9			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%	27	27			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth	9	9			100%			

Table 5b. Stream Problem Areas South Muddy Creek Restoration Project: Project No. 737			
South Muddy Creek (2,787 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Bank Scour	21+20 to 21+30	Right bank (including brush mattress and matting) separating and beginning to slump at beginning of outer meander bend from a combination of poor compaction and scour along the toe of bank.	SPA1
	27+90 to 28+10	Localized scour along left bank resulting in raw, vertical bank, devoid of vegetation and matted protection. Cause appears to be localized eddying within the riffle.	SPA2
	28+40 to 28+80	Localized scour along left bank from what appears to be localized eddying within the riffle.	SPA3

Table 6a. **Vegetation Condition Assessment**

Reach ID **South Muddy Creek**

Planted Acreage **14.1**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres	NA	0	0.00	0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	NA	0	0.00	0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	NA	0	0.00	0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage **17.1**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000 SF	see figure	10	0.97	5.7%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	NA	0	0.00	0.0%

Table 6b. Vegetation Problem Areas South Muddy Creek Restoration Project: Project No. 737			
South Muddy Creek			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Invasive/Exotic Populations	17+25 (right terrace)	*Rosa multiflora* : persisting after treatment	VPA1
	18+00 to 21+00 (right flood bench)	*Campsis radicans* persisting after treatment	VPA2
	20+50 to 23+00 (left flood bench)		
	21+75 to 23+75 (left terrace slope)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA3
	25+50 to 28+50 (left terrace slope)	*Rosa multiflora, Ligustrum sinense,* and *Lonicera japonica* : persisting after treatment within existing tree stand	VPA4
	35+00 to 36+50 (right terrace)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA5
	35+00 to 37+25 (right terrace)	*Pueraria lobata* : persisting after treatment within existing tree stand, terrace, and terrace slope	VPA6
	38+75 (downstream project limits along right bank/terrace)	*Rosa multiflora* and *Ligustrum sinense* : persisting after treatment within existing tree stand	VPA7
	38+75 (downstream project limits along left bank/terrace)	*Lonicera japonica* : persisting after treatment within existing tree stand/potential encroachment from outside	VPA8

South Muddy Creek
Stream Station Photos

South Muddy Creek PID 1 – J-Hook near upstream end of project

South Muddy Creek PID 2 –Constructed Riffle,

South Muddy Creek PID 3 – Log Vane in Meander

South Muddy Creek PID 4 – Constructed Riffle

South Muddy Creek PID 5 – Log Vane in Meander

South Muddy Creek PID 6 – Constructed Riffle

South Muddy Creek PID 7 – J-Hook in Meander

South Muddy Creek PID 8 – Constructed Riffle

South Muddy Creek PID 9 – Log Vane in Meander

South Muddy Creek PID 10 – Stream Crossing

South Muddy Creek PID 11 – Constructed Riffle

South Muddy Creek PID 12 – Log Vane and Root Wad in Meander

South Muddy Creek PID 13 – Constructed Riffle

South Muddy Creek PID 14 – Immediately upstream of Sain Road crossing

South Muddy Creek PID 15 – Constructed Riffle downstream of Sain Road crossing

South Muddy Creek PID 16

South Muddy Creek PID 17 – Log Vane in Meander

South Muddy Creek PID 18 – Constructed Riffle

South Muddy Creek PID 19

South Muddy Creek PID 20 – J-Hook near downstream end of project

South Muddy Creek
Stream Problem Area (SPA) Photos

SPA1 – Right bank separating/overhanging from poor compaction and scour along toe of bank (looking upstream)

SPA2 – Localized scour along left bank from eddying within the riffle (looking downstream)

SPA3 – Localized scour along left bank from eddying within the riffle (looking upstream)

South Muddy Creek
Vegetation Plot Photos

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

Notes:
1. Herbaceous plot located in foreground of each photo.

5/24/2012 - Photo 1: Veg Plot 1

5/24/2012 - Photo 2: Veg Plot 1: Herbaceous Plot

5/24/2012 - Photo 3: Veg Plot 2

5/24/2012 - Photo 4: Veg Plot 2: Herbaceous Plot

5/24/2012 - Photo 5: Veg Plot 3

5/24/2012 - Photo 6: Veg Plot 3: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo 7: Veg Plot 4

5/24/2012 - Photo 8: Veg Plot 4: Herbaceous Plot

5/24/2012 - Photo 9: Veg Plot 5

5/24/2012 - Photo 10: Veg Plot 5: Herbaceous Plot

5/24/2012 - Photo Point 11: Veg Plot 6

5/24/2012 - Photo Point 12: Veg Plot 6: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo Point 13: Veg Plot 7

5/24/2012 - Photo Point 14: Veg Plot 7: Herbaceous Plot

5/24/2012 - Photo Point 15: Veg Plot 8

5/24/2012 - Photo Point 16: Veg Plot 8: Herbaceous Plot

5/24/2012 - Photo Point 17: Veg Plot 9

5/24/2012 - Photo Point 18: Veg Plot 9: Herbaceous Plot

South Muddy Creek Stream Restoration Project
Year 1 Monitoring - Vegetation Plot Photo Log

5/24/2012 - Photo Point 19: Veg Plot 10

5/24/2012 - Photo Point 20: Veg Plot 10: Herbaceous Plot

5/24/2012 - Photo Point 21: Veg Plot 11

5/24/2012 - Photo Point 22: Veg Plot 11: Herbaceous Plot

5/24/2012 - Photo Point 23: Veg Plot 12

5/24/2012 - Photo Point 24: Veg Plot 12: Herbaceous Plot

South Muddy Creek
Vegetation Problem Area (VPA) Photos

VPA1 – Multiflora Rose

VPA2 – Trumpet vine persisting after treatment

VPA3 – Multiflora Rose and Chinese Privet

VPA4 – Multiflora Rose, Chinese Privet, Honeysuckle

VPA5 - Multiflora Rose and Chinese Privet

VPA6 – Kudzu persisting after treatment

VPA7 - Multiflora Rose and Chinese Privet

VPA8 – Japanese Honeysuckle

APPENDIX C

VEGETATION PLOT DATA

Table 7. Vegetation Plot Criteria Attainment South Muddy Creek Mitigation Plan: EEP Project No. 737			
Vegetation Plot ID	**Vegetation Survival Threshold Met?**	**Total/Planted Stem Count***	**Tract Mean**
1	Y	567/486	725
2	Y	2023/809	
3	Y	769/809	
4	Y	647/728	
5	Y	850/688	
6	Y	850/486	
7	Y	607/526	
8	Y	486/688	
9	Y	405/445	
10	Y	567/688	
11	Y	445/445	
12	Y	486/728	
Note: *Total/Planted Stem Count reflects the changes in stem density based on the density of stems at the time of the As-Built Survey (Planted) and the current total density of planted stems including volunteers (Total).			

Table 8. CVS Vegetation Plot Metadata South Muddy Creek Mitigation Plan: EEP Project No. 737	
Report Prepared By	Carmen Horne-McIntyre
Date Prepared	6/6/2012 12:18
Database name	cvs-eep-entrytool-v2.2.7_South Muddy_Hoppers.mdb
Database location	L:\Monitoring\Monitoring Guidance\Vegetation\CVS EEP Entrytool V2.2.7
Computer name	ASHEWCMCINTYR
File size	28475392
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY	
Project Code	92251
Project Name	South Muddy Cr. Stream Restoration
Description	This mitigation project consists of 7,389 LF of stream restoration and preservation efforts on South Muddy Creek and South Fork Hoppers (including 1 unnamed tributary) at the Melton Farm.
River Basin	Catawba
Length(ft)	7389
Stream-to-edge width (ft)	120
Area (sq m)	164733.86
Required Plots (calculated)	24
Sampled Plots	12

Table 9. CVS Stem Count Total and Planted by Plot and Species (with Annual Means)
South Muddy Creek Mitigation Plan: EEP Project No. 737

Tree Species	Common Name	Type	Current Data (MY1 2012)																						Annual Means									
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9		Plot 10		Plot 11		Plot 12		Current Mean		AB (2011)		MY2 (2013)		MY3 (2014)		MY4 (2015)		MY5 (2016)	
			P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Betula nigra	River Birch	Tree	1	1	2	2			5	3	5	1	1	0	5	4	2	2					3	3			3	2	3	3								
Celtis laevigata	Sugarberry	Shrub	3	2	1	1	4	1			2	1	0	1	1	1	1	1	0	1							2	1	2	2								
Diospyros virginiana	Persimmon	Tree			0	3					0	3				1			0	3			0	1	0	3	0	3	2	2								
Fraxinus pennsylvanica	Green Ash	Tree			4	4	2	1	1	1	2	2			1	2	1	0	4	4	5	5			2	2	2	3	2	2								
Juglans nigra	Black Walnut	Tree									1	1	2	1	2	2							1	1			2	1	2	2								
Liriodendron tulipfera	Tulip Poplar	Tree	4	3	6	5	5	5	5	5	2	1	3	2					3	2			1	1	4	1	4	3	4	4								
Nyssa sylvatica	Blackgum	Tree							1	1																	1	1	1	1								
Platanus occidentalis	Sycamore	Tree	1	0	4	4	7	7	3	3	3	5			2	2	4	4	1	0	4	4	4	4	9	5	4	3	4	4								
Quercus pagoda	Cherrybark Oak	Tree									0	3															0	3	0	0								
Quercus palustris	Pin Oak	Tree	3	0			2	0	2	2	2	0	3	3	1		3	1	2	0	1	0	1	0	3	1	2	1	2	2								
Quercus phellos	Willow Oak	Tree					0	4							1	1			1	0			1	0			1	1	1	1								
Quercus rubra	N. Red Oak	Shrub	0	2	3	0			1	0			3	2			6	2			7	5					3	2	4	4								
Volunteers																																						
Acer rubrum	Red Maple	Tree																																				
Diospyros virginiana	Persimmon	Tree																						1				1										
Juglans nigra	Black Walnut	Tree		2								4																3										
Liriodendron tulipfera	Tulip Poplar	Tree		2		5				1						1		2										2										
Platanus occidentalis	Sycamore	Tree		1		25		1						12														10										
Quercus rubra	N. Red Oak	Tree		1		1										1												1										
	Plot area (acres)		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025													
	Species Count		5	6	6	7	5	5	7	6	7	8	5	6	7	9	6	6	5	4	4	3	6	5	4	5	6	6	6	6								
	Planted Stems/Plot		12	8	20	19	20	18	18	15	17	17	12	9	13	13	17	10	11	10	17	14	11	10	18	12	16	13	16	16								
P=Planted	Total Stems/Plot		12	14	20	50	20	19	18	16	17	21	12	21	13	15	17	12	11	10	17	14	11	11	18	12	16	18	16	16								
T=Total	Planted Stems Per Acre		486	324	809	769	809	728	728	607	688	688	486	364	526	526	688	405	445	405	688	567	445	405	728	486	627	523	627	627								
	Total Stems Per Acre (including volunteers)		567		2023		769		647		850		850		607		486		405		567		445		486		725		627	627								

Notes: CVS Level 1 Survey performed. In most cases, the volunteers observed were less than 10 cm in height. The information presented is purely for providing information about the species of trees that may occupy the riparian area that were not planted. In Plot 2, multiple sycamore seedlings noted; counting stopped at 25.

APPENDIX D

STREAM SURVEY DATA

South Muddy Creek

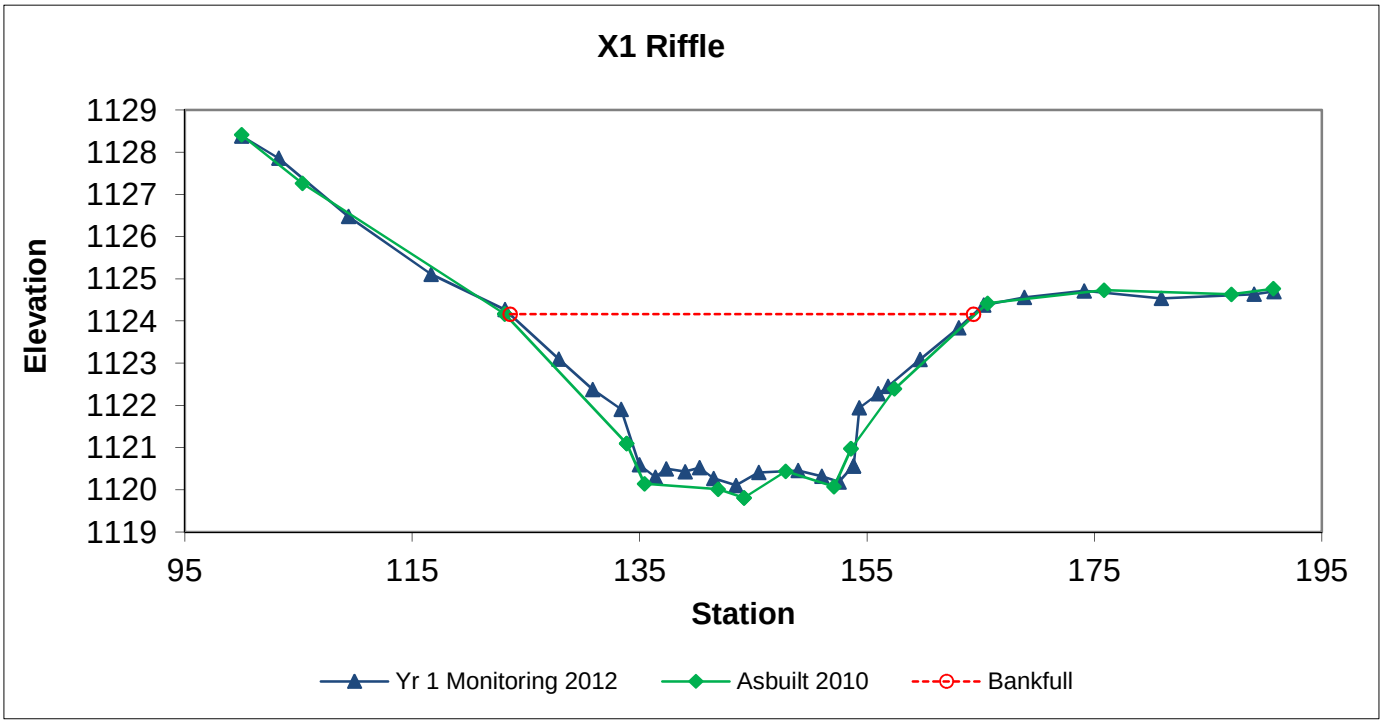
Permanent Cross Section X1

(Year 1 Monitoring - September 2012)

LEFT BANK

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	100.5	40.78	2.46	4.06	16.54	1.1	2.2	1124.16	1124.72



South Muddy Creek

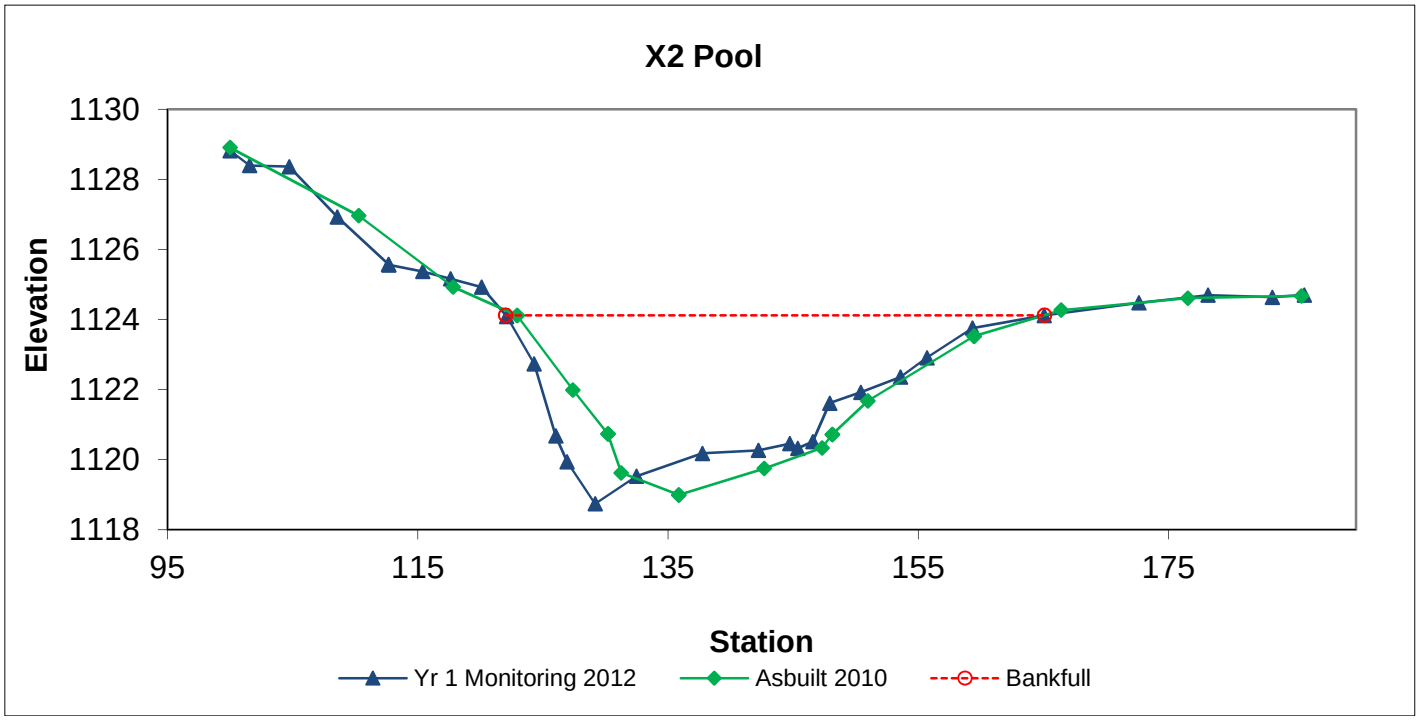
Permanent Cross Section X2

(Year 1 Monitoring - September 2012)

LEFT BANK

RIGHT BANK

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		115.8	43.06	2.69	5.38	16.01	1.1	2	1124.12	1124.7



South Muddy Creek

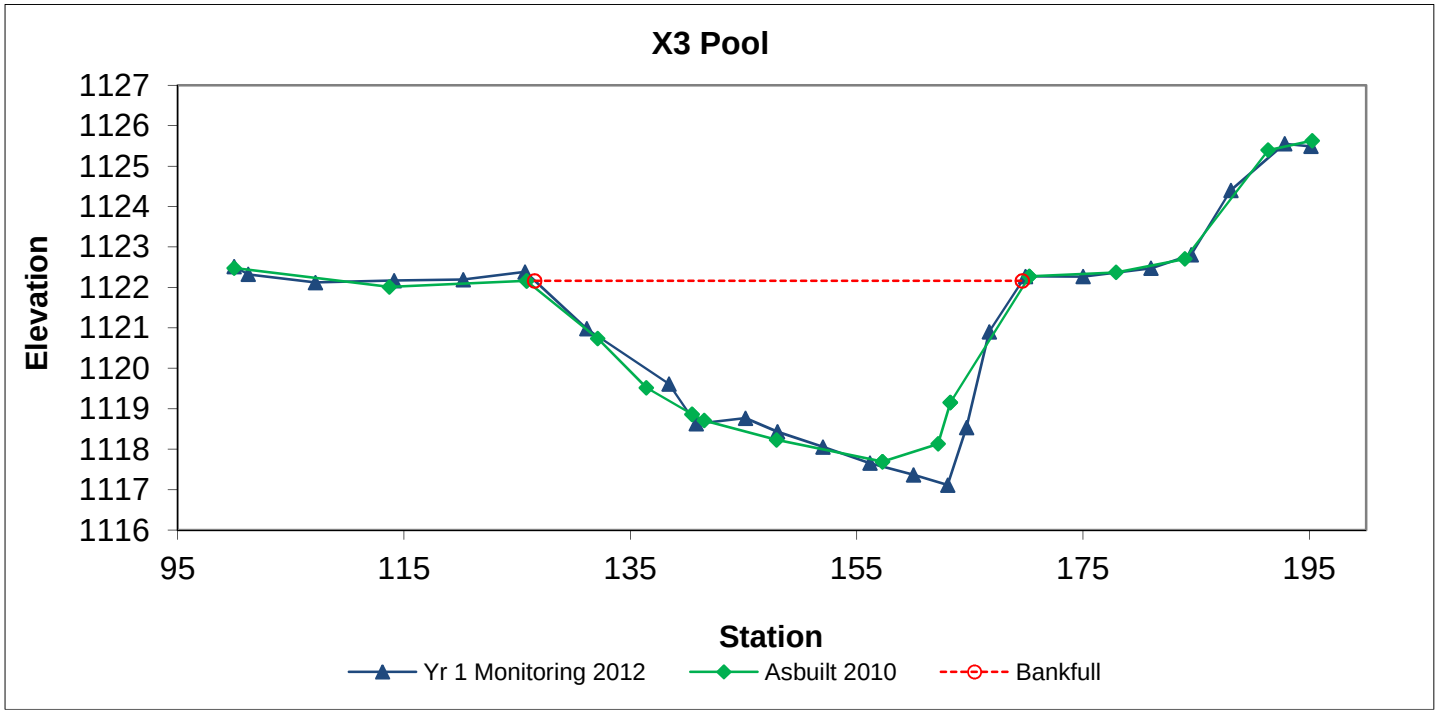
Permanent Cross Section X3

(Year 1 Monitoring - September 2012)

LEFT BANK

RIGHT BANK

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		129	43.08	2.99	5.05	14.39	1	2.2	1122.2	1122.27



South Muddy Creek

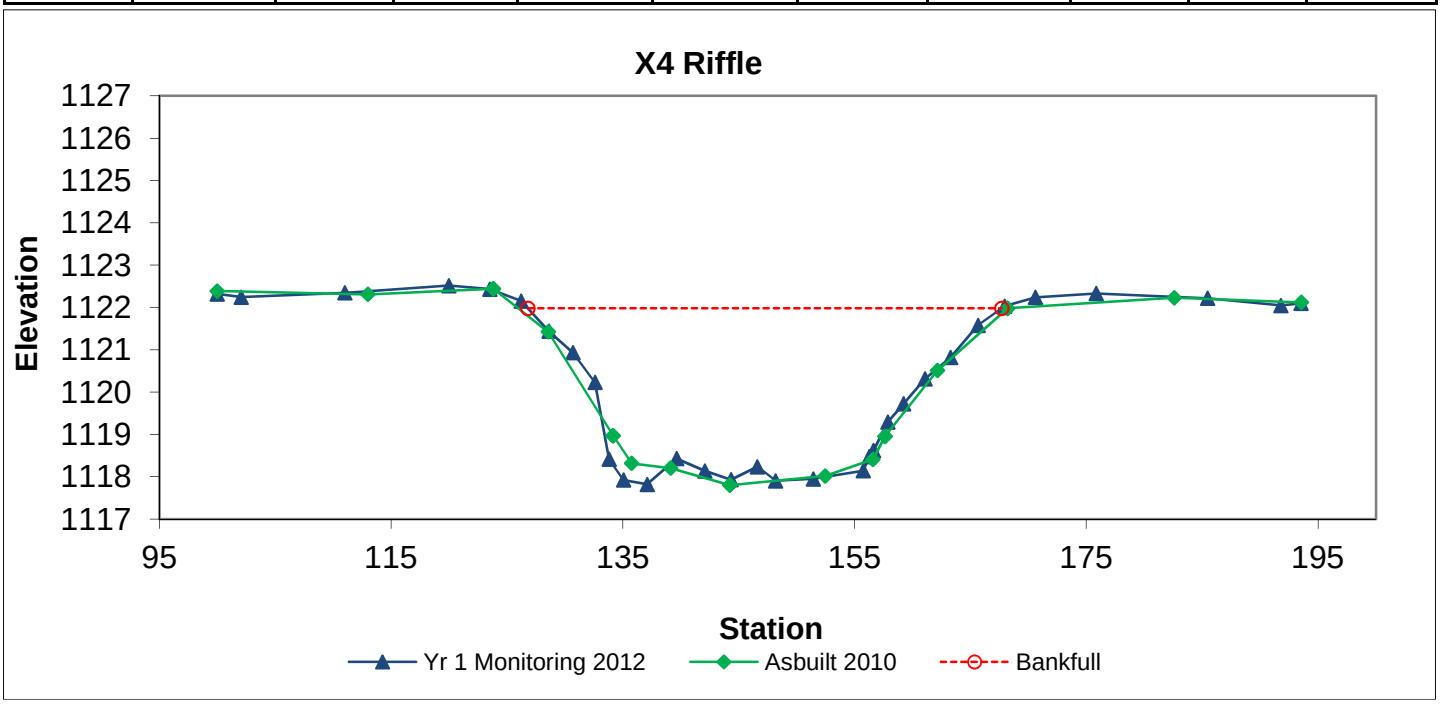
Permanent Cross Section X4

(Year 1 Monitoring - September 2012)

LEFT BANK

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	113.3	40.89	2.77	4.16	14.75	1	2.3	1121.98	1122.03



South Muddy Creek
Profile Chart
Year 1 Monitoring - September 2012

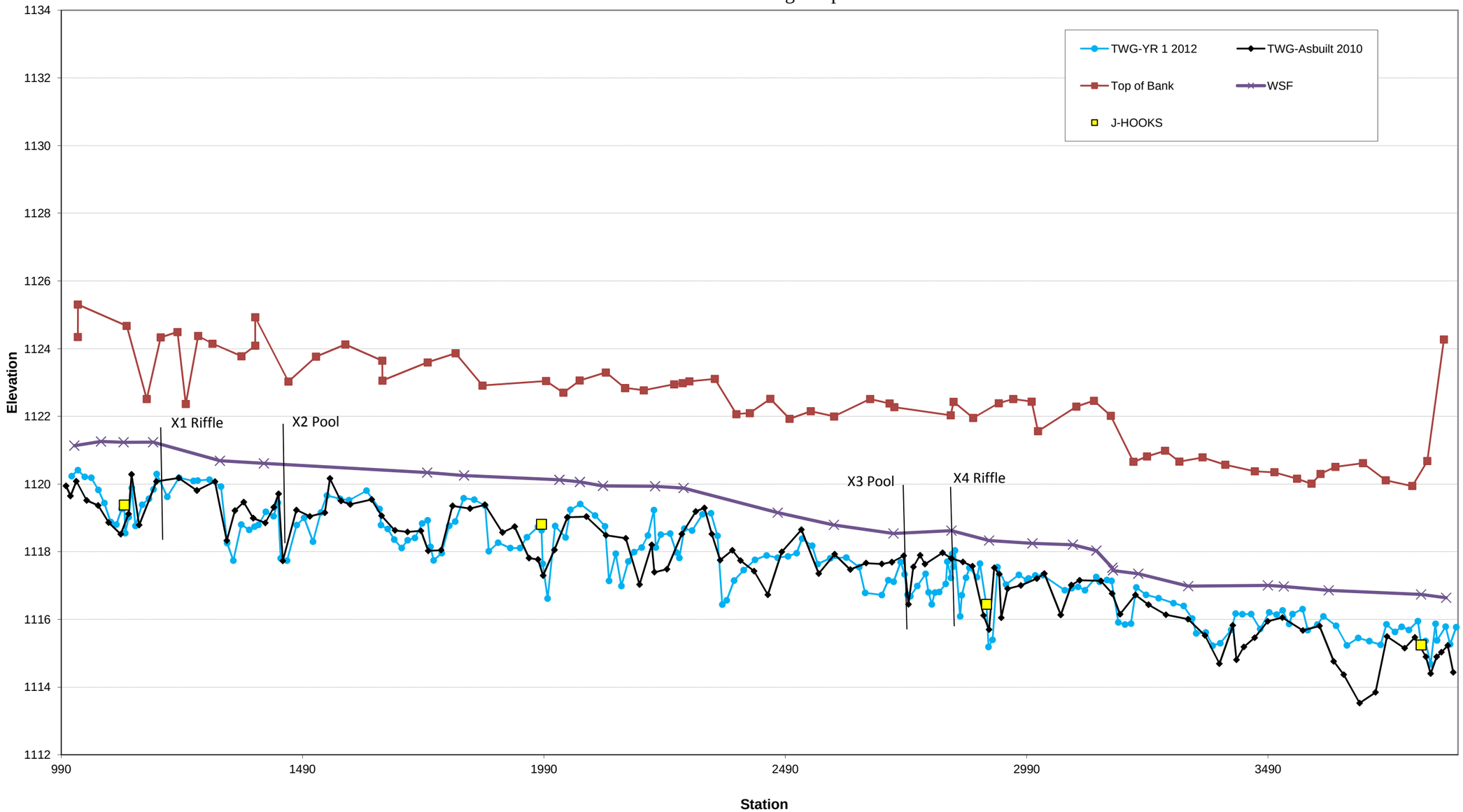
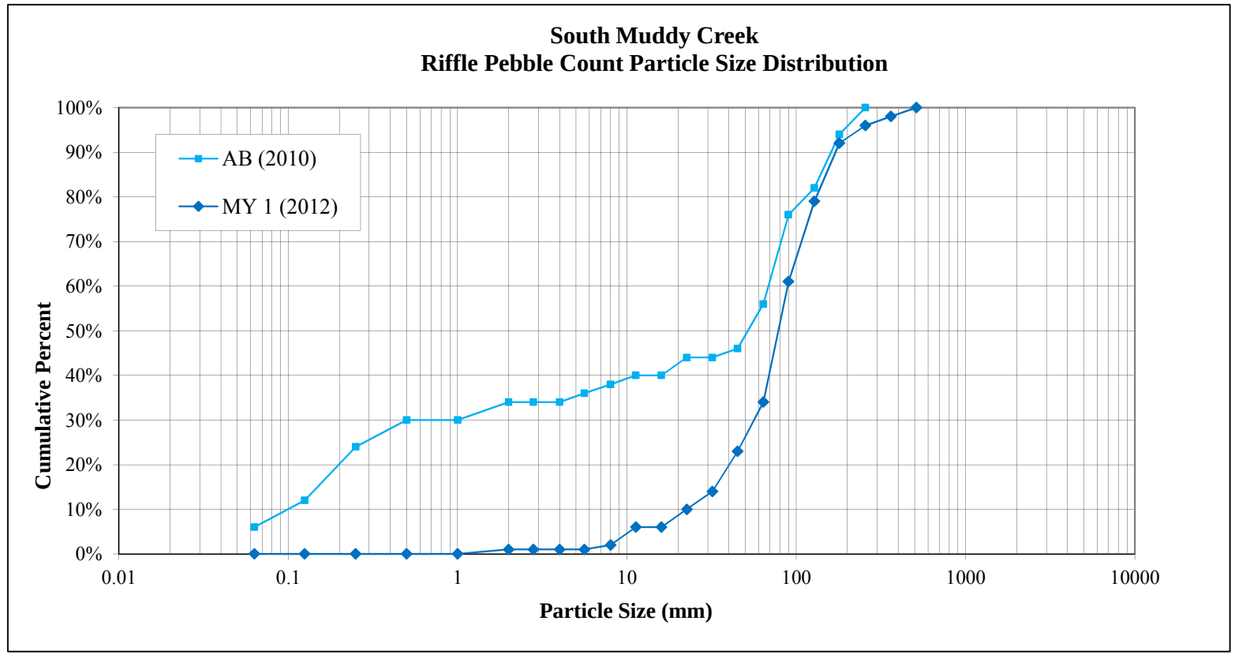


Figure 5. Riffle Pebble Count Size Class Distribution with Annual Overlays

BAKER PROJECT NO.	128221
SITE OR PROJECT:	South Muddy Creek Stream Restoration Project
REACH/LOCATION:	South Muddy Creek - Cross-section 4 (Riffle)
DATE COLLECTED:	9/12/2012
FIELD COLLECTION BY:	mw re
DATA ENTRY BY:	mw re

			PARTICLE CLASS COUNT	Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Class %	% Cum
SILT/CLAY	Silt / Clay	< .063			0%
SAND	Very Fine	.063 - .125			0%
	Fine	.125 - .25			0%
	Medium	.25 - .50			0%
	Coarse	.50 - 1.0			0%
	Very Coarse	1.0 - 2.0	1	1%	1%
GRAVEL	Very Fine	2.0 - 2.8			1%
	Very Fine	2.8 - 4.0			1%
	Fine	4.0 - 5.6			1%
	Fine	5.6 - 8.0	1	1%	2%
	Medium	8.0 - 11.0	4	4%	6%
	Medium	11.0 - 16.0			6%
	Coarse	16.0 - 22.6	4	4%	10%
	Coarse	22.6 - 32	4	4%	14%
	Very Coarse	32 - 45	9	9%	23%
	Very Coarse	45 - 64	11	11%	34%
COBBLE	Small	64 - 90	27	27%	61%
	Small	90 - 128	18	18%	79%
	Large	128 - 180	13	13%	92%
	Large	180 - 256	4	4%	96%
BOULDER	Small	256 - 362	2	2%	98%
	Small	362 - 512	2	2%	100%
	Medium	512 - 1024			
	Large-Very Large	1024 - 2048			
BEDROCK	Bedrock	> 2048			
		Total	100	100%	100%

Cummulative	
Channel materials (mm)	
D_{16} =	34.5
D_{35} =	64.8
D_{50} =	78.3
D_{84} =	145.9
D_{95} =	234.4
D_{100} =	362 - 512



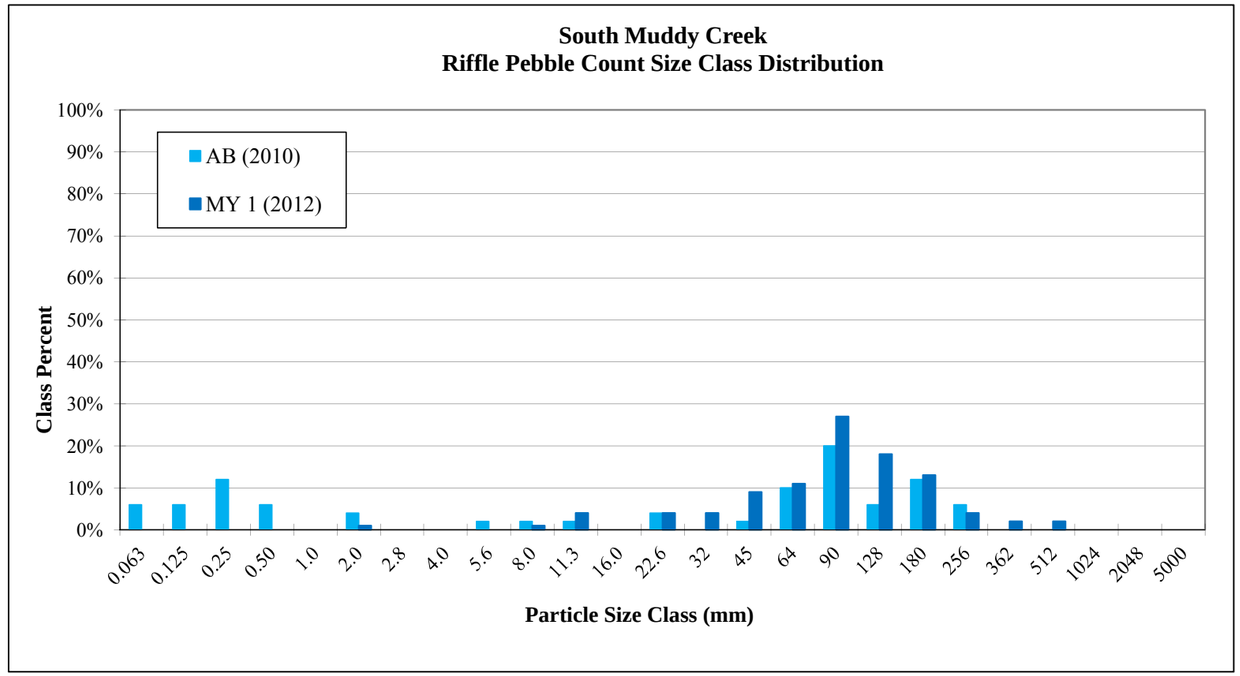


Table 10. Baseline Stream Summary
South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

Parameter	USGS Gauge	Regional Curve Interval (Harman et al, 1999)[1]			Pre-Existing Condition						Reference Reach(es) Data												Design						Monitoring Baseline (As-built)					
											Morgan Creek						Barnes Creek																	
		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
Dimension and Substrate - Riffle																																		
BF Width (ft)	-----	23.0	80.0	42.0	24.1	32.3	-----	51.2	-----	5	33.2	-----	-----	33.5	-----	2	60.7	-----	-----	69	-----	2	-----	43.2	-----	-----	-----	1	41.4	-----	-----	42.2	-----	2
Floodprone Width (ft)	-----	-----	-----	-----	29.6	44.8	-----	72.7	-----	5	77.5	-----	-----	86.8	-----	2	219	-----	-----	220	-----	2	-----	210+	-----	-----	-----	1	90.7	-----	-----	93.6	-----	2
BF Mean Depth (ft)	-----	2.3	5.8	3.8	1.9	2.7	-----	3.0	-----	5	2.3	-----	-----	2.4	-----	2	2.9	-----	-----	3.8	-----	2	-----	3.0	-----	-----	-----	1	2.7	-----	-----	2.8	-----	2
BF Max Depth (ft)	-----	-----	-----	-----	3.3	3.6	-----	4.0	-----	5	2.8	-----	-----	2.9	-----	2	3.9	-----	-----	5.2	-----	2	-----	4.2	-----	-----	-----	1	4.2	-----	-----	4.4	-----	2
BF Cross-sectional Area (ft²)	-----	80.0	300.0	157.6	72.8	83.8	-----	97.2	-----	5	75.1	-----	-----	79.8	-----	2	199	-----	-----	288	-----	2	-----	128.5	-----	-----	-----	1	110.8	-----	-----	115.9	-----	2
Width/Depth Ratio	-----	-----	-----	-----	8.1	12.9	-----	26.9	-----	5	14.1	-----	-----	14.7	-----	2	16	-----	-----	23.8	-----	2	-----	14.4	-----	-----	-----	1	15.4	-----	-----	15.5	-----	2
Entrenchment Ratio	-----	-----	-----	-----	1.1	1.4	-----	1.7	-----	5	2.3	-----	-----	2.6	-----	2	3.2	-----	-----	3.6	-----	2	-----	4.9+	-----	-----	-----	1	2.2	-----	-----	2.2	-----	2
Bank Height Ratio	-----	-----	-----	-----	2.4	2.8	-----	2.8	-----	5+	-----	1.0	-----	-----	-----	2	-----	-----	-----	-----	-----	-----	-----	1.0	-----	-----	-----	1	1.0	-----	-----	1.0	-----	2
d50 (mm)	-----	-----	-----	-----	-----	4.0	-----	-----	-----	1	-----	3.0	-----	-----	-----	1	-----	60	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pattern																																		
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	128.0	-----	-----	209.0	-----	9	143.0	168.3	164.0	244.0	32.2	8
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	84.0	-----	-----	138.0	-----	9	96.0	121.2	114.0	152.0	18.9	9
Rc:Bankfull width (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.9	-----	-----	3.2	-----	9	2.3	2.9	2.7	3.6	0.5	9
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	345.0	-----	-----	506.0	-----	6	387.0	400.8	396.5	418.0	12.9	6
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.0	-----	-----	4.8	-----	9	3.4	4.0	3.9	5.8	0.8	8
Profile																																		
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	61	80	88	122	23	3
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.003	0.004	-----	0.006	-----	3	0.01	-----	-----	0.02	-----	2		-----	-----	-----	-----		0.0034	-----	-----	0.0054	-----	7	0.000	0.006	0.005	0.011	0.004	3
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	80	163	-----	240	-----	4	46	-----	-----	277	-----	2		-----	-----	-----	-----		154.0	-----	-----	327.0	-----	10	167	272	257	335	53	3
Pool Max Depth (ft)	-----	-----	-----	-----	3.8	4.8	-----	5.8	-----	4	-----	4.1	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	6.2	-----	-----	10.3	-----	11		-----	-----	-----	-----	-----
Pool Volume (ft³)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Substrate and Transport Parameters																																		
Ri% / Ru% / P% / G% / S%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
SC% / Sa% / G% / B% / Be%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----			<0.06 / 0.2 / 4 / 25 / 44						N/A / 1.2 / 3 / 77 / 800						0.4 / 11 / 60 / 512 / >2048						-----	-----	-----	-----	-----	-----			0.15 / 5 / 52 / 135 / 190			
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	0.18	-----	-----	0.3	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.28	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	95.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	90.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	10.8	-----	-----	24	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	12.6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																																		
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	-----	18.8	-----	-----	-----	-----	-----	8.4	-----	-----	-----	-----	-----	23.0	-----	-----	-----	-----	-----	18.8	-----	-----	-----	-----	-----	18.8	-----	-----
Impervious cover estimate (%)	-----	-----	-----	-----		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rosgen Classification	-----	-----	-----	-----	-----	G4c	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C4	-----	-----	-----	-----	-----	C5	-----	-----	-----	-----
BF Velocity (fps)	-----	-----	-----	-----	4.1	-----	-----	5.5	-----	5	-----	7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.1	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----
BF Discharge (cfs)	-----	290.0	2000.0	741.1	-----	400	-----	-----	-----	-----	-----	524.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	400.0	-----	-----	-----	-----	-----	340.0	-----	-----	-----	-----
Valley Length	-----	-----	-----	-----		2446	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2409	-----	-----	-----	-----
Channel length (ft)	-----	-----	-----	-----	-----	2593	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2842	-----	-----	-----	-----	-----	2787	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	1.06	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.20	-----	-----	-----	-----	-----	1.18	-----	-----	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	-----	-----	-----		0.0016	-----	-----	-----	-----	-----	0.0070	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.0017	-----	-----	-----	-----	-----	0.0016	-----	-----	-----	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bankfull Floodplain Area (acres)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BEHI VL% / L% / M% / H% / VH% / E%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel Stability or Habitat Metric	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Biological or Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

* Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. Wildland Hydrology. AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

Table 11a. Cross-section Morphology Data Table

South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

	Cross-section 1 (Riffle)						Cross-section 2 (Pool)						Cross-section 3 (Pool)						Cross-section 4 (Riffle)					
Dimension and substrate	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
Based on fixed baseline bankfull elevation																								
Record Elevation (Datum) Used (ft)	1124.2	1124.2					1124.1	1124.1					1122.2	1122.2					1122.0	1122.0				
BF Width (ft)	41.4	40.8					42.1	43.1					44.2	43.1					42.2	40.9				
BF Mean Depth (ft)	2.7	2.5					2.8	2.7					2.9	3.0					2.8	2.8				
Width/Depth Ratio	15.5	16.5					15.3	16.0					15.4	14.4					15.4	14.8				
BF Cross-sectional Area (ft²)	110.8	100.5					115.8	115.8					126.5	129.0					115.9	113.3				
BF Max Depth (ft)	4.4	4.1					5.1	5.4					4.5	5.1					4.2	4.2				
Width of Floodprone Area (ft)	90.7	89.8					85.6	85.9					95.3	95.1					93.6	93.5				
Entrenchment Ratio	2.2	2.2					N/A	N/A					N/A	N/A					2.2	2.3				
Bank Height Ratio	1.0	1.0					1.0	1.1					1.0	1.0					1.0	1.0				
Wetted Perimeter (ft)	46.8	45.7					47.6	48.4					49.9	49.1					47.7	46.4				
Hydraulic Radius (ft)	2.4	2.2					2.4	2.4					2.5	2.6					2.4	2.4				

Table 11b. Baseline Stream Summary
South Muddy Creek Mitigation Plan: EEP Project No. 737

South Muddy Creek (2,787 LF)

Parameter	Monitoring Baseline (As-built)						MY-1						MY-2						MY-3						MY-4						MY-5					
Dimension and Substrate - Riffle	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
BF Width (ft)	41.4	-----	-----	42.2	-----	2	40.8	-----	-----	40.9	-----	2																								
Floodprone Width (ft)	90.7	-----	-----	93.6	-----	2	89.8	-----	-----	93.5	-----	2																								
BF Mean Depth (ft)	2.7	-----	-----	2.8	-----	2	2.5	-----	-----	2.8	-----	2																								
BF Max Depth (ft)	4.2	-----	-----	4.4	-----	2	4.1	-----	-----	4.2	-----	2																								
BF Cross-sectional Area (ft^2)	110.8	-----	-----	115.9	-----	2	100.5	-----	-----	113.3	-----	2																								
Width/Depth Ratio	15.4	-----	-----	15.5	-----	2	14.8	-----	-----	16.5	-----	2																								
Entrenchment Ratio	2.2	-----	-----	2.2	-----	2	2.2	-----	-----	2.3	-----	2																								
Bank Height Ratio	1.0	-----	-----	1.0	-----	2	1.0	-----	-----	1.0	-----	2																								
Pattern																																				
Channel Beltwidth (ft)	143.0	168.3	164.0	244.0	32.2	8																														
Radius of Curvature (ft)	96.0	121.2	114.0	152.0	18.9	9																														
Rc:Bankfull width (ft/ft)	2.3	2.9	2.7	3.6	0.5	9																														
Meander Wavelength (ft)	387.0	400.8	396.5	418.0	12.9	6																														
Meander Width Ratio	3.4	4.0	3.9	5.8	0.8	8																														
Profile																																				
Riffle Length (ft)	61	80	88	122	23	3	72	101	98	133	30.610456	3																								
Riffle Slope (ft/ft)	0.000	0.006	0.005	0.011	0.004	3	0.002	0.005	0.005	0.009	0.004	3																								
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Pool Spacing (ft)	167	272	257	335	53	3	209	251	253	290	41	3																								
Pool Max Depth (ft)		-----	-----		-----	-----		-----	-----		-----	-----																								
Substrate and Transport Parameters																																				
d16 / d35 / d50 / d84 / d95			0.15 / 5 / 52 / 135 / 190						34.5 / 64.8/78.3 / 145.9 / 234.4																													
Reach Shear Stress (competency) lb/f	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Stream Power (transport capacity) W/m^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								
Additional Reach Parameters																																				
Drainage Area (SM)	-----	-----	-----	18.8	-----	-----	-----	-----	-----	18.8	-----	-----																								
Rosgen Classification	-----	C5	-----	-----	-----	-----	-----	C5	-----	-----	-----	-----																								
BF Velocity (fps)	-----	3.0	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----																								
BF Discharge (cfs)	-----	340.0	-----	-----	-----	-----	-----	318.0	-----	-----	-----	-----																								
Valley Length	-----	2409	-----	-----	-----	-----	-----	2409	-----	-----	-----	-----																								
Channel length (ft)	-----	2787	-----	-----	-----	-----	-----	2787	-----	-----	-----	-----																								
Sinuosity	-----	1.18	-----	-----	-----	-----	-----	1.18	-----	-----	-----	-----																								
Water Surface Slope (Channel) (ft/ft)	-----	0.0016	-----	-----	-----	-----	-----	0.0016	-----	-----	-----	-----																								
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----																								

APPENDIX E

HYDROLOGIC DATA

Table 12. Verification of Bankfull or Greater than Bankfull Events
South Muddy Creek Mitigation Plan: EEP Project No. 737

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (feet above bankfull)
May 18, 2012	September 2010 (crest gauge installation for asbuilt) - May 18th, 2012*	Gauge measurement	0.17
August 1, 2012	May 18th - August 1st 2012*	Gauge measurement	0.08

* Date of event(s) occurred sometime between the date range specified.