FINAL
MONITORING REPORT
YEAR 4 (2021)
MUD LICK CREEK MITIGATION SITE
Chatham County, North Carolina
NCDMS Project No. 93482
Contract No. 7683
USACE Action ID No. SAW-2014-00736 & DWR Project No 2014-1127
SCO No. 1209857-01
Data Collection: April-October 2021
Submission: January 2022

PREPARED FOR:

N.C. DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF MITIGATION SERVICES
1601 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699-1601

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PREPARED BY:

AXIOM ENVIRONMENTAL, INC.
218 SNOW AVENUE
RALEIGH, NORTH CAROLINA 27603

Axiom Environmental, Inc.

Axiom Environmental, Inc.

218 Snow Avenue, Raleigh, NC 27603 919-215-1693

January 6, 2022

Mr. Jeremiah Dow
North Carolina Department of Environmental Quality
Division of Mitigation Services
1652 Mail Service Center
Raleigh, North Carolina 27699-1652

RE: Mud Lick Creek Monitoring (DMS Project # 93482, Contract #7683)
Final MY4 (2021) Annual Monitoring Report

Dear Mr. Dow:

Axiom Environmental, Inc. (AXE) is pleased to provide you with the Final Mud Lick Creek MY4 (2021) Annual Monitoring Report. We received your comments via email on January 4, 2022, and have addressed them as follows:

1. In the fish sampling report in Appendix F, it appears that the Reach 2 baseline NCIBI score of 20 was summed incorrectly and should have been 24. We don't expect you to have Three Oaks change the report but simply wanted to note it for the record so it can be corrected for the next round of fish monitoring.
   This has been noted and will be corrected during MY7 fish monitoring.
2. Please submit the stream areas of concern features as lines and ensure that these areas are reflected in Table 5.
   A stream areas of concern line feature has been included in the digital submittal. These areas were not included on Table 5 due to the fact that they occur on Enhancement II reaches.
3. Please ensure that areas outside of the main channel (determined by the low bank height) are excluded from the cross sectional area calculation before the bankfull elevation is adjusted to achieve the MY0 cross sectional area. For example, XS-4 should have a BHR less than 1.0 when these points are excluded.
   Areas outside the main channel were excluded from the cross-sectional areas prior to adjusting the bankfull elevation for all cross-sections. Cross-section 4 has a low bank height of 2.047941 and BF max depth of 2.063948, making its bank height ratio 0.99, which was rounded to 1.0.
4. We recommend removing the green dotted line on all cross sections. Also, it may make analysis easier to display the MY-04 LTOB as a line instead of a point. We also recommend not reporting BHR on pools, and we really only need to see LTOB identified on pool features.
   The MY0 TOB line was removed from all cross-section figures. The MY-04 LTOB point was changed to a line. BHR values were removed from pool cross-sections.

Please let me know if you have any questions or comments regarding any component of this submittal. Thank you for the opportunity to continue to assist the Division of Mitigation Services with this important project.

Sincerely,
AXIOM ENVIRONMENTAL, INC

Kenan Jernigan

PROJECT SUMMARY

The North Carolina Division of Mitigation Services (NCDMS) has established the Mud Lick Creek Mitigation Site (Site) located within the Cape Fear River Basin Cataloging Unit (CU) 03030003 in the Upper Rocky River local watershed planning (LWP) area and 14-digit HUC 03030003070010. The Site was identified as a priority mitigation project in the *Detailed Assessment and Targeting of Management Report* (Tetra Tech 2005). The main stressors to aquatic resources identified during the watershed assessments described in the LWP documents include the following.

- Nutrient (nitrogen and phosphorous) loading from farming;
- Sediment loading from overland runoff, disturbed surfaces, and streambank erosion;
- Cattle access to streams increasing bank erosion and fecal coliform contamination; and
- Insufficient bank vegetation.

The project will contribute to meeting management recommendations to offset these stressors as described above for the LWP area by accomplishing the following primary goals.

- Control and reduce nutrient sources from the Site;
- Reduce sediment loads from disturbed areas on the Site and from eroding stream banks;
- Increased aeration of flows within the project extent promoting increases in dissolved oxygen concentrations;
- Reduce sources of fecal coliform pollution;
- Improve instream habitat;
- Reduce thermal loadings;
- Reconnect channels with floodplains and raise local water table; and
- Restore riparian habitat.

These goals will be accomplished through the following objectives:

- Restore riparian vegetation on the Site and thereby reduce sediment loads to streams from stream banks and existing pastures, increase on-Site retention of sediment and nutrients, create riparian habitat, and provide shade for streams to reduce thermal loadings;
- Stabilize eroding streambanks to reduce sediment inputs;
- Install fencing around the perimeter of the conservation easement to eliminate livestock access to streams, thereby reducing sediment, nutrient, and fecal coliform inputs;
- Plant restored and stabilized streambanks with native species to improve stability and habitat;
- Install instream structures to improve stability, create habitat, and help aerate stream flows;
- Raise streambeds to reconnect restored channels to floodplains and raise local water tables; and
- Restore streams and vegetation so the Site looks natural and aesthetically pleasing.

Stream Success Criteria: The stream restoration performance criteria for the Site will follow approved performance criteria presented in the 2015 *Mud Lick Creek Mitigation Site Final Mitigation Plan* as described below.

Stream Dimension: Riffle cross-sections on the restoration reaches and enhancement II reaches, where banks were re-graded (three reaches of Mud Lick Creek), should be stable and should show little change in bankfull area, maximum depth, and width-to-depth ratio. Bank-height-ratios shall not exceed 1.2 and entrenchment ratios shall be at least 2.2 for restored channels to be considered stable. All riffle cross-sections should fall within the parameters defined for channels of the appropriate stream type. If any changes do occur, these changes will be evaluated to assess whether the stream channel is showing signs of instability. Indicators of instability include a vertically incising thalweg or eroding channel banks. Changes in the channel that indicate a movement toward stability or enhanced habitat include a decrease in

the width-to-depth ratio in meandering channels or an increase in pool depth. Remedial action would not be taken if channel changes indicate a movement toward stability.

Stream Pattern and Profile: The as-built survey will include a longitudinal profile for the baseline monitoring report. Longitudinal profile surveys will not be conducted during the seven-year monitoring period unless other indicators during the annual monitoring indicate a trend toward vertical and lateral instability.

Substrate: Substrate materials in the restoration reaches should indicate a progression towards or the maintenance of coarser materials in the riffle features and smaller particles in the pool features.

Hydraulics: Two bankfull flow events, in separate monitoring years, must be documented on the restoration reaches and enhancement II reaches where banks were re-graded (three reaches of Mud Lick Creek) within the seven-year monitoring period.

Vegetation Success Criteria: The final vegetative success criteria will be the survival of 210 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of the required monitoring period (year seven). The interim measure of vegetative success for the Site will be the survival of at least 320 planted stems per acre at the end of the third monitoring year and at least 260 stems per acre at the end of the fifth year of monitoring. If this performance standard is met by year five and stem density is trending towards success (i.e., no less than 260 stems/acre), monitoring of vegetation on the Site may be terminated with written approval by the USACE in consultation with the NC Interagency Review Team. The extent of invasive species coverage will also be monitored and controlled as necessary throughout he required monitoring period (seven years).

Photo Documentation: Photographs should illustrate the Site's vegetation and morphological stability on an annual basis. Cross-section photos should demonstrate no excessive erosion or degradation of the banks. Longitudinal photos should indicate the absence of persistent bars within the channel or vertical incision. Grade control structures should remain stable. Deposition of sediment on the bank side of vane arms is preferable. Maintenance of scour pools on the channel side of vane arms is expected.

Visual Assessments: Visual assessments should support performance standards as described above.

As per Sections 7.2 and 12.4 of the Mitigation Plan, physio-chemical and biological parameters were included as part of specialized monitoring, depending on the data that could be obtained during the baseline period. Monitoring of these parameters was for investigative purposes only and not tied to mitigation success or credit. The sample size and variability of the pre-construction physio-chemical data was inadequate for the purposes of post-construction comparison and therefore, these will not be monitored moving forward. However, fish and macrobenthos will be monitored at the stations indicated in the asset and monitoring features map (Figure 2, Appendix B).

Site Background: The Site is located in northwestern Chatham County, north of Siler City and northwest of Silk Hope (Figure 1, Appendix B). The Site is located within United States Geological Survey (USGS) Hydrologic Unit and Targeted Local Watershed 03030003070010 (North Carolina Division of Water Resources Subbasin 03-06-12) of the Cape Fear River Basin. Prior to construction, the Site was used for agricultural livestock production. The proposed project will improve water quality as well as provide numerous ecological benefits within the Cape Fear River Basin. The project will help meet management recommendations of the *Upper Rocky River Local Watershed Plan* by restoring a vegetated riparian buffer zone, stabilizing eroding stream banks, and removing livestock from streams and riparian zones. These activities will result in reduced nutrient, sediment, and fecal coliform inputs; improved aquatic and riparian habitat, and other ecological benefits.

Mitigation Components: Project mitigation efforts will generate 2832 Stream Mitigation Units (SMUs) as the result of the following (Table 1, Appendix A & Figure 2, Appendix B).

- Restoration of 1215 linear feet of Site streams
- Enhancement (Level II) of 2426 linear feet of Site streams

Site design was completed in June 2015. Site construction occurred May 24–August 25, 2017 (final walkthrough) and the Site was planted in February 2018. Completed project activities, reporting history, completion dates, project contacts, and project attributes are summarized in Tables 1-4 (Appendix A). The assets and credits in the report and shown in Table 1 are based upon approved as-built numbers as approved by the IRT on 11/1/2018.

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APPENDICES

1.0 METHODS

Monitoring of restoration efforts will be performed for seven years, or until success criteria are fulfilled. Monitoring is proposed for the stream channel and vegetation. In general, the restoration success criteria, and required remediation actions, are based on the *Stream Mitigation Guidelines* (USACE et al. 2003). Monitoring features are summarized in the following table and described below; monitoring features are depicted on Figure 2 (Appendix B).

Monitoring Summary

Parameter	Monitoring Feature	Quantity	Frequency
Streams			
Dimension	Cross-sections	7 riffles & 3 pools	annually
Substrate	Pebble counts	3 riffles	annually
Hydrology	Crest gauges	3	annually
Vegetation	Vegetation Plots	12	annually
	Warranty Plots	10	MY1
Visual assessments		Entire Site	biannually
Exotic & nuisance species		Entire Site	annually
Project boundary		Entire Site	annually
Reference photographs		22	annually
Supplemental Monitoring			
Biological	Macrobenthos	5 sites (Preconstruction only) 3 sites (MY3, MY5, & MY7)	
	Fish	3 sites (Preconstruction only) 2 sites (MY4 & MY7)	

Streams

The restored stream reaches are proposed to be monitored for geometric activity as follows.

- 7 permanent riffle cross-sections
- 3 permanent pool cross-sections
- 3 riffle pebble count samples for substrate analysis
- 3 stream crest gauges

The data will be presented in graphic and tabular format. Data to be presented will include 1) cross-sectional area, 2) bankfull width, 3) average depth, 4) maximum depth, and 5) width-to-depth ratio. Substrate analysis will be evaluated through pebble counts at three riffle cross-sections and data presented as a D50 for stream classification and tracking purposes. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology including bank-height-ratios and entrenchment ratios will be tracked and reported by comparing data to asbuilt measurements in addition to each successive monitoring year. Annual photographs will include 22 fixed station photographs (12 vegetation plots and 10 cross-sections) (Appendix B). The Site contains three stream crest gauges to assist with documentation of bankfull events. No bankfull events were documented during monitoring year 4 (2021), lack of bankfull events is attributed to a relatively dry year and lack of tropical systems that have historically trigged these events. A of total of five bankfull events have been documented over the monitoring period to date (Table 12, Appendix E).

Year 4 cross-section 8 data are characterized by a bank height ratio of less than 1. Pool cross-sections (like cross-section 8) are typically not monitored for bank-height-ratio because they are naturally sediment storage and transport areas within a stream. This is apparent in review of the varying D_{max} and LBH values exhibited by cross-section 8 throughout the monitoring period. Bank erosion has not been noted within or adjacent to cross-section 8, and overall, the reach appears stable. Cross-section 2 has been characterized by in increased bank height ratio for the past several monitoring years. This cross-section is located within an Enhancement (Level II) reach of stream that has scoured in previous years; however, the scour appears to have been minimized and the cross section has remained relatively consistent and stable for the past 3 monitoring years. All site cross-sections are meeting success criteria during year 4 (2021).

Two stream areas of concern were observed during monitoring year 4 (2021); both were documented during previous monitoring years. Stream Area of Concern #1 is located along Mud Lick Creek R2 where approximately 50 feet of the right bank and 20 feet of the left bank have eroded to the point of bank sloughing. This area remains relatively unchanged from year 1 (2018); the establishment of dense herbaceous vegetation and lack of high discharge events have allowed this area to continue to stabilize. Stream Area of Concern #2 consists of scour and sloughing along an outer bend along Mud Lick Creek R3, immediately downstream from cross-section 1. It was noted during year 4 (2021) that the material that had sloughed from the bank was generally stable and herbaceous vegetation was vigorous. Both stream areas of concern are located within enhancement II stream reaches; all stream reaches generating restoration credit are stable throughout and functioning as designed. Stream areas of concern are depicted on Figure 2 in Appendix B.

Vegetation

Restoration monitoring procedures for vegetation health will monitor plant survival and species diversity. After planting of the area was completed, 12 permanent vegetation plots were installed and monitored at the Site; annual results are in Appendix C. Annual measurements of vegetation will consist of the following.

- 10 plant warranty inspection plots (only MY1)
- 12 CVS vegetation plots

A photographic record of plant growth should be included in each annual monitoring report; baseline photographs are included in Appendix B. During the first year, vegetation will receive a cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed as outlined in the *CVS-EEP Protocol for Recording Vegetation, Version 4.2* (Lee et al. 2008) in late fall/early winter of the first monitoring year and annually toward the end of the growing for the remainder of the monitoring period until vegetation success criteria are achieved.

Locations of exotic and nuisance vegetation are documented and depicted on Figure 2 (Appendix B).

Year 4 (2021) stem count measurements for twelve permanent CVS plots indicate the planted stem density across the Site is 300 planted stems per acre. Eight of the twelve individual CVS plots met success criteria based on planted stems alone; however, when including naturally recruited stems of American sycamore *(Platanus occidentalis)* the stem densities of plots 6 and 10 are above success criteria (Table 8, Appendix C). Plot 1 was one stem shy of success, likely due to herbaceous competition. Plot 11 was two stems shy of success criteria. This plot is dominated by dense herbaceous vegetation and many natural recruits of sweetgum (*Liquidambar styraciflua*). Areas within the site remaining below success criteria are primarily due to herbaceous competition with dense fescue (*festuca* spp.). There are several isolated areas of dense

sweetgum along North Branch R2 that are likely out competing more desirable tree species. During vegetation data collection an abundance of deer browse was documented in all permanent CVS plots. Additionally, several populations of dense Chinese privet (*Ligustrum sinense*) and tree of heaven (*Ailanthus altissima*) were observed scattered throughout the Site, these areas are relatively unchanged from previous years. Invasive populations are depicted on Figure 2 (Appendix B). Overall, the site is trending towards success. It is expected that desirable hardwood species recruits will continue to establish and planted stems will continue to thrive.

Project Boundaries & Visual Assessments

Locations of any fence damage, vegetation damage, boundary encroachments, etc. will be documented and included on mapping.

Visual assessments will be performed along all streams on a bi-annual basis during the seven-year monitoring period. Problem areas will be noted such as channel instability (i.e. lateral and/or vertical instability, in-stream structure failure/instability and/or piping, headcuts), vegetated buffer health (i.e. low stem density, vegetation mortality, invasive species or encroachment), beaver activity, or livestock access. Areas of concern will be mapped and photographed accompanied by a written description in the annual report. Problem areas will be re-evaluated during each subsequent visual assessment.

During year 3 (2020) monitoring, onsite beaver activity was observed including a significant dam along North Branch R3, a dam along Mud Lick Creek R2, and several smaller dams throughout the Site. In response, on November 4, 2020, USDA trapped beaver and removed six dams. Beaver activity was not observed during year 4 (2021) monitoring period.

Supplementary Monitoring

Supplemental monitoring will include biological monitoring in the Spring as follows.

- 3 benthos sampling sites (MY3, MY5, & MY7)
- 2 fish sampling sites (MY4 & MY7)

Additional parameters are being monitored for analytical purposes and are not tied to mitigation success and associated credit releases. The primary criteria for indication of improvement for the benthos and fish will be an increase of at least one bioclassification between the pre-con assessment and the post-con monitoring. Richness and EPT metrics will be analyzed as well. Based on values tabulated on Habitat Assessment Field Data Sheets, benthic macroinvertebrate habitat appears to be improving at the Site. Overall values for the data sheets improved by 15 to 60 points. In addition, each independent variable on the data sheets show improvement, except for channel modification. Biotic index (tolerance of a stream benthic community) has not shown significant improvement, with station MLC-2 shifting from a Fairly Poor to Very Poor designation. The other two stations appear to have biotic indices showing improving water quality shifting from Poor to Fairly Poor. Fish sampling was conducted in May of 2021, there was a slight improvement in the community from pre-construction sampling. The report is included in Appendix F. A summary of benthic results including preconstruction Habitat Field Data Assessment Sheets and Biotic Index values from laboratory analysis results is presented below.

Site	MLC-2		MLC-3		MLC-5	
Habitat Assessment Field Data Sheet Data	**Precon (2015)**	**MY 3 (2020)**	**Precon (2015)**	**MY 3 (2020)**	**Precon (2015)**	**MY 3 (2020)**
Channel Modification	5	3	5	3	4	5
Instream Habitat	11	14	11	11	9	18
Bottom Substrate	3	8	3	11	1	11
Pool Variety	4	10	6	10	0	10
Riffle Habitats	7	14	7	10	0	16
Bank Stability and Veg	8	4	13	6	10	14
Light Penetration	7	7	7	7	2	2
Riparian Veg Zone Width	2	10	1	10	12	10
Total Score	**47**	**70**	**53**	**68**	**26**	**86**
Biotic Index	6.01	8.05	6.64	6.31	6.90	5.90

2.0 REFERENCES

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2008. CVS-EEP Protocol for Recording Vegetation. Version 4.2. North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. Raleigh, North Carolina.

North Carolina Division of Mitigation Services (NCDMS) 2015. Mud Lick Creek Mitigation Site Final Mitigation Plan.

Rosgen D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

Tetra Tech, 2005. Upper Rocky River Local Watershed Plan Preliminary Findings Report. Prepared for the North Carolina Ecosystem Enhancement Program.

United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), North Carolina Wildlife Resources Commission (NCWRC), Natural Resources Conservation Service (NRCS), and North Carolina Division of Water Quality (NCDWQ). 2003. Stream Mitigation Guidelines. State of North Carolina.

Appendix A.
Background Tables

Table 1. Project Mitigation Components
Table 2. Project Activity and Reporting History
Table 3. Project Contacts Table
Table 4. Project Attributes Table

Table 1. Mud Lick Creek (ID-93482) - Mitigation Assets and Components**

Project Component (reach ID, etc.)	Wetland Position and HydroType	Existing Footage	Stationing	Mitigation Plan Footage	As-Built Footage *	Restoration Level	Approach Priority Level	Mitigation Ratio (X:1)	Mitigation Credits	Notes/Comments
North Branch R1		318	100+10 - 103+28	327	318	EII	-	1.5	212.000	Planting, fencing
North Branch R2		522	103+28 - 108+66	520	538	R	PI	1	538.000	
North Branch R3		351	108+66 - 111+51	303	265	R	P2	1	265.000	20 LF of restoration was removed from North Branch Reach 2 in order to account for an easement break
East Branch R1		165	200+05 - 201+69	168	164	EII	-	1.5	109.333	Planting, fencing
East Branch R2		315	201+69 - 205+81	409	412	R	P2	1	412.000	
Mud Lick Creek R1		525	300+72 - 306+23	623	551	EII	-	1.5	367.333	Planting, fencing, bank repairs
Mud Lick Creek R2		718	306+23 - 313+14	693	660	EII	-	1.5	440.000	Planting, fencing, bank repairs; 31 LF of enhancement II was removed from Mud Lick Creek Reach 2 in order to account for an easement break
Mud Lick Creek R3		733	313+14 - 320+47	748	733	EII	-	1.5	488.667	Planting, fencing, bank repairs

*Reach start and end stationing may differ slightly from the mitigation plan due to removal of stream lengths that are outside the conservation easement. The upstream ends of Mud Lick Creek, North Branch, and East Branch experienced footage reductions of 72', 10', and 5' respectively, while the downstream end of Mud Lick Creek experienced a footage reduction of 17'.

**The assets and credits in the report and shown in Table 1 are based upon approved as-built numbers as approved by the IRT on 11/1/2018

Length and Area Summations by Mitigation Category

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)
		Riverine	Non-Riverine	
Restoration	1215			
Enhancement				
Enhancement I				
Enhancement II	2426			
Creation				
Preservation				
High Quality Pres				

Overall Assets Summary

Asset Category	Overall Credits
Stream	2,832.333

Table 2. Project Activity and Reporting History
Mud Lick Creek (ID-93482)

Elapsed Time Since Grading Complete: 4 years 5 months
Elapsed Time Since Planting Complete: 3 years 11 months
Number of Reporting Years: 4

Activity or Deliverable	Data Collection Complete	Completion or Delivery
Project Institution	--	February 13, 2013
Mitigation Plan	--	December 2015
404 Permit Date	--	March 25, 2016
Final Design – Construction Plans	--	June 2015
Construction	--	August 25, 2017
Bare Root; Containerized; and B&B Plantings for the Entire Project Site	February 2018	February 2018
Baseline Monitoring Document (Year 0 Monitoring Baseline)	July 2018	September 2018
Monitoring Year 1 (2018) Document	December 2018	December 2018
Monitoring Year 2 (2019) Document	September 2019	January 2020
Monitoring Year 3 (2020) Document	September/October 2020	January 2021
Monitoring Year 4 (2021) Document	October 2021	January 2022

Table 3. Project Contact Table

Mud Lick Creek (ID-93482)

Designer	Wildlands Engineering, Inc. (License No. F-0831) 312 West Millbrook Rd, Suite 225 Raleigh, NC 27609 Angela N. Allen, PE (919) 851-9986
Construction Plans and Sediment and Erosion Control Plans	Wildlands Engineering, Inc. (License No. F-0831) 312 West Millbrook Rd, Suite 225 Raleigh, NC 27609 Angela N. Allen, PE (919) 851-9986
Construction Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101 Michael Anderson (336) 725-2010
Planting Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101 Stephen Joyce (336) 725-2010
As-built Surveyors	Allied Associates, PA 4720 Kester Mill Road Winston Salem, NC 27103 David Alley (336) 765-2377
Baseline Data Collection	Axiom Environmental, Inc. 218 Snow Avenue Raleigh, NC 27603 Grant Lewis (919) 215-1693

Table 4. Project Baseline Information and Attributes

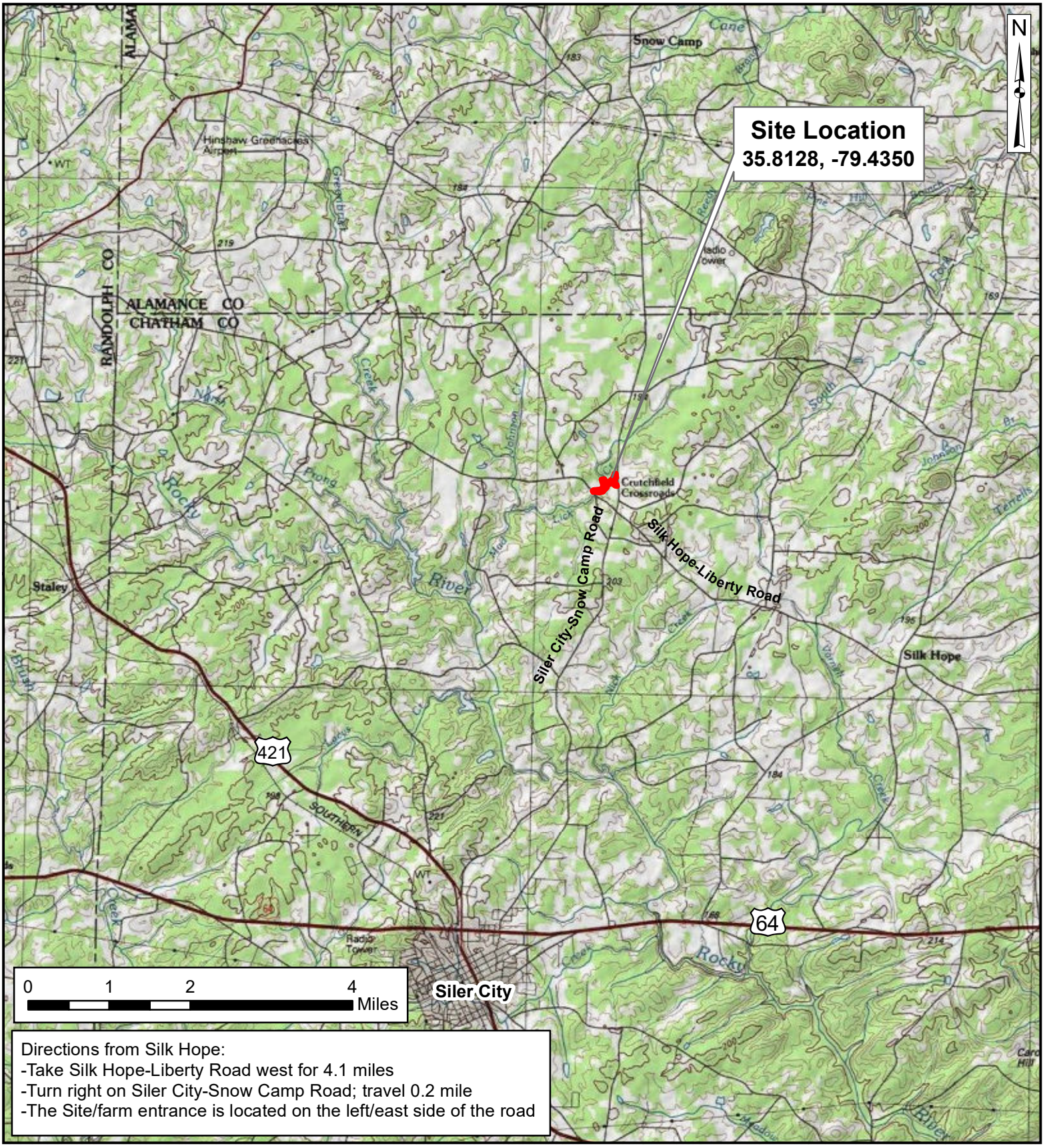
Mud Lick Creek (ID-93482)

Project Information						
Project name	Mud Lick Creek Mitigation Site					
Project county	Chatham County, North Carolina					
Project area (Acres)	11.2					
Project coordinates (lat/long)	35.8128°N, 79.4350°W					
Planted Acres	9.6					
Project Watershed Summary Information						
Physiographic region	Carolina Slate Belt of the Piedmont Physiographic Province					
Project river basin	Cape Fear River Basin					
USGS hydrologic unit (8 digit/14-digit)	03030003/03030003070010					
NCDWR Sub-basin	03-06-12					
Project drainage area (mi^2)	3.64					
% Drainage area impervious	< 1%					
CGIA land use classification	Developed, Forested/Scrubland, Agriculture/Managed Herb., Open Water					
Reach Summary Information						
Parameters	**Mud Lick Creek – R1**	**Mud Lick Creek – R2**	**Mud Lick Creek – R3**	**North Branch – R1**	**North Branch – R2**	**East Branch**
Restored length (linear feet)	551	660	733	856	265	576
Valley confinement	Slightly confined - unconfined					
Drainage area (acres/mi^2)	1747/2.73	2170/3.39	2330/3.64	236.8/0.37	416/0.65	172.8/0.27
Perennial (P), Intermittent (I)	P	P	P	P	P	P
NCDWR water quality classification	WS-III, CA					
Stream Classification (existing)	E4	C4	E4	E4	B4c	B4c
Stream Classification (proposed)	E4	C4	E4	C4	C4	C4
Evolutionary trend (Simon & Hupp)	IV/V	IV/V	IV/V	IV	IV	IV
FEMA classification	AE	AE	AE	AE	AE	AE

Regulatory Considerations			
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**
Waters of the US – Section 404	Yes	Yes	SAW-2014-00736
Waters of the US – Section 401	Yes	Yes	SAW-2014-00736
Endangered Species Act	Yes	Yes	No Effect – CE Document
Historic Preservation Act	No	NA	CE Document
Coastal Zone Management Act (CZMA/CAMA)	No	NA	NA
FEMA Floodplain Compliance	Yes	Yes	Chatham County Floodplain Development Permit #14-001
Essential Fisheries Habitat	No	NA	NA

Appendix B
Visual Assessment Data

Figure 1. Site Location
Figure 2. Current Conditions Plan View
Tables 5A-5C. Visual Stream Morphology Stability Assessment
Table 6. Vegetation Condition Assessment
Vegetation Plot Photographs



Directions from Silk Hope:
-Take Silk Hope-Liberty Road west for 4.1 miles
-Turn right on Siler City-Snow Camp Road; travel 0.2 mile
-The Site/farm entrance is located on the left/east side of the road

Axiom Environmental, Inc.
Axiom Environmental
218 Snow Avenue
Raleigh, NC 27603
(919) 215-1693

SITE LOCATION
MUD LICK CREEK MITIGATION SITE
DMS PROJECT NUMBER 93482
Chatham County, North Carolina

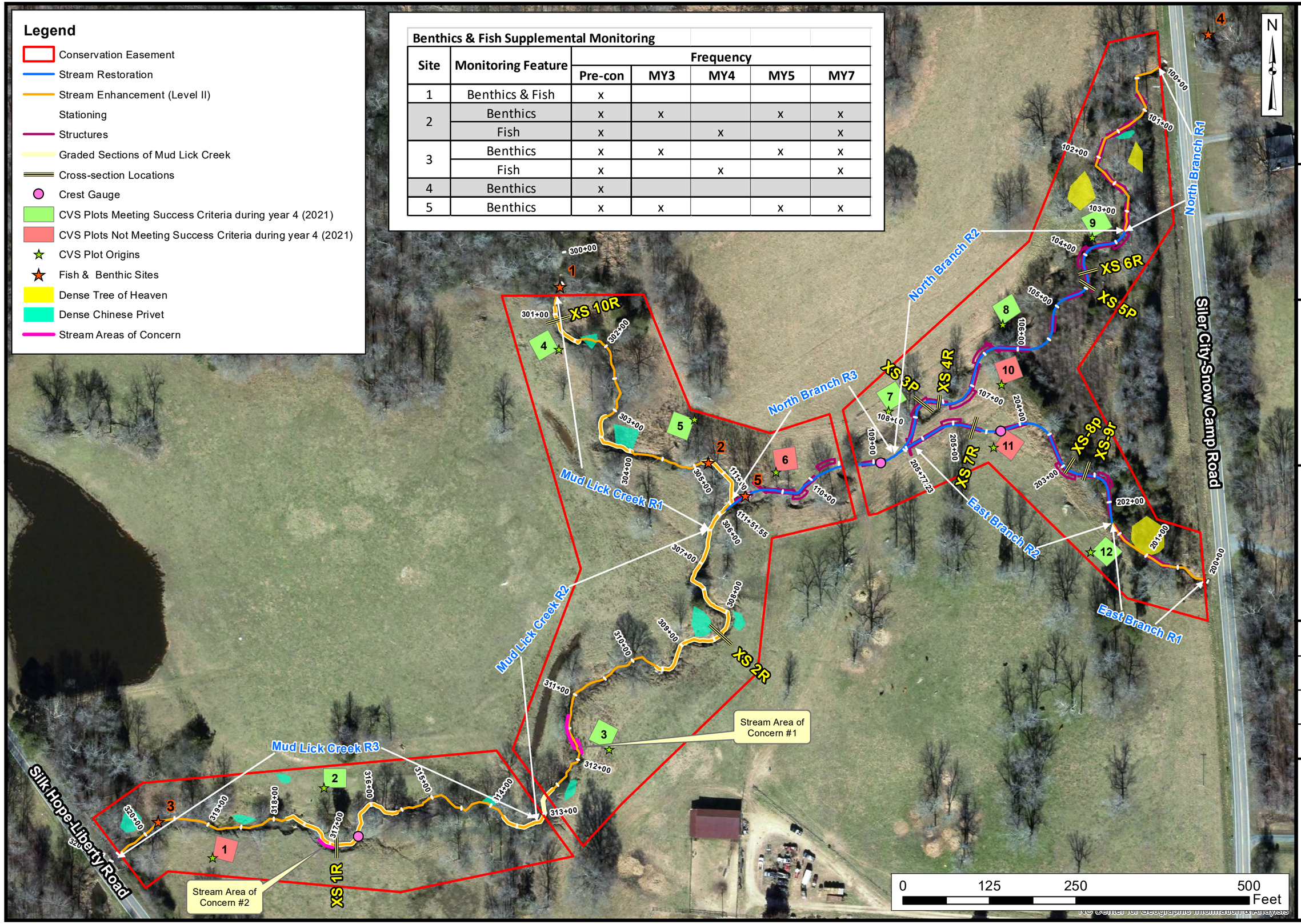
Dwn. by. CLF	FIGURE
Date: July 2018	1
Project: 12-004.22	

Legend

- Conservation Easement
- Stream Restoration
- Stream Enhancement (Level II)
- Stationing
- Structures
- Graded Sections of Mud Lick Creek
- Cross-section Locations
- Crest Gauge
- CVS Plots Meeting Success Criteria during year 4 (2021)
- CVS Plots Not Meeting Success Criteria during year 4 (2021)
- CVS Plot Origins
- Fish & Benthic Sites
- Dense Tree of Heaven
- Dense Chinese Privet
- Stream Areas of Concern

Benthics & Fish Supplemental Monitoring

Site	Monitoring Feature	Frequency				
		Pre-con	MY3	MY4	MY5	MY7
1	Benthics & Fish	x				
2	Benthics	x	x		x	x
	Fish	x		x		x
3	Benthics	x	x		x	x
	Fish	x		x		x
4	Benthics	x				
5	Benthics	x	x		x	x



Axiom Environmental, Inc.

Prepared for:

North Carolina Department of Environmental Quality

Division of Mitigation Services

Project:

MUD LICK CREEK MITIGATION SITE

DMS Project Number 93482
Chatham County, NC

Title:

CURRENT CONDITIONS PLAN VIEW

Drawn by: PHP, CLF

Date: JAN 2022

Scale: 1:1,500

Project No.: 12-004.22

FIGURE

2

Table 5A **Visual Stream Morphology Stability Assessment**
Reach ID **North Branch R-2**
Assessed Length **538**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	8	8			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	8	8			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	8	8			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	8	8			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	8	8			100%			

Table 5B **Visual Stream Morphology Stability Assessment**
Reach ID North Branch R-3
Assessed Length 265

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	3	3			100%			

Table 5C **Visual Stream Morphology Stability Assessment**
Reach ID **East Branch R-2**
Assessed Length **412**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	5	5			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	5	5			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	5	5			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	5	5			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	5	5			100%			

Table 6 Vegetation Condition Assessment

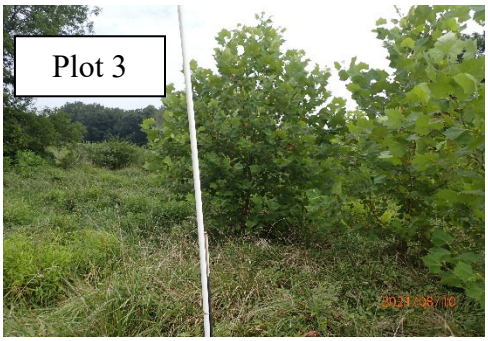
Planted Acreage **9.6**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	None	0.1 acres	None	0	0.00	0.0%
2. Low Stem Density Areas	None	0.1 acres	None	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	None	0.25 acres	None	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage **11.2**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern	Several small areas of dense Chinese privet and dense tree of heaven	200 SF	green and yellow polygons	13	0.20	1.8%
5. Easement Encroachment Areas	None	none	None	0	0.00	0.0%

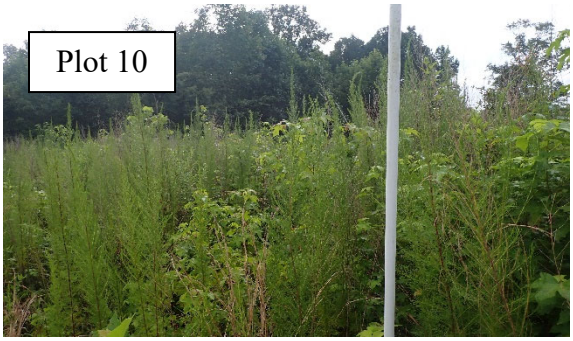
Mud Lick Creek Stream Restoration Site
MY-04 Vegetation Monitoring Photographs
Taken August 2021



Mud Lick Creek Stream Restoration Site
MY-04 Vegetation Monitoring Photographs
Taken August 2021

Plot 9

Plot 10



Plot 11

Plot 12

Appendix C.
Vegetation Plot Data

Table 7. Planted Woody Vegetation
Table 8. Total and Planted Stems by Plot and Species

Table 7. Planted Woody Vegetation
Mud Lick Creek Restoration Project (#93482)

Species	Quantity
Green Ash (*Fraxinus pennsylvanica*)	300
Sycamore (*Platanus occidentalis*)	400
Eastern Redbud (*Cercis canadensis*)	400
Cottonwood *(Populus deltoides)*	300
River birch (*Betula nigra*)	300
Hackberry *(Celtis occidentalis)*	300
Black Gum *(Nyssa sylvatica)*	300
American Elm *(Ulmus americana)*	300
Eastern Hophornbeam *(Ostrya virginica)*	300
Elderberry *(Sambucus spp.)*	300
Black Locust *(Robinia psuedoaccia)*	300
Silky Dogwood *(Cornus ammomum)*	300
Witch Hazel *(Hamamelis virginica)*	550
Buttonbush *(Cephalanthus occidentalis)*	300
Persimmon (*Diospyros virginiana*)	300
Ironwood *(Carpinus caroliniana)*	400
Swamp Tupelo *(Nyssa biflora)*	100
Swamp Chestnut oak (*Quercus michauxii*)	100
Water oak (*Quercus nigra*)	100
Tulip Poplar *(Liridendron tulipifera)*	300
TOTAL	**5950**

Table 8. Total and Planted Stems by Plot and Species
DMS Project Code 93482. Project Name: Mud Lick Creek

			Current Plot Data (MY4 2021)																									
			93482-01-0001			93482-01-0002			93482-01-0003			93482-01-0004			93482-01-0005			93482-01-0006			93482-01-0007			93482-01-0008			93482-01-0009		
Scientific Name	**Common Name**	**Species Type**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	boxelder	Tree																					2					
Acer rubrum	red maple	Tree																										
Alnus	alder	Shrub																										
Baccharis halimifolia	eastern baccharis	Shrub																										
Betula nigra	river birch	Tree										1	1	1	1	1	1	2	2	2				3	3	3	1	1	1
Carpinus caroliniana	American hornbeam	Tree																1	1	1				1	1	1	5	5	5
Carya	hickory	Tree																										
Celtis laevigata	sugarberry	Tree	2	2	2																							
Celtis occidentalis	common hackberry	Tree																										
Cephalanthus occidentalis	common buttonbush	Shrub																1	1	1				1	1	1			
Cercis canadensis	eastern redbud	Tree	1	1	1							1	1	1														
Cornus amomum	silky dogwood	Shrub										3	3	3										1	1	1	1	1	1
Corylus americana	American hazelnut	Shrub				1	1	1																				
Diospyros virginiana	common persimmon	Tree										1	1	1													1	1	1
Fraxinus pennsylvanica	green ash	Tree	1	1	1	1	1	1				1	1	1	8	8	8												
Juglans nigra	black walnut	Tree																										
Liquidambar styraciflua	sweetgum	Tree																		60								
Liriodendron tulipifera	tuliptree	Tree																1	1	1							1	1	2
Nyssa	tupelo	Tree																										
Nyssa biflora	swamp tupelo	Tree				2	2	2	1	1	1																	
Ostrya virginiana	hophornbeam	Tree																			2	2	2					
Platanus occidentalis	American sycamore	Tree	2	2	2				5	5	5	1	1	1						20	4	4	4						1
Populus deltoides	eastern cottonwood	Tree																										
Quercus	oak	Tree																										
Quercus michauxii	swamp chestnut oak	Tree																						3	3	3		
Quercus nigra	water oak	Tree																									1	1	1
Robinia pseudoacacia	black locust	Tree																										
Ulmus americana	American elm	Tree				3	3	3	2	2	2																	
Ulmus rubra	slippery elm	Tree				1	1	1													1	1	1					
Unknown		Shrub or Tree																										
Viburnum dentatum	southern arrowwood	Shrub																										
Stem count			6	6	6	8	8	8	8	8	8	8	8	8	9	9	9	5	5	85	7	7	9	9	9	9	10	10	12
size (ares)			1			1			1			1			1			1			1			1			1		
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
Species count			4	4	4	5	5	5	3	3	3	6	6	6	2	2	2	4	4	6	3	3	4	5	5	5	6	6	7
Stems per ACRE			242.8	242.8	242.8	323.7	323.7	323.7	323.7	323.7	323.7	323.7	323.7	323.7	364.2	364.2	364.2	202.3	202.3	3440	283.3	283.3	364.2	364.2	364.2	364.2	404.7	404.7	485.6

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

PnoLS = Planted excluding livestakes
P-all = Planting including livestakes
T = All planted and natural recruits including livestakes
T includes natural recruits

Table 8. Total and Planted Stems by Plot and Species (continued)
DMS Project Code 93482. Project Name: Mud Lick Creek

			Current Plot Data (MY4 2021)									Annual Means														
			93482-01-0010			93482-01-0011			93482-01-0012			MY4 (2021)			MY3 (2020)			MY2 (2019)			MY1 (2018)			MY0 (2018)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree												2			8			4	1	1	3	1	1	10
Acer rubrum	red maple	Tree															3						2			10
Alnus	alder	Shrub																								3
Baccharis halimifolia	eastern baccharis	Shrub						2						2						2						
Betula nigra	river birch	Tree										8	8	8	8	8	8	8	8	8	6	6	6	4	4	4
Carpinus caroliniana	American hornbeam	Tree				1	1	1	2	2	2	10	10	10	10	10	10	11	11	11	12	12	12	15	15	15
Carya	hickory	Tree																								1
Celtis laevigata	sugarberry	Tree										2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Celtis occidentalis	common hackberry	Tree	1	1	1	1	1	1				2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
Cephalanthus occidentalis	common buttonbush	Shrub										2	2	2	3	3	3	3	3	3	3	3	3	4	4	4
Cercis canadensis	eastern redbud	Tree										2	2	2	2	2	2	3	3	3	8	8	8	6	6	6
Cornus amomum	silky dogwood	Shrub							2	2	2	7	7	7	7	7	7	9	9	9	9	9	9	8	8	8
Corylus americana	American hazelnut	Shrub										1	1	1												
Diospyros virginiana	common persimmon	Tree	2	2	2	1	1	1	1	1	1	6	6	6	7	7	8	5	5	5	4	4	4	5	5	5
Fraxinus pennsylvanica	green ash	Tree							1	1	1	12	12	12	11	11	12	11	11	11	14	14	15	12	12	13
Juglans nigra	black walnut	Tree									3			3			3			4			1			5
Liquidambar styraciflua	sweetgum	Tree			102			110			6			278			124			98			19			10
Liriodendron tulipifera	tuliptree	Tree										2	2	3	4	4	8	4	4	7						
Nyssa	tupelo	Tree													1	1	1	2	2	2						
Nyssa biflora	swamp tupelo	Tree				1	1	1				4	4	4	5	5	5	5	5	5	6	6	6	6	6	6
Ostrya virginiana	hophornbeam	Tree										2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
Platanus occidentalis	American sycamore	Tree	1	1	3							13	13	36	11	11	13	12	12	14	7	7	7	7	7	7
Populus deltoides	eastern cottonwood	Tree																3	3	3	4	4	4	3	3	3
Quercus	oak	Tree				1	1	1				1	1	1	1	1	1	1	1	1						
Quercus michauxii	swamp chestnut oak	Tree	1	1	1	1	1	1	1	1	1	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7
Quercus nigra	water oak	Tree	1	1	1							2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
Robinia pseudoacacia	black locust	Tree													1	1	1	1	1	1	1	1	1	1	1	1
Ulmus americana	American elm	Tree										5	5	5	5	5	5	5	5	5	4	4	5			
Ulmus rubra	slippery elm	Tree										2	2	2	2	2	2	2	2	2						
Unknown		Shrub or Tree													1	1	1	2	2	2	3	3	3	3	3	3
Viburnum dentatum	southern arrowwood	Shrub													2	2	2									
Stem count			6	6	110	6	6	118	7	7	16	89	89	398	96	96	242	102	102	215	97	97	123	90	90	129
size (ares)			1			1			1			12			12			12			12			12		
size (ACRES)			0.02			0.02			0.02			0.30			0.30			0.30			0.30			0.30		
Species count			5	5	6	6	6	8	5	5	7	19	19	23	22	22	26	22	22	26	19	19	22	18	18	23
Stems per ACRE			242.8	242.8	4452	242.8	242.8	4775	283.3	283.3	647.5	300.1	300.1	1342	323.7	323.7	816.1	344	344	725.1	327.1	327.1	414.8	303.5	303.5	435

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

PnoLS = Planted excluding livestakes
P-all = Planting including livestakes
T = All planted and natural recruits including livestakes
T includes natural recruits

Appendix D.
Stream Geomorphology Data

Tables 10a-10c. Baseline Stream Data Summary
Tables 11a-11f. Monitoring Data-Dimensional Data Summary
Cross-section Plots
Substrate Plots

Table 10a. Baseline Stream Data Summary (Mud Lick Creek)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (Mud Lick Creek)					Reference Reach(es) Data					Design (Mud Lick Creek)			Monitoring Baseline (Mud Lick Creek)					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD	Min	Mean	Med	Max	SD	Min	Max	Med	Min	Mean	Med	Max	SD	n
BF Width (ft)					18.2		22.0	24.6		5.3		10.8	12.3					18.3		19.8	21		3
Floodprone Width (ft)					250.0		306.0	378.0		14		60	125					100		100	100		3
BF Mean Depth (ft)					1.9		2.1	2.3		0.8		1.0	1.8					1.6		2.0	2.7		3
BF Max Depth (ft)					3.0		4.0	4.2		1.0		1.5	2.6					3.6		3.7	3.8		3
BF Cross Sectional Area (ft^2)					41.3		46.3	47.5		5.4		10.6	19.7					33.0		40.4	49.8		3
Width/Depth Ratio					8.0		10.5	12.8		5.2		8.6	14.4					6.8		9.9	13.1		3
Entrenchment Ratio					12.4		13.7	17.2		1.7		4.3	>10.2					4.8		5.1	5.5		3
Bank Height Ratio					1.1		1.2	1.2		1.0		1.0	1.1					1.0		1.0	1.3		3
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704										
Pool length (ft)																							
Pool Max depth (ft)					3.7		4.4	5.2		1.2		1.8	3.3										
Pool spacing (ft)										9.0		46.0	73.0										
Pattern																							
Channel Beltwidth (ft)					26.1		52.9	69.9		10		41	102										
Radius of Curvature (ft)					9.9		24.8	58.8		11		21	85										
Rc:Bankfull width (ft/ft)					0.5		1.1	2.39		1.3		2	9.1										
Meander Wavelength (ft)					59.9		159.6	244.4		-		-	-										
Meander Width ratio					1.4		2.2	3.8		1.6		4.4	8.9										
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					E/C4					E/C4								E/C-type					
Bankfull Velocity (fps)					3.0 - 3.4					2.2 - 5.6													
Bankfull Discharge (cfs)					123.9 - 157.42					20 -97													
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1.20 - 1.37					1.0 - 2.3													
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 10b. Baseline Stream Data Summary (North Branch)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (North Branch)					Reference Reach(es) Data					Design (North Branch)			Monitoring Baseline (North Branch)					
Dimension and Substrate - Riffle Only		**LL**	**UL**	**Eq.**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Max**	**Med**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)					8.3			10.4		5.3		10.8	12.3		13.8	14.0		14.6		16.2	17.7		2
Floodprone Width (ft)					33.3			80.0		14		60	125		30	70		100		100	100		2
BF Mean Depth (ft)					0.7			1.5		0.8		1.0	1.8		1.0	1.2		0.8		0.9	1.0		2
BF Max Depth (ft)					1.5			2.3		1.0		1.5	2.6		1.3	2.0		1.8		1.8	1.8		2
BF Cross Sectional Area (ft^2)					7.7			12.7		5.4		10.6	19.7		14.4	16.3		14.2		14.4	14.5		2
Width/Depth Ratio					5.4			14.0		5.2		8.6	14.4		12.0	13.0		14.6		18.4	22.1		2
Entrenchment Ratio					1.9			10.1		1.7		4.3	>10.2		2.2	5.0		5.6		6.2	6.8		2
Bank Height Ratio					1.7			2.0		1.0		1.0	1.1		1.0	1.0		1.0		1.0	1.0		2
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704		0.0060	0.0340							
Pool length (ft)																							
Pool Max depth (ft)					2.1			2.7		1.2		1.8	3.3		1.3	4.7							
Pool spacing (ft)										9.0		46.0	73.0		19.0	92.0							
Pattern																							
Channel Beltwidth (ft)					11		26	38.5		10		41	102		41	125							
Radius of Curvature (ft)					6.1		17	37		11		21	85		25	42							
Rc:Bankfull width (ft/ft)					0.73		1.6	4.46		1.3		2	9.1		1.8	3							
Meander Wavelength (ft)					37.9		64.1	100.6		-		-	-		41	168							
Meander Width ratio					1.1		2.8	4.6		1.6		4.4	8.9		3	15							
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					E5/B5c					E/C4					C4			C-type					
Bankfull Velocity (fps)					3.3 - 3.5					2.2 - 5.6					2.4 - 4.3								
Bankfull Discharge (cfs)					25.41 - 44.45					20 -97					34.6 - 70.1								
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1.22 - 1.32					1.0 - 2.3					1.2 - 1.3								
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 10c. Baseline Stream Data Summary (East Branch)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (East Branch)					Reference Reach(es) Data					Design (East Branch)			Monitoring Baseline (East Branch)					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD	Min	Mean	Med	Max	SD	Min	Max	Med	Min	Mean	Med	Max	SD	n
BF Width (ft)						4.3				5.3		10.8	12.3				11.0	8.9		12.8	16.6		2
Floodprone Width (ft)						23.0				14		60	125		24	55		100		100	100		2
BF Mean Depth (ft)						1.1				0.8		1.0	1.8				0.9	0.6		0.7	0.8		2
BF Max Depth (ft)						1.4				1.0		1.5	2.6		0.9	1.5		1.2		1.4	1.5		2
BF Cross Sectional Area (ft^2)						4.8				5.4		10.6	19.7				9.7	6.7		8.7	10.6		2
Width/Depth Ratio						3.9				5.2		8.6	14.4				12.4	11.1		19.4	27.7		2
Entrenchment Ratio						2.1				1.7		4.3	>10.2		2.2	5.0		6.0		8.6	11.2		2
Bank Height Ratio						1.9				1.0		1.0	1.1		1.0	1.0		1.0		1.0	1.0		2
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704		0.0156	0.0442							
Pool length (ft)																							
Pool Max depth (ft)						1.6				1.2		1.8	3.3		1.0	3.5							
Pool spacing (ft)										9.0		46.0	73.0		15.0	73.0							
Pattern																							
Channel Beltwidth (ft)						--				10		41	102		22	98							
Radius of Curvature (ft)						--				11		21	85		20	30							
Rc:Bankfull width (ft/ft)						--				1.3		2	9.1		1.8	3							
Meander Wavelength (ft)						--				-		-	-		33	132							
Meander Width ratio						--				1.6		4.4	8.9		3	12							
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					B4c					E/C4					C4			C-type					
Bankfull Velocity (fps)					4.2					2.2 - 5.6					3.3								
Bankfull Discharge (cfs)					20.2					20 -97					32								
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1					1.0 - 2.3					1.20 -1.30								
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 11a. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 1 (Mud Lick Cr)							Cross Section 2 (Mud Lick Cr)							Cross Section 10 (Mud Lick Cr)						
	Riffle							Riffle							Riffle						
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+
BF Width (ft)	18.3	18.8	18.6	19.1	18.0			21.0	22.0	14.9	15.9	14.6			19.8	19.6	18.9	18.4	18.1		
Floodprone Width (ft) (approx)	100.0	100.0	100.0	100.0	100.0			100.0	100.0	100.0	100.0	100.0			100.0	100.0	100.0	100.0	100.0		
BF Mean Depth (ft)	2.7	2.6	2.7	2.6	2.8			1.6	1.5	2.2	2.1	2.3			2.0	2.1	2.1	2.2	2.2		
BF Max Depth (ft)	3.8	3.8	3.8	3.6	3.7			3.7	3.6	3.3	3.5	3.3			3.6	3.4	3.5	3.7	3.8		
Low Bank Height	5.0	5.1	5.0	3.7	3.9			3.7	3.6	3.9	4.0	3.7			3.6	3.4	3.7	3.8	4.0		
BF Cross Sectional Area (ft^2)	49.8	49.8	49.8	49.8	49.8			33.0	33.0	33.0	33.0	33.0			40.4	40.4	40.4	40.4	40.4		
Area at Low Bank (ft^2)	49.8	NA	75.8	75.8	52.5			33.0	NA	42.6	42.6	39.8			40.4	NA	43.2	43.2	45.9		
Width/Depth Ratio	6.7	7.1	6.9	7.3	6.5			13.4	14.7	6.7	7.7	6.5			9.7	9.5	8.8	8.4	8.1		
Entrenchment Ratio	5.5	5.3	NA**	NA**	NA**			4.8	4.5	NA**	NA**	NA**			5.1	5.1	NA**	NA**	NA**		
Bank Height Ratio*	1.3	1.3	1.3	1.0	1.04			1.0	1.0	1.2	1.1	1.13			1.0	1.0	1.1	1.0	1.08		
d50 (mm)	9.9	4.4	4.3	4.3	3.8			9.9	4.4	4.3	4.3	3.8			9.9	4.4	4.3	4.3	3.8		

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.

Table 11b. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Baseline (Mud Lick Creek)						MY-1 (Mud Lick Creek)						MY-2 (Mud Lick Creek)						MY-3 (Mud Lick Creek)						MY-4 (Mud Lick Creek)						MY-5 (Mud Lick Creek)					
Dimension and Substrate - Riffle Only	**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)	18.3		19.8	21		3	18.8		19.6	22		3	14.9		18.6	18.9		3	15.9		18.4	19.1		3	14.6		18.0	18.1		3						
Floodprone Width (ft)	100		100	100		3	100		100.0	100		3	100		100	100		3	100		100	100		3	100		100	100		3						
BF Mean Depth (ft)	1.6		2.0	2.7		3	1.5		2.1	2.7		3	2.1		2.2	2.7		3	2.1		2.2	2.6		3	2.2		2.3	2.8		3						
BF Max Depth (ft)	3.6		3.7	3.8		3	3.4		3.6	3.8		3	5.3		3.5	3.8		3	3.5		3.6	3.7		3	3.3		3.7	3.8		3						
BF Cross Sectional Area (ft^2)	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3						
Area at Low Bank (ft^2)	33.0		40.4	49.8		3	NA		NA	NA		NA	42.6		43.2	75.8		3	42.6		43.2	75.8		3	48.4		54.9	71.2		3						
Width/Depth Ratio	6.8		9.9	13.1		3	7.0		9.3	14.7		3	6.8		6.9	9.0		3	7.3		7.6	8.4		3	6.4		6.5	8.1		3						
Entrenchment Ratio	4.8		5.1	5.5		3	4.5		5.1	5.3		3	5.3		5.4	6.7		3	5.2		5.4	6.3		3	5.5		5.6	6.9		3						
Bank Height Ratio	1.0		1.0	1.3		3	1.0		1.0	1.3		3	1.1		1.2	1.3		3	1.0		1.0	1.1		3	1.0		1.1	1.1		3						
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						Ce-type						Ce-type						Ce-type						Ce-type											
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%P%G%/S%																																				
SC%/SA%/G%/C%/B%BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

Table 11c. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 3 (North Branch)							Cross Section 4 (North Branch)							Cross Section 5 (North Branch)							Cross Section 6 (North Branch)						
	Pool							Riffle							Pool							Riffle						
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+
BF Width (ft)	14.2	13.7	13.3	13.2	12.0			17.7	22.7	20.7	22.1	19.8			14.2	14.6	15.1	14.2	12.4			14.6	15.1	14.8	19.4	17.2		
Floodprone Width (ft) (approx)	NA	NA	NA	NA	NA			100.0	100.0	100.0	100.0	100.0			NA	NA	NA	NA	NA			100.0	100.0	100.0	100.0	100.0		
BF Mean Depth (ft)	1.1	1.1	1.2	1.2	1.3			0.8	0.6	0.7	0.6	0.7			1.3	1.3	1.2	1.3	1.5			1.0	1.0	1.0	0.7	0.8		
BF Max Depth (ft)	2.2	2.1	2.2	2.3	2.4			1.8	1.9	1.8	1.8	2.1			2.6	2.6	2.7	2.8	2.7			1.8	1.8	1.8	1.9	2.0		
Low Bank Height	2.2	2.1	2.3	2.5	2.7			1.8	1.9	1.8	1.8	2.0			2.6	2.6	2.8	2.9	2.8			1.8	1.8	1.8	2.1	2.2		
BF Cross Sectional Area (ft^2)	15.5	15.5	15.5	15.5	15.5			14.2	14.2	14.2	14.2	14.2			18.6	18.6	18.6	18.6	18.6			14.5	14.5	14.5	14.5	14.5		
Area at Low Bank (ft^2)	15.5	NA	18.0	18.0	19.9			14.2	NA	14.2	14.2	13.8			18.6	NA	20.3	20.3	19.7			14.5	NA	15.0	15.0	16.9		
Width/Depth Ratio	NA	NA	NA	NA	NA			22.1	36.3	30.2	34.4	27.6			NA	NA	NA	NA	NA			14.7	15.7	15.1	26.0	20.4		
Entrenchment Ratio	NA	NA	NA	NA	NA			5.6	4.4	NA**	NA**	NA**			NA	NA	NA	NA	NA			6.8	6.6	NA**	NA**	NA**		
Bank Height Ratio*	NA	NA	NA	NA	NA			1.0	1.0	1.0	1.0	1.0			NA	NA	NA	NA	NA			1.0	1.0	1.0	1.11	1.06		
d50 (mm)	--	--	--	--	--			18.8	8.0	8.4	4.0	4.9			--	--	--	--	--			18.8	8.0	8.4	4.0	4.9		

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.

Table 11d. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Baseline (North Branch)						MY-1 (North Branch)						MY-2 (North Branch)						MY-3 (North Branch)						MY-4 (North Branch)						MY-5 (North Branch)					
Dimension and Substrate - Riffle Only	**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)	14.6		16.2	17.7		2	15.1		18.9	22.7		2	14.8		17.8	20.7		2	19.4		20.8	22.1		2	17.2		18.5	19.8		2						
Floodprone Width (ft)	100		100	100		2	100		100.0	100		2	100		100	100		2	100		100	100		2	100		100	100		2						
BF Mean Depth (ft)	0.8		0.9	1.0		2	0.6		0.8	1.0		2	0.7		0.9	1.0		2	0.6		0.8	1.0		2	0.7		0.8	0.8		2						
BF Max Depth (ft)	1.8		1.8	1.8		2	1.8		1.9	1.9		2	1.8		1.8	1.8		2	1.8		1.8	1.9		2	2.0		2.1	2.1		2						
BF Cross Sectional Area (ft^2)	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2						
Area at Low Bank (ft^2)	14.2		14.4	14.5		2	NA		NA	NA		NA	14.2		14.6	15.0		2	14.2		14.6	15.0		2	11.6		11.6	13.8		2						
Width/Depth Ratio	14.6		18.4	22.1		2	15.1		26.5	37.8		2	14.8		17.8	20.7		2	19.4		28.1	36.8		2	20.4		24.0	27.7		2						
Entrenchment Ratio	5.6		6.2	6.8		2	4.4		5.5	6.6		2	4.8		5.8	6.8		2	4.5		4.8	5.2		2	5.1		5.4	5.8		2						
Bank Height Ratio	1.0		1.0	1.0		2	1.0		1.0	1.0		2	1.0		1.0	1.0		2	1.0		1.1	1.1		2	1.0		1.0	1.1		2						
Profile																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						C-type						C-type						C-type						C-type											
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%P%G%/S%																																				
SC%/SA%/G%/C%/B%BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

Table 11e. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 7 (East Branch)							Cross Section 8 (East Branch)							Cross Section 9 (East Branch)						
	Riffle							Pool							Riffle						
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+
BF Width (ft)	8.9	11.1	10.2	14.4	9.4			7.6	10.8	8.2	7.5	9.7			16.6	21.1	18.6	24.6	21.9		
Floodprone Width (ft) (approx)	100.0	100.0	100.0	100.0	100.0			NA	NA	NA	NA	NA			100.0	100.0	100.0	100.0	100.0		
BF Mean Depth (ft)	0.8	0.6	0.7	0.5	0.7			1.4	1.0	1.3	1.4	1.1			0.6	0.5	0.6	0.4	0.5		
BF Max Depth (ft)	1.2	1.4	1.3	1.4	1.4			2.4	1.5	2.1	2.4	2.0			1.5	1.6	1.5	1.5	1.7		
Low Bank Height	1.2	1.4	1.4	1.4	1.6			2.4	1.5	2.2	2.4	1.6			1.5	1.6	1.5	1.5	1.7		
BF Cross Sectional Area (ft^2)	6.7	6.7	6.7	6.7	6.7			10.5	10.5	10.5	10.5	10.5			10.6	10.6	10.6	10.6	10.6		
Area at Low Bank (ft^2)	6.7	NA	7.5	7.5	8.4			10.5	NA	11.7	11.7	7.6			10.6	NA	10.7	10.7	10.2		
Width/Depth Ratio	11.8	18.4	15.5	30.9	13.2			NA	NA	NA	NA	NA			26.0	42.0	32.6	57.1	45.2		
Entrenchment Ratio	11.2	9.0	NA**	NA**	NA**			NA	NA	NA	NA	NA			6.0	4.7	NA**	NA**	NA**		
Bank Height Ratio*	1.0	1.0	1.1	1.0	1.12			NA	NA	NA	NA	NA			1.0	1.0	1.0	1.0	1.0		
d50 (mm)	14.3	3.7	5.4	2.5	2.5			--	--	--	--	--			14.3	3.7	5.4	2.5	2.5		

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.

Table 11f. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

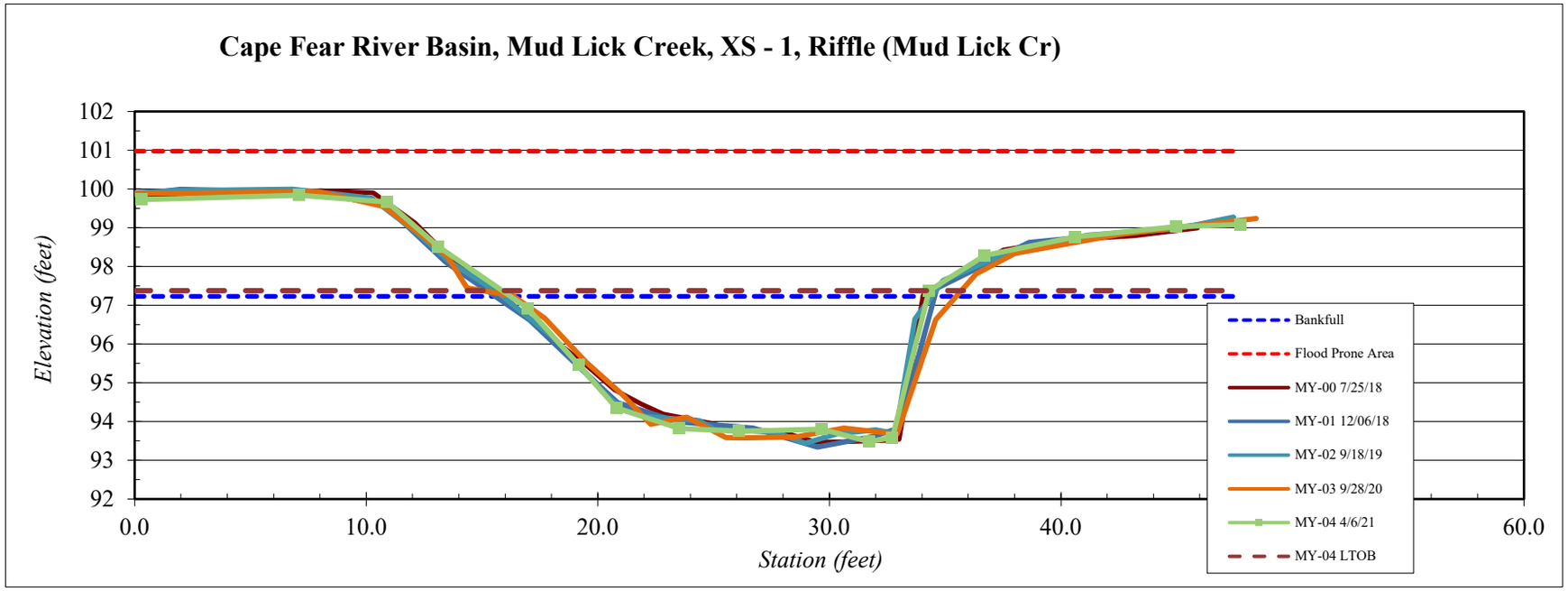
Parameter	Baseline (East Branch)						MY-1 (East Branch)						MY-2 (East Branch)						MY-3 (East Branch)						MY-4 (East Branch)						MY-5 (East Branch)					
Dimension and Substrate - Riffle Only	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
BF Width (ft)	8.9		12.8	16.6		2	11.1		16.2	21.2		2	10.2		14.5	18.7		2	14.4		19.5	24.6		2	9.4		15.6	21.9		2						
Floodprone Width (ft)	100		100	100		2	100		100	100		2	100		100	100		2	100		100	100		2	100		100	100		2						
BF Mean Depth (ft)	0.6		0.7	0.8		2	0.5		0.6	0.6		2	0.6		0.7	0.7		2	0.4		0.5	0.5		2	0.5		0.6	0.7		2						
BF Max Depth (ft)	1.2		1.4	1.5		2	1.4		1.5	1.6		2	1.3		1.4	1.5		2	1.4		1.5	1.5		2	1.4		1.6	1.7		2						
BF Cross Sectional Area (ft^2)	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2						
Area at Low Bank (ft^2)	6.7		8.7	10.6		2	NA		NA	NA		NA	7.5		9.1	10.7		2	7.5		9.1	10.7		2	8.4		8.6	8.8		2						
Width/Depth Ratio	11.1		19.4	27.7		2	18.5		30.5	42.2		2	14.6		22.9	31.2		2	28.8		45.2	61.5		2	13.1		29.1	45.1		2						
Entrenchment Ratio	6.0		8.6	11.2		2	4.7		6.9	9		2	5.3		7.6	9.8		2	4.1		5.5	6.9		2	4.6		7.6	10.7		2						
Bank Height Ratio	1.0		1.0	1.0		2	1		1	1		2	1.0		1.0	1.1		2	1.0		1.0	1.0		2	1.0		1.0	1.1		2						
Profile																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						C-type						C-type						C-type						C-type											
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%P%G%/S%																																				
SC%/SA%/G%/C%/B%BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 1, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.30	99.73
7.12	99.84
10.90	99.67
13.12	98.51
16.98	96.92
19.18	95.46
20.82	94.35
23.53	93.82
26.12	93.75
29.67	93.80
31.70	93.48
32.72	93.59
34.31	97.38
36.71	98.28
40.62	98.77
44.99	99.03
47.76	99.08

SUMMARY DATA	
Bankfull Elevation:	97.2
Bankfull Cross-Sectional Area:	49.8
Area at Low Bank:	71.2
Bankfull Width:	18.0
Flood Prone Area Elevation:	101.0
Flood Prone Width:	100.0
Max Depth at Bankfull:	3.7
Low Bank Height:	3.9
Mean Depth at Bankfull:	2.8
W / D Ratio:	6.5
Entrenchment Ratio:	NA
Bank Height Ratio:	1.04

Stream Type	E

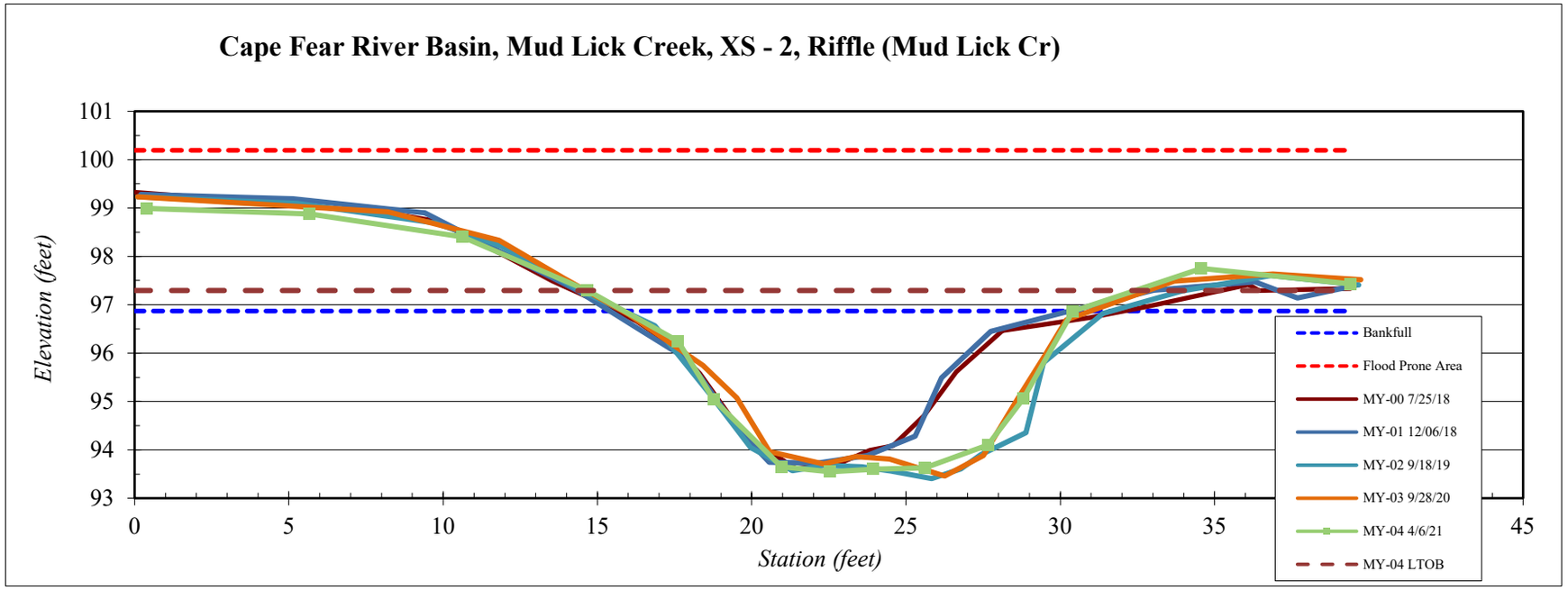


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 2, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.40	98.99
5.67	98.88
10.61	98.41
14.68	97.29
17.61	96.25
18.76	95.04
20.97	93.65
22.54	93.55
23.94	93.60
25.61	93.63
27.66	94.10
28.80	95.05
30.41	96.86
34.58	97.75
39.42	97.43

SUMMARY DATA	
Bankfull Elevation:	96.9
Bankfull Cross-Sectional Area:	33.0
Area at Low Bank:	48.8
Bankfull Width:	14.6
Flood Prone Area Elevation:	100.2
Flood Prone Width:	100.0
Max Depth at Bankfull:	3.3
Low Bank Height:	3.7
Mean Depth at Bankfull:	2.3
W / D Ratio:	6.4
Entrenchment Ratio:	NA
Bank Height Ratio:	1.13

Stream Type	E



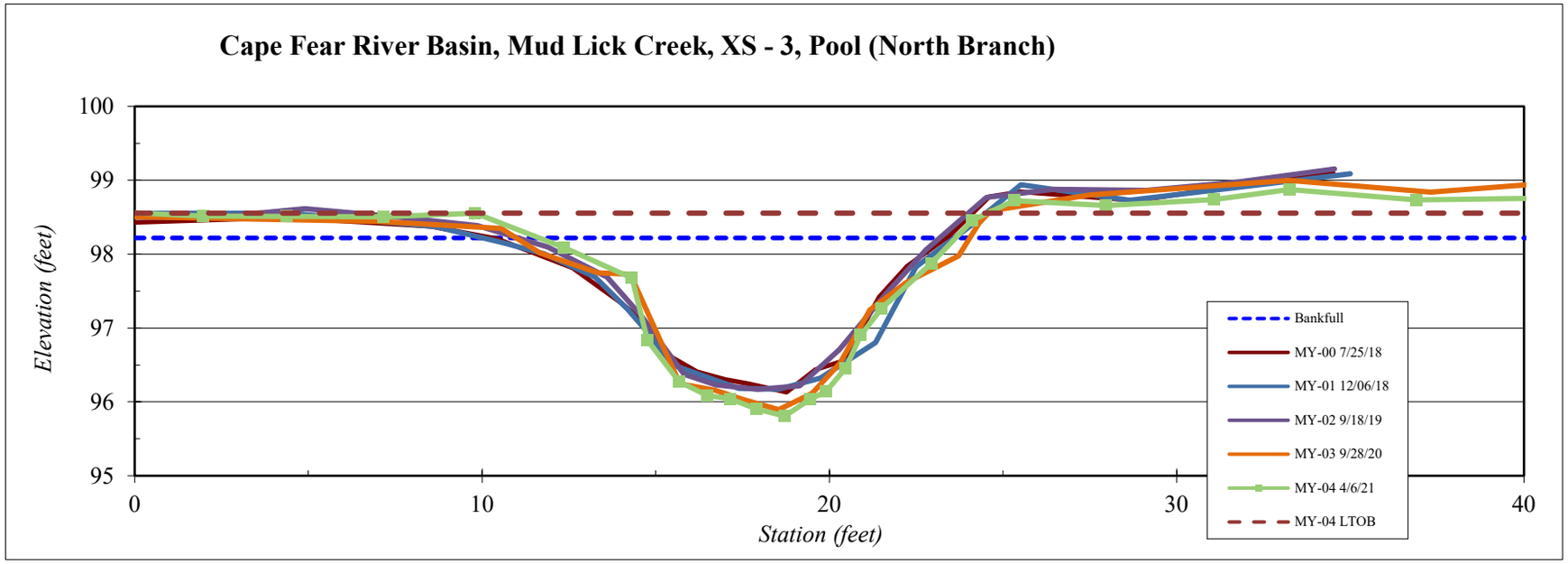
Scouring on the right bank of this cross-section is apparent, howerver this is an EII reach and localized at this location.

River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 3, Pool (North Branch)
Drainage Area (sq mi):	0.65
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
-0.20	98.56
1.96	98.52
4.37	98.51
7.18	98.51
9.81	98.56
12.35	98.09
14.32	97.68
14.77	96.83
15.68	96.28
16.48	96.09
17.16	96.04
17.91	95.90
18.72	95.81
19.45	96.04
19.90	96.14
20.46	96.45
20.91	96.90
21.50	97.27
22.94	97.88
24.12	98.46
25.32	98.72
27.96	98.66
31.07	98.74
33.24	98.88
36.91	98.73
40.73	98.76

SUMMARY DATA	
Bankfull Elevation:	98.2
Bankfull Cross-Sectional Area:	15.5
Area at Low Bank:	19.9
Bankfull Width:	12.0
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.4
Low Bank Height:	2.7
Mean Depth at Bankfull:	1.3
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	E

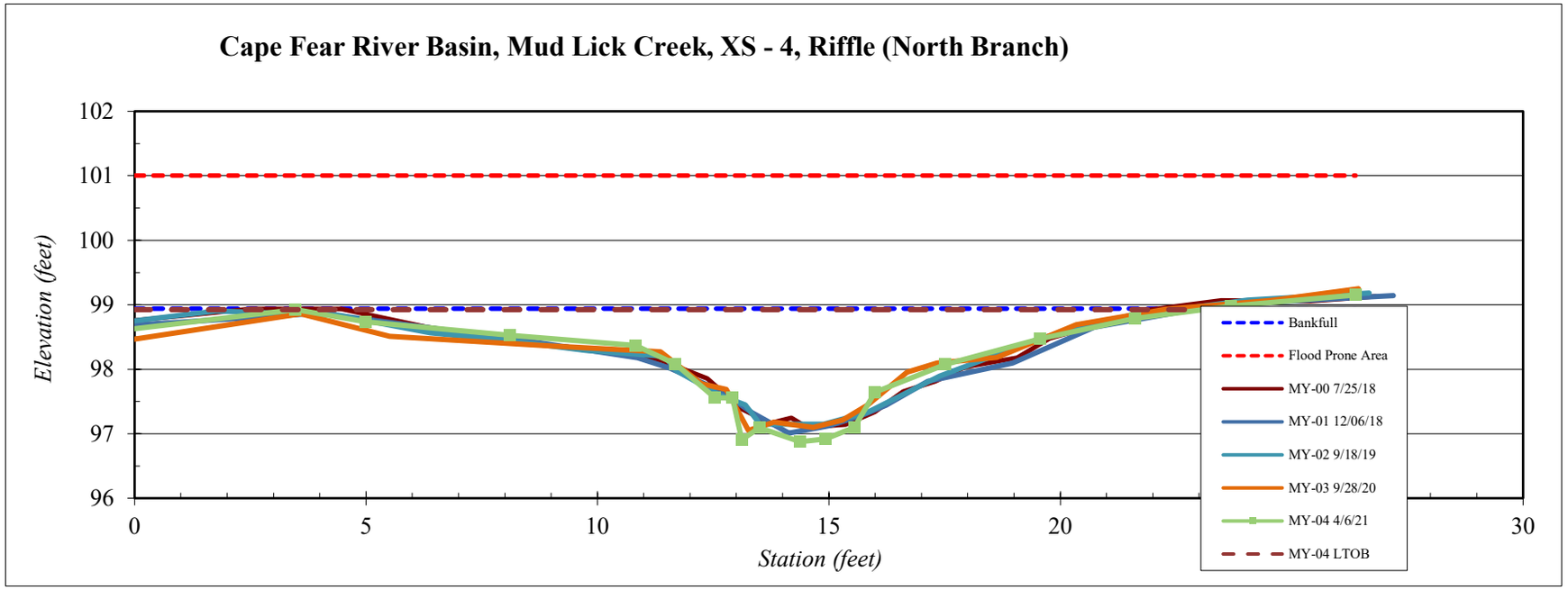


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 4, Riffle (North Branch)
Drainage Area (sq mi):	0.65
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
-0.10	98.62
3.48	98.92
5.00	98.74
8.10	98.53
10.82	98.37
11.69	98.08
12.54	97.55
12.92	97.55
13.12	96.91
13.50	97.09
14.38	96.88
14.93	96.92
15.55	97.10
16.00	97.65
17.52	98.08
19.57	98.47
21.62	98.79
23.69	98.98
26.38	99.15

SUMMARY DATA	
Bankfull Elevation:	98.9
Bankfull Cross-Sectional Area:	14.2
Area at Low Bank:	13.8
Bankfull Width:	19.8
Flood Prone Area Elevation:	101.0
Flood Prone Width:	100.0
Max Depth at Bankfull:	2.1
Low Bank Height:	2.0
Mean Depth at Bankfull:	0.7
W / D Ratio:	27.7
Entrenchment Ratio:	NA
Bank Height Ratio:	1.0

Stream Type	C

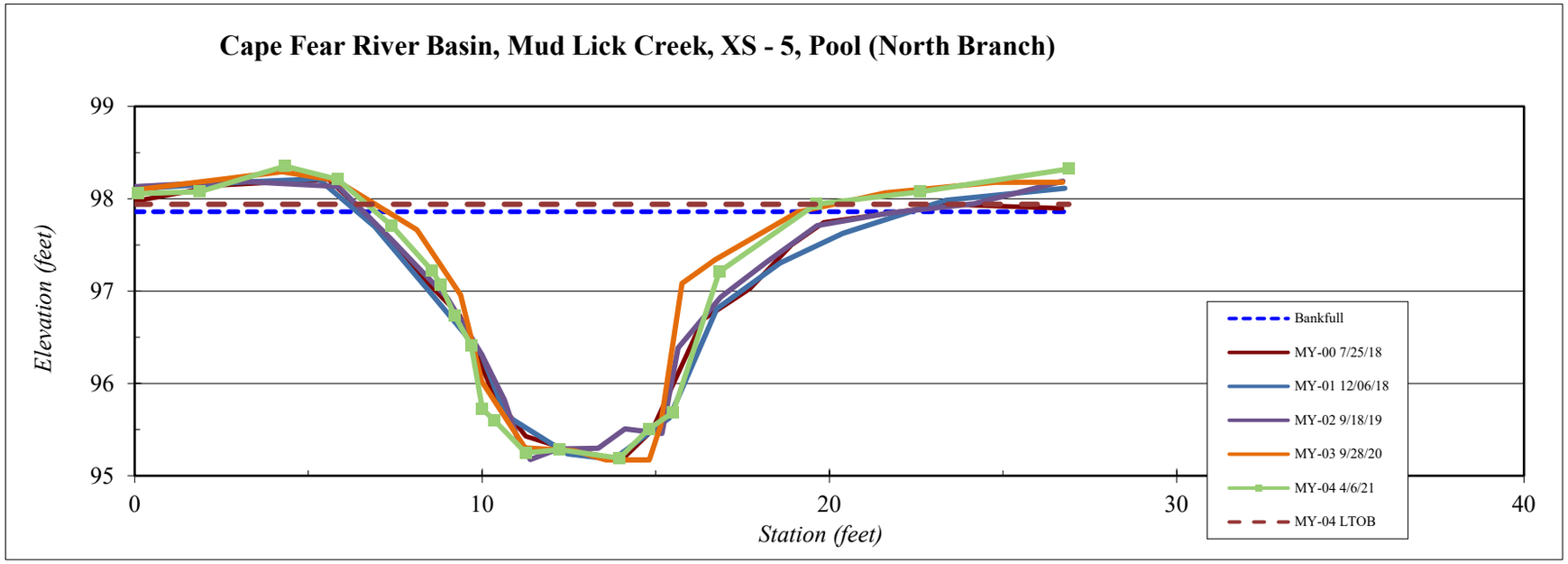


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 5, Pool (North Branch)
Drainage Area (sq mi):	0.65
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.10	98.06
1.86	98.07
4.33	98.35
5.85	98.21
7.40	97.71
8.57	97.22
8.81	97.07
9.21	96.73
9.69	96.41
10.01	95.72
10.36	95.60
11.26	95.25
12.24	95.28
13.95	95.19
14.81	95.51
15.51	95.69
16.83	97.21
19.62	97.94
22.62	98.07
26.90	98.32

SUMMARY DATA	
Bankfull Elevation:	97.9
Bankfull Cross-Sectional Area:	18.6
Area at Low Bank:	19.7
Bankfull Width:	12.4
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.7
Low Bank Height:	2.8
Mean Depth at Bankfull:	1.5
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	C

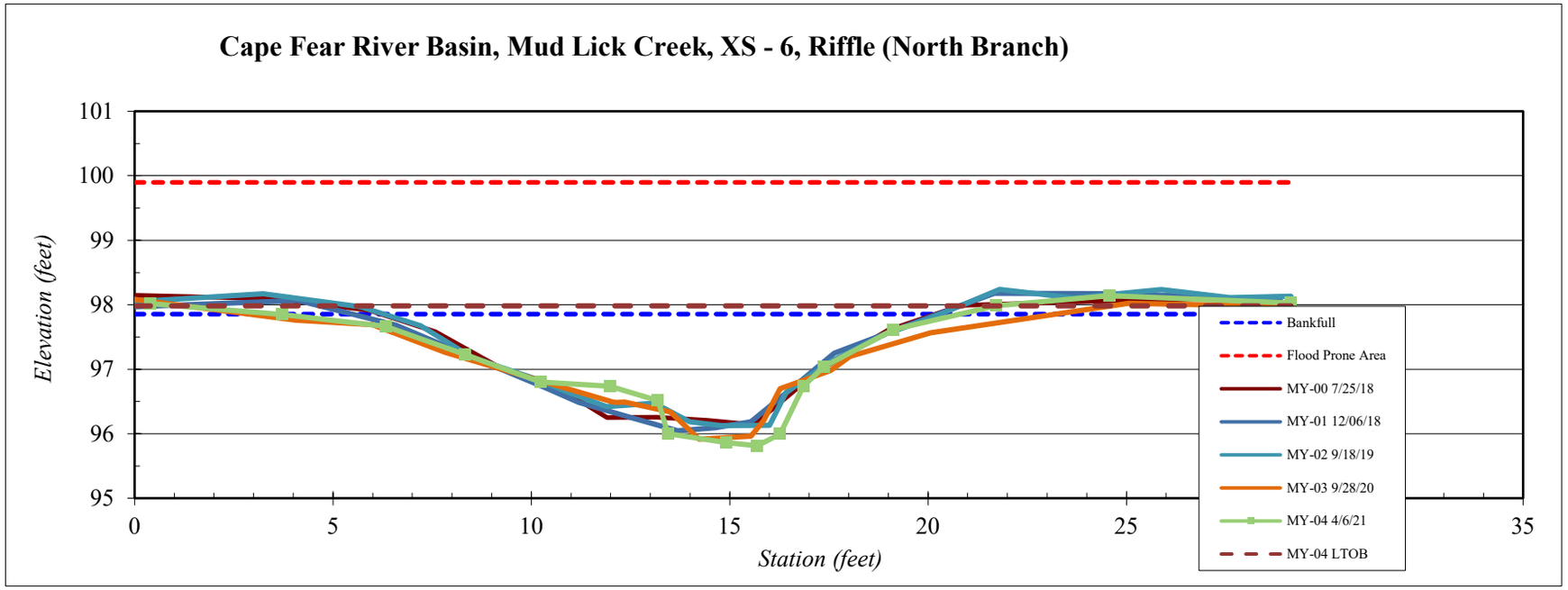


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 6, Riffle (North Branch)
Drainage Area (sq mi):	0.65
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.40	98.02
3.73	97.85
6.33	97.66
8.33	97.22
10.23	96.80
11.98	96.74
13.20	96.51
13.45	96.00
14.91	95.86
15.69	95.81
16.27	96.00
16.86	96.74
17.37	97.03
19.13	97.61
21.71	97.98
24.57	98.14
29.15	98.03

SUMMARY DATA	
Bankfull Elevation:	97.9
Bankfull Cross-Sectional Area:	14.5
Area at Low Bank:	11.6
Bankfull Width:	17.2
Flood Prone Area Elevation:	99.9
Flood Prone Width:	100.0
Max Depth at Bankfull:	2.0
Low Bank Height:	2.2
Mean Depth at Bankfull:	0.8
W / D Ratio:	20.4
Entrenchment Ratio:	NA
Bank Height Ratio:	1.06

Stream Type	C

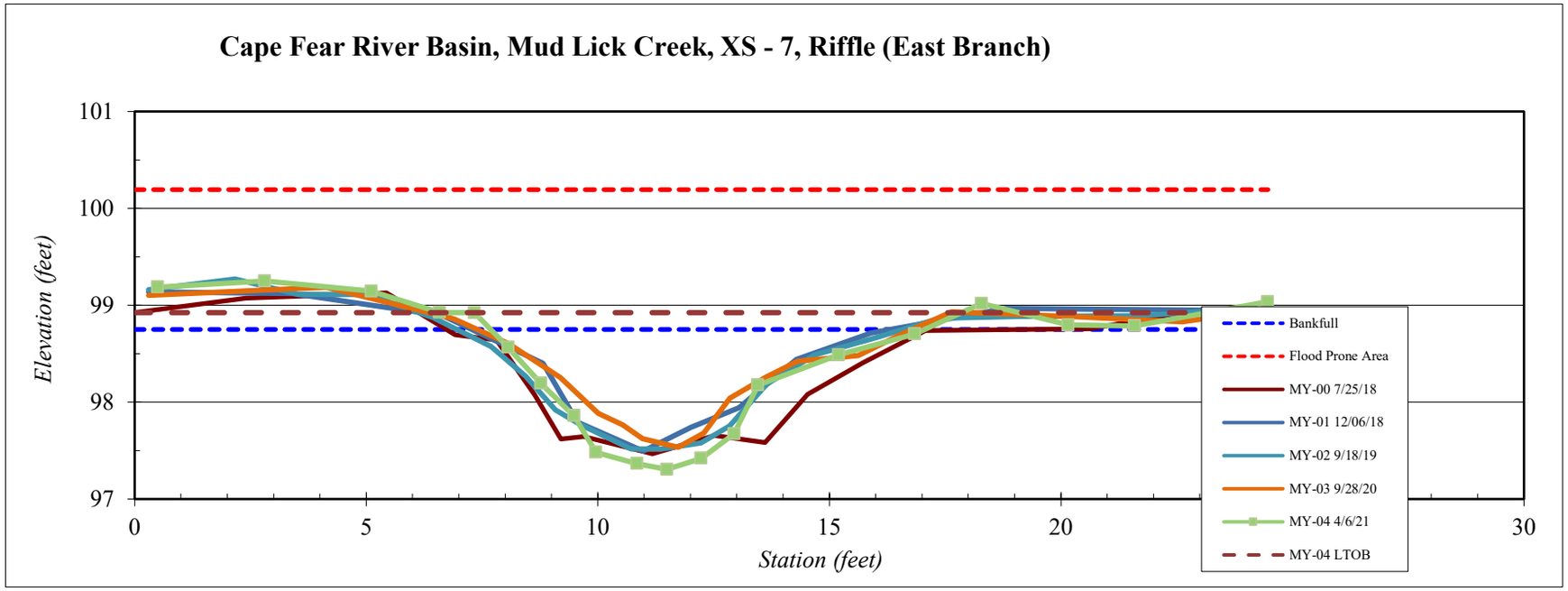


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 7, Riffle (East Branch)
Drainage Area (sq mi):	0.27
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.50	99.19
2.81	99.25
5.11	99.14
6.59	98.92
7.34	98.92
8.06	98.57
8.77	98.19
9.49	97.86
9.96	97.48
10.85	97.36
11.49	97.31
12.23	97.42
12.95	97.67
13.46	98.18
15.20	98.49
16.84	98.70
18.29	99.02
20.16	98.80
21.59	98.79
24.47	99.04

SUMMARY DATA	
Bankfull Elevation:	98.8
Bankfull Cross-Sectional Area:	6.7
Area at Low Bank:	8.4
Bankfull Width:	9.4
Flood Prone Area Elevation:	100.2
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.4
Low Bank Height:	1.6
Mean Depth at Bankfull:	0.7
W / D Ratio:	13.1
Entrenchment Ratio:	NA
Bank Height Ratio:	1.12

Stream Type	C

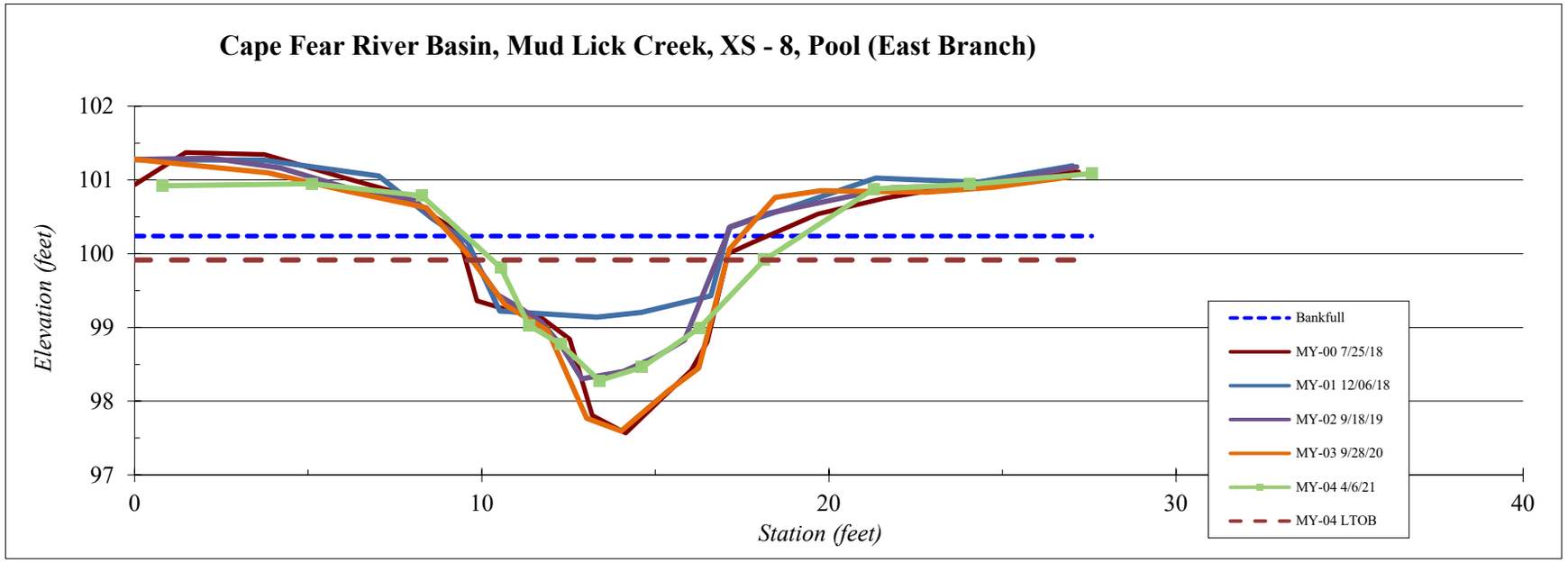


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 8, Pool (East Branch)
Drainage Area (sq mi):	0.27
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.80	100.92
5.11	100.95
8.27	100.79
10.55	99.81
11.36	99.03
12.27	98.78
13.39	98.28
14.62	98.46
16.27	98.99
18.13	99.91
21.29	100.88
24.06	100.94
27.57	101.09

SUMMARY DATA	
Bankfull Elevation:	100.2
Bankfull Cross-Sectional Area:	10.5
Area at Low Bank:	16.6
Bankfull Width:	9.7
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.0
Low Bank Height:	1.6
Mean Depth at Bankfull:	1.1
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	C

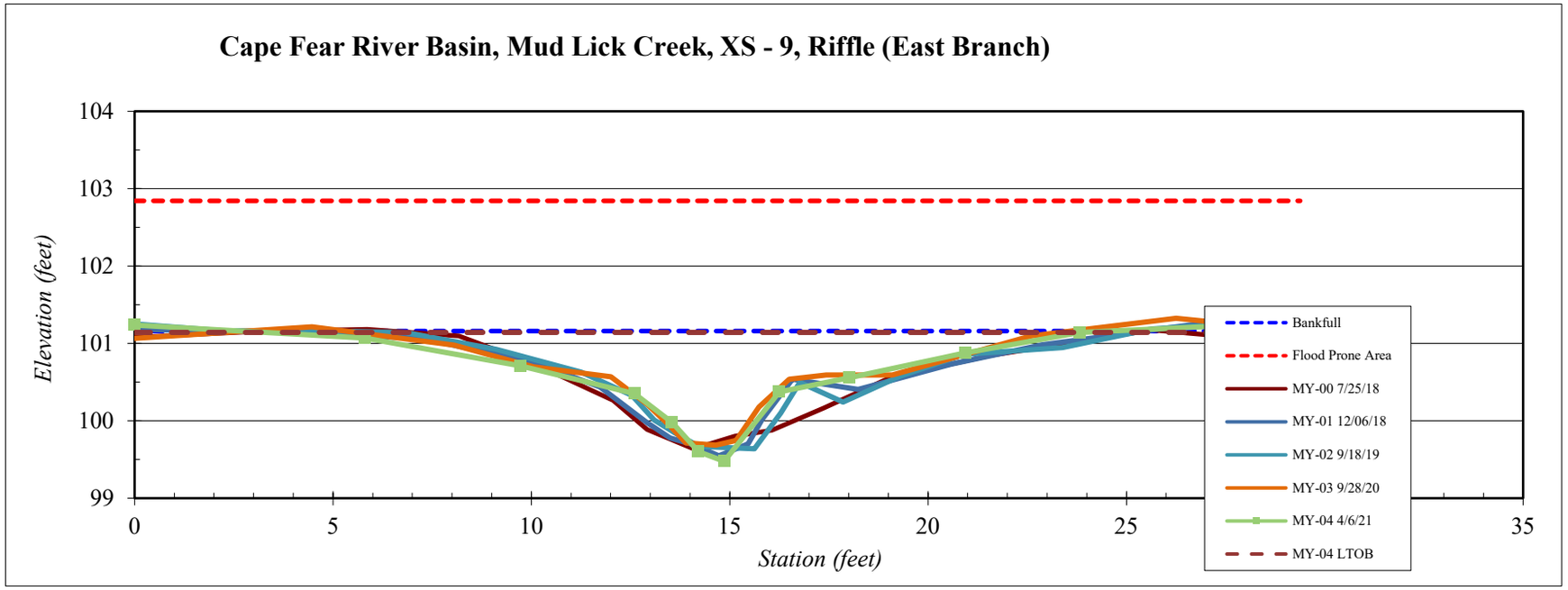


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 9, Riffle (East Branch)
Drainage Area (sq mi):	0.27
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.00	101.24
5.81	101.07
9.73	100.71
12.60	100.35
13.55	99.98
14.22	99.60
14.86	99.48
16.25	100.37
18.01	100.56
20.94	100.88
23.83	101.14
27.29	101.22
29.38	101.24

SUMMARY DATA	
Bankfull Elevation:	101.2
Bankfull Cross-Sectional Area:	10.6
Area at Low Bank:	8.8
Bankfull Width:	21.9
Flood Prone Area Elevation:	102.8
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.7
Low Bank Height:	1.7
Mean Depth at Bankfull:	0.5
W / D Ratio:	45.1
Entrenchment Ratio:	NA
Bank Height Ratio:	1.0

Stream Type	C

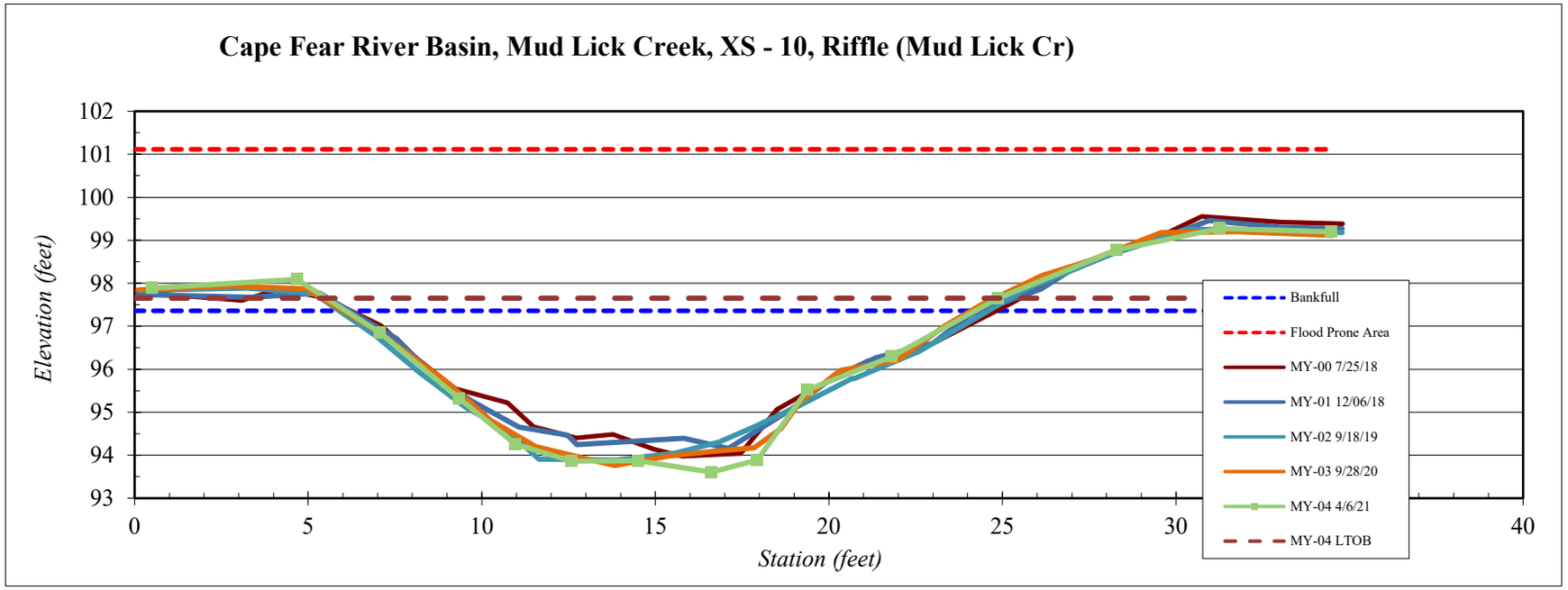


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 10, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	4/6/2021
Field Crew:	Adams, Lawson

Station	Elevation
0.50	97.89
4.67	98.09
7.08	96.85
9.35	95.31
10.98	94.25
12.60	93.86
14.52	93.87
16.61	93.61
17.94	93.89
19.38	95.52
21.81	96.29
24.87	97.65
28.30	98.78
31.26	99.27
34.47	99.20

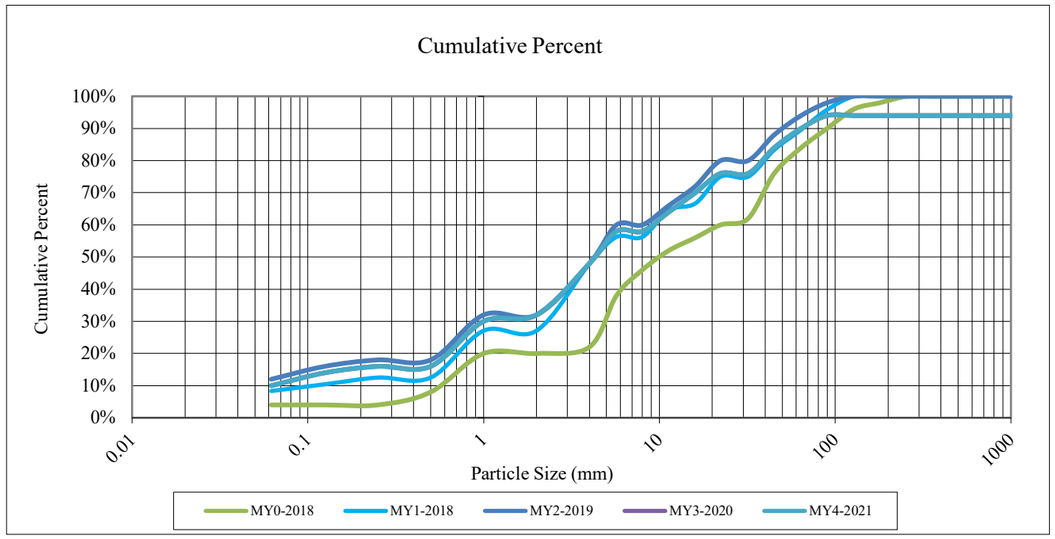
SUMMARY DATA	
Bankfull Elevation:	97.4
Bankfull Cross-Sectional Area:	40.4
Area at Low Bank:	54.9
Bankfull Width:	18.1
Flood Prone Area Elevation:	101.1
Flood Prone Width:	100.0
Max Depth at Bankfull:	3.8
Low Bank Height:	4.0
Mean Depth at Bankfull:	2.2
W / D Ratio:	8.1
Entrenchment Ratio:	NA
Bank Height Ratio:	1.08

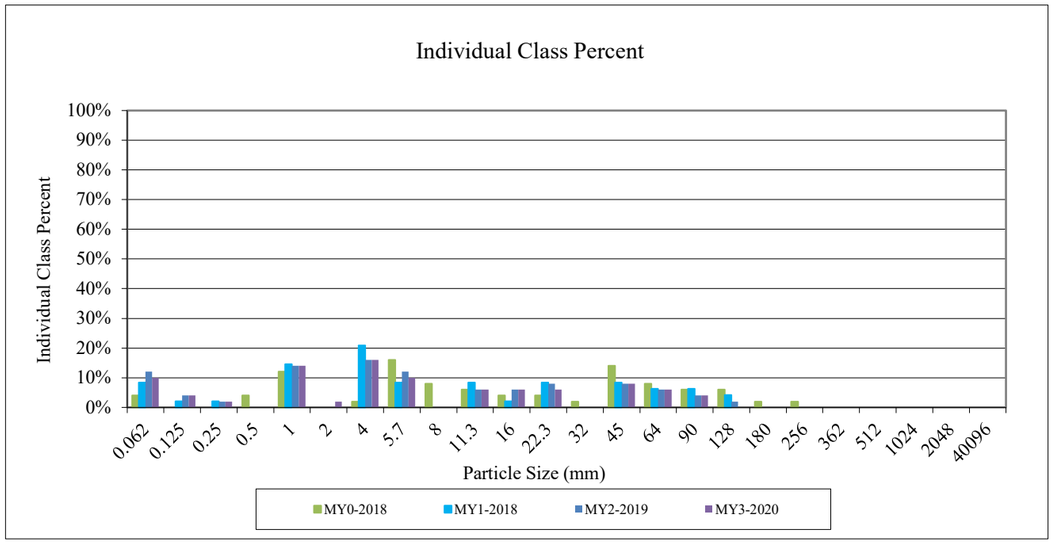
Stream Type	E



Project Name: Mudlick Creek					
Cross-Section: 2					
Feature: Riffle					
			2021		
Description	**Material**	**Size (mm)**	**Total #**	**Item %**	**Cum %**
Silt/Clay	silt/clay	0.062	5	11%	11%
Sand	very fine sand	0.125	2	4%	15%
	fine sand	0.250	1	2%	17%
	medium sand	0.50	0	0%	17%
	coarse sand	1.00	7	15%	32%
	very coarse sand	2.0	1	2%	34%
Gravel	very fine gravel	4.0	8	17%	51%
	fine gravel	5.7	5	11%	62%
	fine gravel	8.0	0	0%	62%
	medium gravel	11.3	3	6%	68%
	medium gravel	16.0	3	6%	74%
	course gravel	22.3	3	6%	81%
	course gravel	32.0	0	0%	81%
	very coarse gravel	45	4	9%	89%
	very coarse gravel	64	3	6%	96%
Cobble	small cobble	90	2	4%	100%
	medium cobble	128	0	0%	100%
	large cobble	180	0	0%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			47	100%	100%

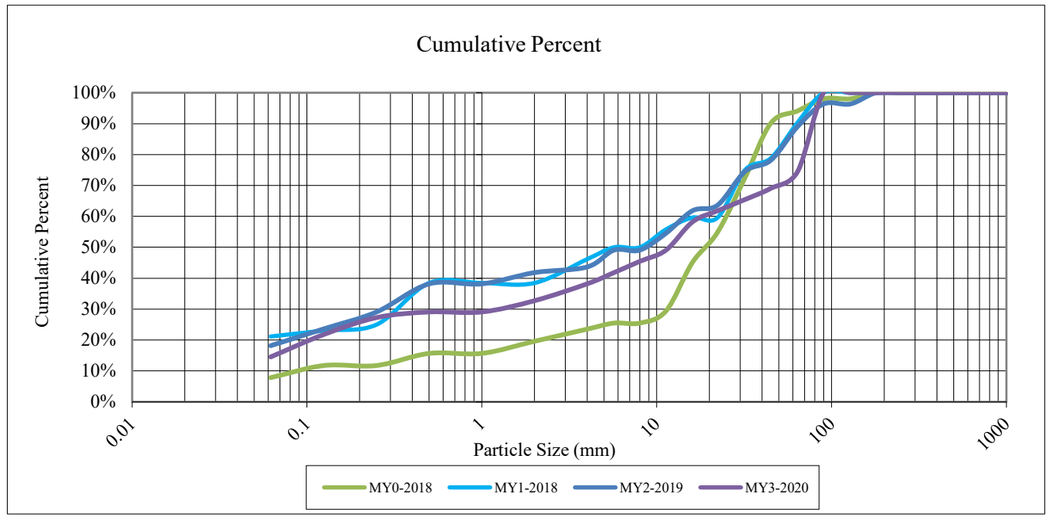
Summary Data	
D16	0.179
D35	2.08
D50	3.8
D84	36
D95	61

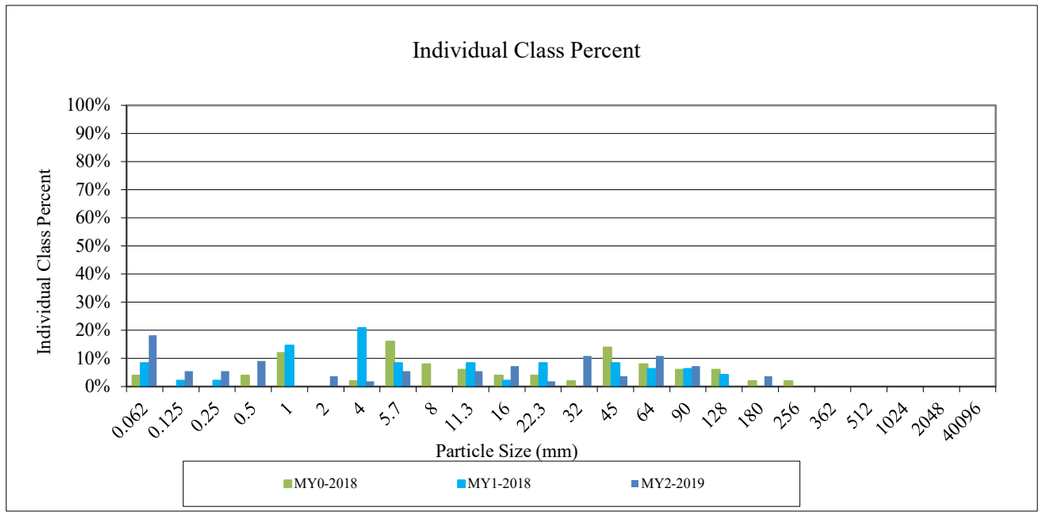




Project Name: North Branch					
Cross-Section: 4					
Feature: Riffle					
			2021		
Description	**Material**	**Size (mm)**	**Total #**	**Item %**	**Cum %**
Silt/Clay	silt/clay	0.062	12	24%	24%
Sand	very fine sand	0.125	3	6%	30%
	fine sand	0.250	1	2%	32%
	medium sand	0.50	1	2%	34%
	coarse sand	1.00	3	6%	40%
	very coarse sand	2.0	0	0%	40%
Gravel	very fine gravel	4.0	4	8%	48%
	fine gravel	5.7	2	4%	52%
	fine gravel	8.0	4	8%	60%
	medium gravel	11.3	2	4%	64%
	medium gravel	16.0	5	10%	74%
	course gravel	22.3	4	8%	82%
	course gravel	32.0	4	8%	90%
	very coarse gravel	45	2	4%	94%
	very coarse gravel	64	3	6%	100%
Cobble	small cobble	90	0	0%	100%
	medium cobble	128	0	0%	100%
	large cobble	180	0	0%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			50	100%	100%

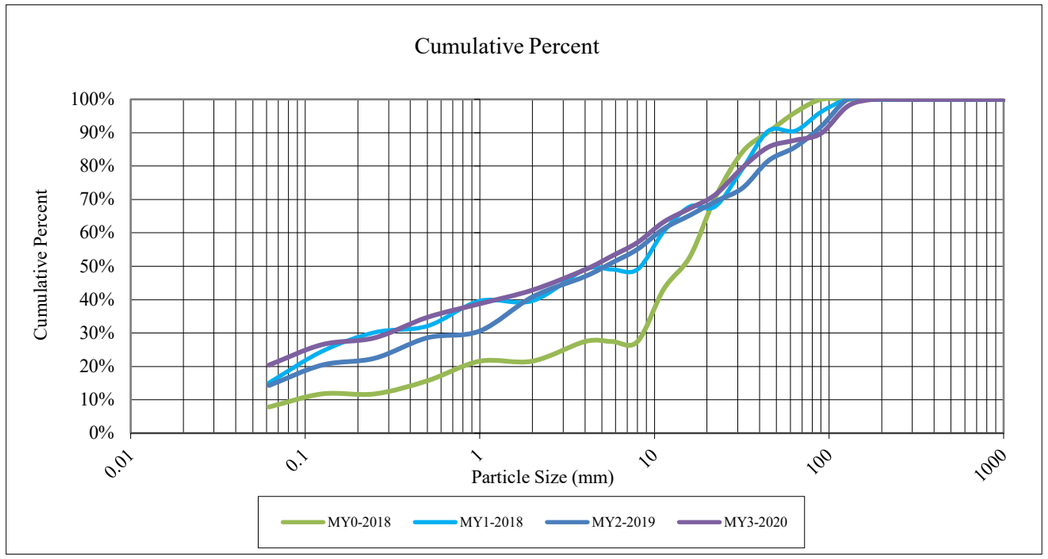
Summary Data	
D16	NA
D35	0.56
D50	4.9
D84	24
D95	48

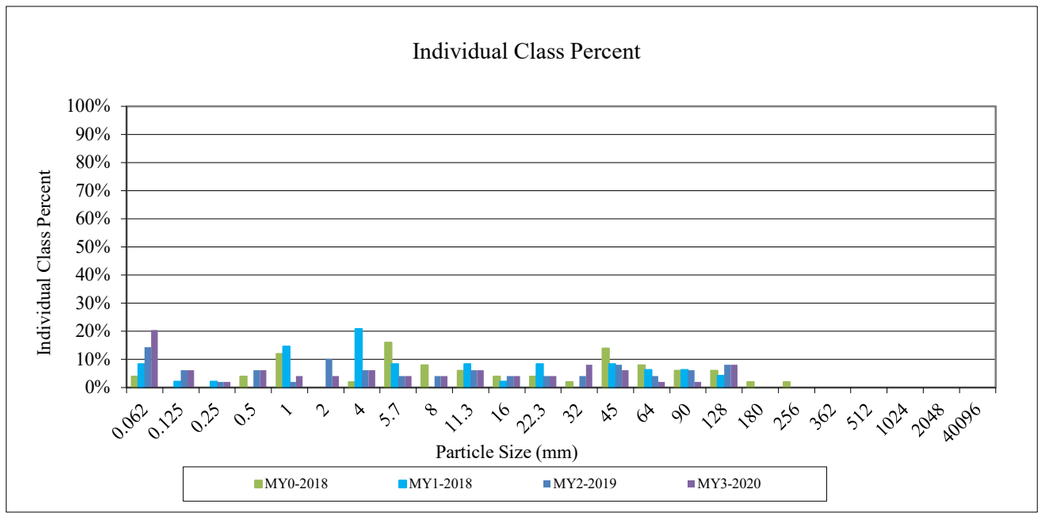




Project Name: East Branch					
Cross-Section: 7					
Feature: Riffle					
			2021		
Description	**Material**	**Size (mm)**	**Total #**	**Item %**	**Cum %**
Silt/Clay	silt/clay	0.062	8	16%	16%
Sand	very fine sand	0.125	4	8%	24%
	fine sand	0.250	1	2%	26%
	medium sand	0.50	3	6%	32%
	coarse sand	1.00	3	6%	38%
	very coarse sand	2.0	5	10%	48%
Gravel	very fine gravel	4.0	3	6%	54%
	fine gravel	5.7	2	4%	58%
	fine gravel	8.0	2	4%	62%
	medium gravel	11.3	5	10%	72%
	medium gravel	16.0	2	4%	76%
	course gravel	22.3	2	4%	80%
	course gravel	32.0	4	8%	88%
	very coarse gravel	45	3	6%	94%
	very coarse gravel	64	1	2%	96%
Cobble	small cobble	90	0	0%	96%
	medium cobble	128	2	4%	100%
	large cobble	180	0	0%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			50	100%	100%

Summary Data	
D16	0.062
D35	0.71
D50	2.5
D84	27
D95	54





Appendix E.
Hydrology Data

Table 12. Verification of Bankfull Events

Table 12. Verification of Bankfull Events
Mud Lick Creek Restoration Site (DMS Project No. 93482)

Date of Data Collection	Date of Occurrence	Method	Photo (if available)
December 6, 2018	October 16-17, 2018	Observations throughout floodplain and crest gauge indicate a bankfull event after 4.61 inches of rain fell over 48 hours.	1, 2
May 8, 2019	February 24, 2019	Observation of wrack in floodplain along North Branch R2 and crest gauge data from all site crest gauges indicate a bankfull event after 2.27 inches of rain fell over 48 hours.	3
September 18, 2019	July 24, 2019	Observation of wrack on Mud Lick Creek R2 floodplain fences and crest gauge data from all site crest gauges indicate a bankfull event after 3.02 inches of rain fell over 48 hours.	4
May 29, 2020	February 7, 2020	Observations of wrack throughout site along all stream reaches, and crest gauge data from all site crest gauges indicate a bankfull event after approximately 3.59 inches of rain fell over 24-hour period.	5, 6, 7
November 16, 2020	November 12, 2020	Observations of wrack throughout site along all stream reaches, and crest gauge data from all site crest gauges indicate a bankfull event after approximately 4.60 inches of rain fell over 48-hour period.	8, 9


Photo-5
2020/05/29


Photo-6
2020/05/29


Photo-7
2020/05/29


Photo-8


Photo-9

Appendix F.
2021 Fish Survey Report

Mud Lick Creek Mitigation Site Monitoring: Year 04 Fish Community Sampling

Chatham County, North Carolina

Mud Lick Creek Reach 1 MY-04

Prepared for:

Environmental Quality

Division of Mitigation Services
217 West Jones Street
Raleigh, NC 27603

July 12, 2021

Prepared By:

Three Oaks Engineering
324 Blackwell Street, Suite 1200
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Table of Contents

1.0 INTRODUCTION

The Mud Lick Creek Mitigation Site (The Site) is a North Carolina Department of Environmental Quality Division of Mitigation Services (NCDMS) project designed to restore and enhance a total of 3,750 linear feet (LF) of perennial stream in Chatham County, NC. The Site is located in the Upper Rocky River Watershed within Cape Fear River Basin Hydrologic Unit Code (HUC) 03030003 (Cape Fear 03) and within the Upper Rocky River local watershed planning area (LWP) identified as a priority for mitigation. Restoration and enhancement activities have been performed on Mud Lick Creek and two unnamed tributaries referred to as North Branch and East Branch. Three Oaks Engineering (Three Oaks) was retained in 2015 to evaluate the baseline condition of these streams and conducted water quality monitoring, benthic macroinvertebrate community sampling, and fish community sampling within the Site. Following restoration, Three Oaks was tasked with conducting fish community sampling in monitoring years (MY) 04 and 07.

This report details MY-04 fish community results conducted May 18, 2021.

2.0 SITE DESCRIPTIONS

Fish community sampling was conducted in Mud Lick Creek (Reach 1 and 2) and a qualitative survey was conducted in North Branch.

Mud Lick Reach 1 (MLDN encompassing Baseline Site 3). This reach is located just upstream of the Silk Hope Liberty Road crossing. Stream width ranged from three to six meters (m), with an average depth of .15 m and a max depth of .75 m in pools. Banks were between .75 and 1.5 m with moderate erosion in portions of the reach. The creek was characterized by low velocity flow with limited riffle and run habitat present. Instream habitat such as woody debris, leaf packs, snags and undercut banks were common. Substrate consisted primarily of silt and sand, with areas of gravel and cobble associated with riffle and run habitats. The riparian zone consisted of grasses, shrubs and scattered mature trees creating a partial canopy. Active pastureland borders the enclosed riparian conservation area.

Mud Lick Reach 2 (MLWC and MLUP encompassing Baseline Site 2). Mud Lick Creek Site 1 is the most upstream site sampled for the project. Stream width ranged between two and five m, with an average depth of .25 m and a maximum depth of .75 m in pools. Bank height ranged between one and two m high with moderate erosion observed throughout the reach. The creek was characterized primarily by a run with some areas of pool and riffle. Log veins, added through restoration efforts, have created additional riffle habitat. In stream habitat consisted of woody debris, leaf packs, snags and undercut banks. Restoration has also added macrophytes, present throughout the reach. Substrate was comprised primarily of silt, sand and gravel. Significant algal growth was noted throughout the reach. The riparian zone consisted primarily of grasses and shrubs with scattered mature and immature trees providing some canopy cover of the reach. Active pasture borders the riparian zone with fencing providing a barrier.

Site 3 (NBDN). Site 3 is located just upstream of North Branch's confluence with Mud Lick Creek on North Branch. The stream ranged from 0.75 to 1.5 m wide with banks .3 to one m high. The reach has been restored with log veins within the stream channel creating some riffle and pool structure; maximum water depth was .3 m. Substrate consisted mostly of silt and sand with some gravel and cobble present. Matting and revegetation on the banks was observed, erosion was minimal within the reach. The riparian zone consisted of grasses and shrubs. Similar to Reach 1 and 2, the riparian zone was bordered by active pasture.

3.0 FISH COMMUNITY SAMPLING

The freshwater fish populations in the Cape Fear River Basin have been sampled extensively over the years and 95 species have been recorded (Rhode et al. 1994, Menhenick 1991). The health and diversity of the fish fauna is reflective of the water quality of a particular water body and monitoring of the fish fauna is a useful tool in tracking and understanding water quality trends over time.

North Carolina Department of Environmental Quality, Division of Water Resources (NCDWR) has developed a method of assessing water quality by establishing an Index of Biotic Integrity rating, which is based upon the evaluation of the fish community of a particular water body. The evaluation results in a numerical score, which is called the North Carolina Index of Biotic Integrity (NCIBI). The NCIBI evaluates 12 metrics (parameters) pertaining to species richness and composition, trophic composition, and fish abundance and condition. Each metric value is converted into a score of 1, 3, or 5, with 5 representing conditions expected for a relatively undisturbed reference stream in the specific river basin or ecoregion (NCDENR 2013). The NCIBI score translates to biodiversity ratings of Excellent, Good, Good-Fair, Fair and Poor. Currently, Excellent, Good, or Good-Fair ratings indicate that the stream is Fully Supporting its Aquatic Life Use Support classification. A Fair or Poor rating is Not Supporting its Life Use Support stream classification and the water quality standard is not being met.

The study area is within the Outer Piedmont of the Cape Fear River Basin ecoregion for which NCIBI reference indices have been established. These reference indices are needed in order to apply the NCIBI protocol to a given waterbody. In addition, protocol collection methodology and data analysis must be strictly followed.

The purpose of applying the NCIBI methodology is not solely to compare scores generated at each of the monitoring sites with other streams in the reference ecoregion, but also to compare scores generated at the monitoring sites overtime to monitor changes in fish community composition in response to natural or human-induced factors.

3.1 Fish Community Sampling Methods

Fish community surveys were conducted on May 18, 2021 by the Three Oaks team of Tom Dickinson (NC Wildlife Resources Commission Permit 21-SFC00057), Lizzy-Stokes Cawley, and Nathan Howell.

3.1.1 Field Methods

A standard 600 linear feet of stream were surveyed with backpack electrofishing equipment and dip nets at each of the three sites in Mud Lick Creek. Survey methodology, data analysis, and interpretation (scoring) essentially follow procedures outlined in Standard Operating Procedures Biological Monitoring Stream Fish Community Assessment (NCDENR 2013).

3.1.2 Water Chemistry

Water chemistry was measured at each site in conjunction with fish sampling using a YSI-Pro Plus multiparameter water quality meter. Parameters measured were temperature, dissolved oxygen, conductivity, and pH (Table 6).

3.1.3 Habitat Assessment

The habitat assessment method developed by NCDWR was used to evaluate the physical structure and conditions of the stream and surrounding area. Parameters are numerically rated based on current stream conditions and include land use, stream width and depth, bank structure and stability, instream habitat, substrate, habitat, and riparian zone attributes. A total of 12 parameters are individually allotted scores with a possible maximum score for a site of 100 (Table 7).

4.0 RESULTS

Five species of fish were collected during the MY-04 survey efforts. The survey results and associated IBI scoring are provided below by site.

4.1 Reach 1 Mud Lick Creek

A total of 1,894 seconds of electro-shocking time was used during the 2021 surveys.

Table 1. Reach 1 Species List

				Baseline May 6, 2015		**MY-04 May 18, 2021**	
Scientific Name	**Common Name**	**Tolerance Rating**	**Tropic Guild**	**Count**	**# of Size Classes**	**Count**	**# of Size Classes**
Gambusia holbrooki	Eastern Mosquitofish	Tolerant	Insectivore	115	6	10	2
Lepomis cyanellus	Green sunfish	Tolerant	Insectivore	15	5	95	7
Lepomis macrochirus	Bluegill	Intermediate	Insectivore	~	~	4	2
Micropterus salmoides	Largemouth Bass	Intermediate	Piscivore	~	~	1	1
Notemigonus crysoleucas	Golden shiner	Tolerant	Omnivore	~	~	9	2

Table 2. NCIBI Score Mud Lick Creek Reach 1

	Baseline May 6, 2015		MY-04 May 18, 2021	
Metric/score criteria	**Site Metric #**	**Site Metric Score**	**Site Metric #**	**Site Metric Score**
No. of species	2	1	5	1
≥ 16 species = 5				
10-15 species = 3				
<10 species = 1				
No. of fish	130	1	119	1
≥ 225 fish = 5				
150-224 fish = 3				
<150 fish = 1				
No. of species of darters	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
No. of species of sunfish	1	1	2	1
≥ 4 species = 5				
3 species = 3				
0-2 species = 1				
No. of species of suckers	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
No. of intolerant species	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
% of tolerant individuals	100%	1	95.8%	1
≤ 35% = 5				
36-50% = 3				
>50% = 1				
% of omnivorous and herbivorous individuals	0%	1	7.6%	1
10-35% = 5				
36-50% = 3				
>50% or <10% = 1				
% of insectivorous individuals	100%	1	91.6%	1
65-90% = 5				
45-64% = 3				
<45% or >90% = 1				
% of piscivorous individuals	0.0%	1	0.1%	1
1.4-15% = 5				
0.4-1.3% = 3				
<0.4% or >15% = 1				
% of diseased fish	0.00%	5	0.00%	5
≤1.75% = 5				
1.76-2.75% = 3				
>2.75% = 1				
% of species with multiple age groups	100%	5	80.0%	5
≥50% = 5				
35-49% = 3				
<35% = 1				
NCIBI Score		**20 (Poor)**		**20 (Poor)**

4.2 Reach 2 Mud Lick Creek

A total of 1,865 seconds of electro-shocking time was used in 2021 surveys.

Table 3. Reach 2 Species List

				Baseline May 6, 2015		MY-04 May 18, 2021	
Scientific Name	**Common Name**	**Tolerance Rating**	**Tropic Guild**	**Count**	**# of Size Classes**	**Count**	**# of Size Classes**
Gambusia holbrooki	Eastern Mosquitofish	Tolerant	Insectivore	60	6	22	4
Lepomis cyanellus	Green Sunfish	Tolerant	Insectivore	18	9	46	9
Lepomis macrochirus	Bluegill	Intermediate	Insectivore	~	~	2	1
Notemigonus crysoleucas	Golden shiner	Tolerant	Omnivore	~	~	10	2

Table 4. NCIBI Score Mud Lick Creek Reach 2

	Baseline May 6, 2015		MY-04 May 18, 2021	
Metric/score criteria	**Site Metric #**	**Site Metric Score**	**Site Metric #**	**Site Metric Score**
No. of species	2	1	4	1
≥ 16 species = 5				
10-15 species = 3				
<10 species = 1				
No. of fish	78	1	80	1
≥ 225 fish = 5				
150-224 fish = 3				
<150 fish = 1				
No. of species of darters	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
No. of species of sunfish	1	1	2	1
≥ 4 species = 5				
3 species = 3				
0-2 species = 1				
No. of species of suckers	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
No. of intolerant species	0	1	0	1
≥ 3 species = 5				
1-2 species = 3				
0 species = 1				
% of tolerant individuals	100%	1	97.5%	1
≤ 35% = 5				
36-50% = 3				
>50% = 1				
% of omnivorous and herbivorous individuals	0.0%	1	12.5%	5
10-35% = 5				

	Baseline May 6, 2015		MY-04 May 18, 2021	
Metric/score criteria	**Site Metric #**	**Site Metric Score**	**Site Metric #**	**Site Metric Score**
36-50% = 3				
>50% or <10% = 1				
% of insectivorous individuals	100%	5	87.5%	5
65-90% = 5				
45-64% = 3				
<45% or >90% = 1				
% of piscivorous individuals	0.0%	1	0.0%	1
1.4-15% = 5				
0.4-1.3% = 3				
<0.4% or >15% = 1				
% of diseased fish	1.28%	5	1.25%	5
≤1.75% = 5				
1.76-2.75% = 3				
>2.75% = 1				
% of species with multiple age groups	100%	5	75%	5
≥50% = 5				
35-49% = 3				
<35% = 1				
NCIBI Score		**20 (Poor)**		**28 (Poor)**

4.3 Reach 3 North Branch

A short qualitative survey was conducted in North Branch in which three species were identified.

Table 5. Site 3 Species List

Scientific Name	Common Name	Tolerance Rating	Tropic Guild	Count
Gambusia holbrooki	Eastern Mosquitofish	Tolerant	Insectivore	Common
Lepomis cyanellus	Green Sunfish	Tolerant	Insectivore	Common
Micropterus salmoides	Largemouth Bass	Intermediate	Piscivore	Rare

4.4 Water Chemistry

Water chemistry data measured during the fish sampling are listed in Table 6.

Table 6. Physicochemical data collected-Mud Lick Creek

	Baseline May 6, 2015		MY-04 May 18, 2021	
Parameter	**Reach 1 (Site 3)**	**Reach 2 (Site 2)**	**Reach 1**	**Reach 2**
Water Temp (C)	15.5	16.4	15.4	17.6
pH	7.40	6.56	6.31	6.51
Dissolved Oxygen (DO) (mg/L)	8.20	8.75	5.82*	12.20*
Specific Conductivity (uS/cm)	89.3	91.8	117.4	111.7

*Dissolved Oxygen was resampled on May 24th due to DO YSI malfunction May 18th

4.5 Habitat Assessment Scores

Habitat scores were determined using the Habitat Assessment Field Data Sheet for Mountain/ Piedmont Streams (NCDENR 2013) and are shown in Table 7 and Appendix B. These visual-based habitat evaluation scores consist of eight parameters that rate channel modification, in-stream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and riparian vegetation zone width for each sampling reach. A numerical score is used to rate each parameter and the total score gives a relative measure of overall habitat quality.

Table 7. Habitat assessment scores-Mud Lick Creek Fish Sampling Sites

	Baseline May 6, 2015		**MY-04 May 18, 2021**		
	Reach 1 (Site 3)	**Reach 2 (Site 2)**	**Reach 1**	**Reach 2**	**Highest Possible Score**
1. Channel Modification	4	5	4	4	5
2. Instream Habitat	10	16	15	16	20
3. Bottom Substrate	8	4	4	4	15
4. Pool Variety	4	8	4	8	10
5. Riffle Habitats	3	7	3	3	16
6. Bank Stability and Vegetation	7	2	5	5	14
7. Light Penetration	2	2	7	2	10
8. Riparian Vegetative Zone Width	4	0	8	8	10
Total	**42**	**44**	**50**	**50**	**100**

5.0 DISCUSSION

These efforts provide current fish community and habitat data for Mud Lick Creek in two distinct reaches as well as qualitative data for North Branch. The data documents stressed fish communities in both reaches, with Mud Lick Branch Reach 1 scoring 20 (poor) and Reach 2 receiving a score of 28 (poor). NCIBI scores were similar to baseline results in which Reach 1 (Site 3) scored 20 (poor) and Reach 2 (Site 2) scored 20 (poor). Fish counts were similar for Reach 1 and 2 compared to the baseline, however, species richness increased, with five species recorded in Reach 1 and four in Reach 2 during MY-04 efforts; only two species were captured during the baseline efforts at each site. Additional species detected in MY-04 included Largemouth Bass, Bluegill and Golden Shiner. However, the tolerant Eastern Mosquitofish and the non-native Green Sunfish were the most prevalent species detected in the three reaches.

Water quality parameters measured were temperature, pH, DO, and conductivity. Temperature, DO, pH, and conductivity readings were within the normal range of conditions for streams. The high dissolved oxygen levels observed in Reach 2 are likely influenced by the presence of algae in the reach that are contributing to fluxes in DO as a result of photosynthesis occurring during daylight hours.

The rated stream habitat field assessment parameters were channel modification, in-stream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and riparian vegetation zone width. Following restoration overall habitat scores improved in both reaches. Reach 1 saw moderate improvement for instream habitat from baseline scores as undercut banks, snags and logs were common throughout the reach. Pool variety and riffle habitat in Reach 1 and Reach 2 scored the same as baseline values. Stream restoration activity has created more structure for instream habitat through placement of log veins and macrophyte plantings. Instream restoration was more apparent in Reach 2 and North Branch where an increase in habitat and riffle and pool was noted. Growth of mature trees provided additional stream shading and increased scores for light penetration in Reach 1. Scores for both Reach 1 and Reach 2 increased from baseline for riparian vegetative zone width as the exclusion of grazing cattle, and tree and shrub plantings has allowed for a riparian buffer to be established in all assessed reaches. Reach 1 scored a 50 in MY-04 surveys, an improvement from baseline survey score of 42. Reach 2 scored 50 in MY-04 surveys, an improvement from baseline survey score of 44. The score is on a 100-point scale, with 100 indicating highest quality stream habitat.

These efforts provide monitoring data for comparison to previous baseline efforts. While the assessment indicates a stressed fish community, there is potential for future improvement as riparian buffers become more established and additional species and abundance can recolonize newly created habitat. Further fish sampling is planned for MY-07.

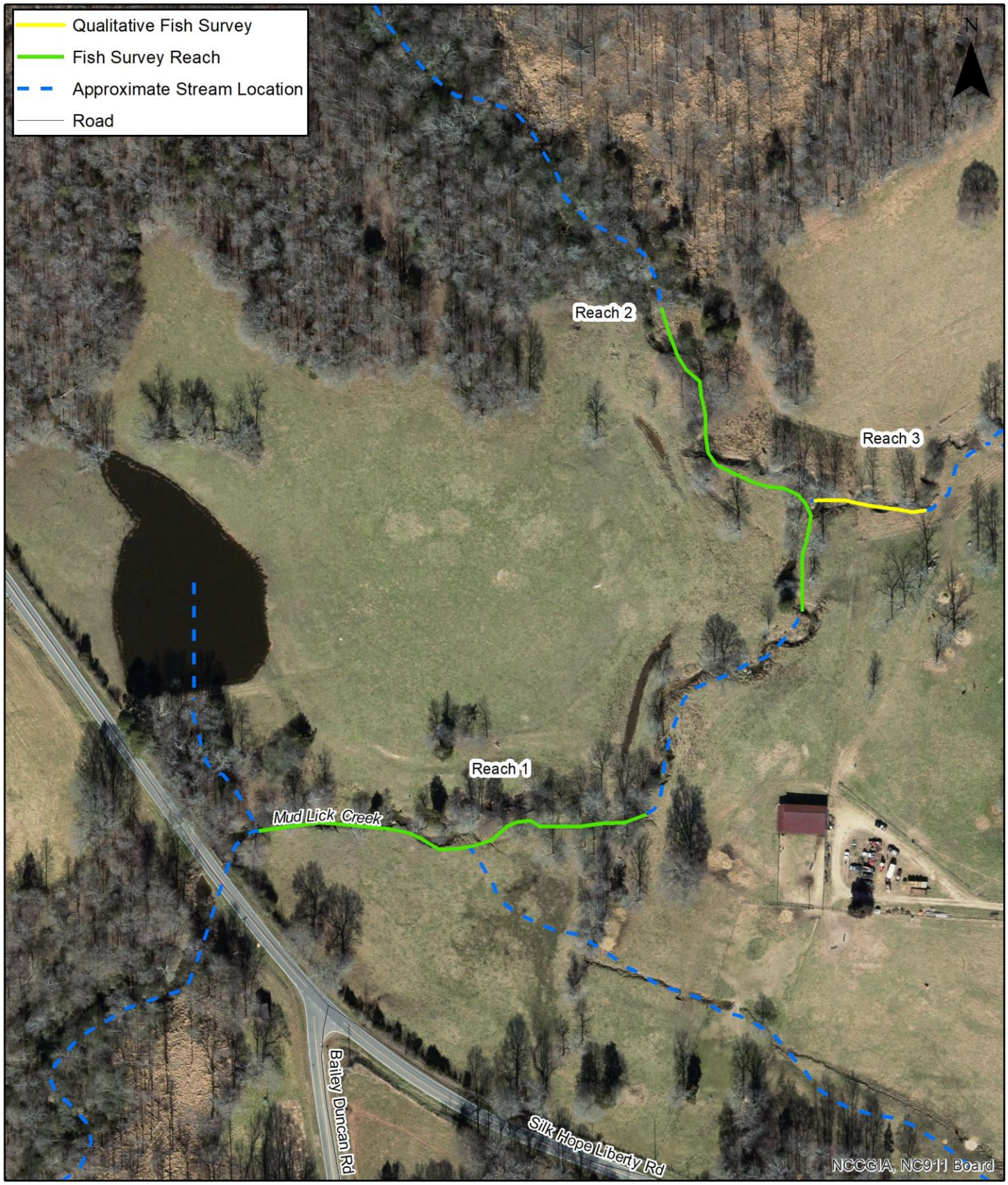
6.0 LITERATURE CITED

Menhinick, E.F., 1991. The freshwater fishes of North Carolina. NC Wildlife Resources Commission, Raleigh, NC. 227 pp.

NCDENR. 2013. Standard Operating Procedures for Biological Monitoring Stream Fish Community Assessment Program, Version 5. December 2013. North Carolina Department of Environmental Quality. Division of Water Resources, Water Sciences Section, Biological Assessment Branch. 52 pp.

Rhode, F. C., R.G. Arndt, D.L. Lindquist and J. F. Parnell. 1994. Freshwater Fishes of the Carolinas, Virginia, Maryland and Delaware. The Univ. North Carolina Press, Chapel Hill.

Appendix A. Figure 1



THREE OAKS ENGINEERING · THREE OAKS ENGINEERING ·

Prepared For:

NC Mitigation Services
ENVIRONMENTAL QUALITY

Mud Lick Creek Mitigation Site

Sampling Locations

Chatham County, North Carolina

Date:	June 2021
Scale	0 50 100 Feet
Job No.:	21-309
Drawn By: KEMS	Checked By: TED

Figure

1

Appendix B: Fish Community Habitat Assessment Data Sheets

Appendix 5. Habitat assessment field data sheet -- Mountain/Piedmont streams.

11/13 Revision 8

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Biological Assessment Branch, DWR TOTAL SCORE 50

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

Stream Mud Lick Creek **Location/road:** Reach 1 **(Road Name** Silk-hope Liberty Rd **County** Chatham County

Date 5/18/2021 **CC#** **Basin** Cape Fear **Subbasin** Deep Subbasin

TD, LSC, NH

Observer(s) _____ **Type of Study.** ☐ Fish ☐ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude 35.811875 **Longitude** -79.437381 **Ecoregion:** ☐ MT ☐ P ☐ Slate Belt ☐ Triassic Basin

Water Quality: Temperature 15.4 °C **DO** 2.63 mg/l **Conductivity (corr.)** 117.4 µS/cm **pH** 6.31

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

Visible Land Use: ____%Forest ____%Residential 80 %Active Pasture ____% Active Crops
____%Fallow Fields ____% Commercial ____%Industrial ____%Other - Describe: 20 Conservation easement

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

Width: (meters) Stream 3-5 m **Channel (at top of bank)** 6m **Stream Depth: (m)** Avg .15 **Max** .75m
☐ Width variable ☐ Large river >25m wide

Bank Height (from deepest part of riffle to top of bank-first flat surface you stand on): (m) 1 m

Bank Angle: 75 ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

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

Channel Flow Status

Useful especially under abnormal or low flow conditions

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

Weather Conditions: Overcast 65°F **Photos:** ☐N ☒Y ☐Digital ☐35mm

Remarks: _____

I. Channel Modification

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

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

Remarks _____ Subtotal 4

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

___Rocks ___Macrophytes X Sticks and leafpacks X Snags and logs X Undercut banks or root mats

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

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

☐ No woody vegetation in riparian zone Remarks _____ Subtotal 15

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

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

Remarks _____ Subtotal 4

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

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

Subtotal 4

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

Remarks _____ Page Total 27

Appendix 5 (continued).

V. Riffle Habitats

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

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

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

Subtotal 3

VI. Bank Stability and Vegetation

A. Erosion

1. No, or very little, erosion present 7
2. Erosion mostly at outside of meanders 6
3. Less than 50% of banks eroding ..... (3)
4. Massive erosion 0

Erosion Score 3

B. Bank Vegetation

1. Mostly mature trees (>12" DBH) present 7
2. Mostly small trees (<12" DBH) present, large trees rare 5
3. No trees on bank, can have some shrubs and grasses 3
4. Mostly grasses or mosses on bank ..... (2)
5. Little or no bank vegetation, bare soil everywhere 0

Vegetation Score 2

Remarks _____

Subtotal 5

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

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

Remarks _____

Subtotal 7

VIII. Riparian Vegetative Zone Width

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

FACE UPSTREAM

Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc)

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. width > 18 meters	5	5
2. width 12-18 meters	(4)	(4)
3. width 6-12 meters	3	3
4. width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. width > 18 meters	4	4
b. width 12-18 meters	3	3
c. width 6-12 meters	2	2
d. width < 6 meters	1	1
2. breaks common		
a. width > 18 meters	3	3
b. width 12-18 meters	2	2
c. width 6-12 meters	1	1
d. width < 6 meters	0	0

Remarks _____

Subtotal 8

Page Total 23

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

TOTAL SCORE 50

Reach 2

Appendix 5. Habitat assessment field data sheet -- Mountain/Piedmont streams.

11/13 Revision 8

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Biological Assessment Branch, DWR TOTAL SCORE 42

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

Stream Mud lick Creek Location/road: Reach 2 (Road Name) County Chatham @ 1:46pm

Date 5/18/2021 CC# Basin Cape Fear Subbasin Deep

Observer(s) TD, LSC, NH Type of Study: ☒ Fish ☐ Benthos ☐ Basinwide ☐ Special Study (Describe)

Latitude 35.812611 Longitude -79.434811 Ecoregion: ☐ MT ☒ P ☐ Slate Belt ☐ Triassic Basin

Water Quality: Temperature 17.6°C DO 5.23 mg/l Conductivity (corr.) 111.7 µS/cm pH 6.51

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

Visible Land Use: ____%Forest ____%Residential 90 %Active Pasture ____% Active Crops
____%Fallow Fields ____% Commercial ____%Industrial ____%Other - Describe: 10 'Conservation area

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

Width: (meters) Stream 10ft Channel (at top of bank) 14ft **Stream Depth:** (m) Avg 1ft Max 2.5 ft
☐ Width variable ☐ Large river >25m wide

Bank Height (from deepest part of riffle to top of bank-first flat surface you stand on): (m) 4 ft

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

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

Channel Flow Status

Useful especially under abnormal or low flow conditions.

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

Weather Conditions: 72° Overcast **Photos:** ☐N ☒Y ☒Digital ☐35mm

Remarks: Structure- ie log vanes have been added for structure in the stream channel

Appendix 5 (continued).

I. Channel Modification

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

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

Remarks _____ Subtotal 4

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

___Rocks X Macrophytes X Sticks and leafpacks X Snags and logs X Undercut banks or root mats

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

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

☐ No woody vegetation in riparian zone Remarks _____ Subtotal 16

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

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

Remarks _____ Subtotal 4

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

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

Subtotal 8

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

Remarks _____

Page Total 32

V. Riffle Habitats

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

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

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

Subtotal 3

VI. Bank Stability and Vegetation

A. Erosion

1. No, or very little, erosion present ... 7
2. Erosion mostly at outside of meanders ... 6
3. Less than 50% of banks eroding ... (3)
4. Massive erosion ... 0

Erosion Score 3

B. Bank Vegetation

1. Mostly mature trees (>12" DBH) present ... 7
2. Mostly small trees (<12" DBH) present, large trees rare ... 5
3. No trees on bank, can have some shrubs and grasses ... 3
4. Mostly grasses or mosses on bank ... (2)
5. Little or no bank vegetation, bare soil everywhere ... 0

Vegetation Score 2

Remarks

Subtotal 5

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

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

Remarks

Subtotal 2

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c. width 6-12 meters	1	1
d. width < 6 meters	0	0

Remarks

Subtotal 8

Page Total 18

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

TOTAL SCORE 50

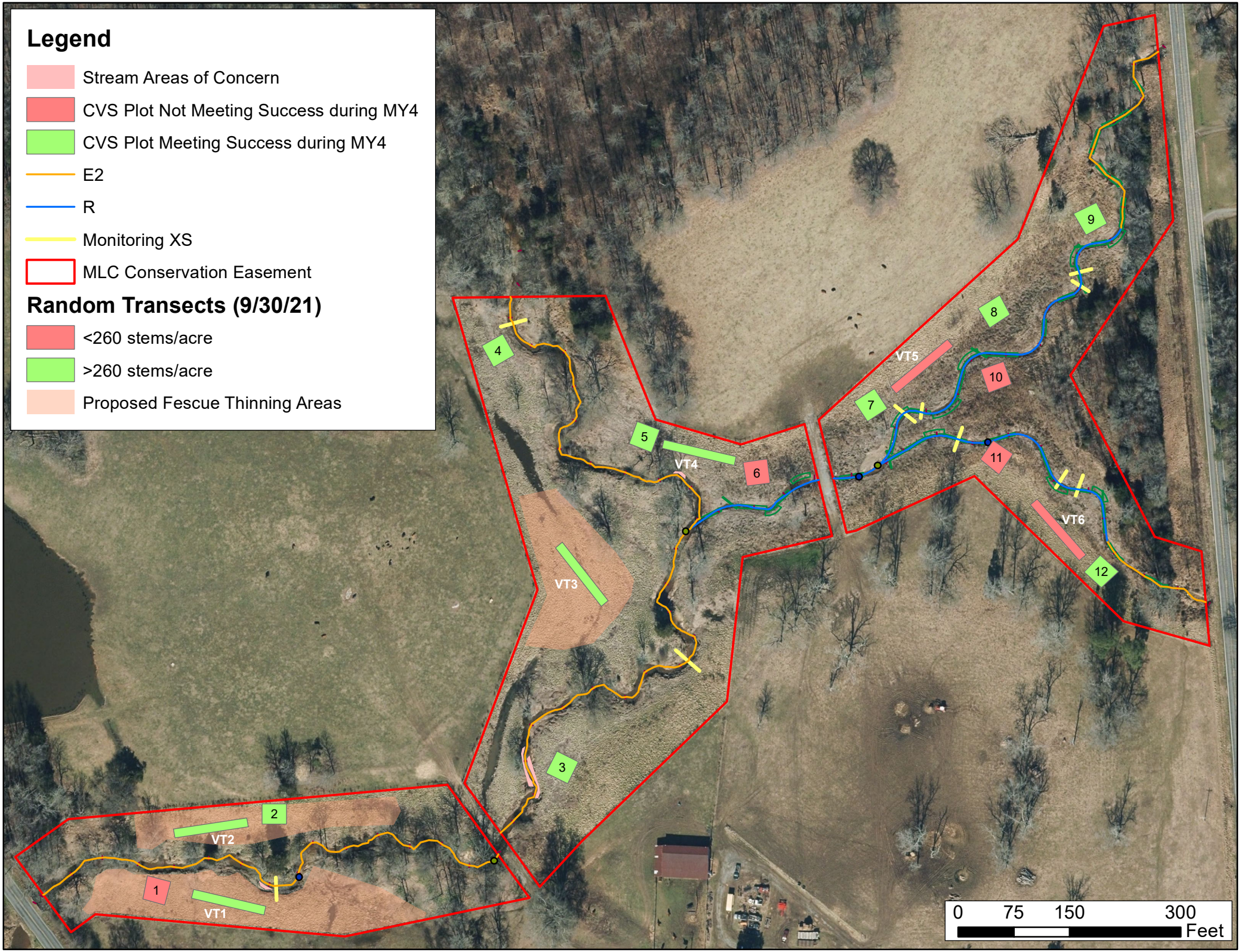
Appendix G.
Random Veg Transect Data

Total and Planted Stems by Plot and Species - Random Transects
Project Code 93482. Project Name: Mud Lick Creek

			Current Plot Data (MY4 2021)													
			VT1		VT2		VT3		VT4		VT5		VT6		Average	
Scientific Name	Common Name	Species Type	PnoLS	T	PnoLS	T	PnoLS	T	PnoLS	T	PnoLS	T	PnoLS	T	PnoLS	T
Acer negundo	boxelder	Tree														
Acer rubrum	red maple	Tree														
Alnus	alder	Shrub														
Baccharis halimifolia	eastern baccharis	Shrub														
Betula nigra	river birch	Tree					1	1					1	1	2	2
Carpinus caroliniana	American hornbeam	Tree														
Carya	hickory	Tree														
Celtis laevigata	sugarberry	Tree														
Celtis occidentalis	common hackberry	Tree			1	1									1	1
Cephalanthus occidentalis	common buttonbush	Shrub														
Cercis canadensis	eastern redbud	Tree														
Cornus amomum	silky dogwood	Shrub					3	3					1	1	4	4
Diospyros virginiana	common persimmon	Tree			2	2			2	2					4	4
Fraxinus pennsylvanica	green ash	Tree	3	3			2	2	5	5					10	10
Juglans nigra	black walnut	Tree														
Liquidambar styraciflua	sweetgum	Tree				5						80				85
Liriodendron tulipifera	tuliptree	Tree														
Nyssa	tupelo	Tree														
Nyssa biflora	swamp tupelo	Tree							15	15			2	2	17	17
Ostrya virginiana	hophornbeam	Tree														
Platanus occidentalis	American sycamore	Tree	4	4	1	1			1	1	4	4			10	10
Populus deltoides	eastern cottonwood	Tree					1	1							1	1
Quercus	oak	Tree														
Quercus michauxii	swamp chestnut oak	Tree														
Quercus nigra	water oak	Tree														
Robinia pseudoacacia	black locust	Tree														
Ulmus americana	American elm	Tree			4	4									4	4
Rhus copallinum	Winged Sumac	Tree												1		1
Ulmus rubra	slippery elm	Tree														
Viburnum dentatum	southern arrowwood	Shrub	1	1			2	2	2	2	1	1	1	1		7
		Stem count	8	8	8	13	9	9	25	25	5	85	5	6	53	146
		size (ares)	1		1		1		1		1		1		1	
		size (ACRES)	0.03		0.03		0.03		0.03		0.03		0.03		0.17	
		Species count	3	3	4	5	5	5	5	5	2	3	4	5	9	12
		Stems per ACRE	290	290	290	472	327	327	908	908	182	3086	182	218	321	883

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

PnoLS = Planted excluding livestakes
T = All planted and natural recruits including livestakes


Legend
Stream Areas of Concern
CVS Plot Not Meeting Success during MY4
CVS Plot Meeting Success during MY4
E2
R
Monitoring XS
MLC Conservation Easement
Random Transects (9/30/21)
<260 stems/acre
>260 stems/acre
Proposed Fescue Thinning Areas
1
2
3
4
5
6
7
8
9
10
11
12
VT1
VT2
VT3
VT4
VT5
VT6
0
75
150
300
Feet