Monitoring Report- Year 5
FINAL VERSION
Pen Dell Mitigation Project
Calendar Year of Data Collection: 2022

NCDEQ DMS Project Identification # 97079
NCDEQ DMS Contract # 6824
Neuse River Basin (Cataloging Unit 03020201)
USACE Action ID Number: SAW-2016-00885
NCDEQ DWR Project # 2016-0403 V2
Johnston County, NC
Contracted Under RFP # 16-006477
Data Collection Period: March and September 2022
Submission Date: November 30th, 2022

Prepared for:

Environmental Quality

North Carolina Department of Environmental Quality
Division of Mitigation Services
1652 Mail Service Center
Raleigh, NC 27699-1652

Prepared by:

WATER & LAND SOLUTIONS
7721 SIX FORKS ROAD, SUITE 130, RALEIGH, NC 27615
(919) 614 - 5111 | waterlandsolutions.com

WATER & LAND SOLUTIONS
7721 SIX FORKS ROAD, SUITE 130, RALEIGH, NC 27615
(919) 614 - 5111 | waterlandsolutions.com

November 30th, 2022

NC Department of Environmental Quality
Division of Mitigation Services
Attn: Lindsay Crocker
217 West Jones Street, Suite 3000-A
Raleigh, NC 27603

RE: WLS Responses to NCDEQ DMS Review Comments for Task 11 Draft Monitoring Report Year 5 for the Pen Dell Mitigation Project, NCDEQ DMS Full-Delivery Project ID #97079, Contract #006824, Neuse River Basin, Cataloging Unit 03020201, Johnston County, NC

Dear Ms. Crocker:

Water & Land Solutions, LLC (WLS) is pleased to present the Final Monitoring Report Year 5 for the Pen Dell Mitigation Project to the North Carolina Department of Environmental Quality (NCDEQ) Division of Mitigation Services (DMS). The Final Monitoring Report Year 5 were developed by addressing NCDEQ DMS's review comments.

Under this cover, we are providing the Final Monitoring Report Year 5, and the required digital data for each (the .pdf copies of the entire updated reports and the updated digital data) via electronic delivery. We are providing our written responses to NCDEQ DMS's review comments on the Draft Monitoring Report Year 5 below. Each of the DMS review comments is copied below in **bold** text, followed by the appropriate response from WLS in regular text:

1. **DMS Comment: Locate irons and determine if there is boundary issue along R2 on the west side of Wendell Road. This area may need additional signage, fencing, or discussions with DMS Property there.** WLS Response: There is a small encroachment along the driveway near R2 of approximately 0.003 acres. This area was marked with string and signage. A gate at the corner of the easement currently swings into the easement and will be fixed in MY6.

2. **DMS Comment: Examine any pine treatment that WLS may elect to do in the thicker area of R1. Locate irons and determine if there is a boundary issue with R1 mowing. Suggest additional signage and horse tape to help landowner visualize and/or planting larger trees there if necessary.** WLS Response: Pine management along R1 will occur early in MY6. During field inspection it was found that mowing had occurred in two spots along the easement boundary of R1. The encroachment is approximately 0.018 acres. Additional t-posts, signs, and horse tape were added to this area.

3. **DMS Comment: Update credit table to show three significant digits (3,030.400 is shown on the credit ledger). Stream footage is measured by the foot, but credit is shown to the thousandth.** WLS Response: The credit table was updated to show total credits to three decimal places.

4. **DMS Comment: There is mention of a red maple threshold for performance criteria in this report, but DMS did not see that requirement in the Mitigation Plan. There are also several plots that exceed that threshold. It appears that this performance standard was added at MY0 and may have come from other similar WLS Wendell projects. Please provide explanation of where that criterion was established, justification for current condition, or remove reference to this.** WLS Response: The red maple threshold states that red maple in a vegetation plot will count for more than 20 percent of the total stems. This

criterion was established in the mitigation plan when red maple were included as a planted species. None of the vegetation plots had greater than 20 percent red maple stems during MY5. An additional column was added to Table 6a with the percent of red maple found in each plot.

Electronic Deliverables

1. **Please revise the mapping threshold on the Vegetation Conditions Assessment for future submissions, both the digital and hard copy tables have been edited to set the Bare Area threshold to 1 acre, it should read 0.01 ac.** WLS Response: The Vegetation Conditions Assessment table was updated to 0.01 ac for the bare area threshold.

2. **Please submit vegetation height data.** WLS Response: Average height of vegetation per plot is provided in Table 6a and in the Veg Data folder.

3. **Submit cross section graphs and data**. WLS Response: Raw cross-section data and graphs are included in the Geomorphology folder.

4. **Submit flow and groundwater gauge data.** WLS Response: Raw hydrology data is included in the Hydro folder.

5. **The stream visual assessment table should be filled out on a reach basis in the future.** WLS Response: The stream visual assessment table was split up by reach.

Please contact me if you have any questions or comments.

Sincerely,

Water & Land Solutions, LLC

Emily Dunnigan
Water & Land Solutions, LLC
7721 Six Forks Road, Suite 130
Raleigh, NC 27615
Office Phone: (919) 614-5111
Mobile Phone: (269) 908-6306
Email: emily@waterlandsolutions.com

Table of Contents

LIST OF APPENDICES

1 Project Summary

Water and Land Solutions, LLC (WLS) completed the construction and planting of the Pen Dell Mitigation Project (Project) full-delivery project for the North Carolina Department of Environmental Quality (NCDEQ), Division of Mitigation Services (DMS) in April 2018. The Project is located in Johnston County, NC, between the Community of Archer Lodge and the Town of Wendell at 35.73125˚, -78.35281˚. The Project site is located in the NCDEQ Sub-basin 03-04-06, in the Lower Buffalo Creek Priority Sub-watershed 030202011504.

The Project involved the restoration, enhancement, preservation and permanent protection of five stream reaches (R1, R2, R3, R4, and R5) and their riparian buffers, totaling 5,064 linear feet of existing streams and 633,803 square feet of riparian buffers (see buffer summary table below). WLS staff visited the site several times throughout 2022. Monitoring Year 5 (MY5) data collection activities occurred in March and September 2022 (Table 2). This report presents the data for MY5. The Project meets the MY5 success criteria for stream hydrology, streambed material condition and stability, and stream flow. All vegetation plots meet the required stems/acre, one plot does not meet the height criteria. Based on these results, the Project is expected to meet the Monitoring Year 6 (MY6) success criteria in 2023.

Table 2. Buffer Project Areas and Assets

RIPARIAN BUFFER (15A NCAC 02B.0295)

Location	Jurisdictional Streams	Restoration Type	Reach ID/Component	Buffer Width (ft)	Total Area (sf)	Creditable Area (sf)*	Initial Credit Ratio (x:1)	% Full Credit	Final Credit Ratio (x:1)	Riparian Buffer Credits	Convertible to Nutrient Offset (Yes or No)	If Converted to Nutrient Offset: Nutrient Offset: N (lbs)	If Converted to Nutrient Offset: Nutrient Offset: P (lbs)
Rural or Urban	Subject or Nonsubject	Restoration		20-29			1	75%	1.33333	0.000		-	0.000
Rural or Urban	Subject or Nonsubject	Restoration	Restoration	0-100	282,274	282,274	1	100%	1.00000	282,274.000	Yes	14,729.435	-
Rural or Urban	Subject or Nonsubject	Restoration		101-200			1	33%	3.03030	0.000		-	0.000
Rural or Urban	Subject or Nonsubject	Enhancement		20-29			2	75%	2.66667	0.000		-	0.000
Rural or Urban	Subject or Nonsubject	Enhancement	Cattle Exc. Enh	0-100	124,085	124,085	2	100%	2.00000	62,042.500	No	-	0.000
Rural or Urban	Subject or Nonsubject	Enhancement		101-200			2	33%	6.06061	0.000		-	0.000
					SUBTOTALS	**406,359**				**344,316.500**		**14,729.435**	**0.000**

			ELIGIBLE PRESERVATION AREA			**135,453**							
Location	**Jurisdictional Streams**	**Restoration Type**	**Reach ID/Component**	**Buffer Width (ft)**	**Total Area (sf)**	**Creditable Area (sf)***	**Initial Credit Ratio (x:1)**	**% Full Credit**	**Final Credit Ratio (x:1)**	**Riparian Buffer Credits**			
Rural	Subject	Preservation		20-29			10	75%	13.33333	0.000			
Rural	Subject	Preservation	Preservation	0-100	222,827	135,453	10	100%	10.00000	13,545.300			
Rural	Subject	Preservation		101-200			10	33%	30.30303	0.000			
Rural	Nonsubject	Preservation		20-29			5	75%	6.66667	0.000			
Rural	Nonsubject	Preservation		0-100			5	100%	5.00000	0.000			
Rural	Nonsubject	Preservation		101-200			5	33%	15.15152	0.000			
Urban	Subject or Nonsubject	Preservation		20-29			3	75%	4.00000	0.000			
Urban	Subject or Nonsubject	Preservation		0-100			3	100%	3.00000	0.000			
Urban	Subject or Nonsubject	Preservation		101-200			3	33%	9.09091	0.000			
					SUBTOTALS	**135,453**				**13,545.300**			
					TOTALS	**541,812**				**357,861.800**			

**Area eligible for preservation may be no more than 25% of total area, where total area is back-calculated with the equation R+E/0.75.*
**Buffers must be at minimum 20' wide for riparian buffer credit, buffers must be 50' wide for nutrient offset credit*
**When preservation areas exceed the total eligible preservation area, select the areas with the best credit ratios as the creditable areas.*
**Previous year total buffer credit was 362,631.200. After removing the area in the powerline right-of-way new total buffer credit is 357,861.800.*

2 Project Background

2.1 Project Location, Setting, and Existing Conditions

The Project site is located in the Upper Buffalo Creek Sub-watershed 030202011502 study area of the Neuse 01 Regional Watershed Plan, in the Wake-Johnston Collaborative Local Watershed Plan, and in Targeted Local Watershed 03020201180050.

The catchment area is 156 acres and has an impervious cover of approximately one percent. The dominant surrounding land uses are agriculture and mixed forest. Prior to construction, livestock had access to R3 and R4, and the riparian buffers were less than 50 feet wide on all reaches except R5.

2.2 Mitigation Project Goals and Objectives

WLS established project mitigation goals and objectives based on the resource condition and functional capacity of the watershed to improve and protect diverse aquatic resources comparable to stable headwater stream systems within the Piedmont Physiographic Province. The proposed mitigation types and design approaches described in the final approved mitigation plan considered the general restoration and resource protection goals and strategies outlined in the 2010 Neuse River Basin Restoration Priority Plan (RBRP). The functional goals and objectives were further defined in the 2013 Wake-Johnston Collaborative Local Watershed Plan and 2015 Neuse 01 Regional Watershed Plan and include:

- Reducing sediment and nutrient inputs to the upper Buffalo Creek Watershed,
- Restoring, preserving and protecting wetlands, streams, riparian buffers and aquatic habitat,
- Implementing agricultural BMPs and stream restoration in rural catchments together as "project clusters".

The following site-specific goals were developed to address the primary concerns outlined in the LWP and RWP and include:

Functional Category (Level)	Functional Goal / Parameter	Functional Design Objective
Hydrology (Level 1)	Improve Base Flow	Improve and/or remove existing stream crossings and restore a more natural flow regime and aquatic passage.
Hydraulics (Level 2)	Reconnect Floodplain / Increase Floodprone Area Widths	Lower BHRs from >2.0 to <1.2 and increase ERs at 2.2 or greater.
Geomorphology (Level 3)	Improve Bedform Diversity	Increase riffle/pool percentage and pool-to-pool spacing ratios.
	Increase Lateral Stability	Reduce BEHI/NBS streambank erosion rates comparable to downstream reference condition and stable cross-section values.
	Establish Riparian Buffer Vegetation	Plant native species vegetation a minimum 50' wide from the top of the streambanks with a composition/density comparable to downstream reference condition.
Physicochemical (Level 4)	Improve Water Quality	Remove cattle from riparian corridor and reduce fecal coliform bacteria levels.
Biology (Level 5)	Improve Macroinvertebrate Community and Aquatic Species Health	Incorporate native woody debris into channel

2.3 Project History, Contacts, and Timeframe

The chronology of the project history and activity is presented in Appendix A Table 2. Relevant project contact information is presented in Appendix A Table 3. Relevant project background information is presented in Appendix A Table 4

3 Project Mitigation Components

Refer to Appendix B Figure 1 and Appendix A Table 1 for the project components/asset information. A recorded conservation easement consisting of 15.95 acres protects and preserves all stream reaches, existing wetland areas, and riparian buffers in perpetuity.

3.1 Stream Mitigation Types and Approaches

Stream restoration practices involved raising the existing streambed and reconnecting the stream to the relic floodplain. Some portions of the existing degraded channels that were abandoned within the restoration areas were filled to decrease surface and subsurface drainage and raise the local water table. The project also included restoring, enhancing and protecting riparian buffers and riparian wetlands within the conservation easement. Permanent cattle exclusion fencing was provided around all restored reaches and riparian buffers, particularly along R3 and R4. The vegetative components of this project included stream bank, floodplain, and transitional upland zones planting. The Site was planted with native species riparian buffer vegetation and is now protected through a permanent conservation easement. Table 1 and Figure 1 (Appendix A) provide a summary of the project components.

3.1.1 R1 Enhancement Level II

Work along the R1 involved Enhancement Level II practices to improve the current channel condition and aquatic function. This area has been historically disturbed through agricultural practices and the channel exhibits limited morphology. Prior to construction, the existing channel experienced minimal bank erosion and channel incision throughout most of its length. WLS planted native woody species vegetation and restored the riparian buffer in excess of 50 feet within the conservation easement. Additionally, a 20-foot long culverted pipe crossing and the associated embankment was removed, and a water quality treatment feature was installed outside of the conservation easement to reduce direct sediment and nutrient inputs.

3.1.2 R2 Enhancement Level I

Work along R2 involved Enhancement Level I activities by slightly raising the bed elevation and excavating floodplain benches. In-stream structures were installed to dissipate flow energies and protect streambanks. In-stream structures included constructed riffles for grade control and aquatic habitat, and log weirs/jams for encouraging step-pool formation, bank stability, and bedform diversity. Bioengineering techniques such as geolifts and live stakes were also to protect streambanks and promote woody vegetation growth along the streambanks. A water quality treatment feature was installed outside the permanent conservation easement along the pond periphery to provide habitat diversity and capture fine sediment and nutrients coming from the active agricultural field areas across Wendell Road. Riparian buffers in excess of 50 feet were restored and protected along R2. Additionally, permanent fencing was installed to permanently exclude livestock and reduce sediment and nutrient inputs.

3.1.3 R3 Enhancement Level I

Enhancement activities along R3 involved a Priority Level II restoration approach by slightly raising the bed elevation along the upper section and providing an active floodplain area within the valley. In-stream structures, such as log vanes, log steps, and log jam riffles were used to dissipate flow energy, protect streambanks, and eliminate potential for future incision. Channel banks were graded to stable side slopes and bioengineering techniques such as geolifts and live stakes were also be used to protect streambanks and promote woody vegetation growth. Healthy mature trees or significant native vegetation were

protected and incorporated into the design and riparian buffers of at least 50 feet wide were established along the entire reach. Additionally, permanent fencing was installed along with alternative watering systems to exclude livestock and reduce direct sediment and nutrient inputs. The existing perched pipe culverts were removed, and a new culverted stream crossing was installed at a lower elevation to help improve flood flows and aquatic passage.

3.1.4 R4 Restoration

Work along R4 involved relocating the existing degraded channel towards the center of the valley and implementing a Priority Level I Restoration approach by raising the bed elevation and reconnecting the stream with its abandoned floodplain. This approach promotes more frequent over bank flooding in areas with hydric soils, thereby creating favorable conditions for wetland enhancement. The reach was restored as a Rosgen 'C5' stream type using appropriate riffle-pool morphology with a conservative meander planform geometry that accommodates the natural valley slope and width. This approach allowed restoration of a stable channel form with appropriate bedform diversity, as well as improved biological functions through increased aquatic and terrestrial habitats. In-stream structures were incorporated to control grade, dissipate flow energies, protect streambanks, and eliminate the potential for channel incision. In-stream structures included constructed wood riffles for grade control and habitat, log j-hook vanes, and log weirs/jams for encouraging step-pool formation energy dissipation, bank stability, and bedform diversity. Riparian buffers greater than 50 feet were restored and protected along the entire length of R4. Mature trees and significant native vegetation were protected and incorporated into the design. Additionally, shallow floodplain depressions were created to provide habitat diversity, temporary sediment storage and improved treatment of overland flows.

3.1.5 R5 Preservation

Preservation was implemented along this reach since the existing stream and wetland system is mostly stable with a mature riparian buffer due to minimal historic impacts. The preservation area is protected in perpetuity through a permanent conservation easement. This approach will extend the wildlife corridor from the project boundary throughout the entire riparian valley, while providing a hydrologic connection and critical habitat linkage within the catchment area.

4 Performance Standards

The applied success criteria for the Project will follow necessary performance standards and monitoring protocols presented in final approved mitigation plan. Annual monitoring and semi-annual site visits will be conducted to assess the condition of the project throughout the monitoring period. Monitoring activities will be conducted for a period of seven years with the final duration dependent upon performance trends toward achieving project goals and objectives. The following Proposed Monitoring Plan Summary from the approved final mitigation plan summarizes the measurement methods and performance standards. Specific success criteria components and evaluation methods follow.

Functional Category (Level)	Project Goal / Parameter	Measurement Method	Performance Standard	Potential Functional Uplift
Hydrology (Level 1)	Improve Base Flow Duration and Overbank Flows (i.e. channel forming discharge)	Well device (pressure transducer), regional curve, regression equations, catchment assessment	Maintain seasonal flow for a minimum of 30 consecutive days during normal annual rainfall.	Create a more natural and higher functioning headwater flow regime and provide aquatic passage.
Hydraulics (Level 2)	Reconnect Floodplain / Increase Floodprone Area Widths	Bank Height Ratio, Entrenchment Ratio, crest gauge	Maintain average BHRs at 1.2 and ERs at 2.2 or greater and document out of bank and/or geomorphically significant flow events.	Provide temporary water storage and reduce erosive forces (shear stress) in channel during larger flow events.
Geomorphology (Level 3)	Improve Bedform Diversity	Pool to Pool spacing, riffle-pool sequence, pool max depth ratio, Longitudinal Profile	Increase riffle/pool percentage and pool-to-pool spacing ratios compared to reference reach conditions.	Provide a more natural stream morphology, energy dissipation and aquatic habitat/refugia.
	Increase Vertical and Lateral Stability	BEHI / NBS, Cross-sections and Longitudinal Profile Surveys, visual assessment	Decrease streambank erosion rates comparable to reference condition cross-section, pattern and vertical profile values.	Reduce sedimentation, excessive aggradation, and embeddedness to allow for interstitial flow habitat.
	Establish Riparian Buffer Vegetation	CVS Level I & II Protocol Tree Veg Plots (Strata Composition and Density), visual assessment	Minimum of 320 stems per acre must be present at year three; a minimum of 260 stems per acre must be present at year five; and a minimum of 210 stems per acre must be present at year seven.	Increase woody and herbaceous vegetation will provide channel stability and reduce streambank erosion, runoff rates and exotic species vegetation.
Physicochemical (Level 4)	Improve Water Quality	N/A	N/A	Removal of excess nutrients, FC bacteria, and organic pollutants will increase the hyporheic exchange and dissolved oxygen (DO) levels.
Biology (Level 5)	Improve Benthic Macroinvertebrate Communities and Aquatic Health	DWR Small Stream/ Qual v4 sampling, IBI (MY7)	N/A	Increase leaf litter and organic matter critical to provide in-stream cover/shade, wood recruitment, and carbon sourcing.

Note: Level 4 and 5 project parameters and monitoring activities will not be tied to performance standards nor required to demonstrate success for credit release.

4.1 Streams

4.1.1 Stream Hydrology

Two separate bankfull events must be documented within the seven-year monitoring period. These two bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years. In addition to the two bankfull flow events, two geomorphically significant flow events ($Q_{gs}=0.66Q_2$) must also be documented during the monitoring

period. There are no temporal requirements regarding the distribution of the geomorphically significant flows.

4.1.2 Stream Profiles, Vertical Stability, and Floodplain Access

Stream profiles, as a measure of vertical stability will be evaluated by looking at Bank Height Ratios (BHR). The BHR shall not exceed 1.2 within riffles along the restored project reaches. This standard only applies to the restored project reaches where BHRs were corrected through design and construction. In addition, observed bedforms should be consistent with those observed for channels of the design stream type(s).

4.1.3 Stream Horizontal Stability

Cross-sections will be used to evaluate horizontal stream stability. There should be little change expected in as-built restoration cross-sections. If measurable changes do occur, they should be evaluated to determine if the changes represent a movement toward a more unstable condition (e.g., downcutting, erosion) or a movement towards increased stability (e.g., settling, vegetation establishment, deposition along the streambanks, decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen Stream Classification method and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

4.1.4 Streambed Material Condition and Stability

Pebble counts or streambed material samples will not be collected per the DMS Pebble Count Data Requirements memo sent on October 19, 2021. The IRT reserves the right to request pebble count data/particle distributions if deemed necessary during the monitoring period.

4.1.5 Jurisdictional Stream Flow

The restored stream systems must be classified as at least intermittent, and therefore must exhibit base flow with at least 30 days of continuous flow during a year with normal rainfall conditions as described in the approved mitigation plan.

4.2 Vegetation

Vegetative restoration success for the project during the intermediate monitoring years will be based on the survival of at least 320, three-year-old planted trees per acre at the end of Year 3 of the monitoring period and at least 260, five-year-old, planted trees per acre at the end of Year 5 of the monitoring period. The final vegetative restoration success criteria will be achieving a density of not less than 210, seven-year-old planted stems per acre in Year 7 of monitoring. Planted vegetation (for projects in coastal plain and piedmont counties) must average seven feet in height at Year 5 of monitoring and 10 feet in height at Year 7 of monitoring. Volunteer stems are only counted toward success if they are at least 18” tall, on the approved planting list, and surviving for at least 2 years. For all of the monitoring years (Year 1 through Year 7), the number of Red maple (*Acer rubrum*) stems cannot exceed 20 percent of the total stems in any of the vegetation monitoring plots.

5 Monitoring Year 5 Assessment and Results

Annual monitoring was conducted during MY5 in accordance with the monitoring plan as described in the approved mitigation plan to document site conditions. All monitoring device locations are depicted on the CCPV (Figure 1). MY5 monitoring results are provided in the appendices. The Project meets the MY5 success criteria for stream hydrology and jurisdictional stream flow. Visual surveys indicate that the

stream horizontal and vertical stability are meeting requirements. All vegetation plots meet the required success criteria of 260 stems/acre (Figure 1). One plot does not meet the height criteria.

5.1 Stream Hydrology

Monitoring to document the occurrence of the two required bankfull events (overbank flows) and the two required geomorphically significant flow events (Q_{gs}=0.66Q_2) within the monitoring period, along with floodplain access by flood flows, is being conducted using a crest gauge installed near the middle of Reach R3 (Figure 1) to record the watermark associated with the highest flood stage between monitoring site visits. Photographs are also being used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits. At least one bankfull event occurred during MY5 (see table below). These events were documented using the described crest gauge and photography (Appendix E Table 8). The documented occurrence of previous flow events satisfies the requirement of the occurrence of four bankfull events (overbank flows) in at least two separate years.

Monitoring Year	Documented Bankfull Events	Requirement Met
1	2	No
2	1	No
3	2	Yes
4	2	Yes
5	1	Yes

5.2 Stream Horizontal & Vertical Stability

Visual assessment and monitoring of eight permanent cross sections were utilized for assessment of MY5 horizontal and vertical stream stability. The visual assessments for each stream reach concluded that the MY5 stream channel pattern and longitudinal profiles, instream structure locations, still closely match the profile design parameters and MY0/baseline conditions. (Appendix D). The MY5 plan form geometry or pattern still appears to fall within acceptable ranges of the design parameters for all restored reaches. Only minor channel adjustments in riffle slopes, pool depths and pattern were observed and therefore did not present a stability concern or indicate a need for remedial action. Maximum riffle depths are expected to fluctuate slightly throughout the monitoring period as the channels adjust to the new flow regime. It is expected over time that some pools may accumulate fine sediment and organic matter, however, this may not be an indicator of channel instability.

5.4 Jurisdictional Stream Flow Documentation

Jurisdictional stream flow documentation and monitoring of restored intermittent reaches is achieved using a flow gauge (pressure transducer) within the thalweg of the channel towards the middle portion of enhanced Reach R1 (Figure 1). Additionally, to determine if rainfall amounts are normal for the given year, precipitation data was obtained from CLAY Central Crops Research Station in Johnston County, approximately nine miles southwest of the site. The flow gauge documented that the stream exhibited surface flow for 61 consecutive days from January 1st to March 2nd, 2022 (see Figure 3).

5.5 Vegetation

Vegetation monitoring for MY5 was conducted utilizing the seven vegetation monitoring plots, with monitoring conducted in accordance with the CVS-EEP Level I & II Monitoring Protocol (CVS, 2008) and DMS Stream and Wetland Monitoring Guidelines (DMS, 2017). See Figure 1 in Appendix B for the vegetation monitoring plot locations. Summary data and photographs of each plot can be found in Appendix B and C.

The seven vegetation plots met the required success criteria at year 5 of 260 stems per acre. The vegetation plots had a range of 324 to 849 stems per acre (including appropriate volunteers). All plots except plot 1 meet the average height requirement of seven feet. Plot 1 has an average stem height of 6.7 feet. The percentage of red maple stems did not exceed 20 percent in any vegetation plot.

The MY5 vegetation monitoring was also conducted utilizing visual assessment throughout the easement. A small encroachment area (VPA1) of approximately 0.05 acres was found along R1 left floodplain during a spring MY4 site visit. No trees were damaged due to mowing, only herbaceous vegetation. During MY5, encroachment in this area has stopped. Three additional encroachments were discovered during MY5. VPA2 (0.006 acres) and VPA3 (0.012 acres) are small encroachments due to mowing along the farm field of the right floodplain of R1. VPA4 (0.003 acres) is a small encroachment caused by mowing along the driveway adjacent to the easement near R2. All encroachments have been marked with additional t-posts and horse tape. These areas will be monitored closely in MY6 to ensure encroachments have ceased.

An area along R1 with dense pine volunteers was identified during MY5 (0.58 acres). During MY6, pine will be thinned to allow desirable volunteer and planted species to further establish. Pine will be thinned by hand. The results of the visual assessment did not indicate any additional significant negative changes to the existing vegetation community.

5.6 Wetlands

Wetland mitigation credits are not contracted or proposed for this project and no performance standards for wetland hydrology success were proposed in the Mitigation Plan. One groundwater monitoring well was installed during the baseline monitoring along Reach R4 (wetland gauge 2). Two additional groundwater monitoring wells, including an additional one along Reach R4 (wetland gauge 1) and an additional one along Reach R5 (wetland gauge 3) (reference), were installed after the first year of monitoring in March of 2019. All groundwater monitoring wells are pressure transducers. The wells were installed to document groundwater levels within restoration area and for reference and comparison to the preservation areas, at the request of the NCIRT (DWR). Data for the gauges can be found in Appendix E. Wetland gauges 1 and 2 are exhibiting an 8.37 percent and 13.22 percent max hydroperiod for the MY5 growing season. This is greater than the 2.20 percent max hydroperiod documented in the reference wetland. A gauge malfunction resulted in the loss of data for wetland gauge 2 from August 19th, 2022, to September 12th, 2022. The malfunctioning gauge will be repaired in winter 2022.

6 References

Doll, B.A., Grabow, G.L., Hall, K.A., Halley, J., Harman, W.A., Jennings, G.D., and Wise, D.E. 2003. Stream Restoration A Natural Channel Design Handbook.

Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

KCI Associates of NC, DMS. 2010. Using Pressure Transducers for Stream Restoration Design and Monitoring.

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

North Carolina Department of Environmental Quality, Division of Mitigation Services, Wildlands Engineering, Inc. 2015. Neuse 01 Regional Watershed Plan Phase II. Raleigh, NC.

North Carolina Department of Environmental Quality, Division of Mitigation Services, 2017. Annual Monitoring Report Format, Data and Content Requirement. Raleigh, NC.

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

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

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. North Carolina Natural Heritage Program. NCDENR Division of Parks and Recreation. Raleigh, NC.

United States Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. Environmental Laboratory. US Army Engineer Waterways Experiment Station. Vicksburg, MS.

___. 1997. Corps of Engineers Wetlands Research Program. Technical Note VN-RS-4.1. Environmental Laboratory. U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

___. 2003. Stream Mitigation Guidelines, April 2003, U.S. Army Corps of Engineers. Wilmington District.

Water and Land Solutions, LLC (2017). Pen Dell Mitigation Project Final Mitigation Plan. NCDMS, Raleigh, NC.

Appendix A:
Background Tables and Figures

Table 1. Mitigation Assets and Components
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)

Project Component (reach ID, etc.)[1]	Wetland Position and HydroType[2]	Existing Footage or Acreage	Stationing	Mitigation Plan Footage or Acreage	As-Built Footage or Acreage	Restoration Level	Approach Priority Level	Mitigation Ratio (X:1)	Mitigation Credits *	Notes/Comments
R1	--	1017	10+00 -20+17	1017	1017	EII	EII	2.5	407	Constucted Riffle Above Road Crossing, Planted Buffer, Permanent Conservation Easement
R2	--	546	20+77 - 26+25	526	546	EI	EI	1.5	351	Planted Buffer, Exclusion of Livestock, Permanent Conservation Easement.
R3	--	617	30+93 - 37+00	617	601	EI	EI	1.5	411	Channel Enhancement, Floodplain Grading, Planted Buffer, Exclusion of Livestock, Permanent Conservation Easement.
R4	--	1846	37+00 - 54+87	1779**	1724	R	R	1	1744	Full Channel Restoration, Planted Buffer, Exclusion of Livestock, Permanent Conservation Easement.
R5	--	1176	56+26 - 68+02	1176	1176	P	P	10	118	Invasive Control, Permanent Conservation Easement.

Length and Area Summations by Mitigation Category

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)
		Riverine	Non-Riverine	
Restoration	1779**			
Enhancement				
Enhancement I	1143			
Enhancement II	1017			
Creation				
Preservation	1176			
High Quality Pres				

Overall Assets Summary

Asset Category	Overall Credits*
Stream	**3,030.400**
RP Wetland	
NR Wetland	

* Mitigation Credits are from approved Mitigation Plan, as verified by the as-built survey.
**Credits on R4 reduced by 35' for powerline ROW realized at As-Built

Table 2. Project Activity and Reporting History
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)

Elapsed Time Since grading complete:	**4 yrs 6 months**
Elapsed Time Since planting complete:	**4 yrs 6 months**
Number of reporting Years[0]:	**5**

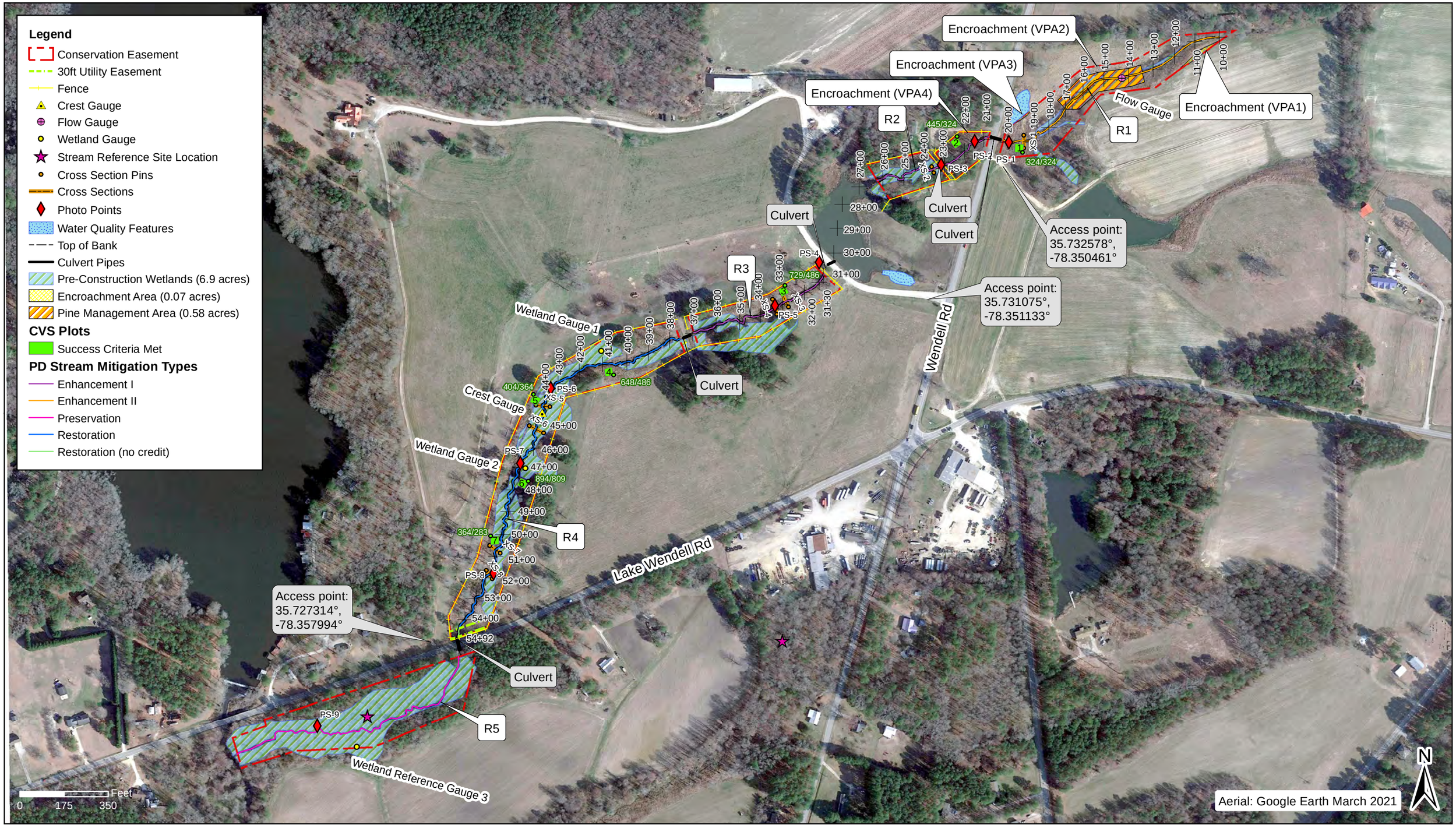
Activity or Deliverable	Data Collection Complete	Completion or Delivery
Project Contract Execution	N/A	3/18/2016
Final Mitigation Plan Submittal	N/A	9/29/2017
Section 404 General (Regional and Nationwide) Permit Verfication	N/A	1/12/2018
Begin Construction	N/A	1/29/2018
Mitigation Site Earthwork Completed	N/A	4/1/2018
Mitigation Site Planting Completed	N/A	4/6/2018
Installation of Monitoring Devices Completed	N/A	4/19/2018
Installation of Survey Monumentation and Boundary Marking	N/A	6/7/2018
As-built/Baseline (Year 0) Monitoring Report Submittal	6/23/2018	12/3/2018
Year 1 Monitoring Report Submittal	11/24/2018	12/4/2019
Year 2 Monitoring Report Submittal	10/18/2019	12/31/2019
Year 3 Monitoring Report Submittal	10/14/2020	12/11/2020
Encroachment Documented (VPA1)	3/17/2021	N/A
Year 4 Monitoring Report Submittal	9/14/2021	10/20/2021
Enroachment Documented (VPA2, VPA3, VPA4)	11/22/2022	N/A
Year 5 Monitoring Report Submittal	9/12/2022	11/30/2022
Year 6 Monitoring Report Submittal	N/A	N/A
Year 7 Monitoring Report Submittal	N/A	N/A

Table 3. Project Contacts Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)	
Mitigation Provider	Water & Land Solutions, LLC
	7721 Six Forks Road, Suite 130, Raleigh, NC 27615
Primary Project POC	Catherine Manner Phone: 571-643-3165
Construction Contractor	RiverWorks Construction
	114 W. Main Street, Suite 106, Clayton, NC 27520
Primary Project POC	Bill Wright Phone: 919-590-5193
Survey Contractor (Existing Condition Surveys)	WithersRavenel
	115 MacKenan Drive, Cary, NC 27511
Primary Project POC	Marshall Wight, PLS Phone: 919-469-3340
Survey Contractor (Conservation Easement, Construction and As-Builts Surveys)	True Line Surveying, PC
	205 West Main Street, Clayton, NC 27520
Primary Project POC	Curk T. Lane, PLS 919-359-0427
Planting Contractor	RiverWorks Construction
	114 W. Main Street, Suite 106, Clayton, NC 27520
Primary Project POC	Bill Wright Phone: 919-590-5193
Seeding Contractor	RiverWorks Construction
	114 W. Main Street, Suite 106, Clayton, NC 27520
Primary Project POC	Bill Wright Phone: 919-590-5193
Seed Mix Sources	Green Resource
	5204 Highgreen Ct., Colfax, NC 27235
	Rodney Montgomery Phone: 336-215-3458
Nursery Stock Suppliers	Foggy Mountain Nursery (Live Stakes) 797 Helton Creek Rd, Lansing, NC 28643 Glenn Sullivan Phone: 336-977-2958
	Dykes & Son Nursery (Bare Root Stock) 825 Maude Etter Rd, Mcminnville, Tn 37110 Jeff Dykes Phone: 931-668-8833
Monitoring Performers	Water & Land Solutions, LLC
	7721 Six Forks Road, Suite 130, Raleigh, NC 27615
Stream Monitoring POC	Emily Dunnigan Phone: 269-908-6306
Vegetation Monitoring POC	Emily Dunnigan Phone: 269-908-6306

Table 4. Project Information and Attributes					
Project Name	Pen Dell Mitigation Project				
County	Johnston				
Project Area (acres)	16.1				
Project Coordinates (latitude and longitude)	35.7303778 N, -78.3557472 W				
Planted Acreage (Acres of Woody Stems Planted)	8.74				
Project Watershed Summary Information					
Physiographic Province	Piedmont				
River Basin	Neuse				
USGS Hydrologic Unit 8-digit	03020201				
DWR Sub-basin	30406				
Project Drainage Area (Acres and Square Miles)	156 acres, 0.24 sq mi				
Project Drainage Area Percentage of Impervious Area	<1%				
CGIA Land Use Classification	2.01.03, 2.99.05, 413, 4.98 (39% crops/hay, 31% pasture, 24% mixed forest, 2% open water/pond)				
Reach Summary Information					
Parameters	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Length of reach (linear feet)	1017	546	617	1846	1176
Valley confinement (Confined, moderately confined, unconfined)	unconfined	mod. confined	unconfined	unconfined	unconfined
Drainage area (Acres and Square Miles)	63 acres, 0.1 sq mi	73 acres, 0.11 sq mi	105 acres, 0.16 sq mi	134 acres, 0.21 sq mi	156 acres, 0.24 sq mi
Perennial, Intermittent, Ephemeral	Intermittent	Perennial/Intermittent	Perennial	Perennial	Perennial
NCDWR Water Quality Classification	C; NSW	C; NSW	C;NSW	C; NSW	C; NSW
Stream Classification (existing)	G5c	E5(incised)	E5(incised)	E5(incised), F5	E5
Stream Classification (proposed)	C5b	C5	C5	C5	E5
Evolutionary trend (Simon)	I	II	III/IV	III/IV	I
FEMA classification	N/A	N/A	N/A	N/A	Zone AE
Wetland Summary Information					
Parameters	**Wetland 1**	**Wetland 2**	**Wetland 3**		
Size of Wetland (acres)	N/A	N/A	N/A		
Wetland Type (non-riparian, riparian riverine or riparian non-riverine)					
Mapped Soil Series					
Drainage class					
Soil Hydric Status					
Source of Hydrology					
Restoration or enhancement method (hydrologic, vegetative etc.)					
Regulatory Considerations					
Parameters	**Applicable?**	**Resolved?**	**Supporting Docs?**		
Water of the United States - Section 404	Yes	Yes	Categorical Exclusion		
Water of the United States - Section 401	Yes	Yes	Categorical Exclusion		
Endangered Species Act	No	Yes	Categorical Exclusion		
Historic Preservation Act	No	N/A	Categorical Exclusion		
Coastal Zone Management Act (CZMA or CAMA)	No	N/A	Categorical Exclusion		
FEMA Floodplain Compliance	Yes	Yes	Categorical Exclusion		
Essential Fisheries Habitat	No	N/A	Categorical Exclusion		

Appendix B:
Visual Assessment Data

Figure 1: Current Condition Plan View (CCPV)
Table 5a-e: Visual Stream Morphology Stability Assessment
Table 5f: Vegetation Condition Assessment
Stream Station Photographs
Vegetation Plot Photographs
Vegetation Problem Area Photographs



WATER & LAND™ SOLUTIONS	NC Mitigation Services ENVIRONMENTAL QUALITY	**Pen Dell Mitigation Project** **Johnston County, North Carolina**	NCDMS Contract No. 6824 NCDMS Project No. 97079 November 2022 MY5	USACE Current Conditions Plan View Monitoring Year 5 NAD 1983 2011 State Plane North Carolina FIPS 3200 FT US	FIGURE 1

Table 5a	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R1
Assessed Length	1,017

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.	1	1			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	0	0			#DIV/0!			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	0	0			#DIV/0!			
	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)	0	0			#DIV/0!			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			#DIV/0!			

Table 5b	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R2
Assessed Length	546

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.	6	6			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	1	1			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			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)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

Table 5c	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R3
Assessed Length	601

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.	12	12			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)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

Table 5d	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R4
Assessed Length	1,724

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.	52	52			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	6	6			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	15	15			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)	17	17			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	17	17			100%			

Table 5e	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R5
Assessed Length	1,176

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.	0	0			#DIV/0!			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	0	0			#DIV/0!			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	0	0			#DIV/0!			
	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)	0	0			#DIV/0!			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			#DIV/0!			

Table 5f Project Planted Acreage[1]	Vegetation Condition Assessment Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079) 10.1					
Vegetation Category	**Definitions**	**Mapping Threshold**	**CCPV Depiction**	**Number of Polygons**	**Combined Acreage**	**% of Planted Acreage**
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.01 acres	Pattern and Color	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	Pattern and Color	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	Pattern and Color	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage[2]	**15.95**					
Vegetation Category	**Definitions**	**Mapping Threshold**	**CCPV Depiction**	**Number of Polygons**	**Combined Acreage**	**% of Easement Acreage**
4. Invasive Areas of Concern[4]	Areas or points (if too small to render as polygons at map scale).	1000 SF	Pattern and Color	0	0.00	0.0%
5. Easement Encroachment Areas[3]	Areas or points (if too small to render as polygons at map scale).	none	yellow hatch	4	0.07	0.7%

PS-1, R1, facing upstream, Sta 20+00, March 29, 2018 (MY-00)

PS-1, R1, facing upstream, Sta 20+00, March 30, 2022 (MY-05)

PS-2, R2, facing downstream, Sta 21+50, April 27, 2018 (MY-00)

PS-2, R2, facing downstream, Sta 21+50, March 30, 2022 (MY-05)

PS-3, R2, facing upstream at crossing, Sta 23+00, April 27, 2018 (MY-00)

PS-3, R2, facing upstream at crossing, Sta 23+00, March 30, 2022 (MY-05)

PS-4, R3, facing downstream, Sta 31+00, April 27, 2018 (MY-00)

PS-4, R3, facing downstream, Sta 31+00, March 30, 2022 (MY-05)

PS-5, R3, facing upstream, Sta 34+00, April 27, 2018 (MY-00)

PS-5, R3, facing downstream, Sta 34+00, March 30, 2022 (MY-05)

PS-6, R4, facing upstream, Sta 43+50, April 27, 2018 (MY-00)

PS-6, R4, facing upstream, Sta 43+50, March 30, 2022 (MY-05)

PS-7, R4, facing upstream, Sta 47+00, April 27, 2018 (MY-00)

PS-7, R4, facing upstream, Sta 47+00, March 30, 2022 (MY-05)

PS-8, R4, facing upstream, Sta 52+00, April 27, 2018 (MY-00)

PS-8, R4, facing upstream, Sta 52+00, March 30, 2022 (MY-05)

PS-9, R5, facing upstream, near Sta 62+00, Sept 1, 2015, 2018 (MY-00)

PS-9, R5, facing upstream, Sta 62+00, March 30, 2022 (MY-05)

Veg Plot 1, April 12, 2018 (MY-00)

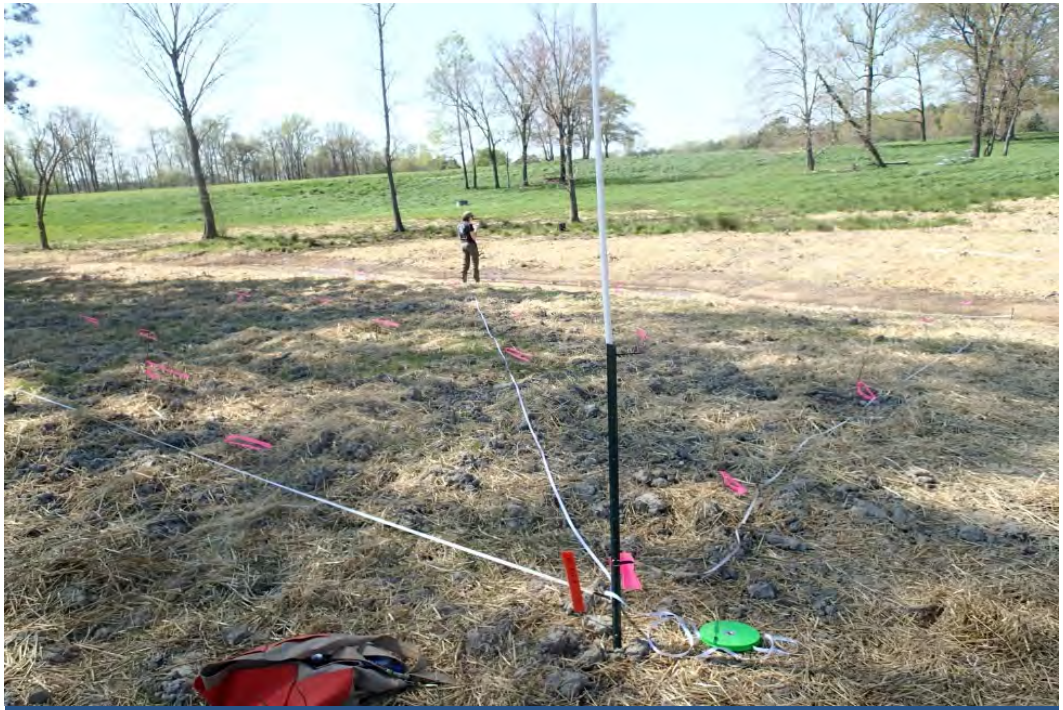
Veg Plot 1, September 13, 2022 (MY-05)

Veg Plot 2, April 12, 2018 (MY-00)

Veg Plot 2, September 13, 2022 (MY-05)

Veg Plot 3, April 12, 2018 (MY-00)

Veg Plot 3, September 13, 2022 (MY-05)

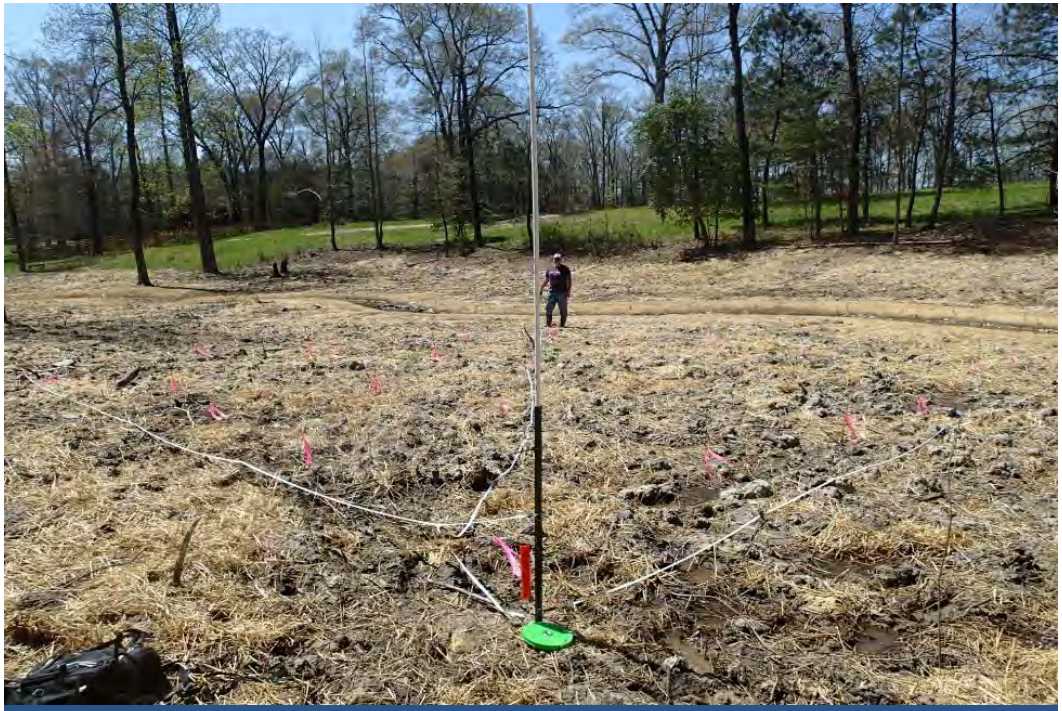


Veg Plot 4, April 12, 2018 (MY-00)

Veg Plot 4, September 13, 2022 (MY-05)

Veg Plot 5, April 12, 2018 (MY-00)

Veg Plot 5, September 13, 2022 (MY-05)



Veg Plot 6, April 12, 2018 (MY-00)

Veg Plot 6, September 13, 2022 (MY-05)

Veg Plot 7, April 12, 2018 (MY-00)

Veg Plot 7, September 13, 2022 (MY-05)

Encroachment (VPA1), R1 Left Floodplain, March 17, 2021 (MY-04)

Encroachment (VPA1), R1 Left Floodplain, September 13, 2022 (MY-05)

Encroachment (VPA1) R1 Left Floodplain, September 14, 2021 (MY-04)

Encroachment (VPA1), R1 Left Floodplain, September 13, 2022 (MY-05)

Encroachment (VPA2), R1 Right Floodplain (MY-05)

Encroachment (VPA2), R1 Right Floodplain (MY-05)

Encroachment (VPA3) R1 Right Floodplain (MY-05)

Encroachment (VPA3), R1 Right Floodplain (MY-05)

Encroachment (VPA4), R2 adjacent driveway, (MY-05)

Encroachment (VPA4), R2 adjacent driveway, (MY-05)

Appendix C:
Vegetation Plot Data

Table 6: Planted and Total Stem Counts
Table 6a: Vegetation Plot Mitigation Success Summary

Table 6: Planted and Total Stem Counts
Pen Dell

			Current Plot Data (MY5 2022)																					Annual Means																	
			002-01-0001			002-01-0002			002-01-0003			002-01-0004			002-01-0005			002-01-0006			002-01-0007			MY5 (2022)			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	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer rubrum		Tree	1	1	1			2			3	1	1	3	1	1	1	1	1	1			1	4	4	12	3	3	38	3	3	30	3	3	14	4	4	122	3	3	3
Alnus serrulata	Tag Alder, Smooth Alde	Shrub Tree	1	1	1				1	1	1							1	1	1				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Baccharis halimifolia	Silverling, High-tide Bu	Shrub Tree						1												2						3			2												
Betula nigra	River Birch, Red Birch	Tree	3	3	3				1	1	4	2	2	4	1	1	1	3	3	3				10	10	15	9	9	9	9	9	9	9	9	9	11	11	11	14	14	14
Carpinus caroliniana		Shrub Tree							1	1	1				1	1	1	3	3	3				5	5	5	5	5	5	5	5	5	5	5	5	9	9	10	10	10	10
Carya	Hickory	Tree																																				1				
Cornus amomum	Silky Dogwood	Shrub Tree							2	2	2										1	1	1	3	3	3	3	3	4	3	3	3	4	4	4	6	6	6	6	6	6
Diospyros virginiana	American Persimmon,	Tree																1	1	1				1	1	1				1	1	1	1	1	1	2	2	2	2	2	2
Fraxinus pennsylvanica	Green Ash, Red Ash	Tree	1	1	1				1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Ilex verticillata	Winterberry	Shrub Tree				3	3	3																3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Lindera benzoin	Northern Spicebush	Shrub Tree																												1	1	1	2	2	2	3	3	3	13	13	13
Liquidambar styraciflua	Sweet Gum, Red Gum	Tree			2			2			4			2												10			10			14			5			3			
Liriodendron tulipifera		Tree				2	2	3																2	2	3	1	1	5	2	2	6	2	2	2	5	5	5	13	13	13
Magnolia virginiana		Shrub Tree				1	1	1	1	1	1	2	2	2							2	2	2	6	6	6	7	7	7	7	7	7	6	6	6	8	8	8	14	14	14
Pinus taeda	Loblolly Pine, Old Field	Tree									3			4												7			1												
Platanus occidentalis	Sycamore, Plane-tree	Tree							2	2	2				4	4	5	4	4	4	1	1	1	11	11	12	11	11	11	11	11	11	11	11	11	14	14	14	14	14	14
Populus deltoides		Tree																																				1				
Quercus michauxii	Basket Oak, Swamp Ch	Tree	2	2	2				3	3	3	2	2	2				3	3	3				10	10	10	10	10	10	10	10	10	9	9	9	11	11	11	9	9	9
Quercus nigra	Water Oak, Paddle Oak	Tree										2	2	2				1	1	2				3	3	4	4	4	4	4	4	5	4	4	4	3	3	3	9	9	9
Quercus phellos	Willow Oak	Tree				2	2	2				1	1	1				1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	6	6	6	8	8	8	8	8	8
Rhus copallinum		Shrub Tree												3						3						6			6									3			
Rosa carolina		Shrub Vine																											1												
Rosa palustris	Swamp Rose	Shrub Vine																																	4			39			
Salix nigra	Black Willow	Tree															2			4			7			13			3						1			7			
Salix sericea	Silky Willow	Shrub Tree																														2									
Sambucus canadensis	Common Elderberry	Shrub Tree																																	5			3			
Ulmus alata	Winged Elm	Tree						3																		3			1			4									
Ulmus rubra	Slippery Elm, Red Elm	Tree																																	2			3			
Viburnum nudum	Southern Wild Raisin, F	Shrub Tree																																					1	1	1
	Stem count		8	8	10	8	8	17	12	12	25	12	12	25	9	9	12	20	20	30	7	7	15	76	76	134	74	74	138	77	77	129	78	78	106	100	100	279	132	132	132
	size (ares)		1			1			1			1			1			1			1			7			7			7			7			7					
	size (ACRES)		0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.17			0.17			0.17			0.17			0.17					
	Species count		5	5	6	4	4	8	8	8	11	7	7	10	5	5	6	10	10	13	5	5	7	14	14	20	13	13	20	15	15	18	15	15	20	15	15	23	16	16	16
	Stems per ACRE		324	324	405	324	324	688	486	486	1012	486	486	1012	364	364	486	809	809	1214	283	283	607	439	439	775	428	428	798	445	445	746	451	451	613	578	578	1613	763	763	763

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%

Table 6a: Vegetation Plot Mitigation Success Summary Table							
Plot #	Planted Stems/Acre	Volunteers/ Acre	Total Stems/Acre	Stems/Acre Success Criteria Met	Average Stem Height (ft)	Height Success Criteria Met	Percent Red Maple
1	324	0	324	Yes	6.7	No	13%
2	324	121	445	Yes	8.3	Yes	18%
3	486	243	729	Yes	11.3	Yes	17%
4	486	162	648	Yes	11.1	Yes	13%
5	364	40	404	Yes	17.2	Yes	10%
6	809	40	849	Yes	8.9	Yes	5%
7	283	40	324	Yes	11.3	Yes	13%
Project Average	439	92	532	Yes	10.7	Yes	12%

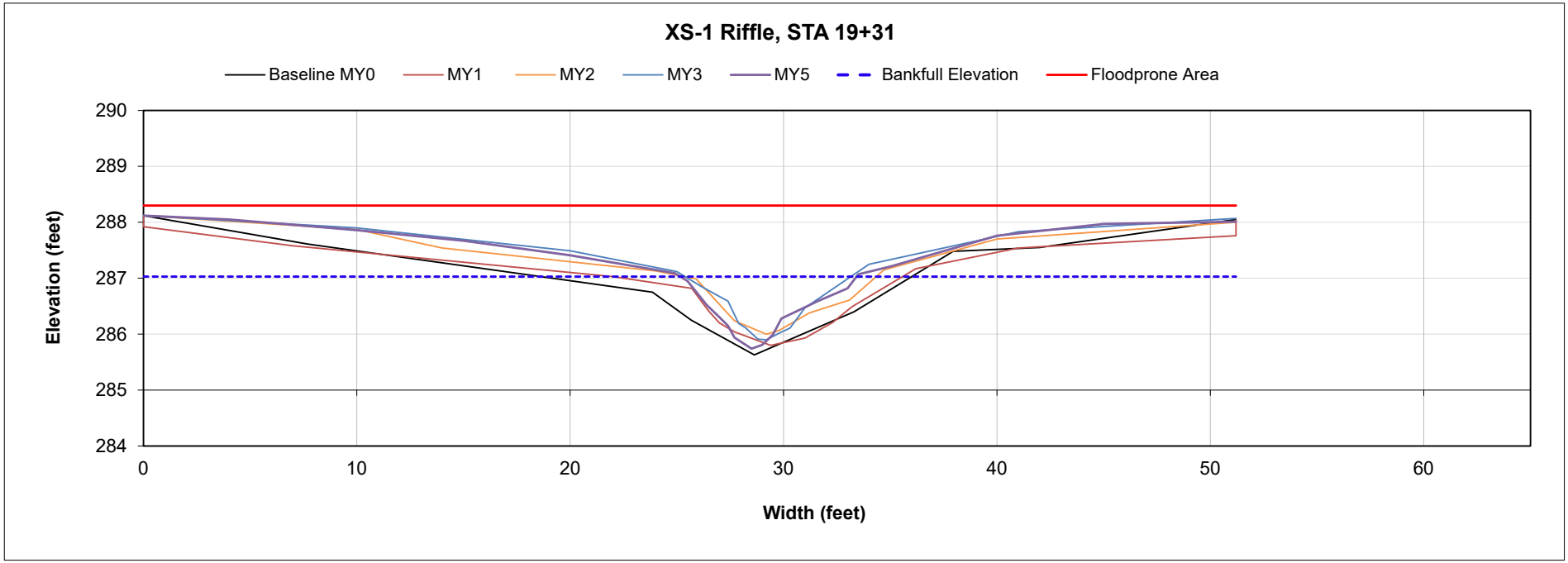
Appendix D:
Stream Measurement and Geomorphology Data

Figure 2: MY5 Cross-Sections
Table 7a: Baseline Stream Data Summary
Table 7b: Cross-section Morphology Data
Table 7c: Stream Reach Morphology Data

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R2
Cross Section ID	XS-1
Field Crew	K. Obermiller, C. Durham

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	287.0
Low Bank Height Elevation (ft)	287.1
Bankfull Max Depth (ft)	1.3
Low Bank Height (ft)	1.3
Bank Height Ratio	1.03
Bankfull X-section Area (ft²)	5.3
% Change Bank Height Ratio	3.0%

Looking Downstream



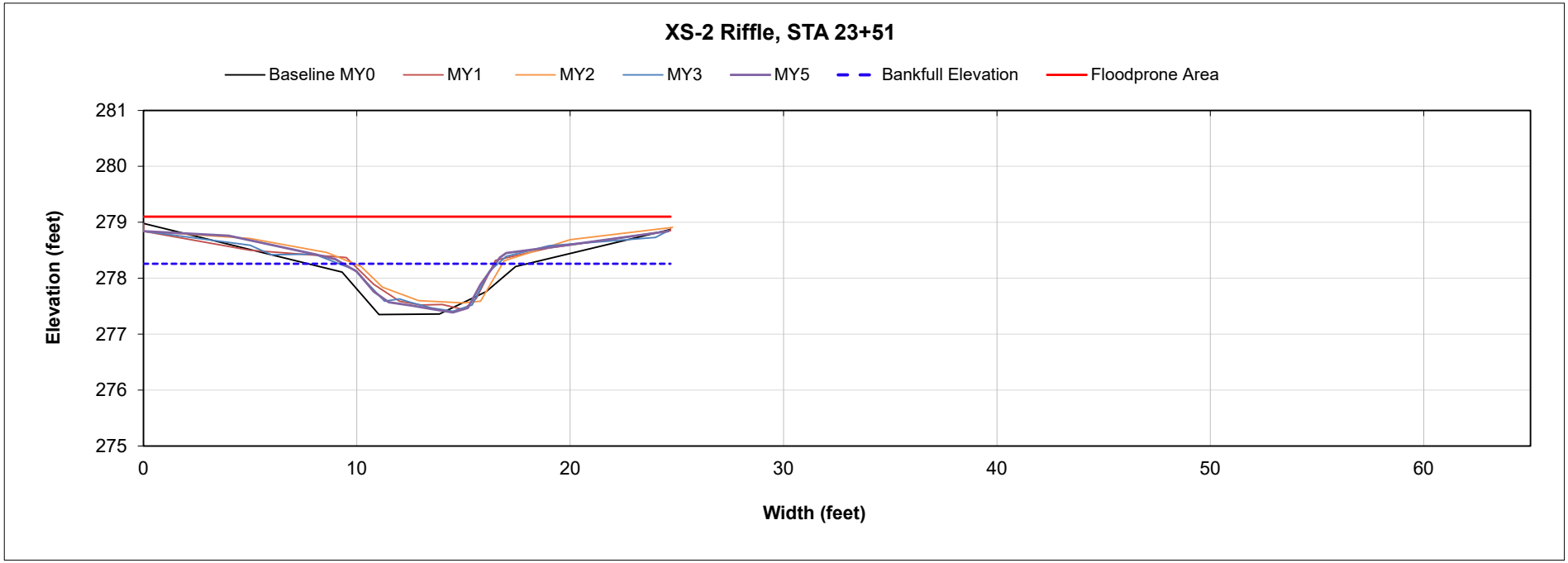
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R2
Cross Section ID	XS-2
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	278.3
Low Bank Height Elevation (ft)	278.3
Bankfull Max Depth (ft)	0.9
Low Bank Height (ft)	0.9
Bank Height Ratio	1.09
Bankfull X-section Area (ft²)	4.1
% Change Bank Height Ratio	9.0%

Looking Downstream



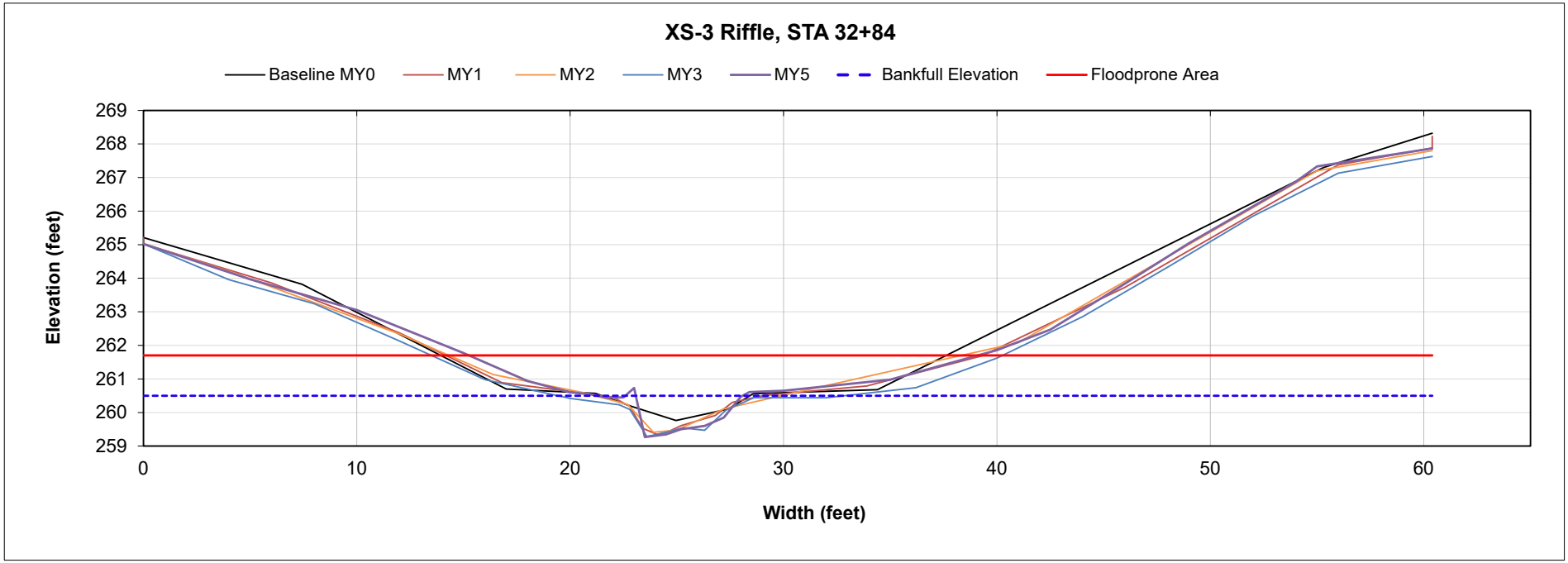
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R3
Cross Section ID	XS-3
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	260.5
Low Bank Height Elevation (ft)	260.4
Bankfull Max Depth (ft)	1.2
Low Bank Height (ft)	1.2
Bank Height Ratio	0.95
Bankfull X-section Area (ft²)	4.3
% Change Bank Height Ratio	5.0%

Looking Downstream



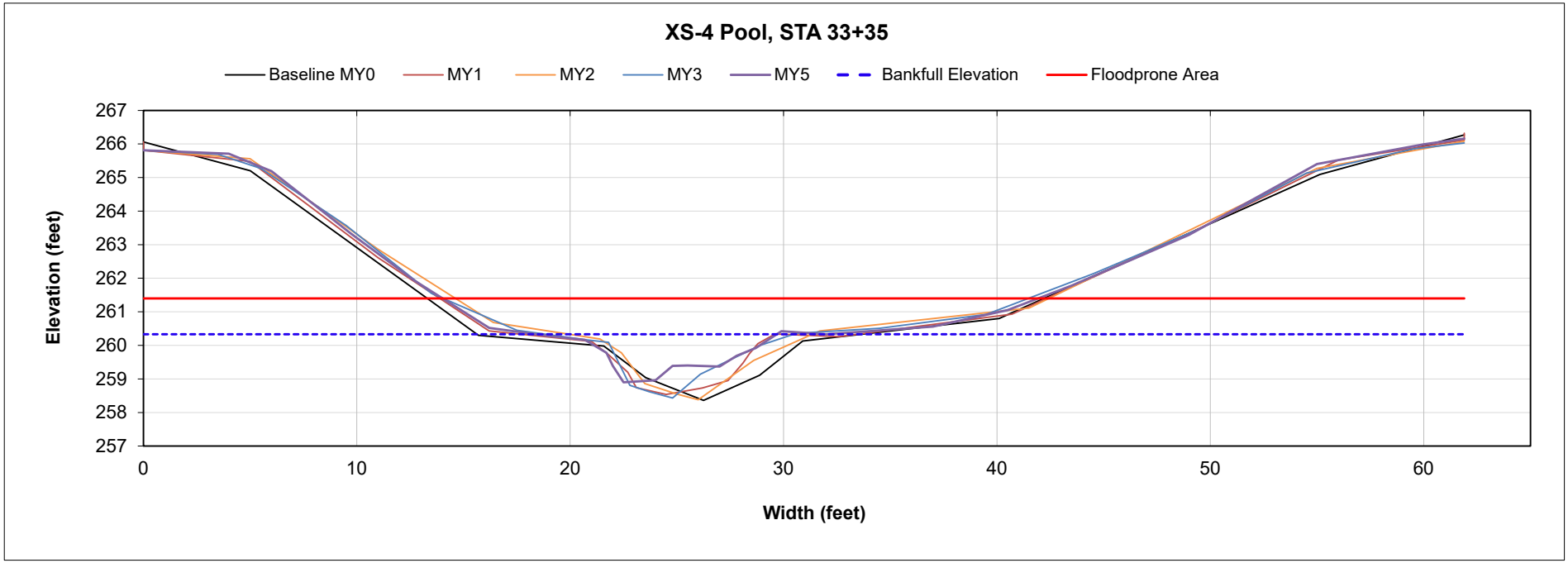
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R3
Cross Section ID	XS-4
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	260.3
Low Bank Height Elevation (ft)	260.3
Bankfull Max Depth (ft)	1.4
Low Bank Height (ft)	1.4
Bank Height Ratio	N/A
Bankfull X-section Area (ft²)	7.8
% Change Bank Height Ratio	N/A

Looking Downstream



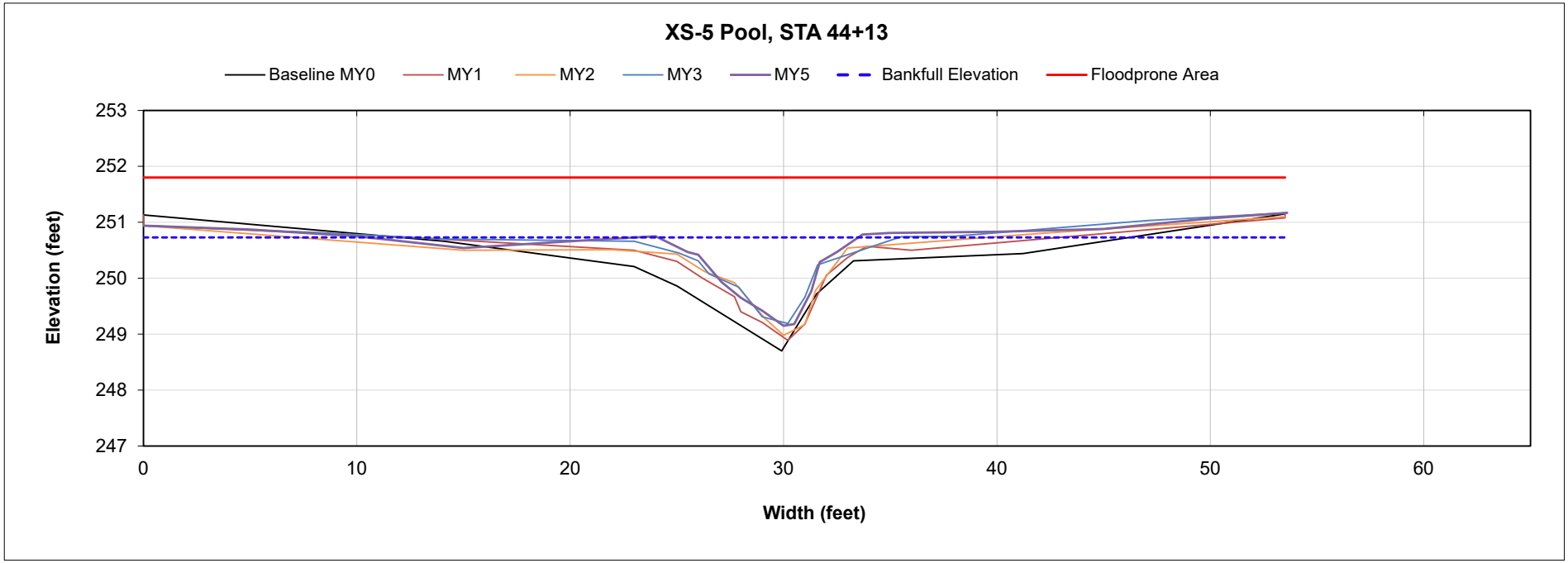
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R4
Cross Section ID	XS-5
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	250.7
Low Bank Height Elevation (ft)	250.7
Bankfull Max Depth (ft)	1.6
Low Bank Height (ft)	1.6
Bank Height Ratio	N/A
Bankfull X-section Area (ft²)	6.9
% Change Bank Height Ratio	N/A

Looking Downstream



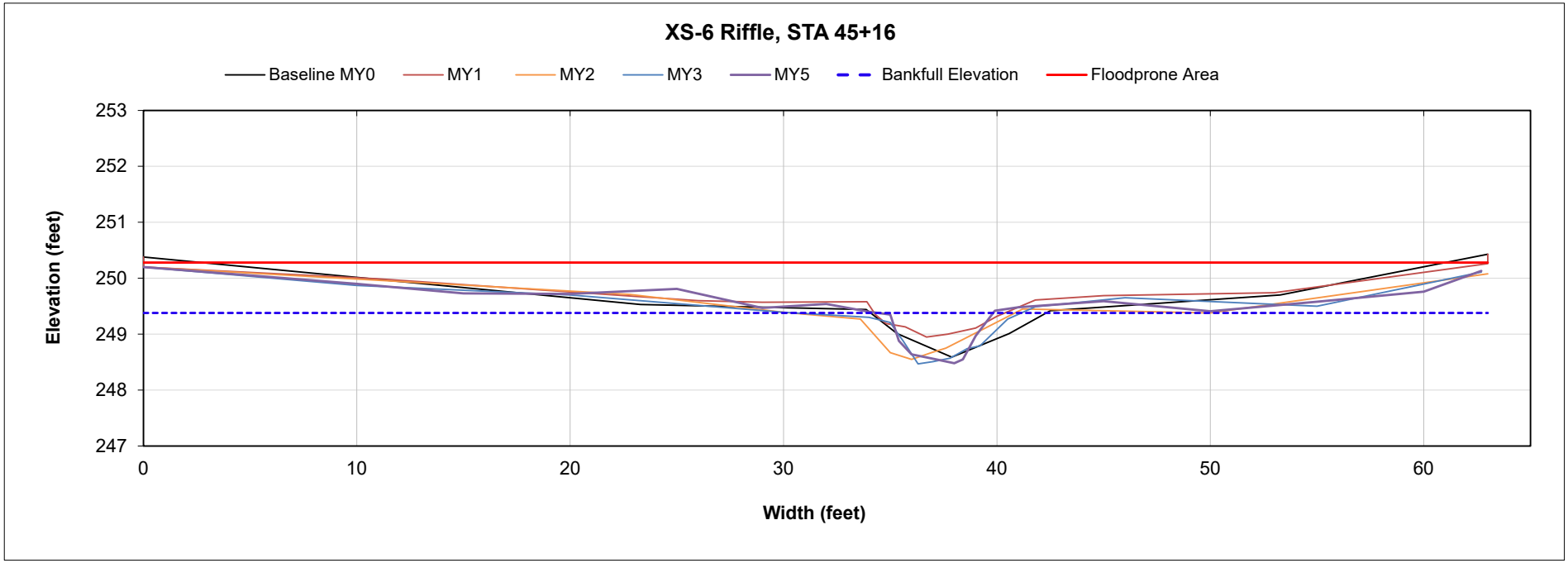
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R4
Cross Section ID	XS-6
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	249.4
Low Bank Height Elevation (ft)	249.4
Bankfull Max Depth (ft)	0.9
Low Bank Height (ft)	0.9
Bank Height Ratio	1.02
Bankfull X-section Area (ft²)	3.0
% Change Bank Height Ratio	2.0%

Looking Downstream



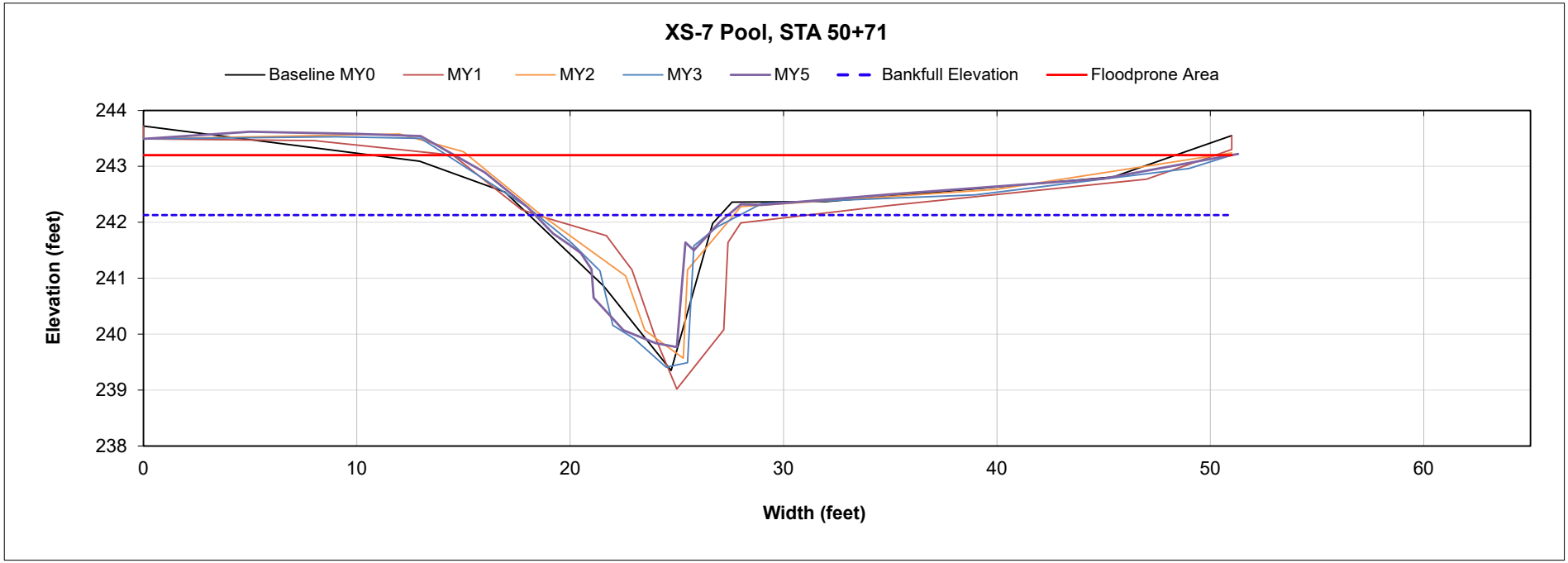
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R4
Cross Section ID	XS-7
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	242.1
Low Bank Height Elevation (ft)	242.3
Bankfull Max Depth (ft)	2.4
Low Bank Height (ft)	2.5
Bank Height Ratio	N/A
Bankfull X-section Area (ft²)	10.7
% Change Bank Height Ratio	N/A

Looking Downstream



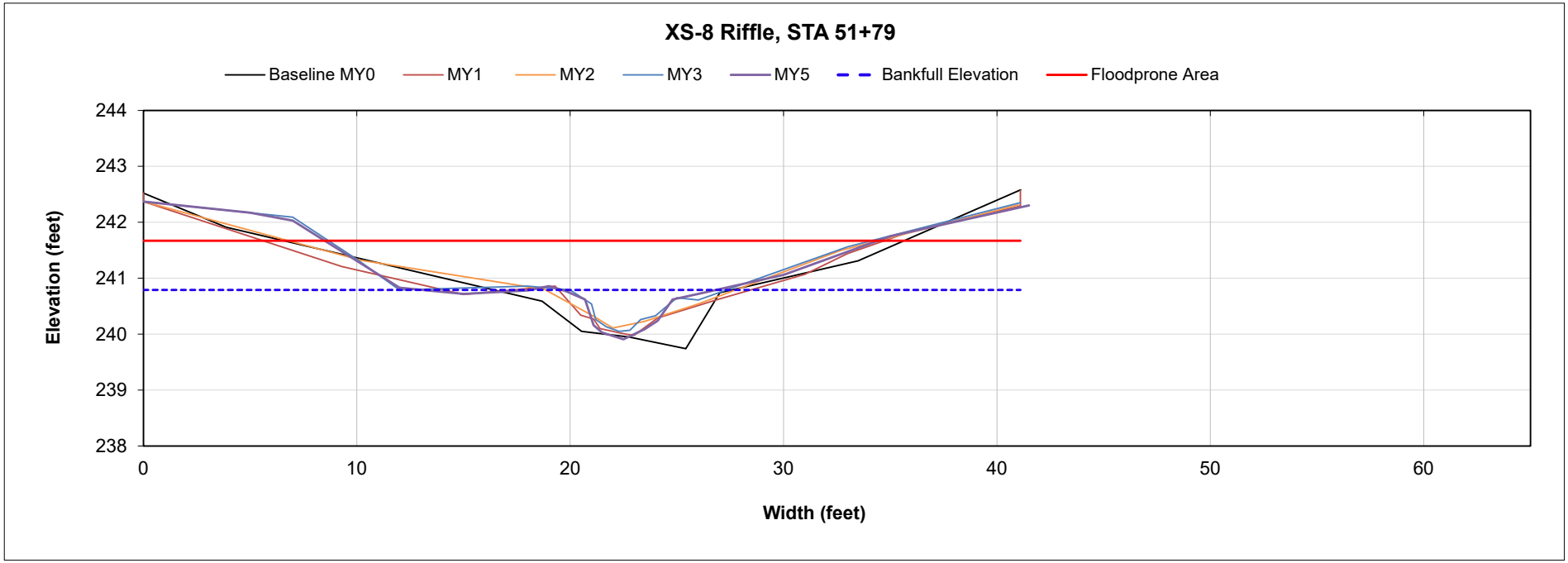
** Bank Height Ratio is calculated based on MY1 cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Project Name	Pen Dell Mitigation Project
Project ID	97079
Reach ID	R4
Cross Section ID	XS-8
Field Crew	C. Durham, K. Obermiller

Dimension Data Summary: MY5 2022	
Bankfull Elevation (ft)	240.8
Low Bank Height Elevation (ft)	240.7
Bankfull Max Depth (ft)	0.9
Low Bank Height (ft)	0.8
Bank Height Ratio	0.92
Bankfull X-section Area (ft²)	2.9
% Change Bank Height Ratio	8.0%

Looking Downstream



** Bank Height Ratio is calculated based on MY1 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 Practitioner sin NC (9/2018). The remainder of the bankfull dimensions are calculated based on the current year's low bank height.*

*** MY1 used in place of as-built (MY0) due to issues with the as-built survey standards identified during MY1.*

Table 7a. Baseline Stream Data Summary
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)

Parameter	Pre-Restoration Condition		Reference Reach Data		Design		As-Built/ Baseline	
Reach ID: R1 (EII)								
Dimension (Riffle)	Min	Max	Min	Max	Min	Max	Min	Max
Bankfull Width (ft)	4.4	6.6	4.5	8.3	5.7	-	11.1	-
Floodprone Width (ft)	15.9	42.0	10.0	20.0	15.0	30.0	49.0	-
Bankfull Mean Depth (ft)	0.4	0.8	0.8	1.6	0.5	-	0.6	-
Bankfull Max Depth (ft)	0.5	0.9	0.9	1.3	0.6	-	1.2	-
Bankfull Cross Sectional Area (ft^2)	1.9	4.2	3.0	5.0	2.7	-	7.0	-
Width/Depth Ratio	8.2	15.2	6.2	14.2	12.0	-	17.7	-
Entrenchment Ratio	1.4	2.2	7.1	8.4	2.6	5.3	4.4	-
Bank Height Ratio	0.7	1.5	0.9	1.1	1.0	-	1.0	-
Profile								
Riffle Length (ft)	6.2	38.2	9.5	22.7	-	-	-	-
Riffle Slope (ft/ft)	0.016	0.037	0.009	0.015	-	-	-	-
Pool Length (ft)	4.1	7.9	6.1	8.7	-	-	-	-
Pool Max Depth (ft)	1.1	2.3	1.8	2.4	-	-	-	-
Pool Spacing (ft)	26.4	83.9	14.4	22.3	-	-	-	-
Pattern								
Channel Beltwidth (ft)	11.0	32.0	23.4	29.0	-	-	-	-
Radius of Curvature (ft)	8.0	50.0	11.2	17.5	-	-	-	-
Rc:Bankfull Width (ft/ft)	1.6	10.0	1.6	2.5	-	-	-	-
Meander Wavelength (ft)	20.0	100.0	43.4	65.1	-	-	-	-
Meander Width Ratio	2.2	6.4	3.9	4.5	-	-	-	-
Transport Parameters								
Boundary Shear Stress (lb/ft^2)	-		-		0.50		-	
Max part size (mm) mobilized at bankful	-		-		2.00		-	
Stream Power (W/m^2)	-		-		36.90		-	
Additional Reach Parameters								
Rosgen Classification	G5c		E5/C5		C5		C5	
Bankfull Velocity (fps)	2.7		4.5		3.7		3.7	
Bankfull Discharge (cfs)	13.0		-		13.0		13.0	
Sinuosity	1.03		1.1 - 1.3		1.10		1.05	
Water Surface Slope (Channel) (ft/ft)	0.017		0.020		0.017		0.017	
Bankfull Slope (ft/ft)	0.017		0.020		0.017		0.017	

Parameter	Pre-Restoration Condition		Reference Reach Data		Design		As-Built/ Baseline	
Reach ID: R2 (EI)								
Dimension (Riffle)	Min	Max	Min	Max	Min	Max	Min	Max
Bankfull Width (ft)	9.5	-	4.5	8.3	6.8	-	7.8	9.5
Floodprone Width (ft)	13.7	-	10.0	20.0	15.0	30.0	13.0	13.7
Bankfull Mean Depth (ft)	0.9	-	0.8	1.6	0.5	-	0.5	0.9
Bankfull Max Depth (ft)	0.9	-	0.9	1.3	0.7	-	0.8	0.9
Bankfull Cross Sectional Area (ft^2)	5.9	-	3.0	5.0	3.6	-	4.2	5.9
Width/Depth Ratio	15.2	-	6.2	14.2	13.0	-	14.6	15.2
Entrenchment Ratio	1.4	-	7.1	8.4	2.2	4.4	1.4	2.9
Bank Height Ratio	1.9	-	0.9	1.1	1.0	-	1.0	1.9
Profile								
Riffle Length (ft)	5.9	27.7	9.5	22.7	-	-	-	-
Riffle Slope (ft/ft)	0.015	0.029	0.009	0.015	-	-	-	-
Pool Length (ft)	3.9	7.8	6.1	8.7	-	-	-	-
Pool Max Depth (ft)	2.0	3.8	1.8	2.4	-	-	-	-
Pool Spacing (ft)	17.0	51.0	14.4	22.3	-	-	-	-
Pattern								
Channel Beltwidth (ft)	13.0	37.0	23.4	29.0	-	-	-	-
Radius of Curvature (ft)	7.0	29.0	11.2	17.5	-	-	-	-
Rc:Bankfull Width (ft/ft)	1.2	4.9	1.6	2.5	-	-	-	-
Meander Wavelength (ft)	42.0	121.0	43.4	65.1	-	-	-	-
Meander Width Ratio	2.3	6.3	3.9	4.5	-	-	-	-
Transport Parameters								
Boundary Shear Stress (lb/ft^2)	-		-		0.51		-	
Max part size (mm) mobilized at bankful	-		-		2.00		-	
Stream Power (W/m^2)	-		-		36.10		-	
Additional Reach Parameters								
Rosgen Classification	E5		E5/C5		E5/C5		E5/C5	
Bankfull Velocity (fps)	2.7		4.5		4.1		4.1	
Bankfull Discharge (cfs)	16.0		-		16.0		16.0	
Sinuosity	1.07		1.1 - 1.3		1.07		1.07	
Water Surface Slope (Channel) (ft/ft)	0.016		0.020		0.016		0.016	
Bankfull Slope (ft/ft)	0.017		0.020		0.017		0.017	

Parameter	Pre-Restoration Condition		Reference Reach Data		Design		As-Built/ Baseline	
Reach ID: R3								
Dimension (Riffle)	Min	Max	Min	Max	Min	Max	Min	Max
Bankfull Width (ft)	7.4	-	4.5	8.3	7.8	-	7.1	-
Floodprone Width (ft)	10.4	39.4	10.0	35.0	17.0	35.0	19.8	-
Bankfull Mean Depth (ft)	0.8	-	0.8	1.6	0.6	-	0.4	-
Bankfull Max Depth (ft)	1.6	-	0.9	1.3	0.7	-	0.8	-
Bankfull Cross Sectional Area (ft^2)	5.0	-	3.0	5.0	4.4	-	3.1	-
Width/Depth Ratio	11.0	-	6.2	14.2	14.0	-	16.3	-
Entrenchment Ratio	1.4	-	7.1	8.4	2.2	4.5	2.8	-
Bank Height Ratio	1.2	2.0	0.9	1.1	1.0	1.0	1.0	-
Profile								
Riffle Length (ft)	11.0	41.0	9.5	22.7	12.0	33.0	12.0	30.0
Riffle Slope (ft/ft)	0.012	0.012	0.009	0.015	0.0	0.0	0.0	0.0
Pool Length (ft)	3.5	7.9	6.1	8.7	8.0	10.5	7.0	9.8
Pool Max Depth (ft)	2.8	-	1.8	2.4	1.4	2.0	1.1	2.0
Pool Spacing (ft)	3.5	9.6	14.4	22.3	25.0	55.0	13.0	48.0
Pattern								
Channel Beltwidth (ft)	29.0	53.0	23.4	29.0	25.0	45.0	25.0	45.0
Radius of Curvature (ft)	9.0	40.0	11.2	17.5	16.0	23.0	15.0	25.0
Rc:Bankfull Width (ft/ft)	1.2	5.4	1.6	2.5	2.0	3.0	1.5	3.0
Meander Wavelength (ft)	52.0	77.0	43.4	65.1	30.0	44.8	30.0	44.8
Meander Width Ratio	3.9	7.2	3.9	4.5	3.3	5.7	3.5	7.1
Transport Parameters								
Boundary Shear Stress (lb/ft^2)	-		-		0.52		-	
Max part size (mm) mobilized at bankful	-		-		2.00		-	
Stream Power (W/m^2)	-		-		30.40		-	
Additional Reach Parameters								
Rosgen Classification	E5 incised (Pond)		E5/C5		E5/C5		E5/C5	
Bankfull Velocity (fps)	2.7		4.5		4.4		4.4	
Bankfull Discharge (cfs)	19.0		-		19.0		19.0	
Sinuosity	1.05		1.1 - 1.3		1.12		1.12	
Water Surface Slope (Channel) (ft/ft)	0.012		0.015		0.015		0.015	
Bankfull Slope (ft/ft)	0.013		0.015		0.015		0.015	

Parameter	Pre-Restoration Condition		Reference Reach Data		Design		As-Built/ Baseline	
Reach ID: R4								
Dimension (Riffle)	Min	Max	Min	Max	Min	Max	Min	Max
Bankfull Width (ft)	6.0	-	4.5	8.3	7.8		8.3	8.6
Floodprone Width (ft)	35.0	-	10.0	35.0	17.0	45.0	25.0	56.0
Bankfull Mean Depth (ft)	1.3	-	0.8	1.6	0.6		0.5	0.6
Bankfull Max Depth (ft)	1.8	-	0.9	1.3	0.8		0.9	1.1
Bankfull Cross Sectional Area (ft^2)	12.3	-	3.0	5.0	4.7		4.1	5.2
Width/Depth Ratio	4.4	-	6.2	14.2	13.0		13.1	18.1
Entrenchment Ratio	6.1	-	7.1	8.4	2.2	5.8	3.0	6.5
Bank Height Ratio	1.5	-	0.9	1.1	1.0		1.0	1.1
Profile								
Riffle Length (ft)	9.5	21.9	9.5	22.7	12.0	33.0	9.5	21.9
Riffle Slope (ft/ft)	0.013	0.022	0.009	0.015	0.0	0.0	0.0	0.0
Pool Length (ft)	6.1	8.5	6.1	8.7	8.0	10.5	6.1	8.5
Pool Max Depth (ft)	2.0	2.2	1.8	2.4	1.4	2.0	2.0	2.2
Pool Spacing (ft)	18.0	44.0	14.4	22.3	25.0	55.0	18.0	44.0
Pattern								
Channel Beltwidth (ft)	13.0	41.0	23.4	29.0	35.0	50.0	28.0	59.0
Radius of Curvature (ft)	7.9	28.9	11.2	17.5	16.0	25.0	12.0	23.0
Rc:Bankfull Width (ft/ft)	1.3	4.8	1.6	2.5	2.0	3.0	1.9	3.3
Meander Wavelength (ft)	36.0	101.0	43.4	65.1	55.0	80.0	52.0	77.0
Meander Width Ratio	2.2	6.8	3.9	4.5	4.5	6.4	4.7	8.5
Transport Parameters								
Boundary Shear Stress (lb/ft^2)	-		-		0.49		-	
Max part size (mm) mobilized at bankful	-		-		2.00		-	
Stream Power (W/m^2)	-		-		32.00		-	
Additional Reach Parameters								
Rosgen Classification	E5/F5		E5/C5		C5		C5	
Bankfull Velocity (fps)	1.9		4.0		4.9		4.9	
Bankfull Discharge (cfs)	23.0		-		23.0		23.0	
Sinuosity	1.14		1.1 - 1.3		1.18		1.18	
Water Surface Slope (Channel) (ft/ft)	0.013		0.015		0.012		0.012	
Bankfull Slope (ft/ft)	0.012		0.015		0.012		0.013	

Table 7b. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

	Cross Section 1 (Riffle)							Cross Section 2 (Riffle)						
Parameters	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	11.1	10.5	9.3	8.6	N/A	8.3		7.8	7.0	7.5	7.6	N/A	7.1	
Floodprone Width (ft)	49.0	49.2	51.5	51.5	N/A	51.5		23.0	25.0	24.0	24.0	N/A	24.6	
Bankfull Mean Depth (ft)	0.6	0.5	0.6	0.6	N/A	0.6		0.5	0.6	0.5	0.5	N/A	0.6	
Bankfull Max Depth (ft)	1.2	1.0	1.1	1.3	N/A	1.3		0.8	0.9	0.8	0.9	N/A	0.9	
Bankfull Cross Sectional Area (ft^2)	7.0	5.3	5.3	5.3	N/A	5.3		4.2	4.1	4.1	4.1	N/A	4.1	
Bankfull Width/Depth Ratio	17.7	20.7	16.4	13.9	N/A	12.9		14.6	11.4	14.0	13.9	N/A	12.4	
Bankfull Entrenchment Ratio	4.4	4.7	5.5	6.0	N/A	6.2		2.9	3.6	3.2	3.2	N/A	3.5	
Bankfull Bank Height Ratio	1.0	1.0	0.9	1.0	N/A	1.03		1.0	1.0	1.0	1.1	N/A	1.09	
d50 (mm)	N/A	1.5	5.1	0.9	15.0	N/A		N/A	1.5	5.1	0.9	15.0	N/A	
	Cross Section 3 (Riffle)							**Cross Section 4 (Pool)**						
Parameters	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	7.1	7.1	8.9	8.2	N/A	5.8		9.2	8.6	8.6	9.1	N/A	10.7	
Floodprone Width (ft)	19.8	24.0	19.8	25.4	N/A	24.1		29.6	30.0	29.6	26.1	N/A	27.9	
Bankfull Mean Depth (ft)	0.4	0.5	0.5	0.5	N/A	0.7		1.0	0.9	0.9	0.9	N/A	0.7	
Bankfull Max Depth (ft)	0.8	1.1	1.1	1.1	N/A	1.2		1.7	1.6	1.7	1.8	N/A	1.4	
Bankfull Cross Sectional Area (ft^2)	3.1	4.3	4.3	4.3	N/A	4.3		9.2	7.8	7.8	7.8	N/A	7.8	
Bankfull Width/Depth Ratio	16.3	13.6	18.1	15.8	N/A	7.9		9.2	9.1	9.6	10.6	N/A	14.7	
Bankfull Entrenchment Ratio	2.8	3.4	2.2	3.1	N/A	4.1		3.2	3.5	3.4	2.9	N/A	2.6	
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	N/A	0.95		N/A	N/A	N/A	N/A	N/A	N/A	
d50 (mm)	N/A	1.5	5.1	0.9	15.0	N/A		N/a	0.4	0.7	0.2	0.6	N/A	
	Cross Section 5 (Pool)							**Cross Section 6 (Riffle)**						
Parameters	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	10.0	10.9	19.7	12.0	N/A	9.4		8.6	7.9	7.7	6.7	N/A	5.4	
Floodprone Width (ft)	53.0	53.5	53.0	53.0	N/A	53.6		63.0	63.0	61.0	60.6	N/A	60.0	
Bankfull Mean Depth (ft)	0.7	0.6	0.3	0.6	N/A	0.7		0.5	0.5	0.4	0.4	N/A	0.6	
Bankfull Max Depth (ft)	1.5	1.6	1.6	1.5	N/A	1.6		0.9	0.7	0.8	0.8	N/A	0.9	
Bankfull Cross Sectional Area (ft^2)	6.9	6.9	6.9	6.9	N/A	6.9		4.1	3.0	3.0	3.0	N/A	3.0	
Bankfull Width/Depth Ratio	14.4	17.3	56.3	20.9	N/A	12.8		18.1	21.0	20.0	14.8	N/A	9.7	
Bankfull Entrenchment Ratio	5.2	4.9	2.7	4.4	N/A	5.7		6.5	8.0	7.9	9.1	N/A	11.1	
Bankfull Bank Height Ratio	N/A	N/A	N/A	N/A	N/A	N/A		1.0	<1	1.0	1.0	N/A	1.02	
d50 (mm)	N/A	0.4	0.7	0.2	0.6	N/A		N/A	1.5	5.1	0.9	15.0	N/A	
	Cross Section 7 (Pool)							**Cross Section 8 (Riffle)**						
Parameters	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	10.0	10.3	9.9	8.1	N/A	9.0		8.1	7.7	8.5	9.1	N/A	6.2	
Floodprone Width (ft)	38.0	51.0	32.0	34.7	N/A	36.6		27.0	25.0	25.0	25.0	N/A	25.9	
Bankfull Mean Depth (ft)	1.3	1.3	1.1	1.3	N/A	1.2		0.5	0.5	0.3	0.3	N/A	0.5	
Bankfull Max Depth (ft)	3.0	3.2	2.7	2.6	N/A	2.4		0.8	0.9	0.7	0.8	N/A	0.9	
Bankfull Cross Sectional Area (ft^2)	13.4	10.7	10.7	10.7	N/A	10.7		4.4	2.9	2.9	2.9	N/A	2.9	
Bankfull Width/Depth Ratio	7.5	8.2	9.2	6.1	N/A	7.7		15.0	14.2	24.8	28.4	N/A	13.2	
Bankfull Entrenchment Ratio	3.8	5.0	3.2	4.3	N/A	4.0		3.3	4.0	2.9	2.7	N/A	4.2	
Bankfull Bank Height Ratio	N/A	N/A	N/A	N/A	N/A	N/A		1.0	1.0	1.1	< 1.0	N/A	0.92	
d50 (mm)	N/A	0.4	0.7	0.2	0.6	N/A		N/A	1.5	5.1	0.9	15.0	N/A	

Table 7c. Monitoring Data - Stream Reach Summary

Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)

Parameter	Baseline		MY1		MY2		MY3		MY4		MY5	
Reach ID: R1 (EII)												
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
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	C5											
Sinuosity (ft)	1.03											
Water Surface Slope (Channel) (ft/ft)	0.017											
BF slope (ft/ft)	0.017											
[3]Ri% / Ru% / P% / G% / S%												
[3]SC% / Sa% / G% / C% / B% / Be%												
[3]d16 / d35 / d50 / d84 / d95 /												
[2]% of Reach with Eroding Banks												
Channel Stability or Habitat Metric												
Biological or Other												

Pattern and Profile data will not typically be collected unless visual data, dimensional data or profile data indicate significant deviations from baseline conditions

Parameter	Baseline		MY1		MY2		MY3		MY4		MY5	
Reach ID: R2 (EI)												
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
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	E5 incised (Pond)											
Sinuosity (ft)	1.07											
Water Surface Slope (Channel) (ft/ft)	0.016											
BF slope (ft/ft)	0.017											
[3]Ri% / Ru% / P% / G% / S%												
[3]SC% / Sa% / G% / C% / B% / Be%												
[3]d16 / d35 / d50 / d84 / d95 /												
[2]% of Reach with Eroding Banks												
Channel Stability or Habitat Metric												
Biological or Other												

Pattern and Profile data will not typically be collected unless visual data, dimensional data or profile data indicate significant deviations from baseline conditions

Parameter	Baseline		MY1		MY2		MY3		MY4		MY5	
Reach ID: R3 (EI)												
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Profile												
Riffle Length (ft)	12	30										
Riffle Slope (ft/ft)	0.013	0.029										
Pool Length (ft)	7	9.8										
Pool Max depth (ft)	1.1	2										
Pool Spacing (ft)	13	48										
Pattern												
Channel Beltwidth (ft)	25	45										
Radius of Curvature (ft)	15	25										
Rc:Bankfull width (ft/ft)	1.5	3										
Meander Wavelength (ft)	30	44.8										
Meander Width Ratio	3.5	7.1										
Additional Reach Parameters												
Rosgen Classification	C5											
Sinuosity (ft)	1.12											
Water Surface Slope (Channel) (ft/ft)	0.015											
BF slope (ft/ft)	0.015											
[3]Ri% / Ru% / P% / G% / S%												
[3]SC% / Sa% / G% / C% / B% / Be%												
[3]d16 / d35 / d50 / d84 / d95 /												
[2]% of Reach with Eroding Banks												
Channel Stability or Habitat Metric												
Biological or Other												

Pattern and Profile data will not typically be collected unless visual data, dimensional data or profile data indicate significant deviations from baseline conditions

Parameter	Baseline		MY1		MY2		MY3		MY4		MY5	
Reach ID: R4												
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Profile												
Riffle Length (ft)	9.5	21.9										
Riffle Slope (ft/ft)	0.013	0.022										
Pool Length (ft)	6.1	8.5										
Pool Max depth (ft)	2	2.2										
Pool Spacing (ft)	18	44										
Pattern												
Channel Beltwidth (ft)	28	59										
Radius of Curvature (ft)	12	23										
Rc:Bankfull width (ft/ft)	1.9	3.3										
Meander Wavelength (ft)	52	77										
Meander Width Ratio	4.7	8.5										
Additional Reach Parameters												
Rosgen Classification	C5											
Sinuosity (ft)	1.18											
Water Surface Slope (Channel) (ft/ft)	0.012											
BF slope (ft/ft)	0.013											
[3]Ri% / Ru% / P% / G% / S%												
[3]SC% / Sa% / G% / C% / B% / Be%												
[3]d16 / d35 / d50 / d84 / d95 /												
[2]% of Reach with Eroding Banks												
Channel Stability or Habitat Metric												
Biological or Other												

Pattern and Profile data will not typically be collected unless visual data, dimensional data or profile data indicate significant deviations from baseline conditions

Appendix E: Hydrologic Data

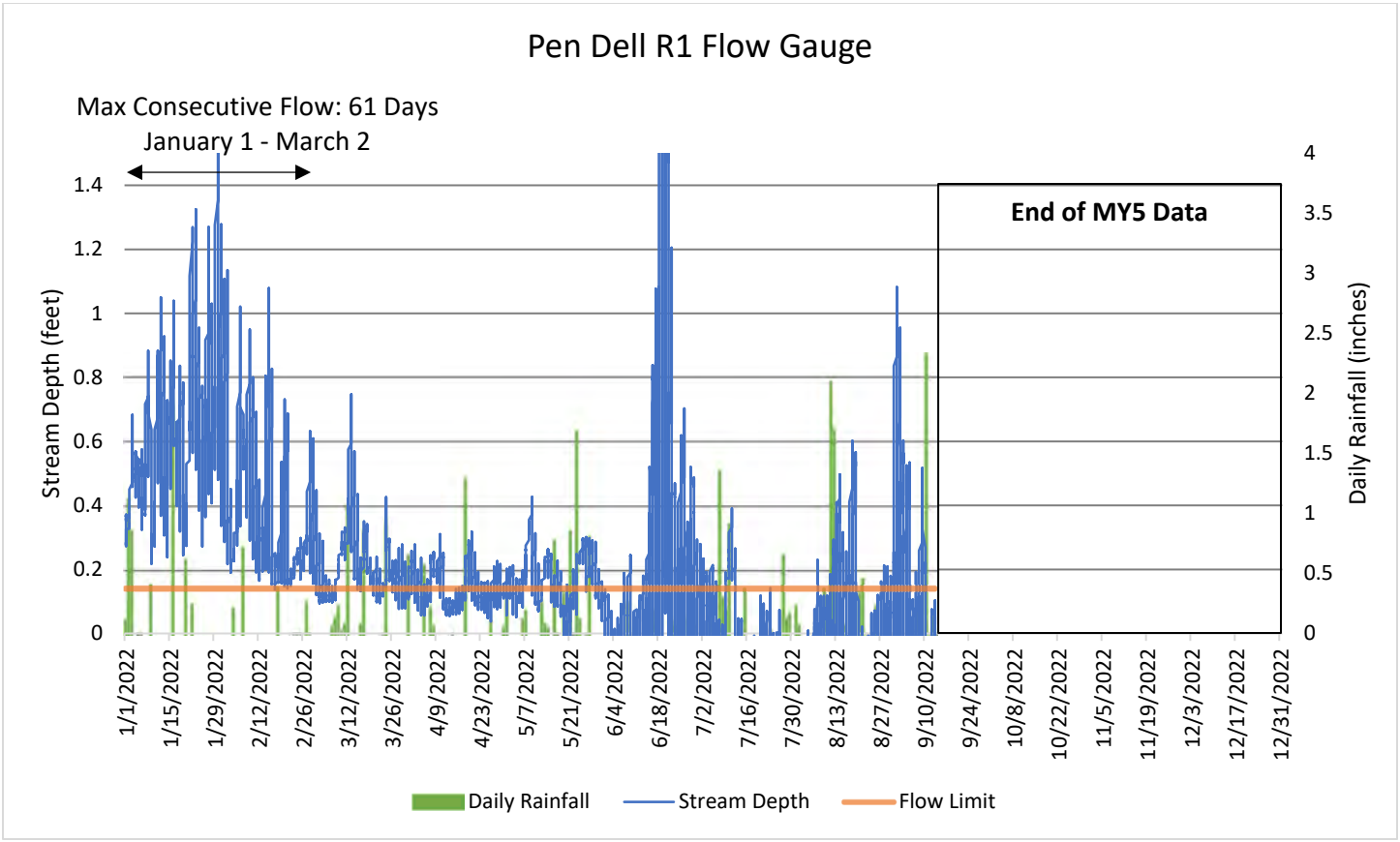
Table 8: Verification of Flow Events
Figure 3a: Hydrograph Data
Figure 3b: Groundwater Gauge Data
Figure 4: Monthly Rainfall Data

Table 8. Verification of Flow Events						
Monitoring Year	Date of Data Collection	Date of Occurrence	Method	Greater than Bankfull (Bkf) or Qgs (Q2*0.66 = 36.64 CFS) Stage?	Photo/ Notes	Measurement above bankfull
MY1	9/17/2018	9/16-9/17/2018	Observed indicators of stage (wrack lines) after sotrm event	Bkf	Photos	NA
	11/21/2018	9/16-9/17/2018	Crest Gauge	Bkf	Photos	
MY2	7/26/2019	7/24/2019	Crest Gauge	Bkf	Photos	0.11 ft
MY3	2/7/2020	Unknown	Crest Gauge	Bkf & Qgs	Photos	0.85 ft
	10/13/2020	Unknown	Crest Gauge	Bkf	Photos	0.13 ft
MY4	1/13/2021	Unknown	Crest Gauge	Bkf	Photos	1.35 ft
	7/13/2021	Unknown	Crest Gauge	Bkf	Photos	1.03 ft
MY5	3/30/2022	Unknown	Crest Gauge and observed recent alluvial deposits	Bkf	Photos	0.80 ft

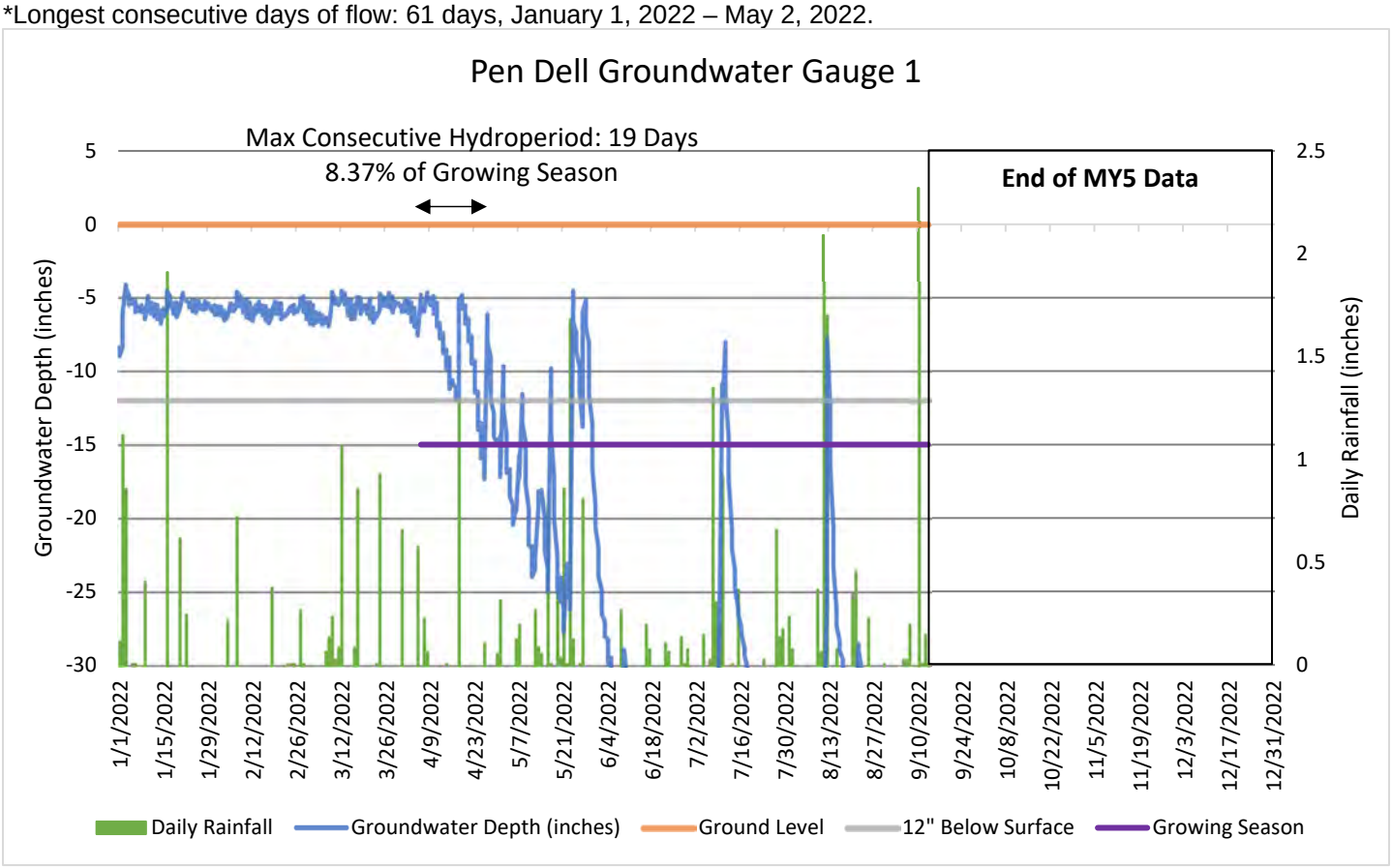
3/30/2022

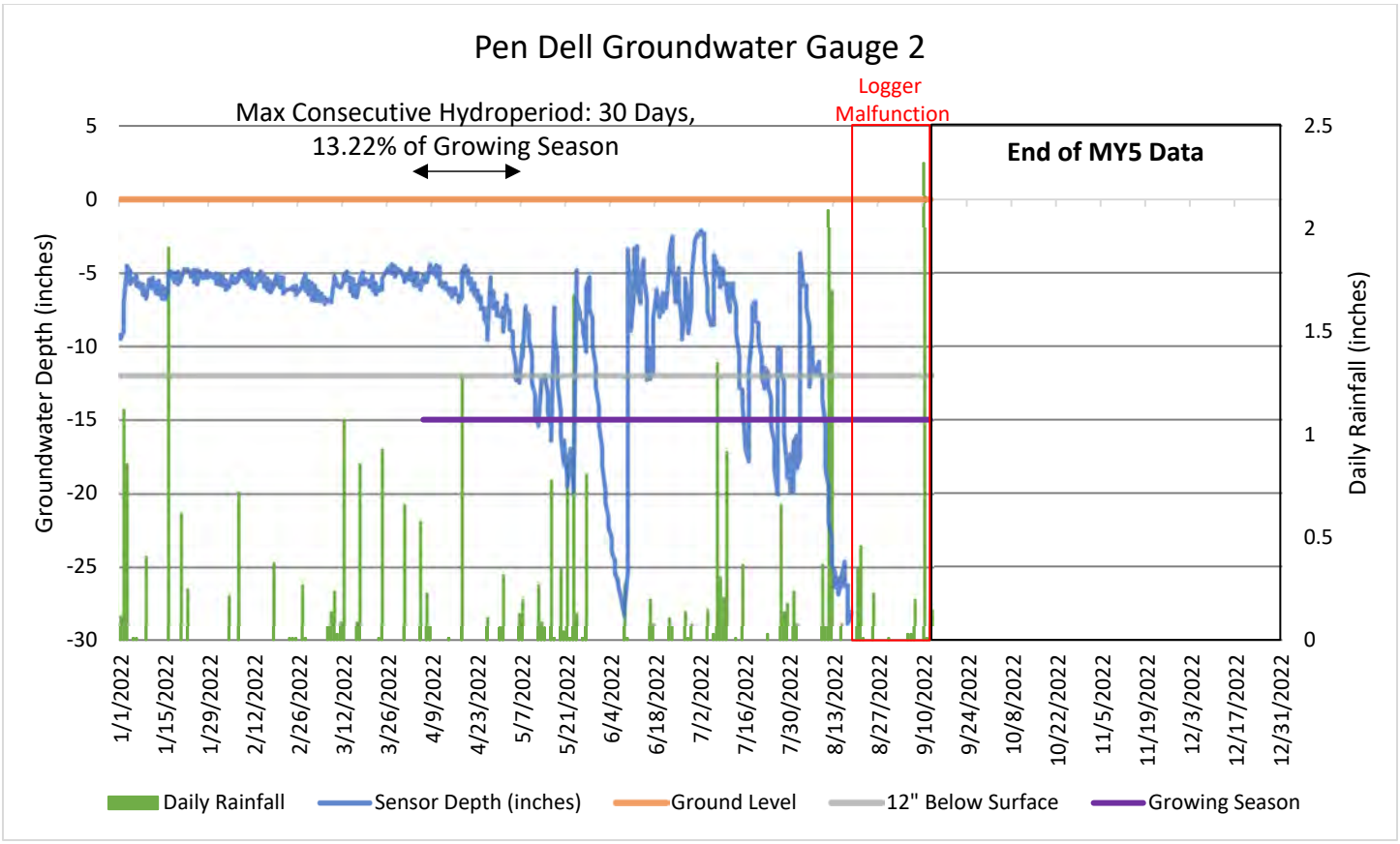
3/30/2022

Figure 3a:



*Longest consecutive days of flow: 61 days, January 1, 2022 – May 2, 2022.




Pen Dell Groundwater Gauge 2
Max Consecutive Hydroperiod: 30 Days,
13.22% of Growing Season
Logger
Malfunction
End of MY5 Data
Groundwater Depth (inches)
Daily Rainfall (inches)
5
0
-5
-10
-15
-20
-25
-30
2.5
2
1.5
1
0.5
0
1/1/2022
1/15/2022
1/29/2022
2/12/2022
2/26/2022
3/12/2022
3/26/2022
4/9/2022
4/23/2022
5/7/2022
5/21/2022
6/4/2022
6/18/2022
7/2/2022
7/16/2022
7/30/2022
8/13/2022
8/27/2022
9/10/2022
9/24/2022
10/8/2022
10/22/2022
11/5/2022
11/19/2022
12/3/2022
12/17/2022
12/31/2022
Daily Rainfall
Sensor Depth (inches)
Ground Level
12" Below Surface
Growing Season

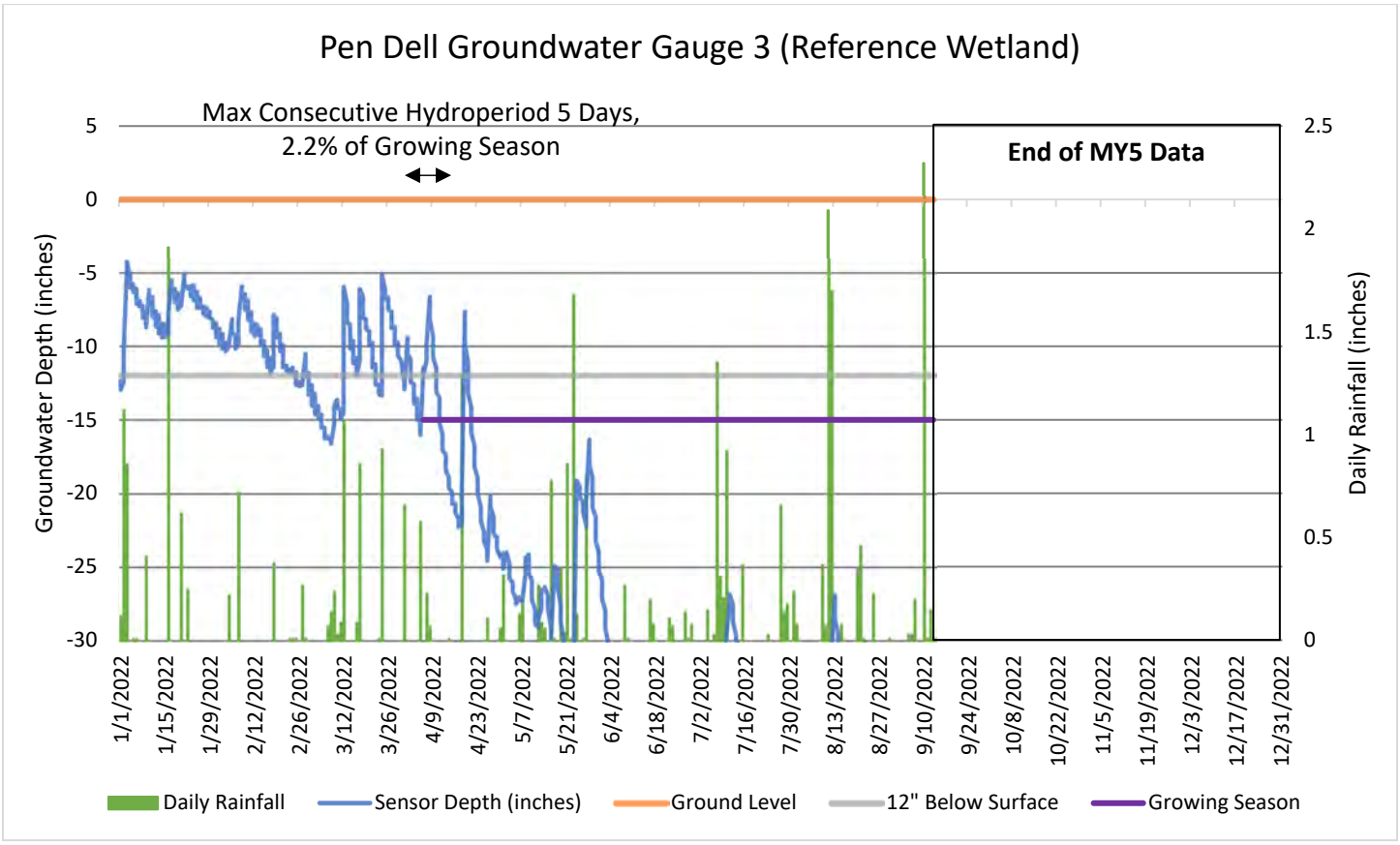
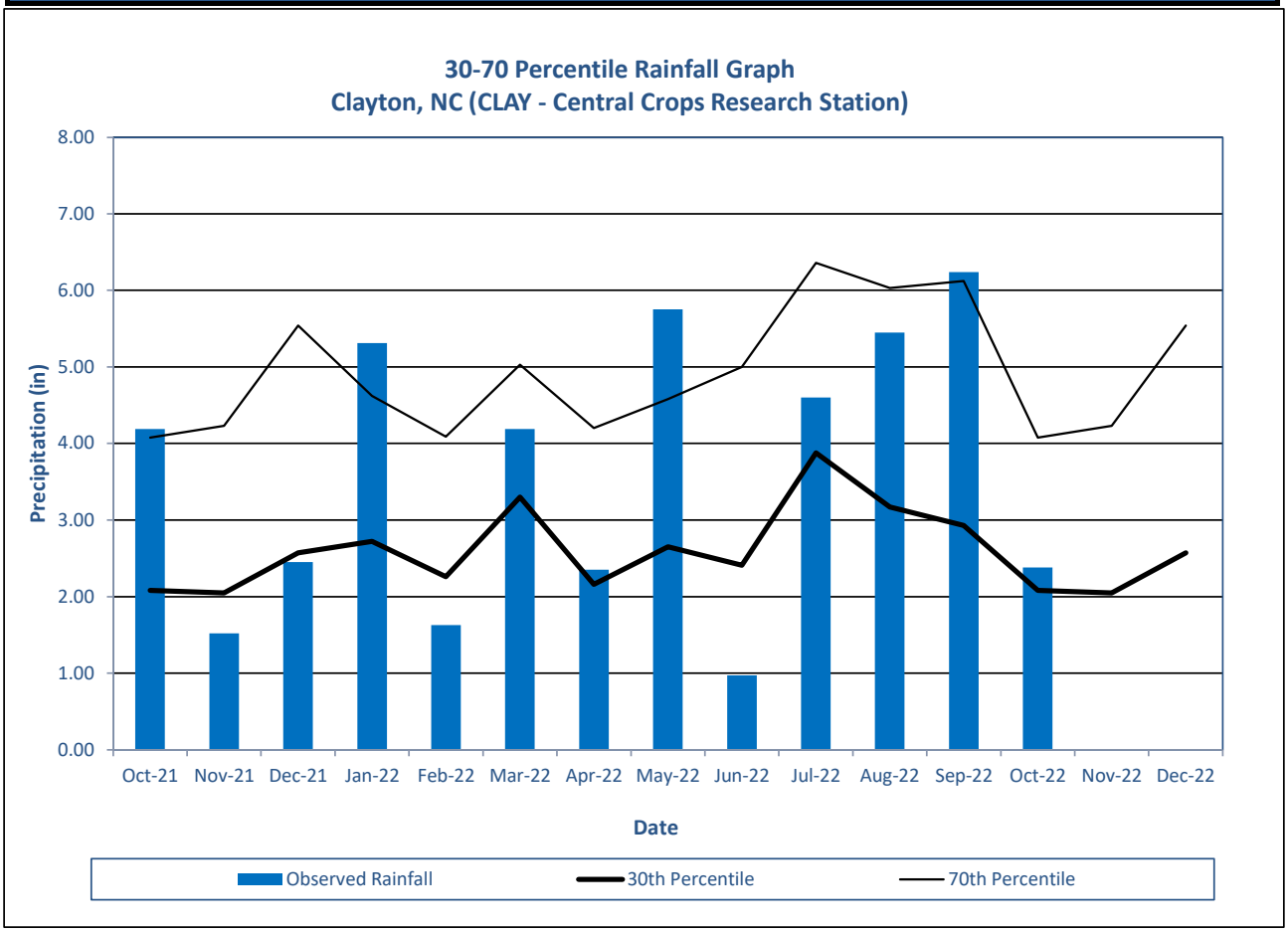

Pen Dell Groundwater Gauge 3 (Reference Wetland)
Max Consecutive Hydroperiod 5 Days,
2.2% of Growing Season
End of MY5 Data
Groundwater Depth (inches)
Daily Rainfall (inches)
5
0
-5
-10
-15
-20
-25
-30
2.5
2
1.5
1
0.5
0
1/1/2022
1/15/2022
1/29/2022
2/12/2022
2/26/2022
3/12/2022
3/26/2022
4/9/2022
4/23/2022
5/7/2022
5/21/2022
6/4/2022
6/18/2022
7/2/2022
7/16/2022
7/30/2022
8/13/2022
8/27/2022
9/10/2022
9/24/2022
10/8/2022
10/22/2022
11/5/2022
11/19/2022
12/3/2022
12/17/2022
12/31/2022
Daily Rainfall
Sensor Depth (inches)
Ground Level
12" Below Surface
Growing Season

Figure 3b: Groundwater Gauge Data

Monitoring Gauge Name	Max Consecutive Hydroperiod: Saturation within 12 Inches of Soil Surface (Percent of Growing Season) WETS Station: 317994 - Smithfield Growing Season: 4/6-11/4 (227 days)							
	2018	2019	2020	2021	2022	2023	2024	Mean
Pen Dell R4 Wetland Gauge 1	M	16.74%	10.57%	10.13%	8.37%			
Pen Dell R4 Wetland Gauge 2	NA	19.38%	17.62%	11.89%	13.22%			
Pen Dell Reference Wetland	94.70%	19.82%	52.42%	9.69%	2.20%			

Annual Precip Total	NA
WETS 30th Percentile	42.7
WETS 70th Percentile	51.8
Normal	Y

Figure 4: Monthly Rainfall Data
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
MY5 2022



*30th and 70th percentile rainfall data collected from weather station CLAY - Central Crops Research Station in Clayton, NC.
**Incomplete Month

Month	30%	70%	Observed
Oct-21	2.08	4.08	4.19
Nov-21	2.05	4.23	1.52
Dec-21	2.57	5.54	2.45
Jan-22	2.72	4.62	5.31
Feb-22	2.26	4.09	1.63
Mar-22	3.30	5.03	4.19
Apr-22	2.16	4.20	2.35
May-22	2.65	4.58	5.75
Jun-22	2.41	5.00	0.97
Jul-22	3.88	6.36	4.6
Aug-22	3.17	6.03	5.45
Sep-22	2.93	6.12	6.24
Oct-22	2.08	4.08	2.38
Nov-22	2.05	4.23	**
Dec-22	2.57	5.54	**