Monitoring Report- Year 4
FINAL VERSION
Pen Dell Mitigation Project
Calendar Year of Data Collection: 2021

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: September 2020
Submission Date: October 20th, 2021

Prepared for:

Environmental Quality

North Carolina Department of Environmental Quality
Division of Mitigation Services
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Prepared by:

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October 20th, 2021

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 10 Draft Monitoring Report Year 4 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 4 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 4 were developed by addressing NCDEQ DMS's review comments.

Under this cover, we are providing the Final Monitoring Report Year 4, 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 4 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: Please add V2 to the end of the DWR report (2016-0403 V2) on the title page.** WLS Response: V2 was added to the DWR report title page.

2. **DMS Comment: Riparian buffer report table 5a and Stream report table 6a: please remove the column with volunteers/acre and total stems/acre or populate these columns with correct data. Please note that volunteers on this table for success should not include pines, sweetgums, or invasives.** WLS Response: The mitigation success criteria tables have been updated to reflect the volunteers per acre and total stems per acre for each veg plot. Species included as volunteers are only those from the approved mitigation plan/planting list.

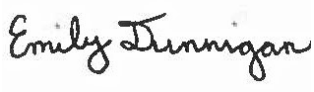
3. **DMS Comment: Clarify in the text where the substrate samples were taken (which reach).** WLS Response: Language was added to clarify the location of the substrate samples. Near station 51+00 on R4.

4. **DMS Comment: Update rain report for additional months if possible.** WLS Response: September rainfall data was added to Figure 5.

Please contact me if you have any questions or comments.

Sincerely,

Water & Land Solutions, LLC



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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 2021. Monitoring Year 4 (MY4) data collection activities occurred in September 2021 (Table 2). This report presents the data for MY4. The Project meets the MY4 success criteria for stream hydrology, streambed material condition and stability, stream flow, and vegetation. Based on these results, the Project is expected to meet the Monitoring Year 5 (MY5) success criteria in 2022.

Buffer Project Areas and Assets

RIPARIAN BUFFER (15A NCAC 02B.0295)

Location	Jurisdictional Streams	Restoration Type	Reach ID/ Component	Buffer Width (ft)	Creditable Area (sf)*	Initial Credit Ratio (x:1)	% Full Credit	Final Credit Ratio (x:1)	Riparian Buffer Credits (BMU)	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			75%	1.33333	0		0.000	0.000
				30-100	286,888	1	100%	1.00000	286888		0.000	0.000
				101-200			33%	3.00000	0		0.000	0.000
		Enhancement		20-29			75%	2.66667	0		0.000	0.000
				30-100	124,088	2	100%	2.00000	62044		0.000	0.000
				101-200			33%	6.00000	0		0.000	0.000
				SUBTOTALS	410976				348932		0.000	0.000
			ELIGIBLE PRESERVATION AREA		136992							
Location	Jurisdictional Streams	Restoration Type	Reach ID/ Component	Buffer Width (ft)	Creditable Area (sf)*	Initial Credit Ratio (x:1)	% Full Credit	Final Credit Ratio (x:1)	Riparian Buffer Credits (BMU)			
Rural	Subject	Preservation		20-29			75%	13.33333	0			
				30-100	222827	10	100%	10.00000	22283			
				101-200			33%	30.00000	0			
	Nonsubject			20-29			75%	6.66667	0			
				30-100		5	100%	5.00000	0			
				101-200			33%	15.00000	0			
Urban	Subject or Nonsubject			20-29			75%	4.00000	0			
				30-100		3	100%	3.00000	0			
				101-200			33%	9.00000	0			
				SUBTOTALS	222827				22283			
				TOTALS	633803				371215			

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 (MY3, MY5, 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 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

After construction, there should be minimal change in the particle size distribution of the streambed materials, over time, given the current watershed conditions and future sediment supply regime. Since the streams are predominantly sand-bed systems with minimal fine/coarse gravel, some coarsening is anticipated after restoration activities, however significant changes in particle size distribution are not expected. Streambed material condition is supplementary and is not part of success criteria.

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 4 Assessment and Results

Annual monitoring was conducted during MY4 in accordance with the monitoring plan as described in the approved mitigation plan and to document the site conditions. All the monitoring device locations are depicted on the CCPV (Figure 1). MY4 monitoring results are provided in the appendices. The Project meets the MY4 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 (Figure 1).

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 two bankfull events occurred during MY4 (see table below). These events were documented using the described crest gauge and photography (Appendix E Table 8). The documented occurrence of these flow events and five events prior to MY4 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

5.2 Stream Horizontal & Vertical Stability

Visual assessment and monitoring of eight permanent cross sections were utilized for assessment of MY4 horizontal and vertical stream stability. The visual assessments for each stream reach concluded that the MY4 stream channel pattern and longitudinal profiles, instream structure locations, still closely match the profile design parameters and MY0/baseline conditions. (Appendix D). Cross-section data collection is not required for MY4 per the mitigation plan, data will be collected in MY5.

5.3 Streambed Material Condition and Stability

A representative sediment sample was collected in R4, near station 51+00, at a constructed riffle and pool to assess streambed material condition and stability. The dominant substrate for the project was verified as coarse sand. The post-construction riffle substrate sampling indicated no significant change in streambed material condition or stability for MY4.

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. A flow gauge malfunction resulted in the loss of data from March 26th, 2021, to September 14th, 2021. The malfunctioning gauge was repaired on September 14th, 2021. The flow gauge documented that the stream exhibited surface flow for 84 consecutive days from January 1st to March 25th, 2021 (see Figure 4).

5.5 Vegetation

Vegetation monitoring for MY4 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 veg plots had a range of 283 to 809 planted stems per acre.

The MY4 vegetation monitoring was also conducted utilizing visual assessment throughout the easement. A small area of encroachment (VPA1) of approximately 0.05 acres was found along R1 left floodplain during a spring 2021 site visit. Encroachment was a result of mowing along the field edge and has been more clearly marked to prevent further encroachment. 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 a 10.13% and 11.89% max hydroperiod for the MY4 growing season. This is greater than the 9.69% max hydroperiod documented in the reference wetland. A gauge malfunction resulted in the loss of data for wetland gauges 1 and 3 from July 14th, 2021, to September 14th, 2021. The malfunctioning gauges were repaired on September 14th, 2021.

6 References

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Appendices

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	**3,031**
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)

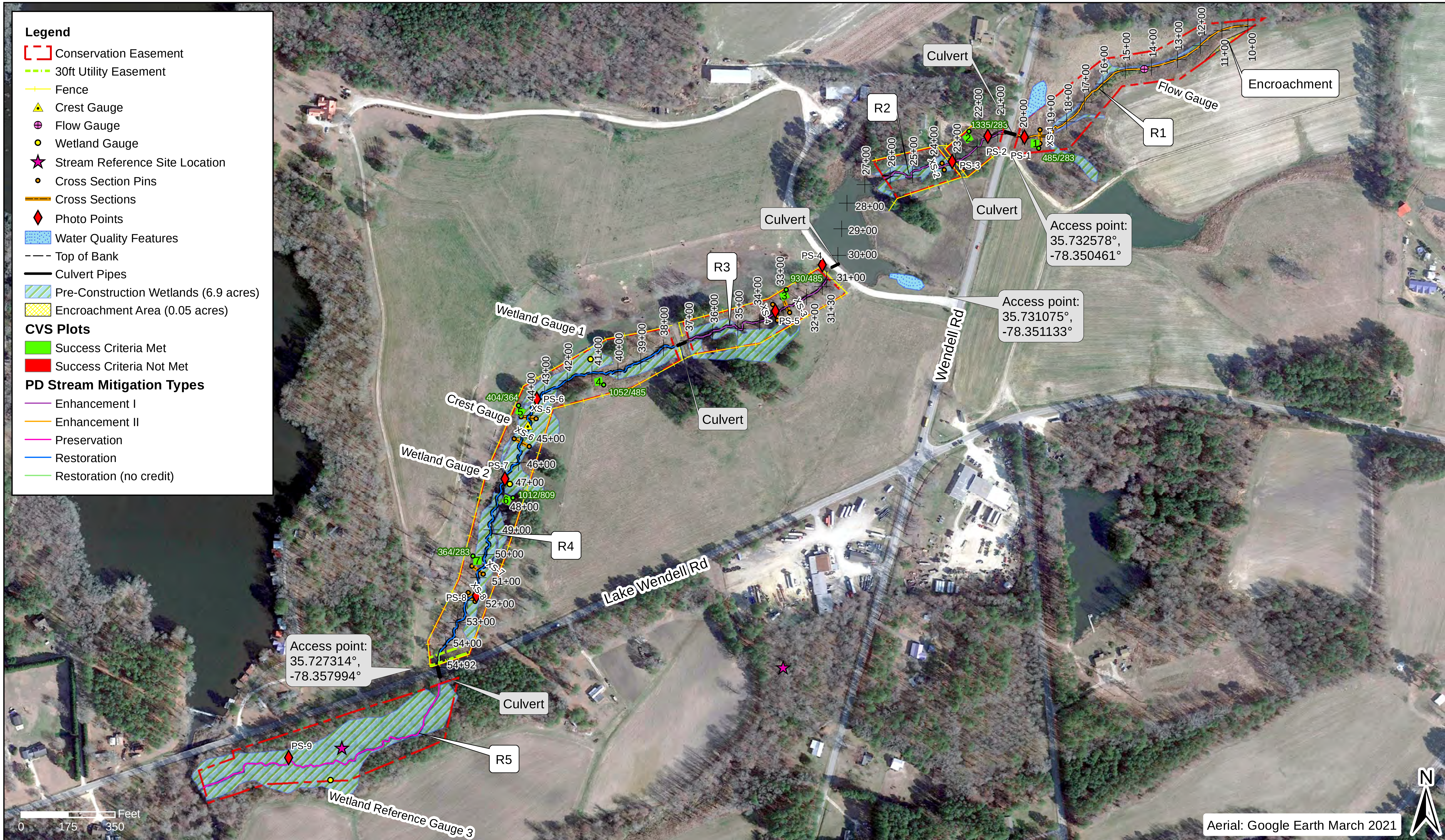
Elapsed Time Since grading complete:	**3 yrs 5 months**
Elapsed Time Since planting complete:	**3 yrs 5 months**
Number of reporting Years[0]:	**4**

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
Year 4 Monitoring Report Submittal	9/14/2021	10/20/2021
Year 5 Monitoring Report Submittal	N/A	N/A
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


Legend
Conservation Easement
30ft Utility Easement
Fence
Crest Gauge
Flow Gauge
Wetland Gauge
Stream Reference Site Location
Cross Section Pins
Cross Sections
Photo Points
Water Quality Features
Top of Bank
Culvert Pipes
Pre-Construction Wetlands (6.9 acres)
Encroachment Area (0.05 acres)
CVS Plots
Success Criteria Met
Success Criteria Not Met
PD Stream Mitigation Types
Enhancement I
Enhancement II
Preservation
Restoration
Restoration (no credit)
Culvert
Encroachment
Flow Gauge
R1
R2
R3
R4
R5
Access point: 35.732578°, -78.350461°
Access point: 35.731075°, -78.351133°
Access point: 35.727314°, -78.357994°
Wendell Rd
Lake Wendell Rd
Wetland Gauge 1
Crest Gauge
Wetland Gauge 2
Wetland Reference Gauge 3
PS-1
PS-2
PS-3
PS-4
PS-5
PS-6
PS-7
PS-8
PS-9
1335/283
485/283
930/485
1052/485
404/364
1012/809
364/283
54+92
Feet
0
175
350
N
Aerial: Google Earth March 2021

WATER & LAND™ SOLUTIONS

Pen Dell Mitigation Project
Johnston County, North Carolina

NCDMS Contract No. 6824
NCDMS Project No. 97079
September 2021
MY4

Current Conditions
Plan View
Monitoring Year 4

NAD 1983 2011 State Plane
North Carolina FIPS 3200 FT US

FIGURE
1

Table 5.	Visual Stream Morphology Stability Assessment
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
Reach ID	R1, R2, R3, R4, R5
Assessed Length	5126

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.	37	37			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	32	32			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	13	13			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)	9	9			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	37	37			100%			

Table 5a. Vegetation Condition Assessment						
Project	Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)					
Planted Acreage[1]	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.	1 acre	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	1	0.05	0.5%

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

PS-1, R1, facing upstream, Sta 20+00, March 17, 2021 (MY-04)

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

PS-2, R2, facing downstream, Sta 21+50, March 17, 2021 (MY-04)

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 17, 2021 (MY-04)

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

PS-4, R3, facing downstream, Sta 31+00, March 17, 2021 (MY-04)

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

PS-5, R3, facing downstream, Sta 34+00, March 17, 2021 (MY-04)

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

PS-6, R4, facing upstream, Sta 43+50, March 17, 2021 (MY-04)

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

PS-7, R4, facing upstream, Sta 47+00, March 17, 2021 (MY-04)

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

PS-8, R4, facing upstream, Sta 52+00, March 17, 2021 (MY-04)

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

PS-9, R5, facing upstream, Sta 62+00, March 17, 2021 (MY-04)

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

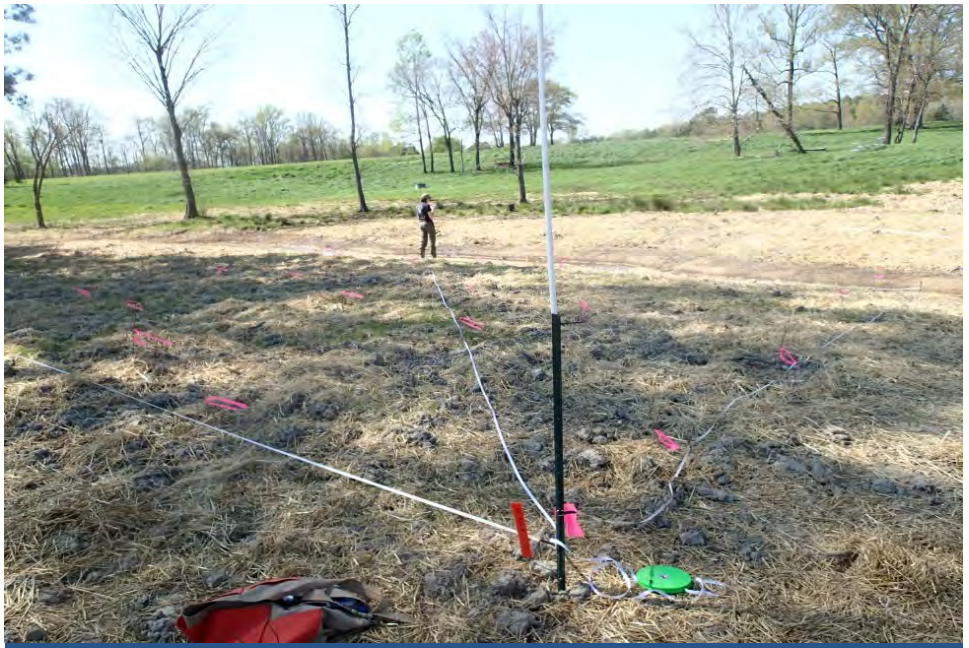
Veg Plot 1, September 14, 2021 (MY-04)

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

Veg Plot 2, September 14, 2021 (MY-04)

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

Veg Plot 3, September 14, 2021 (MY-04)

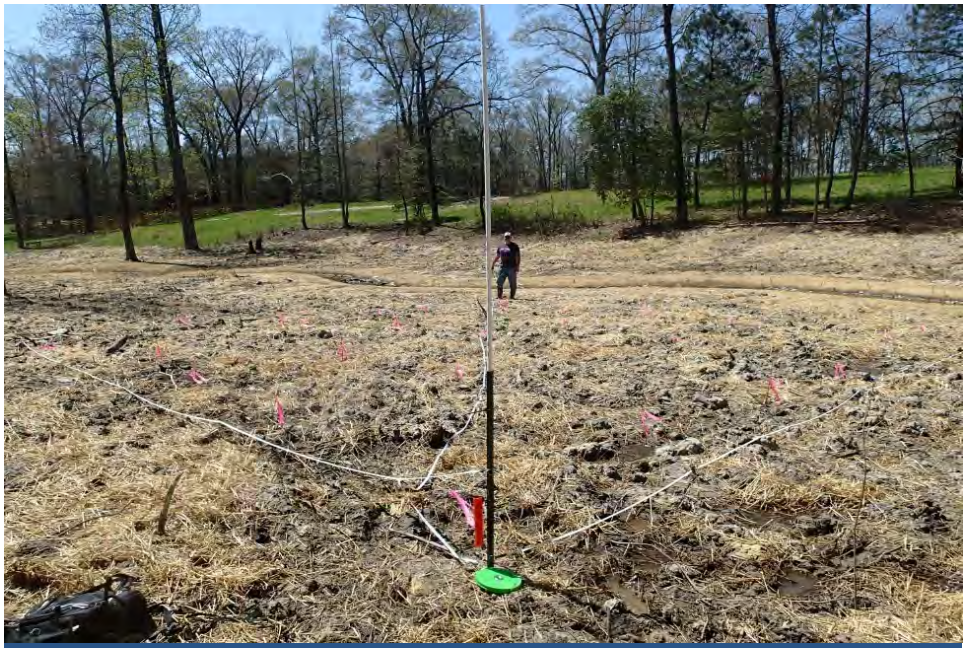


Veg Plot 4, April 12, 2018 (MY-00)

Veg Plot 4, September 14, 2021 (MY-04)

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

Veg Plot 5, September 14, 2021 (MY-04)



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

Veg Plot 6, September 14, 2021 (MY-04)

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

Veg Plot 7, September 14, 2021 (MY-04)

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

Encroachment (VPA1), R1 Left Floodplain, March 25, 2021 (MY-04)

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

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

Appendix C – Vegetation Plot Data

Pen Dell

Table 6: Planted and Total Stem Counts

			Current Plot Data (MY4 2021)																					Annual Means														
			002-01-0001			002-01-0002			002-01-0003			002-01-0004			002-01-0005			002-01-0006			002-01-0007			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**
Acer rubrum		Tree						20			9	1	1	5	1	1	1	1	1	1			2	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
Baccharis halimifolia	Silverling, High-tide Bu	Shrub Tree																		2						2												
Betula nigra	River Birch, Red Birch	Tree	2	2	2				1	1	1	2	2	2	1	1	1	3	3	3				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	9	9	10	10	10	10
Carya	Hickory	Tree																																1				
Cornus amomum	Silky Dogwood	Shrub Tree							2	2	2			1							1	1	1	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	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
Ilex verticillata	Winterberry	Shrub Tree				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			3			2			1			4												10			14			5			3			
Liriodendron tulipifera		Tree				1	1	5																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				1	1	1	2	2	2	7	7	7	7	7	7	6	6	6	8	8	8	14	14	14
Pinus taeda	Loblolly Pine, Old Field	Tree									1															1												
Platanus occidentalis	Sycamore, Plane-tree	Tree							2	2	2				4	4	4	4	4	4	1	1	1	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	9	9	9	11	11	11	9	9	9
Quercus nigra	Water Oak, Paddle Oak	Tree	1	1	1							2	2	2				1	1	1				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	6	6	6	8	8	8	8	8	8
Rhus copallinum		Shrub Tree												4						2						6									3			
Rosa carolina		Shrub Vine																		1						1												
Rosa palustris	Swamp Rose	Shrub Vine																														4			39			
Salix nigra	Black Willow	Tree			2												1									3						1			7			
Salix sericea	Silky Willow	Shrub Tree																											2									
Sambucus canadensis	Common Elderberry	Shrub Tree																														5			3			
Ulmus alata	Winged Elm	Tree												1												1			4									
Ulmus rubra	Slippery Elm, Red Elm	Tree																														2			3			
Viburnum nudum	Southern Wild Raisin, F	Shrub Tree																																		1	1	1
	Stem count		7	7	12	7	7	33	12	12	23	12	12	26	9	9	10	20	20	25	7	7	9	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	7	4	4	6	8	8	11	7	7	11	5	5	6	10	10	13	5	5	6	13	13	20	15	15	18	15	15	20	15	15	23	16	16	16
	Stems per ACRE		283.3	283.3	485.6	283.3	283.3	1335	485.6	485.6	930.8	485.6	485.6	1052	364.2	364.2	404.7	809.4	809.4	1012	283.3	283.3	364.2	427.8	427.8	797.8	445.2	445.2	745.8	450.9	450.9	612.8	578.1	578.1	1613	763.1	763.1	763.1

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	Success Criteria Met	Average Stem Height (ft)
1	283	0	283	Yes	6
2	283	202	485	Yes	5.2
3	485	0	485	Yes	9.4
4	485	40	525	Yes	8.9
5	364	0	364	Yes	14.7
6	809	80	889	Yes	7.1
7	283	0	283	Yes	9.4
Project Average	427	46	473	Yes	8.7

Appendix D – Stream Measurement and Geomorphology Data

Pen Dell

Figure 3: Pebble Count

		Date Collected	9/21/2018	10/18/2019	9/30/2020	9/14/2021			
			MY 1	MY2	MY3	MY4	MY5	MY6	MY7
MATERIAL	PARTICLE	SIZE (mm)	Total #	Total #	Total #	Total #	Total #	Total #	Total #
SILT/CLAY	Silt / Clay	< .063	7	11	18	4			
S A N	Very Fine	.063 - .125	5	3	6				
	Fine	.125 - .25	11	10	17	17			
	Medium	.25 - .50	12	10					
	Coarse	.50 - 1.0	13	15	26	19			
	Very Coarse	1.0 - 2.0	22	4	2	1			
GRAVEL	Very Fine	2.0 - 2.8	14	2		2			
	Very Fine	2.8 - 4.0	6	2		1			
	Fine	4.0 - 5.6	1	2		3			
	Fine	5.6 - 8.0	1	7	2	2			
	Medium	8.0 - 11.0	1	5	6	2			
	Medium	11.0 - 16.0	2	9	11	6			
	Coarse	16 - 22.6	2	9	9	7			
	Coarse	22.6 - 32		5		11			
	Very Coarse	32 - 45	3	4	2	10			
	Very Coarse	45 - 64		1	1	2			
COBBLE	Small	64 - 90		1		8			
	Small	90 - 128				3			
	Large	128 - 180				2			
	Large	180 - 256							
BOULDER	Small	256 - 362							
	Small	362 - 512							
	Medium	512 - 1024							
	rge-Very Lar	1024 - 2048							
BEDROCK	Bedrock	> 2048							
		Total	100	100	100	100	0	0	0

Cumulative	D16	0.16	0.14	0.062	0.2			
	D35	0.5	0.52	0.2	0.83			
	D50	1.1	1.2	0.64	9.4			
	D65	1.7	7.7	0.95	23			
	D84	4	18	14	43			
	D95	22	35	20	90			

MY4	Riffle			Pool	
	Channel materials			Channel materials	
	D16 =	0.68		D16 =	0.15
	D35 =	5.1		D35 =	0.21
	D50 =	15		D50 =	0.58
	D65 =	27		D65 =	0.98
	D84 =	71		D84 =	33
	D95 =	110		D95 =	43

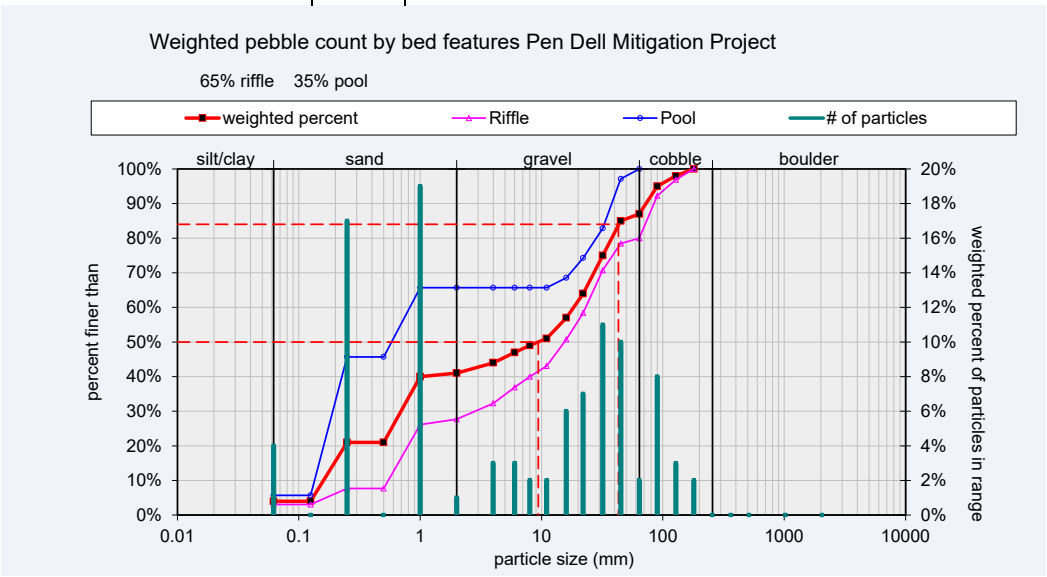


Table 7a. Baseline Stream Data Summary
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)

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			7.8	7.0	7.5	7.6	N/A		
Floodprone Width (ft)	49.0	49.2	51.5	51.5	N/A			23.0	25.0	24.0	24.0	N/A		
Bankfull Mean Depth (ft)	0.6	0.5	0.6	0.6	N/A			0.5	0.6	0.5	0.5	N/A		
Bankfull Max Depth (ft)	1.2	1.0	1.1	1.3	N/A			0.8	0.9	0.8	0.9	N/A		
Bankfull Cross Sectional Area (ft^2)	7.0	5.3	5.3	5.3	N/A			4.2	4.1	4.1	4.1	N/A		
Bankfull Width/Depth Ratio	17.7	20.7	16.4	13.9	N/A			14.6	11.4	14.0	13.9	N/A		
Bankfull Entrenchment Ratio	4.4	4.7	5.5	6.0	N/A			2.9	3.6	3.2	3.2	N/A		
Bankfull Bank Height Ratio	1.0	1.0	0.9	1.0	N/A			1.0	1.0	1.0	1.1	N/A		
d50 (mm)	N/a	1.5	5.1	0.9	15.0			N/a	1.5	5.1	0.9	15.0		
	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			9.2	8.6	8.6	9.1	N/A		
Floodprone Width (ft)	19.8	24.0	19.8	25.4	N/A			29.6	30.0	29.6	26.1	N/A		
Bankfull Mean Depth (ft)	0.4	0.5	0.5	0.5	N/A			1.0	0.9	0.9	0.9	N/A		
Bankfull Max Depth (ft)	0.8	1.1	1.1	1.1	N/A			1.7	1.6	1.7	1.8	N/A		
Bankfull Cross Sectional Area (ft^2)	3.1	4.3	4.3	4.3	N/A			9.2	7.8	7.8	7.8	N/A		
Bankfull Width/Depth Ratio	16.3	13.6	18.1	15.8	N/A			9.2	9.1	9.6	10.6	N/A		
Bankfull Entrenchment Ratio	2.8	3.4	2.2	3.1	N/A			3.2	3.5	3.4	2.9	N/A		
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	N/A			1.0	1.0	1.1	1.0	N/A		
d50 (mm)	N/a	1.5	5.1	0.9	15.0			N/a	0.4	0.7	0.2	0.6		
	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			8.6	7.9	7.7	6.7	N/A		
Floodprone Width (ft)	53.0	53.5	53.0	53.0	N/A			63.0	63.0	61.0	60.6	N/A		
Bankfull Mean Depth (ft)	0.7	0.6	0.3	0.6	N/A			0.5	0.5	0.4	0.4	N/A		
Bankfull Max Depth (ft)	1.5	1.6	1.6	1.5	N/A			0.9	0.7	0.8	0.8	N/A		
Bankfull Cross Sectional Area (ft^2)	6.9	6.9	6.9	6.9	N/A			4.1	3.0	3.0	3.0	N/A		
Bankfull Width/Depth Ratio	14.4	17.3	56.3	20.9	N/A			18.1	21.0	20.0	14.8	N/A		
Bankfull Entrenchment Ratio	5.2	4.9	2.7	4.4	N/A			6.5	8.0	7.9	9.1	N/A		
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	N/A			1.0	<1	1.0	1.0	N/A		
d50 (mm)	N/a	0.4	0.7	0.2	0.6			N/a	1.5	5.1	0.9	15.0		
	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			8.1	7.7	8.5	9.1	N/A		
Floodprone Width (ft)	38.0	51.0	32.0	34.7	N/A			27.0	25.0	25.0	25.0	N/A		
Bankfull Mean Depth (ft)	1.3	1.3	1.1	1.3	N/A			0.5	0.5	0.3	0.3	N/A		
Bankfull Max Depth (ft)	3.0	3.2	2.7	2.6	N/A			0.8	0.9	0.7	0.8	N/A		
Bankfull Cross Sectional Area (ft^2)	13.4	10.7	10.7	10.7	N/A			4.4	2.9	2.9	2.9	N/A		
Bankfull Width/Depth Ratio	7.5	8.2	9.2	6.1	N/A			15.0	14.2	24.8	28.4	N/A		
Bankfull Entrenchment Ratio	3.8	5.0	3.2	4.3	N/A			3.3	4.0	2.9	2.7	N/A		
Bankfull Bank Height Ratio	1.0	<1	1.0	1.0	N/A			1.0	1.0	1.1	< 1.0	N/A		
d50 (mm)	N/a	0.4	0.7	0.2	0.6			N/a	1.5	5.1	0.9	15.0		

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

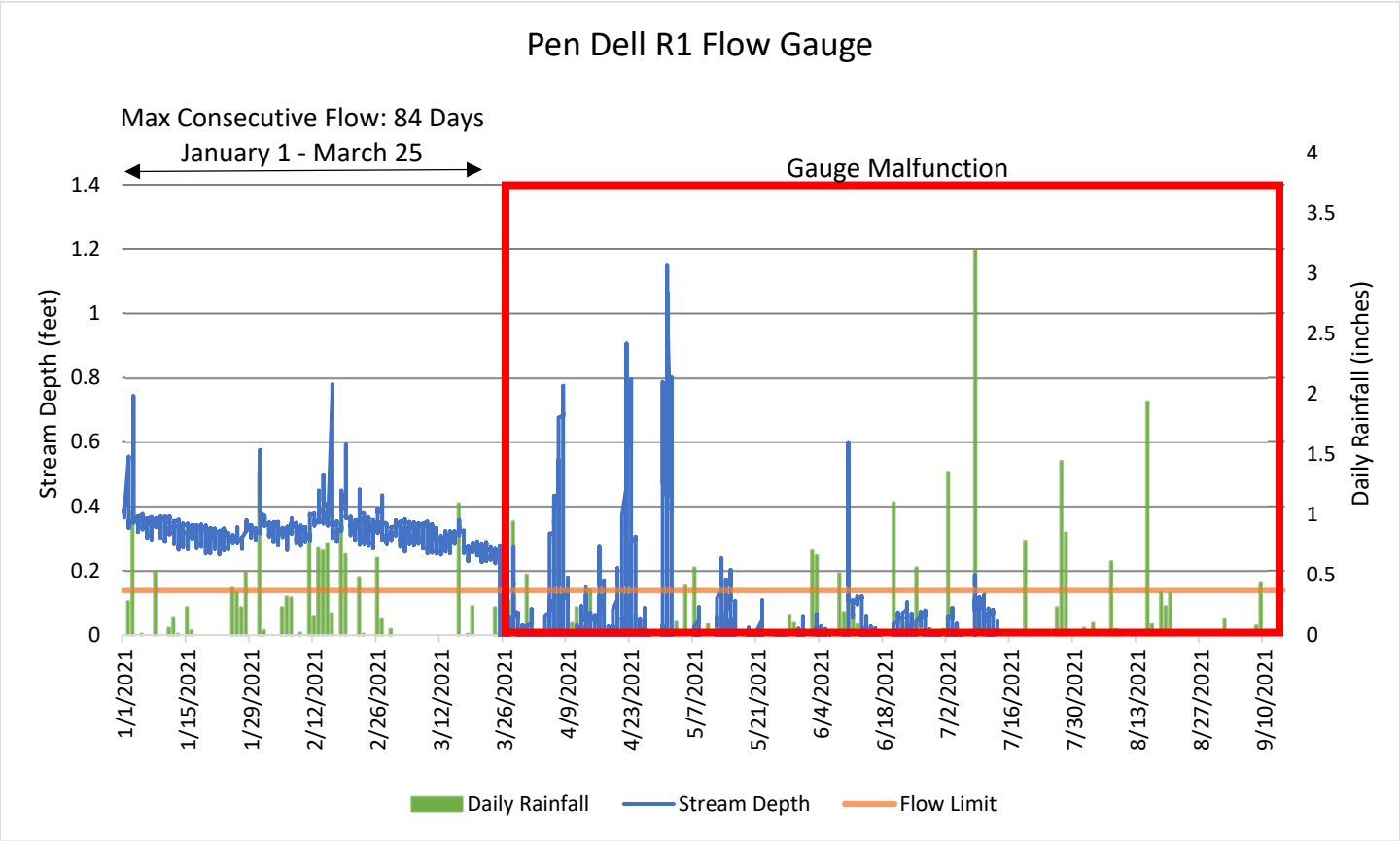
Appendix E – Hydrologic Data

Table 8. Verification of Flow Events						
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	.11 ft
MY3	2/7/2020	Unknown	Crest Gauge	Bkf & Qgs	Photos	.85 ft
	10/13/2020	Unknown	Crest Gauge	Bkf	Photos	.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

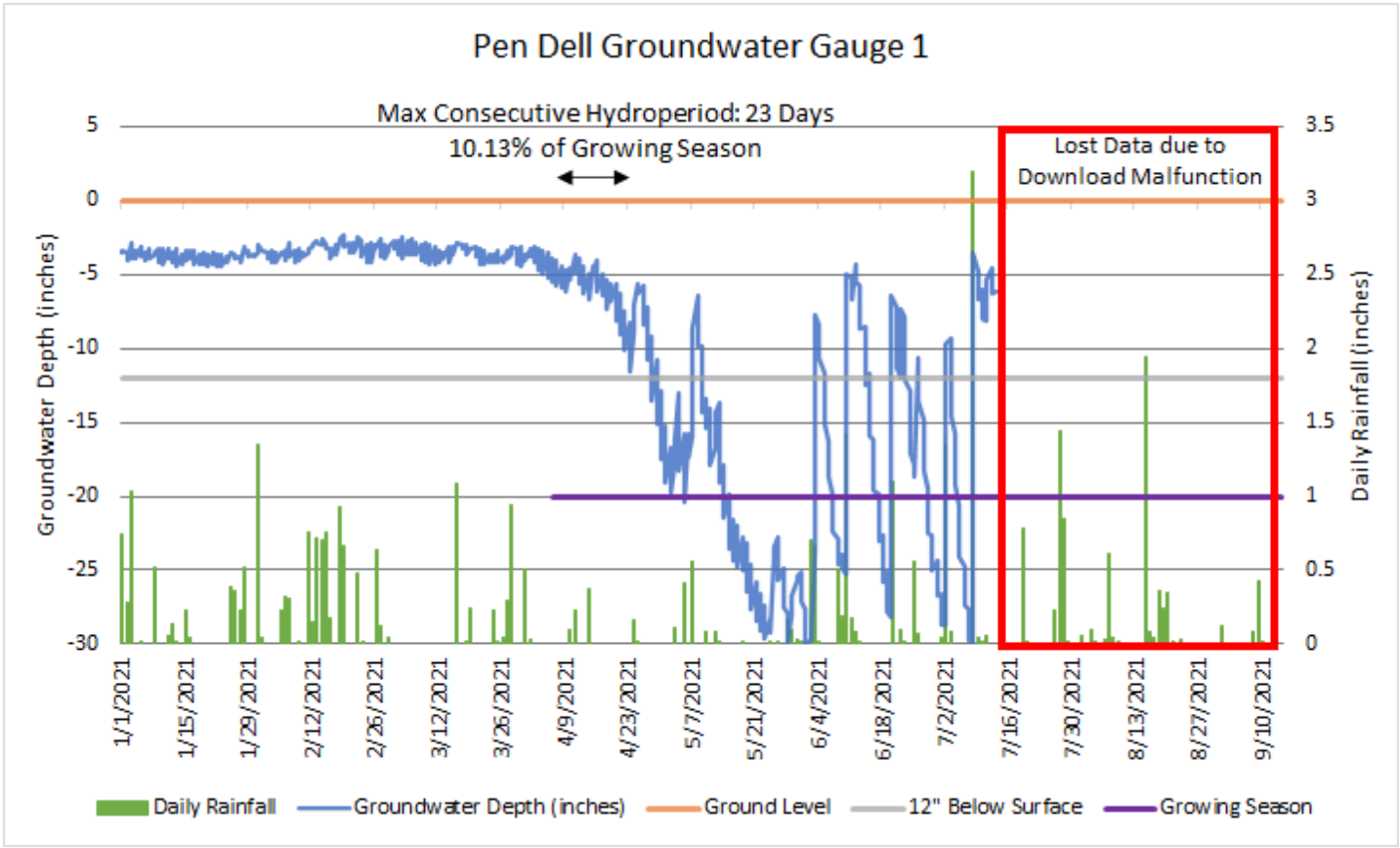
1/13/2021

7/13/2021

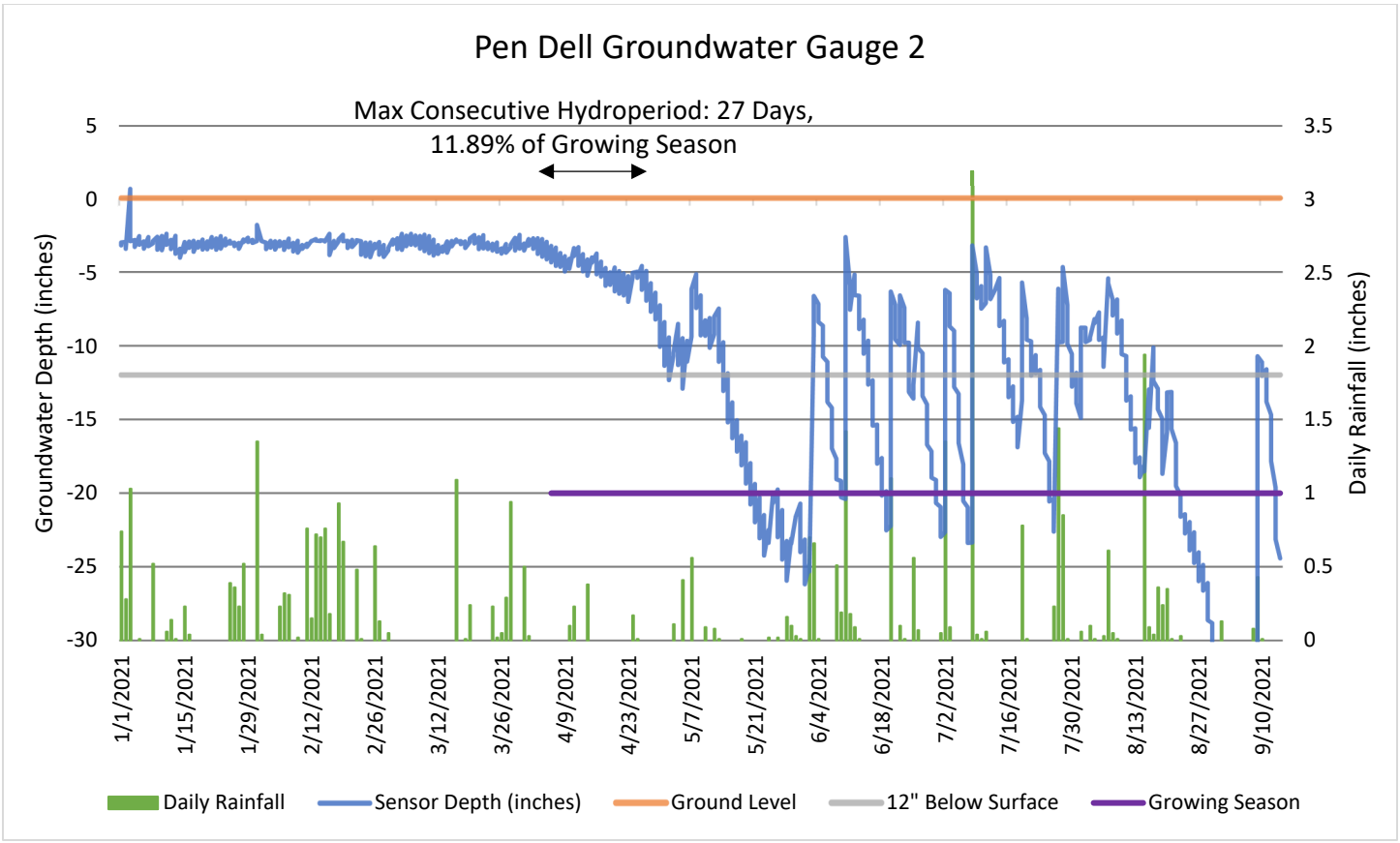
Figure 4a:



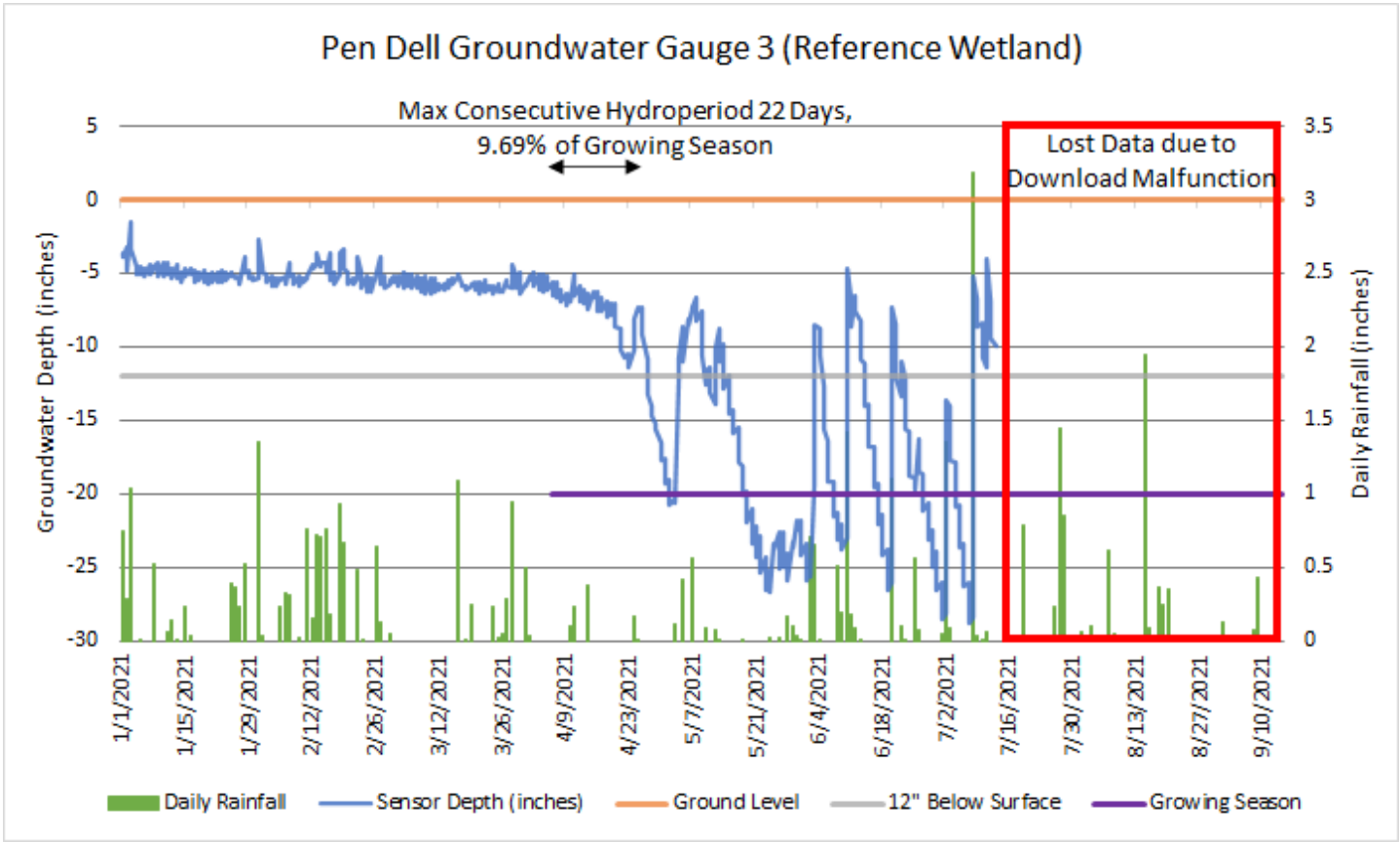
*Longest consecutive days of flow: 84 days, January 1, 2021 - March 25, 2021.



Max Consecutive Hydroperiod: 23 days, April 6, 2021 - April 28, 2021, 10.13 % of Growing Season



Max Consecutive Hydroperiod: 27 days, April 6, 2021 - May 2, 2021, 11.89 % of Growing Season



Max Consecutive Hydroperiod: 22 days, April 6, 2021 - April 27, 2021, 9.69 % of Growing Season

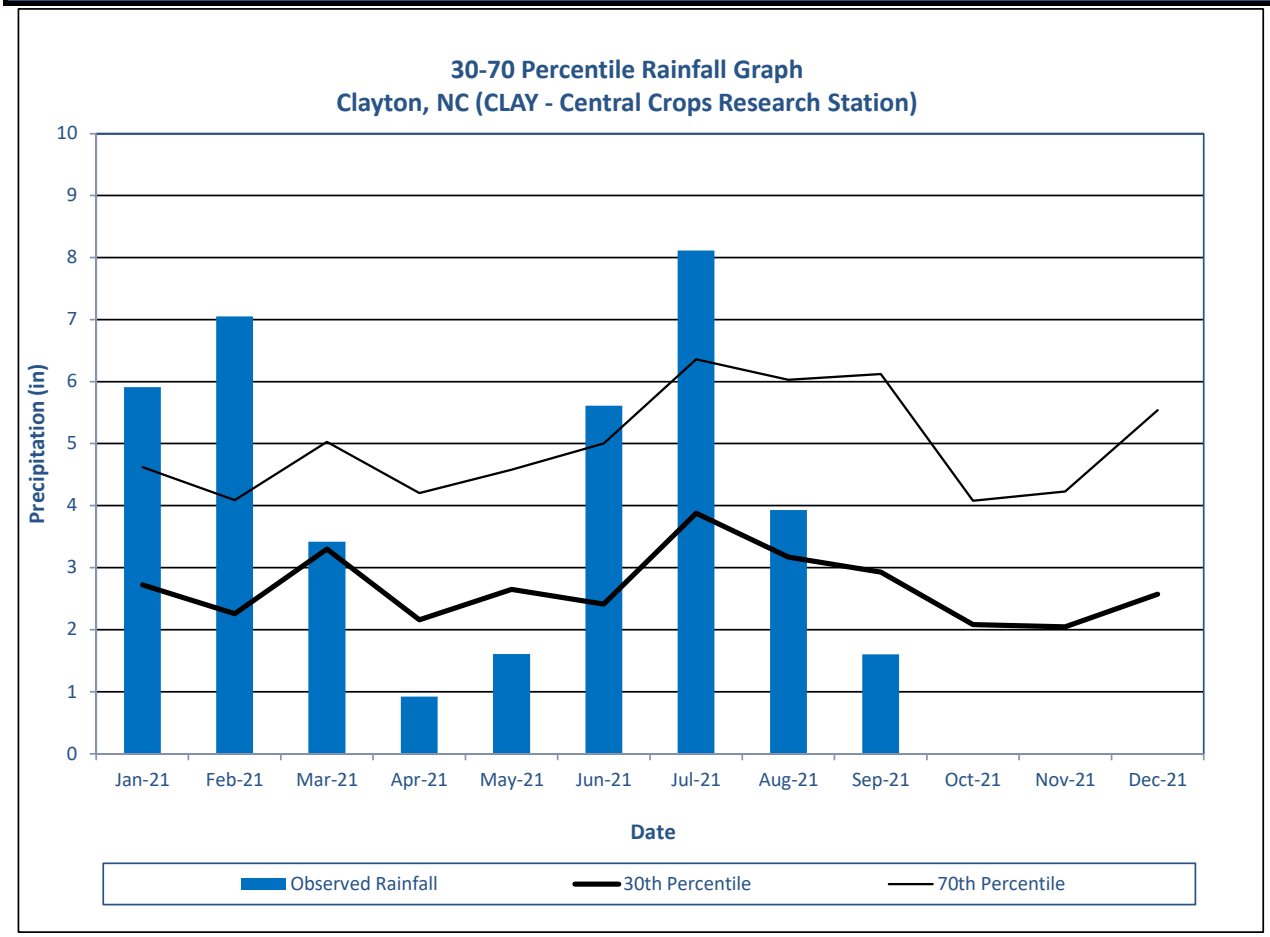
All gauges used are pressure transducers

Figure 4b: 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%				
Pen Dell R4 Wetland Gauge 2	NA	19.38%	17.62%	11.89%				
Pen Dell Reference Wetland	94.70%	19.82%	52.42%	9.69%				

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

Figure 5: Monthly Rainfall Data
Pen Dell Mitigation Project (NCDEQ DMS Project ID# 97079)
MY4 2021



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

Month	30%	70%	Observed
Jan-21	2.72	4.62	5.91
Feb-21	2.26	4.09	7.05
Mar-21	3.30	5.03	3.42
Apr-21	2.16	4.20	0.92
May-21	2.65	4.58	1.61
Jun-21	2.41	5.00	5.61
Jul-21	3.88	6.36	8.11
Aug-21	3.17	6.03	3.93
Sep-21	2.93	6.12	1.6
Oct-21	2.08	4.08	**
Nov-21	2.05	4.23	**
Dec-21	2.57	5.54	**