



MONITORING YEAR 3 ANNUAL REPORT

Final

GLADE CREEK II RESTORATION PROJECT

Alleghany County, NC
DEQ Contract 6843
DMS Project Number 92343
USACE Action ID 2009-00589

Data Collection Period: March 2018 – November 2018
Submission Date: December 12, 2018

PREPARED FOR:



NC Department of Environmental Quality Division of Mitigation Services

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December 12, 2018

Mr. Harry Tsomides
NC Department of Environmental Quality
Division of Mitigation Services
5 Ravenscroft Dr., Suite 102
Asheville, NC 28801

RE: Monitoring Year 3 (MY3) Report – Draft Submittal
Glade Creek II Mitigation Project
DMS Project # 92343
Contract Number 6843
New River Basin - #CU# 05050001 - Alleghany County, North Carolina

Dear Mr. Tsomides:

Wildlands Engineering, Inc. (Wildlands) has reviewed the Division of Mitigation Services (DMS) comments from the Draft Monitoring Year 3 report for the Glade Creek II Mitigation Project. The following Wildlands responses to DMS's report comments are noted in italics lettering.

DMS comment; Section 1.2.4, Stream Areas of Concern – DMS concurs that sediment has redeposited along this reach due to upstream cattle impacts combined with storm events. This was clearly evident following Hurricane Florence. Can Wildlands estimate of the linear feet of impacted channel where wetland features predominate over stream features?

Wildlands response; Wildlands estimates that there are approximately 50 linear feet (STA 12+60 to 13+10) of impacted channel on UT to Glade Creek where wetland features predominate over stream features based on the visual assessment that occurred on 11/8/2018.

Enclosed please find four (4) hard copies and one (1) electronic copy on CD of the Final Monitoring Report. Please contact me at 704-332-7754 x110 if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Kirsten Y. Gimbert".

Kirsten Y. Gimbert
Project Manager
kgimbert@wildlandseng.com

EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) completed design and construction management on a design-bid-build project at the Glade Creek II Restoration Site (Site) for the North Carolina Division of Mitigation Services (DMS) in Alleghany County, NC. The project components included restoring and enhancing 2,579 linear feet (LF) and preserving 129 LF of perennial stream, restoring 0.16 acre of wetlands, and preserving 0.84 acre of existing wetland. Riparian buffers were also established by removing exotic invasive plants and installing a variety of native vegetation. The Site is expected to generate 2,167 stream mitigation units (SMUs) and 0.33 wetland mitigation units (WMUs) for the Glade Creek watershed (Table 1). The Site is located off US Highway 21 in the northern portion of Alleghany County, NC in the New River Basin, eight-digit Cataloging Unit (CU) 05050001 and the 14-digit Hydrologic Unit Code (HUC) 05050001030020 (Figure 1). The project streams consist of one unnamed tributary, UT to Glade Creek, and two reaches along Glade Creek mainstem (Reach 1 and Reach 2) (Figure 2). Glade Creek flows into the Little River 4 miles northeast of the Site near Fox Trot Lane in the Town of Hooker, Alleghany County. The land adjacent to the streams and wetlands is primarily maintained for forestry production of White Pine trees.

The Glade Creek II Restoration Project is located within a DMS Targeted Local Watershed (TLW) (Brush Creek, HUC 05050001030020, as documented within the 2009 River Basin Restoration Priorities (RBRP) for the New River Basin. Furthermore, the project site is located within a priority subwatershed for stream and wetland restoration (and habitat protection), Middle Glade Creek, as identified within 2006 Local Watershed Plan and Preliminary Project Atlas for Little River and Brush Creek. Primary stressors within the Brush Creek TLW and the Middle Glade Creek subwatershed include stream channelization, livestock access, degraded riparian buffers, and Christmas tree farming. Glade Creek is also classified as trout water and the project will help improve trout habitat in the watershed.

The project goals established in the mitigation plan addendum (Confluence, 2013) were completed with careful consideration of goals and objectives described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve water quality by repairing eroding stream banks and establishing riparian buffers;
- Improve the community structure of the buffers;
- Improve stream function and habitat by re-establishing stream-to-floodplain connections;
- Restore long-term stability through the restoration of channel dimension, pattern and profile;
- Improve in-stream habitat using in-stream structures; and
- Remove exotic invasive plant species.

The Site construction was completed between December 2015 and April 2016. Planting was completed in February 2016. The as-built survey was completed in January 2016 with Monitoring Year 0 beginning in May 2016. Storm repairs prior to project closeout were completed in April 2016. Monitoring Year (MY) 3 activities occurred between March and November 2018. Morphological surveys and visual assessments indicate that Glade Creek appears stable and functioning as designed; however, UT to Glade Creek is not flowing properly due to the excessive sediment deposition and vegetation in the channel. The average planted stem density (546 stems per acre) has met the MY3 success criterion with 5 out of 6 plots individually meeting this requirement. The Site's groundwater gage met the performance standard for MY3 and the bankfull performance standard has been met for the project.



GLADE CREEK II RESTORATION PROJECT
Monitoring Year 3 Annual Report

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Section 1: PROJECT OVERVIEW

The Site is a design-bid-build contract with DMS in Alleghany County, NC. The Site is located in the New River Basin, eight-digit Cataloging Unit (CU) 05050001 and the 14-digit Hydrologic Unit Code (HUC) 05050001030020 (Figure 1). Located in the Blue Ridge Belt (USGS,2016), Blue Ridge physiographic province, the project watershed includes primarily agricultural and forest land uses. The drainage area for the project site is 8.0 square miles.

The project stream reaches consist of Glade Creek and UT to Glade Creek (stream restoration). The project wetland areas consist of restoration and preservation (Wetlands A-D). Mitigation work within the Site included restoring and enhancing 2,579 linear feet (LF) and preserving 129 LF of perennial stream, restoring 0.16 acre of wetlands, and preserving 0.84 acre of existing wetland and proposes the generation of 2,167 SMUs and 0.33 WMUs. The stream and wetland areas were planted with native vegetation to improve habitat and protect water quality. Construction activities were completed by Carolina Environmental, Inc. in December 2015. Storm repairs prior to project closeout were completed in April 2016. Turner Land Surveying completed the as-built survey in January 2016 and the storm repairs were judged to have not resulted in changes that would warrant a revised as-built survey. A 12.8-acre conservation easement was purchased in 2008 by the State of North Carolina and was recorded with Alleghany County Register of Deeds. The conservation easement protects the project area in perpetuity. Appendix 1 includes detailed project activity, history, contact information, and watershed/site background information. Directions and a map of the Site are provided in Figure 1 and project components are illustrated for the Site in Figure 2. Please refer to the Project Component Map (Figure 2) for the stream and wetland features and to Table 1 for the project component and mitigation credit information for the Site.

1.1 Project Goals and Objectives

Prior to construction, the streams had been impacted by historic agricultural practices, silviculture and valley filling. In addition, there was widespread bank erosion, especially along the outside meander bends, and mid-channel deposition. The wetlands had been impacted by vegetation clearing, exotic invasive plant species, and the valley fill buried hydric soils. Table 4 in Appendix 1 and Tables 6a and 6b in Appendix 2 present the pre- and post-restoration conditions in detail.

This mitigation site is intended to provide numerous ecological benefits within the New River Basin and addresses habitat degradation, which is the primary water quality stressor described in the New River Basin Restoration Priorities Plan (2009). While many of the benefits are limited to the immediate project area, others, such as pollutant removal, reduced sediment loading, and improved aquatic and terrestrial habitat, have farther-reaching effects. Expected improvements to water quality and ecological processes are outlined below as project goals and objectives. These project goals were met by giving careful consideration to the goals and objectives described in the RBRP.

The project specific goals of the Glade Creek II Restoration Site included the following:

- Improve water quality by repairing eroding stream banks and establishing riparian buffers;
- Improve the community structure of the buffers;
- Improve stream function and habitat by re-establishing stream-to-floodplain connections;
- Restore long-term stability through the restoration of channel dimension, pattern and profile;
- Improve in-stream habitat using in-stream structures; and
- Remove exotic invasive plant species.



The project objectives have been defined as follows:

- Restoration and enhancement of approximately 2260 LF of Glade Creek;
- Restoration of 319 LF of the UT to Glade Creek;
- Preservation of 129 LF of UT to Glade Creek;
- Restoration of 0.16 acre of wetland by improving hydrologic connections;
- Preservation of 0.84 acre of existing jurisdictional wetland; and
- Establishment of riparian buffers by removing exotic invasive plants and installing a variety of native vegetation.

The stream and wetland performance criteria for the Site follow approved performance standards presented in the Glade Creek II Restoration Plan (December 2008). Annual monitoring and semi-annual site visits will be conducted to assess the condition of the finished project. The stream restoration and enhancement reaches (Glade Creek and UT to Glade Creek) of the project were assigned specific performance standards for stream morphology, hydrology, and vegetation. Wetland restoration areas were assigned specific performance standards for wetland hydrology, and vegetation. The Glade Creek Stream Restoration Project was instituted prior to 7/28/2010; therefore, the Site will be monitored for five years post-construction.

1.2 Monitoring Year 3 Data Assessment

Annual monitoring was conducted between March and November 2018 to assess the condition of the project. The stream restoration success criteria for the Site follows the approved monitoring plan presented in the Glade Creek II Restoration Plan (Ward, 2008).

1.2.1 Vegetation Assessment

A total of six vegetation monitoring plots were established during the baseline monitoring within the project easement areas using a standard 10 by 10 meter plot. The final vegetation success criterion will be the survival of 260 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of year five of the monitoring period. The interim measure of vegetation success for the Site is the survival of at least 320 planted stems per acre at the end of year three of the monitoring period. Please refer to Figure 3 in Appendix 2 for the vegetation monitoring locations.

The MY3 vegetation survey was completed in September 2018, resulting in an average planted stem density of 546 stems per acre. The Site has met the interim requirement of 320 stems per acre, with 5 of the 6 plots (83%) individually meeting this requirement. Approximately 88% of the planted stems have a health score (vigor) of 2 or greater. However, about 37% of the stems have a vigor of 2 or less. The poor health is a result of dry soil conditions, insects and debris from storm events. Vegetation monitoring plot 1 contains only 6 stems, resulting in a density of 243 stems per acre; whereas plot 3 contains 18 stems with a density of 728 stems per acre. Please refer to Appendix 2 for vegetation plot photographs and Appendix 3 for vegetation data tables.

1.2.2 Vegetation Areas of Concern

The MY3 vegetation monitoring and visual assessment revealed few vegetation areas of concern. Small patches (approximately 1.1% of the easement area) of bare or poor herbaceous cover in the riparian area of Glade Creek Reach 1 and 2 were observed. Supplemental planting may be warranted due to low density recorded in vegetation plot 1 and low vigor throughout the site. Refer to Figure 3 in Appendix 2 for vegetation areas of concern.



1.2.3 Stream Assessment

Morphological surveys for MY3 were conducted in May 2018. Results indicate that the channel dimensions are stable and functioning as designed on Glade Creek. However, UT to Glade Creek cross-section 4 and cross-section 5 plots show significant sediment deposition that has increased the width-to-depth ratios. In general, the reachwide pebble counts on Glade Creek show coarser materials in the riffles and fines in the pools. The UT to Glade Creek reachwide channel materials resulted in a D_{50} of 0.2 mm (sand) during MY3. This fining of sediment materials was observed in MY2 and continues in MY3 for UT to Glade Creek.

The surveyed longitudinal profile data for the project streams illustrates that bedform features are maintaining lateral and vertical stability on Glade Creek. The longitudinal profile on Glade Creek showed little change in slope (riffle, water surface, bankfull) and pool-to-pool spacing from MY2 to MY3. The longitudinal profile plot for UT to Glade Creek demonstrates the extent of aggradation that has altered the channel profile which is further discussed below in Section 1.2.4. Refer to Appendix 2 for the visual stability assessment table and the CCPV map. Refer to Appendix 4 for the morphological summary data and plots.

1.2.4 Stream Areas of Concern

UT to Glade Creek has continued to experience an increase in fine sediment throughout MY3. Sedimentation has continued despite the adaptive management was performed in March 2018 on UT to Glade Creek to improve stream function and reduce active braiding. At the start of UT to Glade Creek Reach 2, sediment deposition has directed flow through Wetland D on the left floodplain of the channel. This was observed after two large storm events that occurred in September and October 2018. Land management activities and cattle pasture upstream of the project are most likely contributing excessive sediment on UT to Glade Creek.

There are a few areas of minor scour and erosion along Glade Creek. In MY2 it was observed that the brush mattress around station 18+00 had been displaced; therefore, exposing the bank and minor scouring continues to be present. In addition, the left bank between stations 23+00 and 25+00 still show signs of scour under the brush mattress and behind the boulders. In MY3, the right bank around station 23+50 is showing signs of bank instability. Replacing brush mattresses and adding live stakes on Glade Creek where bank erosion is occurring is recommended for bank stabilization. These stream areas of concern are indicated in Table 6 and on Figure 3 in Appendix 2.

1.2.5 Hydrology Assessment

At least one bankfull event occurred on all reaches during the MY3 data collection, which was recorded on crest gages and by visual indicators. Two bankfull flow events must be documented on the restoration reaches within the five-year monitoring period. The two bankfull events must occur in separate years. A bankfull event was also recorded during MY2 and MY1; therefore, the Site has met the bankfull success criteria for the project. Refer to Appendix 5 for hydrologic data and graphs.

1.2.6 Wetland Assessment

One groundwater monitoring gage (GWG 1) was established during the baseline monitoring within the restoration area using logging hydrology pressure transducers. The gage was installed at an appropriate location so that the data collected will provide an indication of groundwater levels throughout the wetland restoration area. The target performance standard for wetland hydrology success consists of groundwater surface within 12 inches of the ground surface for 21 consecutive days (12.5%) of the defined 168 day growing season for Alleghany County (April 26th to October 11th) under typical precipitation conditions. The Site does not contain a rainfall gage; therefore, the daily precipitation data was collected from closest NC CRONOS Station, Sparta 3.5 SSW. The GWG 1 recorded 169 consecutive



days (100%), meeting the performance standard for MY3. According to the climate data from nearby NC CRONOS station, the Site received more than typical amounts of rain in 2018. The monthly rainfall in April, May, August, September, and October exceeded the 70th percentile for the area (USDA, 2018). The rainfall totals were approximately 14 inches in September and 11 inches in October which is over the double the 70th percentile for those respective months. Please refer to Appendix 2 for the groundwater gage locations and Appendix 5 for groundwater hydrology data and plots.

1.2.7 Wetland Areas of Concern

One headcut has formed at the outflow of Wetland B where it meets Glade Creek Reach 2 (around station 22+80). This area will be monitored in future years for signs of accelerated instability. Please refer to the CCPV Figure 3 in Appendix 2.

1.3 Monitoring Year 3 Summary

Glade Creek appears stable and functioning as designed; however, UT to Glade Creek is not flowing properly due to the excessive sediment deposition and vegetation in the channel. This statement is supported by the morphological surveys and visual assessment. The average planted stem density (546 stems per acre) has met the MY3 success criterion with 5 out of 6 plots individually meeting this requirement. The Site's groundwater gage met the performance standard for MY3 and the bankfull performance standard has been met for the project. Some minor adaptive management would be beneficial to the Site. The areas of concern are minor, but repairs and maintenance of these areas would benefit the Site long term and decrease additional impacts to the project.

Summary information and data related to the performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these annual monitoring reports can be found in the Mitigation Plan documents available on DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.



Section 2: METHODOLOGY

Geomorphic data was collected following the standards outlined in The Stream Channel Reference Site: An Illustrated Guide to Field Techniques (Harrelson et al., 1994) and in the Stream Restoration: A Natural Channel Design Handbook (Doll et al., 2003). Longitudinal and cross-sectional data were collected using a total station and were georeferenced. All Integrated Current Condition Plan View mapping was recorded using a Trimble handheld GPS with sub-meter accuracy and processed using Pathfinder and ArcView. Crest gages were installed in surveyed riffle cross-sections and monitored quarterly. Hydrology attainment installation and monitoring methods are in accordance with the USACE (2003) standards. Vegetation monitoring protocols followed the Carolina Vegetation Survey-NCEEP Level 2 Protocol (Lee et al., 2008).



Section 3: REFERENCES

- Confluence Engineering, P.C. (2013). Glade Creek II Restoration Project Final Mitigation Plan Addendum. NCEEP, Raleigh, NC.
- 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.
- Lee, Michael T., Peet, Robert K., Steven D., Wentworth, Thomas R. 2008. CVS-EEP Protocol for Recording Vegetation Version 4.2. Retrieved from: <http://cvs.bio.unc.edu/protocol/cvs-EEP-protocol-v4.2-lev1-2.pdf>
- North Carolina Division of Water Resources (NCDWR), 2011. Surface Water Classifications. <http://portal.ncdenr.org/web/wq/ps/csu/classifications>
- North Carolina Ecosystem Enhancement Program (NCEEP), 2009. New River Basin Restoration Priorities. Accessed from: https://ncdenr.s3.amazonaws.com/s3fs-public/Mitigation%20Services/PublicFolder/Work%20With/Watershed%20Planners/New_RBRP_2009.pdf
- North Carolina Ecosystem Enhancement Program (NCEEP). Little River and Brush Creek Local Watershed Plan. Accessed from: <https://ncdenr.s3.amazonaws.com/s3fs-public/documents/files/LittleRiver-BrushCrk%20LWP%20FactSheet.pdf>
- Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.
- United States Army Corps of Engineers (USACE), 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.
- United States Geological Survey (USGS), 2016. North Carolina Geology. Accessed from: <http://ngmdb.usgs.gov/maps/mapview/>
- Ward Consulting Engineers, P.C. (2008). Glade Creek II Restoration Project Restoration Plan. NCEEP, Raleigh, NC.



APPENDIX 1. General Tables and Figures



 Hydrologic Unit Code (14)
 DMS Targeted Local Watershed
 Project Location

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

Directions to Site:
 From Charlotte, travel Interstate 77 North. Take Exit 83, US-21 Bypass toward Roaring Gap/Sparta. Travel on US-21 approximately 21 miles. Bear right onto Sheriff Road and travel Sheriff Road approximately 0.4 mile. Turn right onto Fox Ridge Road. The project site is located approximately 0.2 miles on the left side of Fox Ridge Road.

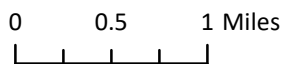


Figure 1 Project Vicinity Map
 Glade Creek II Restoration Project
 DMS Project No. 92343
 Monitoring Year 3 - 2018
 Allegheny County, NC

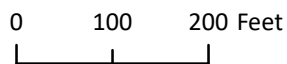
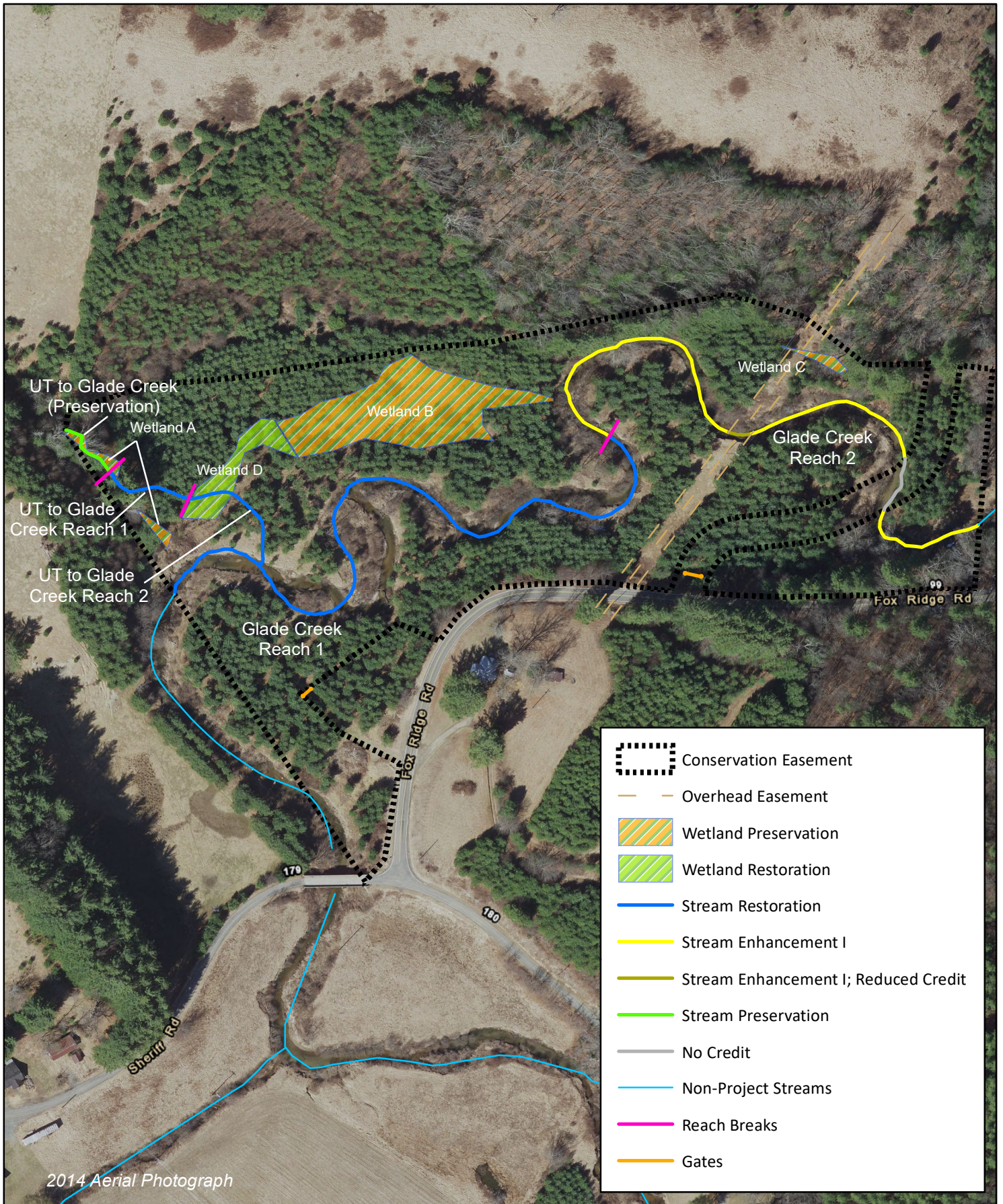


Figure 2 Project Component/Asset Map
 Glade Creek II Restoration Project
 DMS Project No. 92343
 Monitoring Year 3 - 2018
 Allegheny County, NC

Table 1. Project Components and Mitigation Credits

Glade Creek II Restoration Project
 DMS Project No.92343
 Monitoring Year 3 - 2018

Mitigation Credits								
	Stream		Riparian Wetland	Non-Riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	R	RE			
Totals	2,140.667	25.800	0.330	N/A	N/A	N/A		N/A
Project Components								
Reach ID	Existing Footage/Acreage	Approach	Restoration (R) or Restoration Equivalent (RE)	As-Built Stationing/Location	Restoration Footage/Acreage	Mitigation Ratio	Credits (SMU/WMU)	
STREAMS								
Glade Creek Reach 1	1200 LF	P2	Restoration (R)	10+00 - 21+70	1,170	1:1	1170.000	
Glade Creek Reach 2*	1074 LF	P2	Enhancement I (R)	21+70-26+41; 26+86-29+69; 30+59-32+60	1,090	1.5:1	651.667	
UT to Glade Creek Preservation	129 LF	N/A	Preservation (RE)	10+00 - 11+29	129	5:1	25.800	
UT to Glade Creek Reaches 1 and 2	197 LF	P1	Restoration (R)	11+29 - 14+48	319	1:1	319.000	
WETLANDS								
Wetland A, B, C	0.84 AC	N/A	Preservation (RE)	N/A	0.84	5:1	0.168	
Wetland D	0.16 AC	N/A	Restoration (R)	N/A	0.16	1:1	0.160	

Component Summation						
Restoration Level	Stream (LF)	Riparian Wetland (acres)		Non-Riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	1,489		0.16			
Preservation	129		0.84			
Enhancement I	1,090					
Enhancement II						
Creation						

* Stream Enhancement I credit reduced; 90 LF removed at break in conservation easement and 45 LF reduced by 50% at overhead power easement.

Table 2. Project Activity and Reporting History

Glade Creek II Restoration Project
 DMS Project No.92343
Monitoring Year 3 - 2018

Activity or Report	Data Collection Complete	Completion or Scheduled Delivery
Mitigation Plan	December 2008	December 2008
Mitigation Plan Addendum	January 2013	January 2013
Final Design - Construction Plans	January 2015	January 2015
Construction	December 2015 - April 2016	April 2016
Temporary S&E mix applied to entire project area ¹	December 2015 - April 2016	April 2016
Permanent seed mix applied to reach/segments ¹	December 2015 - April 2016	April 2016
Bare root and live stake plantings for reach/segments	February 2016	February 2016
Baseline Monitoring Document (Year 0)	January - May 2016	June 2016
Year 1 Monitoring	Stream Survey	October 2016
	Vegetation Survey	October 2016
Year 2 Monitoring	Stream Survey	May 2017
	Vegetation Survey	September 2017
Year 3 Monitoring	Stream Survey	June 2018
	Vegetation Survey	September 2018
Year 4 Monitoring	Stream Survey	2019
	Vegetation Survey	2019
Year 5 Monitoring	Stream Survey	2020
	Vegetation Survey	2020

¹Seed and mulch is added as each section of construction is completed.

Table 3. Project Contact Table

Glade Creek II Restoration Project
 DMS Project No.92343
Monitoring Year 3 - 2018

Designer Andrew Bick, PE, CFM	Confluence Engineering, PC 16 Broad Street Asheville, NC 28806
Construction Contractor	Carolina Environmental Contracting, Inc. PO Box 1905 Mt. Airy NC 27030
Planting Contractor	Keller Environmental 7921 Haymarket Lane Raleigh, NC 27615
Seeding Contractor	Carolina Environmental Contracting, Inc. PO Box 1905 Mt. Airy NC 27030
Seed Mix Sources	Carolina Environmental Contracting, Inc.
Wetland Enhancement Nursery Stock Suppliers Bare Roots Live Stakes Plugs	---
Monitoring Performers	Wildlands Engineering, Inc.
Monitoring, POC	Kirsten Gimbert 704.332.7754, ext. 110

--- Data not provided

Table 4. Project Information and Attributes

Glade Creek II Restoration Project
 DMS Project No.92343
 Monitoring Year 3 - 2018

Project Information				
Project Name	Glade Creek II Restoration Project			
County	Allegheny			
Project Area (acres)	44.50			
Project Coordinates (latitude and longitude)	36° 28' 37.0878"N, -81° 3' 42.7896"W			
Project Watershed Summary Information				
Physiographic Province	Blue Ridge Mountains			
River Basin	New River			
USGS Hydrologic Unit 8-digit	05050001			
USGS Hydrologic Unit 14-digit	05050001030020			
DWR Sub-basin	05-07-03			
Project Drainage Area (acres)	5,120			
Project Drainage Area Percentage of Impervious Area	<1%			
CGIA Land Use Classification	61% Forested, 35% Agriculture/Livestock, 3% Residential/Commercial			
Reach Summary Information				
Parameters	Glade Creek Reach 1	Glade Creek Reach 2	UT to Glade Creek Reach 1	UT to Glade Creek Reach 2
Length of reach (linear feet) - Post-Restoration	1,170	1,090	129	319
Drainage area (acres)	5,120		13	
NCDWR stream identification score	47		31	
NCDWR Water Quality Classification	C; Tr		-	-
Morphological Description (stream type)	C4		B4	
Underlying mapped soils	Suncook			
FEMA classification	no regulated floodplain		no regulated floodplain	
Native vegetation community	White Pine Plantation			
Percent composition exotic invasive vegetation - Post-Restoration	0%		0%	
Parameters	Wetlands A, B & C		Wetland D	
Size of Wetland (acres)	0.84		0.16	
Wetland Type	Riparian-Non Riverine			
Underlying mapped soils	Suncook			
Drainage class	frequently flooded, excessively drained			
Soil hydric status	N/A			
Source of Hydrology	hillside seep			
Restoration or Enhancement Method (hydrologic, vegetative, etc.)	Preservation		hydrologic/ vegetative	
Regulatory Considerations				
Regulation	Applicable?	Resolved?	Supporting Documentation	
Waters of the United States - Section 404	Yes	Yes	USACE Nationwide Permit No.27 and DWQ 401 Water Quality Certification No. 3885. Action ID # 2009-00589	
Waters of the United States - Section 401	Yes	Yes		
Division of Land Quality (Erosion and Sediment Control)	Yes	Yes	NPDES Construction Stormwater General Permit NCG010000	
Endangered Species Act	Yes	Yes	Glade Creek II Restoration Project; Ward Consulting determined "no affect" on Allegheny County listed endangered species	
Historic Preservation Act	Yes	Yes	No recommendations received.	
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	N/A	N/A	N/A	
FEMA Floodplain Compliance	N/A	N/A	The upper portion of Glade Creek is not currently mapped as a regulated flood zone	
Essential Fisheries Habitat	N/A	N/A	N/A	

--- Data not provided

Table 5. Monitoring Component Summary

Glade Creek II Restoration Project

DMS Project No.92343

Monitoring Year 3 - 2018

Parameter	Monitoring Feature	Quantity/ Length by Reach			Frequency
		Glade Creek	UT to Glade Creek	Wetlands	
Dimension	Riffle Cross Section	2	1	N/A	Annual
	Pool Cross Section	1	1	N/A	
Pattern	Pattern	Yes	Yes	N/A	See Footnote ¹
Profile	Longitudinal Profile	Yes	Yes	N/A	Annual
Substrate	Reach Wide (RW) / Riffle 100 Pebble Count (RF)	RW-1, RF 1	RW-1, RF-1	N/A	Annual
Stream Hydrology	Crest Gage	1	1	N/A	Semi-Annual
Wetland Hydrology	Groundwater Gages	N/A	N/A	Enhancement I (R)	Semi-Annual
Vegetation	CVS Level 2	6			Annual
Visual Assessment	All Streams	Y	Y	Y	Semi-Annual
Exotic and nuisance vegetation					Semi-Annual
Project Boundary					Semi-Annual
Reference Photos	Photographs	9			Annual

¹Pattern measurements will include sinuosity and meander width ratio and will be performed yearly. Measurements of radius of curvature will be monitored on newly constructed meanders for the first year only.

APPENDIX 2. Visual Assessment Data



Table 6a. Visual Stream Morphology Stability Assessment Table

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Glade Creek (2,260 LF)

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	Adjust % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	Aggradation			1	20	99%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	9	9			100%			
		3. Meander Pool Condition	Depth Sufficient	6			6			
	Length Appropriate		6	6			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	6	6			100%			
Thalweg centering at downstream of meander bend (Glide)		6	6	100%						
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion					4	127	94%	n/a
	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%	n/a	n/a	n/a
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	n/a	n/a	n/a
Totals					4	127	94%	n/a	n/a	n/a
3. Engineered Structures ¹	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	7	7			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	7	7			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	6	7			86%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	7	7			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

¹Excludes constructed riffles since they are evaluated in section 1.

Table 6b. Visual Stream Morphology Stability Assessment Table

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

UT to Glade Creek (448 LF)

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	Adjust % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	Aggradation			1	160	64%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	2	5			40%			
		3. Meander Pool Condition	Depth Sufficient	2			4			
	Length Appropriate		2	4			50%			
	4. Thalweg Position ²	Thalweg centering at upstream of meander bend (Run)	2	2			100%			
Thalweg centering at downstream of meander bend (Glide)		2	2	100%						
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion					0	0	100%	n/a
	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%	n/a	n/a	n/a
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	n/a	n/a	n/a
Totals					0	0	100%	n/a	n/a	n/a
3. Engineered Structures ¹	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	7	7			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	7	7			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	7	7			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	7	7			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	4	7			57%			

¹Excludes constructed riffles since they are evaluated in section 1.

²Applicable to only 2 meander bends because the other 2 meander bends are being impacted by sedimentation and the stream has braided.

Table 7. Vegetation Condition Assessment Table

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Planted Acreage 6.4

Vegetation Category	Definitions	Mapping Threshold (acres)	Number of Polygons	Combined Acreage	% of Planted Acreage
Bare Areas	Very limited cover of both woody and herbaceous material	0.1	6	0.05	0.8%
Low Stem Density Areas ¹	Woody stem densities clearly below target levels based on MY3, 4, 5, or 7 stem count criteria.	0.1	1	0.025	0.4%
			Total	7	1.1%
Areas of Poor Growth Rates or Vigor ¹	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25	0	0.0	0%
			Cumulative Total	7	1.1%

Easement Acreage 12.8

Vegetation Category	Definitions	Mapping Threshold (SF)	Number of Polygons	Combined Acreage	% of Planted Acreage
Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000	2	0.03	0.2%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	0	0	0%

¹Acreage calculated from vegetation plots monitored for site.

Stream Photographs



Photo Point 1 – view upstream UT Glade Creek (7/23/2018)



Photo Point 1 – view downstream UT Glade Creek (7/23/2018)



Photo Point 2 – view upstream Glade Creek (7/23/2018)



Photo Point 2 – view downstream Glade Creek (7/23/2018)



Photo Point 2 – view upstream UT Glade Creek (7/23/2018)



Photo Point 3 – view upstream Glade Creek (7/23/2018)



Photo Point 3 – view downstream Glade Creek (7/23/2018)



Photo Point 4 – view upstream Glade Creek (7/23/2018)



Photo Point 4 – view downstream Glade Creek (7/23/2018)



Photo Point 5 – view upstream Glade Creek (7/23/2018)



Photo Point 5 – view downstream Glade Creek (7/23/2018)



Photo Point 6 – view upstream Glade Creek (7/23/2018)



Photo Point 6 – view downstream Glade Creek (7/23/2018)



Photo Point 7 – view upstream Glade Creek (7/23/2018)



Photo Point 7 – view downstream Glade Creek (7/23/2018)



Photo Point 8 – view upstream Glade Creek (7/23/2018)



Photo Point 8 – view downstream Glade Creek (7/23/2018)



Photo Point 9 – view upstream Glade Creek (7/23/2018)



Photo Point 9 – view downstream Glade Creek (7/23/2018)

Vegetation Photographs



Vegetation Plot 1 - (9/10/2018)



Vegetation Plot 2 - (9/10/2018)



Vegetation Plot 3 - (9/10/2018)



Vegetation Plot 4 - (9/10/2018)



Vegetation Plot 5 - (9/10/2018)



Vegetation Plot 6 - (9/10/2018)

APPENDIX 3. Vegetation Plot Data

Table 8. Vegetation Plot Criteria Attainment

Glade Creek II Restoration Project
 DMS Project No. 92343
Monitoring Year 3 - 2018

Plot	MY3 Success Criteria Met (Y/N)	Tract Mean
1	N	83%
2	Y	
3	Y	
4	Y	
5	Y	
6	Y	

Table 9. CVS Vegetation Plot Metadata

Glade Creek II Restoration Project
 DMS Project No. 92343
Monitoring Year 3 - 2018

Report Prepared By	Mimi Caddell
Date Prepared	11/8/2018 13:55
Database Name	cvs-eep-entrytool-v2.5.0 Glade MY3.mdb
Database Location	Q:\ActiveProjects\005-02161 Glade Creek II Monitoring\Monitoring\Monitoring Year 3\Vegetation Assessment
Computer Name	MIMI-PC
File Size	51773440
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT-----	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY-----	
Project Code	92343
Project Name	Glade Creek II Restoration Project
Description	Glade Creek II Restoration Project
Required Plots (calculated)	6
Sampled Plots	6

Table 10. Planted and Total Stem Counts

Glade Creek II Restoration Project
 DMS Project No. 92343
 Monitoring Year 3 - 2018

Scientific Name	Common Name	Species Type	Current Plot Data (MY3 2018)																	
			92343-WEI-0001			92343-WEI-0002			92343-WEI-0003			92343-WEI-0004			92343-WEI-0005			92343-WEI-0006		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
<i>Acer rubrum</i>	Red Maple	Tree	3	3	3													20		
<i>Alnus serrulata</i>	Tag Alder	Shrub Tree				1	1	16				3	3	5	1	1	21	7	7	32
<i>Carpinus caroliniana</i>	American Hornbeam	Shrub Tree				1	1	1	1	1	1	1	1	1				1	1	1
<i>Cercis canadensis</i>	Eastern Redbud	Shrub Tree																		
<i>Cornus amomum</i>	Silky Dogwood	Shrub Tree									2									1
<i>Diospyros virginiana</i>	American Persimmon	Tree				2	2	2				2	2	2	3	3	3	1	1	1
<i>Fraxinus pennsylvanica</i>	Green Ash	Tree	2	2	2															
<i>Hamamelis virginiana</i>	Witch-hazel	Shrub Tree				4	4	4	1	1	1	2	2	2	3	3	3			
<i>Liriodendron tulipifera</i>	Tulip Poplar	Tree				3	3	3	10	10	11	2	2	2	4	4	4	2	2	2
<i>Nyssa sylvatica</i>	Black Gum	Tree				1	1	1	1	1	1	2	2	2						
<i>Platanus occidentalis</i>	Sycamore	Tree	1	1	1	3	3	3	5	5	5	2	2	2	3	3	3			
<i>Sambucus canadensis</i>	Common Elderberry	Shrub Tree										1	1	1	2	2	2			
Stem count			6	6	6	15	15	30	18	18	21	15	15	17	16	16	56	11	11	37
size (ares)			1			1			1			1			1			1		
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02		
Species count			3	3	3	7	7	7	5	5	6	8	8	8	6	6	7	4	4	5
Stems per ACRE			243	243	243	607	607	1214	728	728	850	607	607	688	647	647	2266	445	445	1497

Scientific Name	Common Name	Species Type	Annual Summary											
			MY3 (2018)			MY2 (2017)			MY1 (2016)			MY0 (2016)		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
<i>Acer rubrum</i>	Red Maple	Tree	3	3	23	3	3	4	3	3	3	6	6	6
<i>Alnus serrulata</i>	Tag Alder	Shrub Tree	12	12	74	12	12	57	13	13	20	14	14	14
<i>Carpinus caroliniana</i>	American Hornbeam	Shrub Tree	4	4	4	4	4	4	4	4	4	4	4	4
<i>Cercis canadensis</i>	Eastern Redbud	Shrub Tree									1			
<i>Cornus amomum</i>	Silky Dogwood	Shrub Tree			3									
<i>Diospyros virginiana</i>	American Persimmon	Tree	8	8	8	9	9	9	10	10	10	11	11	11
<i>Fraxinus pennsylvanica</i>	Green Ash	Tree	2	2	2	2	2	2	2	2	2	3	3	3
<i>Hamamelis virginiana</i>	Witch-hazel	Shrub Tree	10	10	10	10	10	10	10	10	10	10	10	10
<i>Liriodendron tulipifera</i>	Tulip Poplar	Tree	21	21	22	23	23	23	24	24	24	28	28	28
<i>Nyssa sylvatica</i>	Black Gum	Tree	4	4	4	4	4	4	6	6	6	7	7	7
<i>Platanus occidentalis</i>	Sycamore	Tree	14	14	14	14	14	14	14	14	14	22	22	22
<i>Sambucus canadensis</i>	Common Elderberry	Shrub Tree	3	3	3	5	5	5	5	5	5	5	5	5
Stem count			81	81	167	86	86	132	91	91	99	110	110	110
size (ares)			6			6			6			6		
size (ACRES)			0.15			0.15			0.15			0.15		
Species count			10	10	11	10	10	10	10	10	11	10	10	10
Stems per ACRE			546	546	1126	580	580	890	614	614	668	742	741.9	741.9

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%
- Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
 P-all: Number of planted stems including live stakes
 T: Total stems

APPENDIX 4. Morphological Summary Data and Plots

Table 11. Baseline Stream Data Summary

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design				As-Built/Baseline			
		Glade Creek		UT to Glade Creek		Glade Creek Restoration		UT to Little Pine Trib 1		Glade Creek		UT to Glade Creek		Glade Creek		UT to Glade Creek	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Shallow																	
Bankfull Width (ft)	N/A	17.7	38.5	5.2	9.9	36.3	48.8	6.2	11.1	33.0		5.4		34.6	37.4	5.3	
Floodprone Width (ft)		47	115	7	12	69	118	14	46	99	165	22	33	106	111	61	
Bankfull Mean Depth		2.6	2.1	0.3	0.5	0.9	1.3	0.9	0.5	2.3		0.3		1.9	2.2	0.5	
Bankfull Max Depth		2.9	4.1	0.5	0.8	1.9	1.9	0.8	1.6	3.0		0.4		2.9	3.2	0.9	
Bankfull Cross-sectional Area (ft ²)		46.9	79.0	2.1	5.1	45.6	64.1	3.8	5.1	76.5		1.7		70.2	77.1	2.4	
Width/Depth Ratio		6.7	18.8	17.3	26.8	40.3	37.2	6.9	24.2	14.2		17.4		15.5	19.9	11.8	
Entrenchment Ratio		2.7	3.1	1.2	1.5	1.9	2.4	2.3	4.1	3.0	5.0	4.0	6.0	2.8	3.2	11.4	
Bank Height Ratio		1.1	1.7	0.0	0.0	1.0	1.0	1.0	2.1	1.0		1.0		1.0		1.0	
D50 (mm)		28.0	31.0	7.0	7.0	44.0	47.0	7.0	7.0	28.0	31.0	7.0		90.0		32.0	
Riffle Length (ft)		N/A					---		---		---		---		33	57	6.8
Riffle Slope (ft/ft)					---		---		---		---		0.0087	0.0271	0.0193	0.0964	
Pool Length (ft)					---		---		5		---		64.0	197.8	8.8	32.9	
Pool Max Depth (ft)	4.4		6.6	0.8		5.0		0.7	1.5	3.3	4.1	0.8	1.0	3.8	5.9	1.5	
Pool Spacing (ft)					---		---		---		---		107	353	33.0	70.0	
Pool Volume (ft ³)					---		---		---		---						
Pattern																	
Channel Beltwidth (ft)	N/A	60	240	7	16	---	---	19	26	112	205	17		155	282	75.0	
Radius of Curvature (ft)		21	114	---	---	---	---	30		59.0	99.0	30		59.0	99.0	30	
Rc:Bankfull Width (ft/ft)		1.2	3.0	---	---	---	---	3.2	5.9	1.8	3.0	5.5-6.0		1.8	3.0	5.5-6.0	
Meander Length (ft) ¹						---		---		---		---		230	425	150	
Meander Width Ratio		3.4	6.2	1.3	1.6	---	---	2.5	3.5	3.4	6.2	3.1	7.0	4.5	7.5	3.1	7.0
Substrate, Bed and Transport Parameters																	
Ri%/Ru%/P%/G%/S%	N/A																
SC%/Sa%/G%/C%/B%/Be%																	
d16/d35/d50/d84/d95/d100		-/3.1/8.6/11.0/16.0		---		-/0.1/0.2/0.5/4.0/8.0		0.1/3.0/8.8/77/180/-						1/26.47/42.3/128/180/>2048		0.11/0.63/13.3/176/241.4/>204	
Reach Shear Stress (Competency) lb/ft ²		---		---						0.48		0.52	0.82	0.11	0.12		
Max part size (mm) mobilized at bankfull																	
Stream Power (Capacity) W/m ²																	
Additional Reach Parameters																	
Drainage Area (SM)	N/A	8.00		0.02		4.60		0.05		8.00		0.02		8.00		0.02	
Watershed Impervious Cover Estimate (%)		---		---		---		---		---		---		---		---	
Rosgen Classification		E4/C4		F4/B4		C4		C4/B4		C4		B4		C4		B4	
Bankfull Velocity (fps)		3.8	5.3	3.8	4.9	3.1	4.4	4.5	6.1	3.9	4.7	---		---			
Bankfull Discharge (cfs)		250	300	8	25	200		23		300		8		---			
Q-NFF regression (2-yr)		493		5		352											
Q-USGS extrapolation (1.2-yr)		561		4		335											
Q-Mannings		213	320	8		153	228										
Valley Length (ft)		---		---		---		---		1,322		280		1,322		280	
Channel Thalweg Length (ft)		1200		197		---		---		2,120		197		2,120		326	
Sinuosity		1.68		1.04		1.18		1.09		1.68		1.14		1.60		1.16	
Water Surface Slope (ft/ft) ²		0.0038		0.048		0.0049		0.0473		0.0038		0.0440		0.0031		0.0397	
Bankfull Slope (ft/ft)		---		---		---		---		---		---		0.0031		0.0326	

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

¹Meander Wave Length was adjusted in the MY2 report.

²Channel was dry during survey, slope was calculated using channel thalweg

Table 12. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Dimension and Substrate	Cross-Section 1, Glade Creek (Riffle)						Cross-Section 2, Glade Creek (Riffle)						Cross-Section 3, Glade Creek (Pool)					
	Base	MY1	MY2	MY3 ¹	MY4	MY5	Base	MY1	MY2	MY3 ¹	MY4	MY5	Base	MY1	MY2	MY3 ¹	MY4	MY5
bankfull elevation (ft)	2571.8	2571.8	2571.8	2572.0			2569.7	2569.7	2569.7	2570.0			2569.8	2569.8	2569.8	2569.9		
low bank elevation (ft)	2571.8	2571.8	2571.3	2571.9			2569.7	2569.7	2569.8	2570.1			2569.8	2569.8	2569.6	2569.9		
Bankfull Width (ft)	37.4	34.4	38.7	38.6			34.6	35.0	36.2	35.5			31.9	30.0	32.5	32.7		
Floodprone Width (ft)	106	106	102	106			111	110	93	110			---	---	---	---		
Bankfull Mean Depth (ft)	1.9	1.9	1.8	1.8			2.2	2.2	2.1	2.2			2.8	2.9	2.8	2.7		
Bankfull Max Depth (ft)	2.9	2.9	2.8	3.1			3.2	3.2	3.2	3.4			4.2	4.2	4.7	4.7		
Bankfull Cross Sectional Area (ft ²)	70.2	66.9	70.2	70.2			77.1	78.0	77.6	77.1			89.0	88.4	91.5	89.0		
Bankfull Width/Depth Ratio	19.9	17.7	21.3	21.3			15.5	15.7	16.9	16.3			11.5	10.2	11.6	12.0		
Bankfull Entrenchment Ratio	2.8	3.1	2.6	2.7			3.2	3.2	2.6	3.1			---	---	---	---		
Bankfull Bank Height Ratio	1.0	1.0	<1.0	1.0			1.0	1.0	1.0	1.0			---	---	---	---		
Dimension and Substrate	Cross-Section 4, UT to Glade Creek (Pool)						Cross-Section 5, UT to Glade Creek (Riffle)											
	Base	MY1	MY2	MY3 ²	MY4	MY5	Base	MY1	MY2	MY3 ¹	MY4	MY5						
bankfull elevation (ft)	2574.0	2574.0	2574.0	2574.3			2573.6	2573.6	2573.6	2573.7								
low bank elevation (ft)	2574.3	2574.3	2574.1	2574.3			2573.6	2573.5	2573.5	2573.5								
Bankfull Width (ft)	5.3	7.1	7.0	6.8			5.3	6.1	5.9	6.4								
Floodprone Width (ft)	---	---	---	---			61	61	61	61								
Bankfull Mean Depth (ft)	0.9	0.8	0.7	0.4			0.5	0.4	0.5	0.4								
Bankfull Max Depth (ft)	1.5	1.3	1.5	0.7			0.9	0.8	1.0	0.9								
Bankfull Cross Sectional Area (ft ²)	4.7	5.5	4.9	2.6			2.4	2.7	3.1	2.4								
Bankfull Width/Depth Ratio	6.0	9.6	10.1	18.0			11.8	13.5	11.4	17.2								
Bankfull Entrenchment Ratio	---	---	---	---			11.4	10.0	10.3	9.5								
Bankfull Bank Height Ratio	---	---	---	---			1.0	1.0	1.0	<1.0								

---: not applicable

¹Prior to MY3, bankfull dimensions were calculated using a fixed bankfull elevation. For MY3 through MY7 bankfull elevation is calculated using a fixed Abkf as described in the Standard Measurement of the BHR Monitoring Parameter provided by NCIRT and NCDMS (9/2018).

²For cross-section 4 dimensions in MY3, the bankfull elevation was not calculated using Abkf because of aggradation in the channel therefore the low bank elevation was used.

Table 13a. Monitoring Data - Stream Reach Data Summary
 Glade Creek II Restoration Project
 DMS Project No. 92343
 Monitoring Year 3 - 2018

Glade Creek

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle												
Bankfull Width (ft)	34.6	37.4	34.4	35.0	36.2	38.7	35.50	38.60				
Floodprone Width (ft)	106	111	97	106	93.3	102.0	106	110				
Bankfull Mean Depth	1.9	2.2	1.9	2.2	1.8	2.1	1.8	2.2				
Bankfull Max Depth	2.9	3.2	2.9	3.2	2.8	3.2	3.1	3.4				
Bankfull Cross-sectional Area (ft ²)	70.2	77.1	66.9	78.0	70.2	77.6	70.2	77.1				
Width/Depth Ratio	15.5	19.9	15.7	17.7	16.9	21.3	16.3	21.3				
Entrenchment Ratio	2.8	3.2	2.8	3.1	2.6		2.7	3.1				
Bank Height Ratio	1.0		1.0		1.0		1.0					
D50 (mm)	90.0		34.3		39.8	47.7	46.5	52.5				
Profile												
Riffle Length (ft)	33	57	20	57	20	85	19	80				
Riffle Slope (ft/ft)	0.0087	0.0271	0.0065	0.0235	0.0011	0.0181	0.0012	0.0162				
Pool Length (ft)	64	198	66	190	62	222	56	240				
Pool Max Depth (ft)	3.8	5.9	4.2		4.4	5.4	3.7	5.8				
Pool Spacing (ft)	107	353	91	384	90	337	86	391				
Pool Volume (ft ³)												
Pattern¹												
Channel Beltwidth (ft)	155	282	155	280	155	283	155	283				
Radius of Curvature (ft)	59.0	99.0	59.0	99.0	59.0	99.0	59.0	99.0				
Rc:Bankfull Width (ft/ft)	1.8	3.0	1.7	2.8	1.6	2.6	1.6	2.6				
Meander Wave Length (ft)	230	425	227	435	216	445	216	445				
Meander Width Ratio	4.5	7.5	4.5	8.0	4.2	7.3	4.2	7.3				
Additional Reach Parameters												
Rosgen Classification	C4		C4		C4		C4					
Channel Thalweg Length (ft)	2,120		2,120		2,120		2,120					
Sinuosity (ft)	1.60		1.60		1.60		1.60					
Water Surface Slope (ft/ft)	0.0031		0.0030		0.0027		0.0027					
Bankfull Slope (ft/ft)	0.0031		0.0031		0.0030		0.0025					
Ri%/Ru%/P%/G%/S%												
SC%/Sa%/G%/C%/B%/Be%												
d16/d35/d50/d84/d95/d100	1/26.47/42.3/128/180/>2048		3.35/19.49/30.4/97.6/137/256.0		3.4/12.5/29.6/75.6/115.5/362.0		0.3/11.0/27.6/109.5/172.5/512.0					
% of Reach with Eroding Banks	0%		0%		2%		6%					

¹Meander Wave Length was adjusted for MY0 and MY1 in the MY2 report.

Table 13b. Monitoring Data - Stream Reach Data Summary

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

UT to Glade Creek

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle												
Bankfull Width (ft)	5.3		6.1		5.9		6.4					
Floodprone Width (ft)	61		32.3				61.0					
Bankfull Mean Depth	0.5		0.4		0.5		0.4					
Bankfull Max Depth	0.9		0.8		1.0		0.9					
Bankfull Cross-sectional Area (ft ²)	2.4		2.7		3.1		2.4					
Width/Depth Ratio	11.8		13.5		11.4		17.2					
Entrenchment Ratio	11.4		5.3		10.3		9.5					
Bank Height Ratio	1.0		1.0		1.0		0.7					
D50 (mm)	32.0		22.6		0.7		Silt/Clay					
Profile												
Riffle Length (ft)	6.8	32.6	17.3	51.4	5.0	42.0	3.0	24.8				
Riffle Slope (ft/ft)	0.0193	0.0964	0.0118	0.0866	0.0148	0.1416	0.0170	0.1410				
Pool Length (ft)	8.8	32.9	15.6	32.6	3.0	5.0	5.0	14.7				
Pool Max Depth (ft)	1.5		1.3		1.1	2.4	1.0	2.5				
Pool Spacing (ft)	33.0	70.0	38.8	84.0	16	99	13	68				
Pool Volume (ft ³)												
Pattern												
Channel Beltwidth (ft)	75.0		75.0		75.0		75.0					
Radius of Curvature (ft)	30		30		30		30					
Rc:Bankfull Width (ft/ft)	5.5-6.0		5.5-6.0		5.5-6.0		5.5-6.0					
Meander Wave Length (ft)	150		150		150		150					
Meander Width Ratio	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0				
Additional Reach Parameters												
Rosgen Classification	B4		B4		B4		B4					
Channel Thalweg Length (ft)	326		326		326		326					
Sinuosity (ft)	1.16		1.16		1.16		1.16					
Water Surface Slope (ft/ft)	0.0397		0.0372		0.0323		0.0342					
Bankfull Slope (ft/ft)	0.0326		0.0317		0.0318		0.0362					
Ri%/Ru%/P%/G%/S%												
SC%/Sa%/G%/C%/B%/Be%												
d16/d35/d50/d84/d95/d100	0.11/0.63/13.3/176/241.4/>2048		0.19/4.65/11.9/124.6/163.3/256		0.2/0.4/0.8/111.2/151.8/256.0		SC/SC/0.2/101.9/128.0/180.0					
% of Reach with Eroding Banks	0%		0%		0%		0%					

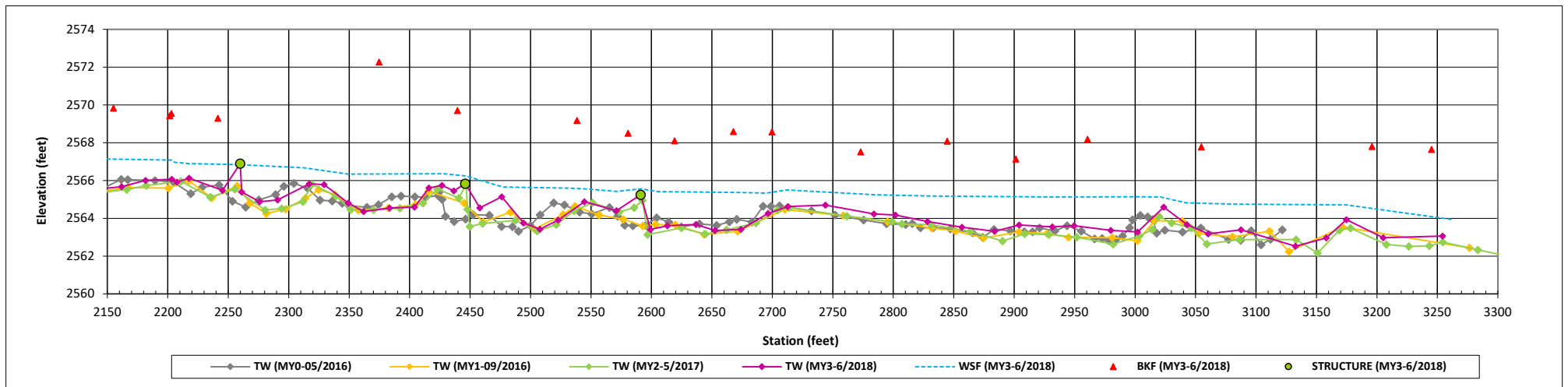
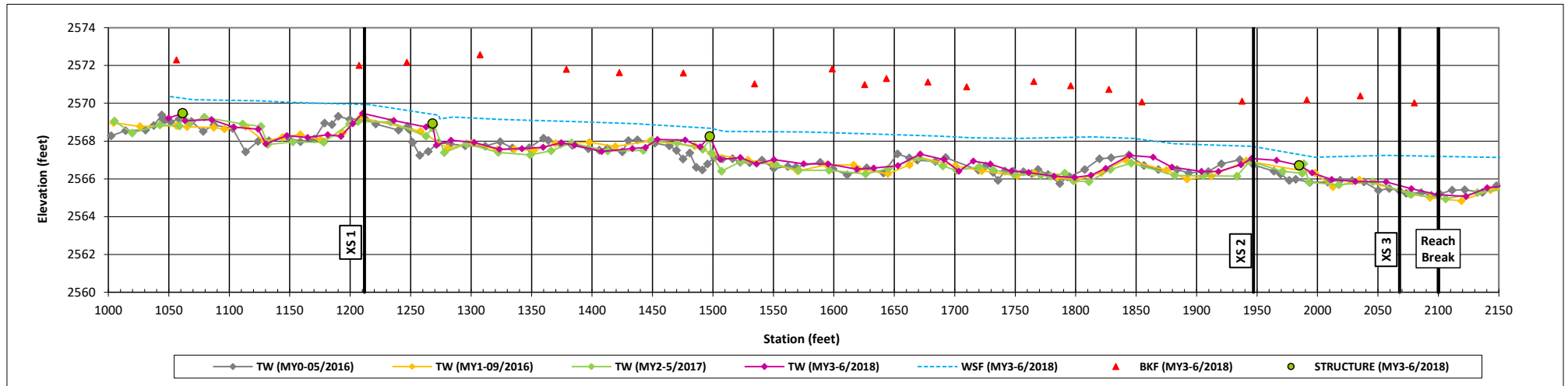
Longitudinal Profile Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Glade Creek Reach 1 and 2 (STA 10+00 - STA 31+20)



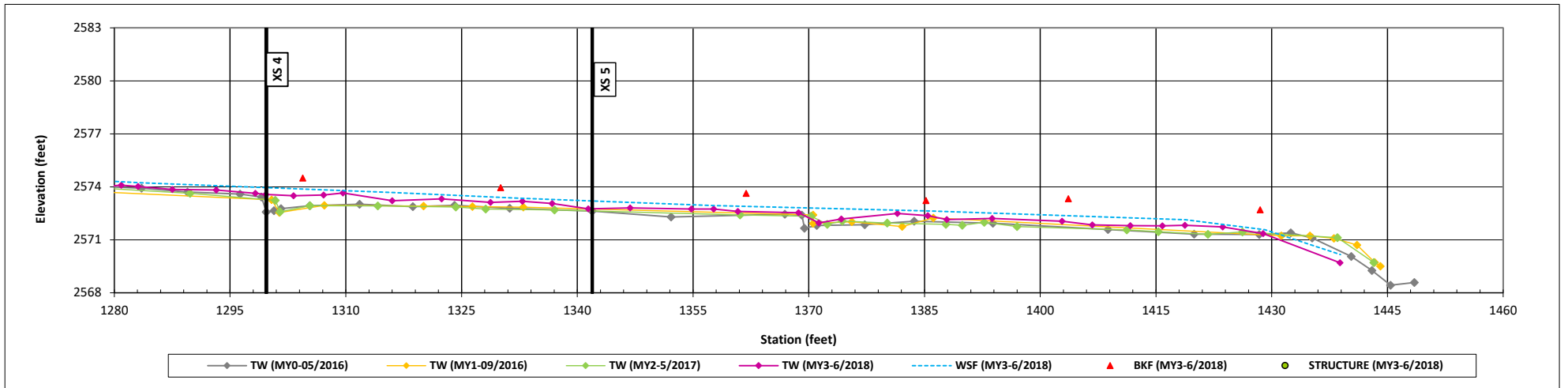
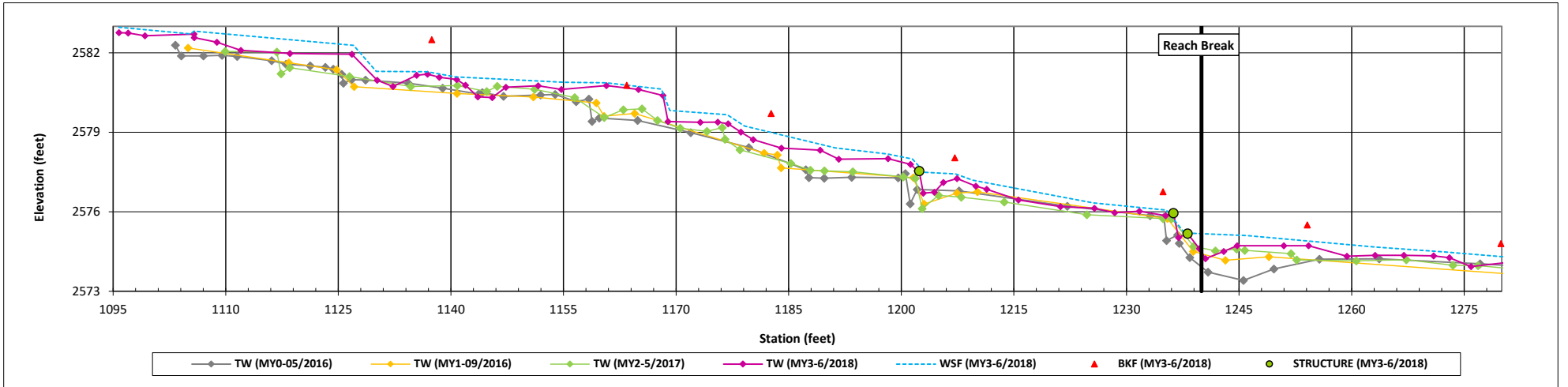
Longitudinal Profile Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

UT Glade Creek (STA 11+29 - STA 14+48)



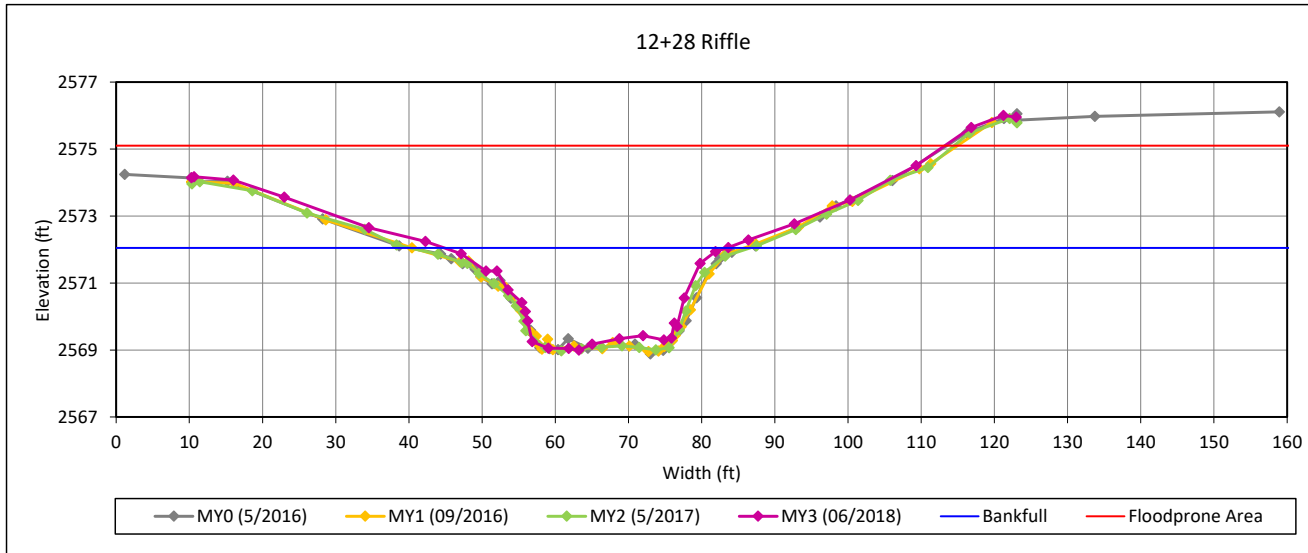
Cross-Section Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Cross-Section 1 - Glade Creek



Bankfull Dimensions

70.2	x-section area (ft.sq.)
38.6	width (ft)
1.8	mean depth (ft)
3.1	max depth (ft)
40.1	wetted perimeter (ft)
1.8	hydraulic radius (ft)
21.3	width-depth ratio
106	W flood prone area (ft)
2.7	entrenchment ratio
1.0	low bank height ratio

Survey Date: 6/2018

Field Crew: Wildlands Engineering



View Downstream

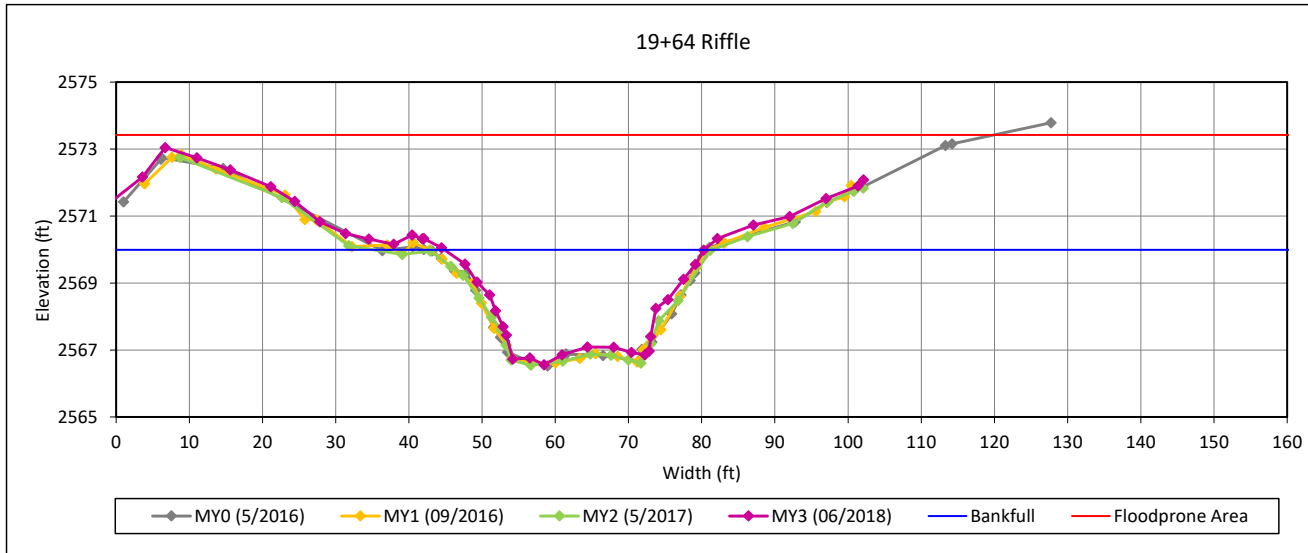
Cross-Section Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Cross-Section 2 - Glade Creek



Bankfull Dimensions

77.1	x-section area (ft.sq.)
35.5	width (ft)
2.2	mean depth (ft)
3.4	max depth (ft)
37.1	wetted perimeter (ft)
2.1	hydraulic radius (ft)
16.3	width-depth ratio
110.0	W flood prone area (ft)
3.1	entrenchment ratio
1.0	low bank height ratio

Survey Date: 6/2018

Field Crew: Wildlands Engineering



View Downstream

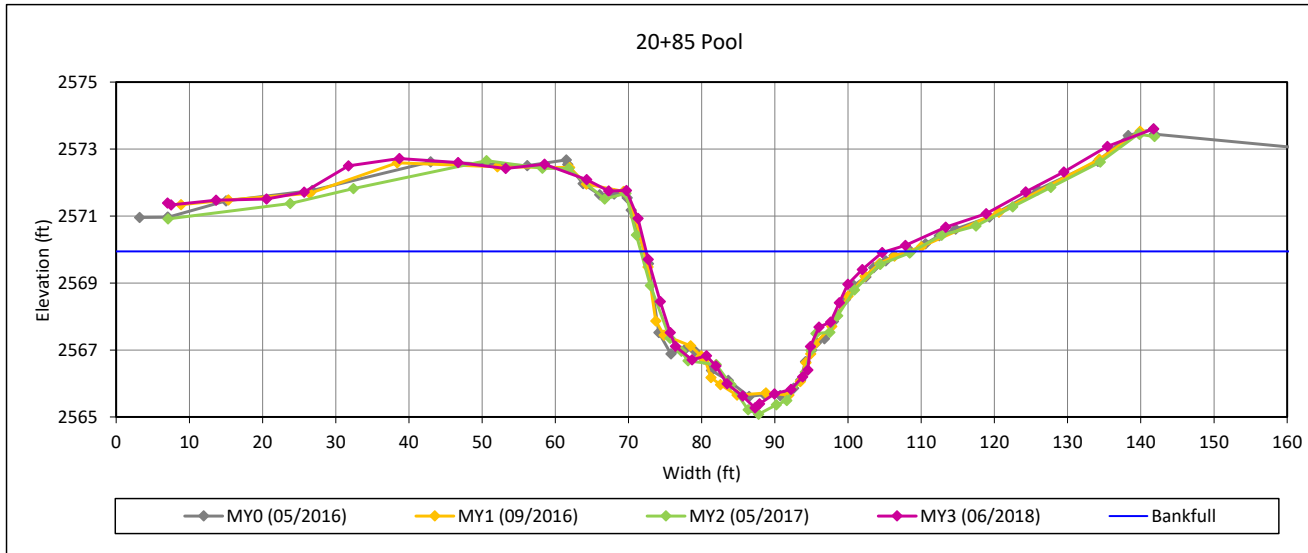
Cross-Section Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Cross-Section 3 - Glade Creek



Bankfull Dimensions

89.0	x-section area (ft.sq.)
32.7	width (ft)
2.7	mean depth (ft)
4.7	max depth (ft)
34.9	wetted perimeter (ft)
2.5	hydraulic radius (ft)
12.0	width-depth ratio

Survey Date: 6/2018

Field Crew: Wildlands Engineering



View Downstream

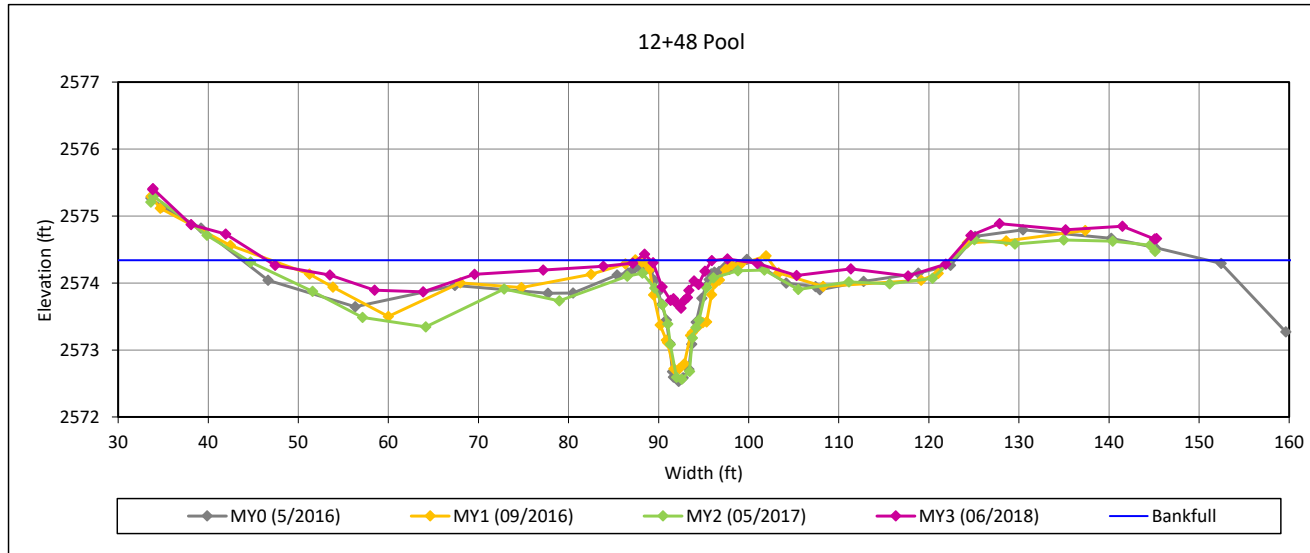
Cross-Section Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Cross-Section 4 - UT to Glade Creek



Bankfull Dimensions

2.6	x-section area (ft.sq.)
6.8	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
7.0	wetted perimeter (ft)
0.4	hydraulic radius (ft)
18.0	width-depth ratio

Survey Date: 6/2018

Field Crew: Wildlands Engineering



View Downstream

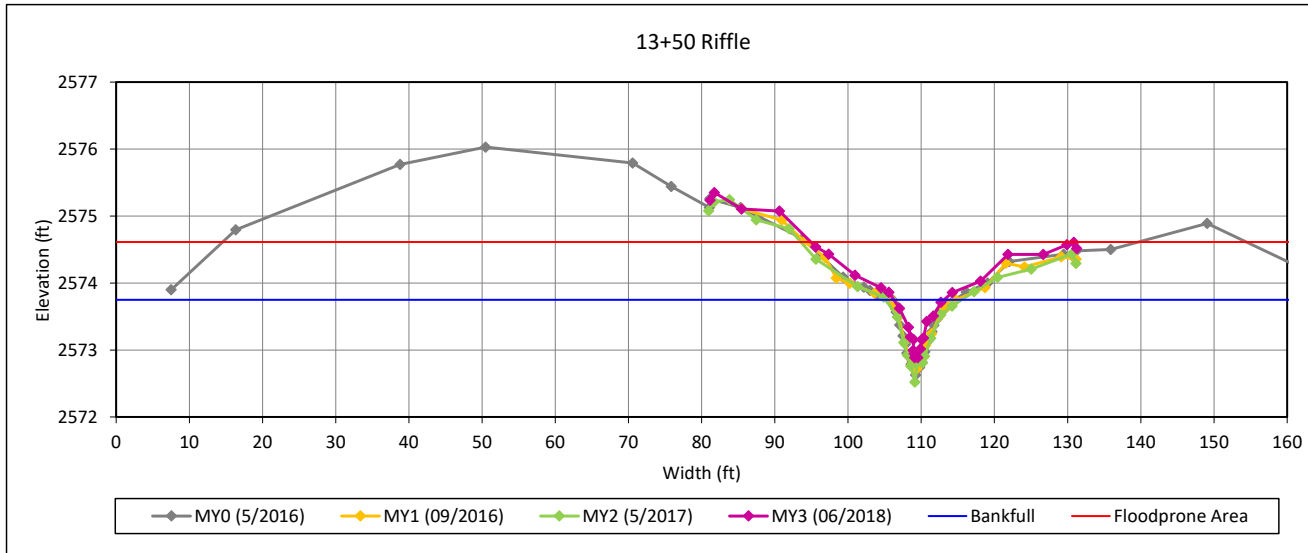
Cross-Section Plots

Glade Creek II Restoration Project

DMS Project No. 92343

Monitoring Year 3 - 2018

Cross-Section 5 - UT to Glade Creek



Bankfull Dimensions

2.4	x-section area (ft.sq.)
6.4	width (ft)
0.4	mean depth (ft)
0.9	max depth (ft)
6.9	wetted perimeter (ft)
0.3	hydraulic radius (ft)
17.2	width-depth ratio
61.0	W flood prone area (ft)
9.5	entrenchment ratio
0.7	low bank height ratio

Survey Date: 6/2018

Field Crew: Wildlands Engineering



View Downstream

Reachwide and Cross-Section Pebble Count Plots

Glade Creek II Restoration Project

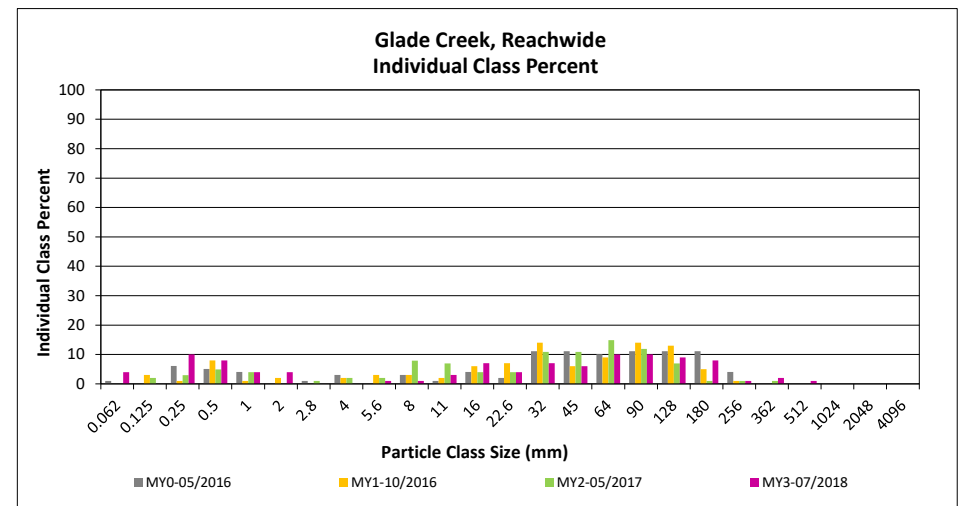
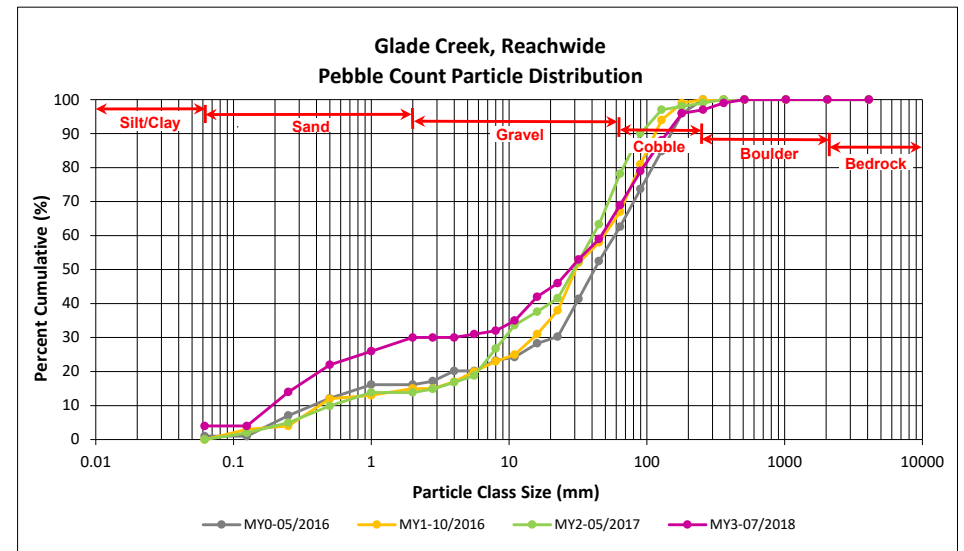
DMS Project No. 92343

Monitoring Year 3 - 2018

Glade Creek, Reachwide

Particle Class		Diameter (mm)		Particle Count			Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062		4	4	4	4
SAND	Very fine	0.062	0.125					4
	Fine	0.125	0.250		10	10	10	14
	Medium	0.25	0.50	1	7	8	8	22
	Coarse	0.5	1.0		4	4	4	26
	Very Coarse	1.0	2.0	2	2	4	4	30
GRAVEL	Very Fine	2.0	2.8					30
	Very Fine	2.8	4.0					30
	Fine	4.0	5.6	1		1	1	31
	Fine	5.6	8.0		1	1	1	32
	Medium	8.0	11.0	2	1	3	3	35
	Medium	11.0	16.0	4	3	7	7	42
	Coarse	16.0	22.6	4		4	4	46
	Coarse	22.6	32	4	3	7	7	53
	Very Coarse	32	45	5	1	6	6	59
	Very Coarse	45	64	9	1	10	10	69
COBBLE	Small	64	90	5	5	10	10	79
	Small	90	128	7	2	9	9	88
	Large	128	180	6	2	8	8	96
	Large	180	256		1	1	1	97
BOULDER	Small	256	362		2	2	2	99
	Small	362	512		1	1	1	100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
Total				50	50	100	100	100

Reachwide Channel materials (mm)	
D ₁₆ =	0.3
D ₃₅ =	11.0
D ₅₀ =	27.6
D ₈₄ =	109.5
D ₉₅ =	172.5
D ₁₀₀ =	512.0



Reachwide and Cross-Section Pebble Count Plots

Glade Creek II Restoration Project

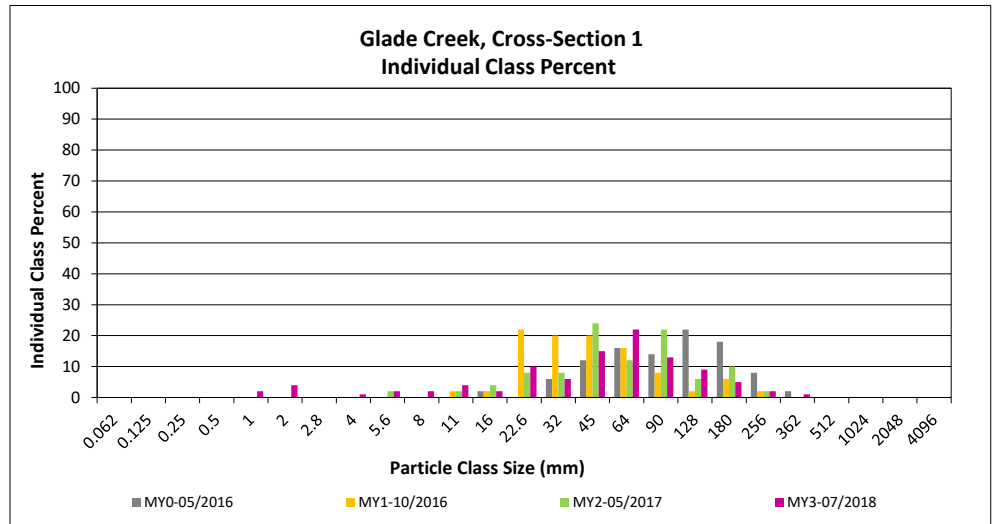
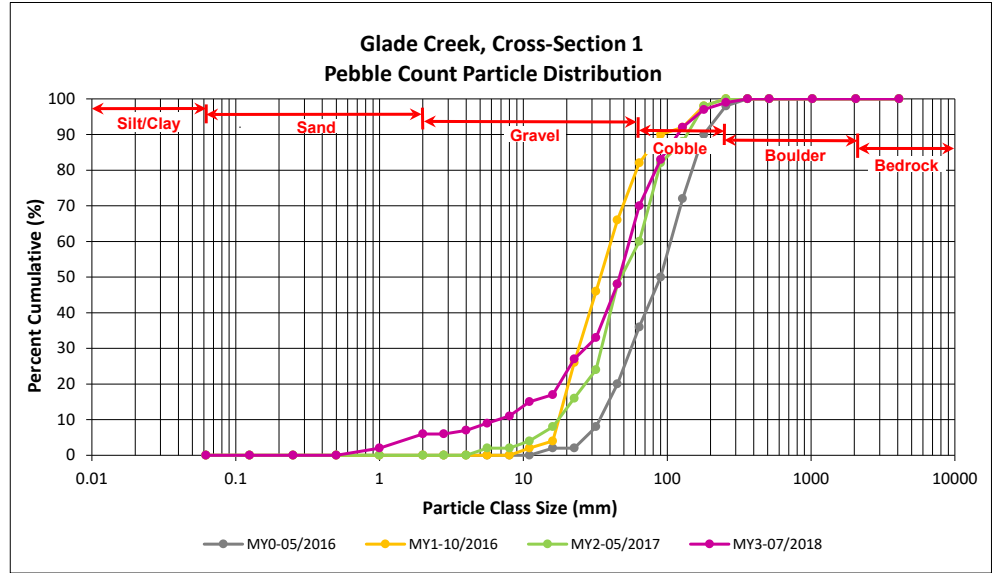
DMS Project No. 92343

Monitoring Year 3 - 2018

Glade Creek, Cross-Section 1

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062			0
SAND	Very fine	0.062	0.125			0
	Fine	0.125	0.250			0
	Medium	0.25	0.50			0
	Coarse	0.5	1.0	2	2	2
	Very Coarse	1.0	2.0	4	4	6
GRAVEL	Very Fine	2.0	2.8			6
	Very Fine	2.8	4.0	1	1	7
	Fine	4.0	5.6	2	2	9
	Fine	5.6	8.0	2	2	11
	Medium	8.0	11.0	4	4	15
	Medium	11.0	16.0	2	2	17
	Coarse	16.0	22.6	10	10	27
	Coarse	22.6	32	6	6	33
	Very Coarse	32	45	15	15	48
	Very Coarse	45	64	22	22	70
COBBLE	Small	64	90	13	13	83
	Small	90	128	9	9	92
	Large	128	180	5	5	97
	Large	180	256	2	2	99
BOULDER	Small	256	362	1	1	100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
Total				100	100	100

Cross-Section 1 Channel materials (mm)	
D ₁₆ =	13.3
D ₃₅ =	33.5
D ₅₀ =	46.5
D ₈₄ =	93.6
D ₉₅ =	157.1
D ₁₀₀ =	362.0



Reachwide and Cross-Section Pebble Count Plots

Glade Creek II Restoration Project

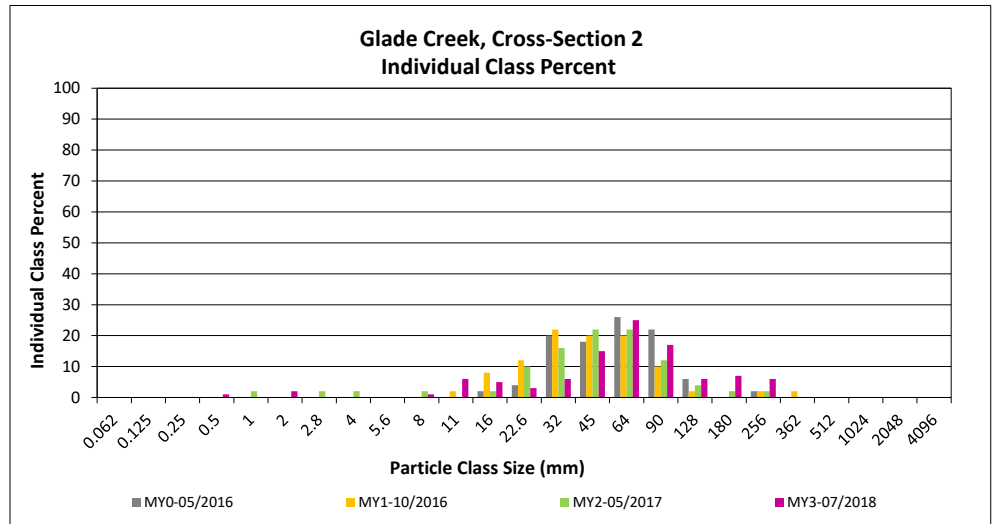
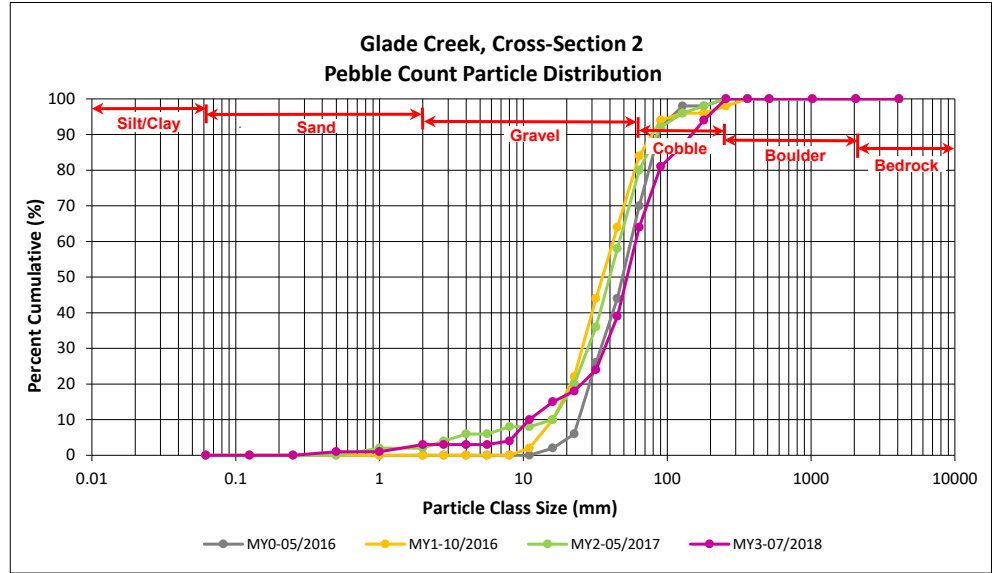
DMS Project No. 92343

Monitoring Year 3 - 2018

Glade Creek, Cross-Section 2

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
<i>SILT/CLAY</i>	Silt/Clay	0.000	0.062			0
<i>SAND</i>	Very fine	0.062	0.125			0
	Fine	0.125	0.250			0
	Medium	0.25	0.50	1	1	1
	Coarse	0.5	1.0			1
	Very Coarse	1.0	2.0	2	2	3
<i>GRAVEL</i>	Very Fine	2.0	2.8			3
	Very Fine	2.8	4.0			3
	Fine	4.0	5.6			3
	Fine	5.6	8.0	1	1	4
	Medium	8.0	11.0	6	6	10
	Medium	11.0	16.0	5	5	15
	Coarse	16.0	22.6	3	3	18
	Coarse	22.6	32	6	6	24
	Very Coarse	32	45	15	15	39
	Very Coarse	45	64	25	25	64
<i>COBBLE</i>	Small	64	90	17	17	81
	Small	90	128	6	6	87
	Large	128	180	7	7	94
	Large	180	256	6	6	100
<i>BOULDER</i>	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
<i>BEDROCK</i>	Bedrock	2048	>2048			100
Total				100	100	100

Cross-Section 2 Channel materials (mm)	
D ₁₆ =	18.0
D ₃₅ =	41.1
D ₅₀ =	52.5
D ₈₄ =	107.3
D ₉₅ =	190.9
D ₁₀₀ =	256.0



Reachwide and Cross-Section Pebble Count Plots

Glade Creek II Restoration Project

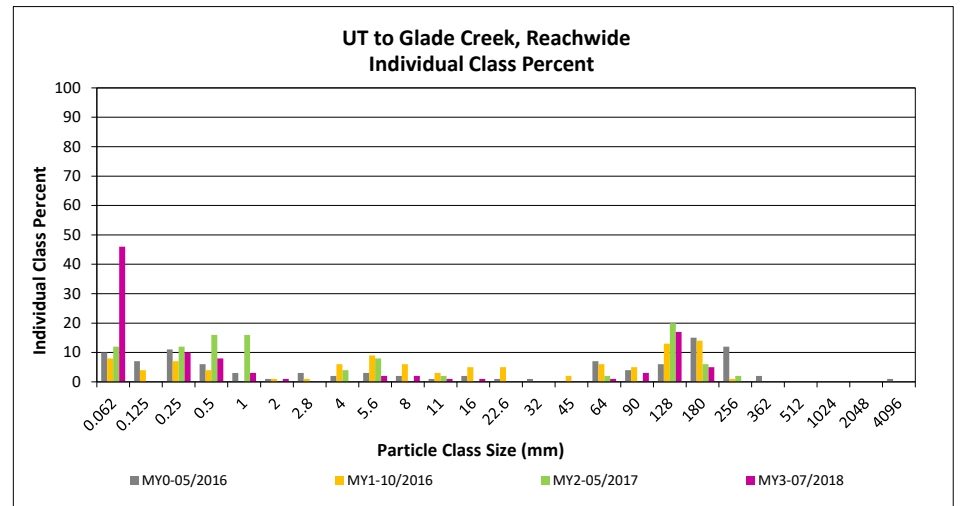
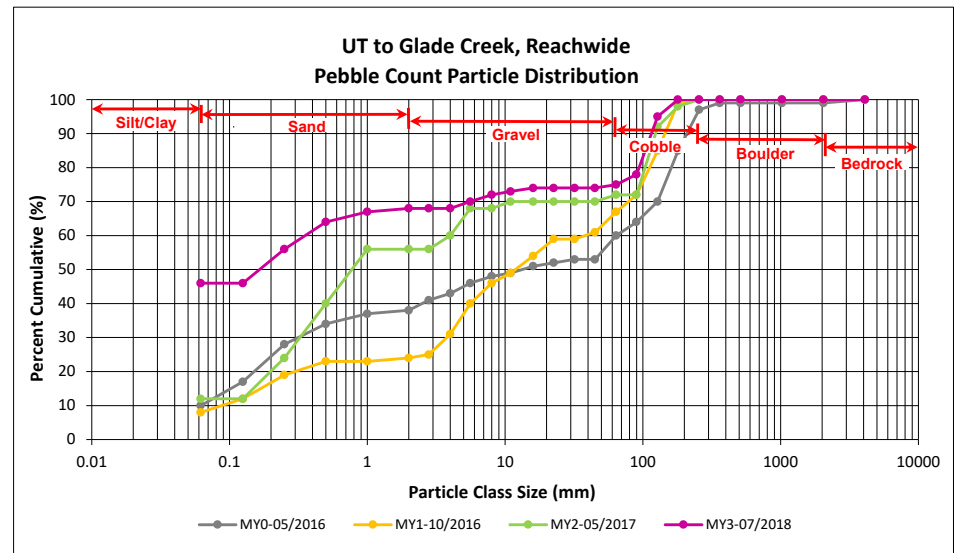
DMS Project No. 92343

Monitoring Year 3 - 2018

UT to Glade Creek, Reachwide

Particle Class		Diameter (mm)		Particle Count			Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	23	23	46	46	46
SAND	Very fine	0.062	0.125					46
	Fine	0.125	0.250	5	5	10	10	56
	Medium	0.25	0.50	1	7	8	8	64
	Coarse	0.5	1.0	1	2	3	3	67
	Very Coarse	1.0	2.0	1		1	1	68
GRAVEL	Very Fine	2.0	2.8					68
	Very Fine	2.8	4.0					68
	Fine	4.0	5.6	1	1	2	2	70
	Fine	5.6	8.0	1	1	2	2	72
	Medium	8.0	11.0	1		1	1	73
	Medium	11.0	16.0		1	1	1	74
	Coarse	16.0	22.6					74
	Coarse	22.6	32					74
	Very Coarse	32	45					74
	Very Coarse	45	64	1		1	1	75
COBBLE	Small	64	90	3		3	3	78
	Small	90	128	17		17	17	95
	Large	128	180	5		5	5	100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
Total				60	40	100	100	100

Reachwide Channel materials (mm)	
D ₁₆ =	Silt/Clay
D ₃₅ =	Silt/Clay
D ₅₀ =	0.2
D ₈₄ =	101.9
D ₉₅ =	128.0
D ₁₀₀ =	180.0



Reachwide and Cross-Section Pebble Count Plots

Glade Creek II Restoration Project

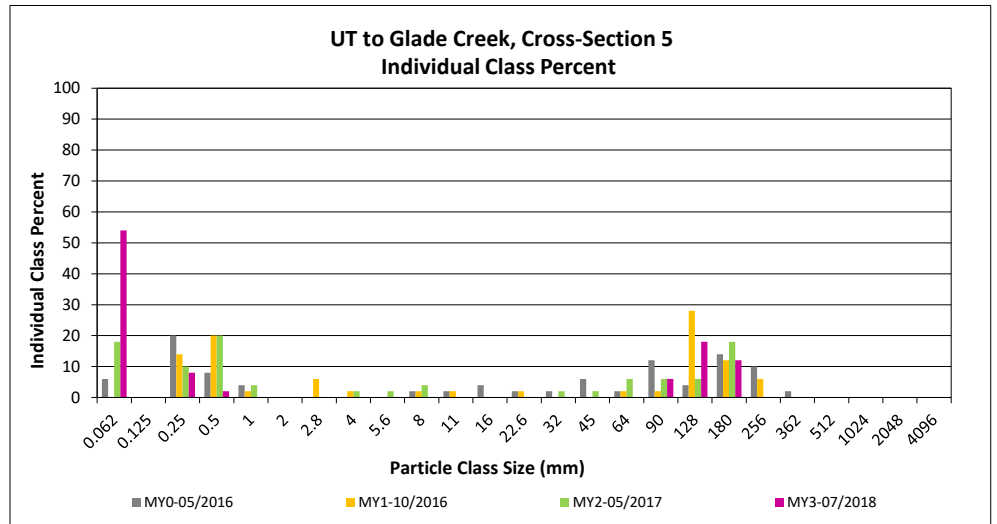
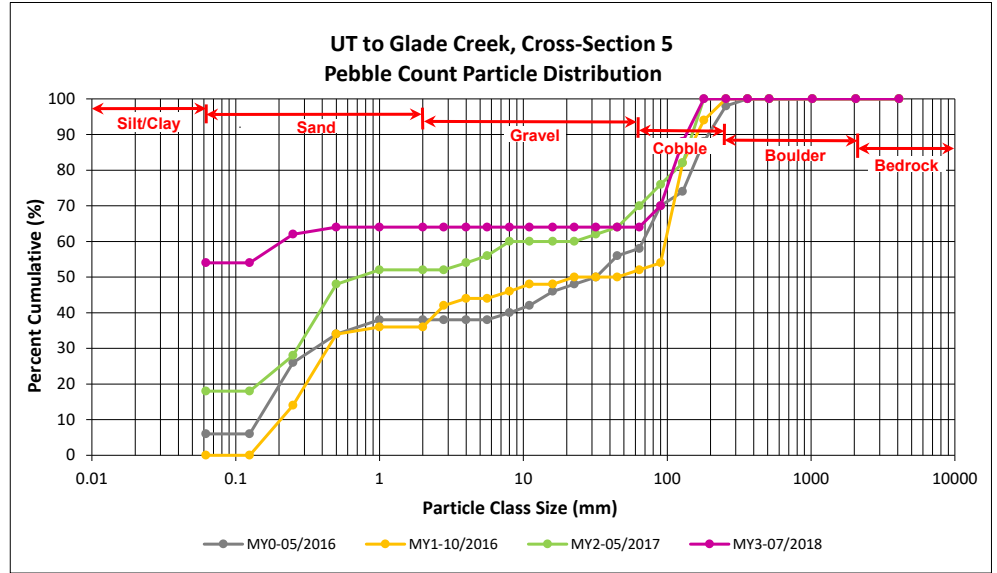
DMS Project No. 92343

Monitoring Year 3 - 2018

UT to Glade Creek, Cross-Section 5

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	54	54	54
SAND	Very fine	0.062	0.125			54
	Fine	0.125	0.250	8	8	62
	Medium	0.25	0.50	2	2	64
	Coarse	0.5	1.0			64
	Very Coarse	1.0	2.0			64
GRAVEL	Very Fine	2.0	2.8			64
	Very Fine	2.8	4.0			64
	Fine	4.0	5.6			64
	Fine	5.6	8.0			64
	Medium	8.0	11.0			64
	Medium	11.0	16.0			64
	Coarse	16.0	22.6			64
	Coarse	22.6	32			64
	Very Coarse	32	45			64
	Very Coarse	45	64			64
COBBLE	Small	64	90	6	6	70
	Small	90	128	18	18	88
	Large	128	180	12	12	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
Total				100	100	100

Cross Section 5 Channel materials (mm)	
D ₁₆ =	Silt/Clay
D ₃₅ =	Silt/Clay
D ₅₀ =	Silt/Clay
D ₈₄ =	118.4
D ₉₅ =	156.2
D ₁₀₀ =	180.0



APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events

Glade Creek II Restoration Project
 DMS Project No. 92343
Monitoring Year 3 - 2018

Glade Creek, UT

Reach	MY of Occurrence	Date of Occurrence	Date of Data Collection	Method
Glade Creek	MY1	6/27/2016	10/4/2016	Crest Gage
	MY2	10/9/2017	12/4/2017	Wrackline
	MY3	2/11/2018	4/2/2018	Wrackline
UT	MY1	6/27/2016	10/4/2016	Crest Gage
	MY2	10/9/2017	12/5/2017	Wrackline
	MY3	2/11/2018	4/2/2018	Crest Gage

Table 15. Wetland Gage Attainment Summary

Glade Creek II Restoration Project
 DMS Project No. 92343
Monitoring Year 3 - 2018

Summary of Groundwater Gage Results for MY3					
Gage	Success Criteria Achieved/Max Consecutive Days During Growing Season (%)				
	Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)
1	Yes/127 Days (75.6%)	Yes/169 Days (100%)	Yes/169 Days (100%)		

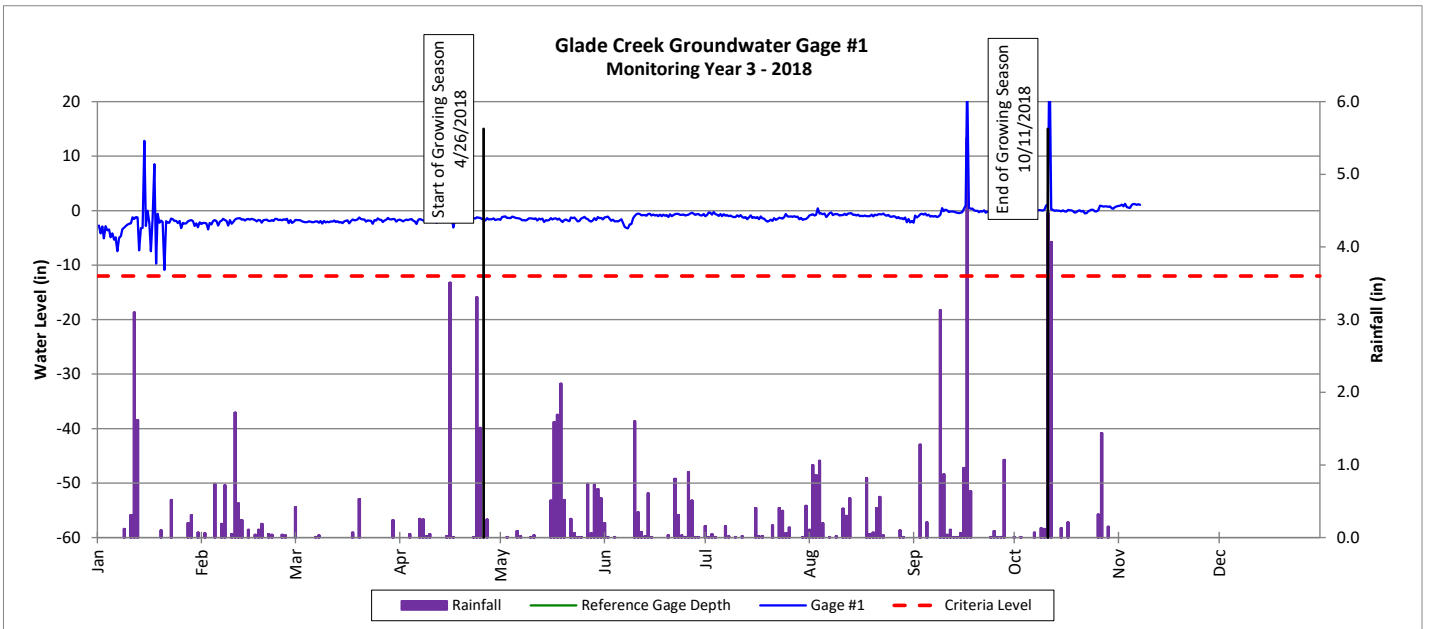
Wetland success criteria is 12.5% of growing season (21 consecutive days).

Groundwater Gage Plots

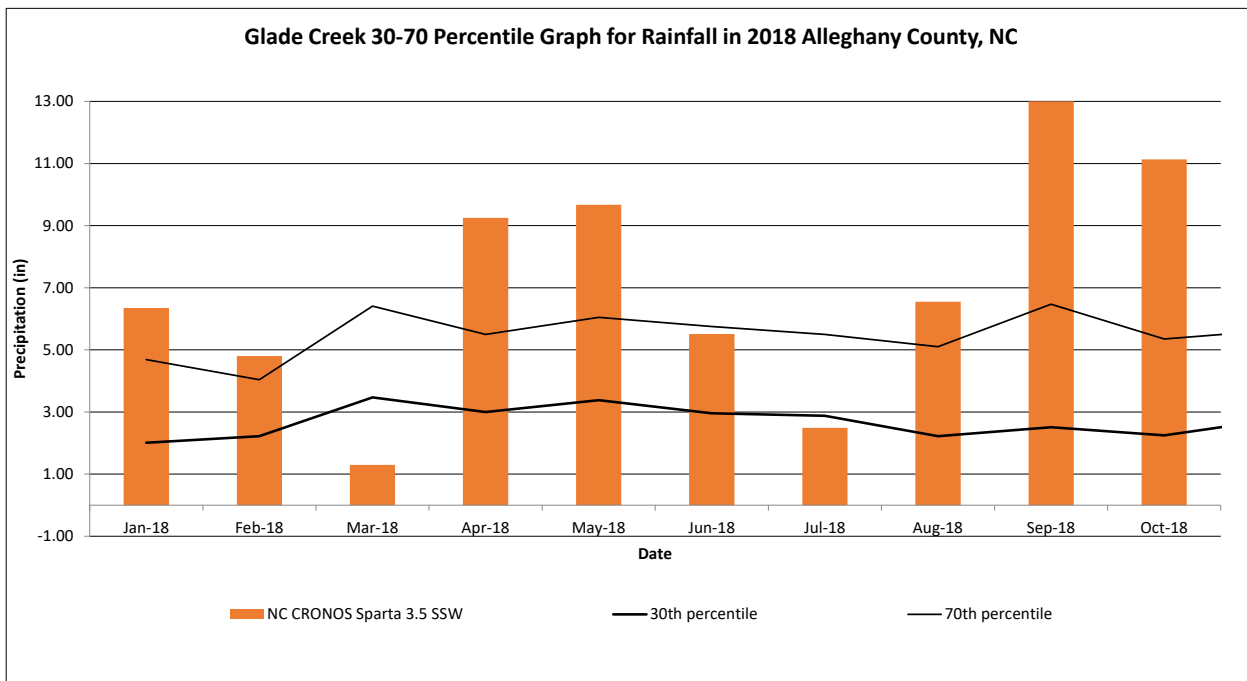
Glade Creek II Restoration Project (DMS Project No. 92343)

Monitoring Year 3 - 2018

Wetland D



Monthly Rainfall Data
 Glade Creek II Restoration Project
 DMS Project No. 92343
 Monitoring Year 3 - 2018



¹ 2018 rainfall collected from NC CRONOS Station Name: Sparta 3.5 SSW (NCSU, 2018)

² 30th and 70th percentile rainfall data collected from weather station Sparta, NC8158 (USDA, 2018)

³ No onsite data available.