Mitigation Project Name	Jacobs Ladder		County	Rowan	USACE Action ID	2012-01007
DMS ID	95023		Date Project Instituted	6/28/2011	NCDWR Permit No	2012-0774
River Basin	Yadkin		Date Prepared	8/28/2018		
Cataloging Unit	03040105					

Credit Release Milestone	Stream Credits						Wetland Credits							
	Scheduled Releases (Stream)	Warm	Cool	Cold	Anticipated Release Year (Stream)	Actual Release Date (Stream)	Scheduled Releases (Forested)	Riparian Riverine	Riparian Non-riverine	Non-riparian	Scheduled Releases (Coastal)	Coastal	Anticipated Release Year (Wetland)	Actual Release Date (Wetland)
Potential Credits (Mitigation Plan)		4,953.000												
Potential Credits (As-Built Survey)		5,231.000												
1 (Site Establishment)	N/A				N/A	N/A	N/A				N/A		N/A	N/A
2 (Year 0 / As-Built)	30%	1,569.300			2014	10/8/2014	30%				30%		N/A	N/A
3 (Year 1 Monitoring)	10%	523.100			2015	4/23/2015	10%				10%		N/A	N/A
Utility Right-of-Way - credits permanently reduced		-25.000				4/23/2015								
4 (Year 2 Monitoring)	10%	523.100			2016	4/25/2016	15%				15%		N/A	N/A
5 (Year 3 Monitoring)	10%	523.100			2017	4/3/2017	20%				20%		N/A	N/A
6 (Year 4 Monitoring) - NOT RELEASED	10%	523.100			2018	Not Released	10%				10%		N/A	N/A
7 (Year 5 Monitoring)	15%				2019		15%				15%		N/A	N/A
Stream Bankfull Standard	15%	784.650			2017	4/3/2017	N/A				N/A			
Total Credits Released to Date		3,898.250												

DEBITS (released credits only)

Ratios			1	1.5	2.5	5	1	3	2	5	1	3	2	5	1	3	2	5
			Stream Restoration	Stream Enhancement I	Stream Enhancement II	Stream Preservation	Riparian Restoration	Riparian Creation	Riparian Enhancement	Riparian Preservation	Nonriparian Restoration	Nonriparian Creation	Nonriparian Enhancement	Nonriparian Preservation	Coastal Marsh Restoration	Coastal Marsh Creation	Coastal Marsh Enhancement	Coastal Marsh Preservation
As-Built Amounts (feet and acres)			4,971.000	306.000	140.000													
As-Built Amounts (mitigation credits)			4,971.000	204.000	56.000													
Percentage Released			75%	75%	75%													
Released Amounts (feet / acres)			3,728.250	229.500	105.000													
Released Amounts (credits)			3,728.250	153.000	42.000													
NCDWR Permit	USACE Action ID	Project Name																
Utility Right-of-Way Easement - credits permanently reduced			25.000															
2016-1074	2016-02325	NCDOT TIP I-3802B, I-85 Improvements, Rowan & Cabarrus Counties	1,596.000															
	2016-02433	SR 1349 - Bridge 353 - Division 9, Rowan County	40.000															
	2017-01808	SR 1221 - Bridge 236 - Division 9, Rowan County	85.000															
Remaining Amounts (feet / acres)			1,982.250	229.500	105.000													
Remaining Amounts (credits)			1,982.250	153.000	42.000													

Contingencies (if any): None

Signature of Wilmington District Official Approving Credit Release

9/6/18
Date

1 - For DMS, no credits are released during the first milestone
2 - For DMS projects, the second credit release milestone occurs automatically when the as-built report (baseline monitoring report) has been made available to the NCIRT by posting it to the NCEEP Portal, provided the following criteria have been met:
1) Approval of the final Mitigation Plan
2) Recordation of the preservation mechanism, as well as a title opinion acceptable to the USACE covering the property
3) Completion of all physical and biological improvements to the mitigation site pursuant to the mitigation plan
4) Reciept of necessary DA permit authorization or written DA approval for porjects where DA permit issuance is not required
3 - A 15% reserve of credits is to be held back until the bankfull event performance standard has been met

Jacob's Ladder
Stream Restoration Monitoring Report
DMS Project # 95023
DMS Contract # 003983
Monitoring Year 05

Submitted to:

NCDEQ-DMS, 1652 Mail Service Center, Raleigh, NC 27699-1652

Construction Completed: January 2014
Data Collection: 2018
Submitted: January 2019

Design and Monitoring Firm

4505 Falls of Neuse Road
Suite 400
Raleigh, NC 27609
Phone: (919) 278-2514
Fax: (919) 783-9266

Project Manager: Tim Morris
Email: tim.morris@kci.com
Project No: 20110669

KCI ASSOCIATES OF NORTH CAROLINA, PA

ENGINEERS • SCIENTISTS • SURVEYORS • CONSTRUCTION MANAGERS

4505 Falls of Neuse Road Suite 400 Raleigh, NC 27609 (919) 783-9214 (919) 783-9266 Fax

MEMORANDUM

Date: February 1, 2019

To: Matthew Reid, DMS Project Manager

From: Adam Spiller, Project Manager
KCI Associates of North Carolina, PA

Subject: Jacob's Ladder Stream Restoration Site
MY-05 Monitoring Report Comments
Yadkin River Basin CU 03040105
Rowan County, North Carolina
NCDMS Project # 95023
Contract # 003983

Please find below our responses in italics to the MY-05 Monitoring Report comments from NCDMS received on January 22, 2019, for the Jacob's Ladder Stream Restoration Site.

The report discusses a supplemental planting that occurred in 2015; however, there are supplemental plantings that occurred in 2016 and 2018 according to the CCPV. Please update discussion in report to reflect these plantings. A short discussion regarding size, quantity and species would be helpful.

- *Two supplemental plantings occurred, one in April 2016 and one in April 2018. The reference to a 2015 supplemental planting has been corrected and a brief discussion of the extent of each planting has been added to the report.*

Please update Table 2 to show all supplemental planting efforts.

- *Table 2 has been updated to show both supplemental planting efforts and the date of the 2016 supplemental planting has been corrected.*

Add location of camera on T1A to CCPV and any additional monitoring devices that may have been installed.

- *The camera at the top of T1A appears on the CCPV. Two additional cameras were installed on T1A, but since no data was available from them at the time this report was put together they aren't shown on the CCPV. They will appear in the closeout report, along with the data gathered from them.*

Consider adding a few photos from TIA camera to show flow and include link/address to video.

- *Several photos from the camera at the top of T1A have been added to the report. A compilation of the videos can be found at https://youtu.be/ZkQ6yl2h9ns*

Is the "Total Cross-section Area" measurement the previous method used to determine area? The report indicates that this is a new metric. A short explanation in the report about this metric would help clear up any confusion. Please list the fixed elevation used for the measurement on the graph and/or table for each cross-section.

- *Total Cross-sectional Area represents the previous method used to determine area (i.e. area under the baseline bankfull elevation.) An explanation of this has been added to the report and the baseline bankfull elevation has been added to Table 11.*

A drain tile was located on T2 near 120+50. Please add this to the CCPV. Also, as discussed at the December 4, 2018 meeting, the tile will need to be located and a shapefile provided to Jeff Horton so it is adequately documented with Stewardship.

- *This has been added to the CCPV and a shapefile has been provided to Jeff Horton.*

Please contact me if you have any questions or would like clarification concerning these responses.

Sincerely,

Adam Spiller
Project Manager

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1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

The Jacob's Ladder Stream Restoration Site is a full-delivery project that was developed for the North Carolina Division of Mitigation Services (DMS). Construction was completed in January 2014. The site restored a total of 4,971 linear feet and enhanced 446 linear feet along three tributaries to Irish Buffalo Creek in the Yadkin-Pee Dee River Basin. The project is located west of China Grove and north of Kannapolis off of Saw Road in Rowan County (Figure 1, Appendix A). This project will expand aquatic and terrestrial habitat in the Rocky River Watershed (03040105). The project is within the 03040105020040 Irish Buffalo Creek Local Watershed Unit (14-digit HUC) (NCDENR, EEP 2009). In the DMS' most recent publication of Excluded and Targeted Local Watersheds/Hydrologic Units, the 03040105020040 14-digit HUC has been identified as a Targeted Local Watershed. The project is located in the Piedmont physiographic province and the project streams initiate as headwater systems out of moderately-sloped, forested hills before reaching the floodplain of Irish Buffalo Creek. The site's 1.07-square mile project watershed is comprised predominantly of pasture and mixed hardwoods, with an area of rural residential development in the northeastern corner. Prior to construction, the site was actively used for timber and cattle production for over five generations.

The project goals and objectives are listed below.

Project Goals

- Restore a diverse riparian corridor that connects forested stream systems upstream and downstream of the project.
- Reduce the sediment supply entering Irish Buffalo Creek.

Project Objectives

- Restore stable channel planforms to streams that have been straightened and modified.
- Reshape and stabilize eroding stream banks.
- Plant the site with native trees to help reestablish a diverse riparian corridor.
- Install exclusion fencing and alternative watering options to keep livestock out of the project streams.

During the Proposal Stage of the project, a section of Reach T2 was identified as Enhancement Level 1 at a 1.5:1 credit ratio. During the assessment and design stage for this reach, a more aggressive restoration approach was determined to be need, and the because of this the decision was made to completely change the stream type from a G-type channel to a C type channel. This required a restoration level approach during construction and because of this KCI requested a reallocation of credit type from the IRT from 1.5:1 to 1:1. After several meetings and discussions with the IRT, this reallocation of credit type was agreed to and resulted in an increase of 250 credits from the credits listed in the mitigation plan. See Appendix F for more information on this change. On March 9, 2015, a utility line that crosses Reach T1 near station 34+00 was identified, and it was determined that 49 linear feet of channel are impacted. This was corrected in the MY03 report and resulted in a reduction of 25 credits from what was reported in reports prior to MY03. See Table 1 and the CCPV for more information.

Vegetation success is based on the criteria established in the USACE Stream Mitigation Guidelines (2003). This document states that vegetation monitoring results should have the following planted stem density minimums in the corresponding monitoring years: 320 stems/acre through Year Three, 288 stems/acre in Year Four, and 260 stems/acre in Year Five. The fifth-year vegetation monitoring was based on the Level 2 CVS-EEP vegetation monitoring protocol. The site's average density for this monitoring period is 597 planted stems/acre. All sixteen of the plots had greater than 260 planted stems/acre. To ensure continued vegetative success, some parts of the site received supplemental planting in early 2016. This consisted of approximately 1300 bare root trees and 100 one gallon size trees spread mostly along the very bottom of each tributary. A second supplemental planting occurred in early 2018 and consisted of approximately 100 one gallon size trees, planted in areas where pasture grass had

grown thickly in the easement and outcompeted the bare root trees that had originally been planted. Including volunteers, the monitoring plots averaged 1,110 total stems/acre. The overall vegetation assessment found the site to be on track to meeting the vegetative success criterion.

Fifth-year monitoring found the Jacob's Ladder streams to be stable, with only minor changes from the as-built conditions. No areas show signs of serious bank erosion. The monitoring components were installed in February/March 2014. An automatic recording gauge has been installed on both T1 and T2. Both gauges recorded bankfull events in 2018. The monitoring plan for each tributary is as follows: T1 has a 1,500 foot longitudinal profile, 3 riffle cross-sections and 2 pool cross-sections; T2 has a 1,500 foot longitudinal profile, 4 riffle cross-sections and 1 pool cross-section; T1A is being monitored visually since it is small, partially intermittent, and a mix of mitigation types. Pebble counts were conducted at all ten cross-sections. Nine permanent photo points have been established with a total of nineteen photos to be taken annually. Monitoring Year Five found both T1 and T2 functioning as designed with little change from the baseline conditions.

On October 26, 2017, DMS met KCI on site to conduct a site walk and Reach T1A was determined to be a reach of concern due to the inconsistent flow in portions of the reach. A camera was installed on this reach at approximately Station 51+50 and set to record once a day starting February 9, 2018. The videos from this camera documented stream flow for most of the year. Some portion of the year the stream was obscured by vegetation growing in front of it or moisture accumulating on the camera lens. The periods of flow include a 62 day stretch from February 9 to April 11, and a 91 day stretch from May 3 to August 1, both of which ended because of vegetation growing in front of the camera.

Based on feedback from the IRT and DMS, the cross-section measurements have been reviewed and have been updated. These measurements are now calculated by adjusting the bankfull elevation so that the cross-sectional area remains the same throughout the monitoring period. A metric called total cross-sectional area has been added that shows the cross-sectional area based off of the baseline bankfull elevation.

Summary information/data related to the occurrence of items such as beaver or encroachment and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report and in the Mitigation Plan documents available on the DMS website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.

2.0 METHODOLOGY

The survey data were collected with a real time kinematic GPS instrument between December 17 and 19, 2018. The CVS-EEP protocol, Level 2 (http://cvs.bio.unc.edu/methods.htm) was used to collect vegetation data from the site. The vegetation monitoring was completed on July 25, 2018.

3.0 REFERENCES

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2008. CVS-EEP Protocol for Recording Vegetation, Version 4.2 (http://cvs.bio.unc.edu/methods.htm)

NCDENR, Ecosystem Enhancement Program. 2009. Lower Yadkin Pee-Dee River Basin Priorities 2009. Raleigh, NC. http://www.nceep.net/services/restplans/Yadkin_Pee_Dee_RBRP_2009_Final.pdf

USACE. 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.

Appendix A

Project Vicinity Map and Background Tables

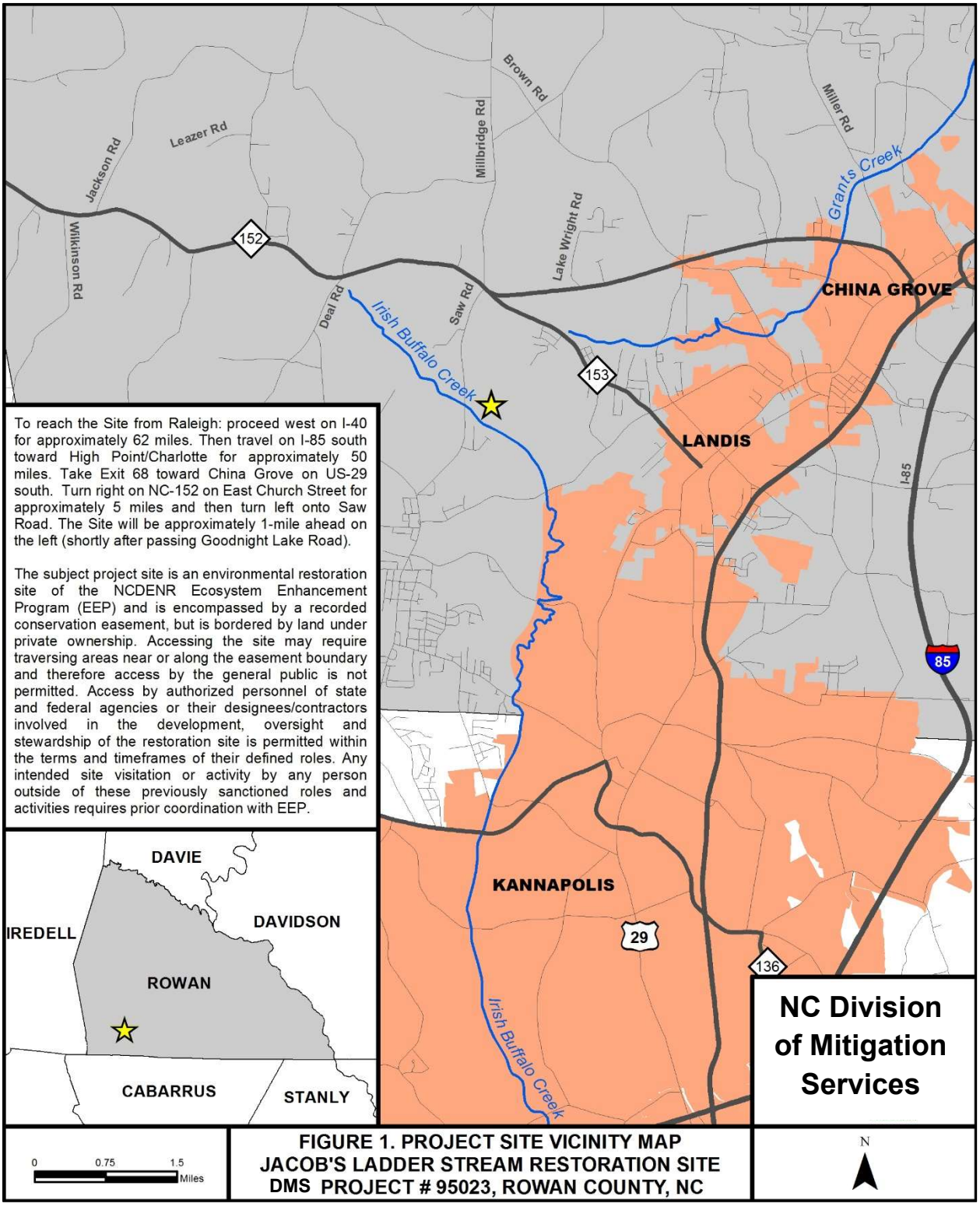


FIGURE 1. PROJECT SITE VICINITY MAP
JACOB'S LADDER STREAM RESTORATION SITE
DMS PROJECT # 95023, ROWAN COUNTY, NC

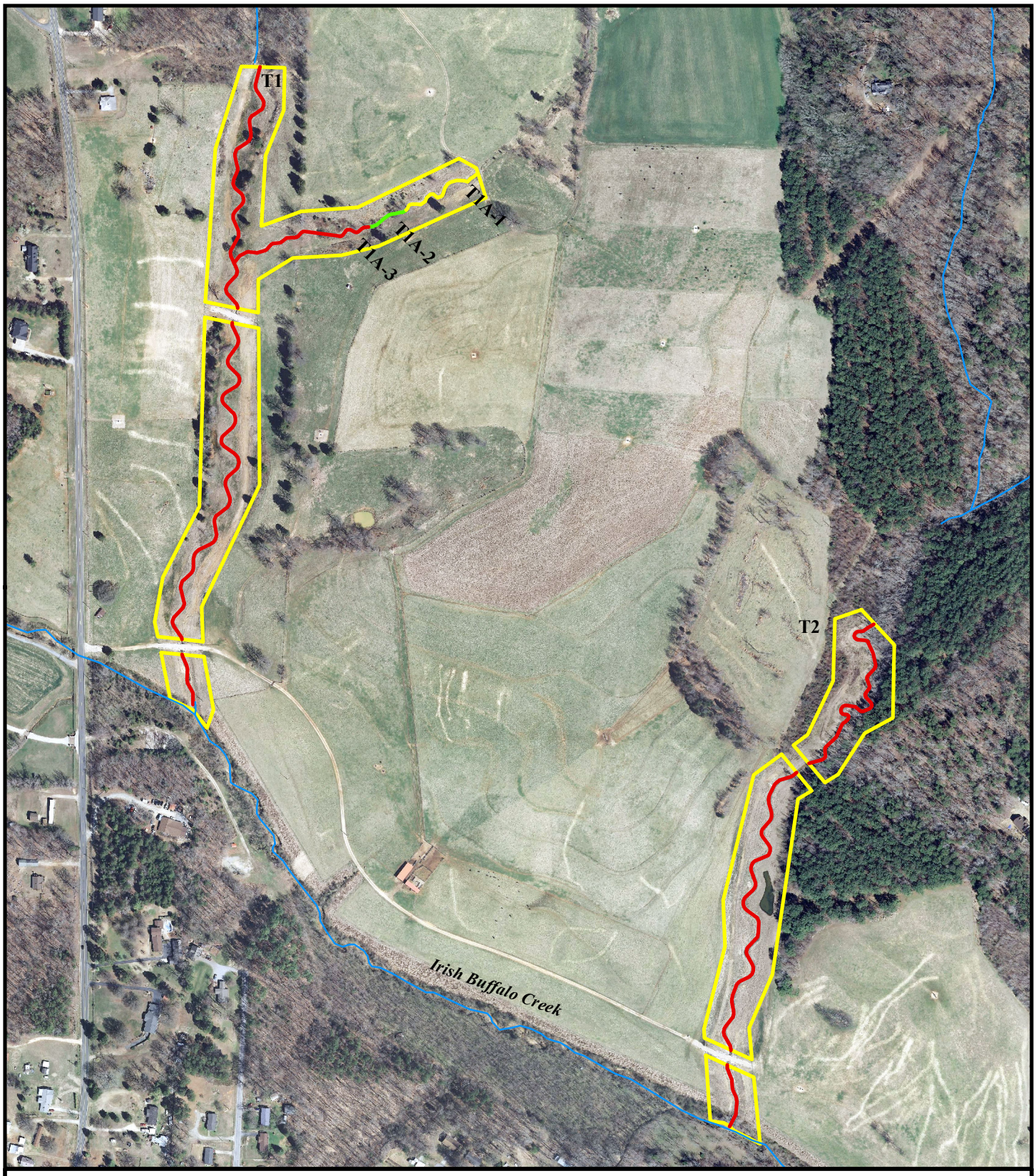


Figure 2. Site Asset Map

KCI

- Restoration
- Enhancement I
- Enhancement II
- Other Streams
- Conservation Easement

1:5,400
1 inch = 450 feet

N

440 220 0 440 Feet

Image Source: NC State Orthoimagery, 2014

Table 1. Project Components and Mitigation Credits
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Mitigation Credits							
	Stream			Riparian Wetland	Non-riparian Wetland	Buffer	Nitrogen Nutrient Offset
Type	R	EI	EII				
Length	4,971	306	140				
Credits	4,946	204	56				
TOTAL CREDITS	5,206						

Project Components						
Project Component -or- Reach ID	Design Stationing/ Location	Existing Footage	Approach (P1, P2 etc.)	Restoration -or- Restoration Equivalent	Restoration Footage	Mitigation Ratio
T1	10+00-34+89*	1,809	P1	Restoration	2,389*	1:1
T1A-1	50+00-53+06	306	-	Enhancement I	306	1:1.5
T1A-2	53+06-54+46	140	-	Enhancement II	140	1:2.5
T1A-3	54+46-59+44	470	P1	Restoration	498	1:1
T2	99+75-121+60*	1,246	P1	Restoration	2,084*	1:1

Component Summation		
Restoration Level	Stream (linear feet)	Mitigation Units (SMU)
Restoration	4,971	4,971
Enhancement I	306	204
Enhancement II	140	56

*Mitigation units have been calculated to exclude the easement exceptions and utility crossings.
There were no BMP elements included in this project.

Table 2. Project Activity & Reporting History Jacob's Ladder Stream Restoration Site, DMS Project # 95023		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Mitigation Plan		Sept 2012
Final Design - Construction Plans		Dec 2012
Construction		Aug 2013
Planting		Jan 2014
Baseline Monitoring/Report	March 2014	April 2014
Vegetation Monitoring	Feb 20, 2014	
Photo Points	March 11, 2014	
Stream Survey	Feb 20, 2014	
Year 1 Monitoring	Nov 2014	Jan 2015
Vegetation Monitoring	Oct 4, 2014	
Photo Points	Nov 4, 2014	
Stream Survey	Nov 4, 2014	
Year 2 Monitoring	Dec 2015	Dec 2015
Vegetation Monitoring	July 28, 2015	
Photo Points	Dec 17, 2015	
Stream Survey	Aug 12, 2015	
Supplemental Planting		April 2016
Year 3 Monitoring	Nov 2016	Dec 2016
Vegetation Monitoring	Nov 2, 2016	
Photo Points	Nov 15, 2016	
Stream Survey	June 9, 2016	
Year 4 Monitoring	Nov 2017	Jan 2018
Vegetation Monitoring	June 28, 2017	
Photo Points	Nov 21, 2017	
Stream Survey	June 1, 2017	
Supplemental Planting		April 2018
Year 5 Monitoring	Dec 2018	Jan 2019
Vegetation Monitoring	July 25, 2018	
Photo Points	Dec 19, 2018	
Stream Survey	Dec 19, 2018	

Table 3. Project Contacts Jacob's Ladder Stream Restoration Site, DMS Project # 95023	
Design Firm	KCI Associates of North Carolina, PC 4505 Falls of Neuse Road Suite 400 Raleigh, NC 27609 Contact: Mr. Tim Morris Phone: (919) 278-2512 Fax: (919) 783-9266
Construction Contractor	Wright Contracting, LLC 160 Walker Road Lawndale, NC 28090 Contact: Mr. Stephen James Phone: (704) 692-4633
Planting Contractor	Forestree Management Co. 1280 Maudis Road Bailey, NC 27807 Contact: Mr. Tony Cortez Phone: (252) 243-2513
Monitoring Performers	
	KCI Associates of North Carolina, PC 4505 Falls of Neuse Road Suite 400 Raleigh, NC 27609 Contact: Mr. Adam Spiller Phone: (919) 278-2514 Fax: (919) 783-9266

Table 4. Project Information Jacob's Ladder Stream Restoration Site, DMS Project # 95023			
Project Name	Jacob's Ladder Stream Restoration Site		
County	Rowan County		
Project Area (acres)	17.2 acres		
Project Coordinates (lat. and long.)	35.552956 N, 80.653116 W		
Project Watershed Summary Information			
Physiographic Province	Piedmont		
River Basin	Yadkin-Pee Dee		
USGS Hydrologic Unit 8-digit	03040105	USGS Hydrologic Unit 14-digit	03040105020040
DWQ Sub-basin	13-17-09		
Project Drainage Area	682 acres/1.06 square miles		
Project Drainage Area Percentage of Impervious Area	1.1%/8 acres		
CGIA Land Use Classification	15.8% Cultivated, 35.1% Managed Herbaceous Cover, 41.6% Mixed Upland Hardwoods, 6.9% Mixed Hardwoods/Conifers, and 0.5% Southern Yellow Pine		
Reach Summary Information (Post-Restoration)			
Parameters	**T1**	**T1A-1, T1A-2, T1A-3**	**T2**
Length of reach (linear feet)	2,389	944	2,084
Valley classification	VIII	VIII	VIII
Drainage area (acres)	231.6 acres	34.5 acres	450.1 acres
NCDWQ Water Quality Classification	Class C, WSIII	Class C, WSIII	Class C, WSIII
Morphological Description (stream type)	C4	B4c/C4	C4
Evolutionary trend	Stage II (Constructed)	Stage II (Constructed)	Stage II (Constructed)
Mapped Soil Series	Chewacla loam	Pacolet sandy loam	Pacolet sandy loam & Chewacla loam
Drainage class	Poorly drained	Well drained	Well drained
Soil Hydric status	Non hydric	Non hydric	Non hydric
Slope	0-2%	0-2%	0-2%
FEMA classification	AE (portion in backwater of Irish Buffalo Creek only)	N/A	AE (portion in backwater of Irish Buffalo Creek only)
Native vegetation community	Piedmont Alluvial Forest	Mesic Mixed Hardwood Forest & Piedmont Alluvial Forest	Piedmont Alluvial Forest
Percent composition of exotic invasive vegetation	0%	0%	0%
Regulatory Considerations			
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**
Waters of the United States – Section 404	Yes	Yes, received 404 permit	N/A
Waters of the United States – Section 401	Yes	Yes, received 401 permit	N/A
Endangered Species Act	No	N/A	N/A
Historic Preservation Act	No	N/A	N/A
Coastal Zone Management Act (CZMA)/ Coastal Area Management Act (CAMA)	No	N/A	N/A
FEMA Floodplain Compliance	Yes	Floodplain development permit completed through Rowan County	N/A
Essential Fisheries Habitat	No	N/A	N/A

Appendix B

Visual Assessment Data

BEGIN REACH T1A-1
SUPPLEMENTAL PLANTING (2018)
VP10 1255 / 890
FLOW CAMERA
PP2
BEGIN REACH T1A-2
BEGIN REACH T1A-3
VP11 364 / 364
SUPPLEMENTAL PLANTING (2016)
BEGIN REACH T1
VP8 567 / 364
BEGIN PROFILE T1
VP9 607 / 567
PP1
XS1
XS2
PP3
VP12 1902 / 769
VP13 809 / 647
VP14 1174 / 567
PP4
XS3
XS4
VP15 405 / 405
50 FEET EASEMENT EXCEPTION
END PROFILE T1
XS5 (GAUGE 1)
PP5
SUPPLEMENTAL PLANTING (2016)
VP16 728 / 405
50 FEET EASEMENT EXCEPTION
20 FEET UTILITY ROW
IRISH BUFFALO CREEK
SAW ROAD S.R. 1350

LEGEND

- CONSERVATION EASEMENT
- CROSS-SECTION (XS)
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION
- 1110 / 597 VEG PLOT TOTAL / PLANTED STEM DENSITY
- PHOTO POINT (PP)
- GAUGE LOCATION
- FLOW CAMERA
- SUPPLEMENTAL PLANTING

IMAGE SOURCE: NC 2014 STATEWIDE ORTHOIMAGERY

NC GRID NAD '83

-80' -40' 0' 80' 160'

GRAPHIC SCALE

REVISIONS

DATE	DESCRIPTION	BY

NCDEQ – DIVISION OF MITIGATION SERVICES

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4505 FALLS OF NEUSE ROAD, SUITE 400
RALEIGH, NORTH CAROLINA 27609

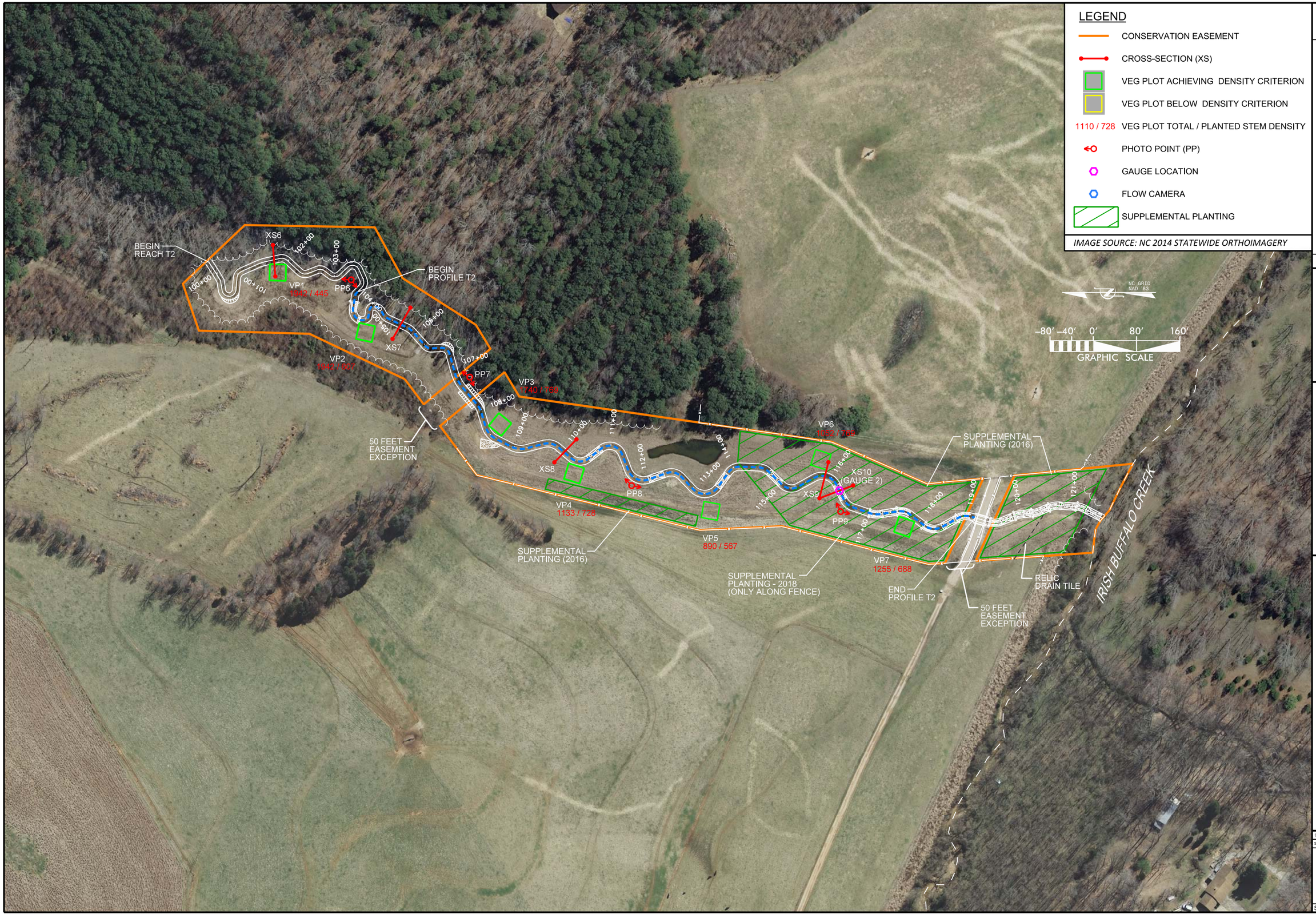
JACOB'S LADDER STREAM MITIGATION PROJECT MONITORING YEAR 5

CHINA GROVE, ROWAN COUNTY, NORTH CAROLINA

REACH T1

DATE: JAN 2019
SCALE: GRAPHIC

CURRENT CONDITION PLAN VIEW



REVISIONS

DATE	DESCRIPTION	STVL

NCDEQ – DIVISION OF MITIGATION SERVICES

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4505 FALLS OF NEUSE ROAD, SUITE 400
RALEIGH, NORTH CAROLINA 27609

JACOB'S LADDER STREAM MITIGATION PROJECT MONITORING YEAR 5

CHINA GROVE, ROWAN COUNTY, NORTH CAROLINA

REACH T2

DATE: JAN 2019
SCALE: GRAPHIC

CURRENT CONDITION PLAN VIEW

Table 5. Visual Stream Morphology Stability Assessment
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

	Assessed Length	2,389	Reach - T1				
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**
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	18	22			82%
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	14	21			67%
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	14	21			67%
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	11	11			100%
		2. Thalweg centering at downstream of meander (Glide)	11	11			100%
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			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%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%
				Totals	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	9	9			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	9	9			100%
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			100%
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	2	2			100%
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			N/A

Table 5. Visual Stream Morphology Stability Assessment
Jacob's Ladder Stream Restoration Site, DMS Project # 95023
Assessed Length 2,084 **Reach - T2**

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
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	13	20			65%
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	8	11			73%
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	8	11			73%
	4. **Thalweg Position**[+]	1. Thalweg centering at upstream of meander bend (Run)	10	10			N/A
		2. Thalweg centering at downstream of meander (Glide)	10	10			N/A
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			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%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%
				Totals	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	6	6			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	6	6			100%
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	0	0			N/A
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			N/A

Table 6. Vegetation Condition Assessment
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Planted Acreage 15.9 **Easement Acreage 17.2**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 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 acre	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 acre	Pattern and Color	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1,000 SF	Pattern and Color	0	0.00	0.0%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	Pattern and Color	0	0.00	0.0%

Photo Reference Points

PP1U – MY-00 – 3/11/14

PP1U – MY05 – 12/19/18

PP1D – MY-00 – 3/11/14

PP1D – MY05 – 12/19/18

PP2U – MY-00 – 3/11/14

PP2U – MY05 – 12/19/18

PP2D – MY-00 – 3/11/14

PP2D – MY05 – 12/19/18

PP3 Tributary – MY-00 – 3/11/14

PP3 Tributary – MY05 – 12/19/18

PP3U – MY-00 – 3/11/14

PP3U – MY05 – 12/19/18

PP3D – MY-00 – 3/11/14

PP3D – MY05 – 12/19/18

PP4U – MY-00 – 3/11/14

PP4U – MY05 – 12/19/18

PP4D – MY-00 – 3/11/14

PP4D – MY05 – 12/19/18

PP5U – MY-00 – 3/11/14

PP5U – MY05 – 12/19/18

PP5D – MY-00 – 3/11/14

PP5D – MY05 – 12/19/18

PP6U – MY-00 – 3/11/14

PP6U – MY05 – 12/19/18

PP6D – MY-00 – 3/11/14

PP6D – MY05 – 12/19/18

PP7U – MY-00 – 3/11/14

PP7U – MY05 – 12/19/18

PP7D – MY-00 – 3/11/14

PP7D – MY05 – 12/19/18

PP8U – MY-00 – 3/11/14

PP8U – MY05 – 12/19/18

PP8D – MY-00 – 3/11/14

PP8D – MY05 – 12/19/18

PP9U – MY-00 – 3/11/14

PP9U – MY05 – 12/19/18

PP9D – MY-00 – 3/11/14

PP9D – MY05 – 12/19/18

Vegetation Monitoring Plot Photos

Plot 1 Photo: 7/20/18 – MY05

Plot 2 Photo: 7/20/18 – MY05

Plot 3 Photo: 7/20/18 – MY05

Plot 4 Photo: 7/20/18 – MY05

Plot 5 Photo: 7/20/18 – MY05

Plot 6 Photo: 7/20/18 – MY05

Plot 7 Photo: 7/20/18 – MY05

Plot 8 Photo: 7/20/18 – MY05

Plot 9 Photo: 7/20/18 – MY05

Plot 10 Photo: 7/20/18 – MY05

Plot 11 Photo: 7/20/18 – MY05

Plot 12 Photo: 7/20/18 – MY05

Plot 13 Photo: 7/20/18 – MY05

Plot 14 Photo: 7/20/18 – MY05

Plot 15 Photo: 7/20/18 – MY05

Plot 16 Photo: 7/20/18 – MY05

Appendix C

Vegetation Plot Data

Table 7. Vegetation Plot Criteria Attainment Jacob's Ladder Stream Restoration Site, DMS Project # 95023			
Vegetation Plot ID	**Vegetation Survival Threshold Met?**	**Monitoring Year 05 Planted Stem Density (stems/acre)**	**Monitoring Year 05 Total Stem Density (stems/acre)**
1	Yes	445	1,942
2	Yes	607	1,942
3	Yes	769	1,740
4	Yes	728	1,133
5	Yes	567	890
6	Yes	769	1,052
7	Yes	688	1,255
8	Yes	364	567
9	Yes	567	607
10	Yes	890	1,255
11	Yes	364	364
12	Yes	769	1,902
13	Yes	647	809
14	Yes	567	1,174
15	Yes	405	405
16	Yes	405	728

Report Prepared By	Drew Rosso
Date Prepared	8/2/2018 10:44 AM
database name	KCI-2015-J.mdb
database location	M:\2011\20110669-Jacobs Ladder\Monitoring\Vegetation CVS Database
computer name	12-927DM12
file size	62529536
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	95023
project Name	Jacobs Ladder
Description	Stream Restoration Site
River Basin	
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	16

Table 9. CVS Stem Count Total and Planted by Plot and Species

DMS Project Code 95023, Jacob's Ladder

			Current Plot Data (MY5 2018)																							
			95023-01-0001			95023-01-0002			95023-01-0003			95023-01-0004			95023-01-0005			95023-01-0006			95023-01-0007			95023-01-0008		
Scientific Name	**Common Name**	**Species Type**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	boxelder	Tree						1						1									2			
Acer rubrum	red maple	Tree																								
Alnus serrulata	hazel alder	Shrub				1	1	2			8				1	1	1									
Baccharis halimifolia	eastern baccharis	Shrub						4																		
Betula nigra	river birch	Tree				7	7	7	6	6	6				2	2	2	16	16	17	2	2	4	1	1	1
Callicarpa americana	American beautyberry	Shrub										2	2	2							1	1	1			
Diospyros virginiana	common persimmon	Tree			3																					
Fraxinus pennsylvanica	green ash	Tree	5	5	5	1	1	1	5	5	5	10	10	10	3	3	3				8	8	8	7	7	7
Juglans nigra	black walnut	Tree																								
Juniperus virginiana	eastern redcedar	Tree																								
Liquidambar styraciflua	sweetgum	Tree			26			1			3			6												
Liriodendron tulipifera	tuliptree	Tree	4	4	6	2	2	2	4	4	5	2	2	2	3	3	3									
Nyssa biflora	swamp tupelo	Tree																2	2	3						
Pinus echinata	shortleaf pine	Tree																								
Pinus taeda	loblolly pine	Tree			4			8			1															
Platanus occidentalis	American sycamore	Tree						1	1	1	1	1	1	1							1	1	1			
Populus deltoides	eastern cottonwood	Tree						2									1				2	2	3			
Quercus	oak	Tree																								
Quercus alba	white oak	Tree																								
Quercus michauxii	swamp chestnut oak	Tree																								
Quercus nigra	water oak	Tree																								
Quercus palustris	pin oak	Tree																								
Quercus phellos	willow oak	Tree	2	2	2	1	1	1	1	1	1	3	3	3	1	1	1						1			
Quercus rubra	northern red oak	Tree																								
Salix nigra	black willow	Tree			2	2	2	15	2	2	13			3	4	4	11			2	3	3	11			5
Sambucus canadensis	Common Elderberry	Shrub				1	1	2										1	1	1						
Taxodium distichum	bald cypress	Tree																						1	1	1
Ulmus alata	winged elm	Tree						1												1						
Ulmus americana	American elm	Tree																		2						
Unknown		Shrub or Tree																								
		Stem count	11	11	48	15	15	48	19	19	43	18	18	28	14	14	22	19	19	26	17	17	31	9	9	14
		size (ares)	1			1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	3	3	7	7	7	14	6	6	9	5	5	8	6	6	7	3	3	6	6	6	8	3	3	4
		Stems per ACRE	445	445	1942	607	607	1942	769	769	1740	728	728	1133	567	567	890	769	769	1052	688	688	1255	364	364	567

Table 9. CVS Stem Count Total and Planted by Plot and Species

DMS Project Code 95023, Jacob's Ladder

			Current Plot Data (MY5 2018)																							
			95023-01-0009			95023-01-0010			95023-01-0011			95023-01-0012			95023-01-0013			95023-01-0014			95023-01-0015			95023-01-0016		
Scientific Name	**Common Name**	**Species Type**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	boxelder	Tree												3						1						7
Acer rubrum	red maple	Tree			1																					
Alnus serrulata	hazel alder	Shrub	2	2	2							5	5	5												
Baccharis halimifolia	eastern baccharis	Shrub												1												
Betula nigra	river birch	Tree	2	2	2	2	2	2										1	1	1						
Callicarpa americana	American beautyberry	Shrub	1	1	1										7	7	7									
Diospyros virginiana	common persimmon	Tree				5	5	5						2												
Fraxinus pennsylvanica	green ash	Tree	7	7	7	4	4	4	7	7	7	7	7	9	7	7	7	5	5	6	6	6	6	6	6	6
Juglans nigra	black walnut	Tree																								
Juniperus virginiana	eastern redcedar	Tree						1									1			1						
Liquidambar styraciflua	sweetgum	Tree						7						18			2			10						
Liriodendron tulipifera	tuliptree	Tree													1	1	2									
Nyssa biflora	swamp tupelo	Tree																						3	3	4
Pinus echinata	shortleaf pine	Tree																								
Pinus taeda	loblolly pine	Tree						1																		
Platanus occidentalis	American sycamore	Tree													1	1	1	5	5	5				1	1	1
Populus deltoides	eastern cottonwood	Tree																		1						
Quercus	oak	Tree												1												
Quercus alba	white oak	Tree				1	1	1										1	1	1	1	1	1			
Quercus michauxii	swamp chestnut oak	Tree							1	1	1										1	1	1			
Quercus nigra	water oak	Tree																								
Quercus palustris	pin oak	Tree				9	9	9																		
Quercus phellos	willow oak	Tree	1	1	1	1	1	1	1	1	1	7	7	7				2	2	2	1	1	1			
Quercus rubra	northern red oak	Tree	1	1	1																					
Salix nigra	black willow	Tree																		1						
Sambucus canadensis	Common Elderberry	Shrub																								
Taxodium distichum	bald cypress	Tree																			1	1	1			
Ulmus alata	winged elm	Tree																								
Ulmus americana	American elm	Tree												1												
Unknown		Shrub or Tree																								
		Stem count	14	14	15	22	22	31	9	9	9	19	19	47	16	16	20	14	14	29	10	10	10	10	10	18
		size (ares)	1			1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	6	6	7	6	6	9	3	3	3	3	3	9	4	4	6	5	5	10	5	5	5	3	3	4
		Stems per ACRE	567	567	607	890	890	1255	364	364	364	769	769	1902	647	647	809	567	567	1174	405	405	405	405	405	728

Table 9. CVS Stem Count Total and Planted by Plot and Species

DMS Project Code 95023, Jacob's Ladder

			Annual Means																	
			MY5 (2018)			MY4 (2017)			MY3 (2016)			MY2 (2015)			MY1 (2014)			MY0 (2014)		
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
Acer negundo	boxelder	Tree			15			13			6			6	1	1	2			
Acer rubrum	red maple	Tree			1			2						1			1			
Alnus serrulata	hazel alder	Shrub	9	9	18	9	9	14	9	9	15	9	9	9	7	7	7			
Baccharis halimifolia	eastern baccharis	Shrub			5			6			5			2						
Betula nigra	river birch	Tree	39	39	42	40	40	42	32	32	41	23	23	23	17	17	24	39	39	39
Callicarpa americana	American beautyberry	Shrub	11	11	11	11	11	11	12	12	12	11	11	11	9	9	9			
Diospyros virginiana	common persimmon	Tree	5	5	10	5	5	14	5	5	8	6	6	12	6	6	8	1	1	1
Fraxinus pennsylvanica	green ash	Tree	88	88	91	86	86	86	75	75	80	66	66	66	32	32	32			
Juglans nigra	black walnut	Tree									1									
Juniperus virginiana	eastern redcedar	Tree			3			2			2									
Liquidambar styraciflua	sweetgum	Tree			73			43			51			20			7			
Liriodendron tulipifera	tuliptree	Tree	16	16	20	17	17	20	15	15	18	26	26	26	15	15	15	40	40	40
Nyssa biflora	swamp tupelo	Tree	5	5	7	6	6	6	4	4	4									
Pinus echinata	shortleaf pine	Tree						1												
Pinus taeda	loblolly pine	Tree			14			8			6			2						
Platanus occidentalis	American sycamore	Tree	10	10	11	11	11	11	12	12	13	12	12	13	15	15	17	62	62	62
Populus deltoides	eastern cottonwood	Tree	2	2	7	2	2	7	2	2	5	2	2	4	2	2	8			
Quercus	oak	Tree			1						1				1	1	1	2	2	2
Quercus alba	white oak	Tree	3	3	3	3	3	7	2	2	2	2	2	3			1			
Quercus michauxii	swamp chestnut oak	Tree	2	2	2	3	3	3	1	1	1	1	1	1						
Quercus nigra	water oak	Tree																1	1	1
Quercus palustris	pin oak	Tree	9	9	9	9	9	9	10	10	10	10	10	10	7	7	7			
Quercus phellos	willow oak	Tree	21	21	22	21	21	21	18	18	19	19	19	19	17	17	17	24	24	24
Quercus rubra	northern red oak	Tree	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Salix nigra	black willow	Tree	11	11	63	12	12	64	12	12	56	12	12	54	14	14	26	13	13	13
Sambucus canadensis	Common Elderberry	Shrub	2	2	3	2	2	2	2	2	2	1	1	2			2			
Taxodium distichum	bald cypress	Tree	2	2	2	3	3	3												
Ulmus alata	winged elm	Tree			2															
Ulmus americana	American elm	Tree			3			3			2									
Unknown		Shrub or Tree										1	1	1	6	6	6	51	51	51
		Stem count	236	236	439	241	241	399	212	212	361	202	202	286	150	150	191	233	233	233
		size (ares)	16			16			16			16			16			16		
		size (ACRES)	0.40			0.40			0.40			0.40			0.40			0.40		
		Species count	17	17	26	17	17	25	16	16	24	16	16	21	15	15	19	9	9	9
		Stems per ACRE	597	597	1110	610	610	1009	536	536	913	511	511	723	379	379	483	589	589	589

Appendix D

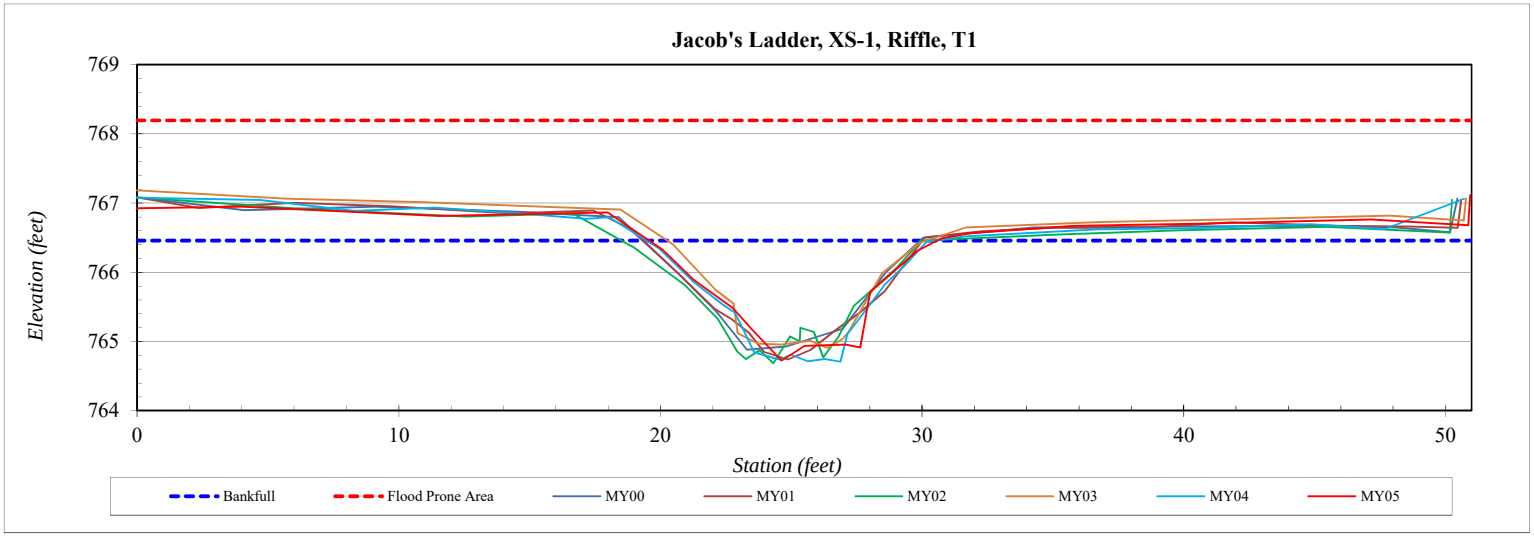
Stream Survey Data

Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-1
Drainage Area (sq mi):	0.21
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	766.92
4.02	766.94
11.53	766.81
17.99	766.86
20.08	766.33
21.27	765.89
22.76	765.48
23.52	765.17
24.63	764.72
25.50	764.93
27.08	764.96
27.64	764.91
28.02	765.71
29.82	766.31
30.70	766.49
31.81	766.56
35.77	766.67
40.69	766.70
47.16	766.76
50.88	766.68
50.95	767.11

SUMMARY DATA	
Current Bankfull Elevation:	766.5
Bankfull Cross-Sectional Area:	10.1
Total Cross-Sectional Area:	10.4
Bankfull Width:	11.0
Flood Prone Area Elevation:	768.2
Flood Prone Width:	50.9
Max Depth at Bankfull:	1.7
Mean Depth at Bankfull:	0.9
W / D Ratio:	12.0
Entrenchment Ratio:	4.6
Bank Height Ratio:	1.0

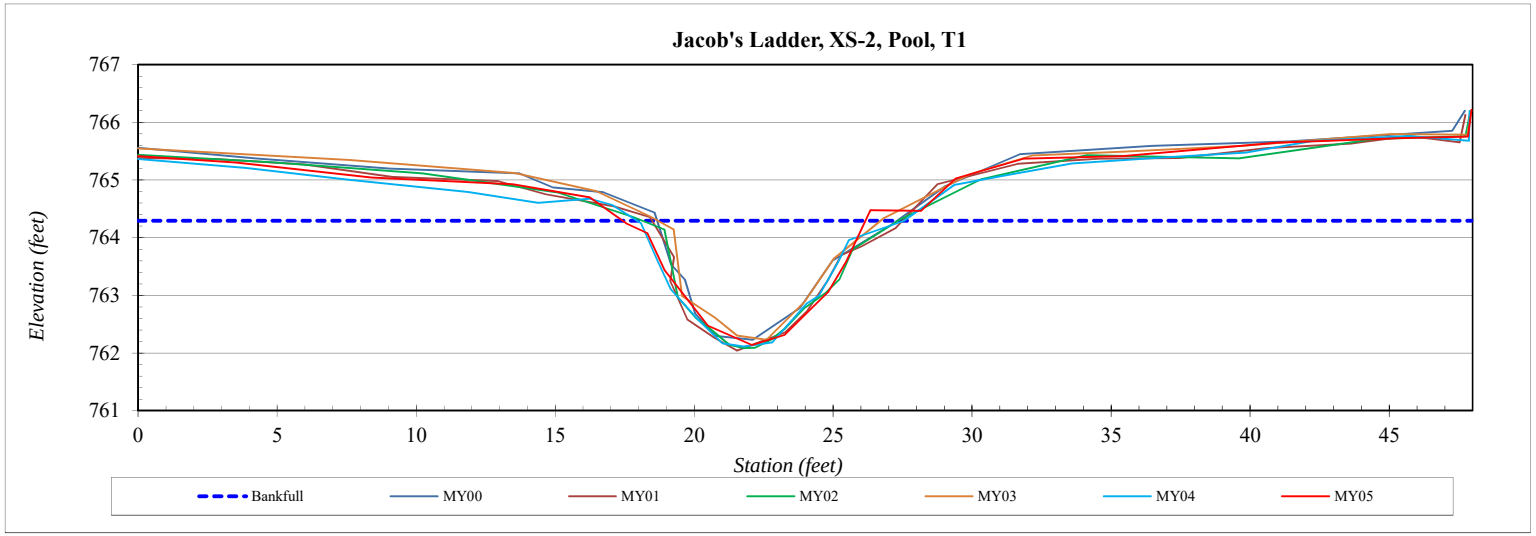


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-2
Drainage Area (sq mi):	0.21
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	765.41
3.51	765.30
8.41	765.04
13.49	764.92
16.25	764.70
17.56	764.25
18.31	764.08
18.93	763.44
20.49	762.48
22.09	762.14
23.26	762.32
24.80	763.05
25.46	763.58
26.34	764.47
28.16	764.46
29.42	765.03
31.84	765.37
35.42	765.41
40.98	765.65
45.35	765.73
47.83	765.75
47.96	766.22

SUMMARY DATA	
Current Bankfull Elevation:	764.3
Bankfull Cross-Sectional Area:	11.5
Total Cross-Sectional Area:	12.7
Bankfull Width:	8.7
Flood Prone Area Elevation:	---
Flood Prone Width:	---
Max Depth at Bankfull:	2.2
Mean Depth at Bankfull:	1.3
W / D Ratio:	---
Entrenchment Ratio:	---
Bank Height Ratio:	---

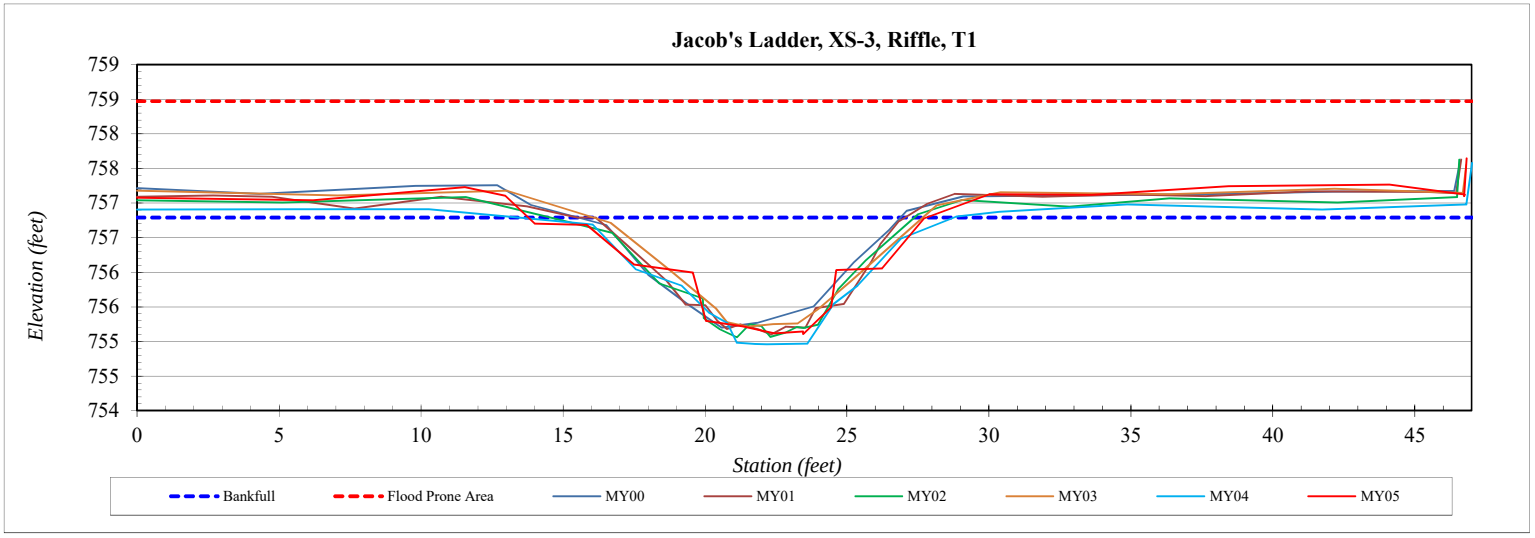


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-3
Drainage Area (sq mi):	0.36
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	757.08
6.20	757.04
11.54	757.23
12.97	757.10
14.00	756.70
15.84	756.68
17.51	756.11
19.58	756.00
20.04	755.30
21.33	755.22
22.45	755.11
23.45	755.14
23.47	755.11
24.45	755.50
24.63	756.03
26.24	756.05
27.72	756.78
30.01	757.13
33.62	757.12
38.44	757.24
44.11	757.26
46.76	757.12
46.73	757.10
46.83	757.65

SUMMARY DATA	
Current Bankfull Elevation:	756.79
Bankfull Cross-Sectional Area:	11.6
Total Cross-Sectional Area:	12.7
Bankfull Width:	11.9
Flood Prone Area Elevation:	758.5
Flood Prone Width:	46.8
Max Depth at Bankfull:	1.7
Mean Depth at Bankfull:	1.0
W / D Ratio:	12.3
Entrenchment Ratio:	3.9
Bank Height Ratio:	0.9

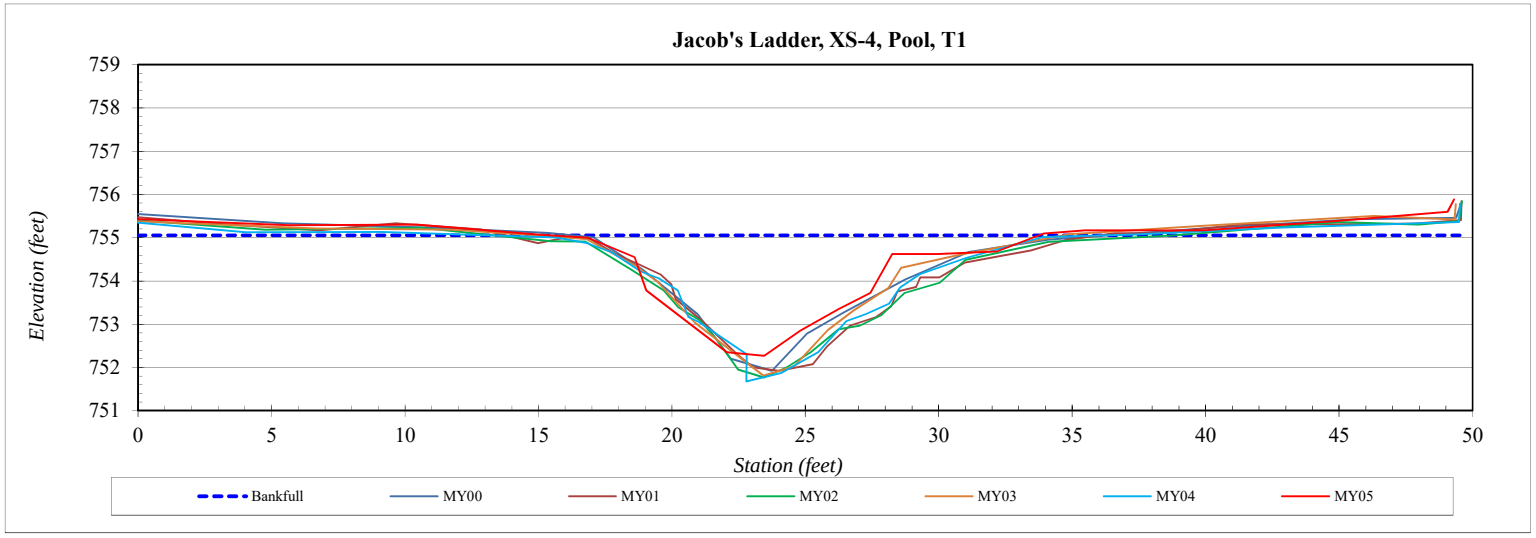


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-4
Drainage Area (sq mi):	0.36
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	755.42
5.68	755.29
10.44	755.30
14.95	755.07
16.87	755.00
18.60	754.55
19.04	753.79
20.75	751.13
22.07	752.35
23.47	752.27
24.81	752.85
26.23	753.34
27.43	753.72
28.25	754.62
29.96	754.62
32.16	754.68
33.92	755.09
35.48	755.17
39.93	755.17
44.85	755.38
49.06	755.60
49.30	755.89

SUMMARY DATA	
Current Bankfull Elevation:	755.1
Bankfull Cross-Sectional Area:	21.4
Total Cross-Sectional Area:	19.8
Bankfull Width:	18.5
Flood Prone Area Elevation:	---
Flood Prone Width:	---
Max Depth at Bankfull:	2.8
Mean Depth at Bankfull:	1.2
W / D Ratio:	---
Entrenchment Ratio:	---
Bank Height Ratio:	---

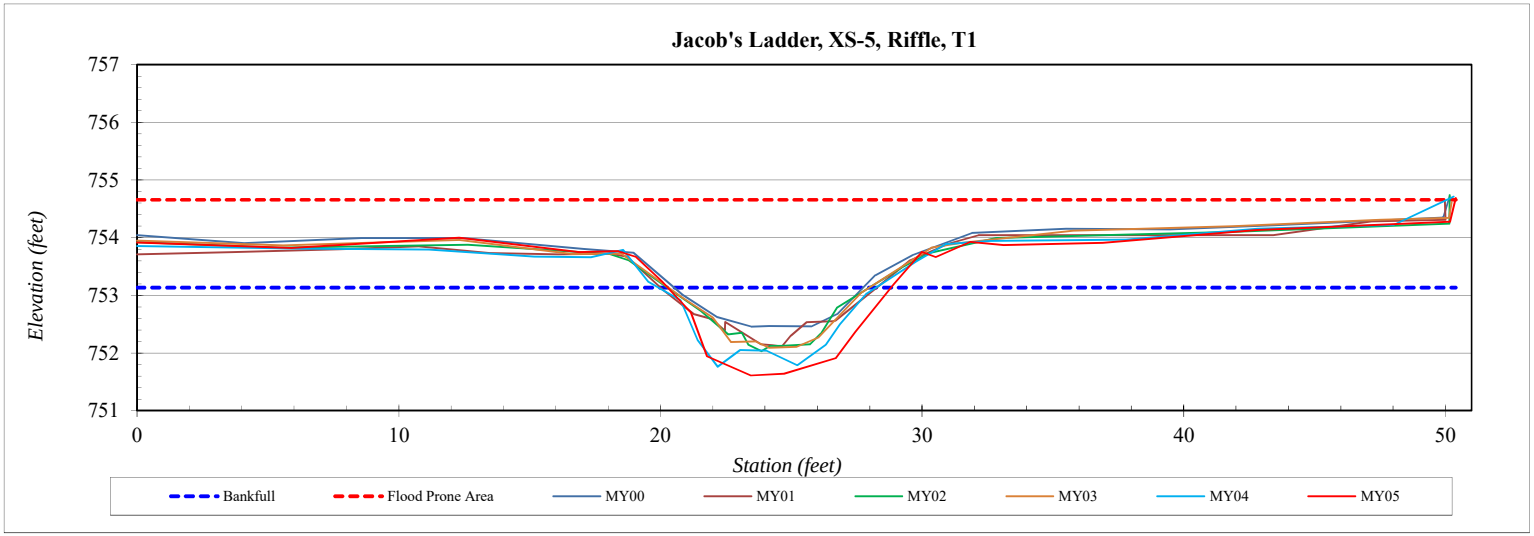


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-5
Drainage Area (sq mi):	0.36
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	753.92
5.89	753.82
12.31	754.00
16.89	753.75
18.39	753.77
19.06	753.67
20.07	753.24
21.18	752.70
21.78	751.94
23.46	751.61
24.72	751.64
26.70	751.91
27.45	752.37
28.92	753.19
30.00	753.75
30.53	753.66
31.83	753.93
33.12	753.87
36.91	753.91
42.77	754.13
50.17	754.27
50.39	754.69

SUMMARY DATA	
Current Bankfull Elevation:	753.1
Bankfull Cross-Sectional Area:	8.8
Total Cross-Sectional Area:	14.7
Bankfull Width:	8.5
Flood Prone Area Elevation:	754.7
Flood Prone Width:	50.4
Max Depth at Bankfull:	1.5
Mean Depth at Bankfull:	1.0
W / D Ratio:	8.3
Entrenchment Ratio:	5.9
Bank Height Ratio:	1.4

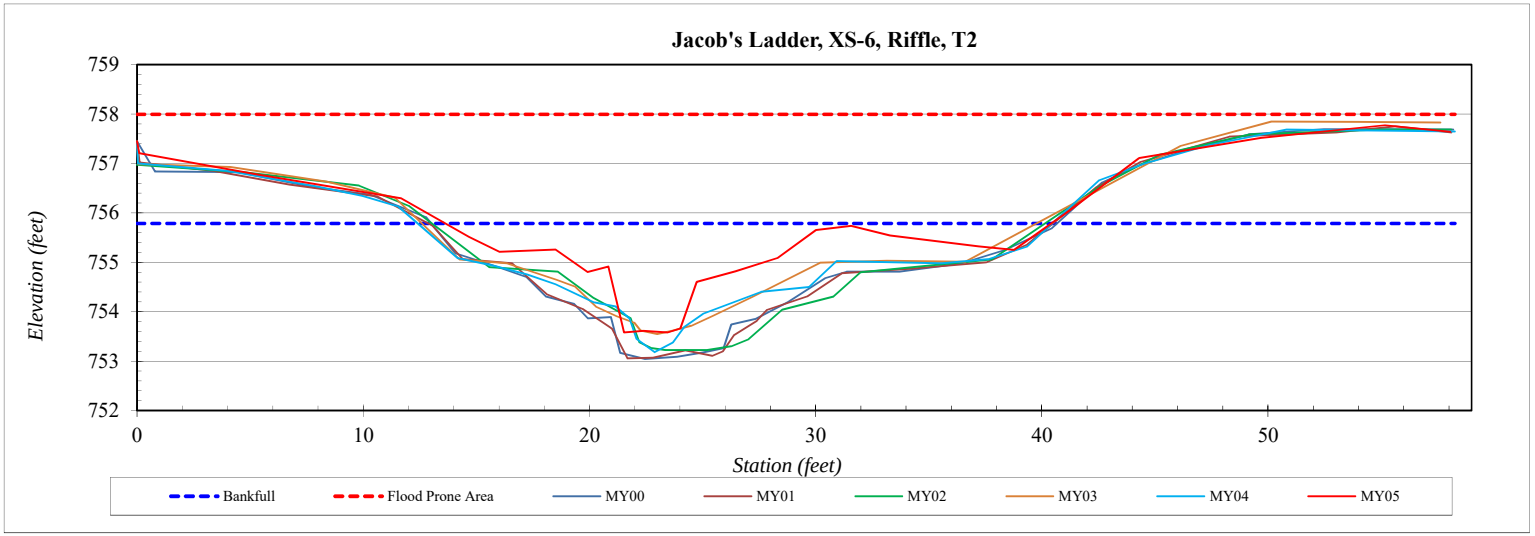


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-6
Drainage Area (sq mi):	0.67
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	757.45
0.10	757.21
5.36	756.77
11.68	756.30
14.67	755.52
16.03	755.21
18.50	755.26
19.93	754.80
20.84	754.91
21.53	753.58
22.40	753.61
23.45	753.58
24.02	753.67
24.75	754.60
26.46	754.82
28.31	755.09
30.00	755.66
31.56	755.74
33.30	755.54
37.19	755.32
38.76	755.25
41.19	756.04
44.30	757.11
49.69	757.52
55.17	757.78
58.05	757.64

SUMMARY DATA	
Current Bankfull Elevation:	755.8
Bankfull Cross-Sectional Area:	13.9
Total Cross-Sectional Area:	4.0
Bankfull Width:	13.1
Flood Prone Area Elevation:	758.0
Flood Prone Width:	58.1
Max Depth at Bankfull:	2.2
Mean Depth at Bankfull:	1.1
W / D Ratio:	12.3
Entrenchment Ratio:	4.4
Bank Height Ratio:	0.8

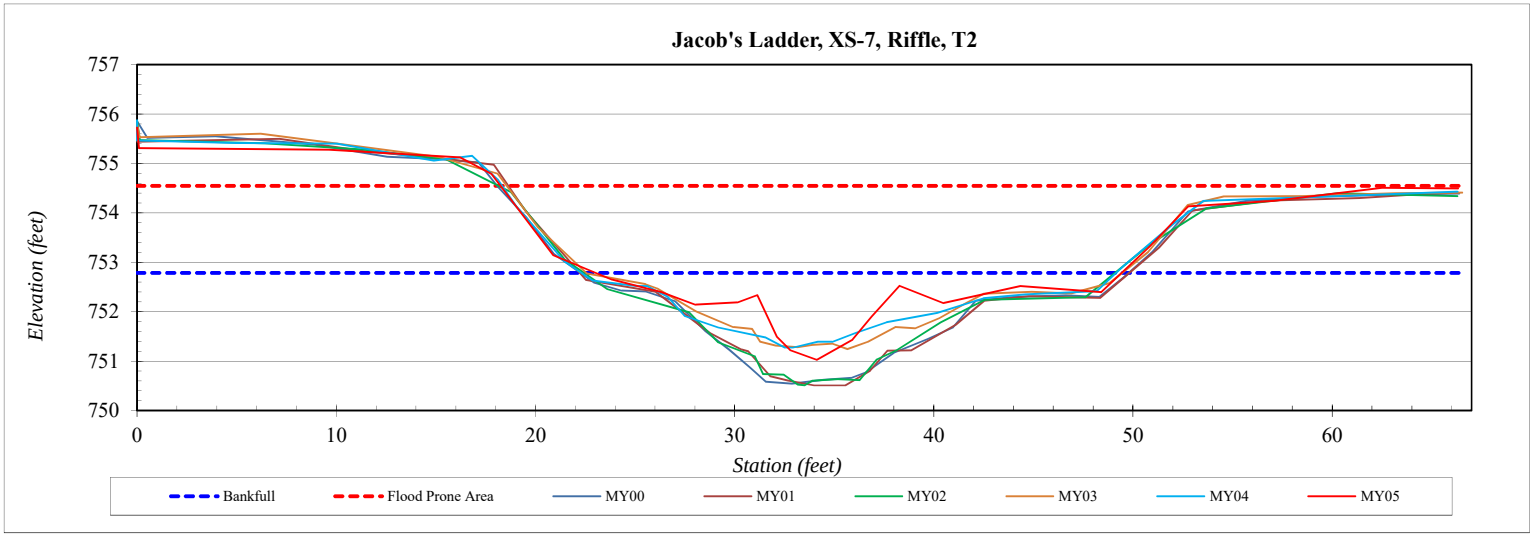


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-7
Drainage Area (sq mi):	0.67
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	755.73
0.09	755.31
9.64	755.28
16.22	755.13
17.78	754.79
20.88	753.15
23.85	752.65
26.31	752.39
28.03	752.15
30.14	752.19
31.13	752.34
32.11	751.50
32.79	751.23
34.12	751.03
35.92	751.44
36.89	751.91
38.28	752.53
40.49	752.18
44.35	752.52
48.40	752.40
50.86	753.33
52.78	754.13
57.05	754.24
62.52	754.51
66.32	754.50

SUMMARY DATA	
Current Bankfull Elevation:	752.8
Bankfull Cross-Sectional Area:	16.3
Total Cross-Sectional Area:	4.9
Bankfull Width:	26.4
Flood Prone Area Elevation:	754.5
Flood Prone Width:	48.1
Max Depth at Bankfull:	1.8
Mean Depth at Bankfull:	0.6
W / D Ratio:	42.7
Entrenchment Ratio:	1.8
Bank Height Ratio:	0.7

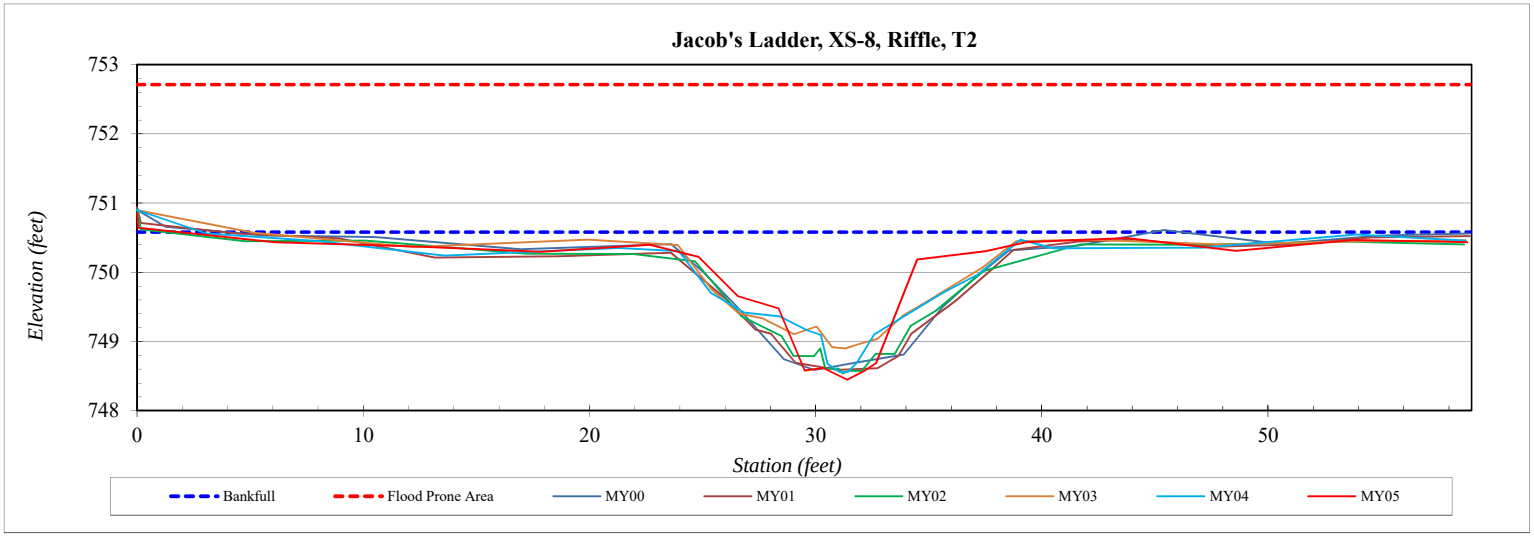


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-8
Drainage Area (sq mi):	0.70
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	750.85
0.06	750.64
6.07	750.44
12.18	750.37
17.87	750.29
22.66	750.39
24.83	750.22
26.56	749.65
28.35	749.48
29.52	748.58
30.35	748.62
31.39	748.45
32.09	748.56
32.69	748.69
34.50	750.18
37.52	750.31
39.30	750.43
43.76	750.49
48.60	750.31
53.78	750.47
58.81	750.43

SUMMARY DATA	
Current Bankfull Elevation:	750.6
Bankfull Cross-Sectional Area:	15.2
Total Cross-Sectional Area:	10.8
Bankfull Width:	16.6
Flood Prone Area Elevation:	752.7
Flood Prone Width:	58.8
Max Depth at Bankfull:	2.1
Mean Depth at Bankfull:	0.9
W / D Ratio:	18.2
Entrenchment Ratio:	3.5
Bank Height Ratio:	0.8

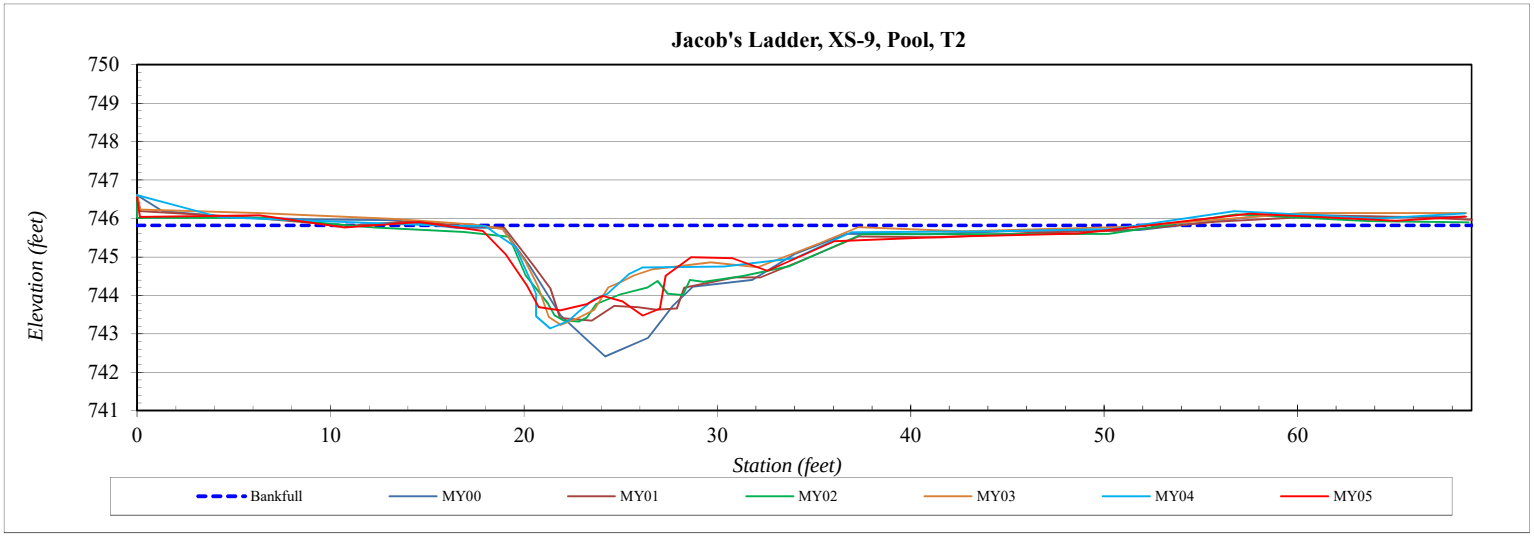


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-9
Drainage Area (sq mi):	0.70
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	746.55
0.15	746.04
6.30	746.08
10.72	745.76
14.60	745.91
17.89	745.67
19.06	745.06
20.15	744.25
20.77	743.69
21.87	743.61
23.21	743.76
24.06	743.99
25.10	743.84
26.14	743.47
27.04	743.66
27.34	744.51
28.62	744.99
30.80	744.96
32.60	744.64
36.03	745.40
41.92	745.52
48.65	745.60
57.51	746.12
65.08	745.93
68.71	746.05

SUMMARY DATA	
Current Bankfull Elevation:	745.8
Bankfull Cross-Sectional Area:	26.5
Total Cross-Sectional Area:	21.0
Bankfull Width:	24.0
Flood Prone Area Elevation:	---
Flood Prone Width:	---
Max Depth at Bankfull:	2.3
Mean Depth at Bankfull:	1.1
W / D Ratio:	---
Entrenchment Ratio:	---
Bank Height Ratio:	---

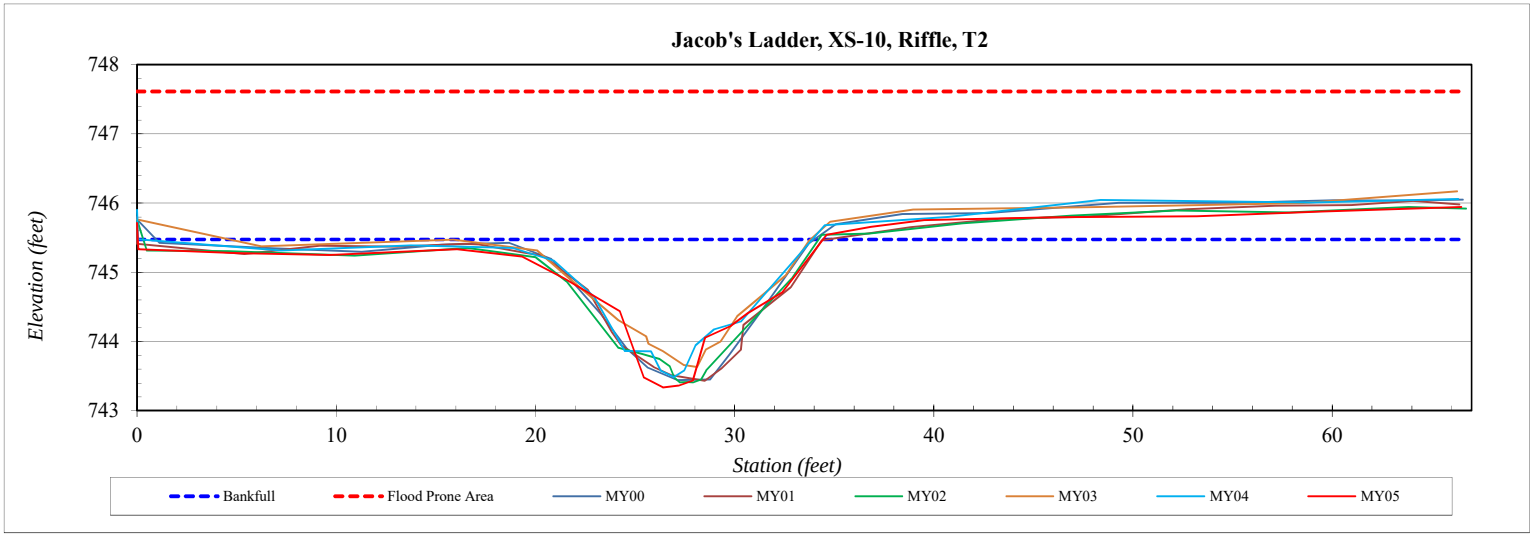


Cross-Section Plots

River Basin:	Yadkin-Pee Dee
Site:	Jacob's Ladder
XS ID	XS-10
Drainage Area (sq mi):	0.70
Date:	12/19/2018
Field Crew:	T. Seelinger and B. Rose

Station	Elevation
0.00	745.71
0.07	745.33
4.94	745.28
9.67	745.25
16.06	745.33
19.35	745.22
21.45	744.91
24.23	744.44
25.43	743.48
26.40	743.34
27.19	743.36
27.91	743.43
28.51	744.05
29.79	744.22
30.66	744.41
32.40	744.71
34.60	745.54
36.84	745.66
39.51	745.75
46.08	745.79
53.21	745.81
59.56	745.88
66.48	745.94

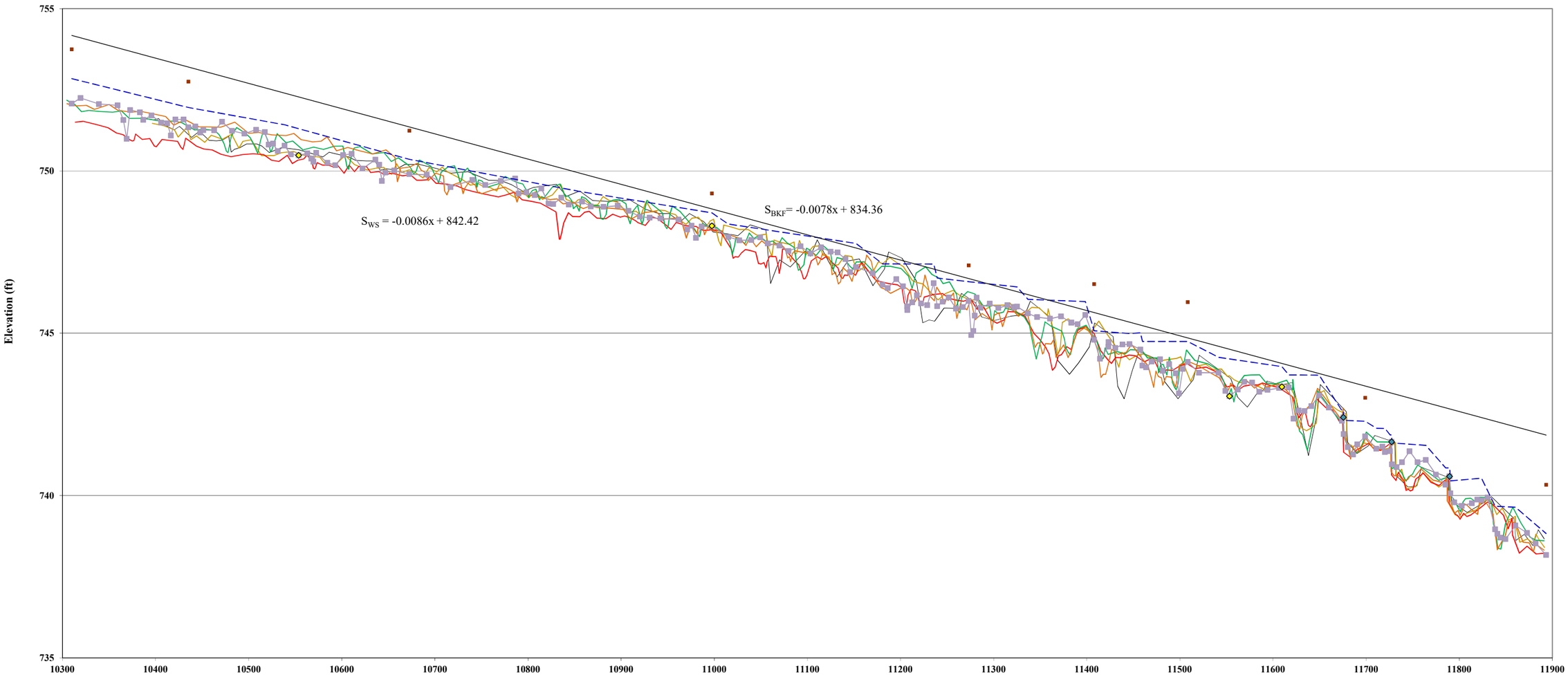
SUMMARY DATA	
Current Bankfull Elevation:	745.5
Bankfull Cross-Sectional Area:	16.2
Total Cross-Sectional Area:	15.4
Bankfull Width:	15.1
Flood Prone Area Elevation:	747.6
Flood Prone Width:	66.5
Max Depth at Bankfull:	2.1
Mean Depth at Bankfull:	1.1
W / D Ratio:	14.0
Entrenchment Ratio:	4.4
Bank Height Ratio:	0.9



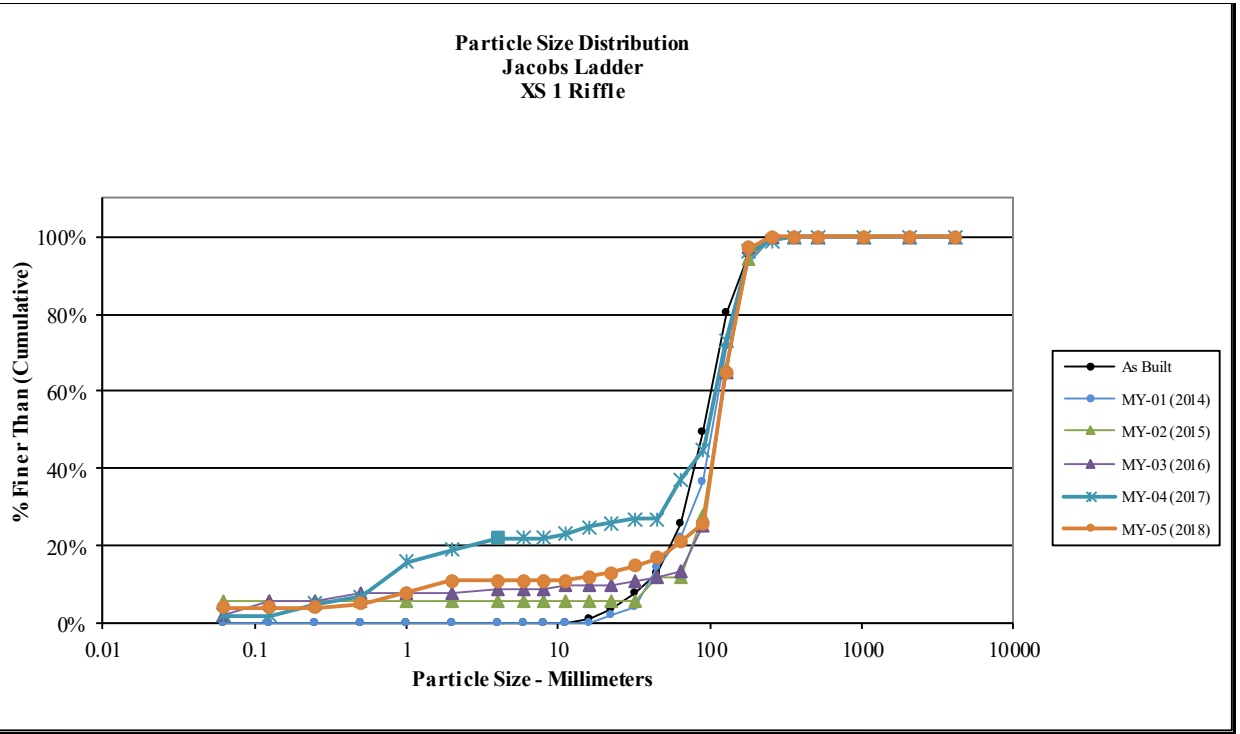
Jacob's Ladder Stream Restoration Site
Longitudinal Profile
T1 MY-05

As-Built, 2/20/14 | MY-01, 10/29/14 | MY-02, 8/12/15 | MY-03, 6/8/2016 | MY-04, 6/1/17 | MY-05, 12/19/18 | Cross Sections | Structures | Bankfull | Water Surface | Linear (Bankfull) | Linear (Water Surface)

Jacob's Ladder Stream Restoration Site
Longitudinal Profile
T2 MY-05



Cross-Section 1 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	4
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	1
Coarse	.50 - 1	D	3
Very Coarse	1 - 2	S	3
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	1
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	2
Very Coarse	45 - 64		4
Small	64 - 90	C	5
Small	90 - 128	O	39
Large	128 - 180	B	32
Large	180 - 256	L	3
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100
Note:			



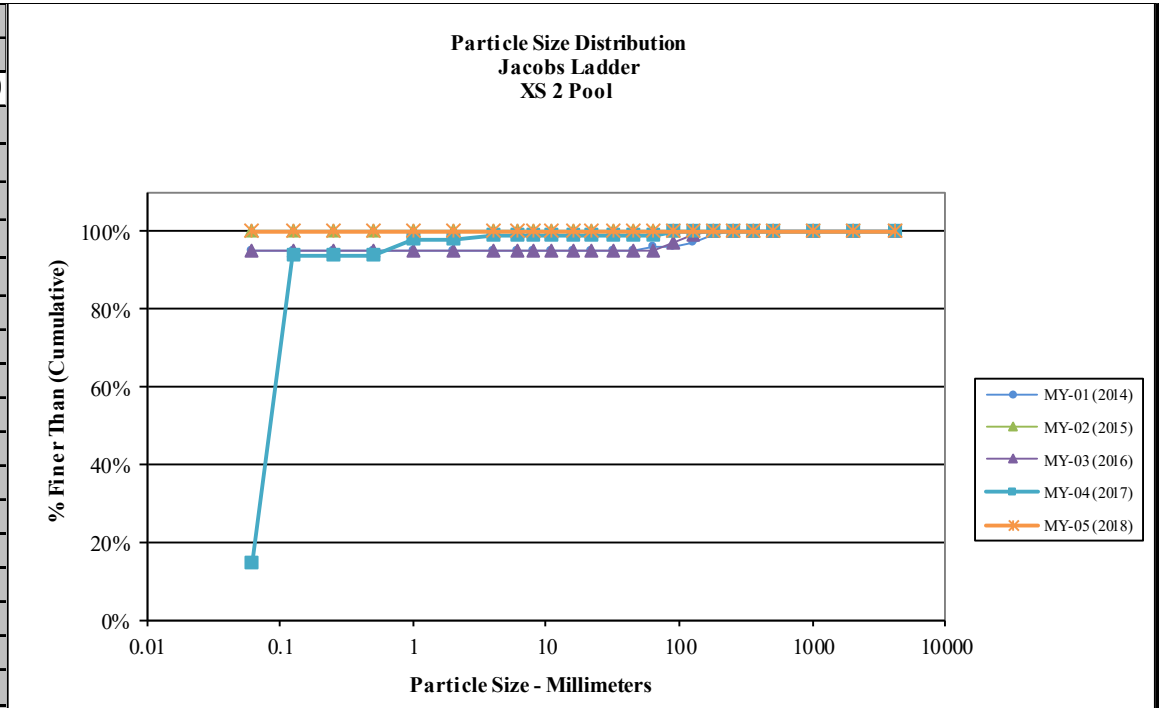
Size (mm)	
D16	1
D35	60
D50	96
D65	120
D84	150
D95	180

Size Distribution	
mean	12.2
dispersion	48.8
skewness	-0.61

Type	
silt/clay	4%
sand	7%
gravel	10%
cobble	79%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Pool - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	100
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:

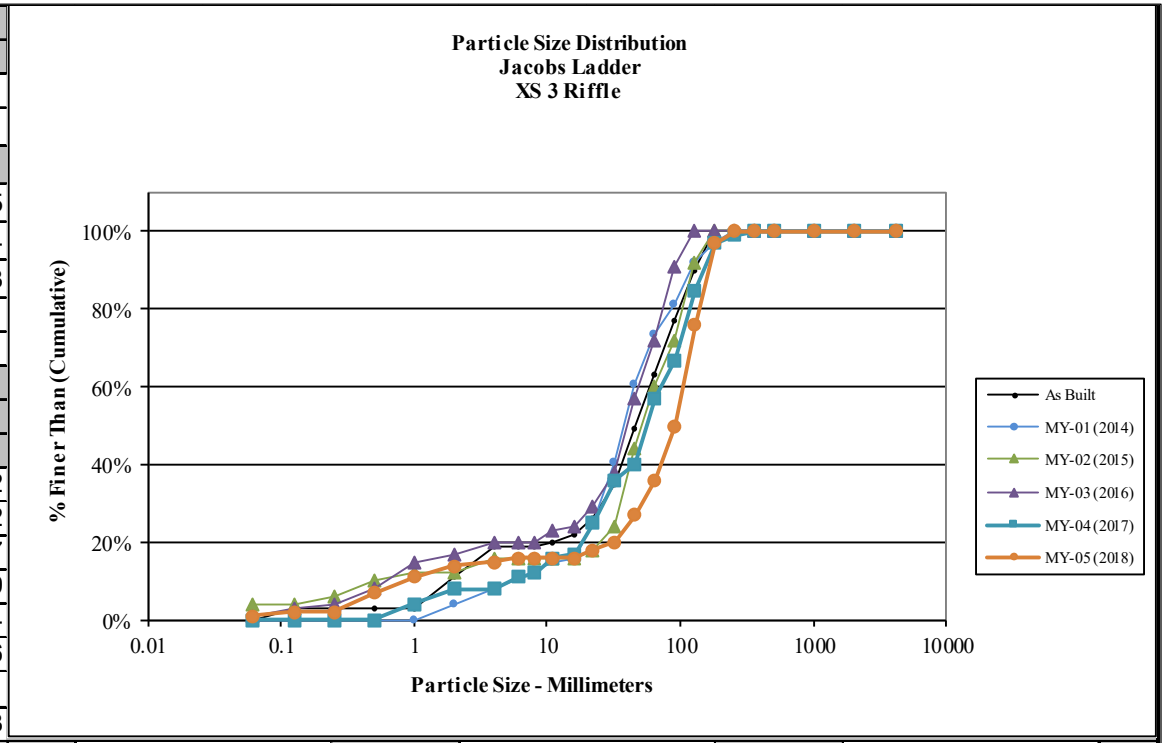


Size (mm)	
D16	0.062
D35	0.074
D50	0.085
D65	0.097
D84	0.11
D95	0.59

Size Distribution	
mean	0.1
dispersion	1.3
skewness	-0.03

Type	
silt/clay	100%
sand	0%
gravel	0%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	1
Fine	.125 - .25	A	
Medium	.25 - .50	N	5
Coarse	.50 - 1	D	4
Very Coarse	1 - 2	S	3
Very Fine	2 - 4		1
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	2
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	7
Very Coarse	45 - 64		9
Small	64 - 90	C	14
Small	90 - 128	O	26
Large	128 - 180	B	21
Large	180 - 256	L	3
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100
Note:			



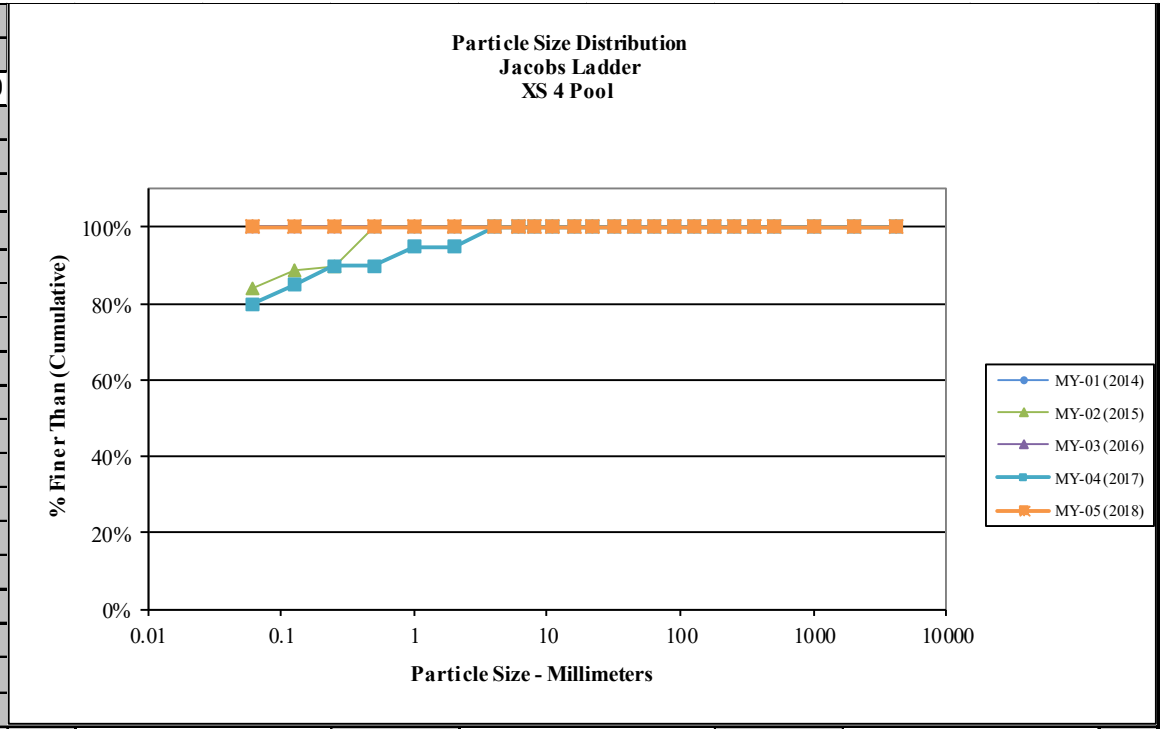
Size (mm)	
D16	11
D35	31
D50	55
D65	84
D84	130
D95	170

Size Distribution	
mean	37.8
dispersion	3.7
skewness	-0.16

Type	
silt/clay	1%
sand	13%
gravel	22%
cobble	64%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Pool - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	100
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:

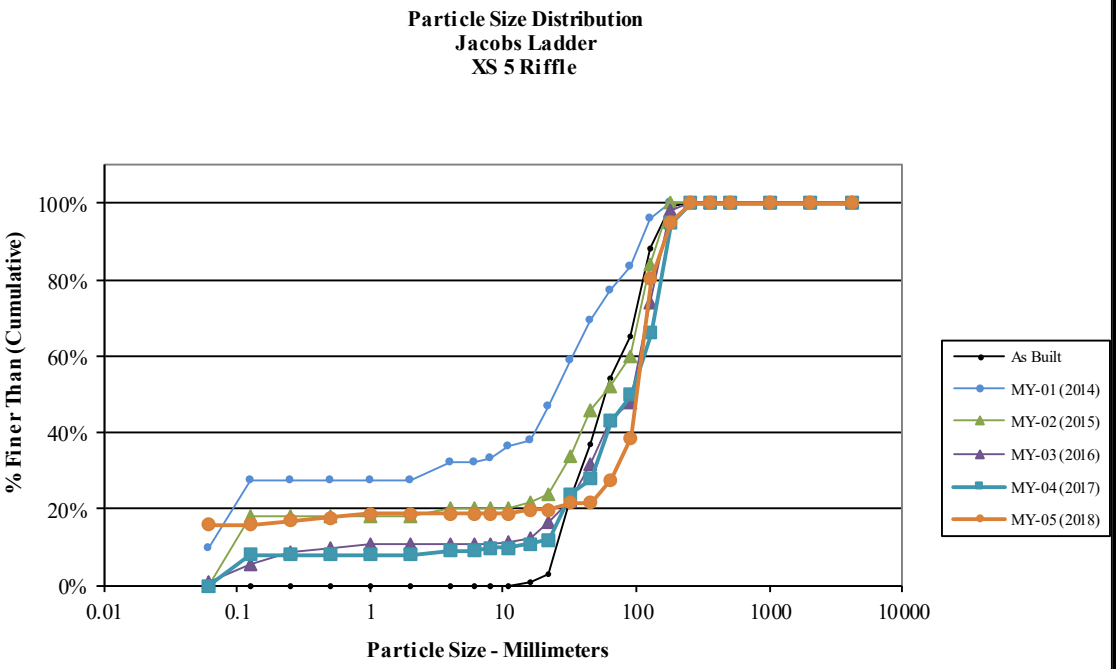


Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.062
D84	0.11
D95	1.9

Size Distribution	
mean	0.1
dispersion	1.4
skewness	0.25

Type	
silt/clay	100%
sand	0%
gravel	0%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	16
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	1
Medium	.25 - .50	N	1
Coarse	.50 - 1	D	1
Very Coarse	1 - 2	S	
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	1
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		6
Small	64 - 90	C	11
Small	90 - 128	O	42
Large	128 - 180	B	15
Large	180 - 256	L	5
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	101
Note:			

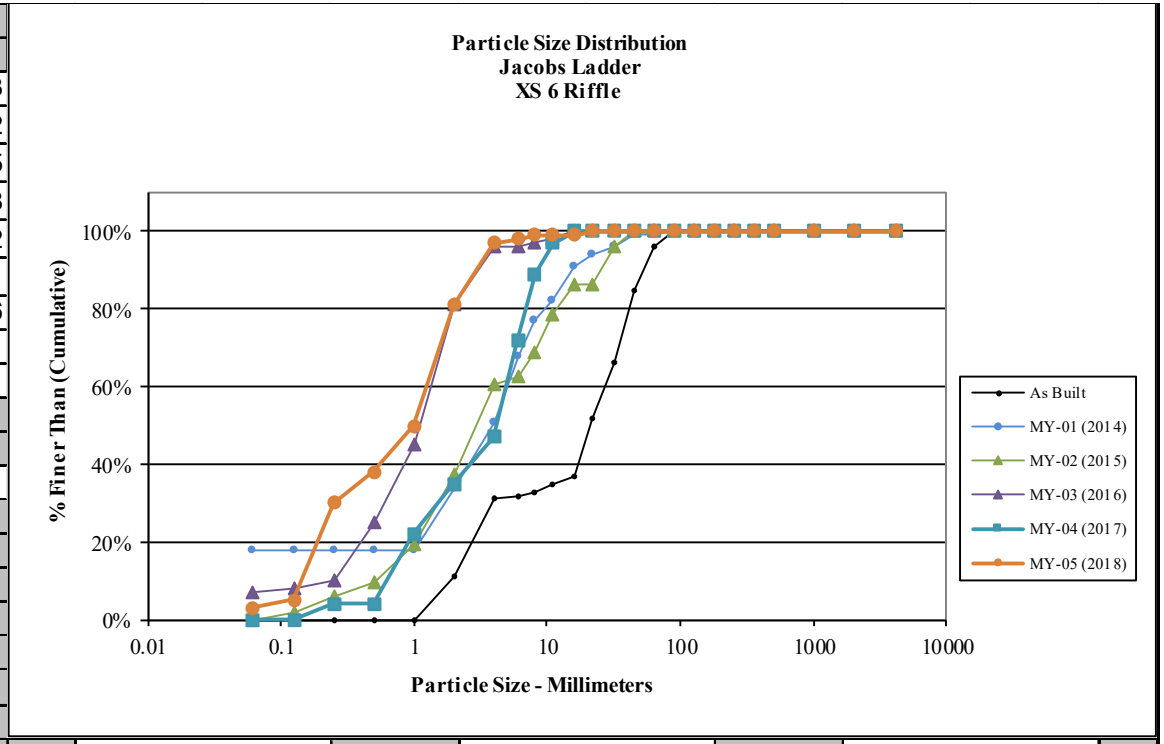


Size (mm)	
D16	25
D35	53
D50	90
D65	130
D84	160
D95	180

Size Distribution	
mean	63.2
dispersion	2.7
skewness	-0.17

Type	
silt/clay	16%
sand	3%
gravel	9%
cobble	72%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 6 Riffle -MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	3
Very Fine	.062 - .125	S	2
Fine	.125 - .25	A	25
Medium	.25 - .50	N	8
Coarse	.50 - 1	D	12
Very Coarse	1 - 2	S	31
Very Fine	2 - 4		16
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100
Note:			

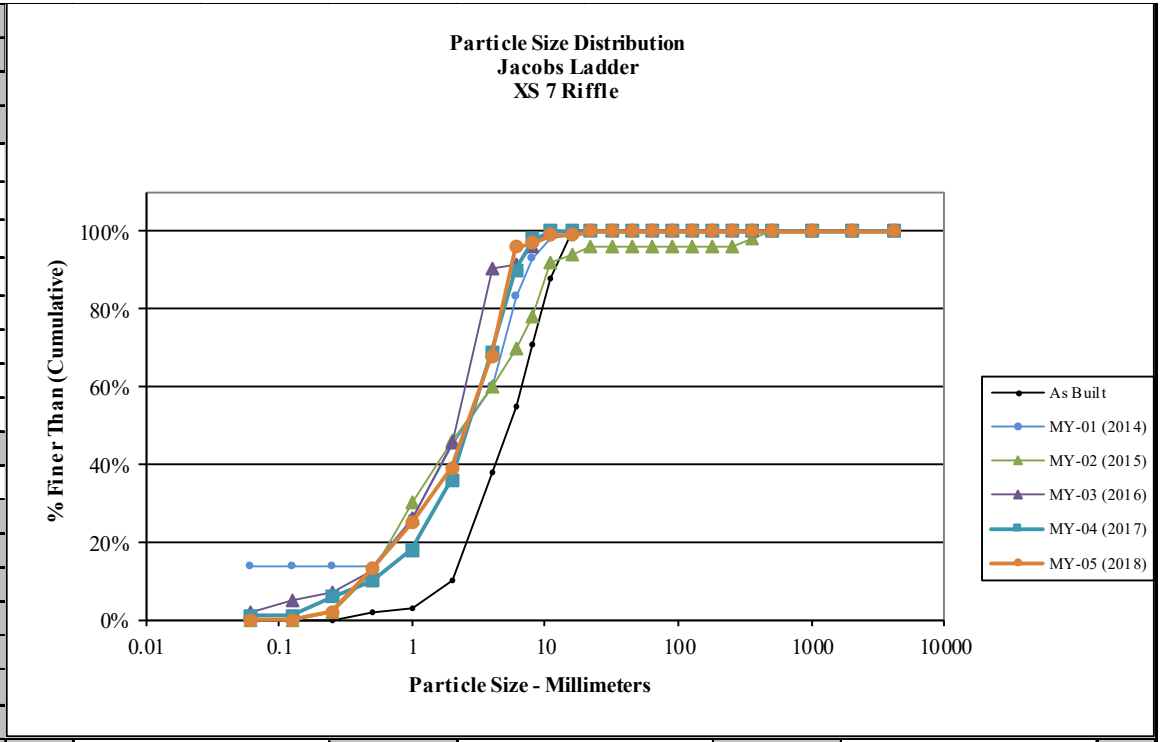


Size (mm)	
D16	0.79
D35	2.0
D50	4.2
D65	5.4
D84	7.4
D95	10

Size Distribution	
mean	2.4
dispersion	3.5
skewness	-0.24

Type	
silt/clay	3%
sand	78%
gravel	19%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 7 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	2
Medium	.25 - .50	N	11
Coarse	.50 - 1	D	12
Very Coarse	1 - 2	S	14
Very Fine	2 - 4		29
Fine	4 - 5.7	G	28
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100
Note:			



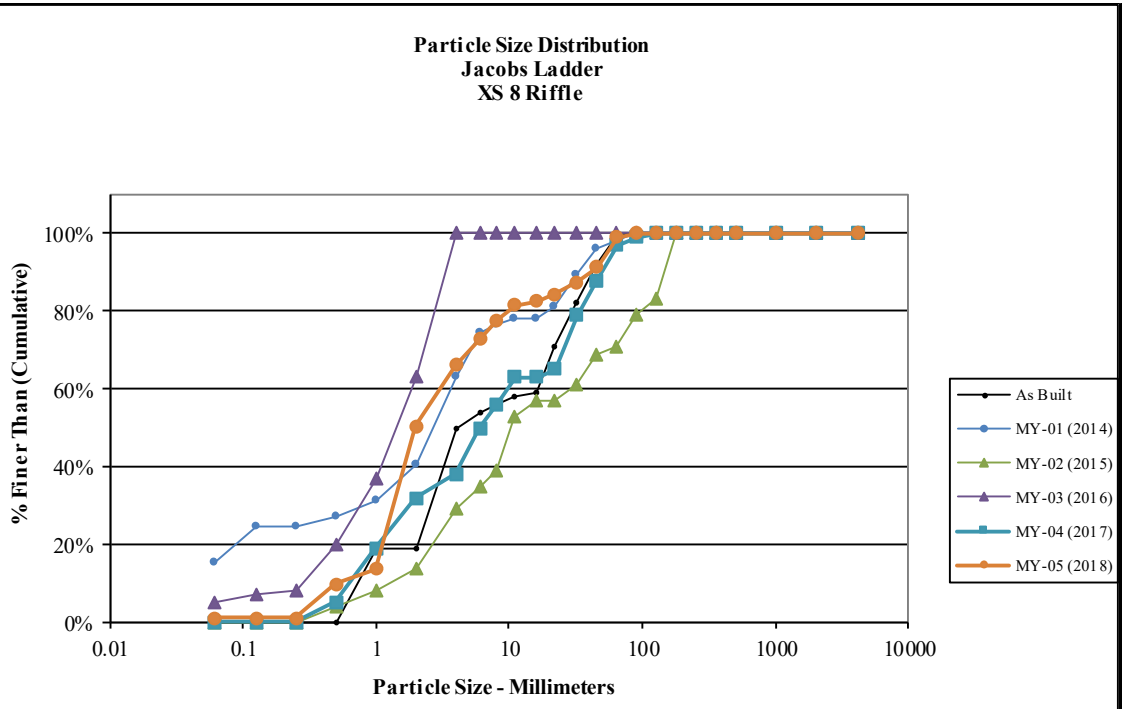
Size (mm)	
D16	0.84
D35	1.90
D50	2.7
D65	3.7
D84	5.3
D95	7.2

Size Distribution	
mean	2.1
dispersion	2.6
skewness	-0.12

Type	
silt/clay	0%
sand	39%
gravel	61%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 8 Riffle -MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	9
Coarse	.50 - 1	D	4
Very Coarse	1 - 2	S	38
Very Fine	2 - 4		16
Fine	4 - 5.7	G	7
Fine	5.7 - 8	R	5
Medium	8 - 11.3	A	4
Medium	11.3 - 16	V	1
Coarse	16 - 22.6	E	2
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	4
Very Coarse	45 - 64		8
Small	64 - 90	C	1
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	103

Note:

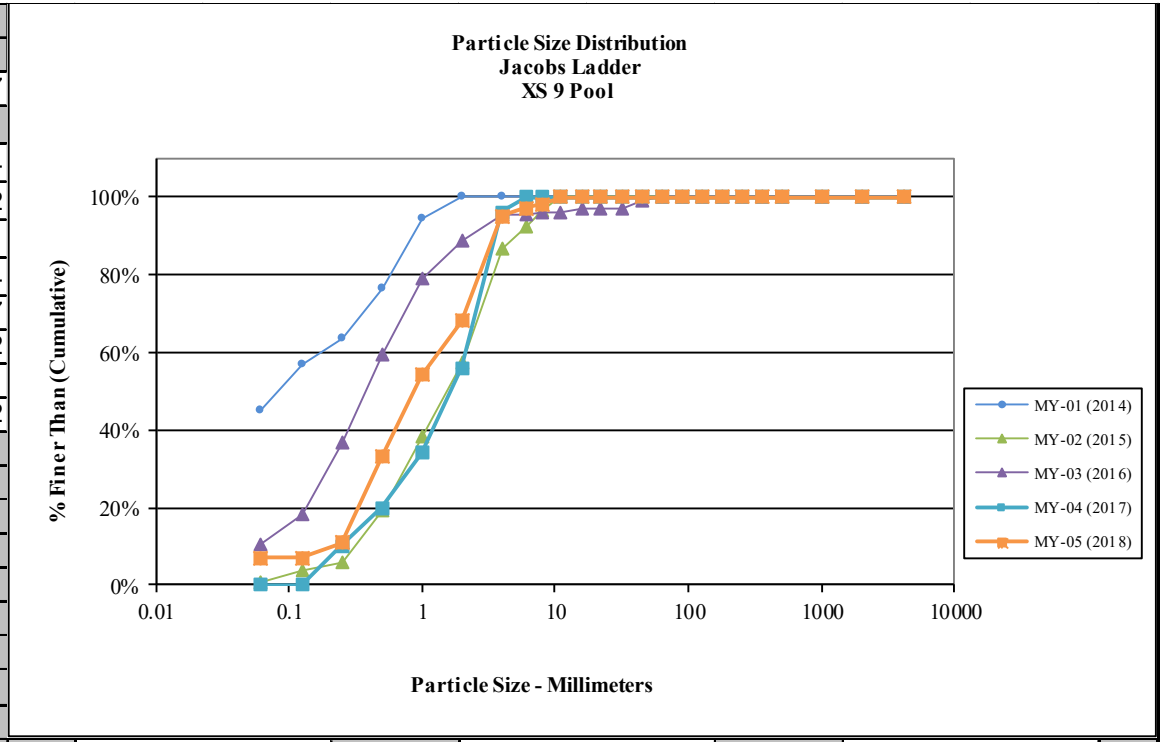


Size (mm)	
D16	0.86
D35	2.8
D50	6
D65	22
D84	39
D95	59

Size Distribution	
mean	5.8
dispersion	6.7
skewness	-0.01

Type	
silt/clay	1%
sand	50%
gravel	49%
cobble	1%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 9 Pool - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	7
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	4
Medium	.25 - .50	N	22
Coarse	.50 - 1	D	21
Very Coarse	1 - 2	S	14
Very Fine	2 - 4		27
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100
Note:			



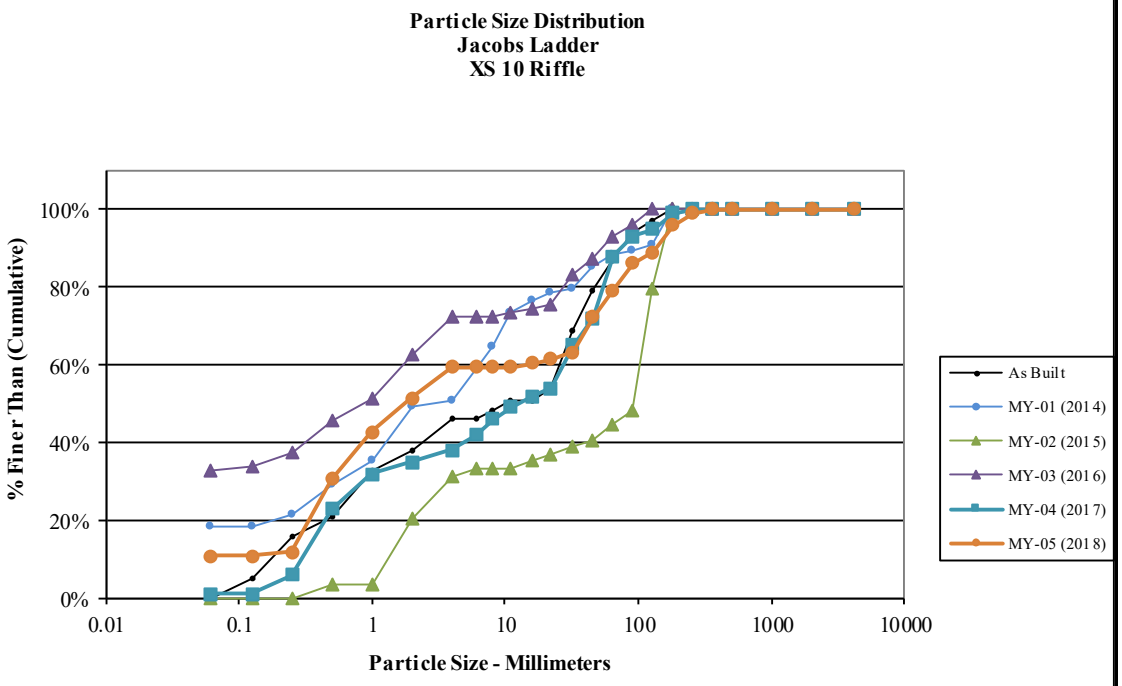
Size (mm)	
D16	0.38
D35	1.0
D50	1.7
D65	2.3
D84	3.2
D95	3.9

Size Distribution	
mean	1.1
dispersion	3.2
skewness	-0.20

Type	
silt/clay	7%
sand	61%
gravel	32%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 10 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	11
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	1
Medium	.25 - .50	N	19
Coarse	.50 - 1	D	12
Very Coarse	1 - 2	S	9
Very Fine	2 - 4		8
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	1
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	9
Very Coarse	45 - 64		7
Small	64 - 90	C	7
Small	90 - 128	O	3
Large	128 - 180	B	7
Large	180 - 256	L	3
Small	256 - 362	B	1
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	101

Note:



Size (mm)	
D16	0.38
D35	2
D50	12
D65	32
D84	59
D95	130

Size Distribution	
mean	4.7
dispersion	18.2
skewness	-0.27

Type	
silt/clay	11%
sand	41%
gravel	28%
cobble	21%
boulder	1%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Table 10a. T1 Baseline Stream Data Summary
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Parameter	Pre-Existing Condition					Reference Reach(es) Data					Design		As-built			
Dimension - Riffle	Min	Mean	Med	Max	n	Min	Mean	Med	Max	n	Min	Max	Min	Mean	Max	n
Bankfull Width (ft)	6.7	8.2		9.6	2	6.9				1	10.3	11.5	10.8	11.3	12.4	3
Floodprone Width (ft)	12	14		16	2	23				1	23	70	>45	>48	>50	3
Bankfull Mean Depth (ft)	1.1	1.3		1.5	2	1.1				1	0.9	1.0	0.8	0.9	1.0	3
Bankfull Max Depth (ft)	1.7	2.1		2.4	2	1.6				1	1.4	1.5	1.3	1.5	1.7	3
Bankfull Cross-Sectional Area (ft^2)	9.8	10.2		10.5	2	7.4				1	9.0	11.0	8.8	10.3	11.6	3
Width/Depth Ratio	4.6	6.7		8.8	2	6.4				1	12.0	12.0	11.2	12.6	13.3	3
Entrenchment Ratio	1.3	1.8		2.2	2	3.4				1	2.2	6.0	3.6	4.3	4.6	3
Bank Height Ratio	2.3	2.8		3.3	2	1.0				1	1.0	1.0	1.0	1.0	1.0	3
Pattern																
Channel Beltwidth (ft)	*					14	26		38	2	25	70	25	48	70	
Radius of Curvature (ft)	*					12	19		25	2	20	45	20	33	45	
Rc:Bankfull width (ft/ft)	*					1.7	2.7		3.6	2	2	4	2	3	4	
Meander Wavelength (ft)	*					43	73		102	2	65	140	65	103	140	
Meander Width Ratio	*					2.0	3.8		5.5	2	2.4	5.8	2.4	4.0	5.8	
Profile																
Riffle Length (ft)													20	31	40	21
Riffle Slope (ft/ft)	0.010			0.035		0.011			0.025	2	0.004	0.017	0.003	0.015	0.022	21
Pool Length (ft)						16			23		12	40	18	28	49	19
Pool Spacing (ft)						28			57		47	95	54	76	95	19
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / B% / Be%	0% / 21% / 79% / 0% / 0% / 0%												0% / 4% / 44% / 52% / 0% / 0%			
d16 / d35 / d50 / d84 / d95 (mm)	1 / 6 / 8 / 11 / 17 / 22												27 / 49 / 65 / 89/ 123 / 163			
Additional Reach Parameters																
Channel length (ft)	2,179										2,361		2,389			
Drainage Area (SM)	0.36					0.16					0.36		0.36			
Rosgen Classification	G4					E4					C4		C4			
Sinuosity	1.03					1.18					1.14-1.18		1.14-1.18			
Water Surface Slope (ft/ft)	0.011					0.007					0.011		0.008			

*Not a meandering channel and mostly composed of riffles and runs; therefore no pattern data or pool data was shown

Table 10b. T2 Baseline Stream Data Summary
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Parameter	Pre-Existing Condition					Reference Reach(es) Data					Design		As-built			
Dimension - Riffle	Min	Mean	Med	Max	n	Min	Mean	Med	Max	n	Min	Max	Min	Mean	Max	n
Bankfull Width (ft)	10.6	12.6		16.5	3	6.9				1	13.5	13.5	14.6	14.9	15.2	4
Floodprone Width (ft)	16	24		35	3	23				1	30	70	33	34	66	4
Bankfull Mean Depth (ft)	1.2	1.7		2.3	3	1.1				1	1.1	1.1	0.9	1.1	1.1	4
Bankfull Max Depth (ft)	2.1	2.6		3.4	3	1.6				1	1.8	1.8	1.7	1.7	1.8	4
Bankfull Cross-Sectional Area (ft^2)	18.5	21.4		25.0	3	7.4				1	15.3	15.3	13.9	15.4	16.3	4
Width/Depth Ratio	4.7	8.0		13.2	3	6.4				1	12.0	12.0	13.9	14.4	15.5	4
Entrenchment Ratio	1.5	1.8		2.1	3	3.4				1	2.2	5.2	2.2	3.3	4.4	4
Bank Height Ratio	1.9	2.0		2.0	3	1.0				1	1.0	1.0	1.0	1.0	1.0	4
Pattern																
Channel Beltwidth (ft)	20	40		60	3	14	26		38	2	20	70	20	45	70	
Radius of Curvature (ft)	5	10		15	3	12	19		25	2	20	54	20	37	54	
Rc:Bankfull width (ft/ft)	0.5	1.0		1.4	3	1.7	2.7		3.6	2	2	4	2	3	4	
Meander Wavelength (ft)	23	87		150	3	43	73		102	2	58	140	58	99	140	
Meander Width Ratio	1.8	3.8		5.8	3	2.0	3.8		5.5	2	2.2	5.2	2.2	4.0	5.2	
Profile																
Riffle Length (ft)													5	15	23	23
Riffle Slope (ft/ft)	0.004			0.018	3	0.011			0.025	2			0.001	0.011	0.041	23
Pool Length (ft)						16			23				13	26	49	16
Pool Spacing (ft)						28			57				52	69	92	16
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / B% / Be%	4% / 21% / 75% / 0% / 0% / 0%												0% / 20% / 76% / 5% / 0% / 0%			
d16 / d35 / d50 / d84 / d95 (mm)	1 / 2 / 3 / 6 / 11 / 19												1 / 5 / 10 / 22 / 36 / 57			
Additional Reach Parameters																
Channel length (ft)	2,083										2,084		2,084			
Drainage Area (SM)	0.70					0.16					0.70		0.70			
Rosgen Classification	G4					E4					C4		C4			
Sinuosity	1.00-1.47					1.18					1.16-1.45		1.16-1.45			
Water Surface Slope (ft/ft)	0.006-0.013					0.007					0.007-0.012		0.008			

Table 10c. T1A-1, T1A-2 Baseline Stream Data Summary
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Parameter	Pre-Existing Condition					Reference Reach(es) Data					Design		As-built			
Dimension - Riffle	Min	Mean	Med	Max	n	Min	Mean	Med	Max	n	Min	Max	Min	Mean	Max	n
Bankfull Width (ft)	12.7				1	7.7	9.3		10.8	2	7.0					
Floodprone Width (ft)	30				1	13	15		16	2	0.9					
Bankfull Mean Depth (ft)	0.4				1	0.7	0.8		0.9	2	0.6					
Bankfull Max Depth (ft)	0.9				1	1.3	1.5		1.7	2	0.9					
Bankfull Cross-Sectional Area (ft^2)	4.5				1	6.1	7.5		8.8	2	3.9					
Width/Depth Ratio	35.8				1	8.5	9.9		11.4	2	12.5					
Entrenchment Ratio	2.4				1	1.6	1.8		2.1	2	2.2					
Bank Height Ratio	1.0				1	1.0				1	1.0					
Pattern																
Channel Beltwidth (ft)	*					22				1	10	30				
Radius of Curvature (ft)	*					11			23	2	12	25				
Rc:Bankfull width (ft/ft)	*					1			3	2	2	4				
Meander Wavelength (ft)	*					49			59	2	55	95				
Meander Width Ratio	*					2			3	2	1.0	4.3				
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.013			0.018	2	0.012			0.028	2	0.006	0.020				
Pool Length (ft)						5			9		7	11				
Pool Spacing (ft)											22	63				
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / B% / Be%						0%, 18%, 82%, 1%, 0%, 0%										
d16 / d35 / d50 / d84 / d95 (mm)						3, 7, 9, 13, 17, 25										
Additional Reach Parameters																
Channel length (ft)	446										446					
Drainage Area (SM)	0.05					0.15					0.05					
Rosgen Classification	C4					B4c					B4c/C4					
Sinuosity	1.11					1.20					1.11					
Water Surface Slope (ft/ft)	0.015					0.012					0.012					

*Not a meandering channel and mostly composed of riffles and runs; therefore no pattern data or pool data was shown

Table 10d. T1A-3 Baseline Stream Data Summary
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Parameter	Pre-Existing Condition					Reference Reach(es) Data					Design		As-built			
Dimension - Riffle	Min	Mean	Med	Max	n	Min	Mean	Med	Max	n	Min	Max	Min	Mean	Max	n
Bankfull Width (ft)	9.3				1	9.0	9.5		10.0	2	6.0					
Floodprone Width (ft)	10				1	13	17		21	2	14					
Bankfull Mean Depth (ft)	0.5				1	1.1	1.1		1.2	2	0.5					
Bankfull Max Depth (ft)	0.7				1	1.3	1.4		1.5	2	0.9					
Bankfull Cross-Sectional Area (ft^2)	4.3				1	10.4	10.5		10.7	2	3.2					
Width/Depth Ratio	20.1				1	8.0	9.0		10.0	2	11.2					
Entrenchment Ratio	1.1				1	1.3	1.8		2.3	2	2.2					
Bank Height Ratio	8.6				1	1.0				1	1.0					
Pattern																
Channel Beltwidth (ft)	*					45				1	15	30				
Radius of Curvature (ft)	*					13			42	2	12	27				
Rc:Bankfull width (ft/ft)	*					1.3			4.4	2	2.0	4.5				
Meander Wavelength (ft)	*					93			136	2	50	80				
Meander Width Ratio	*					4.5			5.0	2	2.5	5.0				
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)						0.013			0.028	2	0.020	0.030				
Pool Length (ft)						3			25	2	6	12				
Pool Spacing (ft)						30			39	2	20	40				
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / B% / Be%																
d16 / d35 / d50 / d84 / d95 (mm)																
Additional Reach Parameters																
Channel length (ft)	470										498					
Drainage Area (SM)	0.05					0.40					0.05					
Rosgen Classification	F4					B4c					B4c/C4					
Sinuosity	1.06					1.20					1.09					
Water Surface Slope (ft/ft)	0.018					0.013					0.017					

*Not a meandering channel and mostly composed of riffles and runs; therefore no pattern data or pool data was shown

Table 11. Cross-Section Morphology Data Tables
Jacob's Ladder Stream Restoration Site, DMS Project # 95023

Dimension and Substrate	Cross-Section 1 (T1-Riffle) Station 14+75							Cross-Section 2 (T1-Pool) Station 16+40							Cross-Section 3 (T1-Riffle) Station 24+88							Cross-Section 4 (T1-Pool) Station 26+98							Cross-Section 5 (T1-Riffle) Station 28+75						
Baseline Bankfull Elevation	766.5							764.4							756.9							754.7							753.7						
Based on fixed baseline bankfull area	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	9.5	10.5	11.0	11.0	10.3	11.0		9.1	9.0	9.2	9.7	9.4	8.7		12.4	11.9	12.8	12.6	13.3	11.9		17.1	16.4	15.5	16.5	15.8	18.5		10.8	10.5	10.7	10.4	9.6	8.5	
Floodprone Width (ft)	>50	>50	>50	>50	>50	>50		-	-	-	-	-	-		>45	>45	>45	>45	>45	>45		-	-	-	-	-	-		>50	>50	>50	>50	>50	>50	
Bankfull Mean Depth (ft)	1.1	1.0	0.9	0.9	1.0	0.9		1.3	1.3	1.3	1.2	1.2	1.3		0.9	1.0	0.9	0.9	1.0	1.0		1.3	1.3	1.4	1.3	1.4	1.2		0.8	0.8	0.8	0.8	0.9	1.0	
Bankfull Max Depth (ft)	1.6	1.7	1.7	1.6	1.7	1.7		2.2	2.2	2.2	2.3	2.2	2.2		1.7	1.7	1.7	1.7	1.7	1.7		3.0	2.9	3.0	3.1	3.2	2.8		1.3	1.5	1.5	1.5	1.6	1.5	
Bankfull Cross-Sectional Area (ft^2)	10.1	10.1	10.1	10.1	10.1	10.1		11.5	11.5	11.5	11.5	11.5	11.5		11.6	11.6	11.6	11.6	11.6	11.6		21.4	21.4	21.4	21.4	21.4	21.4		8.8	8.8	8.8	8.8	8.8	8.8	
Total Cross-Sectional Area (ft^2)	10.1	10.8	11.2	9.4	11.1	10.4		11.5	12.9	12.8	10.8	13.0	12.7		11.6	12.4	12.8	11.5	14.5	12.7		21.4	24.6	25.6	22.1	23.5	19.8		8.8	10.7	10.7	10.8	13.2	14.7	
Bankfull Width/Depth Ratio	8.9	11.0	12.0	12.1	10.6	12.0		-	-	-	-	-	-		13.2	12.3	14.1	13.7	12.7	12.3		-	-	-	-	-	-		13.3	12.5	12.8	12.2	10.3	8.3	
Bankfull Entrenchment Ratio	5.3	4.8	4.6	4.6	4.9	4.6		-	-	-	-	-	-		3.8	3.9	3.6	3.7	3.9	3.9		-	-	-	-	-	-		4.6	4.8	4.7	4.8	5.3	5.9	
Bankfull Bank Height Ratio	1.0	1.0	1.0	0.9	1.0	1.0		-	-	-	-	-	-		1.0	1.0	0.9	0.9	1.0	0.9		-	-	-	-	-	-		1.0	1.1	1.1	1.1	1.3	1.4	
d50 (mm)	91	100	110	79	96	110		-	-	-	-	-	-		46	38	51	28	55	90		-	-	-	-	-	-		59	24	57	66	90	99	
	Cross-Section 6 (T2-Riffle)							Cross-Section 7 (T2-Riffle)							Cross-Section 8 (T2-Riffle)							Cross-Section 9 (T2-Pool)							Cross-Section 10 (T2-Riffle)						
Baseline Bankfull Elevation	754.8							752.2							750.3							745.1							745.2						
Based on fixed baseline bankfull area	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	14.7	14.1	15.2	13.8	16.7	13.1		15.2	16.2	20.6	24.2	25.7	26.4		14.6	15.2	16.4	14.9	15.1	16.6		18.3	19.3	18.2	18.4	18.9	24.0		15.0	16.9	14.0	14.3	15.3	15.1	
Floodprone Width (ft)	35.0	34.4	32.5	37.2	44.6	>60		32.9	33.0	33.9	32.7	33.3	48.1		>60	>60	>60	>60	>60	>60		-	-	-	-	-	-		>65	>65	>65	>65	>65	>65	
Bankfull Mean Depth (ft)	0.9	1.0	0.8	0.6	0.6	1.1		1.1	1.0	0.8	0.7	0.6	0.6		1.0	1.0	0.9	1.0	1.0	0.9		1.4	1.4	1.5	1.4	1.4	1.1		1.1	1.0	1.2	1.1	1.1	1.1	
Bankfull Max Depth (ft)	1.8	1.7	1.6	1.6	1.9	2.2		1.7	1.7	1.8	1.4	1.3	1.8		1.7	1.7	1.8	1.6	1.9	2.1		3.2	2.4	2.5	2.9	2.9	2.3		2.0	2.0	2.0	2.0	2.1	2.1	
Bankfull Cross-Sectional Area (ft^2)	13.9	13.9	13.9	13.9	13.9	13.9		16.3	16.3	16.3	16.3	16.3	16.3		15.2	15.2	15.2	15.2	15.2	15.2		26.5	26.5	26.5	26.5	26.5	26.5		16.2	16.2	16.2	16.2	16.2	16.2	
Total Cross-Sectional Area (ft^2)	13.9	14.2	12.7	7.8	8.7	4.0		16.3	16.2	15.4	8.8	8.0	4.9		15.2	15.6	14.6	11.9	12.4	10.8		26.5	23.1	21.9	17.3	18.0	21.0		16.2	16.7	16.4	13.3	14.0	15.4	
Bankfull Width/Depth Ratio	16.3	14.3	19.0	23.0	27.9	12.3		14.1	16.0	25.9	35.7	40.4	42.7		14.0	14.8	17.6	14.7	15.0	18.2		-	-	-	-	-	-		13.8	17.6	12.2	12.6	14.5	14.0	
Bankfull Entrenchment Ratio	2.4	2.4	2.1	2.7	2.7	4.4		2.2	2.0	1.6	1.4	1.3	1.8		4.0	3.9	3.6	3.9	3.9	3.5		-	-	-	-	-	-		4.4	3.9	4.8	4.6	4.3	4.4	
Bankfull Bank Height Ratio	1.0	1.0	1.0	0.9	1.0	0.8		1.0	1.0	1.0	0.8	0.7	0.7		1.0	1.0	0.9	0.9	0.9	0.8		-	-	-	-	-	-		1.0	0.9	0.9	0.8	0.8	0.9	
d50 (mm)	21	3.8	2.9	0.6	4.2	1.0		5.0	2.5	2.4	1.1	2.7	2.6		4.0	2.7	10	0.7	6.0	2.0		-	-	-	-	-	-		10	2.8	92	0.4	12	1.8	

Table 11b. Stream Reach Morphology Data Tables
Jacob's Ladder Stream Restoration Site, DMS Project # 95023
Reach: T1 (2,389 ft.)

Parameter	MY01 (2014)						MY02 (2015)						MY03 (2016)						MY04 (2017)						MY05 (2018)					
Dimension	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)	10.5	11.0	10.5	11.9	0.8	3	10.7	11.5	11.0	12.8	1.1	3	10.4	11.3	11.0	12.6	1.2	3	9.6	11.1	10.3	13.3	2.0	3	8.5	10.5	11.0	11.9	1.8	3
Floodprone Width (ft)	>45	>50	>50	>50		3	>45	>50	>50	>50		3	>45	>50	>50	>50		3	>45	>50	>50	>50		3	>45	>50	>50	>50		3
Bankfull Mean Depth (ft)	0.8	0.9	1.0	1.0	0.1	3	0.8	0.9	0.9	0.9	0.1	3	0.8	0.9	0.9	0.9	0.1	3	0.9	1.0	1	1	0.1	3	0.9	1.0	1.0	1.0	0.1	3
Bankfull Max Depth (ft)	1.5	1.6	1.7	1.7	0.1	3	1.5	1.6	1.7	1.7	0.1	3	1.5	1.6	1.6	1.7	0.1	3	1.6	1.7	1.7	1.7	0.1	3	1.5	1.6	1.7	1.7	0.1	3
Bankfull Cross-Sectional Area (ft^2)	8.8	10.2	10.1	11.6	1.4	3	8.8	10.2	10.1	11.6	1.4	3	8.8	10.2	10.1	11.6	1.4	3	8.8	10.2	10.1	11.6	1.4	3	8.8	10.2	10.1	11.6	1.4	3
Total Cross-Sectional Area (ft^2)	10.7	11.3	10.8	12.4	1.0	3	10.7	11.6	11.2	12.8	1.1	3	9.4	10.6	10.8	11.5	1.1	3	11.1	12.9	13.2	14.5	1.7	3	10.4	12.6	12.7	14.7	2.2	3
Width/Depth Ratio	11.0	11.9	12.3	12.5	0.8	3	12.0	13.0	12.8	14.1	1.1	3	12.1	12.7	12.2	13.7	0.9	3	10.3	11.2	10.6	12.7	1.3	3	8.3	10.9	12	12.3	2.2	3
Entrenchment Ratio	3.9	4.5	4.8	4.8	0.5	3	3.6	4.3	4.6	4.7	0.6	3	3.7	4.4	4.6	4.8	0.6	3	3.9	4.7	4.9	5.3	0.7	3	3.9	4.8	4.6	5.9	1.0	3
Bank Height Ratio	1.0	1.0	1.0	1.1	0.1	3	0.9	1.0	1.0	1.1	0.1	3	0.9	1.0	0.9	1.1	0.1	3	1	1.1	1	1.3	0.2	3	0.9	1.1	1	1.4	0.3	3
Pattern																														
Channel Beltwidth (ft)	25	48		70																										
Radius of Curvature (ft)	20	33		45																										
Rad. of Curv. : Bankfull Width (ft/ft)	2	3		4																										
Meander Wavelength (ft)	65	103		140																										
Meander Width Ratio	234.0	4		5.8																										
Profile																														
Riffle Length (ft)	17	34	35	46	7.00	20	6.4	35.7	37.9	56.2	12.2	20	23.4	41.0	39.2	101.1	16.4	18	6.1	32.4	31.3	101.8	19.3	22	17.6	31.0	29.2	43.5	6.6	18
Riffle Slope (ft/ft)	0.009	0.02	0.02	0.06	0.01	21	0.006	0.02	0.02	0.02	0.004	20	0.01	0.02	0.02	0.02	0.002	18	0.01	0.02	0.02	0.02	0.004	22	0.006	0.01	0.01	0.02	0.005	18
Pool Length (ft)	8.0	28.3	27.1	49.6	10.8	16	4.8	20.2	18.2	49.4	10.8	17	6.7	15.7	14.4	24.8	5.0	14	7.1	22.4	21.2	46.3	9.0	20	17.5	24.6	23.0	44.0	7.6	14
Pool Max Depth (ft)	2.4	2.7		3.0		2	2.3	2.8		3.2		2	2.2	2.7		3.2		2	2.3	2.8		3.3		2	2.2	2.5		2.8		2
Pool Spacing (ft)	38.5	50.8	45.5	99.0	14.6	15	54.1	85.7	75.0	175.8	30.8	16	54.3	91.5	72.9	195.1	43.6	13	21.5	77.1	71.9	208.3	45.3	20	55.9	90.7	74.8	202.7	44.8	13
Additional Reach Parameters																														
Channel Thalweg Length (ft)	2,389						2,389						2,389						2,389						2,389					
Sinuosity	0.36						0.36						0.36						0.36						0.36					
Water Surface Slope (ft/ft)	0.0093						0.0093						0.0087						0.0092						0.0094					
Bankfull Slope (ft/ft)	0.0092						0.0082						0.0082						0.0086						0.0090					
Rosgen Classification	C4						C4						C4						C4						C4					
SC% / Sa% / G% / C% / B% / Be%	41 / 4 / 29 / 26 / 0 / 0						39 / 8 / 18 / 35 / 0 / 0						1 / 10 / 32 / 57 / 0 / 0						19 / 26 / 22 / 32 / 0 / 0						44 / 5 / 8 / 43 / 0 / 0					
d16/d35/d50 / d84 / d95	10 / 19 / 25 / 50 / 64						17 / 34 / 44 / 80 / 100						21 / 42 / 58 / 90/ 107						7 / 29 / 48 / 88 / 106						11 / 48 / 60 / 90 / 106					
% of Reach with Eroding Banks	0%						0%						0%						0%						0%					

Table 11b. Stream Reach Morphology Data Tables
Jacob's Ladder Stream Restoration Site, DMS Project # 95023
Reach: T2 (2,084 ft.)

Parameter	MY01 (2014)						MY02 (2015)						MY03 (2016)						MY04 (2017)						MY05 (2018)					
Dimension	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)	14.1	15.6	15.7	16.9	1.2	4	14.0	16.6	15.8	20.6	2.9	4	13.8	16.8	14.6	24.2	5.0	4	15.1	18.2	16.0	25.7	5.0	4	13.1	17.8	15.9	26.4	5.9	4
Floodprone Width (ft)	33.0	48.1	47.2	65.0	16.8	4	32.5	47.9	47.0	65.0	17.0	4	32.7	48.7	48.6	65.0	16.1	4	33.3	50.7	52.3	65.0	14.5	4	48.1	57.8	59.1	65.0	7.1	4
Bankfull Mean Depth (ft)	1.0	1.0	1.0	1.0	0.0	4	0.8	0.9	0.9	1.2	0.2	4	0.6	0.9	0.9	1.1	0.2	4	0.6	0.8	0.8	1.1	0.3	4	0.6	0.9	1.0	1.1	0.2	4
Bankfull Max Depth (ft)	1.7	1.8	1.7	2.0	0.1	4	1.6	1.8	1.8	2.0	0.2	4	1.4	1.7	1.6	2.0	0.3	4	1.3	1.8	1.9	2.1	0.3	4	1.8	2.05	2.1	2.2	0.2	4
Bankfull Cross-Sectional Area (ft^2)	13.9	15.4	15.7	16.3	1.1	4	13.9	15.4	15.7	16.3	1.1	4	13.9	15.4	15.7	16.3	1.1	4	13.9	15.4	15.7	16.3	1.1	4	13.9	15.4	15.7	16.3	1.1	4
Total Cross-Sectional Area (ft^2)	14.2	15.7	15.9	16.7	1.1	4	12.7	14.8	15.0	16.4	1.6	4	7.8	10.5	10.4	13.3	2.6	4	8.0	10.8	10.6	14.0	2.9	4	4.0	8.8	7.9	15.4	5.3	4
Width/Depth Ratio	14.3	15.7	15.4	17.6	1.5	4	12.2	18.7	18.3	25.9	5.6	4	12.6	21.5	18.9	35.7	10.5	4	14.5	24.4	21.4	40.4	12.3	4	12.3	21.8	16.1	42.7	14.2	4
Entrenchment Ratio	2.0	3.1	3.2	3.9	1.0	4	1.6	3.0	2.9	4.8	1.4	4	1.4	3.1	3.3	4.6	1.4	4	1.3	3.0	3.3	4.3	1.4	4	1.8	3.5	4.0	4.4	1.2	4
Bank Height Ratio	0.9	1.0	1.0	1.0	0.1	4	0.9	1.0	1.0	1.0	0.1	4	0.8	0.9	0.9	0.9	0.1	4	0.7	0.9	0.9	1.0	0.1	4	0.7	0.8	0.8	0.9	0.1	4
Pattern																														
Channel Beltwidth (ft)	20	45		70																										
Radius of Curvature (ft)	20	37		54																										
Rad. of Curv. : Bankfull Width (ft/ft)	2	3		4																										
Meander Wavelength (ft)	58	99		140																										
Meander Width Ratio	2.2	4		5.2																										
Profile																														
Riffle Length (ft)	9.1	37.9	31.1	133.6	28.9	20	5.8	25.8	24.7	44.5	12.9	20	3.0	26.8	21.0	163.5	32.1	27	2.7	15.4	13.8	32.9	8.9	16	5.4	17.7	14.8	33.1	9.5	13
Riffle Slope (ft/ft)	0.003	0.01	0.01	0.05	0.01	20	0.002	0.02	0.01	0.04	0.01	20	0.00	0.02	0.02	0.04	0.01	27	0.01	0.03	0.03	0.06	0.02	16	0.002	0.03	0.03	0.1	0.02	13
Pool Length (ft)	1.7	3.9	0.8	19.3	5.6	14	4.7	8.1	7.1	17.0	3.5	16	3.4002	8.7	6.9	19.1	4.1	29	4.6	14.6	9.3	70.8	17.3	13	6.6	14.7	12.7	28.9	7.5	8
Pool Max Depth (ft)	2.3	2.3		2.3		1	1.2	1.2		1.2		1	2.4	2.4		2.4		1	2.5	2.5		2.5		1	2.3	2.3		2.3		1
Pool Spacing (ft)	22.5	44.4	47.3	237.7	74.9	13	16.4	94.7	51.4	279.5	89.0	15	13.5	48.9	42.9	132.6	28.5	28	22.1	63.3	60.102	112.7	24.1	12	50.4	81.1	62.8	141.0	39.6	7
Additional Reach Parameters																														
Channel Thalweg Length (ft)	2,084						2,084						2,084						2,084						2,084					
Sinuosity	1.16-1.45						1.16-1.45						1.16-1.45						1.16-1.45						1.16-1.45					
Water Surface Slope (ft/ft)	0.0088						0.0083						0.0086						0.0089						0.0086					
Bankfull Slope (ft/ft)	0.0078						0.0074						0.0083						0.0077						0.0078					
Rosgen Classification	C4						C4						C4						C4						C4					
SC% / Sa% / G% / C% / B% / Be%	22 / 32 / 43 / 3 / 0 / 0						0 / 35 / 47 / 17 / 1 / 0						12 / 51 / 35 / 2 / 0 / 0						0 / 38 / 58 / 3 / 0 / 0						4 / 54 / 38 / 4 / 0 / 0					
d16 / d35 / d50 / d84 / d95	0.2 / 1 / 2 / 17 / 46						1.1 / 5 / 22 / 59 / 77						0.2 / 0.4 / 0.7 / 7.2 / 16						0.7 / 2 / 5 / 13 / 23 / 42						0.5 / 1 / 2 / 22 / 47					
% of Reach with Eroding Banks	0%						0%						0%						0%						0%					

Appendix E

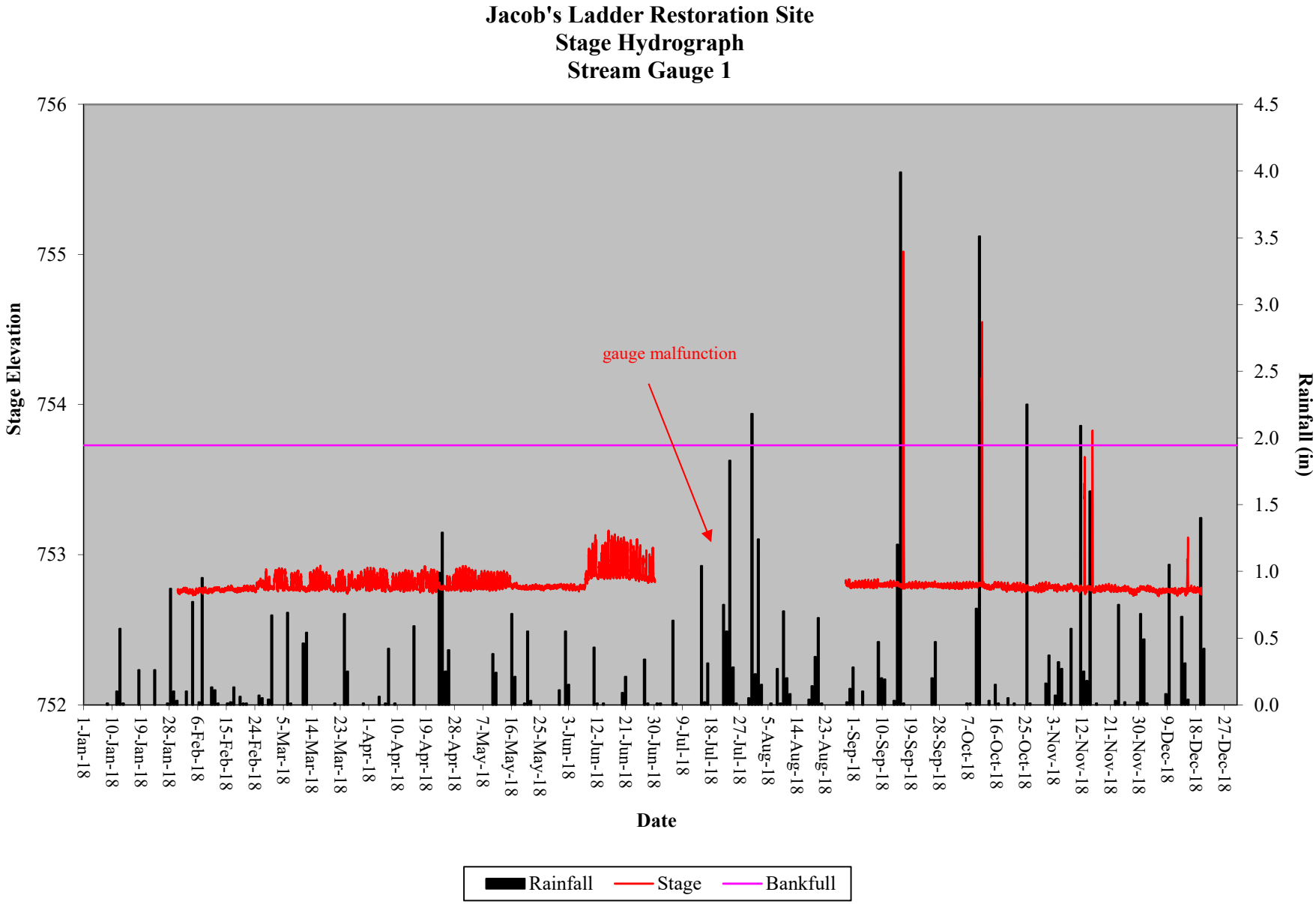
Hydrologic Data

Table 12. Verification of Bankfull Events Jacob's Ladder Stream Restoration Site, DMS Project # 95023			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo Number**
4/20/2015	4/20/2015	Automatic gauge on-site	N/A
12/17/2015	12/17/2015	Wracklines and flattened vegetation observed at bankfull, stream observed above bankfull	1 - 2
12/23/2015	12/23/2015	Automatic gauge on-site (T1 only)	N/A
12/30/2015	12/30/2015	Automatic gauge on-site	N/A
1/5/2016	1/5/2016	Automatic gauge on-site (T1 only)	N/A
1/14/2016	1/14/2016	Automatic gauge on-site (T1 only)	N/A
1/21/2016	1/21/2016	Automatic gauge on-site (T1 only)	N/A
6/14/2016	6/14/2016	Automatic gauge on-site	N/A
6/5/2017	6/5/2017	Automatic gauge on-site (T1 only)	N/A
6/13/2017	6/13/2017	Automatic gauge on-site (T1 only)	N/A
6/19/2017	6/19/2017	Automatic gauge on-site (T1 only)	N/A
6/20/2017	6/20/2017	Automatic gauge on-site	3
2/3/2018	2/3/2018	Automatic gauge on-site (T2 only)	N/A
9/16/2018	9/16/2018	Automatic gauge on-site	N/A
10/11/2018	10/11/2018	Automatic gauge on-site	N/A
11/15/2018	11/15/2018	Automatic gauge on-site (T1 only)	N/A

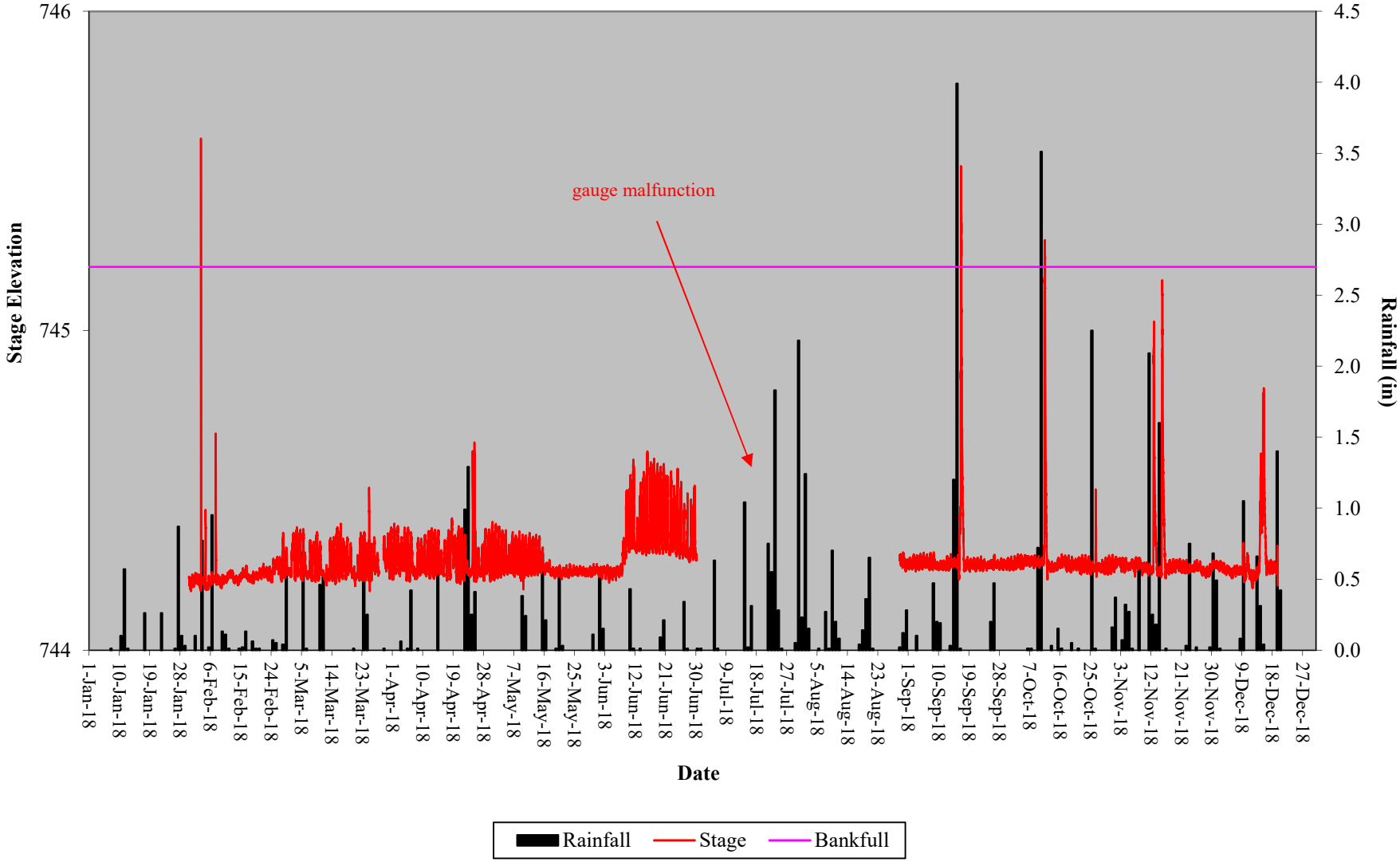
Photo 1. Bankfull indicators along T1, 12/17/15


Photo 2. T2 at bankfull, 12/17/15

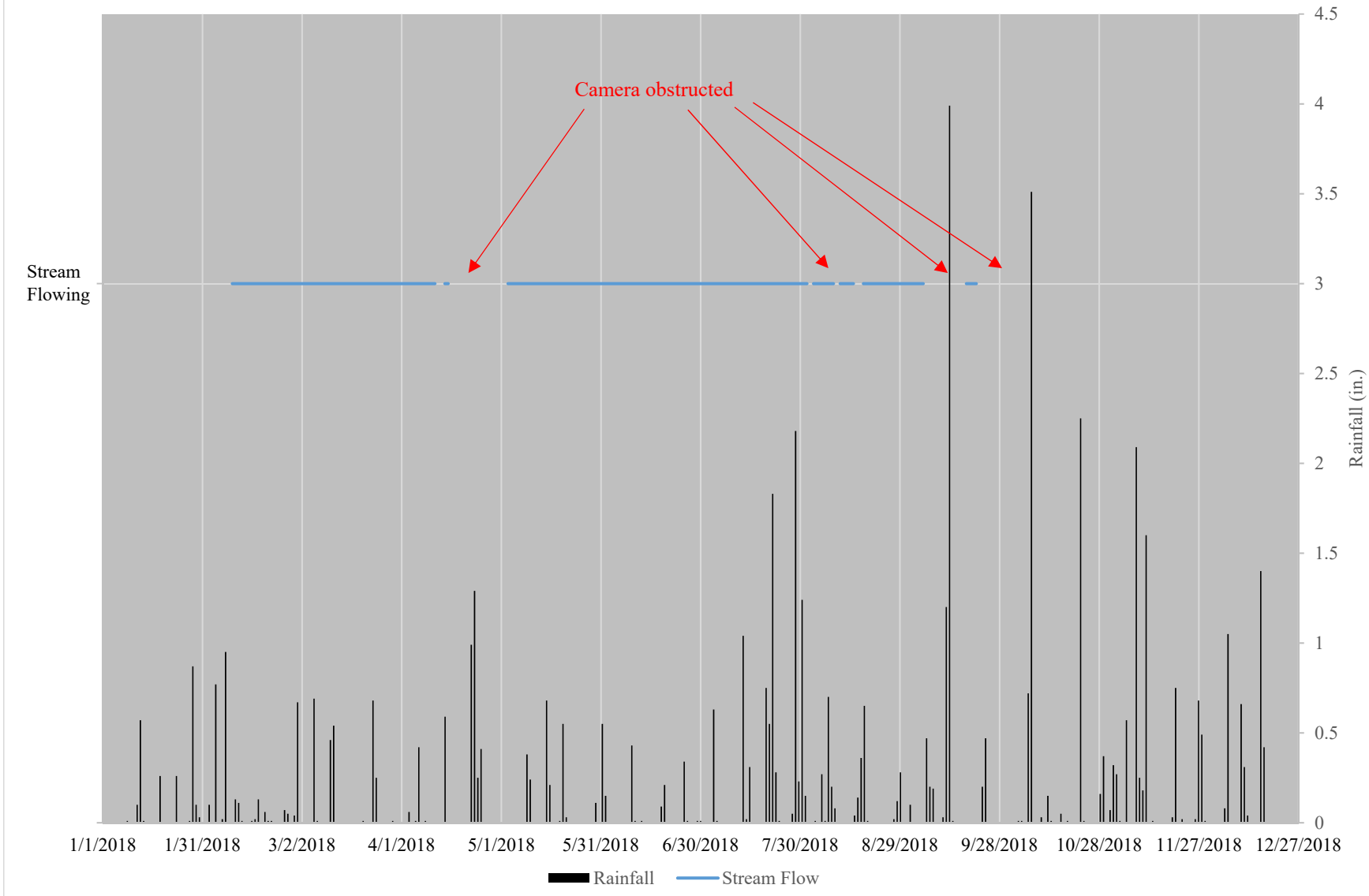

Photo 3. Bankfull indicators along T1, 7/20/18


Jacob's Ladder Restoration Site
Stage Hydrograph
Stream Gauge 1
Stage Elevation
Rainfall (in)
Date
gauge malfunction
Rainfall
Stage
Bankfull
756
755
754
753
752
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1-Jan-18
10-Jan-18
19-Jan-18
28-Jan-18
6-Feb-18
15-Feb-18
24-Feb-18
5-Mar-18
14-Mar-18
23-Mar-18
1-Apr-18
10-Apr-18
19-Apr-18
28-Apr-18
7-May-18
16-May-18
25-May-18
3-Jun-18
12-Jun-18
21-Jun-18
30-Jun-18
9-Jul-18
18-Jul-18
27-Jul-18
5-Aug-18
14-Aug-18
23-Aug-18
1-Sep-18
10-Sep-18
19-Sep-18
28-Sep-18
7-Oct-18
16-Oct-18
25-Oct-18
3-Nov-18
12-Nov-18
21-Nov-18
30-Nov-18
9-Dec-18
18-Dec-18
27-Dec-18

Jacob's Ladder Restoration Site
Stage Hydrograph
Stream Gauge 2



Jacob's Ladder
Flow Camera
T1A-1



Example Stream Flow Pictures

T1A – 2/3/2018

T1A – 4/1/2018

T1A – 5/3/2018

T1A – 6/8/2018

T1A – 7/4/2018

T1A – 8/24/2018

Appendix F

Additional Information

KCI ASSOCIATES OF NORTH CAROLINA, PA

ENGINEERS • SCIENTISTS • SURVEYORS • CONSTRUCTION MANAGERS

Landmark Center II, Suite 220 4601 Six Forks Road Raleigh, NC 27609 (919) 783-9214 (919) 783-9266 Fax

May 22, 2014

Mr. Todd Tugwell
Regulatory Division
Wilmington District
U.S. Army Corps of Engineers
11405 Falls of Neuse Road
Wake Forest, NC 27587

And:

Mr. Tim Baumgartner
Deputy Director
NC DENR
Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699

Subject: Jacob's Ladder (95023) Stream Restoration Project
Request for Mitigation Plan Amendment

Dear Mr. Tugwell and Mr. McDonald,

This letter is in response to the discussions at an Interagency Review Team (IRT) meeting attended by KCI on May 13, 2014. During this meeting KCI presented a request to modify the allocation of stream mitigation credits on the Jacob's Ladder stream restoration project. Citing procedural reasons, the IRT requested that KCI submit a formal request to reallocate credits. This letter will serve as that request.

Request

KCI requests the following changes to the credit table provided in the *Jacob's Ladder Stream Restoration Site - Final Mitigation Plan* dated September 2012 (requested changes shown in red).

Reach	Mitigation Type	Priority Approach	Existing Linear Footage	Designed Linear Footage	Mitigation Units
T1-1	Restoration	P1	587	739	739
T1-2	Restoration	P1	1,592	1,622*	1,622
T2-1	Restoration	P1	837	750*	750
T2-2	Restoration	P1	1,246	1,334*	1,334
T1A-1	Enhancement I	-	306	306	204
T1A-2	Enhancement II	-	140	140	56
T1A-3	Restoration	P1	470	498	498
Total Stream Enhancement I			306	306	204
Total Stream Enhancement II			140	140	56
Total Stream Restoration			4,732	4,943	4,943
Total Mitigation Units					5,203

Justification

The 837 linear feet of stream channel associated with reach T2 was identified during the Proposal Stage (including an IRT site walk) as Enhancement Level 1 at a 1.5:1 ratio. As a matter of practice, KCI attempts to be consistent with the credit-types requested in the Proposal during the assessment and the design stages of the project. Initial thoughts during the proposal stage were to install periodic structures to stabilize the grade and direct flow, selectively grade banks and retrofit a cross section where practical. During the assessment and design stage for Reach T2, a more aggressive restoration approach was utilized. This was primary due to the need to rework the grade on both banks, to create a floodplain bench and to properly tie-in the on-line restoration work with the existing bedrock control and the offline restoration section downstream. These reasons and others resulted in ultimate decision to completely change the stream type from a G-type channel to a C-type channel. This approach was a restoration approach, although it never was properly identified as such in the Mitigation Plan. The approach included the following restoration initiatives:

1. Channel type changed from a G channel to a C channel by installing a typical riffle cross section with a 10.0' bankfull bench and a 1.8' bank height.
2. Adjusted thalweg and centerline (planform) slightly throughout most of the reach and significantly in several areas to allow for the incorporation of the bankfull bench. Bench location and width varied from cross section depending on condition of valley and the ability to accommodate the full bankfull width given the valley condition.
3. Installed significant number of structures (1 step pools, 2 soil lifts, 17 riffle enhancements) to stabilize the profile and create in-stream habitat.
4. Added bedform diversity and stabilized the planform.

All of the items mentioned above support the reallocation of credit type to restoration (or enhancement at a higher ratio). KCI requests that the IRT support the correction of the 1.5:1 Enhancement I ratio proposed for Reach 2 in the Final Mitigation Plan to 1:1 ratio. KCI can provide amended copies of the

Mitigation Plan, if desired. Please understand that the exact number of credits may vary slightly when the as-built plans are analyzed. These numbers are based on the modification of the mitigation plan, not the actual, constructed condition.

We hope you find this information appropriate in order to move forward with your decision. If you have further questions or comments, feel free to contact me at 919-278-2511 or tim.morris@kci.com .

Sincerely,

Timothy J. Morris
Senior Environmental Scientist

cc: Joe Pfeiffer, KCI (email)
Adam Spiller (email)
Mike McDonald, EEP (email)

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
69 DARLINGTON AVENUE
WILMINGTON, NORTH CAROLINA 28403-1343

REPLY TO
ATTENTION OF:

September 2, 2014

Regulatory Division

Re: Request for Modification to the Jacob's Ladder and Jacob's Landing Mitigation Sites (USACE AIDs 2012-01007 and 2012-01006)

Mr. Tim Baumgartner
North Carolina Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

Dear Mr. Baumgartner:

Please reference the North Carolina Interagency Review Team (IRT) meeting of May 13, 2014, during which we discussed the Jacob's Ladder and Jacob's Landing stream mitigation projects. The discussion dealt with a request by NCEEP to the U.S. Army Corps of Engineers, Wilmington District (District) to modify a reach within each project resulting in a change in the mitigation approach and associated credit.

During the IRT meeting, we asked that a written request be submitted to provide information on the specifics of each project modification so that the IRT could review the requests and provide comment back to us. Two letters dated May 22, 2014, were prepared by the project provider (KCI, Inc.) and distributed to the IRT. The following responses were received from the IRT agency members:

1. Travis Wilson, North Carolina Wildlife Resources Commission, 5/29/2014:
   A switch from enhancement to restoration should have been addressed earlier during design. As I understood it during the presentation most of the design elements outlined in the modification request were incorporated under the enhancement level and only slight changes occurred during construction, and I don't want to establish a practice where the IRT is constantly reviewing requests from providers on a credit hunt to cover contractual deficiencies. However, with that said, I agree the improvements on the two subject reaches are consistent with a restoration approach, and if successful it will provide a restoration level of uplift. WRC does not object to the modification request.

2. Eric Kulz, North Carolina Division of Water Resources, 5/29/2014:
   The approaches described in the mitigation plans for the referenced reaches were fairly non-quantitative and appeared to represent an Enhancement I approach, which was approved by the IRT. The activities conducted appeared consistent with the descriptions of mitigation measures proposed in the approved mitigation plans. Again, the mitigation plans were not quantitative in nature, and E1 spans a wide variety of mitigation treatments.

During the analysis phase of these projects, if the provider and EEP felt the initial assessment and proposal were incorrect/inappropriate, consultation with the IRT and re-review of the project stream conditions and mitigation approaches should have been requested and approval of revisions sought (note process taken with the Pancho bank site).

Minor adjustments often occur during construction and are expected, and are described in the as-built report. Linear footage/acreage of mitigation and associated credits are then normally finalized. However, in this case changing the name of the mitigation approach and associated credit after construction does not appear warranted as the activities conducted appear to be fairly consistent with what was described in the approved mitigation plans.

In addition to the responses above, we conducted a review of the information submitted and other information available regarding the two projects, including the mitigation plans for the projects. In the May 22nd request letters for the two projects, the explanation for the additional credit request was based on the fact that a more aggressive restoration approach was determined to be needed during the assessment and design stages of the two projects. The new approach for the streams on both projects was similar, in that it included such activities as adjusting the thalweg and centerline of the streams, installing a significant number of structures, incorporating bankfull benches, and adding bedform diversity.

In the case of both Jacob's Ladder and Jacob's Landing, the IRT reviewed the projects in the field in August, 2011, and agreed to the mitigation approach described in the respective mitigation plans, which were finalized in September, 2012. As noted by Mr. Kulz' comments, the work that was done and is now the basis for the request for additional credit appears to be fairly consistent with what was proposed in the mitigation plan. In the case of Jacob's Ladder, the mitigation plan states that for Tributary T2-1 "Enhancement will include shaping the banks, creating a bankfull bench, creating a more stable and heterogeneous stream bed, and replanting the riparian buffer to achieve a mix of native tree species." For Jacob's Landing, the mitigation plan states that for Tributary T2A "This reach will be enhanced by shaping the banks to creating a bankfull bench, and installing grade control structures to gradually drop the bed elevation down. The reach will be stabilized by replanting the riparian buffer to achieve a mix of native tree species." Despite this fact, if the amount of functional uplift resulting from the work is sufficient to be credited at a 1:1 ratio, we do not want to penalize these projects for failing to identify an appropriate credit ratio up front in the mitigation plan.

Another concern that arises from these requests is the way in which the changes to mitigation plan and credit yield were handled. As stated in the documentation submitted to the IRT, the need for a more aggressive approach was identified during the assessment and design stages of the mitigation process. This implies that the need to modify the approaches and associated credit structure for these tributaries was known well before construction yet not brought to the IRT's attention until the as-built stage of the project. Any modification to a project that results in a change to the mitigation approach substantial enough to warrant a different credit amount must be approved by the District prior to implementing that modification. In this case, the IRT was not notified of the change until the as-built stage of the project.

Lastly, the information submitted in support of the requested change is not consistent. The final credit amounts presented during the IRT meeting do not match the credit amounts listed in the supporting information that was submitted after the meeting. Specifically, Jacob's Landing was shown

to have 4,528 credits (SMUs) in the presentation and 4,524 credits in the supporting letter dated May 22, 2014. Similarly, Jacob's Ladder was shown to have 5,231 credits in the presentation and 5,203 credits in the supporting letter. In order to fully resolve this issue, please explain the discrepancy and identify the correct amount of credit to be generated by the two projects.

To conclude, it is our intention to make sure that the amount of credit generated by mitigation projects, as expressed by the mitigation ratio, is supported by the level of uplift resulting from the work. In the case of these two projects, we agree that the uplift provided by the mitigation activities conducted in the two reaches in question may be credited at a 1:1 ratio. However, for future projects, changes such as this that result in a modification to the amount of credit must be approved in advance so that the District and IRT has the opportunity to comment and agree with the proposed approach. For all NCEEP projects that were instituted after the approval of the Instrument on July 28, 2010, such modifications should be approved in accordance with the streamlined review process outlined in Section 332.8(g)(2) of the Federal Mitigation Rule, unless the district engineer determines those changes are of a significant nature and must be processed through the normal procedures. In cases where such modifications are time-sensitive (e.g., construction is on-going), we will endeavor to expedite the review and approval to the extent allowable under the Rule.

Thank you for working with us to address these issues. Please contact me if you have any questions about this letter, or if there is any additional information you need. I can be contacted at telephone (919) 846-2564.

Sincerely,

Todd Tugwell
Special Projects Manager

Enclosures

Electronic Copies Furnished:
Mr. Tim Morris, KCI, Inc.
NCIRT Distribution List