CANDIFF CREEK RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2016 (YEAR 5)

NCDEQ-DMS Project Number: 92767

Submitted to:

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FINAL

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

M3, M2, and M1 Lower Summary

This Annual Monitoring Report details the monitoring activities during 2016 (Monitoring Year 5) for the Candiff Creek Restoration Project ("Site"). As per the approved Mitigation Plan for the Site, this Annual Monitoring Report presents stream geometry data, stem count data from vegetation monitoring stations, and discusses any observed tendencies relating to stream stability and vegetation survival success.

Prior land use on the Site consisted primarily of pasture and forest. Candiff Creek had been channelized and riparian vegetation was cleared in the lower half of the site. The upstream reaches of the project had a narrow, early successional buffer that included several exotic vegetation species. Prior to restoration, Candiff Creek was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

A total of 13 monitoring plots, 100 square meters (m^2) (10m x 10m) in size, are used to predict survivability of the woody vegetation planted on the Site. Data from Year 5 monitoring for the 13 vegetation plots exhibited a survivability range of 607 to 931 stems per acre. The data showed that the Site had an average survivability of 738 stems per acre following Year 5 monitoring. Vegetation Plots 1 through 12 on reach M2 and M3 did not exhibit any invasive or aggressive species occurring on the Site.

Cross-sectional monitoring data for stream stability were collected during Year 5 monitoring. A longitudinal profile survey was completed during Year 5 monitoring for approximately 3,150 linear feet (LF) of stream on the Site. The longitudinal profile was completed for Reach M3 only.

The cross-sectional data and the longitudinal profile indicate that Reach M3 has remained stable throughout the monitoring period and is still functioning as designed.

Two pools located at stations 46+50 and 55+50 exhibited areas of erosion during Year 4 monitoring. The erosional areas observed in 2015 are have not expanded and are currently stable. The erosional areas are occurring on outer bends below root wads and are approximately 10 feet or less in length. These two minor problem areas make up approximately 0.28% of the total as-built stream length of 7,018 feet. The erosional areas are isolated and are not trending towards long-term instability.

Year 5 stream profile monitoring revealed that the Site has three beaver dams located along the Reach 3 profile. The dams are located at stations 43+75, 48+75 and 51+75 on Reach 3. The dams are relatively small with the largest dam being at station 48+50. As of October 2016, the dams were not exhibiting adverse effects on the stream or stream banks. The beaver(s) are currently being trapped and the dams will be removed when the beaver have been eliminated from the Site. All beavers and dams will be removed prior to closeout. (See Appendix for photo point PP20, Station 48+75 in the Stream Photo Log).

According to the on-site crest gauge, the Site experienced at least one significant bankfull flow events during Year 5 monitoring. The largest on-site bankfull flow event documented at the M3 crest gauge occurred on August 4, 2016. It is estimated that the height of highest flow at the M3 crest gauge observed in Year 5 was approximately 3.24 feet above bankfull stage.

Overall Summary for M3, M2, and M1 Lower

In summary, M3, M2 and the lower portion of M1 has met the hydrologic, vegetative, and stream success criteria as specified in the Site Restoration Plan in all areas.

M1 Upper Stream Enhancement Summary

Additionally, stream enhancement work along M1 and UT1 was completed in September 2015. Bankfull benches were excavated and vertical stream banks were sloped to stable angles. Vane structures and toe wood were installed along meander bends to protect the stream banks, provide additional habitat, and to provide long-term stream bank stabilization. No additional credit is being requested as a result of this work. During this time, the existing kudzu plants and roots were cleared within a large portion of the easement area. Per the permit conditions for the enhancement work, monitoring along M1 and UT1 will be conducted for a minimum of one additional year beyond the monitoring required in the mitigation plan. This monitoring will include visual assessments conducted twice per year and the installation and annual monitoring of two bank pin arrays installed in the outside of meander bends. No exposed bank pins were noted as part of the Year 5 monitoring efforts.

Additional bare-root trees were planted during the winter of 2015 in the riparian buffer areas along M1 and UT1 to increase density and to offset mortality from treating kudzu.

During Year 5 monitoring, the majority of kudzu *(Pueraria montana*) which was present on the Site in the vicinity of vegetation plot 13 and the M1 Enhancement area has been mostly eradicated. The 2016 site inspection did not note any areas of kudzu greater than 100 ft2. This area of kudzu was previously treated during construction in the spring of 2012, August 2014, October 2014, early August 2015, late August 2015 and in spring 2016. This area was treated by use of the herbicides Glyphosate and Triclopyr. Any remaining kudzu in this area will be treated again during the early growing season 2017. Property boundary fencing in the M1 vicinity was installed during the summer of 2015. This fence allows the landowner to graze cattle outside of the fenced conservation easement, which will prevent kudzu re-establishment.

Overall Summary for M1 Upper

In summary, after remedial activities conducted in winter 2015 and summer 2016, to control kudzu and improve tree density along M1, the Site is on track to meet the vegetative and stream success criteria as specified in the Site Restoration Plan in all areas.

2.0 PROJECT BACKGROUND

The project involved the restoration of 4,081 linear feet (LF) of stream, 1,757 of stream Enhancement (265 LF of Enhancement I and 1,492 LF of Enhancement II) and 1,200 LF of stream preservation. The final stream lengths for all reaches are shown in Table 1 and Figure 2 and summarizes the restoration zones on the Site. A total of 27.54 acres of stream and riparian buffer are protected through a permanent conservation easement.

2.1 Project Goals and Objectives

The specific goals for the Candiff Creek Restoration Project were as follows:

- Create geomorphically stable conditions along Candiff Creek through the project area,
- Prevent cattle from accessing the project reaches, reducing excessive bank erosion,
- Improve habitat quality in a riffle dominated stream by adding pool/riffle sequences and expanding the floodplain, while improving overall ecosystem functionality,
- Improve water quality within the Candiff Creek Restoration Project area through reduction of bank erosion and reductions in nutrient and sediment loads,
- Stabilize streambanks through installation of in-stream structures and establishing a riparian buffer consisting of native plant species,
- Improve aquatic and terrestrial habitat through increased substrate and in-stream cover, additional woody debris, and reduced water temperature by increasing stream shading, and restored terrestrial habitat.

To accomplish these goals, this project will pursue the following objectives:

- Restore existing incised, eroding, and channelized streams by creating a stable channel with access to its floodplain,
- Improve in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools and areas of water re-aeration, and reducing bank erosion,
- Control invasive species within the project reaches,
- Establish native stream bank and floodplain vegetation protected by a permanent conservation easement to increase stormwater runoff filtering capacity, improve bank stability, shade the stream to decrease water temperature, and provide improved wildlife habitat quality.

2.2 Project Structure, Restoration Type and Approach

For analysis and design purposes, Michael Baker International (Baker) divided on-site streams into reaches. The reaches were numbered sequentially from upstream to downstream, with a "M" designation for the "mainstem" and a "UT" designation for unnamed tributaries. Two UTs are located on the Site (labeled UT1 and UT2). The on-site streams are described as follows: M1 begins on the upstream section of the Site at the River-Siloam Road culvert, and then flows southward to the confluence with UT2. M2 begins at the M1/UT2 confluence and flows south 265 feet to the beginning of the restored portion of the mainstem. M3 begins at the restored channel and then flows southeastward for 4,123 feet and terminates at the property line adjacent to the Yakin Valley Railroad right-of-way located at the downstream end of the Site. UT1 flows onto the Site from the southern

Wall property line and flows southward for 885 feet to the confluence with M1. UT2 flows onto the Site from the eastern Aztar Group, LLC property line and flows eastward for 1,162 feet and terminates at the M1/M2 transition. The reaches described above are presented in the plan sheets located in Figures 3A through Figure 3G.

The restoration design allows stream flows greater than the bankfull discharge, to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. The in-stream structures installed consist of constructed riffles, cover logs, log/rock vanes, log/rock j-hook vanes, rock cross vanes, vegetated geolifts, vegetated brush mattresses and root wads. These structures promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles, grade control rock j-hook vanes, and rock cross vanes were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, temporary and permanent seeding, live stakes, transplants, brush mattresses and geolifts. Transplants provide areas for living root mass to increase streambank stability and also to create holding areas for fish and aquatic biota.

The purpose of the project is to restore stream functions to the impaired reaches the Site. Native species vegetation was planted across the Site and the entire project area is protected through a permanent conservation easement.

Table 1. Design Approach for the Candiff Creek Restoration Project

Candiff Creek Restoration Project: DMS Project No. 92767								
Project Segment or Reach ID	**Existing Feet/Acres**	**Mitigation Type ***	**Approach****	**Linear Footage**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
M1	690	E	EII	690	2.5:1	276	10+00 - 17+35	Invasive species vegetation removal and buffer planting; 45 LF of stream length removed for one stream crossing. In-stream structures installation and bankfull bench excavation conducted in 2015 along with replanting of buffer.
M2	265	E	EI	265	1.5:1	177	17+35 - 20+00	Installed in-stream structures to control grade and reduce bank erosion
M3	3,828	R	P1, P2	4,081	1:1	4,081	20+00 - 61+23	Invasive species removal and buffer planting; 42 linear feet of stream length removed for two stream crossings
UT1 (Lower Reach)	885	E	EII	485	2.5:1	194	14+00 - 18+85	Invasive species vegetation removal, buffer planting, and livestock exclusion fencing.
UT1 (Upper Reach)		P	N/A	400	5:1	80	10+00 - 14+00	Preservation area - no construction activities in this area
UT2 (Lower Reach)	1,117	E	EII	317	2.5:1	127	18+00 - 21+62	Invasive species vegetation removal, buffer planting, and livestock exclusion fencing. 45 LF of stream length removed for one stream crossing.
UT2 (Upper Reach)		P	N/A	800	5:1	160	10+00 - 18+00	Preservation area - no construction activities in this area

Mitigation Unit Summations					
Stream (SMU)	Riparian Wetland (Ac)	Non-riparian Wetland (Ac)	Total Wetland (Ac)	Planted Riparian Buffer (Ac)	Permanent Conservation Easement (Ac)
5,095	0	0	0	17.31	27.54

* R = Restoration
E = Enhancement
P = Preservation

** P1 = Priority I
P2 = Priority II
EII = Enhancement II

2.3 Location and Setting

The Site is located in Surry County in western North Carolina, approximately 1.75 miles west of Siloam Township, and just north of the Surry-Yadkin County line, as shown in Figure 1. The Site lies in the Yadkin Pee-Dee River Basin, within the US Geological Survey (USGS) and North Carolina Department of Environmental Quality Division of Mitigation Services (NCDEQ DMS) subbasin 03040101 (previously categorized as subbasin 03-07-02) and Targeted Local Watershed (TLW) 03040101-110060 of the Yadkin Pee Dee River Basin.

2.4 Project History and Background

Land use at the Site consists primarily of pasture and forest. Candiff Creek had been channelized and riparian vegetation had been cleared at the lower half of the Site. The upstream end of the Site had a narrow, early successional buffer that included several exotic vegetation species. Prior to restoration, Candiff Creek was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

The chronology of the Candiff Creek Restoration Project is presented in Table 2. The contact information for the designers, contractors, and relevant suppliers is presented in Table 3. Relevant project background information is provided in Table 4.

2.5 Project Plan

Plans illustrating the as-built conditions of the major project elements, locations of permanent monitoring cross-sections, and locations of permanent vegetation monitoring plots are presented in Figures 3A through 3G of this report. In addition to the as-built plans, a Current Condition Plan View Map (Figure 4 through 4c) set is included in the Figures section in this report.

Table 2. Project Activity and Reporting History

Candiff Creek Restoration Project: DMS Project No. 92767			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan Prepared	Jul-10	N/A	Jul-10
Restoration Plan Amended	Aug-10	N/A	Aug-10
Restoration Plan Approved	Aug-10	N/A	Aug-10
Final Design – (at least 90% complete)	Jul-10	N/A	Jun-11
Construction Begins	N/A	N/A	Sep-11
Temporary S&E mix applied to entire project area	N/A	N/A	Apr-12
Permanent seed mix applied to entire project area	N/A	N/A	Apr-12
Planting of live stakes	N/A	N/A	Apr-12
Planting of bare root trees	N/A	N/A	Apr-12
End of Construction	NA	N/A	Mar-12
Survey of As-built conditions (Year 0 Monitoring-baseline)	N/A	Mar-12	Mar-12
Year 1 Monitoring	Oct-12	Oct-12	Dec-12
Year 2 Monitoring	Oct-13	Nov-13	Dec-13
Year 3 Monitoring	Oct-14	Nov-14	Nov-14
Year 4 Monitoring	Oct-15	Oct-15	Oct-15
Year 5 Monitoring	Oct-16	Oct-16	Nov-16
Year 6 Monitoring[1]	Oct-17	Oct-17	Oct-17

[1] Year 6 monitoring will be limited to the visual assessment of M1 and UT1, and bank pin measurements along M1 as described in the executive summary.

Table 3. Project Contacts

Candiff Creek Restoration Project: DMS Project No. 92767	
Designer Michael Baker Engineering, Inc.	797 Haywood Road, Suite 201 Asheville, NC 28806 Contact: Jake Byers, P.E., Telephone: 828-350-1408
Construction Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-1002
Planting Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-1002
Seeding Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-102
Seed Mix Sources Nursery Stock Suppliers	Green Resources, 336-855-6363 ArborGen, Inc., 843-528-3204
Monitoring Performers Michael Baker Engineering, Inc. Stream Monitoring Point of Contact: Vegetation Monitoring Point of Contact:	797 Haywood Road, Suite 201 Asheville, NC 28806 Jake Byers, P.E., Telephone: 828-350-1408 Jake Byers, P.E., Telephone: 828-350-1408

Table 4. Project Background Table

Candiff Creek Restoration Project: DMS Project No. 92767		
Project County:		Surry County, NC
Drainage Area:		
	Reach:	square miles (mi²):
	M1	2.35
	M2	2.53
	M3	2.74
	UT1	0.06
	UT2	0.14
Estimated Drainage % Impervious Cover:		
	M1, M2, M3, UT1, UT2	<5%
Stream Order:		
	UT1	1
	UT2	2
	M1, M2, M3	3
Physiographic Region		Piedmont
Ecoregion		Northern Inner Piedmont
Rosgen Classification* of As-built:		
	M1, M2, M3	C
	UT1 (Lower Reach)	N/A
	UT1 (Upper Reach)	N/A
	UT2 (Lower Reach)	N/A
	UT2 (Upper Reach)	N/A
Cowardin Classification*:		
	M1, M2, M3, UT2	Riverine, Upper Perennial, Cobble-Gravel
	UT1	Riverine, Intermittent, Cobble-Gravel
Dominant Soil Types*:		
	M1, M2, M3, UT1 (Lower Reach), UT2 (Lower Reach)	CsA
	UT1 (Upper Reach), UT2 (Upper Reach)	FsE
	UT1 (Upper Reach)	FeC2
Reference site ID		On-site
USGS HUC for Project		03040101
NCDWQ Sub-basin		03-07-02
NCDWQ classification for Project and Reference:		
	M1, M2, M3, UT1, UT2	C
Any portion of any project segment 303d listed?		No
Any portion of any project segment upstream of a 303d listed segment?		No
Reasons for 303d listing or stressor?		N/A
% of project easement fenced		100%

*Rosgen, 1994; *Cowardin;*-USDA, 2007

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 Vegetation Assessment

3.1.1 Description of Vegetative Monitoring

As a final stage of construction, the stream margins and riparian areas of the Site were planted with bare root trees, live stakes, and a seed mixture of temporary and permanent herbaceous vegetation to establish ground cover. The woody vegetation was planted randomly from the top of the stream banks to the outer edge of the project's re-vegetation limits. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Live stakes were installed two to three feet apart in meander bends and six to eight feet apart in the riffle cross-sections. The live stakes were set up using triangular spacing along the stream banks between the toe of the stream bank and bankfull elevation. The tree species planted at the Site are shown in Table 5. The temporary seed planted following construction was rye grain. The permanent seed mix of herbaceous species planted in the project's riparian area included: redtop (*Agrostis alba*), big bluestem (*Andropogon gerardii*), beggartick (*Bidens frondosa*), lanceleaf tickseed (*Coreopsis lanceolata*), deertongue (*Pancium clandestinum*), Virginia wildrye (*Elymus virginicus*), soft rush (*Juncus effusus*), switchgrass (*Panicum virgatum*), smartweed (*Polygonum pennsylvanicum*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutan),* and eastern gamma grass (*Tripsacum dactyloides*). This seed mixture was broadcast on the Site at a rate of 15 pounds per acre. All planting was completed in April 2012.

At the time of planting, 13 vegetation plots – labeled 1 through 13 - were established on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.025 acre in size, or 10 meters x 10 meters. All of the planted stems inside the plots were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future. The trees also were marked and labeled with aluminum metal tags to ensure that the correct identification is made during future monitoring of the vegetation plots. In addition to flagging and tags, the locations of planted stems and vegetation plot corners were recorded by use of survey equipment.

3.1.2 Vegetative Success Criteria

To characterize vegetation success criteria objectively, specific goals for woody vegetation density have been defined. Data from vegetation monitoring plots should display a surviving tree density of at least 320 trees per acre at the end of the third year of monitoring, and a surviving tree density of at least 260 five-year-old trees per acre at the end of the five-year monitoring period.

Table 5. Vegetation Species Planted Across the Restoration Project

Candiff Creek Restoration Project: DMS Project No. 92767			
Scientific Name	**Common Name**	**Percent Planted by Species**	**Total Number of Stems**
Bare Root Trees Species			
Betula nigra	river birch	23.3%	1,800
Diospyros virginiana	persimmon	7.8%	600
Fraxinus pennsylvanica	green ash	15.6%	1,200
Liriodendron tulipfera	tulip poplar	7.8%	600
Platanus occidentalis	sycamore	22.1%	1,700
Quercus michauxii	swamp chestnut oak	15.6%	1,200
Quercus phellos	willow oak	7.8%	600
Bare Root Shrub Species			
Asimina triloba	paw paw	9.5%	400
Carpinus caroliniana	ironwood	12%	500
Cercus canadensis	redbud	14%	600
Cornus amomum	silky dogwood	19%	800
Lindera benzoin	spicebush	9.5%	400
Sambucus canadensis	elderberry	19%	800
Viburnum dentatum	arrowwood	17%	700
Native Herbaceous Species			
Agrostis alba	redtop	10%	NA
Andropogon gerardii	big bluestem	5%	NA
Bidens frondosa	devil's beggartick	5%	NA
Coreopsis lanceolata	lanceleaf tickseed	10%	NA
Dichanthelium clandestinum	deertongue	15%	NA
Elymus virginicus	Virginia wild rye	15%	NA
Juncus effusus	soft rush	5%	NA
Panicum virgatum	switchgrass	15%	NA
Polygonum pennsylvanicum	Pennsylvania smartweed	5%	NA
Schizachyrium scoparium	little bluestem	5%	NA
Sorghastrum nutans	Indiangrass	5%	NA
Tripsacum dactyloides	eastern gamagrass	5%	NA
Woody Vegetation for Live Stakes			
Cornus amomum	silky dogwood	30%	2,100
Salix sericia	silky willow	30%	2,100
Salix nigra	black willow	10%	700
Sambucus canadensis	elderberry	30%	2,100

3.1.3 Vegetative Observations and Results

Permanent ground cover has been successfully established through the planting of the permanent seed mixture planted at the Site, as observed during Year 5 monitoring of the Site.

Tables A.1 through A.7 in Appendix A presents vegetation metadata, vegetation vigor, vegetation damage and stem count data for the monitoring plots at the end of Year 5 monitoring. Data from Year 5 monitoring for the 13 vegetation plots exhibited a range of 607 to 931 stems per acre. The data show that the Site had an average survivability of 738 stems per acre following Year 5 monitoring. In comparison, following as-built conditions, the Site demonstrated an average survivability of 915 stems per acre.

Trees within each monitoring plot are re-flagged regularly to prevent planted trees from losing their identifying marks due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure they are all accounted for during the annual stem counts and calculation of tree survivability. Labeled aluminum tags with wire hangers are used on surviving stems to aid in relocation during future counts. The aluminum tags are moved to a single branch instead of the main stem once the tree becomes established. Flags are also used to mark trees because they do not interfere with the growth of the tree.

During Year 5 monitoring, volunteer species including tulip poplar (*Liriodendron tulipfera*) and redbud (*Cercus canadensis)* were noted in plots 8 and 4, respectively.

3.1.4 Vegetative Problem Areas

The kudzu problem area is located on the upstream portion of Reach M1, downstream of River-Siloam Road. During Year 5 monitoring, the majority of kudzu (*Pueraria montana*) which was present on the Site in the vicinity of vegetation plot 13 and the M1 Enhancement area has been mostly eradicated. The 2016 site inspection did not note any areas of kudzu greater than 100 ft^2. This area of kudzu was previously treated during construction in the spring of 2012, August 2014, October 2014, early August 2015, late August 2015 and in spring 2016. This area was treated by use of the herbicides Glyphosate and Triclopyr. Any remaining kudzu in this area will be treated again during the early growing season 2017.

Additionally, stream enhancement work along M1 and UT1 was completed in September 2015. During this time, the existing kudzu plants and roots were cleared within a large portion of the easement area. Property boundary fencing in the M1 vicinity was installed during the summer of 2015. This fence allows the landowner to graze cattle outside of the fenced conservation easement, which will prevent kudzu re-establishment.

Additional bare-root trees were planted during the winter of 2015 in the riparian buffer areas along M1 and UT1 to increase density and to offset mortality from treating kudzu. Following Year 5 monitoring, the newly planted stems in the enhancement are proving successful and are beginning to establish along the riparian buffer.

Vegetation Plots 1 through 12 on reach M2 and M3 did not exhibit any invasive or aggressive species occurring on the Site.

3.1.5 Vegetation Photographs

Photographs are used to visually document vegetation plot success. A total of 13 reference stations were established to document tree conditions at each vegetation plot across the Site.

Reference photos of tree plots are taken at least once per year. Photos of the tree plots for Year 5 monitoring that show the on-site planted stems are included in Appendix A of this report.

3.2 Stream Assessment

3.2.1 Morphometric Success Criteria

To document the stated success criteria, the following monitoring program was instituted following construction completion on the Site:

Cross-sections: Two permanent cross-sections were installed per 1,000 LF of stream restoration work, with one of the locations being a riffle cross-section and one location being a pool cross-section in each series. A total of 10 permanent cross-sections were established across the Site. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. The permanent cross-section pins are surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success:

- There should be little change in as-built cross-sections
- If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio)
- Cross-sections will be classified using the Rosgen Stream Classification System (Rosgen, 1994), and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

Longitudinal Profiles: A complete longitudinal profile was surveyed following construction completion to record as-built conditions and to establish a baseline profile. The profile was conducted for the entire length of each restored channel for all reaches. Measurements included thalweg, water surface, inner berm, bankfull, and top of low bank. Each of these measurements was taken at the head of each feature (e.g., riffle, pool, and glide). In addition, maximum pool depth was recorded. All surveys were tied to a single, permanent benchmark.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success:

- A longitudinal profile will be completed annually for the five-year monitoring period
- The profile will be conducted for 3,000 LF of restored Candiff Creek channel
- The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading
- Pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and shallower than the pools

- Bedforms observed should be consistent with those observed for channels of the designed stream type.

3.2.2 Morphometric Results

Year 5 cross-section monitoring data for stream stability was completed during October 2016. The 10 permanent cross-sections along the restored channels (5 located across riffles and 5 located across pools) were re-surveyed to document stream dimension at the end of Monitoring Year 5. Data from each of these cross-sections are presented in Appendix B. Tables B.1 and B.3 in Appendix B present visual stability assessment data, the baseline stream summary and the morphologic and hydraulic monitoring summary.

Cross-sections 1, 4, 6, 8 and 10 are situated across riffles that are located between pools. Monitored cross-sections 1, 4, 6, 8, and 10 are located on M3 and based on the survey data, these cross-sections demonstrated minor fluctuations in riffle dimension during Year 5 of monitoring and currently remain stable.

Cross-sections 2, 3, 5, 7 and 9 are situated across pools, which are located at the apex of meander bends. Based on the Year 5 survey data, all five pool Cross-sections 2, 3, 5, 7 and 9 have demonstrated minor fluctuations in pool dimensions since as-built conditions. Based on the Year 5 monitoring survey data, all pool cross-sections show the development of point bar features on the inside banks of the meander bends.

According to the Year 5 cross-section data, all cross-sections are currently meeting the success-criteria as stated in the Site Mitigation Plan. Note that some riffle cross sections are shown as having bank height ratios greater than 1.0. This is due to using the same bankfull elevation for each years monitoring and not adjusting this elevation to the yearly indicator, which may change due to natural deposition and channel fluctuation. These channels are not incised and are functioning as designed.

The longitudinal profile for Year 5 monitoring was also completed in October 2016. The Year 5 longitudinal profile monitoring data were compared to the data collected during the as-built condition survey completed in April 2012. During Year 5 monitoring, the longitudinal profile survey was completed for Reach M3. A total stream length of 3,150 LF was surveyed for M3. The longitudinal profiles for M3 is presented in Appendix B.

Year 5 monitoring data for the M3 longitudinal profile indicate that the riffles in this reach have essentially maintained the same bed elevations since as-built conditions. It is noted that increased pool depths were observed throughout most of M3. The deeper pools noted in M3 are benefiting the overall functionality of the Site by providing increased channel stability and also providing an area for energy dissipation while promoting greater habitat diversity. While the pools remain deep, the survey data indicate that the M3 riffles are stable. Additionally, the longitudinal profile for M3 demonstrates that the in-stream structures within the reach are stable and functioning as designed.

According to the Year 5 longitudinal profile data, the restored stream thalweg is stable and currently meeting the success-criteria as stated in the Site Mitigation Plan.

In-stream structures installed within the restored stream included constructed riffles, log vanes, rock j-hooks, log j-hooks, rock cross vanes, root wads and stream ford crossings. Visual observations of these structures throughout Year 5 monitoring indicate that all structures are

functioning as designed and holding their post-construction grade. Structures that were installed to develop deeper pools, such as cross vanes and j-hooks, are performing their designed functions. Log vanes placed in meander areas have provided scour in pools to provide cover for aquatic wildlife. J-hooks placed in the lower end of the riffle areas have maintained riffle elevations and have provided downstream scour holes that provides aquatic habitat. Additionally, bioengineered structures placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms.

However, two minor pool problem areas were observed during Year 5 monitoring. These two areas are described in Section 3.2.5.

3.2.3 Hydrologic Criteria

One crest gauge was installed on the Site to document bankfull events. The gauge is checked during each site visit and records the stage of the highest out-of-bank flow between site visits. The gauge is located on the left bank on the downstream portion of M3 at station 55+50.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success: Two bankfull flow events must be documented within the five-year monitoring period. The two bankfull events must occur in separate years, otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

3.2.4 Hydrologic Monitoring Results

According to the on-site crest gauge, the Site experienced at least one significant bankfull flow event during Year 5 monitoring. The largest on-site bankfull flow event documented at the M3 crest gauge occurred on August 4, 2016. It is estimated that the height of highest flow at the M3 crest gauge observed in Year 5 was approximately 3.24 feet above bankfull stage. Photos of the reading and bankfull evidence are included in Appendix B.

The approved Mitigation Plan requires that two bankfull flow events must be documented within the five-year monitoring period. Since As-built conditions, eight documented bankfull events have been recorded. Each of the five years of monitoring has documented at least one bankfull event within the restored channel. As such, the hydrologic success criteria for the Site has been met. Crest gauge readings from all five years of monitoring are presented in Table 6 and photos of the crest gauge in 2016 and out-of-bank evidence are presented in Appendix B Stream Photo Log.

Table 6. Verification of Bankfull Events

Candiff Creek Restoration Project: DMS Project No. 92767			
Date of Data Collection	Estimated Occurrence of Bankfull Event	Method of Data Collection	M3 Crest (feet)
5/22/2012	4/2012 - 5/2012 storms	Crest Gauge	1.60
2/7/2013	1/18/2013	Crest Gauge	2.49
9/23/2013	7/5/2013	Crest Gauge	1.21
4/9/2014	1/11/2014	Crest Gauge	0.82
7/23/2014	4/29/2014	Crest Gauge	0.23

4/30/2015	4/20/2015	Crest Gauge	2.85
10/19/2015	10/4/2015	Crest Gauge	1.60
10/11/2016	8/4/2016	Crest Gauge	3.24

3.2.5 Stream Problem Areas

Year 5 stream monitoring revealed that the Site has three beaver dams located along Reach 3. The dams are located at stations 43+75, 48+75 and 51+75. The dams are relatively small with the largest dam being at station 48+50. As of October 2016, the dams were not exhibiting adverse effects on the stream or stream banks. The beaver(s) are currently being trapped and the dams will be removed when the beaver have been eliminated from the Site. All beavers and dams will be removed prior to closeout (See Appendix for photo point PP20, Station 48+75 in the Stream Photo Log).

Two pools located at stations 46+50 and 55+50 exhibited areas of erosion during Year 4 monitoring. The erosional areas observed in 2015 have not expanded and are currently stable. The erosional areas are occurring on outer bends below root wads and are approximately 20 feet in length combined. These two minor problem areas make up approximately 0.28% of the total as-built stream length of 7,018 feet. The erosional areas are isolated and are not trending towards long-term instability.

Additional stream enhancement work along M1 and UT1 was completed in September 2015. Bankfull benches were excavated and vertical stream banks were sloped to stable angles. In addition, vane structures and toe wood were installed along meander bends to protect the stream banks, provide additional habitat, and to provide long-term stream bank stabilization. No additional credit is being requested as a result of this work. During this time, the existing kudzu plants and roots were cleared within a large portion of the easement area. Per the permit conditions for the enhancement work, monitoring along M1 and UT1 will be conducted for a minimum of one additional year beyond the monitoring required in the mitigation plan. This monitoring will include visual assessments conducted twice per year and the installation and annual monitoring of two bank pin arrays installed in the outside of meander bends.

3.2.6 Stream Photographs

Photographs are used to document restoration success visually. A total of 59 reference stations were installed and photographed after construction. Photographs of these reference stations will be collected for at least five years following construction. Reference photos are taken at least twice per year, and are taken in enough locations to document the condition of the restored system. Permanent markers were established to ensure that the same locations (and view directions) on the Site are documented in each monitoring period.

The stream systems are photographed longitudinally, beginning at the downstream portion of the restoration reaches, and moving upstream to the beginning of the reaches. Photographs are taken looking upstream at designated locations. Reference photo locations are marked and described for future reference. Points are spaced sufficiently close to provide an overall view of the reach. The angle of the photograph depends on which direction provides the best view and is noted and will be continued for future photos. When modifications to photo position and/or direction are made due to obstructions or other reasons, the modified photo position

and/or direction is noted, along with any landmarks. The modified position is used in all future photographs of that site.

Additional photographs are taken to document any observed evidence of flooding patterns such as debris, wrack lines, water marks, channel features, etc.

Also, both stream banks are photographed at all permanent cross-section photo stations. For each stream bank photo, the photo view line follows a survey tape placed across the channel, perpendicular to flow (representing the cross-section line). The photograph is framed so that the survey tape is centered in the photo (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame. In each cross-section photo showing the left bank, flow is moving to the right. Conversely, in each cross-section photo showing the right bank, flowing is moving to the left.

A photo log of the restored channel is presented in Appendix B of this report. Photos for each of the 10 permanent cross-sections are included in Appendix B.

Photographs of the restored channel were taken in October 2016 to document the evolution of the stream geometry. Herbaceous vegetation and shrubs were dense along the banks of M2 and M3, making the photography of some of the stream channel areas difficult. Additionally, photographs of the enhancement work performed along M1 and UT1 are provided in Appendix B.

3.2.7 Stream Stability Assessment

Table B.1 and Table B.1a provide a summary of the results obtained from the visual inspection of in-stream structures performed during Year 5 monitoring. The percentages noted are a general, overall field evaluation of the how the features were performing at the time of the photo point survey. According to the visual stability assessment (Table B.1) and the visual morphological stability assessment (Table B.1a) following Year 5 monitoring, and after a visual evaluation throughout 2016, it was determined that all features at the Site along M2, M3, and UT2 are currently performing as designed. With the recent enhancement activities, kudzu treatment, and planned re-planting, the features along M1 and UT1 also meet performance standards.

3.2.8 Quantitative Measures Summary Tables

The quantitative pre-construction, reference reach, and design data used to determine restoration approach, as well as the as-built baseline data used during the project's post construction monitoring period are summarized in Appendix B.

4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Stream Monitoring - The total length of stream channel restored, enhanced and/or preserved on the Site was 7,038 LF. The project involved the restoration of 4,081 linear feet (LF) of stream along M3. Additionally 1,757 of stream Enhancement (265 LF of Enhancement I along M2 and 1,492 LF of Enhancement II along M1, UT1 and UT2) and 1,200 LF of stream preservation along UT1 and UT2. This entire length was inspected during Year 5 monitoring to assess stream performance. Year 5 monitoring did not reveal any significant problem areas within the boundaries of the Site.

Cross-section monitoring data for stream stability were collected during Year 5 monitoring. Additionally, a longitudinal profile survey was also completed during Year 5 monitoring for approximately 3,150 LF of stream on the Site. The longitudinal profile was completed for Reach M3 only. Year 5 monitoring data for the M3 longitudinal profile show that the riffles in this reach have maintained relatively the same bed elevations since as-built conditions. The longitudinal profile demonstrates that the in-stream structures within M3 are stable and functioning as designed. The Year 5 cross-sectional data also indicate that Reach M3 is stable and functioning as designed.

According to the on-site crest gauge, the Site experienced at least one significant bankfull flow events during Year 5 monitoring. The largest on-site bankfull flow event documented at the M3 crest gauge occurred on August 4, 2016. It is estimated that the height of highest flow at the M3 crest gauge observed in Year 5 was approximately 3.24 feet above bankfull stage.

Since As-built conditions, eight documented bankfull events have been recorded as shown in Table 6. The approved Mitigation Plan requires that two bankfull flow events must be documented within the five-year monitoring period.

Given that each of the five years of monitoring has documented a bankfull event within the restored channel, it is noted that the hydrologic success criteria for the Site has been met.

Two pools located at stations 46+50 and 55+50 exhibited areas of erosion during Year 4 monitoring. The erosional areas observed in 2015 have not expanded and are currently stable (see photographs in Appendix B). The erosional areas are occurring on outer bends below root wads and are approximately 20 feet in length combined. These two areas are isolated and are not trending towards long-term instability.

Additional stream enhancement work along M1 and UT1 was completed in September 2015. Bankfull benches were excavated and vertical stream banks were sloped to stable angles. In addition, vane structures and toe wood were installed along meander bends to protect the stream banks, provide additional habitat, and to provide long-term stream bank stabilization. As a result of this work, no additional credit is being requested. M1 and UT1 have remained stable and are functioning as designed. It is also noted that no exposed bank pins were noted during Year 5 monitoring.

Year 5 stream monitoring revealed that the Site has three beaver dams located along Reach 3. The dams are located at stations 43+75, 48+75 and 51+75 on Reach 3. The dams are relatively small with the largest dam being at station 48+50. As of October 2016, the dams were not exhibiting adverse effects on the stream or stream banks. The beaver(s) are currently being trapped and the dams will be removed when the beaver have been eliminated from the Site. See Appendix for photo point PP20, Station 48+75 in the Stream Photo Log).

Vegetation Monitoring - Data from Year 5 monitoring for the 13 vegetation plots exhibited a range of 607 to 931 stems per acre. The data showed that the Site had an average of survivability of 738 stems per acre.

During Year 5 monitoring, the majority of kudzu (*Pueraria montana*) which was present on the Site in the vicinity of vegetation plot 13 and the M1 Enhancement area has been mostly eradicated. The 2016 site inspection did not note any areas of kudzu greater than 100 ft2. This area of kudzu was previously treated during construction in the spring of 2012, August 2014, October 2014, early August 2015, late August 2015 and in spring 2016. This area was treated by use of the herbicides Glyphosate and Triclopyr. Any remaining kudzu in this area will be treated again during the early growing season 2017. Kudzu in this area is now under control and of minimal concern.

Vegetation Plots 1 through 12 on reach M2 and M3 did not exhibit any invasive or aggressive species occurring on the Site.

The additional bare-root trees that were planted during the winter of 2015 in the riparian buffer areas along M1 and UT1 are healthy and meeting success.

5.0 WILDLIFE OBSERVATIONS

Observations of deer and raccoon tracks are common at the Site. During Year 5 monitoring, small animals such frogs, rodents, snakes, and fish were periodically observed. Various songbirds and birds of prey were observed on the Site throughout Year 5 monitoring.

6.0 REFERENCES

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

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C

USDA, Natural Resource Conservation Service, *Soil Survey of Surry County*, North Carolina, 2007.

FIGURES

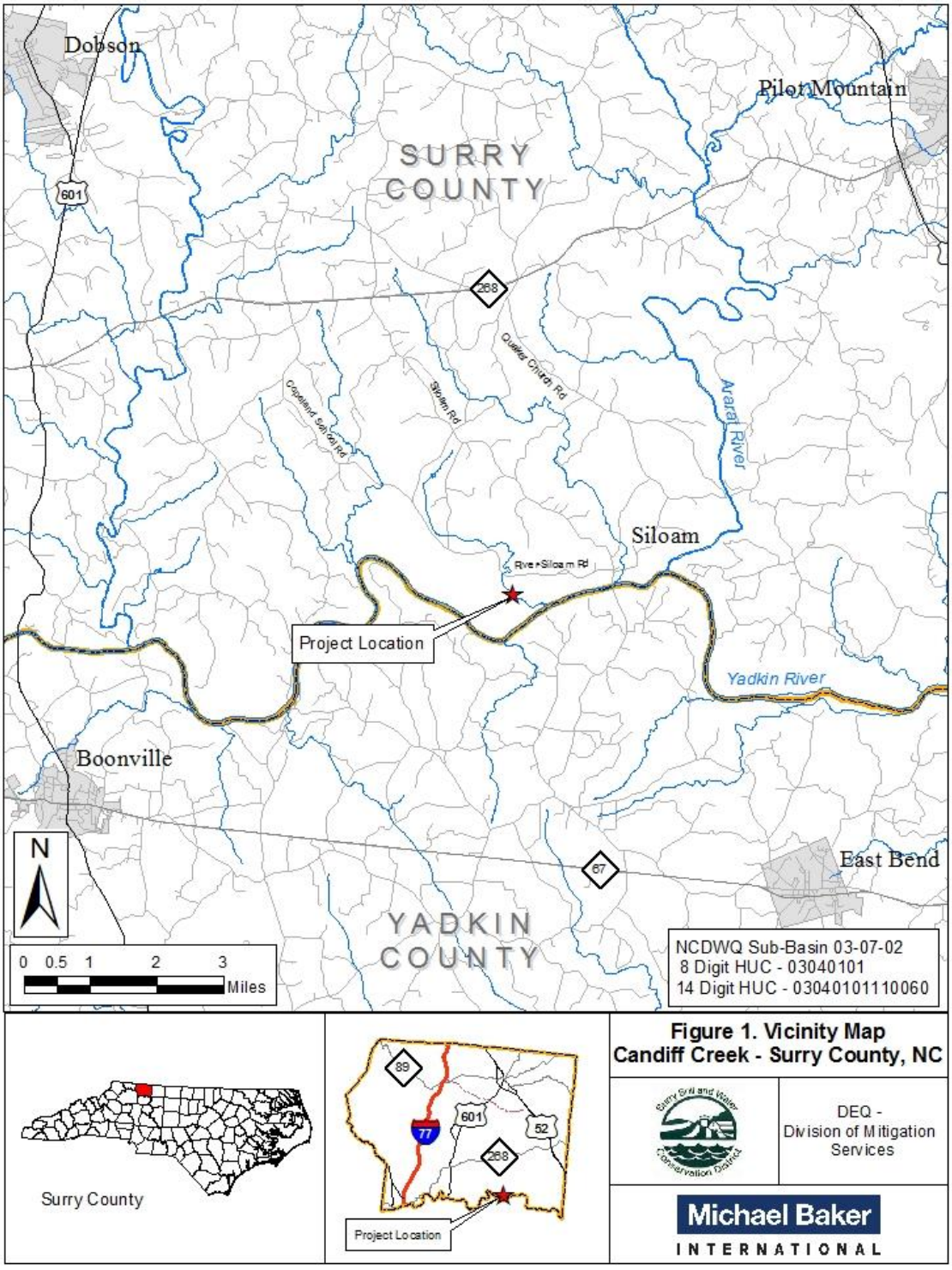


Figure 1. Vicinity Map of Candiff Creek Restoration Project.

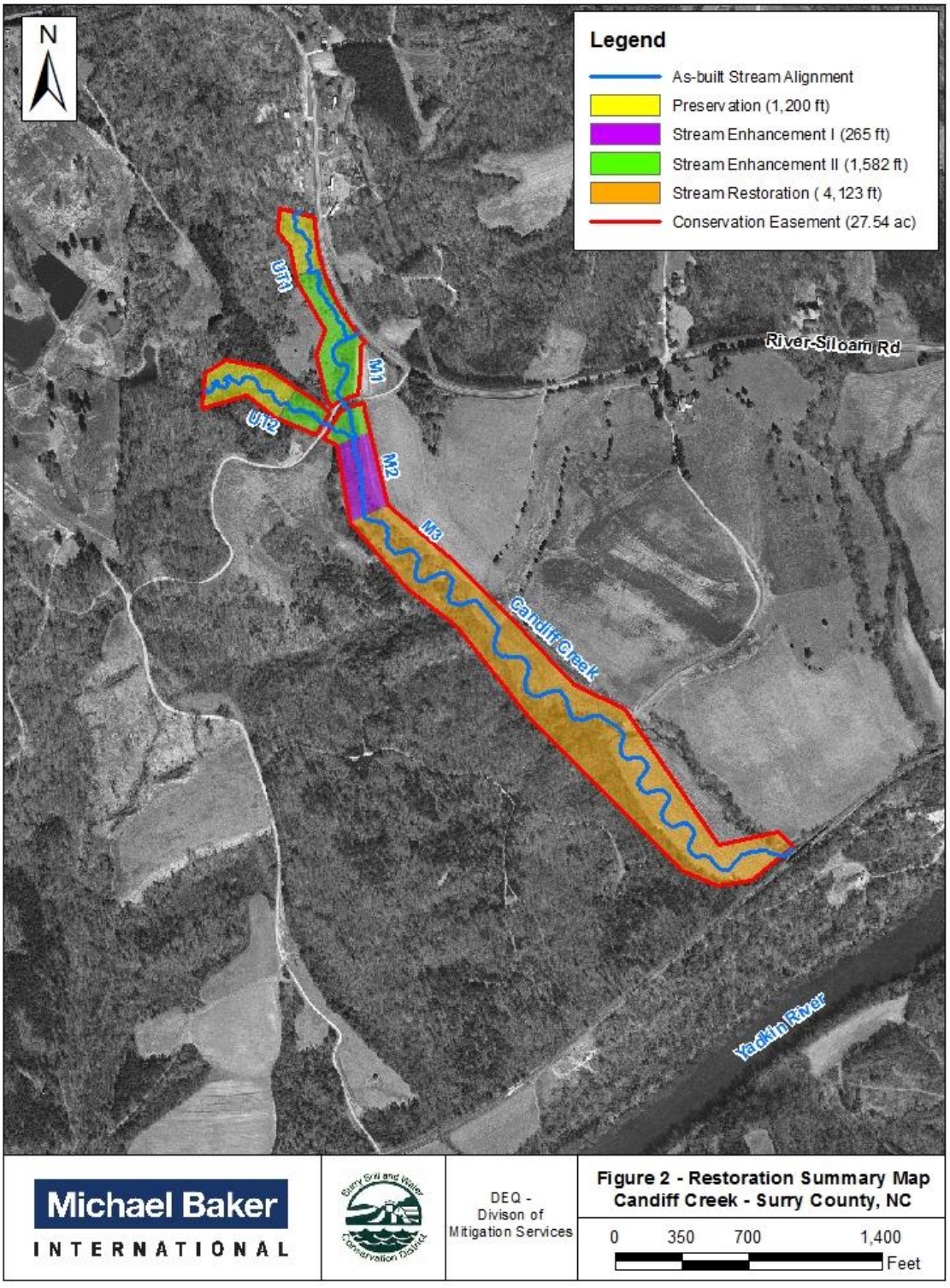
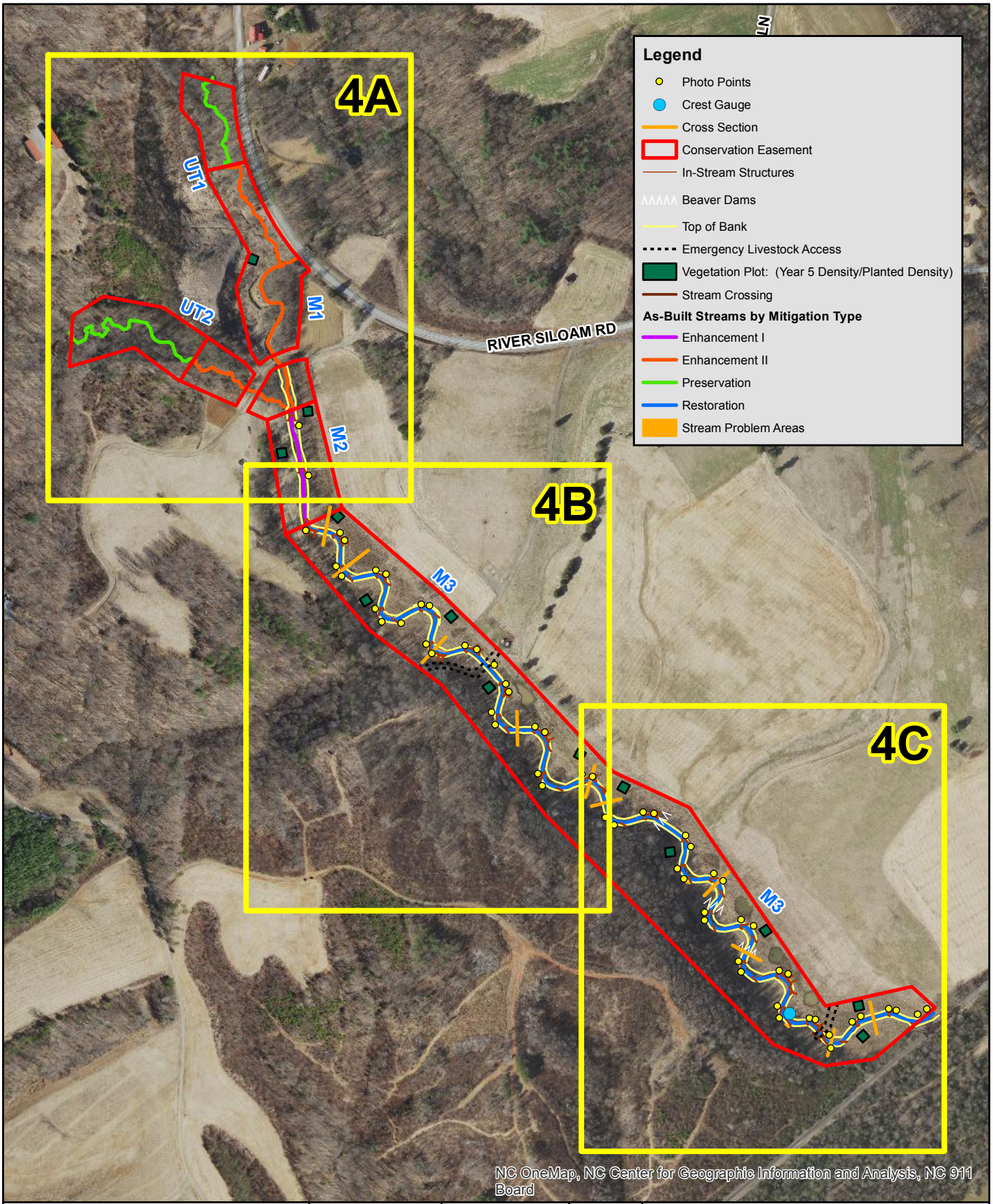


Figure 2. Restoration Summary Map of Candiff Creek Restoration Project.



Michael Baker INTERNATIONAL

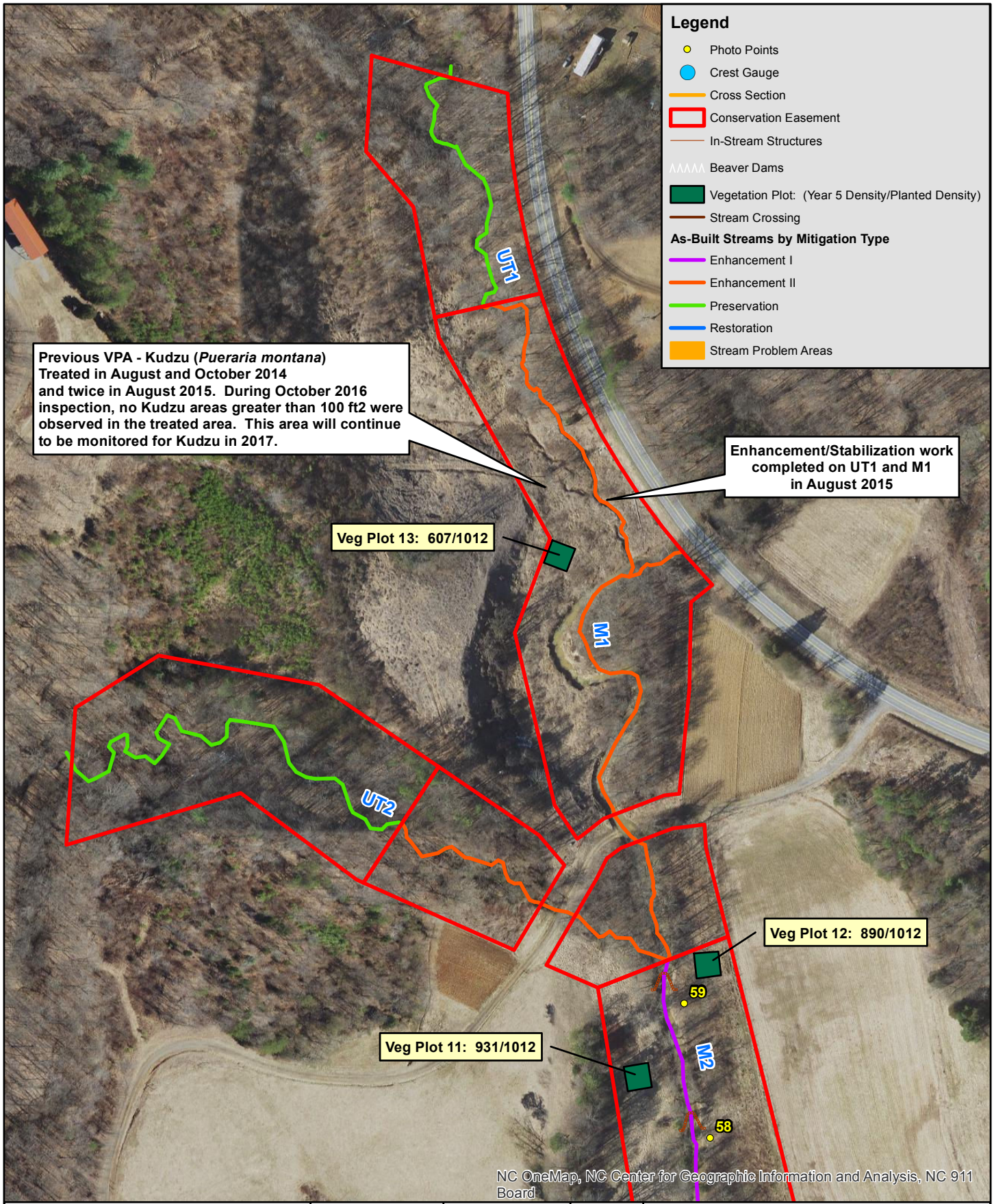
Surry Soil and Water Conservation District

DEQ - Division of Mitigation Services
DMS Project # 92767

N

Current Condition Plan View Figure Index
Candiff Creek - Surry County, NC

0 250 500 1,000 Feet



Michael Baker INTERNATIONAL

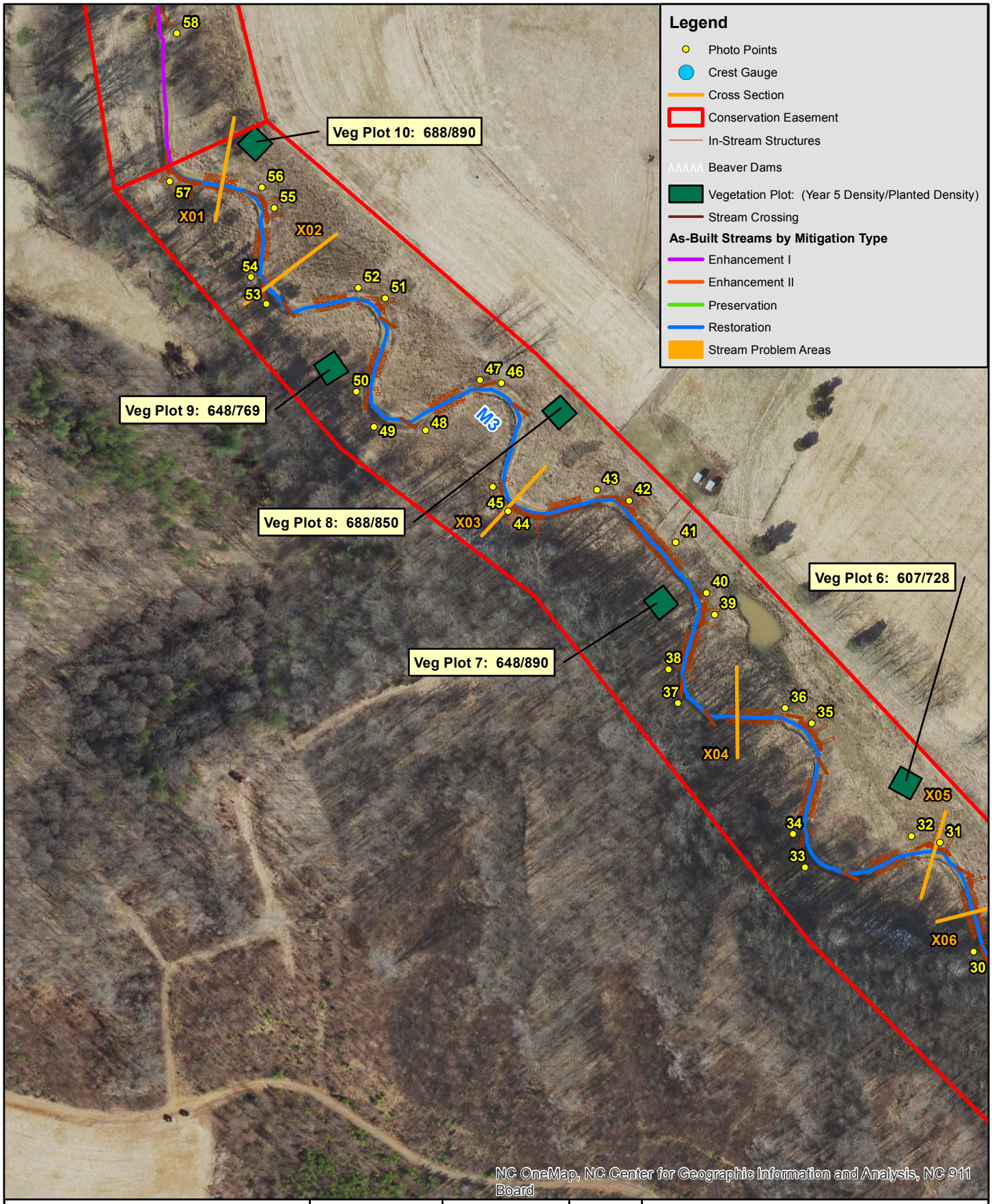
Surry Soil and Water Conservation District

DEQ - Division of Mitigation Services
DMS Project # 92767

N

Current Condition Plan View Figure 4A
Candiff Creek - Surry County, NC

0 87.5 175 350 Feet



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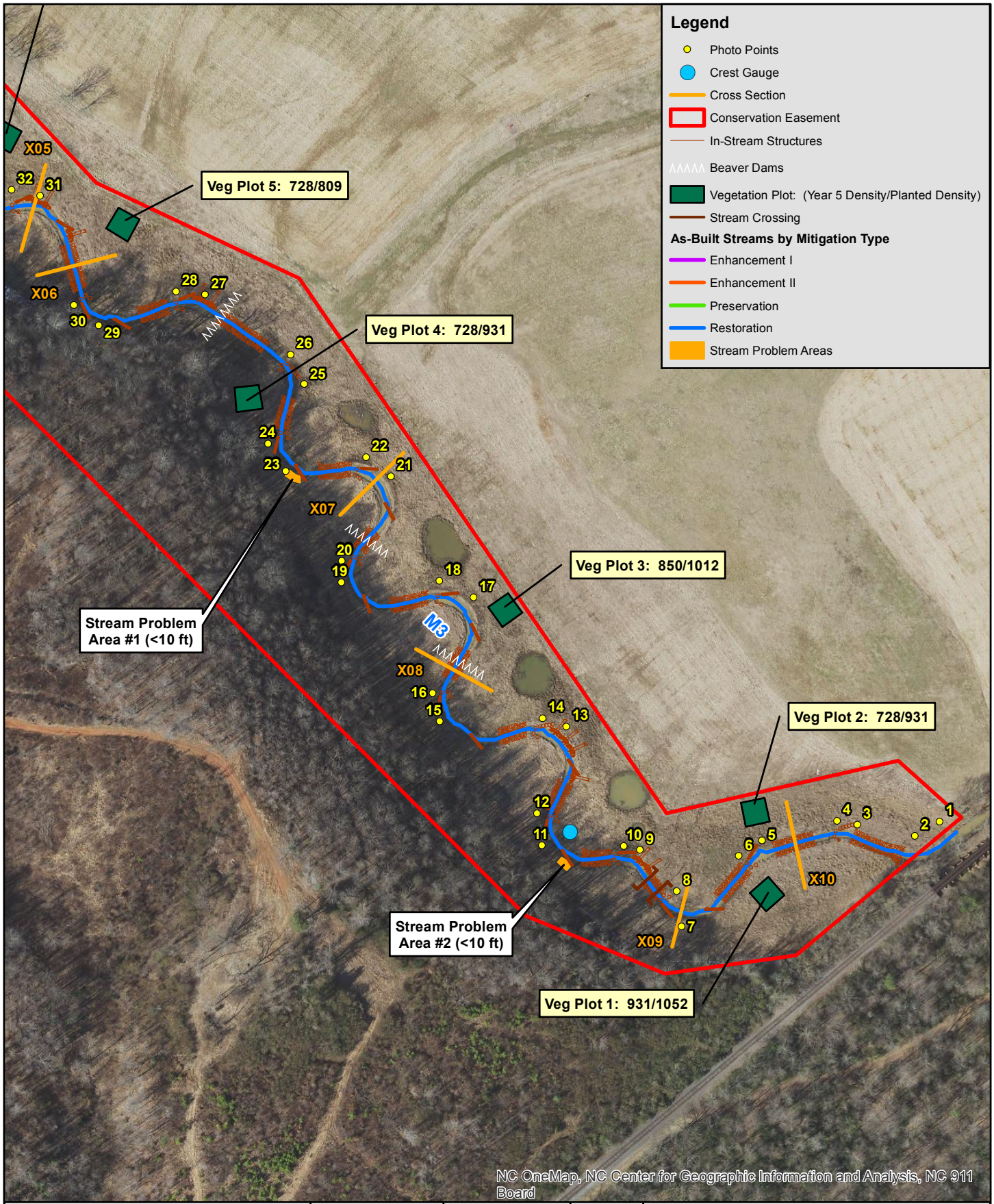
DEQ - Division of Mitigation Services
DMS Project # 92767

N

Current Condition Plan View Figure 4B
Candiff Creek - Surry County, NC

0 87.5 175 350 Feet



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DEQ - Division of Mitigation Services
DMS Project # 92767

N

Current Condition Plan View Figure 4C
Candiff Creek - Surry County, NC

0 87.5 175 350 Feet

APPENDIX A

VEGETATION DATA

VEGETATION TABLES

Table A.1. Vegetation Metadata

Candiff Creek Restoration Project: Project No. 92767	
Report Prepared By	Dwayne Huneycutt
Date Prepared	10/18/2016 11:00
database name	MichaelBaker_2016_Candiff_UTMillSwamp.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool\Candiff_UT to Mill Swamp
computer name	CARYLDHUNEYCUTT
file size	59187200
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.
PROJECT SUMMARY----------	
Project Code	92767
project Name	Candiff
Description	Stream and Buffer Restoration
River Basin	Yadkin-Pee Dee
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	13

Table A.2. Vegetation Vigor by Species

Candiff Creek Restoration Project: Project No. 92767									
	Species	**Common Name**	**4**	**3**	**2**	**1**	**0**	**Missing**	**Unknown**
	Asimina triloba	pawpaw	1						
	Betula nigra	river birch	48	2			3		
	Cornus amomum	silky dogwood		9	10	3	3		
	Diospyros virginiana	common persimmon	19	7	1		1		
	Fraxinus pennsylvanica	green ash	6	1		1			
	Quercus michauxii	swamp chestnut oak	14	11	2		2		
	Quercus phellos	willow oak	8	2					
	Sambucus canadensis	Common Elderberry	8	1			1		
	Viburnum dentatum	southern arrowwood	1						
	Carpinus caroliniana	American hornbeam	5	3		1			
	Cercis canadensis	eastern redbud		3	2	2	3		
	Quercus rubra	northern red oak	1						
	Liriodendron tulipifera	tuliptree	6	1					
	Platanus occidentalis	American sycamore	54	4	1	1			
TOTAL			**171**	**44**	**16**	**8**	**13**		

Table A.3. Vegetation Damage by Species

Candiff Creek Restoration Project: Project No. 92767						
	Species	Common Name	Count of Damage Categories	No Damage		
	Asimina triloba	pawpaw	0	1		
	Betula nigra	river birch	0	53		
	Carpinus caroliniana	American hornbeam	0	9		
	Cercis canadensis	eastern redbud	0	10		
	Cornus amomum	silky dogwood	0	25		
	Diospyros virginiana	common persimmon	0	28		
	Fraxinus pennsylvanica	green ash	0	8		
	Liriodendron tulipifera	tuliptree	0	7		
	Platanus occidentalis	American sycamore	0	60		
	Quercus michauxii	swamp chestnut oak	0	29		
	Quercus phellos	willow oak	0	10		
	Quercus rubra	northern red oak	0	1		
	Sambucus canadensis	Common Elderberry	0	10		
	Viburnum dentatum	southern arrowwood	0	1		
TOTAL			**0**	**252**		

Table A.4. Vegetation Damage by Plot

Candiff Creek Restoration Project: Project No. 92767				
	Plot	Count of Damage Categories	(no damage)	
	92767-01-0001-year:5	0	23	
	92767-01-0002-year:5	0	19	
	92767-01-0003-year:5	0	21	
	92767-01-0004-year:5	0	20	
	92767-01-0005-year:5	0	20	
	92767-01-0006-year:5	0	17	
	92767-01-0007-year:5	0	20	
	92767-01-0008-year:5	0	18	
	92767-01-0009-year:5	0	17	
	92767-01-0010-year:5	0	17	
	92767-01-0011-year:5	0	23	
	92767-01-0012-year:5	0	22	
	92767-01-0013-year:5	0	15	
TOTAL	**13**	**0**	**252**	

Table A.5. Planted Stems by Plot and Species

Candiff Creek Restoration Project: Project No. 92767

	Comment	Species	SpType	CommonName	Total Planted Stems	# of Species in Plots	Average # of Stems	Plot 92767-01-0001	Plot 92767-01-0002	Plot 92767-01-0003	Plot 92767-01-0004	Plot 92767-01-0005	Plot 92767-01-0006	Plot 92767-01-0007	Plot 92767-01-0008	Plot 92767-01-0009	Plot 92767-01-0010	Plot 92767-01-0011	Plot 92767-01-0012	Plot 92767-01-0013
		Asimina triloba	Shrub Tree	pawpaw	1	1	1										1			
		Betula nigra	Tree	river birch	50	10	5	10	2	5	4	5		2	6	9	6		1	
		Carpinus caroliniana	Shrub Tree	American hornbeam	9	5	1.8	2				1					3		2	1
		Cercis canadensis	Shrub Tree	eastern redbud	7	3	2.33				5		1				1			
		Cornus amomum	Shrub	silky dogwood	22	6	3.67	1	4	6			4	4					3	
		Diospyros virginiana	Tree	common persimmon	27	9	3			1	1	3		3	5	1	1	8	4	
		Fraxinus pennsylvanica	Tree	green ash	8	7	1.14		1	1		1		2		1		1	1	
		Liriodendron tulipifera	Tree	tuliptree	7	3	2.33								1				5	1
		Platanus occidentalis	Tree	American sycamore	60	11	5.45	9	1	5	5	7	6	1		4		10	6	6
		Quercus michauxii	Tree	swamp chestnut oak	27	8	3.38		3	2	3		3	3	5		5	3		
		Quercus phellos	Tree	willow oak	10	4	2.5		7	1			1			1				
		Quercus rubra	Tree	northern red oak	1	1	1													1
		Sambucus canadensis	Shrub Tree	Common Elderberry	9	4	2.25	1				1					1			6
		Viburnum dentatum	Shrub Tree	southern arrowwood	1	1	1							1						
TOTAL					**239**	**14**		**23**	**18**	**21**	**18**	**18**	**15**	**16**	**17**	**16**	**17**	**23**	**22**	**15**

Table A.6. Plot Species and Densities

Candiff Creek Restoration Project: DMS Project No. 92767															
Tree Species	**Plots**													**Year 5 Totals**	**Yearly Average Stems/acre**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**		
Betula nigra	10	2	5	4	5		2	6	9	6		1		50	
Diospyros virginiana			1	1	3		3	5	1	1	8	4		27	
Fraxinus Pennsylvanica		1	1		1		2		1		1	1		8	
Liriodendron tulipifera								1				5	1	7	
Platanus occidentalis	9	1	5	5	7	6	1		4		10	6	6	60	
Quercus michauxii		3	2	3		3	3	5		5	3			27	
Quercus phellos		7	1			1			1					10	
Quercus rubra													1	1	
Shrub Species															
Asimina triloba											1			1	
Carpinus caroliniana	2				1					3		2	1	9	
Cercis canadensis				5		1				1				7	
Cornus amomum	1	4	6			4	4					3		22	
Lindera benzoin														0	
Sambucus canadensis	1				1					1			6	9	
Viburnum dentatum							1							1	
Number of volunteer stems/plot	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Number of planted stems/plot	23	18	21	18	18	15	16	17	16	17	23	22	15	239	
Total Stems/acre Year 5	931	728	850	728	728	607	648	688	648	688	931	890	607	744	
Total Stems/acre Year 4	931	769	850	809	769	688	809	728	688	688	890	890	40	735	
Total Stems/acre Year 3	1052	769	850	890	769	648	809	728	688	728	890	890	243	766	
Total Stems/acre Year 2	1052	809	850	890	769	648	890	728	728	769	931	890	688	819	
Total Stems/acre Year 1	1052	971	850	931	850	728	890	769	769	809	971	931	890	878	
Total Stems/acre Initial	1052	931	1012	931	809	728	890	850	769	890	1012	1012	1012	915	

Table A.7. Planted and Total Stem Summary

Candiff Creek Restoration Project: DMS Project ID No. 92767

			Current Plot Data (MY5 2016)																				
			92767-01-0001			92767-01-0002			92767-01-0003			92767-01-0004			92767-01-0005			92767-01-0006			92767-01-0007		
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
Asimina triloba	pawpaw	Tree																					
Betula nigra	river birch	Tree	10	10	10	2	2	2	5	5	5	4	4	4	5	5	5				2	2	2
Carpinus caroliniana	American hornbeam	Tree	2	2	2										1	1	1						
Cercis canadensis	eastern redbud	Tree										5	5	5				1	1	1			
Cornus amomum	silky dogwood	Shrub	1	1	1	4	4	4	6	6	6							4	4	4	4	4	4
Diospyros virginiana	common persimmon	Tree							1	1	1	1	1	1	3	3	3				3	3	3
Fraxinus pennsylvanica	green ash	Tree				1	1	1	1	1	1				1	1	1				2	2	2
Liriodendron tulipifera	tuliptree	Tree																					
Platanus occidentalis	American sycamore	Tree	9	9	9	1	1	1	5	5	5	5	5	5	7	7	7	6	6	6	1	1	1
Quercus michauxii	swamp chestnut oak	Tree				3	3	3	2	2	2	3	3	3				3	3	3	3	3	3
Quercus phellos	willow oak	Tree				7	7	7	1	1	1							1	1	1			
Quercus rubra	northern red oak	Tree																					
Sambucus canadensis	common elderberry	Shrub	1	1	1										1	1	1						
Unknown		Shrub or Tree																					
Viburnum dentatum	southern arrowwood	Shrub																			1	1	1
		Stem count	23	23	23	18	18	18	21	21	21	18	18	18	18	18	18	15	15	15	16	16	16
		size (ares)	1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	5	5	5	6	6	6	7	7	7	5	5	5	6	6	6	5	5	5	7	7	7
		Stems per ACRE	930.8	930.8	930.8	728.4	728.4	728.4	849.8	849.8	849.8	728.4	728.4	728.4	728.4	728.4	728.4	607.0	607.0	607.0	647.5	647.5	647.5

			Current Plot Data (MY5 2016)																				
			92767-01-0008			92767-01-0009			92767-01-0010			92767-01-0011			92767-01-0012			92767-01-0013					
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			
Asimina triloba	pawpaw	Tree										1	1	1									
Betula nigra	river birch	Tree	6	6	6	9	9	9	6	6	6				1	1	1						
Carpinus caroliniana	American hornbeam	Tree							3	3	3				2	2	2	1	1	1			
Cercis canadensis	eastern redbud	Tree							1	1	1												
Cornus amomum	silky dogwood	Shrub													3	3	3						
Diospyros virginiana	common persimmon	Tree	5	5	5	1	1	1	1	1	1	8	8	8	4	4	4						
Fraxinus pennsylvanica	green ash	Tree				1	1	1				1	1	1	1	1	1						
Liriodendron tulipifera	tuliptree	Tree	1	1	1										5	5	5	1	1	1			
Platanus occidentalis	American sycamore	Tree				4	4	4				10	10	10	6	6	6	6	6	6			
Quercus michauxii	swamp chestnut oak	Tree	5	5	5				5	5	5	3	3	3									
Quercus phellos	willow oak	Tree				1	1	1															
Quercus rubra	northern red oak	Tree																1	1	1			
Sambucus canadensis	common elderberry	Shrub							1	1	1							6	6	6			
Unknown		Shrub or Tree																					
Viburnum dentatum	southern arrowwood	Shrub																					
		Stem count	17	17	17	16	16	16	17	17	17	23	23	23	22	22	22	15	15	15			
		size (ares)	1			1			1			1			1			1					
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02					
		Species count	4	4	4	5	5	5	6	6	6	5	5	5	7	7	7	5	5	5			
		Stems per ACRE	688.0	688.0	688.0	647.5	647.5	647.5	688.0	688.0	688.0	930.8	930.8	930.8	890.3	890.3	890.3	607.0	607.0	607.0			

			Current Plot Data (MY5 2016)																				
			MY5 (2016)			MY4 (2015)			MY3 (2014)			MY2 (2013)			MY1 (2012)								
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						
Asimina triloba	pawpaw	Tree	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						
Betula nigra	river birch	Tree	50	50	50	53	53	53	56	56	56	56	56	56	59	59	59						
Carpinus caroliniana	American hornbeam	Tree	9	9	9	8	8	8	8	8	8	8	8	8	9	9	9						
Cercis canadensis	eastern redbud	Tree	7	7	7	10	10	10	12	12	12	12	12	12	14	14	14						
Cornus amomum	silky dogwood	Shrub	22	22	22	25	25	25	25	25	25	27	27	27	27	27	27						
Diospyros virginiana	common persimmon	Tree	27	27	27	27	27	27	27	27	27	30	30	30	36	36	36						
Fraxinus pennsylvanica	green ash	Tree	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9						
Liriodendron tulipifera	tuliptree	Tree	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6						
Platanus occidentalis	American sycamore	Tree	60	60	60	54	54	54	57	57	57	63	63	63	66	66	66						
Quercus michauxii	swamp chestnut oak	Tree	27	27	27	29	29	29	29	29	29	30	30	30	30	30	30						
Quercus phellos	willow oak	Tree	10	10	10	10	10	10	9	9	9	9	9	9	10	10	10						
Quercus rubra	northern red oak	Tree	1	1	1	1	1	1	3	3	3	5	5	5	6	6	6						
Sambucus canadensis	common elderberry	Shrub	9	9	9	3	3	3	3	3	3	2	2	2	2	2	2						
Unknown		Shrub or Tree										3	3	3	5	5	5						
Viburnum dentatum	southern arrowwood	Shrub	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2						
		Stem count	239	239	239	236	236	236	246	246	246	263	263	263	282	282	282						
		size (ares)	13			13			13			13			13								
		size (ACRES)	0.32			0.32			0.32			0.32			0.32								
		Species count	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15						
		Stems per ACRE	744.0	744.0	744.0	734.7	734.7	734.7	765.8	765.8	765.8	818.7	818.7	818.7	877.9	877.9	877.9						

Exceeds requirements, by greater than 10%

VEGETATION PHOTOS

Candiff Creek Vegetation Plots Year 5

Vegetation Plot 1

Vegetation Plot 2

Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Vegetation Plot 6

Vegetation Plot 7

Vegetation Plot 8

Vegetation Plot 9

Vegetation Plot 10

Vegetation Plot 11

Vegetation Plot 12

Vegetation Plot 13

APPENDIX B

GEOMORPHIC DATA

STREAM TABLES

Table B.1. Categorical Stream Feature Visual Stability Assessment

Candiff Creek Restoration Project: DMS Project No. 92767						
Performance Percentage						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	100%	100%	100%	100%
B. Pools	100%	96%	96%	96%	99%	99%
C. Thalweg	100%	100%	100%	100%	100%	100%
D. Meanders	100%	100%	100%	100%	100%	100%
E. Bed General	100%	100%	100%	100%	100%	100%
F. Bank Condition	100%	100%	100%	100%	99%	99%
G. Wads	100%	100%	100%	100%	99%	99%

Table B.1a Visual Morphological Stability Assessment

Candiff Creek Restoration Project: DMS Project No. 92767						
Feature Category	**Metric (per As-built and reference baselines)**	**(# Stable) Number Performing as Intended**	**Total Number Per As-built**	**Total Number / Feet in Unstable State**	**% Performing in Stable Condition**	**Feature Performing Mean or Total**
A. Riffles	1. Present	27	27	NA	100	100
	2. Armor Stable (e.g. no displacement)	27	27	NA	100	
	3. Facet grade appears stable	27	27	NA	100	
	4. Minimal evidence of embedding/fining	27	27	NA	100	
	5. Length appropriate	27	27	NA	100	
B. Pools	1. Present (e.g. not subject to severe aggradation or migration)	28	28	NA	100	100
	2. Sufficiently Deep (Max Pool D: Mean Bkf >1.6)	28	28	NA	100	
	3. Length appropriate	28	28	NA	100	
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	28	28	NA	100	100
	3. Downstream of meander (glide/inflection) centering	27	27	NA	100	
D. Meanders	1. Outer bend in state of limited/controlled erosion	26	28	20	93.0	97.4
	2. Of those eroding, number with concomitant point bar formation	27	28	NA	96.4	
	3. Apparent Rc within specifications	28	28	NA	100	
	4. Sufficient floodplain access and relief	28	28	NA	100	
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	0/0	100	100
	2. Channel bed aggradation - areas of increasing down-cutting or head cutting	NA	NA	0/0	100	
F. Bank	1. Actively eroding, wasting or slumping bank	NA	NA	0/0	100	100
G. Vanes	1. Free of back or arm scour	29	29	NA	100	100
	2. Height appropriate	29	29	NA	100	
	3. Angle of geometry appear appropriate	29	29	NA	100	
	4. Free of piping or structural failures	29	29	NA	100	
H. Wads/Boulders	1. Free of scour	40	40	NA	100	100
	2. Footing stable	40	40	NA	100	

Table B.2. Baseline Stream Summary

Candiff Creek Restoration Project: DMS Project No. 92767

Candiff Creek - M2

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
Dimension - Riffle			LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	-----	19.8	-----	-----	-----	-----	-----	19.8	-----	-----	-----	-----
Floodprone Width (ft)	-----	-----	-----	-----	-----	-----	23.8	-----	-----	-----	-----	27.7	-----	30.0	-----	-----	-----
BF Mean Depth (ft)	-----	-----	-----	-----	-----	-----	1.42	-----	-----	-----	-----	-----	1.42	-----	-----	-----	-----
BF Max Depth (ft)	-----	-----	-----	-----	-----	-----	1.85	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	-----	28.2	-----	-----	-----	-----	-----	29.0	-----	-----	-----	-----
Width/Depth Ratio	-----	-----	-----	-----	-----	-----	13.9	-----	11	-----	14	-----	13.9	-----	-----	-----	-----
Entrenchment Ratio	-----	-----	-----	-----	-----	-----	1.2	-----	-----	-----	-----	1.4	-----	1.5	-----	-----	-----
Bank Height Ratio	-----	-----	-----	-----	-----	-----	2.6	-----	1	-----	1.1	1	-----	1.1	-----	-----	-----
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	3.7	-----	3.5	-----	5	-----	3.6	-----	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.005	-----	0.0081	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	29.7	-----	99	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	8.3/24.4/36.7/82.0/119.3			-----			8.3/24.4/36.7/82.0/119.3			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	0.35	-----	-----	-----	-----	-----	0.36	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	21.7	-----	-----	-----	-----	-----	21.7	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	265	-----	-----	-----	-----	-----	265	-----	-----	265	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	2.53	-----	-----	-----	-----	-----	2.53	-----	-----	2.53	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	F4/1	-----	-----	-----	-----	-----	B4c/1	-----	-----	B4c/1	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	105	-----	-----	-----	-----	-----	105	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.00	-----	1.2	-----	1.4	-----	1.00	-----	-----	1.00	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.0045	-----	-----	-----	-----	-----	0.0045	-----	-----	0.0045	-----

Candiff Creek - M3

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
Dimension - Riffle			LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	20.7	-----	32.2	-----	-----	-----	-----	20.4	-----	19.8	21.6	25.6
Floodprone Width (ft)	-----	-----	-----	-----	-----	35.5	-----	94.1	-----	-----	-----	60.0	-----	120.0	108.0	120.2	139.9
BF Mean Depth (ft)	-----	-----	-----	-----	-----	0.9	-----	1.4	-----	-----	-----	-----	1.6	-----	1.24	1.44	1.58
BF Max Depth (ft)	-----	-----	-----	-----	-----	2.0	-----	2.4	-----	-----	-----	1.9	-----	2.2	1.96	2.15	2.43
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	29.2	-----	32.6	-----	-----	-----	-----	32.0	-----	28.62	30.77	32.44
Width/Depth Ratio	-----	-----	-----	-----	-----	14.6	-----	34.6	11	-----	14	-----	13.0	-----	12.6	15.4	20.7
Entrenchment Ratio	-----	-----	-----	-----	-----	1.7	-----	2.9	-----	-----	-----	2.9	-----	5.9	4.2	5.6	7.0
Bank Height Ratio	-----	-----	-----	-----	-----	1.0	-----	2.5	1	-----	1.1	1	-----	1.1	1.0	1.0	1.1
BF Velocity (fps)	-----	-----	-----	-----	-----	3.5	-----	3.9	3.5	-----	5	3.5	-----	5	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.5	-----	7	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.0078	-----	0.0104	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	81.6	-----	142.8	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	8.3/24.4/36.7/82.0/119.3			-----			8.3/24.4/36.7/82.0/119.3			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	0.32	-----	-----	-----	-----	-----	0.44	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	22.1	-----	-----	-----	-----	-----	26.6	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	3,828	-----	-----	-----	-----	-----	4,109	-----	-----	4,123	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	2.74	-----	-----	-----	-----	-----	2.74	-----	-----	2.74	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	C4/1, F4/1	-----	-----	-----	-----	-----	C4/1	-----	-----	C4	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	115	-----	-----	-----	-----	-----	115	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.29	-----	-----	-----	-----	-----	1.33	-----	-----	1.41	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.0055	-----	-----	-----	-----	-----	0.0052	-----	-----	0.0052	-----

Table B.3. Morphology and Hydraulic Monitoring Summary

Candiff Creek Restoration Project: DMS Project No. 92767																				
Reach: M3																				
Parameter	Cross-section 1 Riffle					Cross-section 2 Pool					Cross-section 3 Pool					Cross-section 4 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	19.49	19.92	23.30	16.80	16.58	30.60	19.24	13.49	12.38	12.95	33.08	17.96	18.03	17.42	17.02	18.17	19.33	25.62	19.95	19.69
BF Mean Depth (ft)	1.09	1.24	1.23	1.09	1.09	1.14	1.82	2.37	2.48	2.49	1.81	3.02	2.78	2.82	2.37	1.41	1.61	1.18	1.47	1.47
Width/Depth Ratio	17.82	16.00	15.42	15.43	15.21	26.96	10.55	5.70	4.99	5.19	18.31	5.95	6.48	6.19	7.17	12.86	12.03	21.77	13.55	13.36
BF Cross-sectional Area (ft^2)	21.3	16.1	23.3	18.3	18.1	34.7	35.1	31.9	30.7	32.3	59.8	54.2	50.1	49.1	40.4	25.7	31.1	30.2	29.4	29.0
BF Max Depth (ft)	1.56	1.83	1.23	1.61	1.59	3.38	3.99	3.63	3.68	3.57	4.35	4.27	4.42	4.44	3.49	2.03	2.30	2.21	2.17	2.19
Width of Floodprone Area (ft)	73.64	77.58	73.52	73.02	72.48	153.88	153.85	153.95	153.88	153.88	124.67	124.70	124.66	124.69	124.69	120.72	120.78	120.8	120.71	120.74
Entrenchment Ratio	3.8	3.9	3.9	4.3	4.4	5.0	8.0	11.4	12.4	11.9	3.8	6.9	6.9	7.2	7.3	6.6	6.2	4.7	6.1	6.1
Bank Height Ratio	1.1	1.1	1.1	0.9	1.3	1.0	1.0	1.1	1.1	1.3	1.0	1.1	1.0	1.0	1.2	1.1	1.0	1.0	0.9	1.0
Wetted Perimeter (ft)	21.67	22.40	25.76	18.98	18.76	32.88	22.88	18.23	17.34	17.93	36.70	24.00	23.59	23.06	21.76	20.99	22.55	27.98	22.89	22.63
Hydraulic Radius (ft)	0.98	0.72	0.90	0.96	0.96	1.06	1.53	1.75	1.77	1.80	1.63	2.26	2.12	2.13	1.86	1.22	1.38	1.08	1.28	1.28
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			3415			3145			3406			2508			2766.53
Channel Length (ft)			4827			4827			4794			3542			3926.39
Sinuosity			1.41			1.41			1.41			1.41			1.42
Water Surface Slope (ft/ft)			0.0051			0.0052			0.0052			0.0051			0.0051
BF Slope (ft/ft)			0.0073			0.0073			0.0071			0.0072			0.0073
Rosgen Classification			C			C			C			C			C

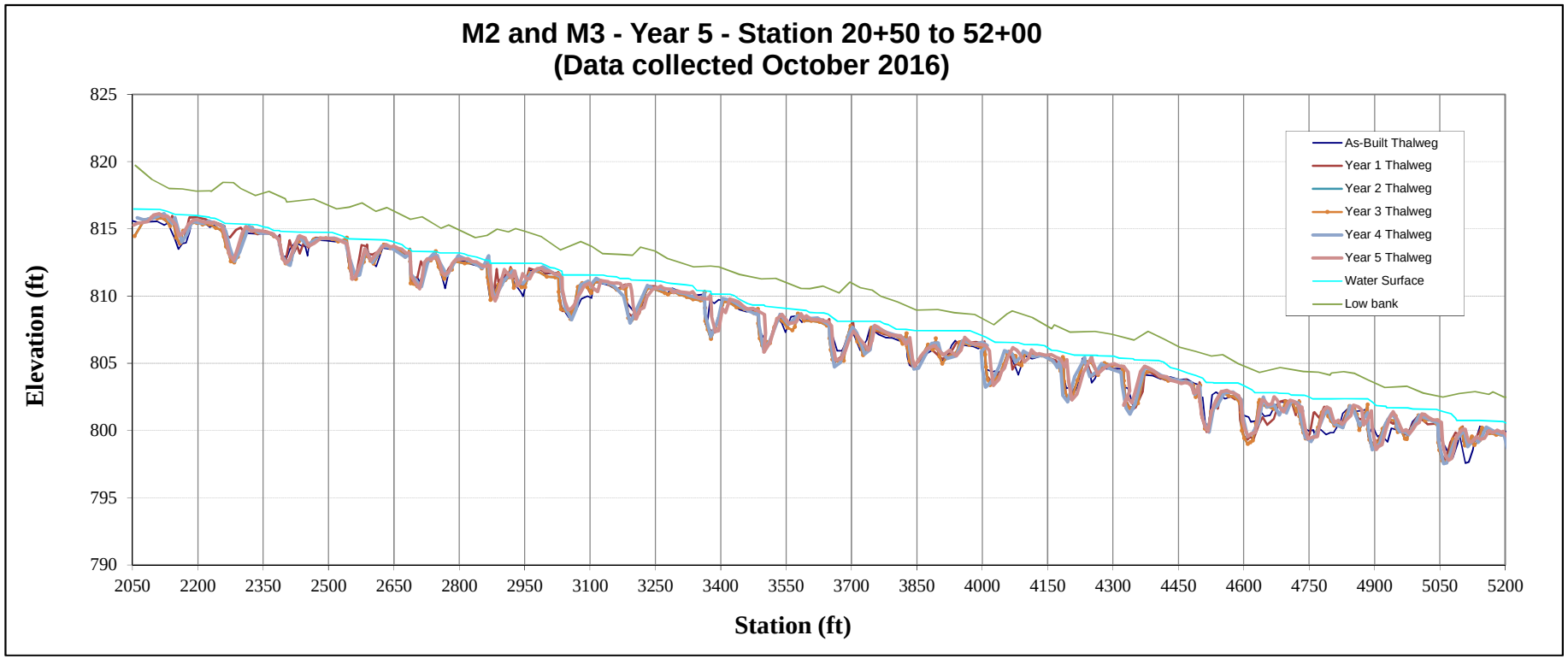
Reach: M3																				
Parameter	Cross-section 5 Pool					Cross-section 6 Riffle					Cross-section 7 Pool					Cross-section 8 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	35.08	34.93	32.78	36.77	17.72	19.57	22.56	21.12	22.49	19.48	41.11	27.78	21.23	19.03	17.01	19.35	19.66	19.55	19.15	19.19
BF Mean Depth (ft)	1.61	1.68	1.63	1.41	2.69	1.41	1.34	1.24	1.15	1.26	1.06	1.70	2.19	2.04	2.94	1.45	1.38	1.36	1.32	1.21
Width/Depth Ratio	21.78	20.81	20.16	26.00	6.59	13.78	16.86	17.05	19.51	15.45	38.84	16.36	9.69	9.31	5.79	13.36	14.23	14.42	14.47	15.84
BF Cross-sectional Area (ft²)	56.5	58.6	53.3	52.0	47.6	27.8	30.2	26.2	25.9	24.6	43.5	47.2	46.5	38.9	50.0	28.0	27.1	26.5	25.4	23.3
BF Max Depth (ft)	4.04	4.37	4.27	4.04	3.81	2.01	2.45	2.10	2.09	1.97	2.57	4.08	4.16	3.58	4.16	2.09	2.17	2.16	2.00	1.92
Width of Floodprone Area (ft)	119.00	119.06	119.06	119.03	119.04	108.03	108.03	108.13	108.00	108.03	118.58	118.63	118.56	118.65	118.63	115.23	115.12	115.21	115.20	115.15
Entrenchment Ratio	3.4	3.4	3.6	3.2	6.7	5.5	4.8	5.1	4.8	5.5	2.9	4.3	5.6	6.2	7.0	6.0	5.9	5.9	6.0	6.0
Bank Height Ratio	1.0	0.9	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.1	1.1	1.1	1.1	1.3
Wetted Perimeter (ft)	38.30	38.29	36.04	39.59	23.10	22.39	25.24	23.60	24.79	22.00	43.23	31.18	25.61	23.11	22.89	22.25	22.42	22.27	21.79	21.61
Hydraulic Radius (ft)	1.48	1.53	1.48	1.31	2.06	1.24	1.20	1.11	1.04	1.12	1.01	1.51	1.82	1.68	2.18	1.26	1.21	1.19	1.17	1.08
Substrate																				
d50 (mm)																				
d84 (mm)																				

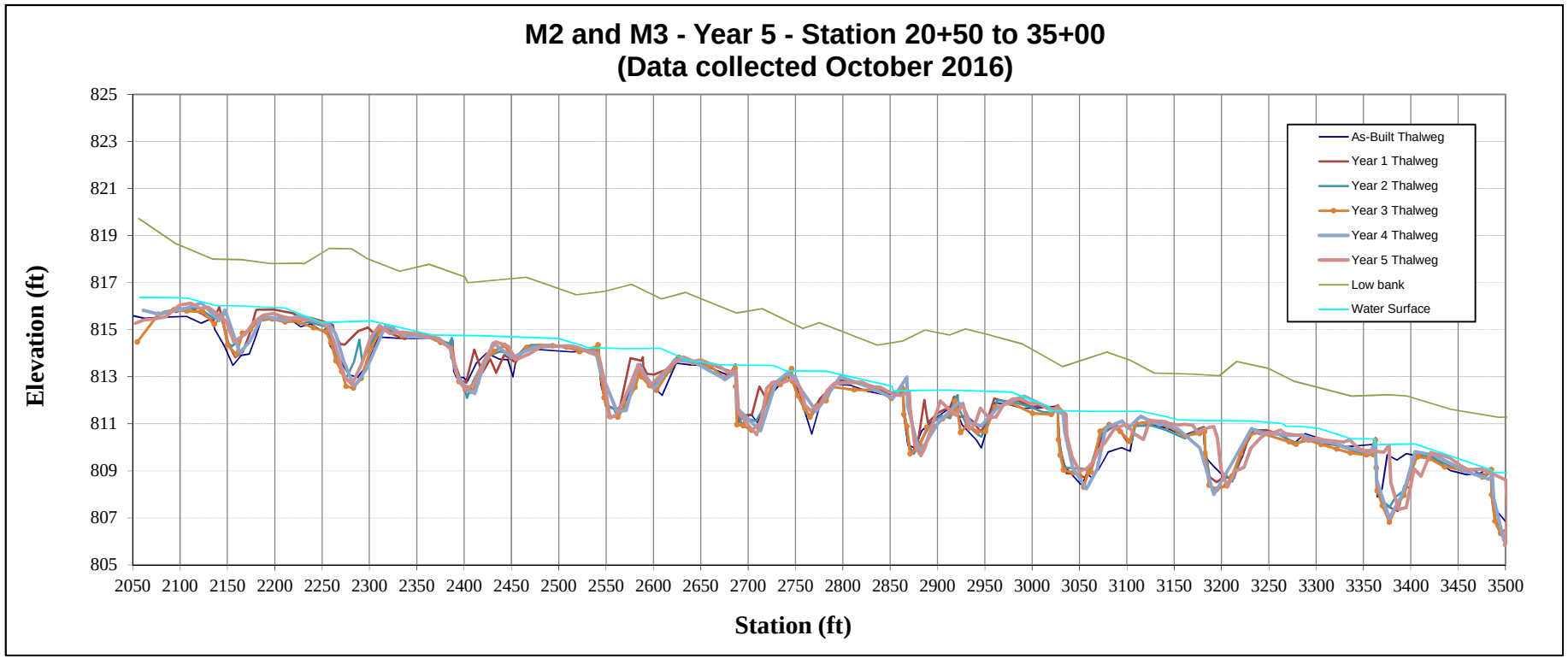
Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			3415			3145			3406			2508			2766.53
Channel Length (ft)			4827			4827			4794			3542			3926.39
Sinuosity			1.41			1.41			1.41			1.41			1.42
Water Surface Slope (ft/ft)			0.0051			0.0052			0.0052			0.0051			0.0051
BF Slope (ft/ft)			0.0073			0.0073			0.0071			0.0072			0.0073
Rosgen Classification			C			C			C			C			C

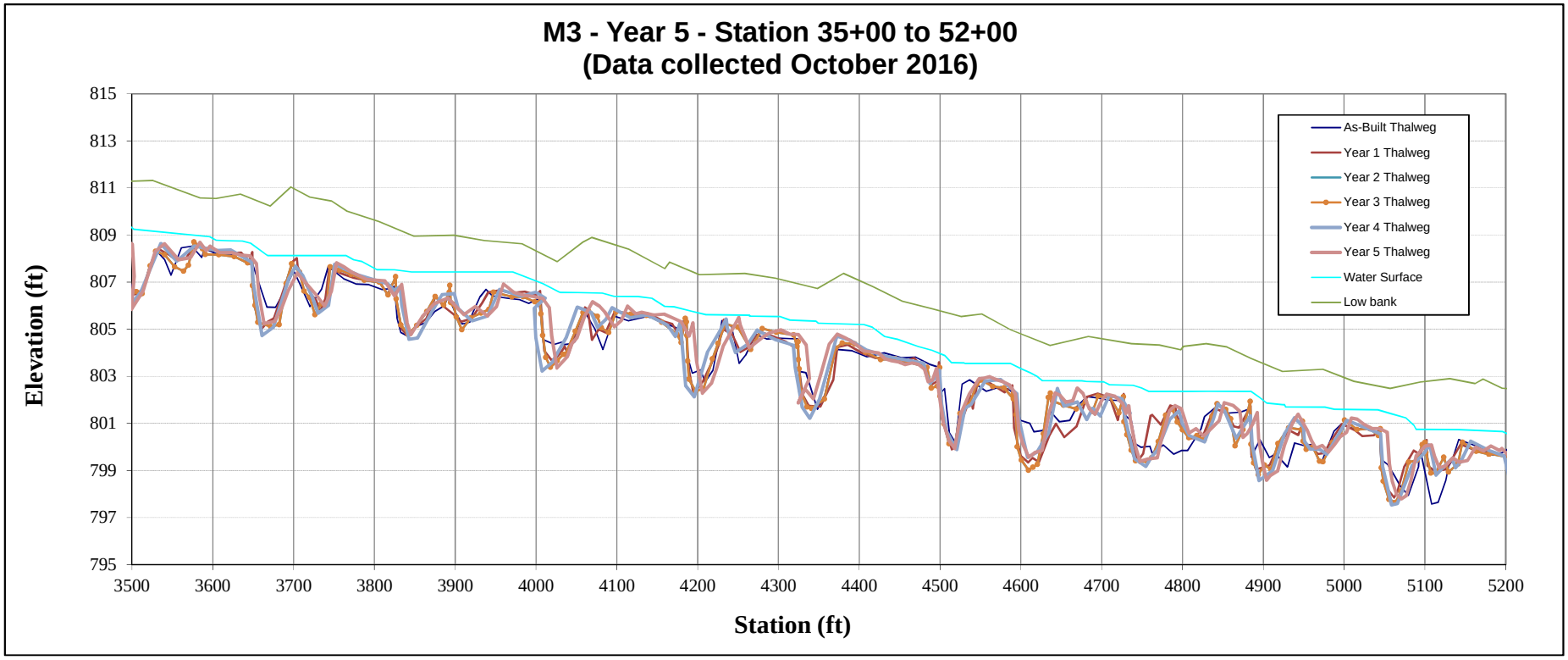
Reach: M3																					
Parameter	Cross-section 9 Pool					Cross-section 10 Riffle															
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5											
Dimension																					
BF Width (ft)	24.25	22.72	16.74	11.51	12.05	24.40	19.04	18.23	17.25	17.59											
BF Mean Depth (ft)	1.30	1.62	1.42	1.93	1.55	1.30	1.30	1.12	1.27	1.20											
Width/Depth Ratio	18.67	14.05	11.75	5.97	7.78	14.37	14.59	16.31	13.62	14.70											
BF Cross-sectional Area (ft²)	31.50	36.80	23.80	22.20	18.70	24.40	24.80	20.40	21.90	21.00											
BF Max Depth (ft)	3.24	3.98	2.98	2.89	2.07	1.83	2.21	1.74	1.92	1.91											
Width of Floodprone Area (ft)	88.14	94.15	82.92	82.43	78.07	117.32	117.30	117.31	117.29	117.27											
Entrenchment Ratio	3.6	4.1	5.0	7.2	6.5	6.3	6.2	6.4	6.8	6.70											
Bank Height Ratio	1.0	1.0	1.0	1.0	1.2	1.0	1.1	1.2	1.0	1.2											
Wetted Perimeter (ft)	26.85	25.96	19.58	15.37	15.15	27.00	21.64	20.47	19.79	19.99											
Hydraulic Radius (ft)	1.17	1.42	1.22	1.44	1.23	0.90	1.15	1.00	1.11	1.05											
Substrate																					
d50 (mm)																					
d84 (mm)																					

Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			3415			3145			3406			2508			2766.53
Channel Length (ft)			4827			4827			4794			3542			3926.39
Sinuosity			1.41			1.41			1.41			1.41			1.42
Water Surface Slope (ft/ft)			0.0051			0.0052			0.0052			0.0051			0.0051
BF Slope (ft/ft)			0.0073			0.0073			0.0071			0.0072			0.0073
Rosgen Classification			C			C			C			C			C

STREAM DATA
AND PHOTOGRAPHS


M2 and M3 - Year 5 - Station 20+50 to 52+00
(Data collected October 2016)
Elevation (ft)
825
820
815
810
805
800
795
790
2050
2200
2350
2500
2650
2800
2950
3100
3250
3400
3550
3700
3850
4000
4150
4300
4450
4600
4750
4900
5050
5200
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 4 Thalweg
Year 5 Thalweg
Water Surface
Low bank


M2 and M3 - Year 5 - Station 20+50 to 35+00
(Data collected October 2016)
Elevation (ft)
825
823
821
819
817
815
813
811
809
807
805
2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 2600 2650 2700 2750 2800 2850 2900 2950 3000 3050 3100 3150 3200 3250 3300 3350 3400 3450 3500
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 4 Thalweg
Year 5 Thalweg
Low bank
Water Surface


M3 - Year 5 - Station 35+00 to 52+00
(Data collected October 2016)
Elevation (ft)
815
813
811
809
807
805
803
801
799
797
795
3500
3600
3700
3800
3900
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100
5200
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 4 Thalweg
Year 5 Thalweg
Water Surface
Low bank

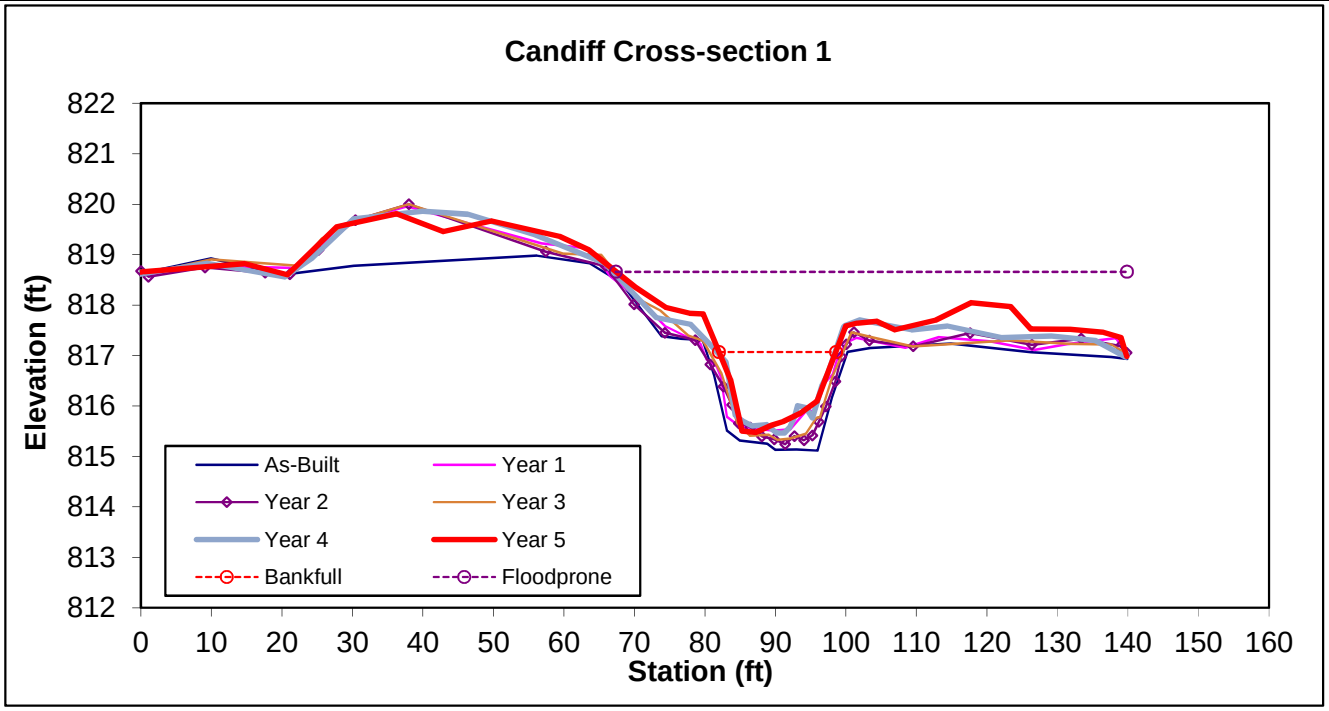
Permanent Cross-section 1

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	18.1	16.58	1.09	1.59	15.21	1.3	4.4	817.07	817.59



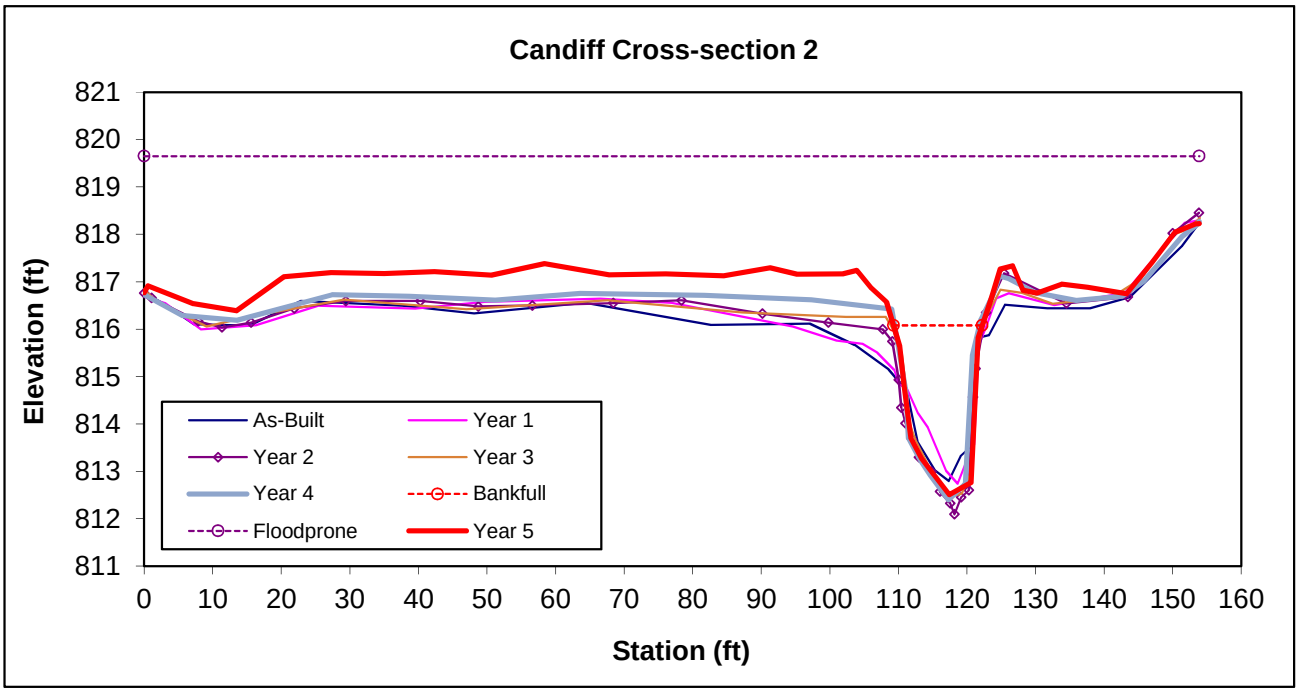
Permanent Cross-section 2

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		32.3	12.95	2.49	3.57	5.19	1.3	11.9	816.08	817.24



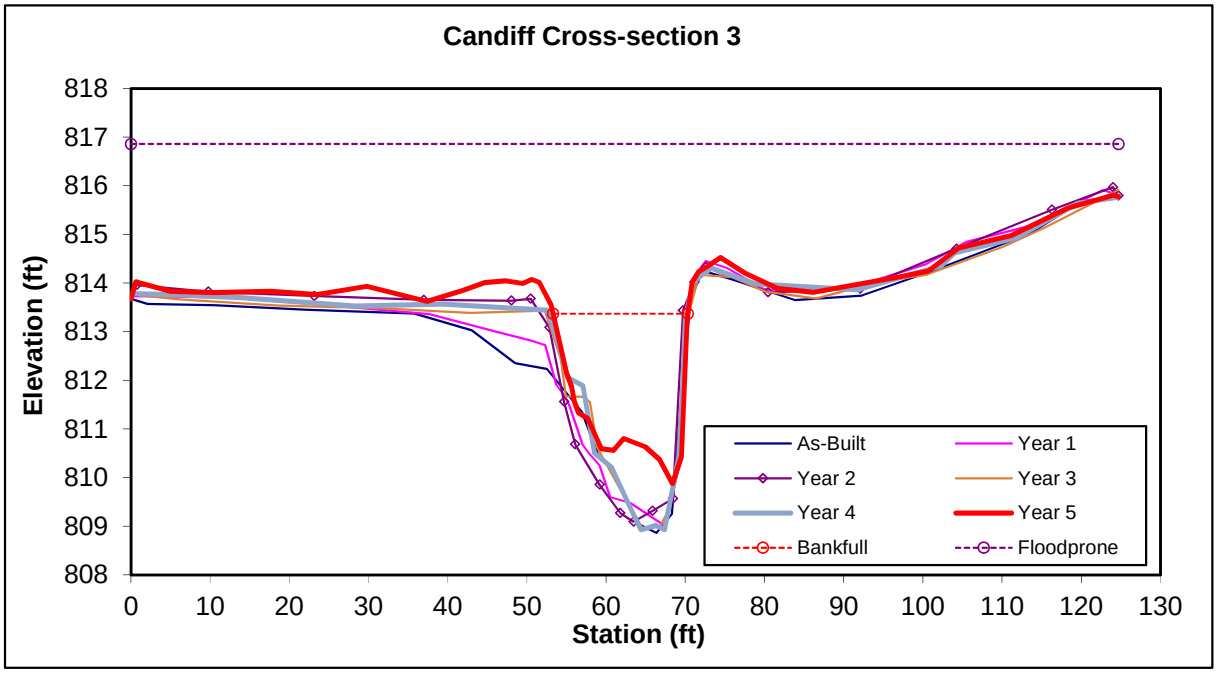
Permanent Cross-section 3

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		40.4	17.02	2.37	3.49	7.17	1.2	7.3	813.37	814.02



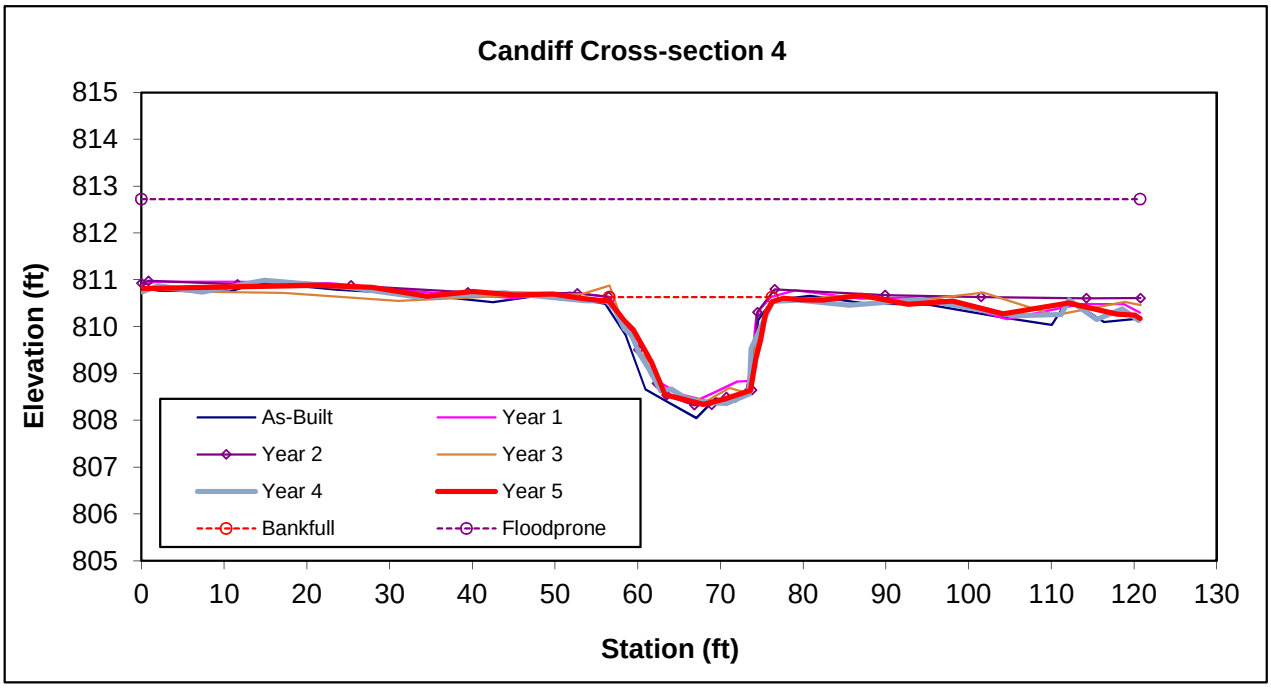
Permanent Cross-section 4

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	29	19.69	1.47	2.19	13.36	1	6.1	810.53	810.53



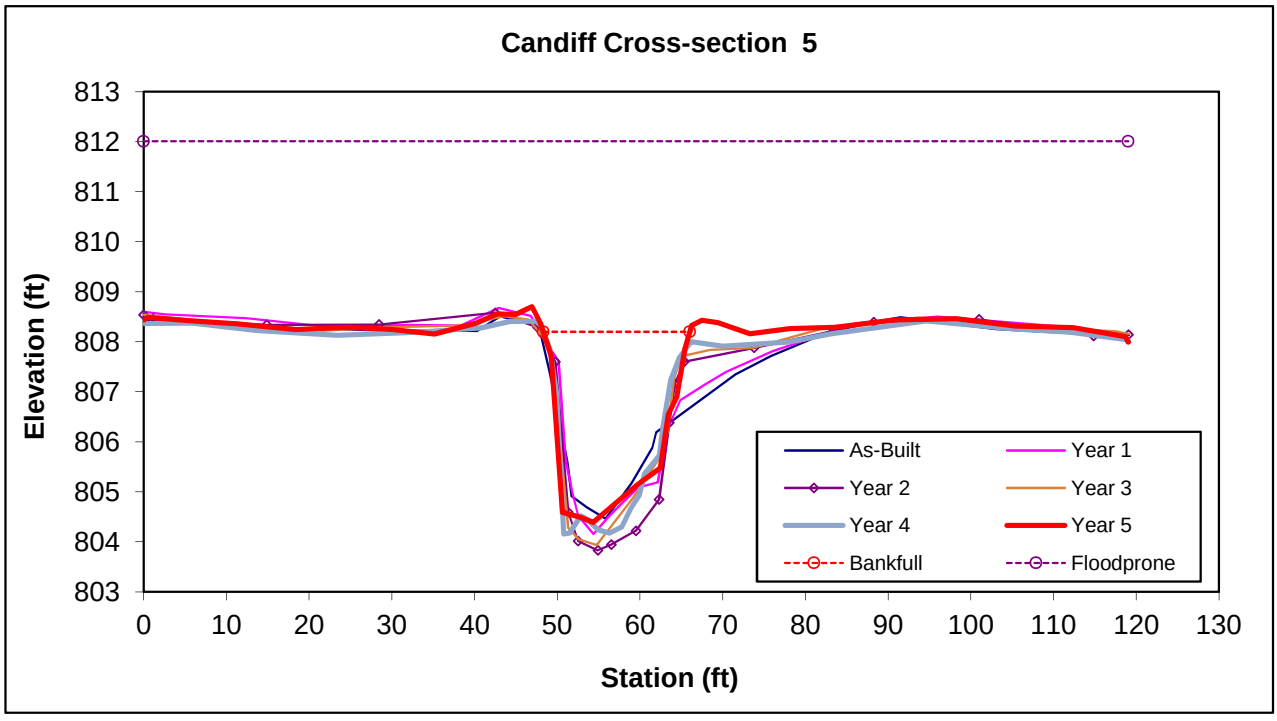
Permanent Cross-section 5

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		47.6	17.72	2.69	3.81	6.59	1	6.7	808.2	808.32



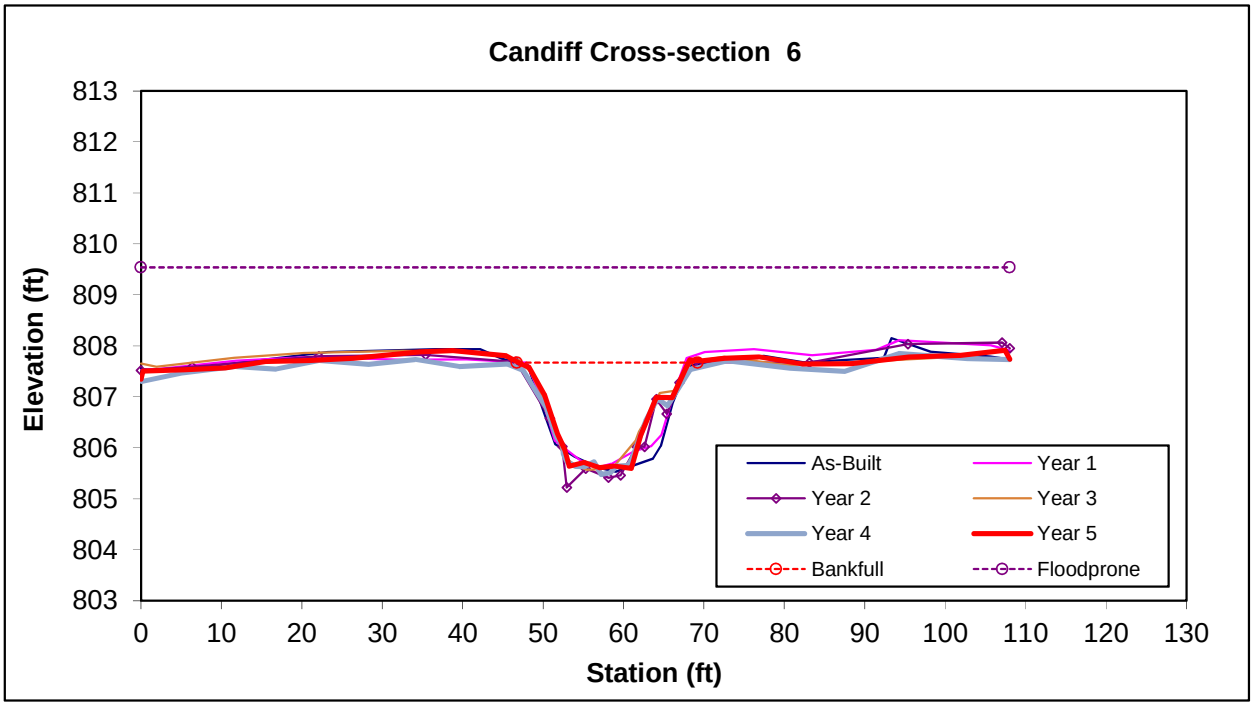
Permanent Cross-section 6

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	24.6	19.48	1.26	1.97	15.45	1	5.5	807.57	807.58



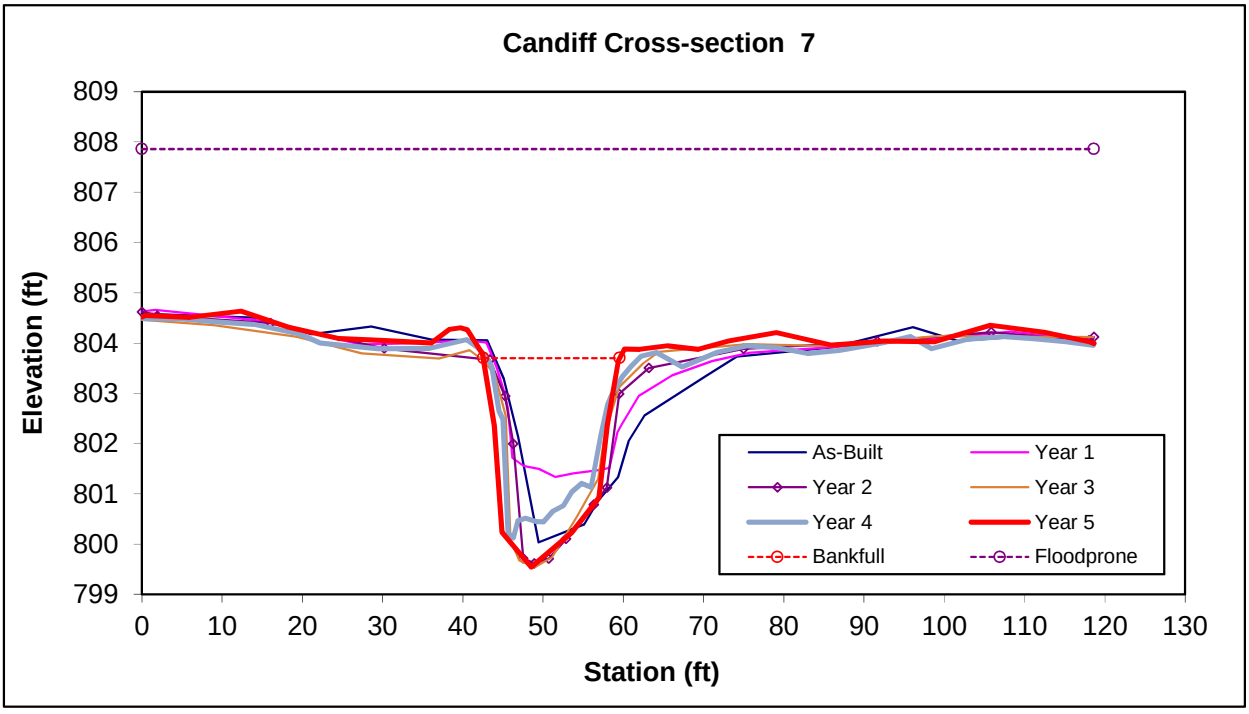
Permanent Cross-section 7

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		50	17.01	2.94	4.16	5.79	1	7	803.7	803.88



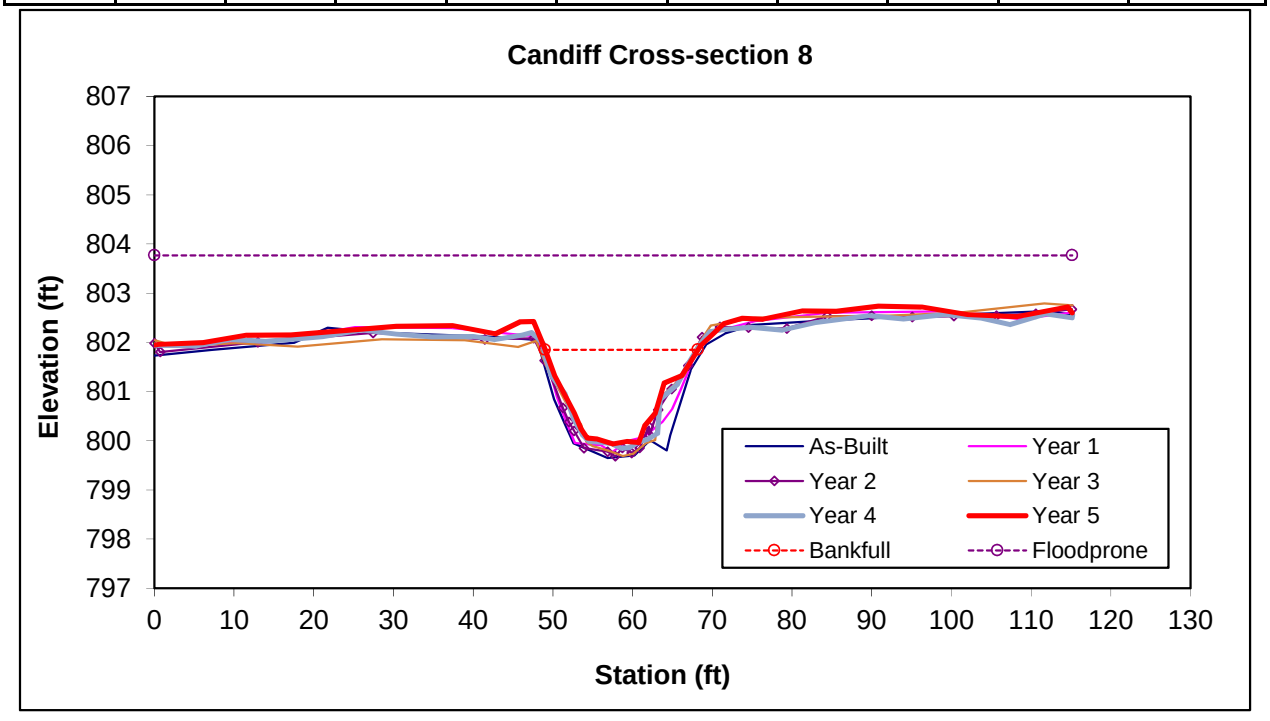
Permanent Cross-section 8

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	23.3	19.19	1.21	1.92	15.84	1.3	6	801.85	802.38



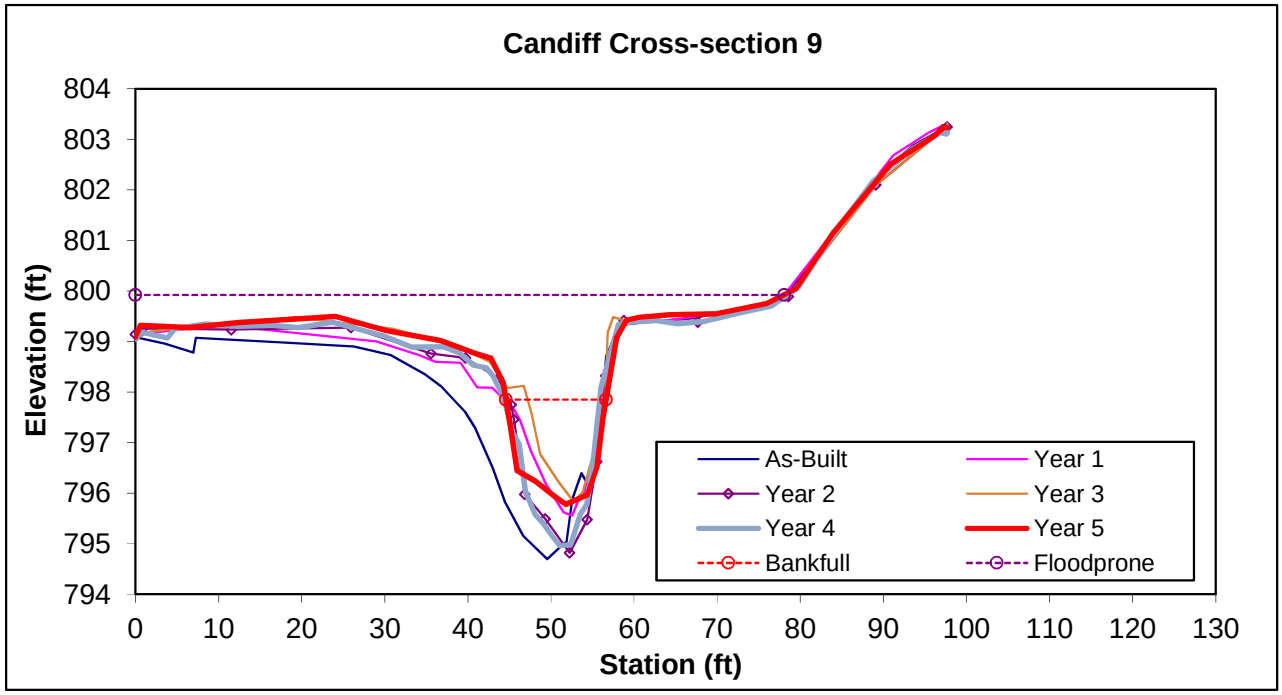
Permanent Cross-section 9

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		18.7	12.05	1.55	2.07	7.78	1.2	6.5	797.85	798.19



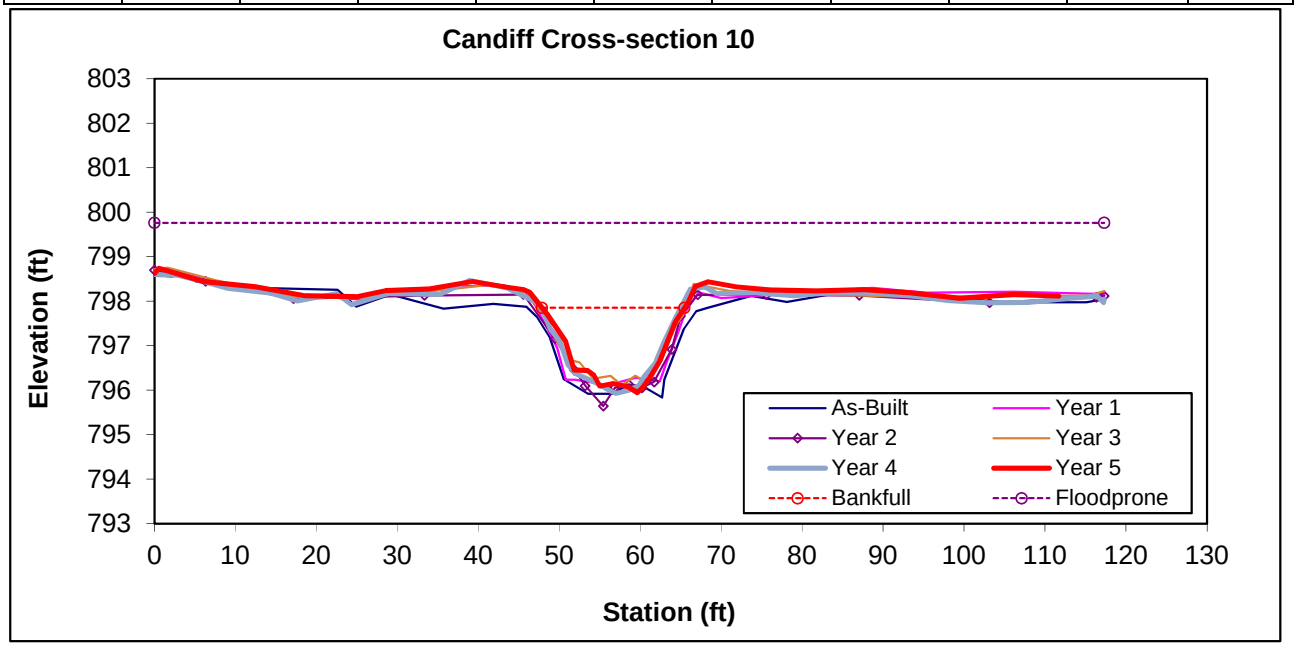
Permanent Cross-section 10

(Year 5 Data - Collected October 2016)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	21	17.59	1.2	1.91	14.7	1.2	6.7	797.85	798.2



Candiff Creek Restoration, M3, M2 and M1 Lower, Year 5 Photographs

PP1 STA 61+60, Constructed Riffle

PP 2 61+25, Constructed Riffle

PP 3 STA 60+25, Rock J-Hook

PP 4 STA 60+10, Constructed Riffle

PP 5 STA 59+10, Log J-Hook

PP 6 STA 58+85, Constructed Riffle

PP 7 STA 57+65, Log J-Hook

PP 8 STA 57+50, Stream Crossing

PP 9 STA 56+70, Log J-Hook

PP 10 STA 56+50, Constructed Riffle

PP 11 STA 55+40, Log J-Hook

PP 12 STA 55+15, Constructed Riffle

PP 13 STA 53+95, Rock J-Hook

PP 14 STA 53+75, Constructed Riffle

PP 15 STA 52+35, Log J-Hook

PP 16 STA 52+05, Constructed Riffle

PP 17 STA 50+75, Log J-Hook

PP 18 STA 50+40, Constructed Riffle

PP 19 STA 49+15, Log J-Hook

PP 20 STA 48+75, Constructed Riffle

PP 21 STA 47+50, Log J-Hook

PP 22 STA 47+25, Constructed Riffle

PP 23 STA 46+15, Log J-Hook

PP 24 STA 46+00, Constructed Riffle

PP 25 STA 45+25, Rock J-Hook

PP 26 STA 44+90, Constructed Riffle

PP 27 STA 43+50, Log J-Hook

PP 28 STA 43+25, Constructed Riffle

PP 29 STA 42+10, Log J-Hook

PP 30 STA 41+80, Constructed Riffle

PP 31 STA 40+25, Log J-Hook

PP 32 STA 40+00, Constructed Riffle

PP 33 STA 38+50, Rock J-Hook

PP 34 STA 38+25, Constructed Riffle

PP 35 STA 36+75, Rock J-Hook

PP 36 STA 36+45, Constructed Riffle

PP 37 STA 35+05, Log J-Hook

PP 38 STA 34+80, Constructed Riffle

PP 39 STA 33+90, Rock J-Hook

PP 40 STA 33+60, Constructed Riffle

P 41 STA 33+00, Stream Crossing

PP 42 STA 32+10, Log J-Hook

PP 43 STA 32+75, Constructed Riffle

PP 44 STA 30+55, Log J-Hook

PP 45 STA 30+20, Constructed Riffle

PP 46 STA 28+80, Log J-Hook

PP 47 STA 28+65, Constructed Riffle

PP 48 STA 27+75, Log Vane/Pool

PP 49 STA 27+10, Log J-Hook

PP 50 STA 26+75, Constructed Riffle

PP 51 STA 25+65, Rock J-Hook

PP 52 STA 25+45, Constructed Riffle

PP 53 STA 24+25, Log J-Hook

PP 54 STA 24+00, Constructed Riffle

PP 55 STA 22+90, Log J-Hook

PP 56 STA 22+70, Constructed Riffle

PP 57 STA 21+65, Log J-Hook

PP 58 STA 19+75, Rock Cross Vane

PP 59 STA 17+75, Rock Cross Vane

M3 crest gauge STA 55+50, October 11, 2016. Crest gauge reading of 3.24 feet.

M3 crest gauge STA 55+50, October 11, 2016. Crest gauge reading of 3.24 feet.

M3 crest gauge bankfull evidence. October 11, 2016.

Stream Problem Area 1 - STA 46+50. Bank heavily vegetated. Seems to have stabilized.

New Candiff Creek Enhancement Area, M1 Upper, Year 5 Photographs

M1 Enhancement, October 2016

M1 Enhancement, October 2016

M1 Enhancement, October 2016

M1 Enhancement, October 2016

M1 Enhancement, October 2016

Bank pin near Station 13+40, pin NOT exposed