Sink Hole Creek Mitigation Project

Year 5 Monitoring Report

Mitchell County, North Carolina

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)

Monitoring Firm POC: Micky Clemmons

Prepared for: North Carolina Division of Mitigation Services (NCDMS)

NCDMS Project Manager: Matthew Reid

Report Prepared By: Michael Baker Engineering, Inc., NC Professional Engineering License #F-1084

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Asheville, NC 28806

Contract Number: D06125-C, DMS Project Number: 92663

Project Construction: 2010

Data Collection Period: Fall 2015

Date Submitted: November, 2015

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EXECUTIVE SUMMARY

The Sink Hole Creek site was restored through a full delivery contract with the North Carolina Division of Mitigation Services (NCDMS). This report presents Year 5 monitoring data, part of the five-year monitoring period. The goals for the restoration project were as follows:

- To create geomorphically stable conditions on the Sink Hole Creek project site;
- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks and the exclusion of livestock from the streams corridors;
- To improve and restore hydrologic connections between the creek and floodplain;
- The restoration and preservation of headwater tributaries to the North Toe River, French Broad River Basin; and
- To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restoration of incised, eroding, and channelized streams by creating stable channels that have access to its floodplain;
- Improvement of water quality by establishing buffers for nutrient removal from runoff and by stabilizing streambanks to reduce bank erosion;
- Improvement of in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion;
- Improvement of terrestrial habitat by planting riparian areas with native vegetation and protection of these areas with a permanent conservation easement and fencing, so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

A total of eight vegetation monitoring plots, 100 square meters (m^2) in size, were surveyed to estimate the survival of woody vegetation planted on-site. Year 5 monitoring of vegetation plots indicates a range of 324 to 809 stems per acre survives, with an average survival rate of 531 stems per acre. The data shows all plots meet the final success criteria of 260 trees per acre by the end of Year 5.

The design implemented at the Sink Hole Creek mitigation project site involved both Priority Level I and II approaches. The resulting design should ultimately yield primarily a B-type channel for Sink Hole Creek and Reach 2 of UT1. Unnamed tributaries 2 and 3 should become stable A and B-type channels. Restoration work was completed in accordance with the approved design approach provided in the mitigation plan for Sink Hole Creek. Longitudinal profile and cross-section data indicate that the project streams have remained stable since baseline monitoring data were collected in the fall of 2010. Although stable, there are sections of UT2 and UT3 where the stream goes subsurface. Due to very dry conditions in this watershed during the spring and summer, we observed more surface flow in UT2-R1 and UT3 than in UT2-R2, likely due to a lowered water table. However, as A-type streams, this is not an unusual circumstance. Additionally, as the photo logs included in this report show, herbaceous cover at the project site is dense and is promoting bank stability and shading of project streams. Based on geomorphic data presented in Appendix B, this site is meeting the success criteria specified in the Sink Hole Creek Mitigation Plan.

Summary information and data related to encroachment or other functional issues, and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Besides subsurface flow in isolated segments on UT2 and UT3, the only other notable project concerns observed during Year 5 monitoring was the temporary encroachment of livestock within the easement area of UT2 and UT3 and three areas of invasive species encroachment. Narrative background and supporting information formerly found in these reports can be found in the Baseline

Monitoring Report (formerly Mitigation Plan) and in the Mitigation Plan (formerly Restoration Plan) documents available on the DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.

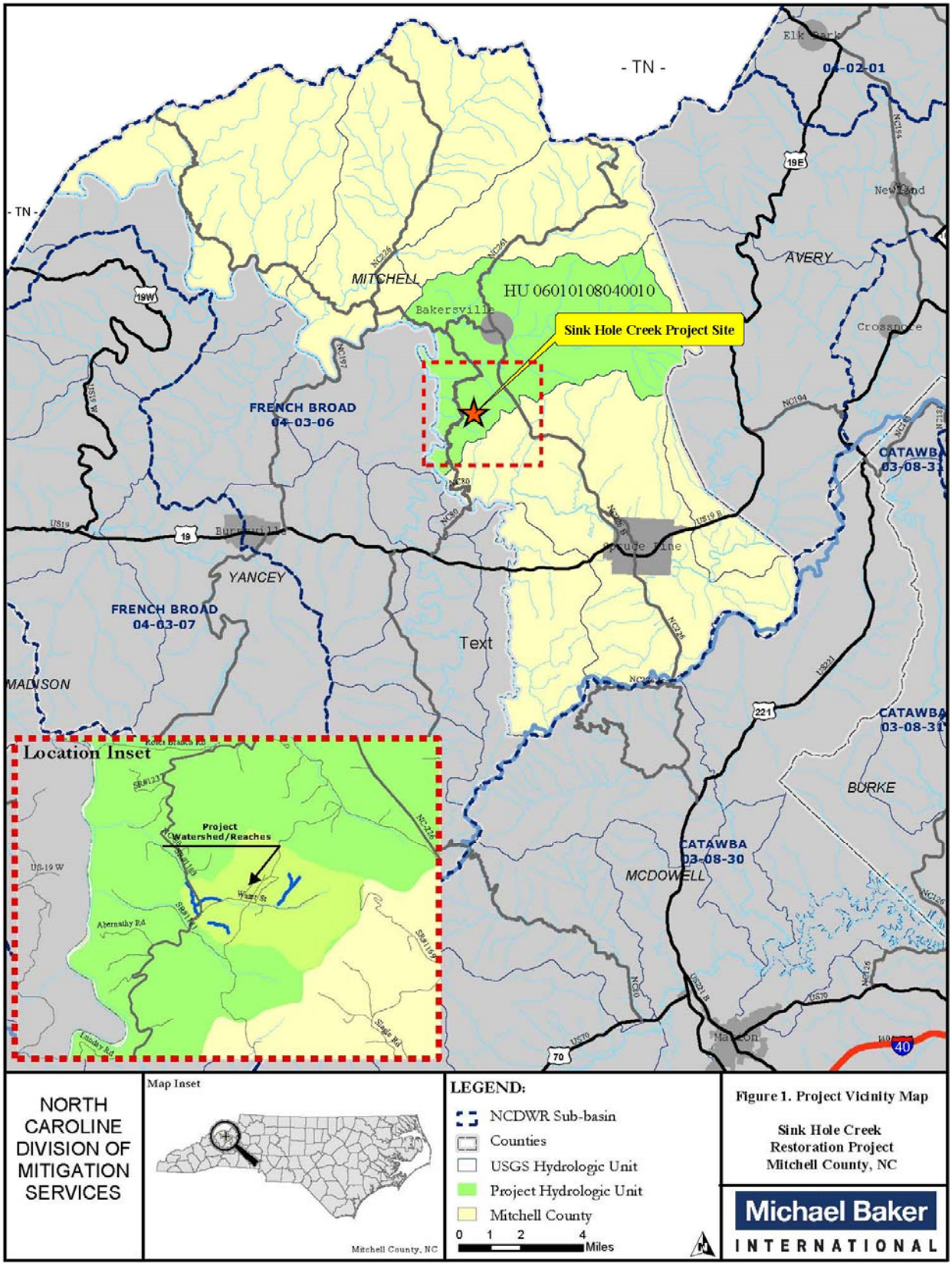
1.0 PROJECT BACKGROUND

The Sink Hole Creek mitigation site is located approximately four miles southwest of Bakersville, in Mitchell County, North Carolina (Figure 1 in Appendix A). The project site is situated in the French Broad River Basin, within North Carolina Division of Water Resources (NCDWR) sub-basin 04-03-06 and United States Geologic Survey (USGS) hydrologic unit 06010108040010. The Sink Hole Creek mitigation project is located in a watershed that is predominantly forested, but also contains a small number of residences near Sink Hole Creek and its tributaries. A quarter of the drainage is in some form of pasture land or hay production. Sink Hole Creek and its tributaries have been impaired by historical and recent land management practices that include timber harvesting, pasture conversion, channelization, and livestock grazing. In addition, a historic mica mine is located 1,000 feet north of the intersection of NC Highway 80 and Water Street (SR 1182). Prior to restoration, stream channelization and channel dredging were evident through much of the project site. Over time, these practices have contributed excessive sediment and nutrient loading to Sink Hole Creek and ultimately to the North Toe River which is home to the endangered Appalachian elktoe mussel (*Alamidonta raveneliana*). A significant loss of woody streambank vegetation occurred during the development of the land for agricultural use. Livestock had open access to portions of Sink Hole Creek, the section of UT1below NC Hwy. 80, UT2, and UT3. Past dredging activities had cut Sink Hole Creek off from its floodplain resulting in an incised channel; while in other sections, stream banks were trampled down, creating over widened channel conditions that contributed to additional sediment and nutrient loading. Land immediately surrounding the preservation reach of UT1 above Hwy. 80 is in forested cover.

The project involved restoration or enhancement of 4,703 LF along four (4) on-site streams: Sink Hole Creek and three (3) smaller unnamed tributaries (UT1, UT2 and UT3). In addition, 1,076 LF of the headwaters of UT 1 were preserved. Sink Hole Creek and UT1 are shown on the USGS topographic quadrangle for the site as being perennial and intermittent streams, respectively. Based on a field evaluation, Sink Hole Creek and the restoration reach of UT1, UT2 and UT3, all were determined to be perennial features using the NCDWR stream assessment protocol.

1.1 Location and Setting

To reach the project site, follow US Highway 19/23 north from Asheville for approximately 20 miles and take US Highway 19N (Exit 9) towards Burnsville and Spruce Pine. Continue along US Highway 19 (which becomes US-19E), for 25 miles. At Spruce Pine, turn left onto NC Highway 226 and continue for approximately 6.5 miles to State Road 1191. Turn left onto 1191, continue for approximately 1.7 miles, turn left onto NC Highway 80 and travel another 6.5 miles to Water Street (State Road 1182). Part of the project area is adjacent to the intersection of Water Street and NC Highway 80; UT 2 and UT3 are located in a pasture approximately 0.6 miles east on Water Street, on the left side of the road (Figure 1).


- TN -
04-02-01
MITCHELL
AVERY
HU 06010108040010
Bakersville
Sink Hole Creek Project Site
FRENCH BROAD
04-03-06
CATAWBA
03-08-31
YANCEY
FRENCH BROAD
04-03-07
Text
MADISON
Location Inset
Project Watershed/Reaches
BURKE
CATAWBA
03-08-30
MCDOWELL
NORTH CAROLINE DIVISION OF MITIGATION SERVICES
Map Inset
Mitchell County, NC
LEGEND:
NCDWR Sub-basin
Counties
USGS Hydrologic Unit
Project Hydrologic Unit
Mitchell County
0 1 2 4 Miles
Figure 1. Project Vicinity Map
Sink Hole Creek
Restoration Project
Mitchell County, NC
Michael Baker
INTERNATIONAL

1.2 Mitigation Structure and Objectives

Table 1 summarizes project data for each reach and restoration approach used. The design implemented at the Sink Hole Creek mitigation project site involved both Priority Level 1 and 2 approaches. The resulting design should ultimately yield primarily a B-type channel for Sink Hole Creek and Reach 2 of UT1. Unnamed tributaries 2 and 3 should become stable A and B-type channels. Restoration and enhancement work were completed in accordance with the approved design approach provided in the mitigation plan for Sink Hole Creek.

Table 1. Project Mitigation Structure and Objectives Table
Sink Hole Creek Mitigation Project-NCDMS Project #92663

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Sink Hole Creek									
Reach 1	1,036 LF	R	PII	Cb/ Eb	1,032LF*	1.0:1	1,032*	0+13 to 11+23	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles. Total of 91' removed due to crossings.
Reach 2	1,062 LF	R	PII		1,073 LF	1.0:1	1,073	11+23 to 22+08	Pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles. Total of 12' removed due to crossings.
UT1									
Reach 1	1,145LF*	P			1,145 LF*	5.0:1	229*	-	Preservation reach-no adjustments made. No crossings.
Reach 2	489 LF	R	PII	B	478 LF*	1.0:1	478*	0+21* to 5+11*	Slight pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles. Total of 12' removed due to crossings.
UT 2									
Reach 1	579 LF	R	PI	Aa^+ / B	593 LF*	1.0:1	593*	0+21* to 6+30	Minor pattern adjustment, extensive improvements to dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via multiple grade control structures and constructed riffles. Total of 16' removed due to crossings.
Reach 2	879 LF	R	PI	B/A	881 LF*	1.0:1	881*	6+30 to 15+11*	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles. No crossings.
UT 3									
Reach 1	586 LF	R	PI	Aa^+ / B	641 LF	1.0:1	641	0+00 to 6+41	Minor pattern adjustment, extensive improvements to dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via multiple grade control structures and constructed riffles. No crossings.

Mitigation Unit Summations					
Stream (SMU)	Riparian Wetland (WMU)	Nonriparian Wetland (WMU)	Total Wetland (WMU)	Buffer (BMU)	Comment
4,927*	NA	NA	NA		
Notes: *Indicates data that has been modified from past reports.					

Anthropogenic land use alteration, such as channelization of streams for agricultural purposes, in the Sink Hole Creek watershed, has resulted in various stream corridor impairments. Incision, bank destabilization, erosion, and other ongoing stream processes typical of streams adjusting to modification, were found along various reaches of Sink Hole Creek and the unnamed tributaries within the project area.

In accordance with the approved mitigation plan for the site, construction activities began in May 2010. Project activity on Sink Hole Creek and UT1-Reach 2, consisted of making adjustments to channel dimension, pattern, and profile. A Priority II Restoration approach was used on these stream reaches to restore floodplain connectivity. In addition, some sinuosity was incorporated based on the valley shape and the channel profile was stabilized by creating a step-pool morphology using grade control structures, including constructed riffles. The dimension was improved by eliminating the presence of vertical banks, improving floodplain connectivity by the removal of manmade levies, and correcting prior channelization by making slight adjustments to channel pattern where feasible.

A Priority I Restoration approach was implemented on UT2 and UT3 to raise the channel bed elevation, create a more stable profile, adjust channel alignment and to re-establish a riparian buffer to stabilize the streambanks. Both channels required extensive work as both had been essentially reduced to functioning as severely incised ditches with vertical, eroding banks and an unstable profile that had been cut off from the surrounding floodplain and had multiple headcuts.

Throughout the project, providing vertical stability was the most important project objective to achieve channel stability, water quality, and habitat goals. In-stream structures (constructed riffles, boulder steps, log vanes, and log rollers) were used to control streambed grade, reduce stresses on streambanks, and promote diversity of bedform and habitat. Reach-wide grade control was provided by the aforementioned in-stream structures and by bedrock where present. Structures were spaced at a distance that resulted in the downstream header protecting the upstream footer to create a redundancy that will ensure long term vertical stability.

Stream dimensions were adjusted to eliminate vertical banks and erosion resulting from excessive shear stress and a lack of floodplain relief. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and live staking. Transplants will provide living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

1.3 Project History and Background

The chronology of the Sink Hole Creek mitigation project is presented in Table 2 while the contact information for designers, contractors and plant material suppliers is presented in Table 3. Relevant project background information is presented in Table 4. Total stream length across the project increased from approximately 5,707 LF to 5,779 LF (excluding easement breaks).

Table 2. Project Activity and Reporting History
Sink Hole Creek Mitigation Project-NCDMS Project #92663

Activity or Report	Data Collection Complete	Completion or Delivery
Restoration Plan		May 2009
Final Design-90%		June 2009
Construction		August 2010
Temporary S&E mix applied to entire project area		May-July 2010
Permanent seed mix applied to project site		August 2010
Installed Fencing along left easement line of UT2 (all of R1) and UT3		August 2010
Containerized and B&B plantings set out		April 2011
Flood Event		July 2010
Installation of crest gauges		January 2011
Installed Fencing along right easement line of UT3 and UT2-R2		April 2011
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	April 2011 (Vegetation Monitoring) November-December 2010 (Geomorphic Monitoring)	May 2011 (last of plantings completed in April)
Year 1 Monitoring	November 2011	April 2012
Year 2 Monitoring	January 2013	March 2013
Installed Fencing along right bank of UT1 and left bank of Sink Hole upstream of confluence with UT1.		July 2012
Year 3 Monitoring	November 2013	February 2014
Year 4 Monitoring	November 2014	December 2014
Supplemental Tree Planting		February 2015
Invasive Treatment		Late Summer 2015
Installed Fencing along left bank of UT1 and left bank of Sink Hole downstream of confluence with UT1.		Fall 2015
Year 5 Monitoring	October 2015	November 2015

Table 3. Project Contacts Table Sink Hole Creek Mitigation Project-NCDMS Project #92663	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.412.6100
Construction Contractor	
River Works, Inc.	6105 Chapel Hill Road, Greensboro, NC 27406 Contact: Bill Wright, Tel. 919.818.6686
Planting & Seeding Contractor	
River Works, Inc.	6105 Chapel Hill Road, Greensboro, NC 27406 Contact: George Morris, Tel. 919.818.6686
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Supplemental Container Trees	Southern Roots Tree Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.412.6100

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCDMS Project #92663	
Project County	Mitchell County, NC
Physiograhic Region	Blue Ridge
Ecoregion	Blue Ridge Mountains-Southern Crystalline Ridges and Mountains
Project River Basin	French Broad
USGS HUC for Project	6010108040010
NCDWR Sub-basin for Project	04-03-06
Within extent of DMS Watershed Plan?	In a TLW (French Broad River Basin Priorities Report-2009)
WRC Class	Cold Water
NCDWR classification	Sink Hole-C; Tr , UT1-n/a UT2-n/a, UT3-n/a
% of Project Easement Fenced or Demarcated	100%
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles)	
Sink Hole Creek Reach 1	.72 mi^2
Sink Hole Creek Reach 2	.84 mi^2
UT1Reach 1	.07 mi^2
UT1 Reach2	.09 mi^2
UT2 Reach 1	.02 mi^2

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCDMS Project #92663	
UT2 Reach 2	.08 mi^2
UT3	.02 mi^2
Stream Order	Sink Hole-2nd , UT1-1st, UT2-zero order, UT3-zero order
Restored Length	
Sink Hole Creek Reach 1	1,019 LF
Sink Hole Creek Reach 2	1,073 LF
UT1Reach 1	1,076 LF
UT1Reach 2	489 LF
UT2 Reach 1	596 LF
UT2 Reach 2	885 LF
UT3	641 LF
Perennial or Intermittent	Perennial except Reach 1 of UT1 (intermittent)
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	66%
Shrub	0.4%
Pasture/Crops	28%
Developed Open Space	6%
Drainage Impervious Cover Estimate (%)	<10%
NCDWR AU/Index #	7-2-56
303d Listed / Upstream of 303d Listed Segment	No/ No
Reasons for 303d Listing or Stressor	-
Total Acreage of Easement	9.46
Total Vegetated Acreage w/in Easement	n/a (Easement vegetated with exception of stream channel)
Total Planted Acreage within the Easement	~9.46 Acres
Rosgen Classification (Pre-existing)	
Sink Hole Creek Reach 1	Eb/Cb
Sink Hole Creek Reach 2	G/Eb
UT1 Reach2	Cb/B
UT2 Reach 1	Aa^+
UT2 Reach 2	A
UT3	A
Rosgen Classification of As-built	
Sink Hole Creek Reach 1	Cb,Eb
Sink Hole Creek Reach 2	Cb,Eb
UT1 Reach2	B
UT2 Reach 1	Aa+,B
UT2 Reach 2	A,B
UT3	Aa+,B

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCDMS Project #92663	
Valley Type	II
Valley Slope	.028-.03 (Sink Hole), .028 (UT1), .1-.055 (UT2), .1 (UT3)
Trout Waters Designation	Yes (Supporting Waters, Trib. to designated TW)
Species of Concern	No

1.4 Monitoring Plan View

The current conditions plan view (CCPV) depicts the monitoring features for the Sink Hole Creek Mitigation Project. The plan set also provides call outs at locations where stream and vegetation problem areas are present. Figure 2 illustrates the project as it is delineated by reach.

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- FENCE
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET (NO PLOTS CURRENTLY MEETING THIS CRITERIA)
- STREAM PROBLEM AREAS
- VEGETATION PROBLEM AREAS

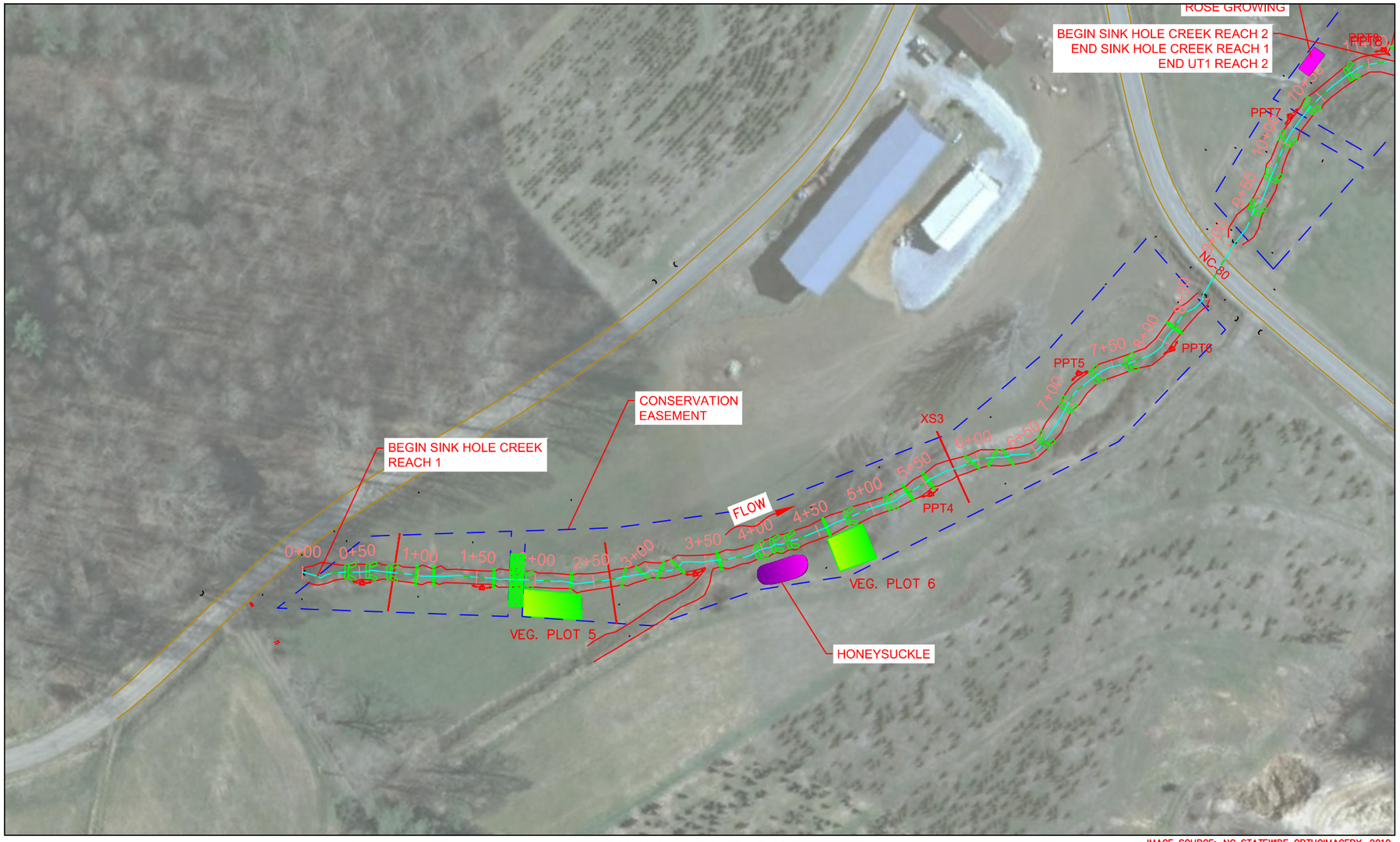
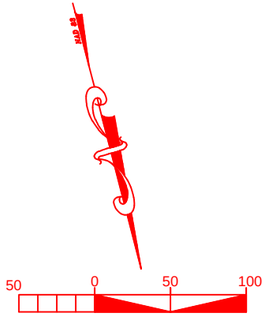


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

SINK HOLE CREEK
CURRENT CONDITION PLAN VIEW
YEAR 5 MONITORING



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SINK HOLE CREEK RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION PLAN VIEW
YEAR 5 MONITORING

NORTH CAROLINE DIVISION OF MITIGATION SERVICES

Prepared for:
Division of Mitigation Services
217 West Jones St. Suite 3000A
Raleigh, NC 27603
Phone 919-707-8976
Fax 828-232-4420

DMS Project No. 92663
Baker Project No. 111084
Date: 11/09/2015
DESIGNED: MDR
DRAWN: MMC
APPROVED: MMC
Monitoring Year: 5 of 5
Sheet: 1 of 4

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- FENCE
- CROSS SECTION
- PHOTO POINT

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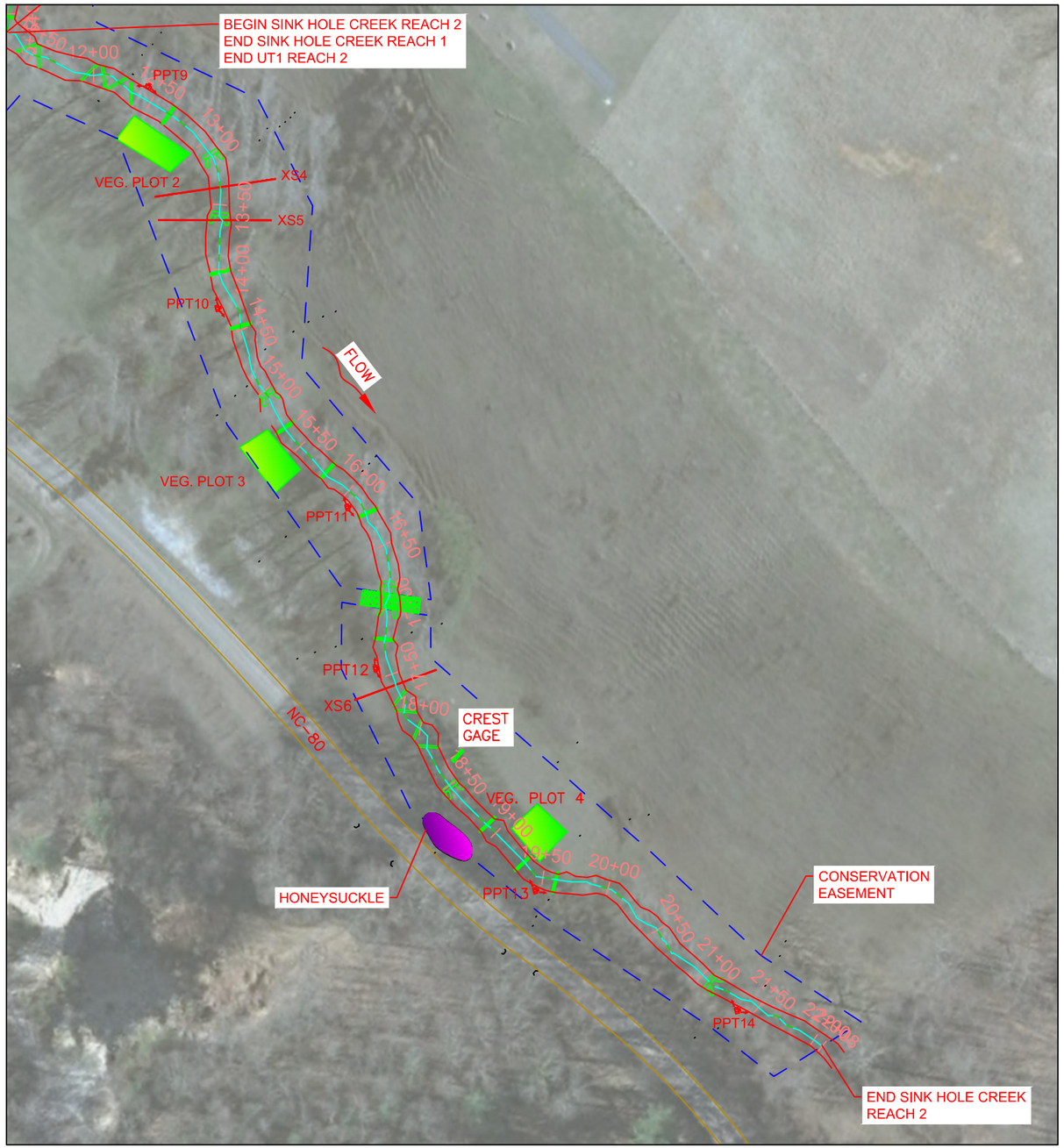

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

SINK HOLE CREEK
CURRENT CONDITION PLAN VIEW
YEAR 5 MONITORING

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MITCHELL COUNTY, NORTH CAROLINA
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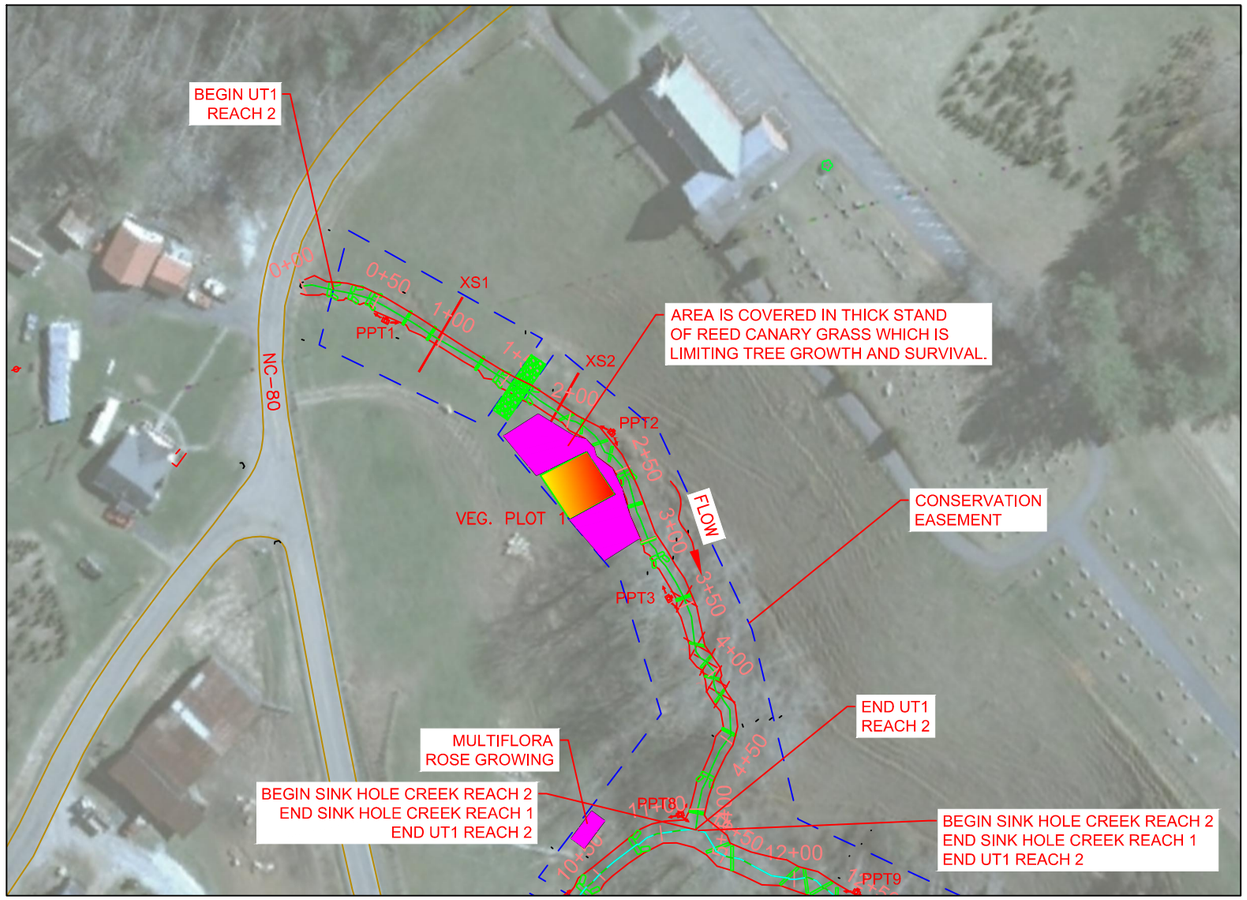

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

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50 0 50 100

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MITCHELL COUNTY, NORTH CAROLINA

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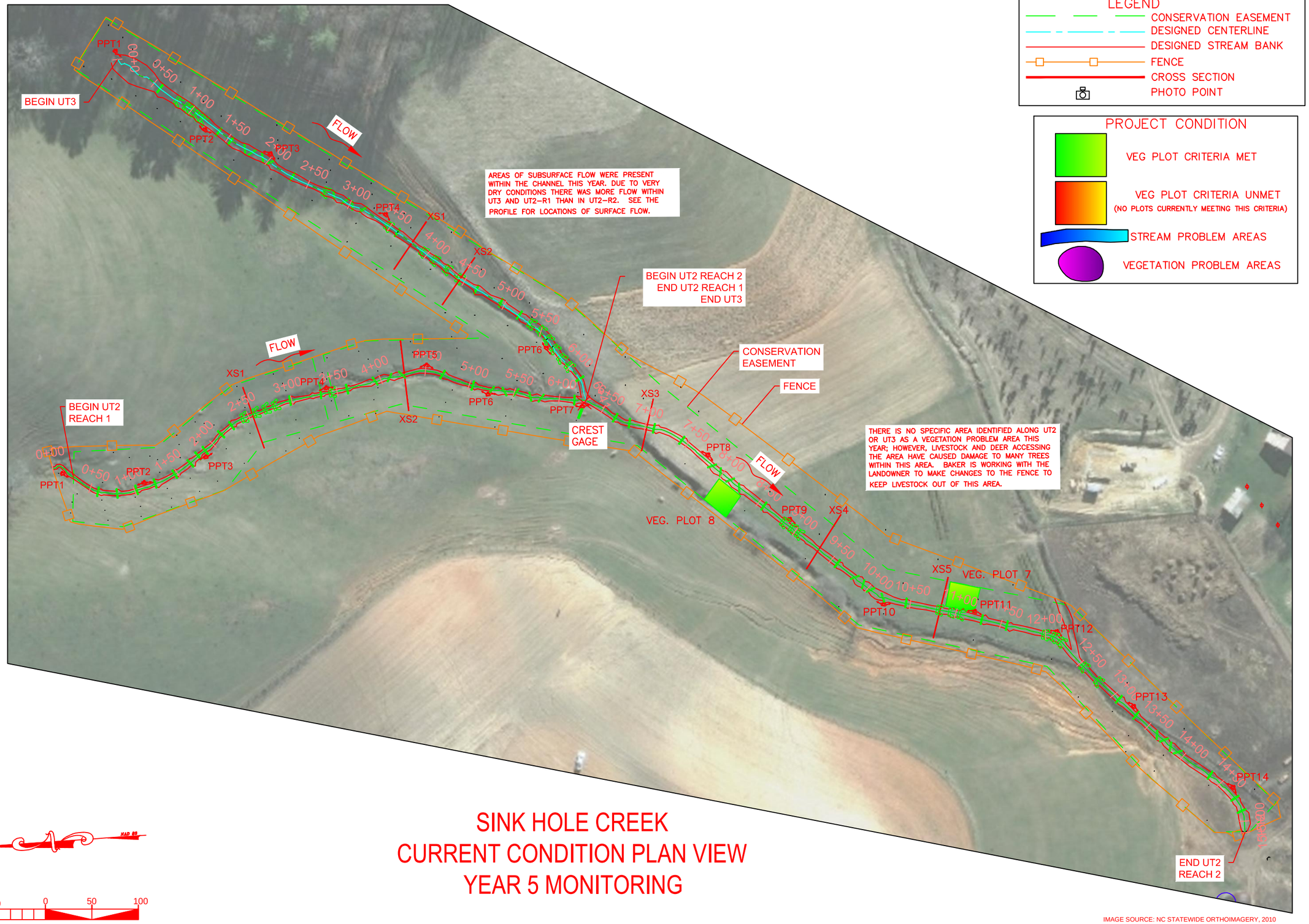

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- VEGETATION PROBLEM AREAS

NAD 83

50 0 50 100

SINK HOLE CREEK
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YEAR 5 MONITORING

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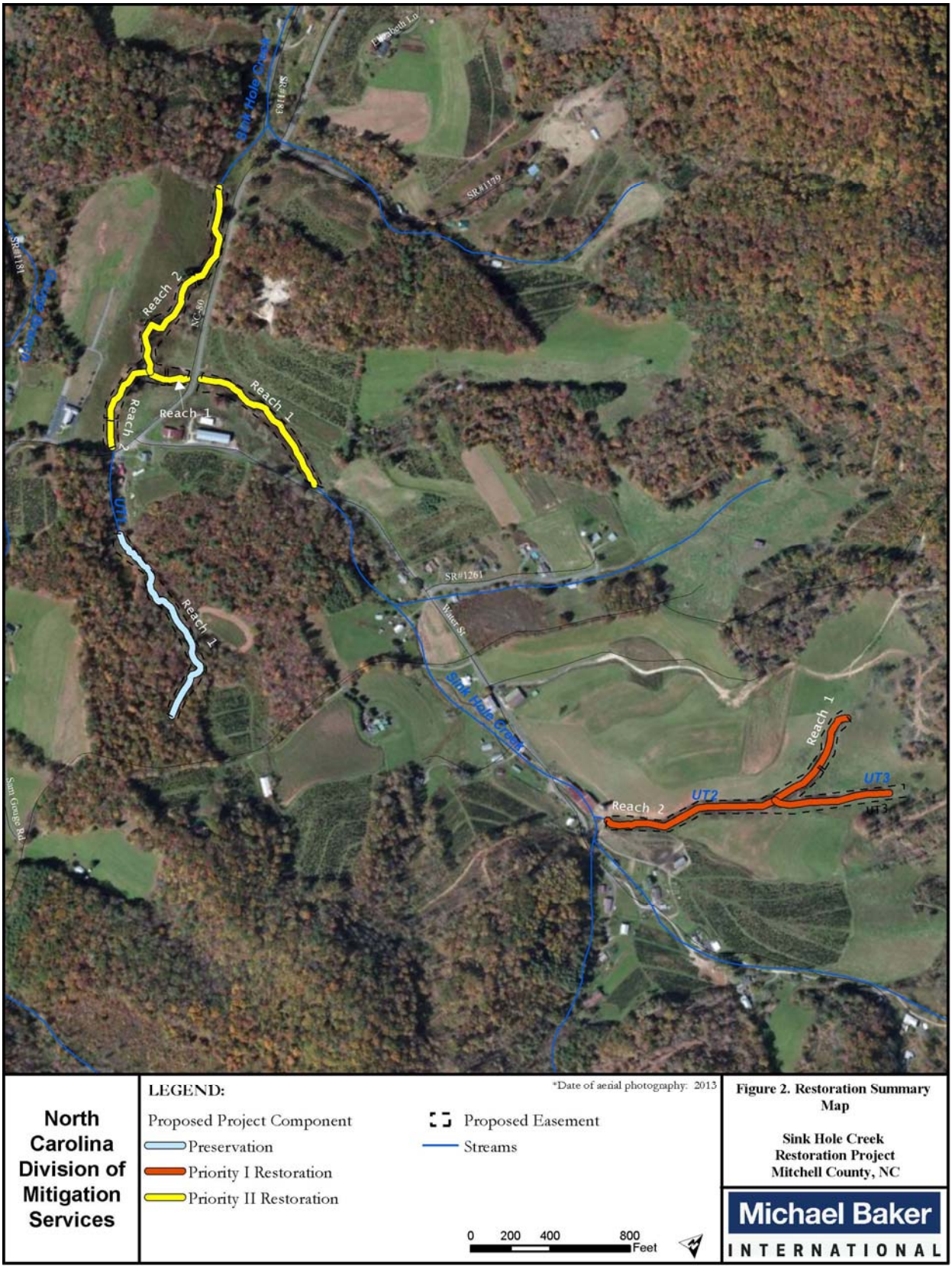
Sink Hole Creek
SR#1179
SR#1181
NC 80
Reach 2
Reach 1
Reach 1
Reach 2
UT1
Reach 1
SR#1261
Water St
Sink Hole Creek
Sam Gouge Rd
Reach 1
UT3
UT2
Reach 2
UT3
LEGEND:
*Date of aerial photography: 2013
Proposed Project Component
Preservation
Priority I Restoration
Priority II Restoration
Proposed Easement
Streams
0 200 400 800
Feet
North Carolina Division of Mitigation Services
Figure 2. Restoration Summary Map
Sink Hole Creek Restoration Project
Mitchell County, NC
Michael Baker
INTERNATIONAL

2.0 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the Sink Hole Creek mitigation project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, reference photo stations and crest gauges are shown on the Year 5 CCPV submitted with this report.

2.1 Vegetation Assessment

2.1.1 Vegetation

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria have been met, eight (8) vegetation monitoring quadrants (veg plots) were installed across the restoration site. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Level 1 CVS vegetation monitoring will occur in the fall prior to leaf fall, if possible. At the end of the first growing season, during baseline surveys, species composition, density, and survival were evaluated. Individual quadrant data, collected during subsequent monitoring events, included diameter (>130cm), height, density, and coverage quantities. Individual trees were marked to ensure that they could be found in succeeding monitoring years. Mortality was determined from the difference between the previous year's living, planted trees and the current year's living, planted trees.

Photographs were used to visually document vegetation success in sample plots. Reference photos of tree and herbaceous condition within plots have been taken at least once per year. Photos of the plots are included in Appendix A of this report.

The interim measure of vegetative success for the site is the survival of at least 320, planted trees per acre at the end of the Year 3 monitoring period. The final vegetative success criteria is the survival of 260 planted trees per acre at the Year 5 monitoring period. Both of these objectives have been met.

Live stakes and bare root trees planted at the site are flourishing and will increasingly contribute to streambank stability and shading of the stream. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A minimum 30-foot buffer was established along all restored stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in a grid pattern. Planting of bare-root trees was completed in the winter of 2010-2011. Species planted are listed below in Table 5.

Table 5. Riparian Buffer Plantings per Acre
Sink Hole Creek Mitigation Project-NCDMS Project #92663

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Riparian Buffer Plantings				
Trees Overstory				
Red Maple	*Acer rubrum*	2%	100	FAC
River Birch	*Betula nigra*	2%	100	FACW
Shagbark hickory	*Carya ovata*	4%	200	FACU
Persimmon	*Diospyros virginiana*	4%	200	FAC
Black walnut	*Juglans nigra*	2%	100	FACU
Tulip Poplar	*Liriodendron tulipifera*	4%	200	FAC
Sycamore	*Platanus occidentalis*	2%	100	FACW-
Black cherry	*Prunus serotina*	4%	200	FACU
White Oak	*Quercus alba*	6%	300	FACU
Swamp chestnut oak	*Quercus michauxii*	2%	100	FACW
Northern Red Oak	*Quercus rubra*	4%	200	FACU
Trees Understory				
Tag Alder	*Alnus serrulata*	2%	100	OBL
Pawpaw	*Asimina triloba*	4%	200	FAC
Ironwood	*Carpinus caroliniana*	6%	300	FAC
Redbud	*Cercis canadensis*	6%	300	FACU
Flowering Dogwood	*Cornus florida*	8%	400	FACU
Hazelnut	*Corylus americana*	1%	50	FACU
Witch Hazel	*Hamamelis virginiana*	8%	400	FACU
Shrubs				
Sweet shrub	*Calycanthus floridus*	6%	300	FACU
Silky Dogwood	*Cornus amomum*	2%	100	FACW
Winterberry	*Ilex verticillata*	1%	50	FACW
Rhododendron	*Rhododendron maximum*	4%	200	FAC-
Elderberry	*Sambucus canadensis*	4%	200	FAC
Highbush Blueberry	*Vaccinium sp*	4%	200	FACU
Possomhaw viburnium	*viburnum prunifolium*	4%	200	FACU
Riparian Livestake Plantings*				
Ninebark	*Physocarpus opulifolius*	10%		FAC-
Elderberry	*Sambucus canadensis*	20%		FACW-
Black Willow	*Salix nigra*	10% or less		OBL
Silky Willow	*Salix sericea*	35%		OBL

Table 5. Riparian Buffer Plantings per Acre
Sink Hole Creek Mitigation Project-NCDMS Project #92663

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Silky Dogwood	*Cornus amomum*	25%		FACW+
* Total numbers of livestakes was not recorded by the planter.				

Table 5a. Supplemental Riparian Buffer Plantings added in February 2015
Sink Hole Mitigation Project- NCDMS Project #92663

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Riparian Buffer Plantings				
Trees				
River Birch	*Betula nigra*	19%	100	FACW
Red Maple	*Acer rubrum*	19%	100	FAC
Shrubs				
Tag Alder	*Alnus serrulata*	36%	190	OBL
Button Bush	*Cephalanthus occidentalis*	7%	40	FAC
Hazelnut	*Corylus americana*	19%	100	FACU
Riparian Livestake Plantings				
Silky Dogwood	*Cornus amomum*	20%	100	FACW+
Black Willow	*Salix nigra*	40%	200	OBL
Silky Willow	*Salix sericea*	40%	200	OBL
An additional 25, 3 Gal containerized trees were planted at this time but specific species were not noted. There would have been 3-4 each from a mix of River Birch, Red Maple, Sycamore, Green Ash, White Oak, Persimmon, American Elm or American hornbeam planted randomly at the site.				

2.1.2 Soil Data

Table 6. Preliminary Soil Data
Sink Hole Creek Mitigation Project-NCDMS Project #92663

Dominant Soil Series and Characteristics	Bandana/ Dillsboro/Saunook-Thunder/Dellwood-Reddies				
	Depth (in.)	% Clay	K Factor	T Factor	% OM
Sink Hole Creek Reach 1	>80”	10-20	.15	4	4-10%
Sink Hole Creek Reach 2	>80”	10-20	.15	4	4-10%
UT1Reach 1	~87”	27-35	.1	5	4-10%
UT1 Reach2	>80”	10-20	.15	4	4-8%
UT2 Reach 1	>80”	7-20/ 15-28	.05/.02	5	4-10%/ 6-14%
UT2 Reach 2	>80”	5-15/ 5-18	.05	3	4-8%
UT3	>80”	7-20/ 15-28	.05/.02	5	4-10%/ 6-14%

2.1.3 Vegetative Problem Areas

There are three areas within the conservation easement where invasive species have encroached. There are two areas of thick honeysuckle growth. One area is on Sink Hole Creek Reach 1 near vegetation plot 6 and another is on Sink Hole Creek Reach 2 near vegetation plot 4 and next to NC 80. These areas of honeysuckle were treated in 2015 and will be again in spring 2016. On Sink Hole Creek Reach 1 below the lower crossing on the left bank area is a thick growth of multiflora rose. It is present in mass at this one spot and there are individual plants scattered along the fence and within in the easement. These invasives were treated in the fall of 2015 and will be treated again in spring 2016. Additionally, there is an area of concern around Veg. Plot 1 where reed canary grass is thick and may be limiting tree survival and growth. In past years there were areas of concern identified near an old mine shaft opening on the mainstem of Sink Hole Creek and along UT2-R2 where ground water was causing extremely wet conditions that was limiting woody stem growth. This was not a problem this year due primarily to dry weather and on the mainstem, the landowner removed debris that was causing the mineshaft to flood out across the floodplain. This allowed flow from the mine to enter the stream directly at one point on the stream bank, limiting the wet area.

2.1.4 Stem Counts

The mitigation plan for the Sink Hole Creek Site specifies that the number of quadrants required will be based on the species/area curve method, as described in NCDMS monitoring guidance documents (Lee et. al. 2007). The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of eight vegetation plots, each 10 by 10 meters or 5 by 20 meters in size, were established across the restored site.

2.1.4.1 Results

Table 7 and 7b in Appendix A present information on the stem counts for each of the vegetation monitoring plots over the five monitoring years. Data from the Year 5 monitoring event showed a range of 324 to 809 planted stems per acre, with approximately 92.2% of the stems showing no signs of damage. The average density of planted bare root stems, based on data collected from the eight monitoring plots during Year 5 monitoring, is 531 stems per acre. This indicates that the Site has meet the interim success criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the CCPV. This average density has increased since last year when the average density was 460 trees per acre. This increase reflects the supplemental plantings that were done in February of 2015 and are shown in Table 5a. During this final year of monitoring we also estimated the number of volunteer trees growing in veg plots. Volunteers were observed in 3 out of the 8 veg plots and there estimated density varied from a low of 202 to a high of 2,550 stems per acre in plots where they were found. When volunteer stems are included in the estimate for the site it increases to 991 stems per acre. The presence of volunteers in plots depends on having a close seed source, so volunteers are more common along the lower mainstem where there are existing trees and almost absent from UT2 and UT3 where a close seed source is absent.

As shown in Table 8 (Appendix A), there are three small areas where invasive species have been identified and an area where thick herbaceous growth is limiting tree survival. Although the density of herbaceous cover varies across the site, conditions observed on-site during the Year 5 monitoring survey found ground cover in the easement area to be extensive and certainly sufficient for providing site stabilization and in some locations is very thick. Survival rates of planted woody stems in the vegetation plots indicate that plantings across the easement area are of sufficient density to meet regulatory requirements, as well as site stabilization and habitat enhancement goals originally set forth in the mitigation plan. A photo log of the vegetation plots is provided in Appendix A.

2.2 Stream Assessment

2.2.1 Morphologic Parameters and Channel Stability

Geomorphic monitoring of restored stream reaches has been conducted over a five-year period to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include channel dimension (cross-sections), profile (longitudinal survey), pattern (to a lesser degree for reasons noted below), bed composition, bank stability, bankfull flows, and stability of reference sites documented by photographs. Crest gauges, as well as high flow marks (wrack lines, laid over vegetation, etc.) will be used to document the occurrence of bankfull events. The methods used and any related success criteria are described below for each parameter. To monitor stream success criteria, fifteen permanent cross-sections, four longitudinal profile sections and two crest gauges were installed. Detailed channel morphology was surveyed with a total station and survey data is georeferenced.

2.2.1.1 Dimension

Fifteen permanent cross-sections were installed to help evaluate the success of the mitigation project. Permanent cross-sections were established throughout the project site as follows: six cross-sections were located on Sink Hole Creek, two cross-sections were located on both UT1 and UT3 and five cross-sections were located on UT2. Cross-sections selected for monitoring were located in representative riffle and pool reaches and each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark is used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys include points measured at breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if these features are present. Riffle cross-sections are classified using the Rosgen Stream Classification System.

There should be little change in the 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).

2.2.1.1.1 Results

Baseline cross-section monitoring data for stream stability was collected in November and December 2010. The fifteen permanent cross-sections along the restored channels were re-surveyed in October 2015 to document stream dimension for Monitoring Year 5. Cross-sectional data is presented in Appendix B and the location of cross-sections is shown on the CCPV submitted with this report.

The cross-sections show that there has been little to no adjustment in stream dimension across the project reaches since construction. What adjustment has occurred has primarily been observed in riffle cross-sections that are exhibiting signs of narrowing or pools that have gotten slightly deeper. Based on field observation, this narrowing of riffles can be attributed to herbaceous vegetation that has become well established. High stream flows over the last two years has caused pools to deepen as an adjustment to higher energy dissipation. At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.2.1.2 Pattern and Longitudinal Profile

Longitudinal profiles for Year 5 were surveyed during October 2015; profiles of the various project reaches are provided in Appendix B. A longitudinal profile was conducted for the entire project length on Sink Hole Creek, UT2, UT3 and Reach 2 of UT1. Longitudinal profiles have been replicated annually during the five-year monitoring period.

Measurements taken along longitudinal profiles include thalweg, water surface, and the top of low bank. The pools should remain relatively deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type. Profile data collected reflect stable channel bedform and a diverse range of riffle and pool complexes.

All measurements were taken at the head of each feature (e.g., riffle, run, pool and glide) and the maximum pool depth. Elevations of grade control structures were also included in the longitudinal profiles surveyed. Surveys were tied to a permanent benchmark. Although pattern adjustments were made on each reach for channel alignment considerations such as following the low point of the valley, pattern adjustments were not made with the intent to increase sinuosity. Sink Hole Creek and its tributaries are A and B-type streams primarily characterized by step-pool sequences. Consequently, pattern information is not provided in Appendix B as these parameters are generally associated with meandering, riffle-pool type channels. However, as the site is monitored, reaches will be evaluated for significant changes in pattern.

2.2.1.2.1 Results

The longitudinal profiles show that the bed features are also stable across the project site. As noted in the Stream Reach Morphology Data Tables in Appendix B (Tables 13 and 14), riffle and pool characteristics do not appear to have changed much and are acceptable when compared to reference reach and design data provided for each of the project reaches. Given the location of these project reaches in the valley and the spacing of structures in these streams, there has been little change in the profiles over the course of the monitoring period.

The Year 5 longitudinal profiles for UT2 and UT3 also do not appear to have changed much since the previous monitoring year. Adjustments that have occurred have been minor in nature, and have not resulted in a loss of structures. Both herbaceous and woody vegetation have grown in well on these tributaries, including the steeper reaches of UT2 Reach 1 and UT3. Closely spaced grade control structures have also helped maintain the overall profile desired. No notable channel profile adjustments or bank erosion were observed.

Although no areas of instability were noted in the project area during Year 5 monitoring, there are intermittent areas on UT2 and UT3 where flow was subsurface. This was not unexpected given that stable Aa+ to B-type streams tend to have short sections where flow periodically goes subsurface. Unnamed tributary 2 and UT3 are both Aa+ to B-type channels as they drain toward Sink Hole Creek. The stationing at which the stream goes subsurface is shown on profiles. Mitchell County like many other North Carolina counties, suffered extremely dry conditions during the summer and fall. This caused a lowering of the ground water elevation, which caused subsurface flow at some locations along these reaches. We believe this to be a short-term, episodic type occurrence and normal for these type channels.

2.2.1.3 Substrate and Sediment Transport

Bed material analysis consisted of pebble counts being taken in the same constructed riffle each year during annual geomorphic surveys of the project site. These samples, combined with evidence provided by changes in cross-sectional and profile data will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

2.2.1.3.1 Results

For this project, a pebble count was collected on Reaches 1 and 2 of Sink Hole Creek. As noted in pebble count exhibits in Appendix B, the pebble count for Reach 1 of Sink Hole indicates a re-coarsening bedload; however, the opposite was seen for the pebble count taken in Reach 2. Visual observations of Sink Hole Creek and its tributaries and a review of pebble count data collected did

not yield any signs that sediment transport functions have been hampered by the mitigation project; specifically, no significant areas of aggradation or degradation within the project area were observed during the Year 5 monitoring survey. The landowner installed livestock fencing along the conservation easement in the area where the Reach 2 pebble count was taken. This activity and the moving of materials over a crossing just upstream may have contributed fines to the reach and resulted in a temporary decrease in bed particle size in that immediate area.

2.2.2 Hydrology

2.2.2.1 Streams

The occurrence of bankfull events within the monitoring period is being documented by the use of crest gauges and photographs. Crest gauges were installed on the floodplain to measure flows at or above the bankfull elevation. One crest gauge was placed near the confluence of UT2 and UT3, while another gauge was set up near the end of the project area on Reach 2 of Sink Hole Creek. The crest gauges record the highest water level between site visits and are checked during each site visit to determine if a bankfull or higher flow event has occurred. Photographs are used to document the occurrence of debris lines and sediment deposition on the floodplain.

Two bankfull flow events must be documented on each crest gauge within the 5-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.

2.2.2.1.1 Results

During the Year 5 monitoring period, the site was found to have had at least one bankfull event based on crest gauge readings obtained on UT2 and Reach 2 of Sink Hole Creek. Information on these events is provided in Table 9 of Appendix B. At this point, multiple bankfull events have been documented at both crest gauges within multiple years and this success criterion has been met.

2.2.3 Photographic Documentation of Site

Photographs will be used to document restoration success visually. Reference stations were photographed during the as-built survey and this was repeated over the last five years. Reference photos are taken once a year, from a height of approximately five to six feet. Permanent markers will ensure that the same locations (and view directions) are utilized during each monitoring period. Selected site photographs are shown in Appendix B.

2.2.3.1 Lateral Reference Photos

Reference photo transects were taken of the right and left banks at each permanent cross-section. A survey tape was captured in most photographs, which represents the cross-section line located perpendicular to the channel flow. The water line was located in the lower edge of the frame in order to document bank and riparian conditions. Photographers have made an effort to consistently maintain the same area in each photo over time.

2.2.3.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored streams are included within the photographs taken at reference photo stations. Photographers have made every effort to consistently maintain the same area in each photo over time.

Lateral and structure photographs are used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and a subjective judgment of the effectiveness of erosion control measure. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

Photographs of the restoration project were taken in November 2015. The photographs illustrate stable conditions across the project site. Vegetative growth along the streambanks and riparian buffers has become dense and improved since construction was completed in 2010. Structures are functioning as designed.

2.2.4 Stream Stability Assessment

In-stream structures installed within the restored streams included constructed riffles, log drops, log sequences, and boulder steps. The Year 5 visual observations of these structures indicate that little or no changes have occurred since the baseline survey was performed; structures are functioning as designed and are holding their elevation and grade. In the area of subsurface flow the structures are functioning properly however flow is minimal and drops below the surface to resurface downstream. UT2 and UT3 are headwater tributaries that receive minimal flow relative to channel size from two springs at the upstream limit of the project reaches.

Frequent spacing of log drops, log sequences and boulder drops have greatly enhanced bedform diversity as well as promoting more stable A and B-type channels. The Categorical Stream Feature Visual Stability Assessment and Visual Morphological Stability Assessment tables in Appendix B (Tables 11 and 12), summarize the condition of project structures.

Quantitative reference reach and design data used to determine the restoration approach, as built data, as well as Year 5 monitoring data are summarized in Tables 13 and 14 of Appendix B.

2.3 Areas of Concern

At this time, no areas of concern were noted in the project reaches. The linear feet and locations of subsurface flow observed in Monitoring Year 5 have changed in comparison to other Monitoring Years; at this time, no actions are proposed.

3.0 REFERENCES

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

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APPENDIX A

VEGETATION RAW DATA

1. VEGETATION SURVEY DATA TABLES
2. VEGETATION MONITORING PLOT PHOTOS

Table 7. Stem Count Arranged by Plot - Year 5
Project Name: Sink Hole Creek Mitigation Project, DMS Project Code 92663.

			Current Plot Data (MY5 2015)																									Annual Means														
			E92663-01-0001			E92663-01-0002			E92663-01-0003			E92663-01-0004			E92663-01-0005			E92663-01-0006			E92663-01-0007			E92663-01-0008			MY5 (2015)			MY4 (2014)			MY3 (2013)			MY2 (2012)			MY0 (2011)		
Scientific Name	Common Name	Species Type	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T
Acer rubrum	red maple	Tree	1		1	5	1	6	2		2		3	3									1		1	2		2	11	11	15	3		3	5		5	5		5	7		7
Acer saccharum	sugar maple	Tree				1		1																			1	1	1	1		1	1		1	1		1	1		1
Alnus serrulata	hazel alder		1		1	4		4										2		2	1		1	3		3	11		11	13		13	9		9	11		11	10		10
Alnus serrulata	hazel alder		1		1	1		1	1		1	3		3				1		1	1		1				8		8												
Asimina triloba	pawpaw	Tree																						1		1	1		1	1		1	5		5	5		5	5		5
Betula alleghaniensis	yellow birch	Tree	4		4																						4		4	4		4	4		4	6		6	6		6
Betula lenta	sweet birch	Tree				2		2	1		1	1		1				1		1							5		5	5		5	4		4	5		5	5		5
Betula nigra	river birch	Tree				2		2				5		5	2		2							2		2	11		11	14		14	16		16	19		19	19		19
Carpinus caroliniana	American hornbeam	Tree								15	15																	15	15												
Carya alba	mockernut hickory	Tree							1		1																1		1	3		3	5		5	7		7	5		5
Cercis canadensis	eastern redbud	Tree							1		1				3		3				2		2				6		6	8		8	12		12	15		15	19		19
Cornus amomum	silky dogwood	Shrub																						1		1	1		1	1		1									
Cornus florida	flowering dogwood	Tree				1		1	1		1				1		1										3		3	3		3	2		2	3		3	3		3
Elaeagnus umbellata	autumn olive	Exotic							1	1	2																1	1	2												
Itea virginica	Virginia sweetspire	Shrub																																					1		1
Lindera benzoin	northern spicebush	Shrub							1		1				1		1										2		2	2		2	4		4	5		5	5		5
Liriodendron tulipifera	tuliptree	Tree					10	10	1	30	31	3	2	5													4	42	46	4		4	5		5	7		7	8		8
Malus	apple	Tree								1	1																	1	1												
Oxydendrum arboreum	sourwood	Tree					12	12		15	15																	27	27												
Physocarpus opulifolius	common ninebark	Shrub																																					1		1	1		1
Pinus	pine	Tree								1	1																	1	1												
Platanus occidentalis	American sycamore	Tree				1		1							1		1	3		3				2		2	7		7	7		7	7		7	7		7	7		7
Quercus alba	white oak	Tree																																					1		1	1		1
Quercus muehlenbergii	chinkapin oak	Tree				1		1																			1		1	1		1	1		1	1		1	1		1
Quercus rubra	northern red oak	Tree	1		1				2		2	2		2	2		2	3		3	2		2				12		12	14		14	17		17	20		20	20		20
Salix nigra	black willow	Tree																1		1							1		1	1		1	1		1	1		1	1		1
Unknown						2		2													1		1	1		1	4		4												
Vaccinium	blueberry	Shrub							2		2																2		2												
Vaccinium stamineum	deerberry	Shrub													2		2										2		2	2		2	2		2	3		3	3		3
Viburnum	viburnum	shrub							1		1	1		1													2		2												
Viburnum prunifolium	blackhaw	shrub										1		1	2		2	1		1							4		4	4		4	3		3	5		5	5		5
	Stem count		8	0	8	20	23	43	15	63	78	16	5	21	14	0	14	12	0	12	8	0	8	12	0	12	105	99	196	91	0	91	103	0	103	128	0	128	133	0	133
	size (ares)		1			1			1			1			1			1			1			1			8			8			8			8			8		
	size (ACRES)		0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.20			0.20			0.20			0.20			0.20		
	Species count		5	0	5	10	3	12	12	6	16	7	2	8	8	0	8	7	0	7	6	0	6	7	0	7	24	8	28	19	0	19	18	0	18	20	0	20	21	0	21
	Stems per ACRE		324	0	324	809	931	1740	607	2550	3157	647	202	850	567	0	567	486	0	486	324	0	324	486	0	486	531	501	991	460	0	460	521	0	521	647	0	647	673	0	673

P = Planted
V = Volunteer
T = Total

Exceeds requirements by 10%
Includes volunteer stems

Table 7b Stem Count

Table 8. Vegetation Problem Areas
Sink Hole Creek Mitigation Project, NCDMS Project No. 92663

Sink Hole Reach 1 (1,019 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	4+00 to 4+25 10+50 to 10+75	Honeysuckle on right flood plain. Multiflora rose growing in this area.	N/A
Sink Hole Reach 2 (1,073 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	18+50 to 19+00	Honeysuckle on right flood plain near road.	N/A
UT1 Reach 2 (489 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	1+50 to 3+00	Reed Canary Grass is so thick that it is affecting tree growth and survival.	N/A
UT2 Reach 1 (596 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A
UT2 Reach 2 (885 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A
UT3 (641 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other - deer horning/breaking trees	all along this reach	deer rut	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A

Sink Hole Creek Mitigation Project
Photo Log – Vegetation Plot Photo Points (Year 5)

Notes: Photos for Sink Hole Site vegetation plots were taken October 21, 2015 (except VP1 was taken on 11/29/15).

1. Vegetation plots marked by t-posts at corners; herbaceous plot marked by stake within larger plot.
2. Planted vegetation flagged and tagged for future identification.

Photo 1: Veg. Plot 1

Photo 2: Veg Plot 1, Herbaceous Plot

Photo 3: Veg Plot 2

Photo 4: Veg Plot 2: Herbaceous Plot

Photo 5: Veg Plot 3

Photo 6: Veg Plot 3: Herbaceous Plot

Photo 7: Veg Plot 4

Photo 8: Veg Plot 4: Herbaceous Plot

Photo 9: Veg Plot 5

Photo 10: Veg Plot 5: Herbaceous Plot

Photo 11: Veg Plot 6

Photo 12: Veg Plot 6: Herbaceous Plot

Photo 13: Veg Plot 7

Photo 14: Veg Plot 7: Herbaceous Plot

Photo 15: Veg Plot 8

Photo 16: Veg Plot 8: Herbaceous Plot

APPENDIX B

1. HYDROLOGICAL (BANKFULL) VERIFICATIONS (TABLE 9)
2. STREAM PROBLEM AREAS (TABLE 10)
3. CROSS-SECTION PLOTS WITH ANNUAL OVERLAYS
4. LONGITUDINAL PROFILES WITH ANNUAL OVERLAYS
5. CATEGORICAL STREAM FEATURE VISUAL STABILITY ASSESSMENT (TABLE 11)
6. VISUAL MORPHOLOGICAL STABILITY ASSESSMENT (TABLE 12)
7. STREAM REACH MORPHOLOGY AND HYDRAULIC DATA (TABLE 13)
8. CROSS-SECTION MORPHOLOGY AND HYDRAULIC DATA (TABLE 14)
9. RIFFLE PEBBLE COUNT SIZE CLASS DISTRIBUTIONS
10. STREAM REFERENCE STATION PHOTO LOGS

Table 9. Verification of Bankfull or Greater than Bankfull Events
Sink Hole Creek Restoration Project-#92663

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (inches)*	
			Sink Hole Cr. Reach 2	UT2 Reach 1
11/4/2011	Between 6/29/11 and 11/04/11	Gauge measurement.	1.97	-
11/4/2011	Between 6/29/11 and 11/04/11	Gauge measurement.	7.48	1.8
11/6/2012	Between 11/04/11 and 11/6/12	Gauge measurement	2.70, 8.25	-
12/19/2012	Between 11/04/11 and 12/19/12	Gauge measurement	-	1.44
11/15/2013	Between 11/16/12 and 11/15/13	Gauge measurement	1.5	.8, 1.9
11/10/2014	Between 11/15/13 and 11/10/14	Gauge measurement	13.75	5.25
10/21/2015	Between 11/10/14 and 10/21/15	Gauge measurement	6.24 in	17 in

* height indicates the highest position of cork shavings on the dowel.

Photo1. Silver Creek crest gauge staff showing cork deposition in red circle at .52 ft above the bottom of the staff, which is at the bankfull elevation.

Photo 2. UT2 crest gauge staff showing cork deposition in red circle at 1.42 ft above the bottom of the staff, which is at the bankfull elevation.

Table 10. Stream Problem Areas
Sink Hole Creek Mitigation Project, NCDMS Project No. 92663

Sink Hole Creek and Uts			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
N/A	N/A	N/A	N/A

Notes:

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		22.3	14.35	1.56	3.28	9.21	1	4.6	2595.11	2595.13

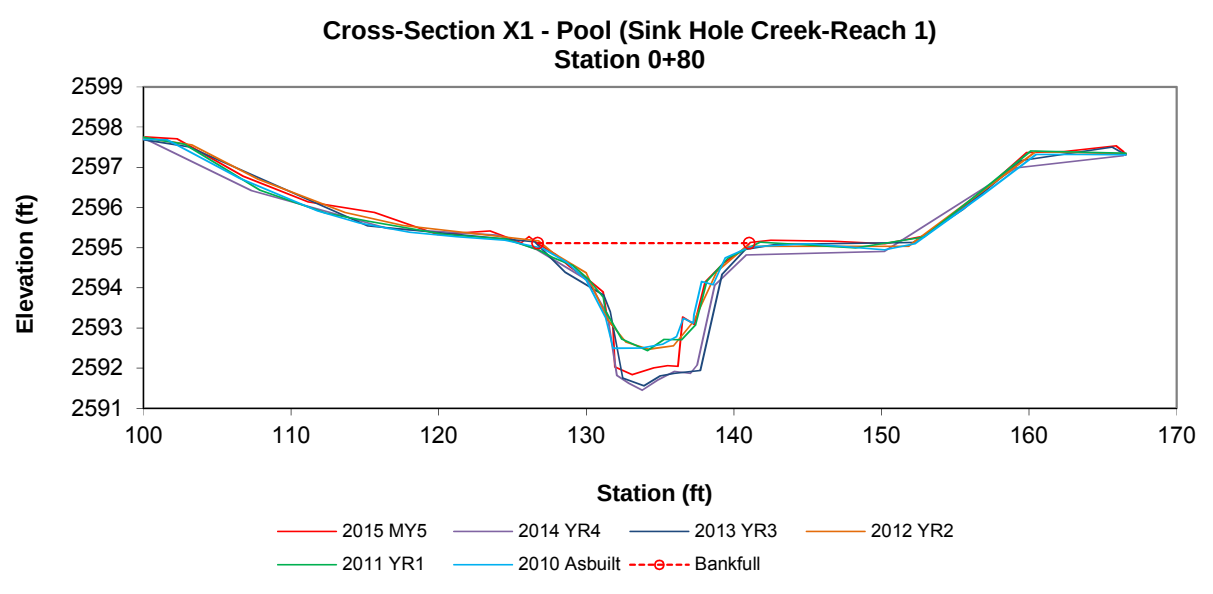


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	5.8	12.76	0.45	1.7	28.18	1	5.4	2590.2	2590.2

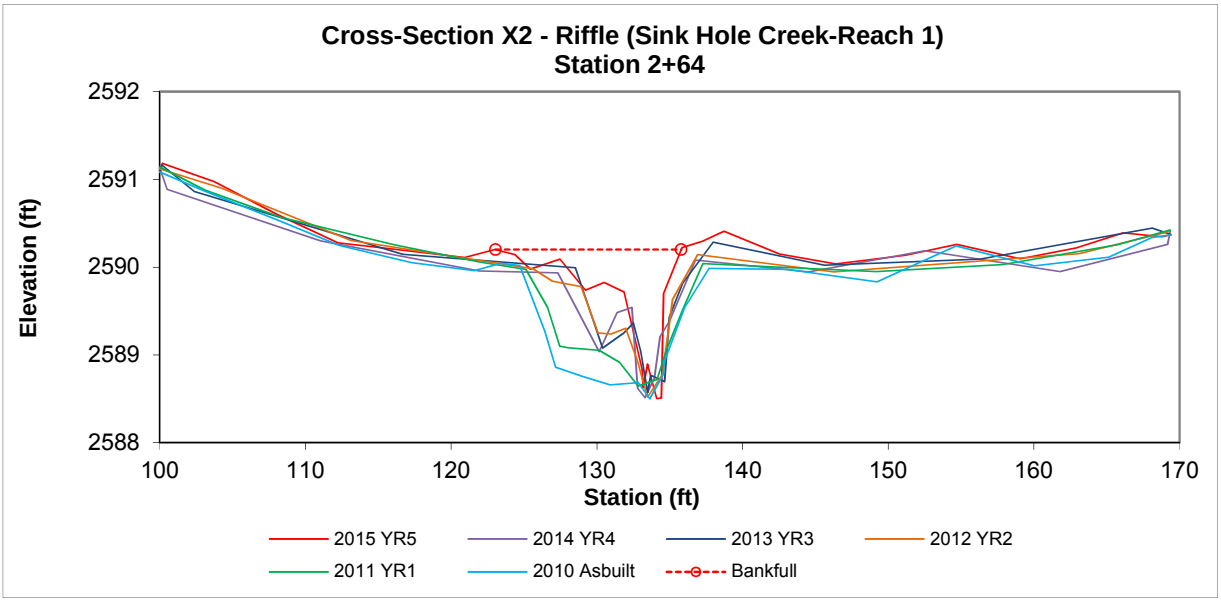


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	15	13.76	1.09	1.84	12.6	1	4.2	2580.7	2580.71

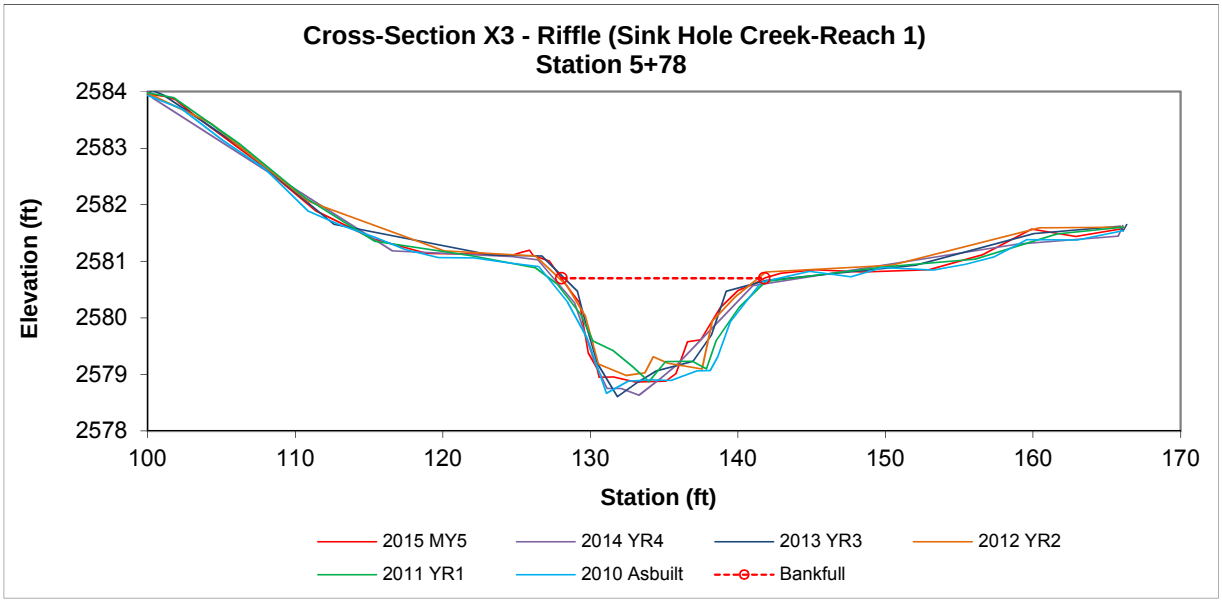


Photo 5: XS-3 facing right bank

Photo 6: XS-3 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		10.5	9.64	1.09	2.28	8.86	1	8.9	2562.41	2562.42

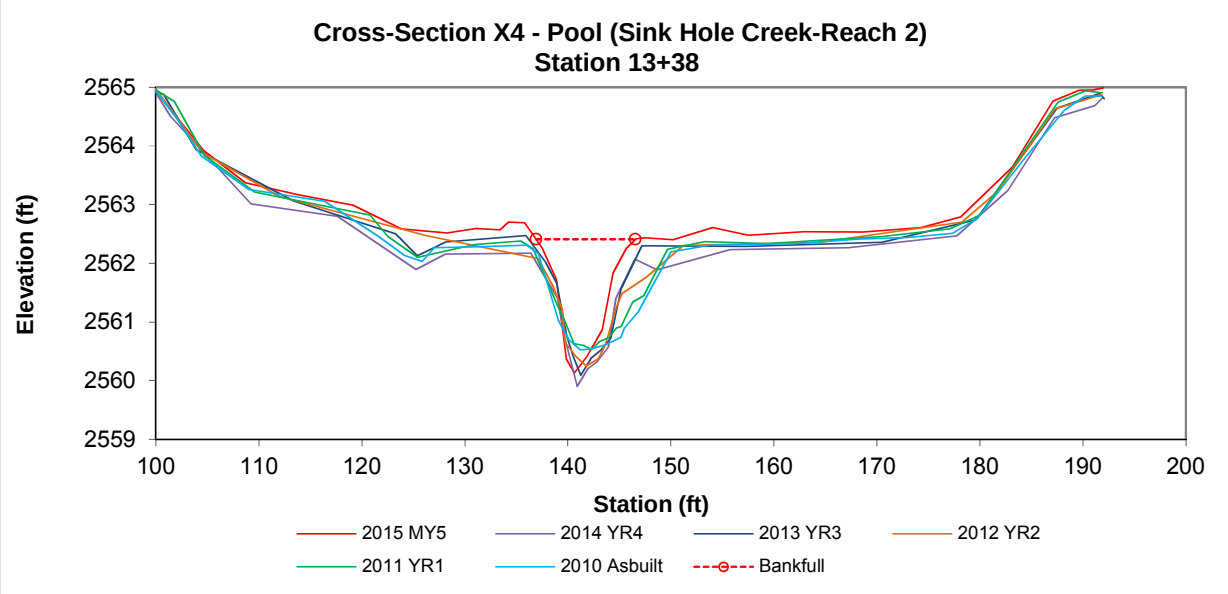


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	23.7	17.34	1.37	2.68	12.69	1	4.3	2561.69	2561.7

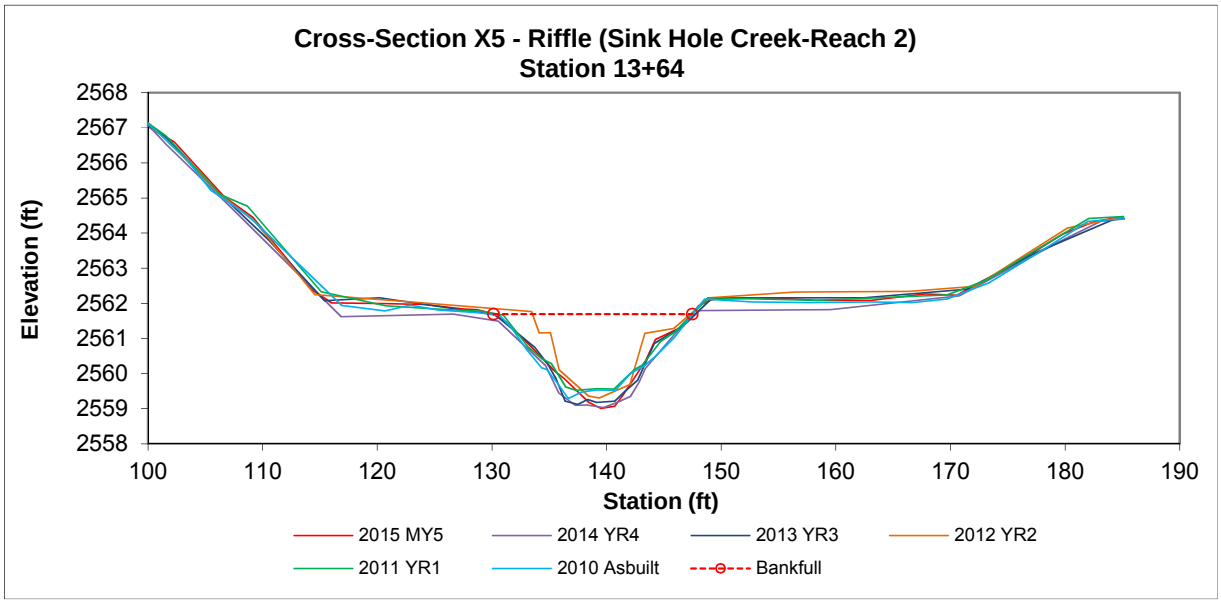


Photo 9: XS-5 facing right bank

Photo 10: XS-5 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	12.6	15.02	0.84	2.03	17.91	1	3.7	2553.47	2553.47

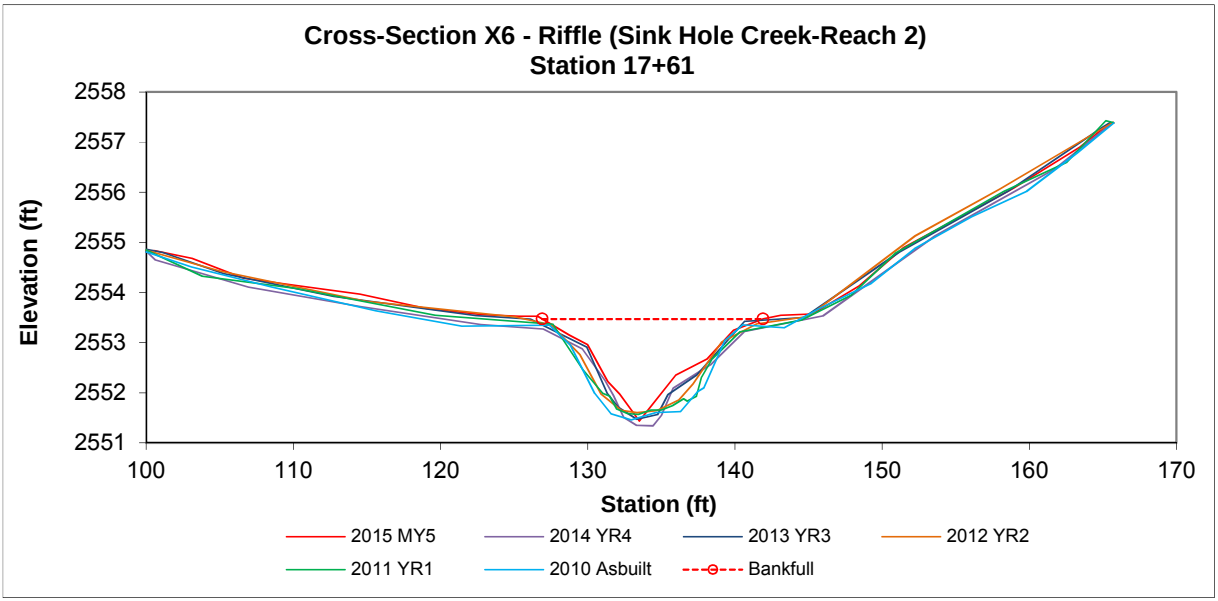


Photo 11: XS-6 facing right bank

Photo 12: XS-6 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		8.5	13.19	0.64	1.38	20.46	1	3.3	2583.12	2583.12

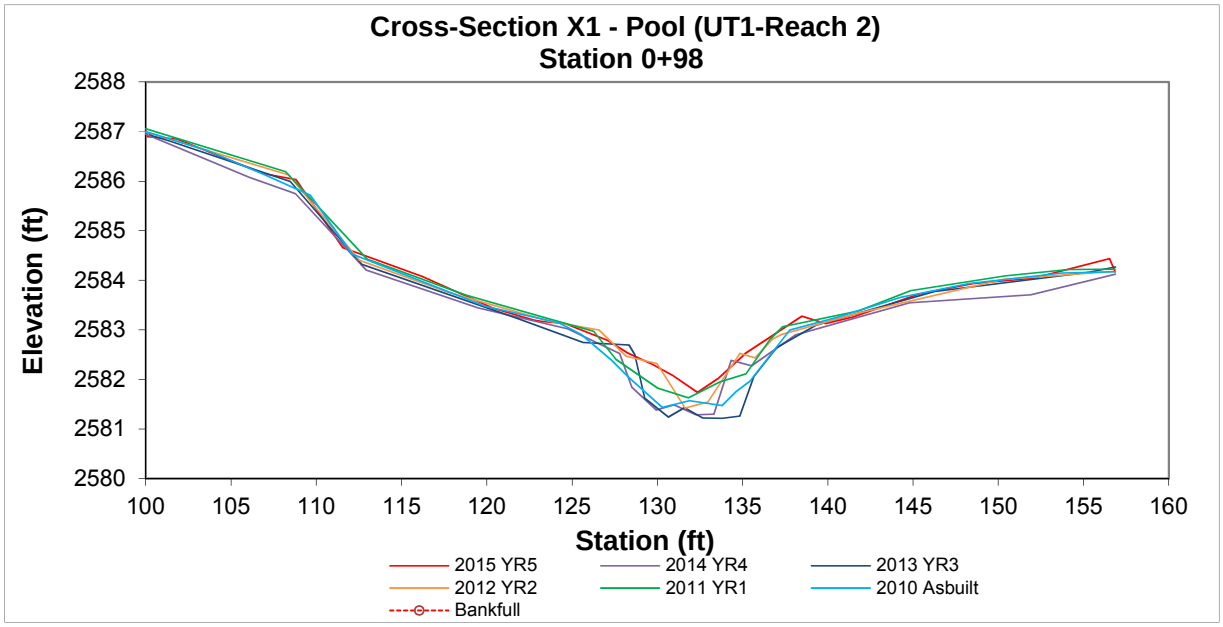


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	3.4	10.44	0.33	0.87	31.95	1	3.6	2579.18	2579.19

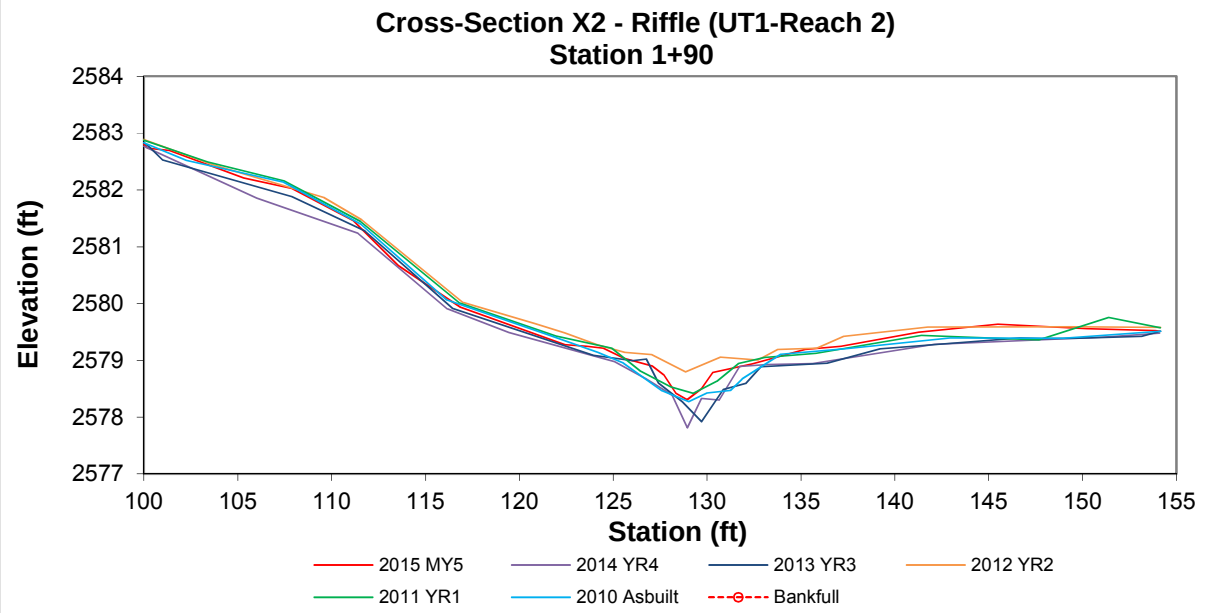


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Ba	0.6	6.22	0.1	0.2	64.2	1	4.2	2769.02	2769.02

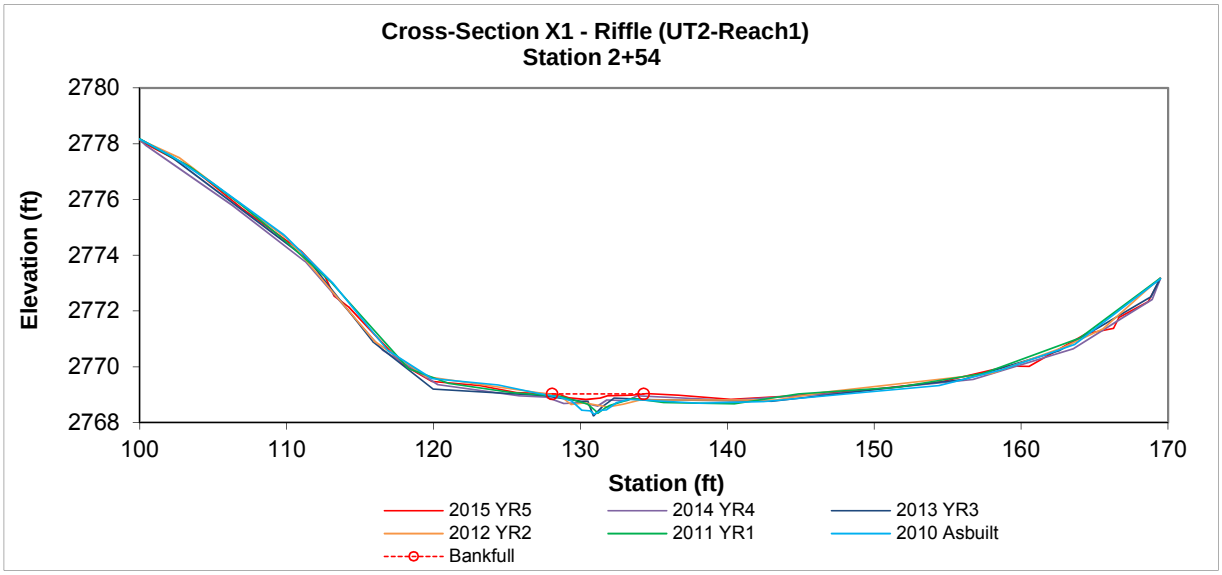


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		4.4	8.41	0.52	1.11	16.12	1	3.5	2753.03	2753.04

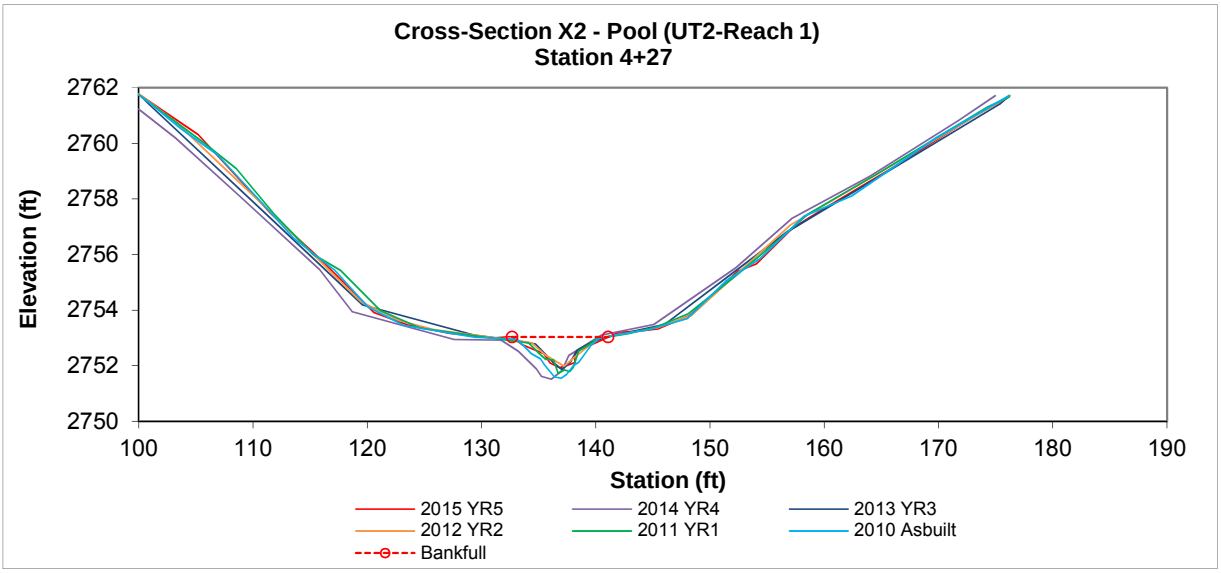


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Ba	2.6	5.3	0.49	0.99	10.81	1.7	7.1	2737.01	2737.68

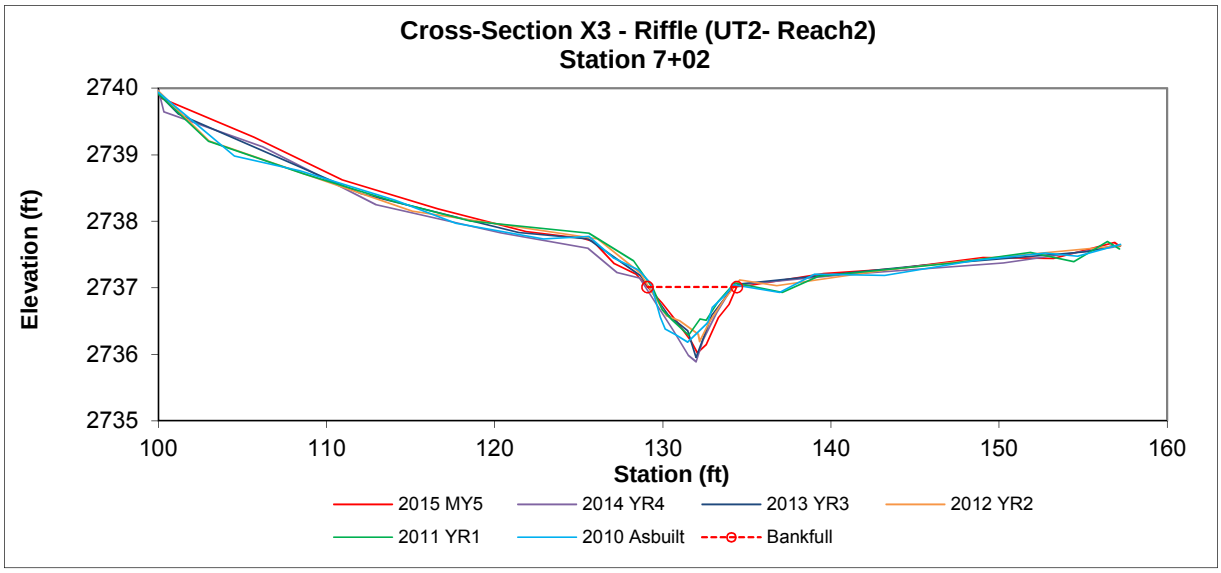


Photo 5: XS-3 facing right bank

Photo 6: XS-3 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Ba	4.7	7.02	0.67	1.37	10.55	1	6.2	2723.93	2723.93

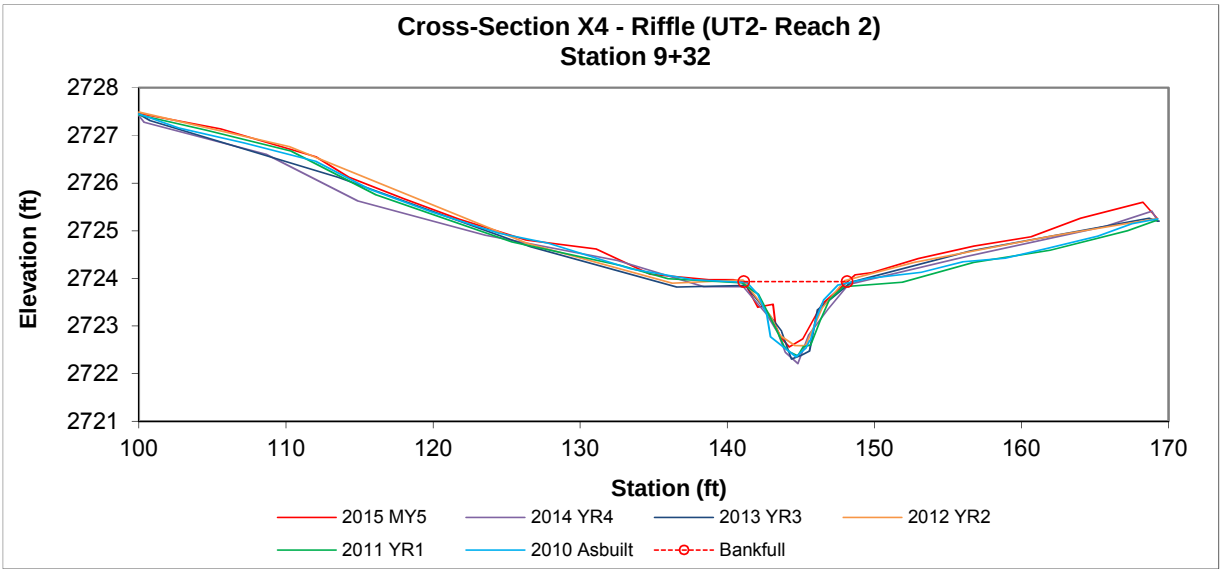


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		6	9	0.66	1.43	13.59	1	6.3	2716.2	2716.2

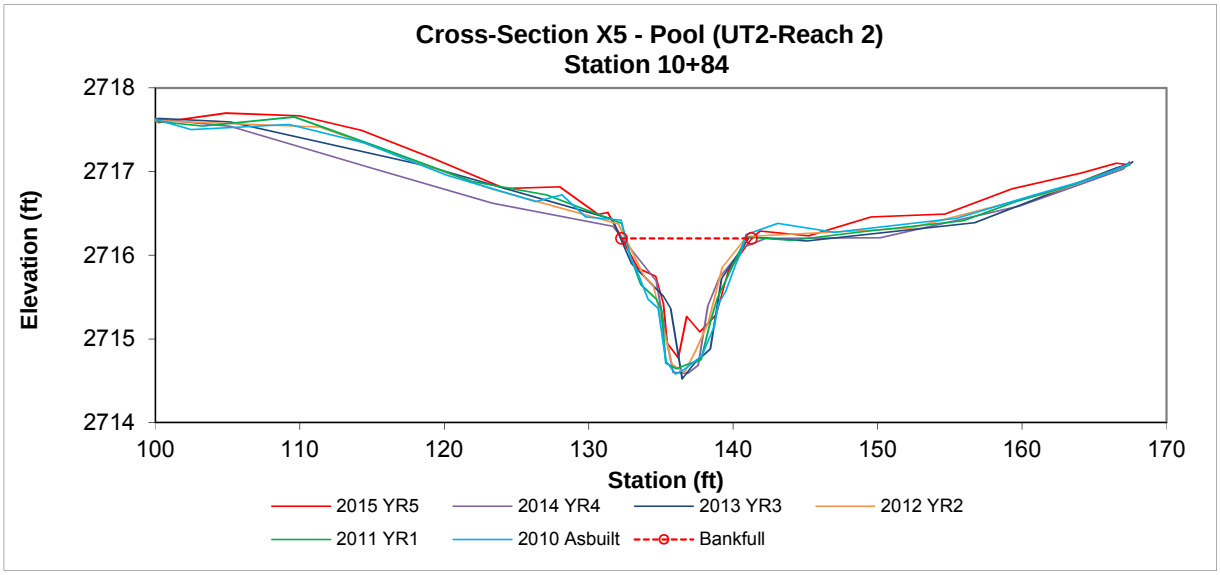


Photo 9: XS-5 facing right bank

Photo 10: XS-5 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Ba	3.7	8.15	0.46	0.91	17.77	1	4.5	2762.79	2762.8

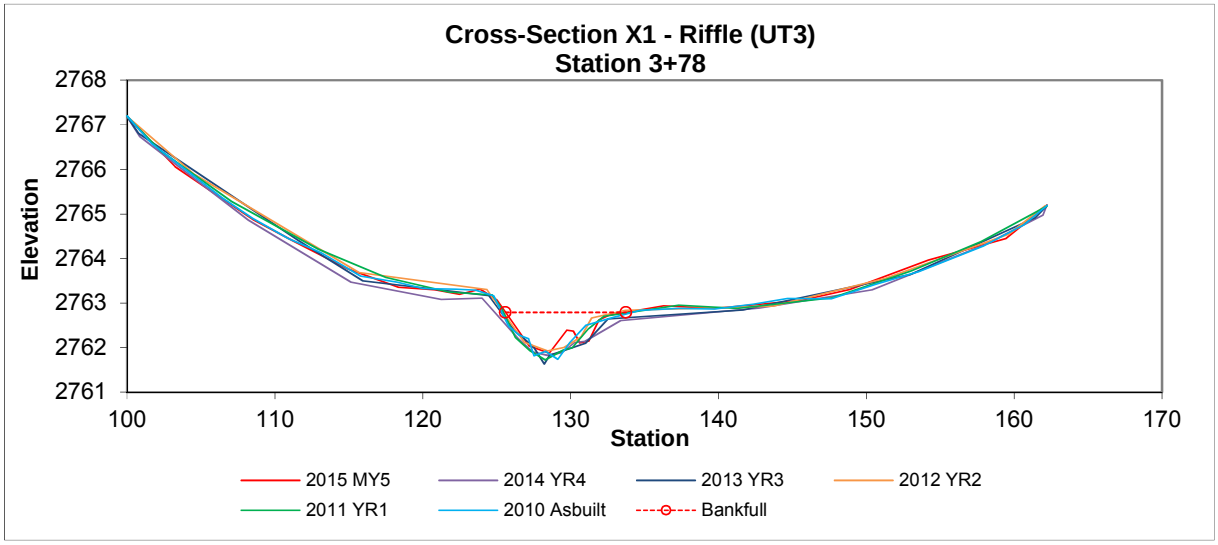


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		4	7.23	0.55	0.82	13.22	1	5.3	2757.41	2757.41

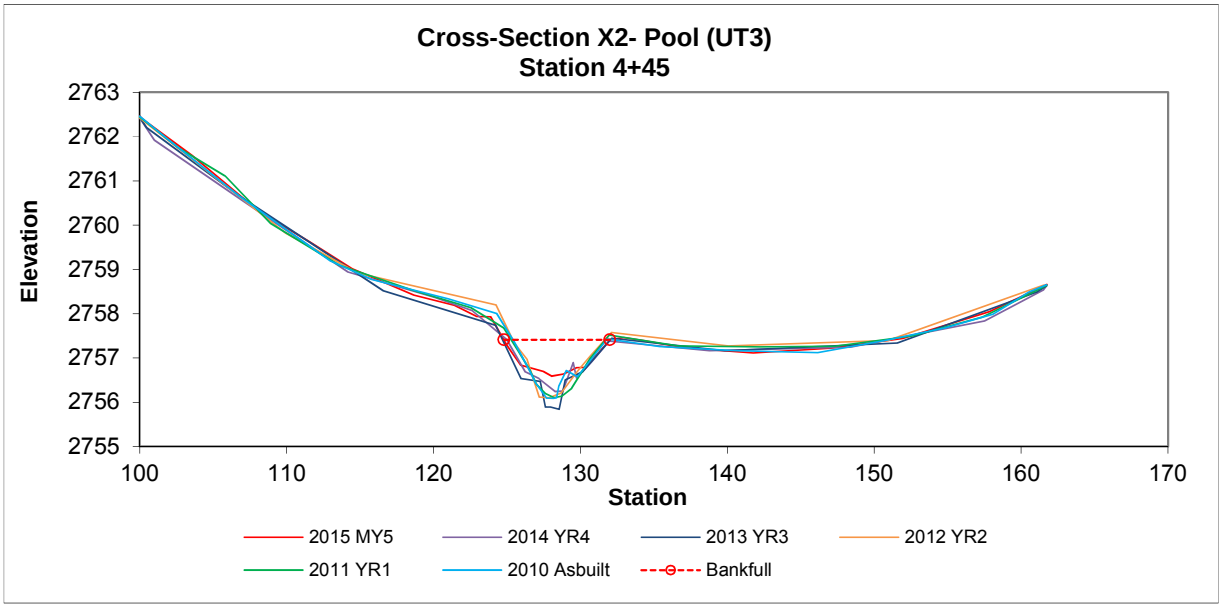
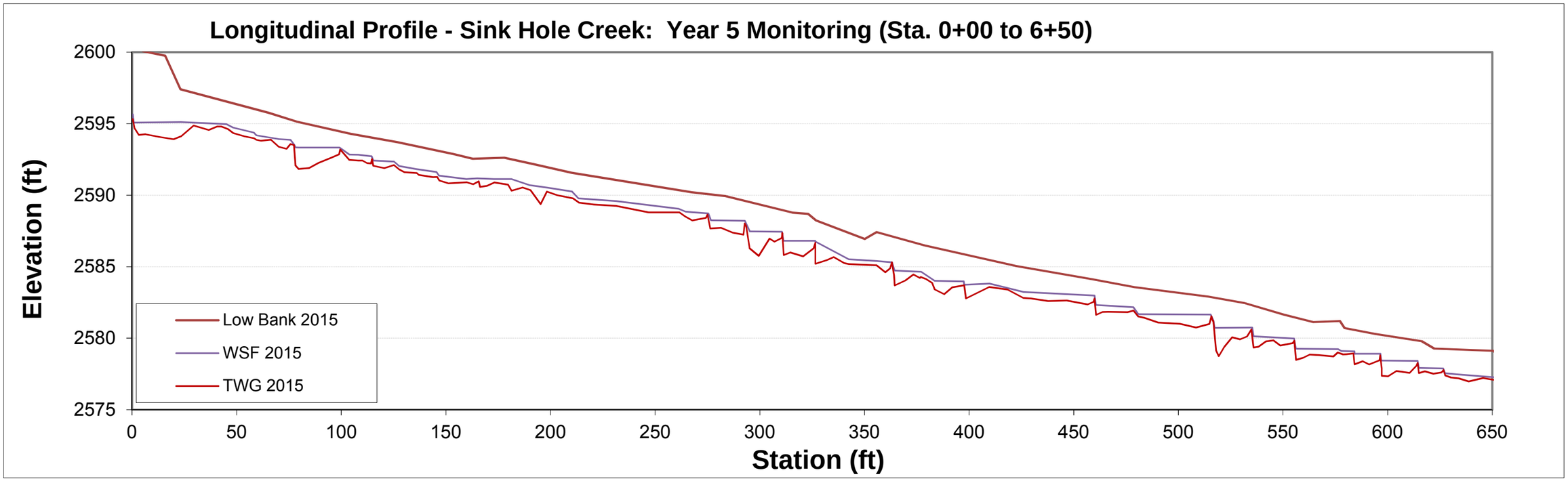
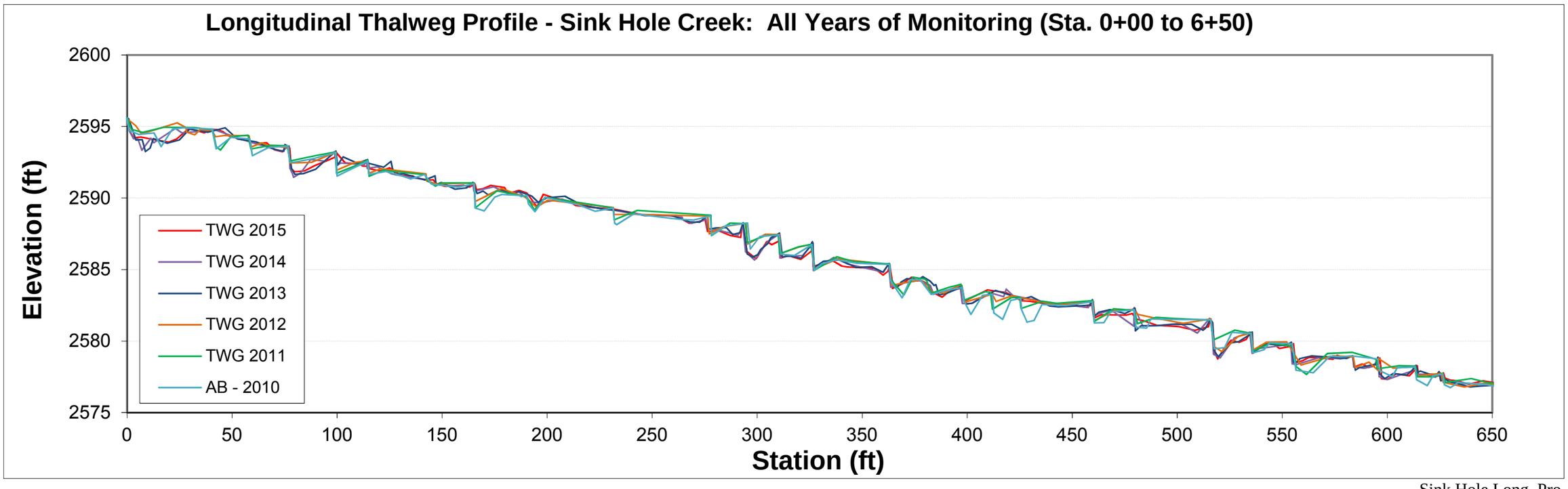


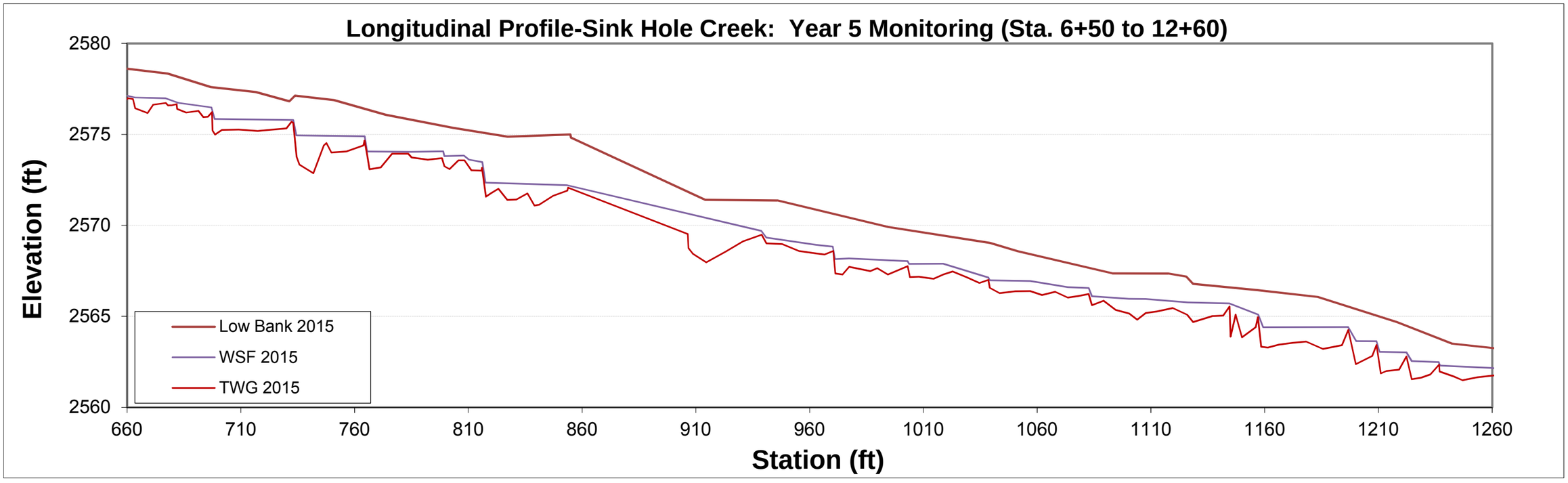
Photo 3: XS-2 facing right bank

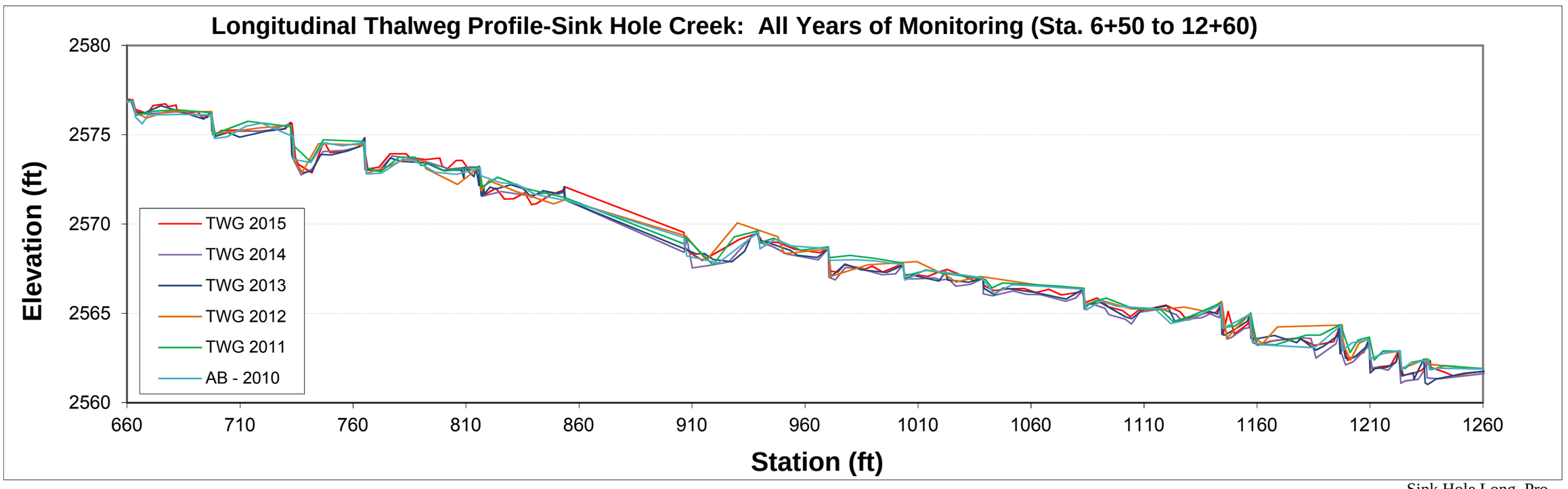
Photo 4: XS-2 facing left bank



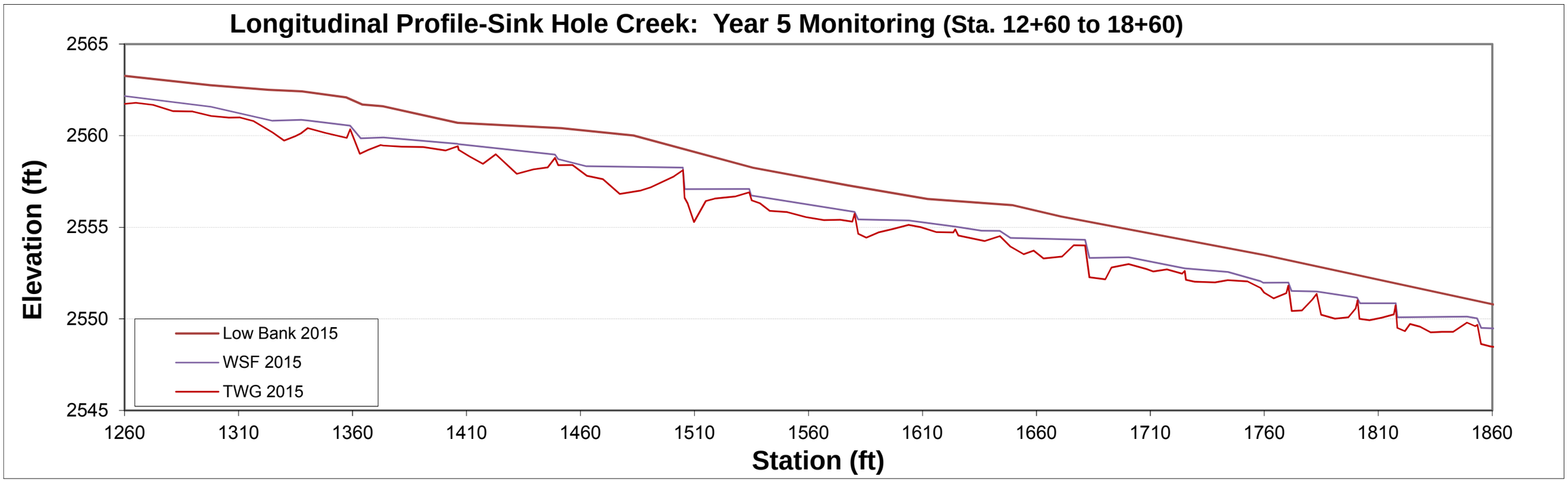


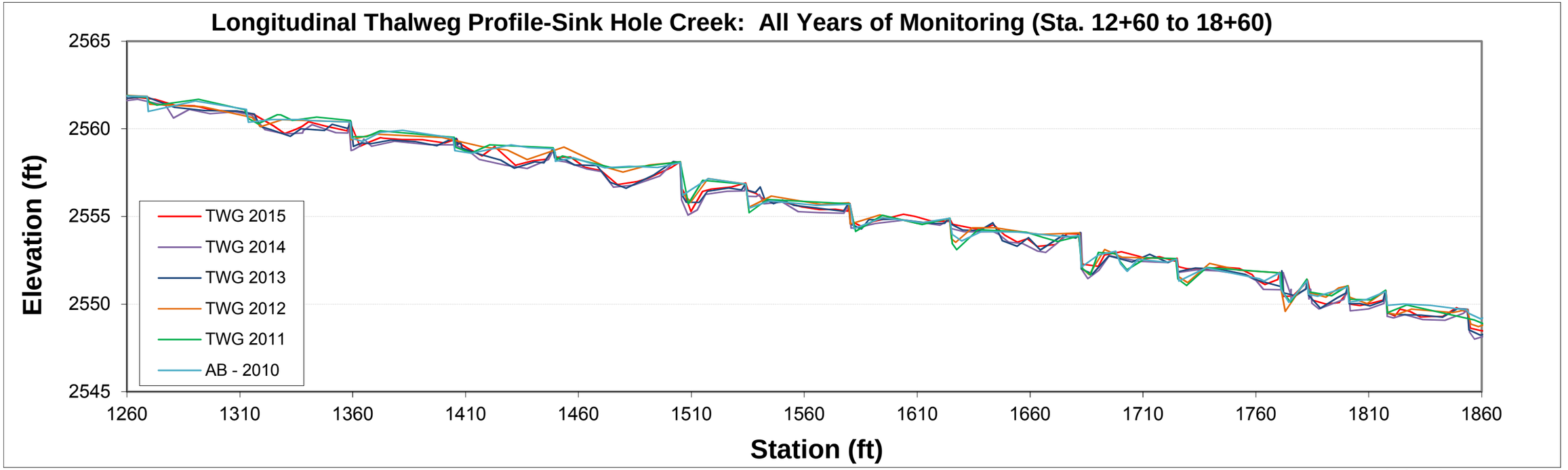
Sink Hole Long. Pro.
0+00 to 6+50



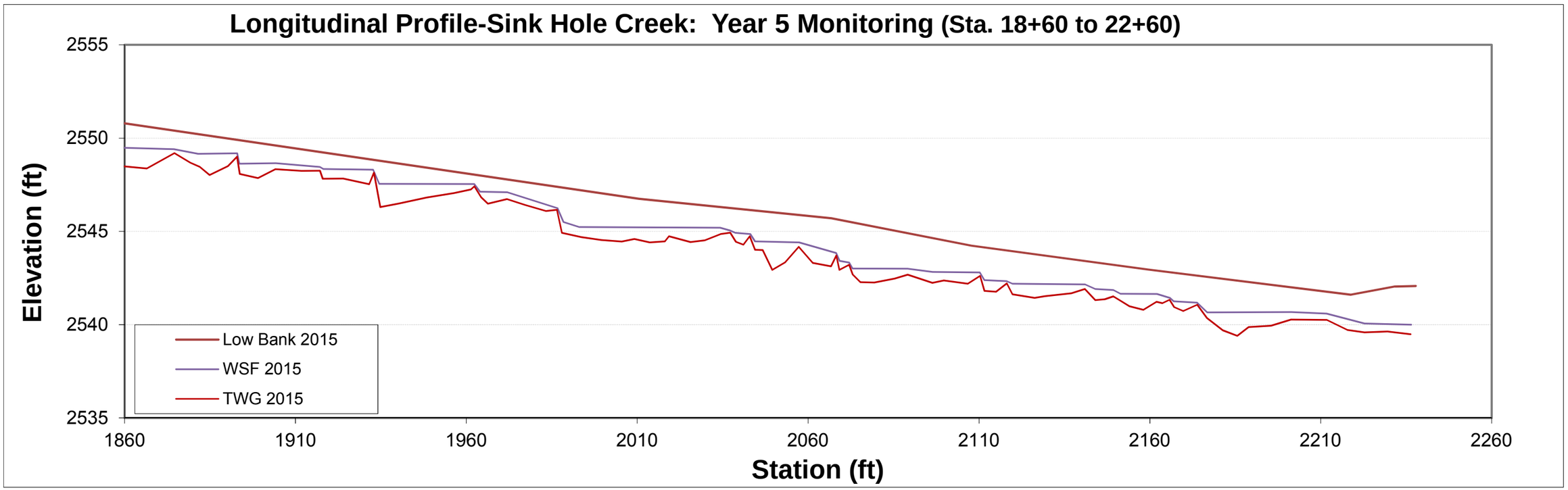


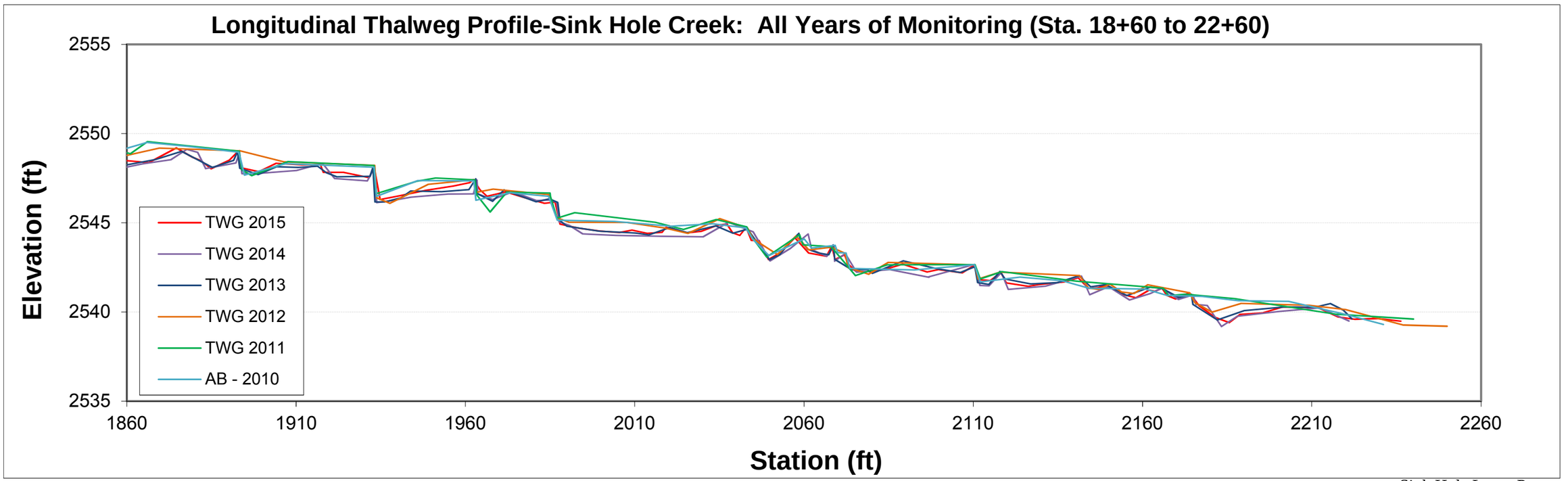
Sink Hole Long. Pro.
6+50 to 12+60





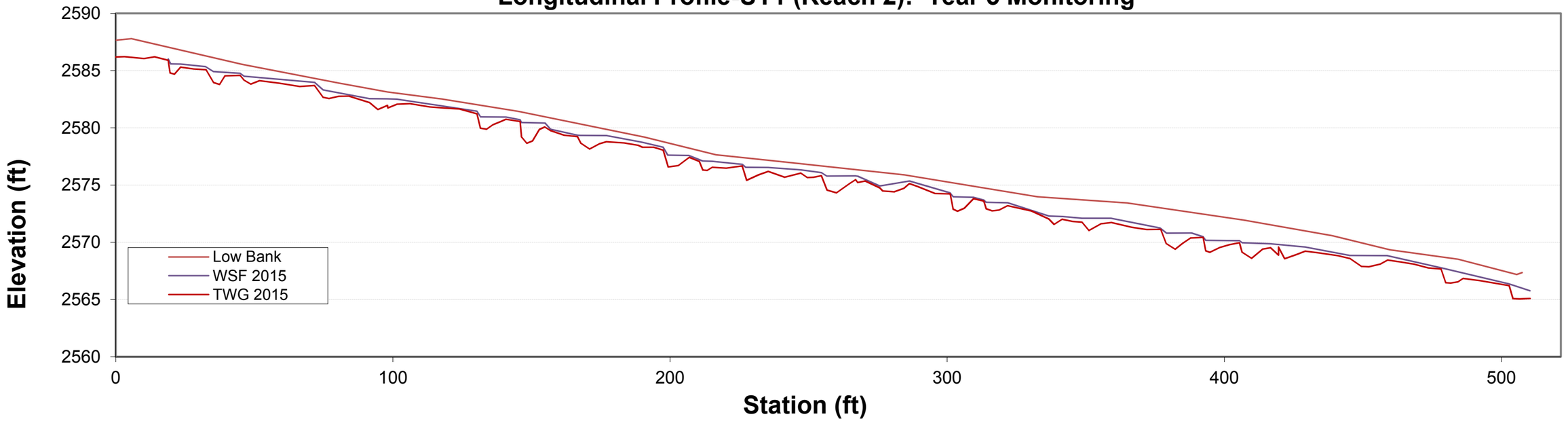
Sink Hole Long. Pro.
12+60 to 18+60



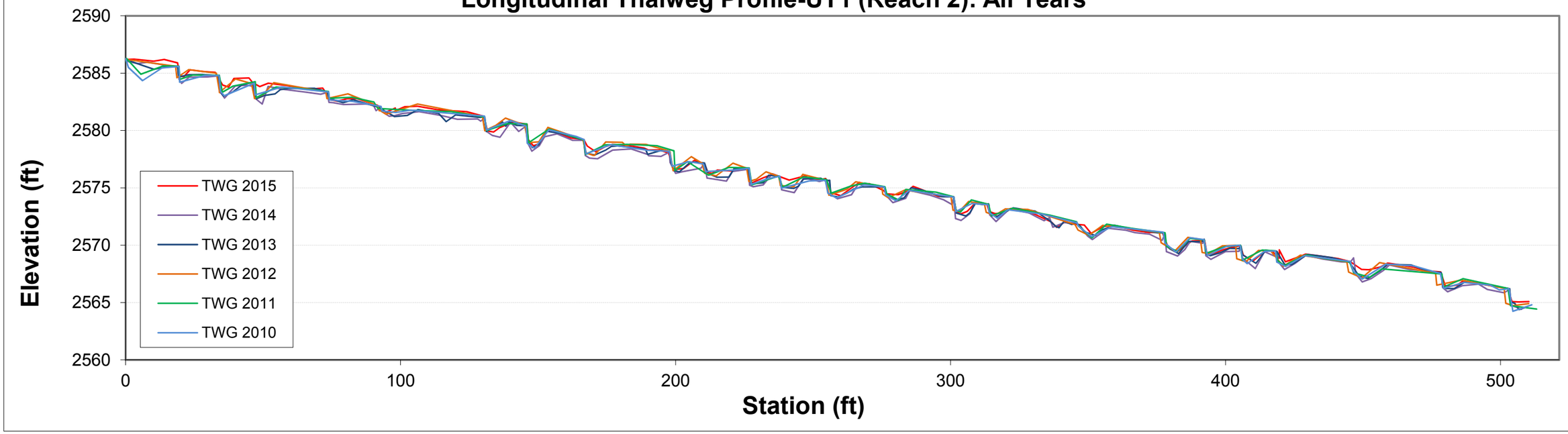


Sink Hole Long. Pro.
18+60 to 22+60

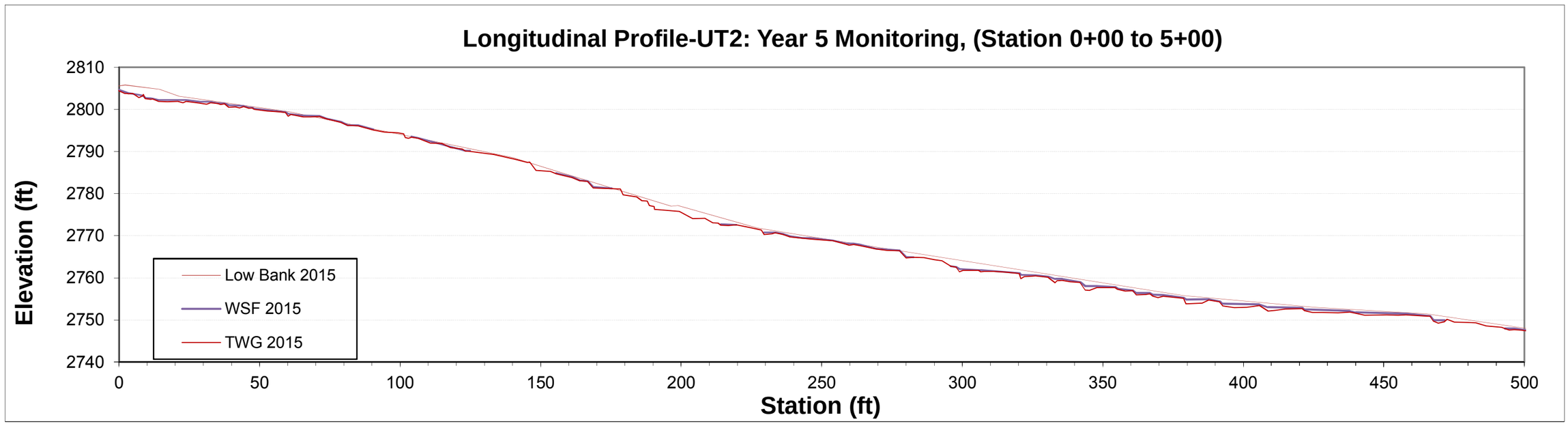
Longitudinal Profile-UT1 (Reach 2): Year 5 Monitoring

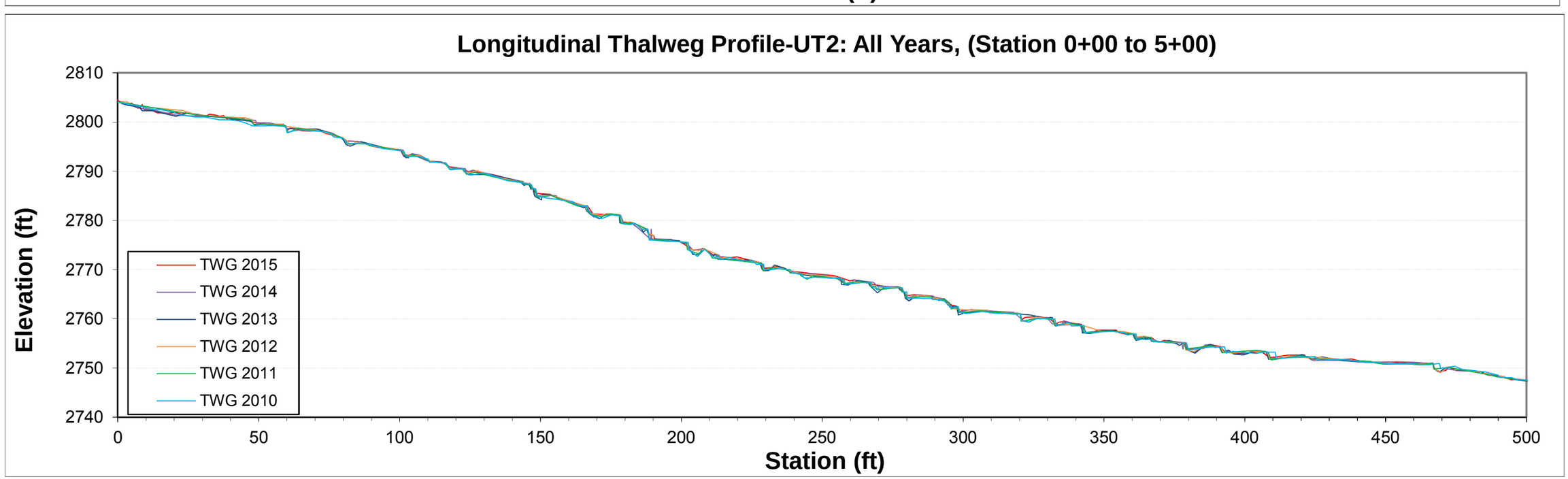


Longitudinal Thalweg Profile-UT1 (Reach 2): All Years

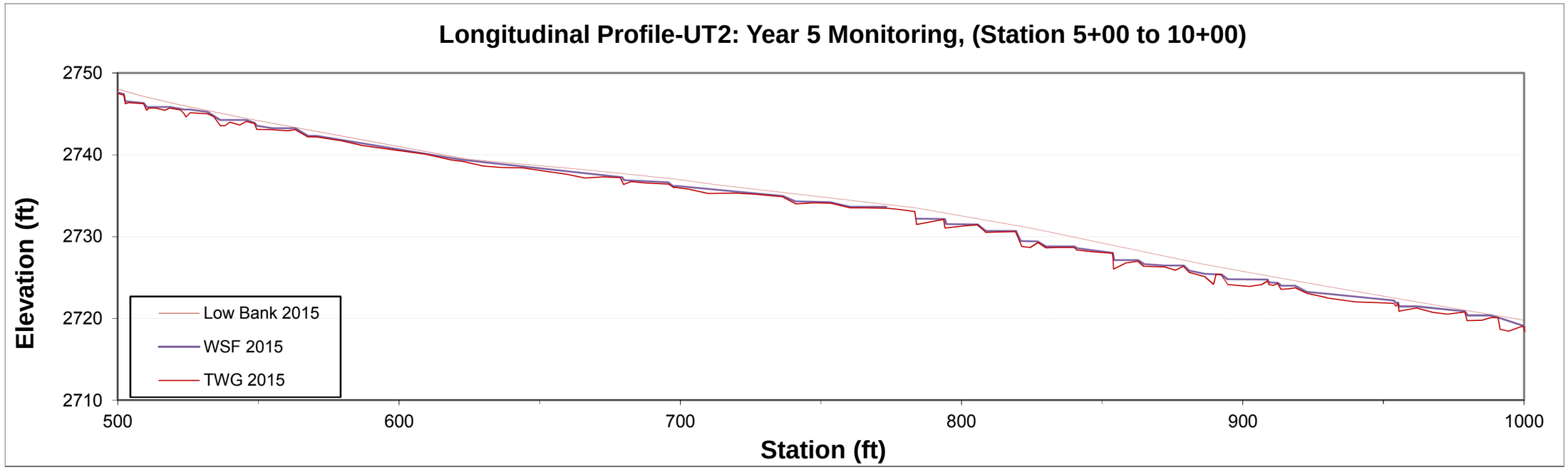


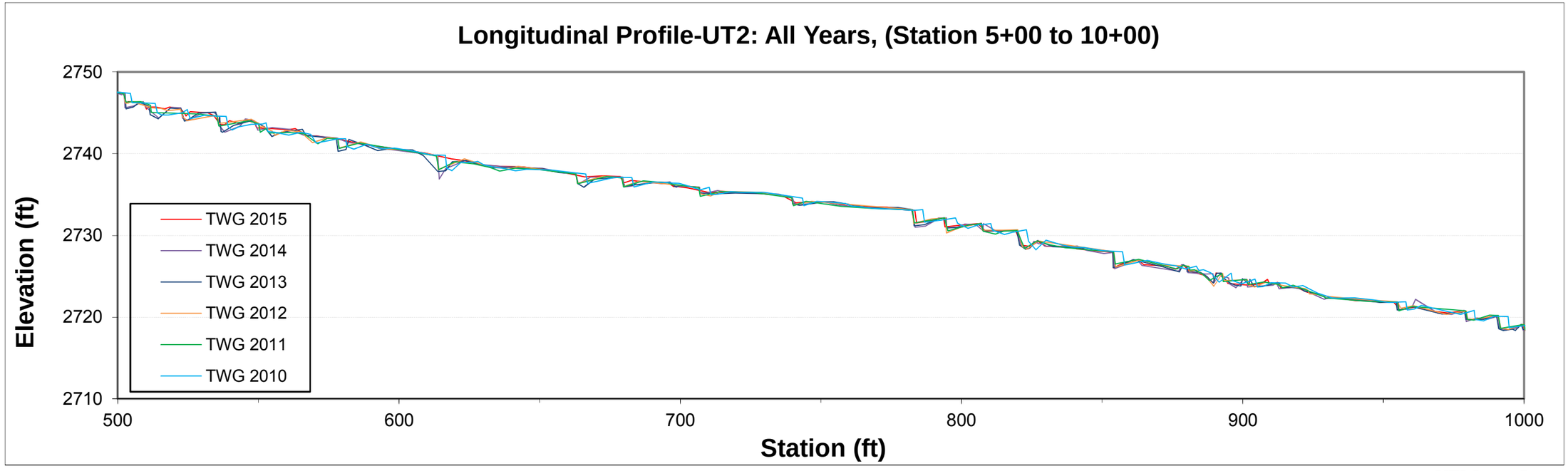
UT1-R2 Long. Pro.



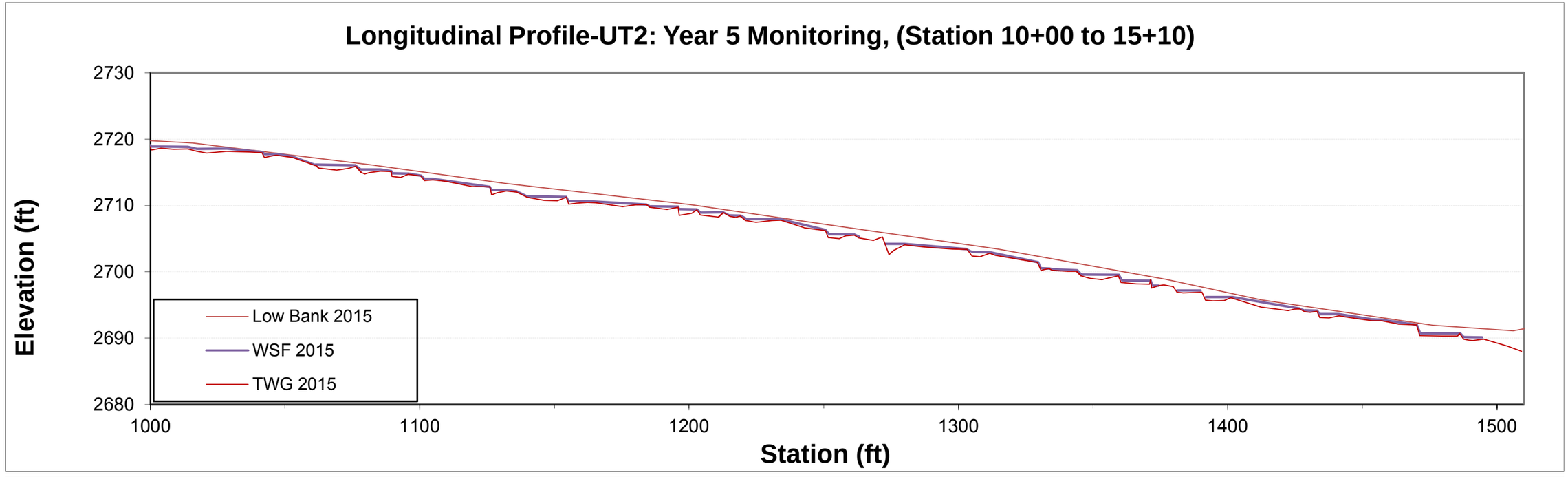


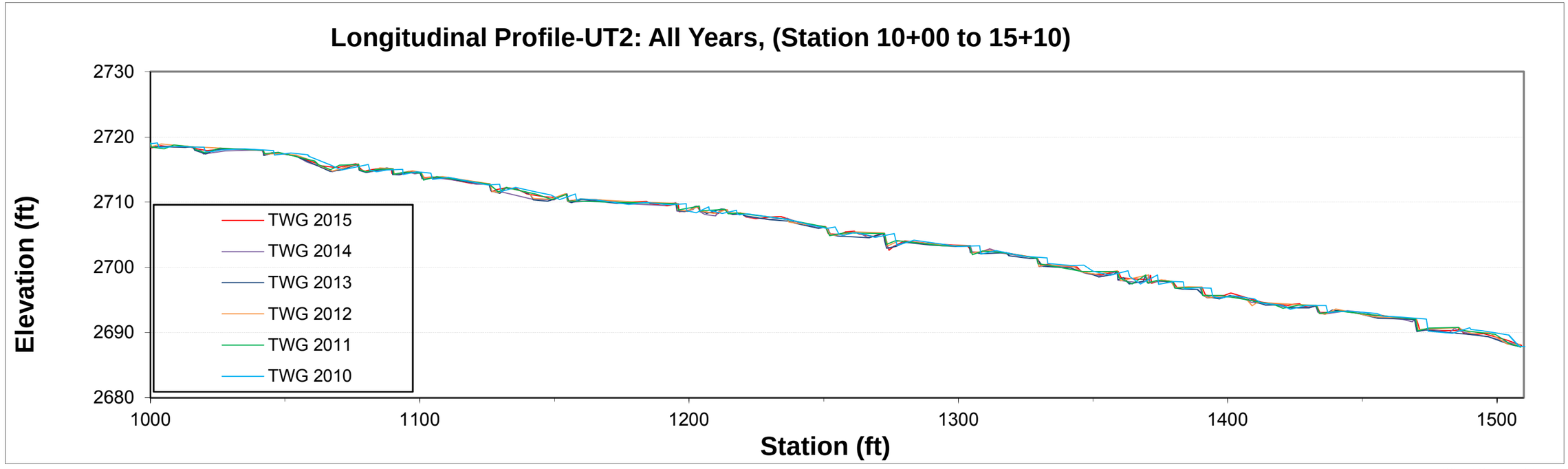
UT2 Long. Pro.
0+00 to 5+00





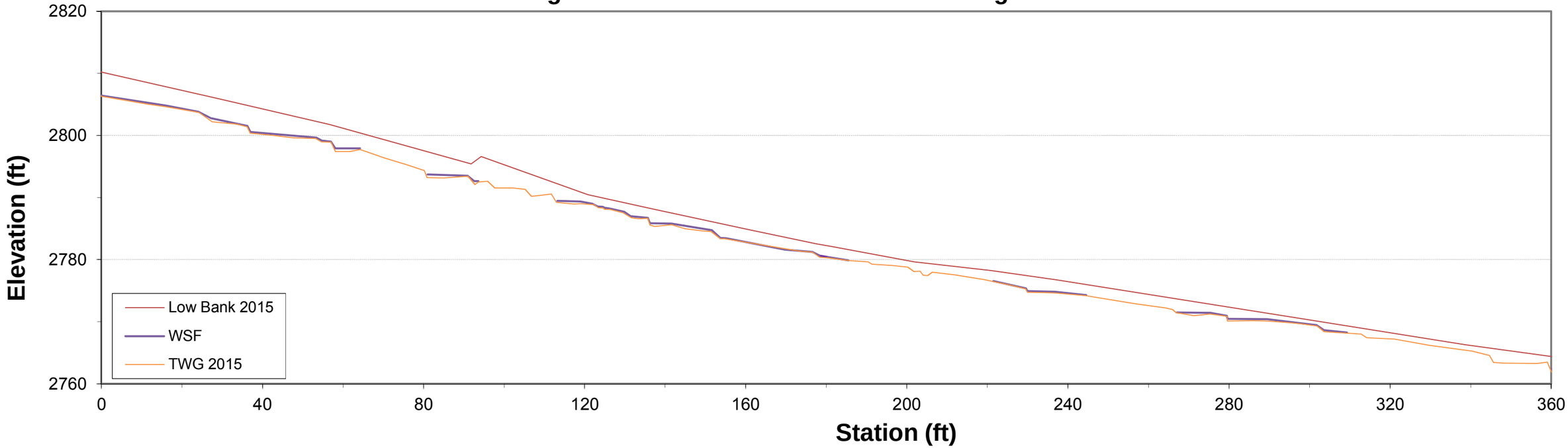
UT2 Long. Pro.
5+00 to 10+00



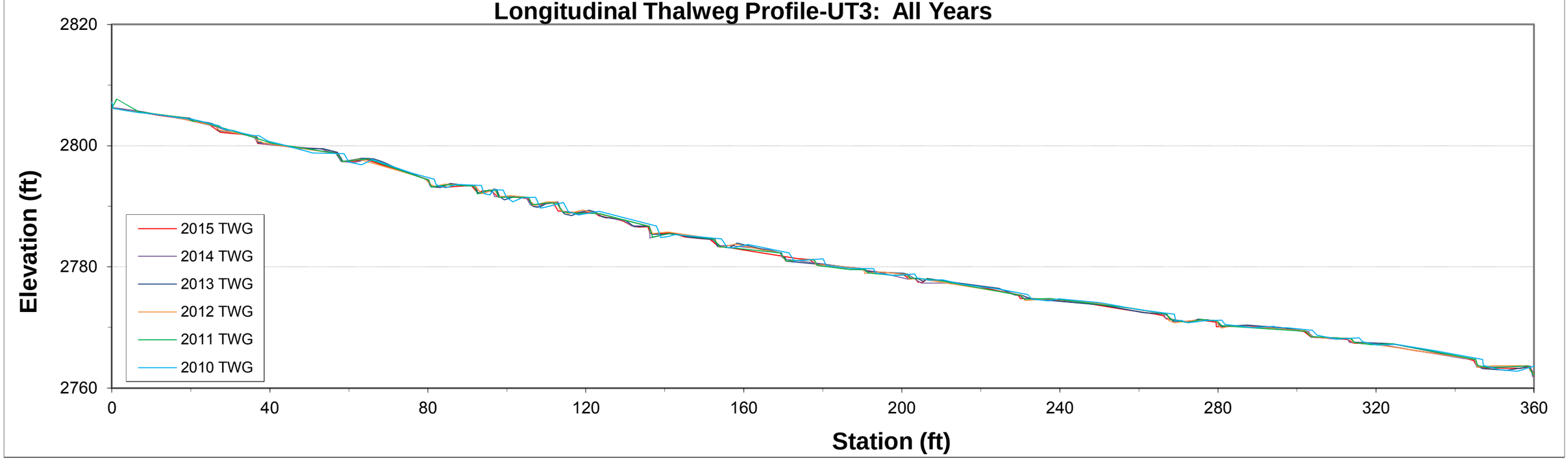


UT2 Long. Pro.
10+00 to 15+00

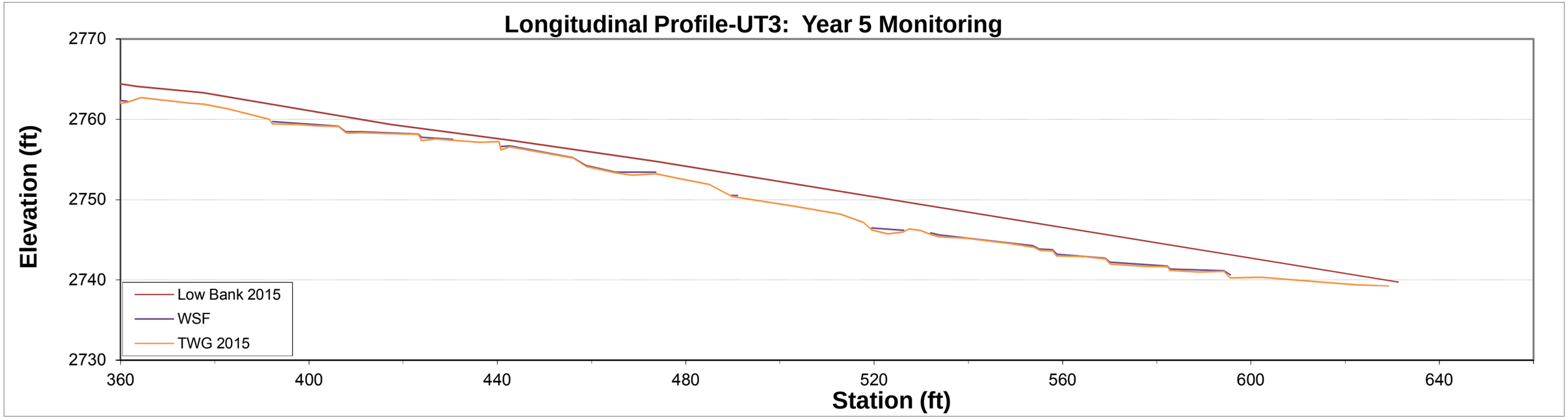
Longitudinal Profile-UT3: Year 5 Monitoring

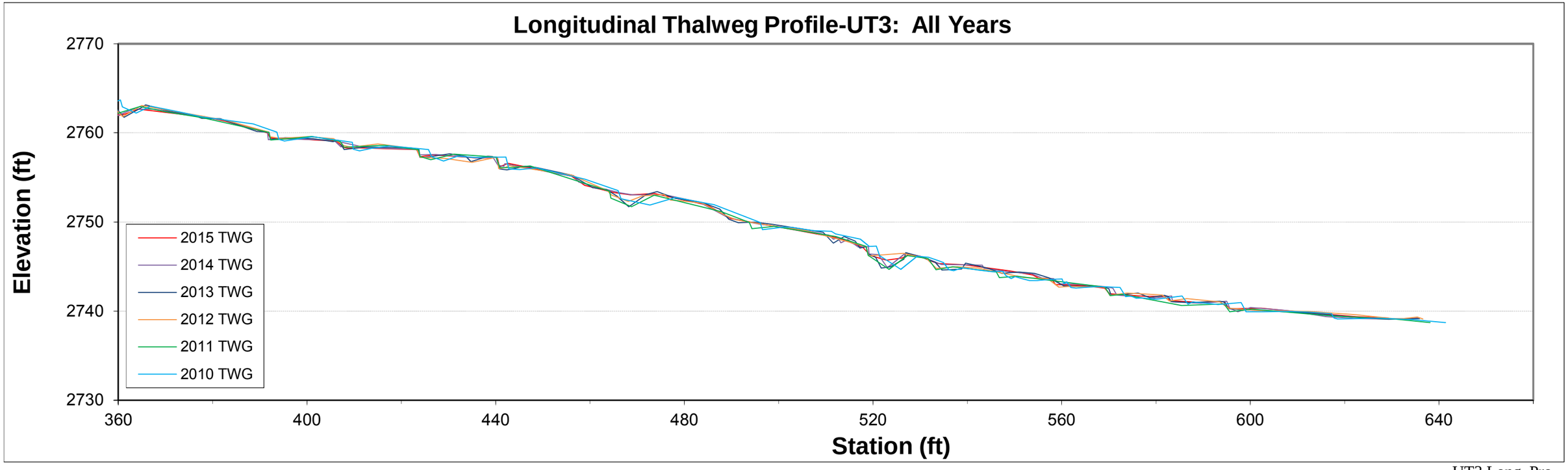


Longitudinal Thalweg Profile-UT3: All Years



UT3 Long. Pro.
0+00 to 3+60





UT3 Long. Pro.
3+60 to 6+40

Table 11. Categorical Visual Morphological Stability Assessment						
Sink Hole Creek Mitigation Project: Project No. 92663						
Sink Hole Creek Reach 1 (1,019 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	100%	100%	100%	100%	100%
Bank Condition	100%	100%	100%	98%	98%	100%
Rock/Log Drops	100%	100%	100%	100%	100%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----
Sink Hole Creek Reach 2 (1,073 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	100%	100%	100%	100%	100%
Bank Condition	100%	100%	100%	100%	100%	100%
Rock/Log Drops	100%	100%	100%	98%	98%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----
UT1 Reach 2 (489 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	100%	100%	100%	100%	100%
Bank Condition	100%	100%	100%	100%	100%	100%
Rock/Log Drops	100%	100%	100%	100%	100%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----

UT2 Reach 1 (596 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	100%	98%	100%	100%	100%
Bank Condition	100%	100%	100%	100%	100%	100%
Rock/Log Drops	100%	100%	97%	100%	100%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----
UT2 Reach 2 (885LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	94%	96%	96%	96%	100%
Bank Condition	100%	100%	100%	100%	100%	100%
Rock/Log Drops	100%	99%	97%	98%	98%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----
UT3 (641 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	100%
Pools	100%	100%	100%	100%	100%	100%
Thalweg	100%	100%	100%	100%	100%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed General	100%	79%	94%	77%	77%	100%
Bank Condition	100%	100%	100%	100%	100%	100%
Rock/Log Drops	100%	99%	93%	88%	88%	100%
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	-----
Wads and Boulders	-----	-----	-----	-----	-----	-----

Table 12. Visual Morphological Stability Assessment
Sink Hole Creek Mitigation Project: Project No. 92663

Sink Hole Reach 1 (1,019 LF)

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 Perfomance Mean or Total
A. Riffles	1. Present?	25	25	0/0	100	
	2. Armor stable (e.g. no displacement)?	25	25	0/0	100	
	3. Facet grades appears stable?	25	25	0/0	100	
	4. Minimal evidence of embedding/fining?	25	25	0/0	100	
	5. Length appropriate?	25	25	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	34	34	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	34	34	0/0	100	
	3. Length appropriate?	34	34	0/0	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%** [1]
E. Bed General	1. General channel bed aggradation areas (bar formation)	1,019	1,019	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	1,019	1,019	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	34	34	0/0	100	
	2. Height appropriate?	34	34	0/0	100	
	3. Angle and geometry appear appropriate?	34	34	0/0	100	
	4. Free of piping or other structural failures?	34	34	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

Sink Hole Reach 2 (1,073 LF)

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 Perfomance Mean or Total
A. Riffles	1. Present?	19	19	0/0	100	
	2. Armor stable (e.g. no displacement)?	19	19	0/0	100	
	3. Facet grades appears stable?	19	19	0/0	100	
	4. Minimal evidence of embedding/fining?	19	19	0/0	100	
	5. Length appropriate?	19	19	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	27	27	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	27	27	0/0	100	
	3. Length appropriate?	27	27	0/0	100	**100%**
C. Thalweg [1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	1,073	1,073	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	1,073	1,073	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	22	24	0/0	100	
	2. Height appropriate?	24	24	0/0	100	
	3. Angle and geometry appear appropriate?	24	24	0/0	100	
	4. Free of piping or other structural failures?	24	24	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT1 Reach 2 (489 LF)

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 Perfomance Mean or Total
A. Riffles	1. Present?	15	15	0/0	100	
	2. Armor stable (e.g. no displacement)?	15	15	0/0	100	
	3. Facet grades appears stable?	15	15	0/0	100	
	4. Minimal evidence of embedding/fining?	15	15	0/0	100	
	5. Length appropriate?	15	15	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	24	24	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	24	24	0/0	100	
	3. Length appropriate?	24	24	0/0	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	2	2	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	2	2	0/0	100	
	3. Apparent Rc within spec?	2	2	0/0	100	
	4. Sufficient floodplain access and relief?	2	2	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	489	489	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	489	489	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	24	24	0/0	100	
	2. Height appropriate?	24	24	0/0	100	
	3. Angle and geometry appear appropriate?	24	24	0/0	100	
	4. Free of piping or other structural failures?	24	24	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT2 Reach 1 (596 LF)						
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 Perfomance Mean or Total
A. Riffles	1. Present?	23	23	0/0	100	
	2. Armor stable (e.g. no displacement)?	23	23	0/0	100	
	3. Facet grades appears stable?	23	23	0/0	100	
	4. Minimal evidence of embedding/fining?	23	23	0/0	100	
	5. Length appropriate?	23	23	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	27	27	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	27	27	0/0	100	
	3. Length appropriate?	27	27	0/0	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	2	2	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	2	2	0/0	100	
	3. Apparent Rc within spec?	2	2	0/0	100	
	4. Sufficient floodplain access and relief?	2	2	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	596	596	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	596	596	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	28	28	0/0	100	
	2. Height appropriate?	28	28	0/0	100	
	3. Angle and geometry appear appropriate?	28	28	0/0	100	
	4. Free of piping or other structural failures?	28	28	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT2 Reach 2 (885 LF)						
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 Perfomance Mean or Total
A. Riffles	1. Present?	23	23	0/0	100	
	2. Armor stable (e.g. no displacement)?	23	23	0/0	100	
	3. Facet grades appears stable?	23	23	0/0	100	
	4. Minimal evidence of embedding/fining?	23	23	0/0	100	
	5. Length appropriate?	23	23	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	37	37	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	37	37	0/0	100	
	3. Length appropriate?	37	37	0/0	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	885	885	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	856	885	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	37	37	0/0	100	
	2. Height appropriate?	37	37	0/0	100	
	3. Angle and geometry appear appropriate?	37	37	0/0	100	
	4. Free of piping or other structural failures?	34	37	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT3 (641 LF)						
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 Perfomance Mean or Total
A. Riffles	1. Present?	25	25	0/0	100	
	2. Armor stable (e.g. no displacement)?	25	25	0/0	100	
	3. Facet grades appears stable?	25	25	0/0	100	
	4. Minimal evidence of embedding/fining?	25	25	0/0	100	
	5. Length appropriate?	25	25	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	34	34	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	34	34	0/0	100	
	3. Length appropriate?	34	34	0/0	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	1	1	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	1	1	0/0	100	
	3. Apparent Rc within spec?	1	1	0/0	100	
	4. Sufficient floodplain access and relief?	1	1	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	641	641	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	641	641	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	34	34	0/0	100	
	2. Height appropriate?	34	34	0/0	100	
	3. Angle and geometry appear appropriate?	34	34	0/0	100	
	4. Free of piping or other structural failures?	18	34	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

* Given the stream types present within the project area, stream flow energy was primarily managed vertically through drop control structures. Pattern adjustments were not designed to increase sinuosity on-site. As a result, the features addressed in Section D. 1-3 are not as common to the project site as they are on C or E-type channels in more gently sloping terrain.

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary
Sink Hole Creek: Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	16.9	11.7	19.7	27.6	12.3	12.7	13.0	12.9	13.5	14.2	12.6	13.5	14.3	10.8	12.6	14.4	8.1	10.8	13.5	9.1	11.0	13.0	12.8	13.3	13.8
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	58.0	63.7	69.4	56.7	63.0	69.4	58.0	63.6	69.3	58.6	64.0	69.4	60.0	60.0	60.0	56.0	62.5	69.0
Bankfull Mean Depth (ft)	1.00	0.60	0.85	1.10	1.00	1.05	1.10	0.95	1.09	1.23	0.78	0.90	1.01	0.56	0.84	1.11	0.65	0.86	1.07	0.61	0.86	1.11	0.45	0.77	1.09
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.48	1.72	1.96	1.34	1.55	1.76	1.46	1.65	1.83	1.42	1.74	2.05	1.42	1.68	1.93	1.70	1.77	1.84
Bankfull Cross Sectional Area (ft2)	17.7	18.3	19.4	20.4	12.6	13.3	14.0	12.2	14.8	17.4	9.8	12.2	14.5	6.0	11.0	16.0	5.3	9.9	14.5	5.5	10.0	14.4	5.8	10.4	15.0
Width/Depth Ratio	-----	8.6	12.0	15.4	11.8	11.9	12.0	11.6	12.6	13.6	14.1	15.2	16.2	13.0	16.1	19.2	12.6	12.6	12.6	11.8	13.3	14.8	12.6	20.4	28.2
Entrenchment Ratio	-----	1.6	2.0	2.4	5.4	6.8	8.1	4.1	4.8	5.4	4.0	4.7	5.5	4.0	5.2	6.4	4.3	6.4	8.5	4.4	6.1	7.7	4.2	4.8	5.4
Bank Height Ratio	-----	1.0	1.4	1.8	-----	1.0	-----	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bankfull Velocity (fps)	-----	-----	8.3	-----	-----	6.3	-----	----	5.7	----	----	6.9	----	----	7.6	----	----	8.5	----	----	8.4	----	----	8.1	----
Pattern																									
Channel Beltwidth (ft)*	-----	16	36	55	45	60	74	30	47	70	30	47	70	30	47	70	30	47	70	30	47	70	30	47	70
Radius of Curvature (ft)*	-----	28	38	47	31	38	45	32	39	47	32	39	47	32	39	47	32	39	47	32	39	47	32	39	47
Meander Wavelength (ft)*	-----	70	165	260	138	142	145	135	140	146	135	140	146	135	140	146	135	140	146	135	140	146	135	140	146
Meander Width Ratio*	-----	1.1	2.6	4.1	3.7	4.7	5.7	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	9	21	32	7	21	32	10	23	46	19	30	46	7	35	37	9	26	66
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.010	0.023	0.053	0.016	0.027	0.062	0.003	0.02173	0.052	0.015	0.027	0.041	0.009	0.030	0.088	0.021	0.032	0.052
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	7	15	21	8	14	22	11	15	17	13	19	23	10	22	44	3	15	29
Pool Spacing (ft)	-----	42	137	231	18	40	62	17	35	66	15	33	46	15	33	57	21	38	61	8	31	93	13	26	66
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.1/6.6/14/71/110			.3/8/10/50/95			8/20/31/93/152			.6/16/34/110/172			6/25/42/119/185			9/25/41/113/165			24.7/41.6/55.6/134.4/274.4			5.4/19/26/68/110		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.9	-----	-----	1.6	-----	-----	1.5	-----	-----	1.1	-----	-----	1.4	-----	-----	1.6		-----	1.5	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	12.0	-----	-----	8.8	-----	-----	10.5	-----	-----	8.6	-----	-----	12.1	-----	-----	13.5		-----	12.1	-----
Additional Reach Parameters																									
Channel length (ft)*	-----	-----	-----	-----	-----	1099	-----	-----	1122	-----	-----	1122	-----	-----	1122	-----	-----	1122	-----	-----	1122	-----	-----	1150	-----
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----
Rosgen Classification	-----	-----	B4c	-----	-----	B4c/C4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----
Bankfull Discharge (cfs)	78	-----	161	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----
Sinuosity	-----	1.08	1.09	1.09	1.10	1.15	1.20	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.13	-----
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.026	-----	-----	0.029	-----	-----	0.029	-----	-----	0.029	-----	-----	0.029	-----	-----	0.026	-----

Notes: Pattern data generated from subreach of Reach 1, directly upstream of the NC Hwy. 80 culvert, where channel slope decreases. * Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. Sink Hole R1 Stream Reach Morphology Data Table

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary
Sink Hole Creek: Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	17.7	11.7	19.7	27.6	12.3	12.7	13.0	13.1	14.9	16.7	12.3	14.4	16.4	13.9	14.0	14.1	14.2	15.8	17.4	13.3	17.0	20.6	15.0	19.4	23.7
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	54.3	62.2	70.1	51.3	59.5	67.7	52.2	62.0	71.8	54.6	64.2	73.8	55.0	64.7	74.4	56.0	62.5	69.0
Bankfull Mean Depth (ft)	1.04	0.60	0.85	1.10	1.00	1.05	1.10	1.18	1.29	1.40	1.04	1.18	1.31	1.00	1.17	1.33	0.97	1.19	1.40	0.90	1.11	1.32	0.84	1.11	1.37
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.88	2.12	2.36	1.65	1.90	2.14	1.75	2.11	2.46	1.95	2.25	2.55	1.88	2.26	2.64	2.03	2.36	2.68
Bankfull Cross Sectional Area (ft2)	19.2	18.3	19.4	20.4	12.6	13.3	14.0	15.5	19.4	23.3	12.8	17.1	21.4	13.8	16.3	18.8	13.8	19.1	24.3	11.9	19.5	27.1	12.6	18.2	23.7
Width/Depth Ratio	-----	8.6	12.0	15.4	11.8	11.9	12.0	11.0	11.5	11.9	11.8	12.2	12.5	10.6	12.2	13.9	12.4	13.5	14.6	14.9	15.2	15.6	12.7	15.3	17.9
Entrenchment Ratio	-----	1.6	2.0	2.4	5.4	6.8	8.1	4.2	4.2	4.2	4.1	4.2	4.2	3.8	4.4	5.1	3.8	4.1	4.3	3.6	3.8	4.0	3.7	4.0	4.3
Bank Height Ratio	-----	1.0	1.4	1.8	-----	1.0	-----	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bankfull Velocity (fps)	-----	-----	7.2	-----	-----	6.4	-----	----	4.4	----	----	5.0	----	----	5.2	----	----	4.5	----	----	4.4	----	----	4.7	----
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	1.1	2.6	4.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	10	24	56	9	27	46	9	25	40	20	27	40	7	19	30	10	24	51
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.017	0.023	0.046	0.007	0.021	0.046	0.008	0.022	0.046	0.016	0.020	0.025	0.010	0.030	0.069	0.019	0.019	0.019
Pool Length (ft)	-----	13	15	16	-----	-----	-----	9	13	18	4	10	17	7	11	25	10	18	32	8	21	55	10	24	48
Pool Spacing (ft)	-----	42	137	231	18	42	65	12	42	62	11	42	62	9	39	77	9	32	67	8	24	50	10	33	51
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.1/6.6/14/71/110			.3/8/10/50/95			8/18/26/79/135			11/20/34/134/212			19/41/58/143/245			17/35/52/128/245			24.7/41.6/55.6/134.4/274.4			6/12/19/33/72/130		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.5	-----	-----	1.6	-----	-----	1.6	-----	-----	1.4	-----	-----	1.6	-----	-----	1.6	-----	-----	1.4	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	9.6	-----	-----	7.1	-----	-----	8.1	-----	-----	7.4	-----	-----	7.0	-----	-----	6.8	-----	-----	6.6	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1062	-----	-----	1109	-----	-----	1119	-----	-----	1119	-----	-----	1118	-----	-----	1118	-----	-----	1086	-----
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----
Rosgen Classification	-----	-----	B4c	-----	-----	B4c	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----
Bankfull Discharge (cfs)	88	-----	139	-----	----	85	----	----	85	----	----	85	----	----	85	----	----	85	----	----	85	----	----	85	----
Sinuosity	-----	-----	1.16	-----	1.10	1.15	1.20	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.07	-----
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.023	-----	-----	0.025	-----	-----	0.023	-----	-----	0.023	-----	-----	0.023	-----	-----	0.025	-----

* Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. Sink Hole R2 Stream Reach Morphology Data Table

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary: UT1 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.8	11.7	19.7	27.6	6.0	6.7	7.4	-----	9.5	-----	-----	12.5	-----	-----	11.0	-----	-----	10.5	-----	-----	6.2	-----	-----	10.4	-----
Floodprone Width (ft)	-----	20.0	30.5	41.0	20.0	30.5	41.0	-----	36.9	-----	-----	37.3	-----	-----	33.1	-----	-----	38.7	-----	-----	>38.0	-----	-----	>39.1	-----
Bankfull Mean Depth (ft)	0.53	0.60	0.85	1.10	0.50	0.55	0.60	-----	0.45	-----	-----	0.33	-----	-----	0.15	-----	-----	0.38	-----	-----	0.44	-----	-----	0.33	-----
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	-----	0.83	-----	-----	0.79	-----	-----	0.41	-----	-----	1.10	-----	-----	1.08	-----	-----	0.87	-----
Bankfull Cross Sectional Area (ft2)	5.1	10.2	21.6	33.0	3.2	3.9	4.6	-----	4.3	-----	-----	4.1	-----	-----	1.7	-----	-----	4.0	-----	-----	2.7	-----	-----	3.4	-----
Width/Depth Ratio	-----	10.7	18.9	27.0	11.4	11.7	12.0	-----	21.1	-----	-----	37.7	-----	-----	72.4	-----	-----	27.4	-----	-----	13.9	-----	-----	32.0	-----
Entrenchment Ratio	-----	1.3	16.7	32.0	9.5	13.1	16.7	-----	3.9	-----	-----	3.0	-----	-----	3.0	-----	-----	3.7	-----	-----	6.2	-----	-----	3.6	-----
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	0.7	-----	-----	1.0	-----	-----	1.1	-----	-----	1.0	-----	-----	1.0	-----
Bankfull Velocity (fps)	-----	-----	1.0	-----	-----	5.1	-----	-----	4.7	-----	-----	4.9	-----	-----	11.8	-----	-----	5.0	-----	-----	7.4	-----	----	5.9	----
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	5	13	20	5	14	21	5	14	21	13	16	18	3	14	24	8	22	98
Riffle Slope (ft/ft)	-----	0.040	0.043	0.046	0.038	0.068	0.098	0.025	0.043	0.062	0.021	0.037	0.073	0.029	0.049	0.083	0.030	0.043	0.053	0.012	0.038	0.077	0.013	0.044	0.144
Pool Length (ft)	-----	13	15	16	9	23	37	5	8	11	4	8	13	5	7	10	8	11	14	5	11	17	5	9	13
Pool Spacing (ft)	-----	42	137	231	9	23	37	11	19	34	10	19	37	10	20	34	12	19	32	11	20	40	10	18	33
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/12/32/81/155			.2/12/32/81/155			-----			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.5	-----	-----	1.0	-----	-----	0.8	-----	-----	0.4	-----	-----	1.0	-----	-----	1.0	-----	-----	-----	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	7.7	-----	-----	4.8	-----	-----	3.8	-----	-----	4.3	-----	-----	5.1	-----	-----	7.8	-----	-----	-----	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	514	-----	-----	511	-----	-----	513	-----	-----	510	-----	-----	509	-----	-----	508	-----	-----	510	-----
Drainage Area (SM)	-----	-----	0.09	-----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----
Rosgen Classification	-----	-----	A6a+/B4c	-----	-----	B4/C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----
Bankfull Discharge (cfs)	16	-----	22	-----	----	20	----	----	20	----	----	20	----	----	20	----	----	20	----	----	20	----	----	20	----
Sinuosity	-----	-----	1.16	----	1.10	1.15	1.20	-----	1.16	-----	-----	1.16	-----	-----	1.16	-----	-----	1.16	-----	-----	1.16	-----	-----	1.1	----
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.042	-----	-----	0.04	-----	-----	0.041	-----	-----	0.041	-----	-----	0.041	-----	-----	0.041	----

Note: * Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. UT1-R2
Stream Reach Morphology
Data Table

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary: UT2 Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.5	11.7	19.7	27.6	-----	4.0	-----	-----	4.2	-----	-----	4.4	-----	-----	5.1	-----	-----	3.8	-----	-----	5.8	-----	-----	6.2	-----
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	-----	30.6	-----	-----	31.9	-----	-----	19.2	-----	-----	36.5	-----	-----	27.2	-----	-----	27.0	-----
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.26	-----	-----	0.20	-----	-----	0.15	-----	-----	0.18	-----	-----	0.2	-----	-----	0.10	-----
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.53	-----	-----	0.53	-----	-----	0.25	-----	-----	0.65	-----	-----	0.3	-----	-----	0.20	-----
Bankfull Cross Sectional Area (ft2)	2.1	10.2	21.6	33.0	----	1.5	----	-----	1.1	-----	-----	0.9	-----	-----	0.7	-----	-----	0.7	-----	-----	0.8	-----	-----	0.6	-----
Width/Depth Ratio	-----	10.7	18.9	27.0	----	10.8	----	-----	16.3	-----	-----	21.5	-----	-----	34.0	-----	-----	20.5	-----	-----	39.8	-----	-----	64.2	-----
Entrenchment Ratio	-----	1.3	16.7	32.0	17.4	21.1	24.8	-----	7.2	-----	-----	7.3	-----	-----	34.8	-----	-----	9.7	-----	-----	4.7	-----	-----	4.2	-----
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	0.8	-----	-----	1.1	-----	-----	1.0	-----
Bankfull Velocity (fps)	-----	-----	1.1	-----	-----	3.3	-----	-----	4.6	-----	-----	5.6	-----	-----	6.8	-----	-----	7.1	-----	-----	6.3	-----	-----	8.3	-----
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	4	12	18	7	12	18	4	12	19	12	16	22	4	14	25	7	22	52
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.136	0.152	0.167	0.046	0.107	0.149	0.045	0.112	0.176	0.047	0.121	0.185	0.112	0.136	0.170	0.022	0.088	0.143	0.058	0.124	0.202
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3	6	10	3	8	11	7	11	14	8	11	13	3	7	13	3	8	12
Pool Spacing (ft)	-----	-----	-----	-----	6	14	21	10	14	22	7	14	22	9	15	34	11	16	34	9	19	49	9	12	19
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----			-----			-----			-----			-----			-----	
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																									
Channel length (ft)*	-----	-----	-----	-----	-----	594	-----	-----	627	-----	-----	627	-----	-----	626	-----	-----	624	-----	-----	627	-----	-----	625	-----
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----
Rosgen Classification	-----	-----	Aa+	-----	-----	Aa+4	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----
Bankfull Discharge (cfs)	5	-----	24	-----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----
Sinuosity	-----	-----	1.07	----	1.10	1.15	1.20	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.03	-----
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.107	-----	-----	0.107	-----	-----	0.109	-----	-----	0.109	-----	-----	0.109	-----	-----	0.105	-----

Note: No stream bed particle data was collected for UT2 and UT3 during the design phase. For UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile. * Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. UT2 - R1
Stream Reach Morphology
Data Table

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary: UT2 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.5	11.7	19.7	27.6	6.0	6.7	7.4	4.9	5.5	6.0	5.1	5.8	6.5	5.7	6.3	6.9	5.3	6.1	6.9	6.0	6.5	7.0	5.3	6.2	7.0
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	38.3	43.7	49.1	33.2	40.9	48.6	39.1	43.3	47.5	40.9	44.2	47.5	43.7	47.9	52.1	43.0	43.0	43.0
Bankfull Mean Depth (ft)	0.51	0.60	0.85	1.10	0.50	0.55	0.60	0.52	0.67	0.81	0.43	0.58	0.72	0.47	0.61	0.74	0.47	0.59	0.70	0.51	0.62	0.73	0.49	0.58	0.67
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	0.86	1.18	1.50	0.79	1.12	1.45	0.92	1.15	1.37	1.10	1.33	1.55	1.16	1.39	1.61	0.99	1.18	1.37
Bankfull Cross Sectional Area (ft2)	4.7	10.2	21.6	33.0	3.2	3.9	4.6	2.5	3.7	4.9	2.2	3.5	4.7	2.7	3.9	5.1	2.5	3.7	4.8	3.1	4.1	5.1	2.6	3.7	4.7
Width/Depth Ratio	-----	10.7	18.9	27.0	11.4	11.7	12.0	7.4	8.5	9.5	9.0	10.5	11.9	9.3	10.7	12.1	9.9	10.6	11.3	9.6	10.6	11.7	10.6	10.7	10.8
Entrenchment Ratio	-----	1.3	16.7	32.0	9.5	13.1	16.7	7.8	8.0	8.2	6.5	7.0	7.5	6.9	6.9	6.9	6.9	7.4	7.8	7.3	7.4	7.4	6.2	6.7	7.1
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bankfull Velocity (fps)	-----	-----	0.6	-----	-----	4.9	-----	-----	5.1	-----	-----	5.5	-----	-----	4.9	-----	-----	5.2	-----	-----	4.6	-----	-----	5.2	-----
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	13	18	27	11	19	27	8	16	27	12	18	27	9	24	39	7	16	25
Riffle Slope (ft/ft)	-----	0.040	0.043	0.046	0.081	0.089	0.098	0.052	0.072	0.091	0.025	0.060	0.092	0.034	0.062	0.097	0.041	0.057	0.084	0.011	0.047	0.081	0.026	0.050	0.069
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	5	8	11	3	7	11	3	8	11	7	10	13	4	11	27	1	11	20
Pool Spacing (ft)	-----	-----	21	-----	9	23	37	9	25	43	12	26	43	11	27	43	12	27	43	10	21	43	9	21	40
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/12/32/81/155			.2/12/32/81/155			-----			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																									
Channel length (ft)*	-----	-----	-----	-----	-----	879	-----	-----	882	-----	-----	882	-----	-----	883	-----	-----	884	-----	-----	881	-----	-----	884	-----
Drainage Area (SM)	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----
Rosgen Classification	-----	-----	Aa+	-----	-----	A4	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----
Bankfull Discharge (cfs)	15	-----	14	-----	----	19	----	----	19	----	----	19	----	----	19	----	----	19	----	----	19	----	----	19	----
Sinuosity	-----	-----	1.04	----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.03	-----
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.055	-----	-----	0.056	-----	-----	0.055	-----	-----	0.055	-----	-----	0.055	-----	-----	0.055	-----

Note: No sediment data was collected for UT2 and UT3 during the design phase. For UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile. * Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. UT2 - R2
Stream Reach Morphology
Data Table

Table 13. Stream Reach Morphology Data Table

Sink Hole Creek Mitigation Project, NCDMS Project #92663

Stream Reach Data Summary: UT3

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.5	11.7	19.7	27.6	-----	4.0	-----	-----	5.2	-----	-----	6.6	-----	-----	6.2	-----	-----	6.9	-----	-----	9.2	-----	-----	8.2	-----
Floodprone Width (ft)	-----	20.0	30.5	41.0	69.6	84.4	99.2	-----	25.2	-----	-----	35.9	-----	-----	29.2	-----	-----	37.8	-----	-----	36.2	-----	-----	37.0	-----
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.41	-----	-----	0.58	-----	-----	0.50	-----	-----	0.53	-----	-----	0.43	-----	-----	0.46	-----
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.76	-----	-----	0.98	-----	-----	0.76	-----	-----	1.01	-----	-----	0.81	-----	-----	0.91	-----
Bankfull Cross Sectional Area (ft2)	2.1	10.2	21.6	33.0	----	1.5	----	-----	2.1	-----	-----	3.9	-----	-----	3.1	-----	-----	3.6	-----	-----	3.9	-----	-----	3.7	-----
Width/Depth Ratio	-----	10.7	18.9	27.0	----	10.8	----	-----	12.7	-----	-----	11.5	-----	-----	12.5	-----	-----	13.1	-----	-----	21.4	-----	-----	17.8	-----
Entrenchment Ratio	-----	1.3	16.7	32.0	17.4	21.1	24.8	-----	4.8	-----	-----	5.4	-----	-----	4.7	-----	-----	5.5	-----	-----	3.9	-----	-----	4.5	-----
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----
Bankfull Velocity (fps)	-----	-----	0.5	-----	-----	3.3	-----	-----	2.3	-----	-----	1.3	-----	-----	1.6	-----	-----	1.4	-----	-----	1.3	-----	-----	1.4	-----
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	10	17	27	11	17	21	5	17	28	10	19	31	4	15	33	13	21	28
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.136	0.152	0.167	0.060	0.113	0.168	0.064	0.125	0.169	0.091	0.116	0.158	0.093	0.124	0.168	0.010	0.092	0.232	0.097	0.119	0.214
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3	5	6	4	5	9	2	4	7	4	6	7	4	9	14	4	10	18
Pool Spacing (ft)	-----	-----	-----	-----	6	13	20	10	15	21	8	15	23	9	15	24	10	15	22	4	17	32	5	14	23
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----			-----			-----			-----			-----			-----	
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																									
Channel length (ft)*	-----	-----	-----	-----	-----	586	-----	-----	638	-----	-----	638	-----	-----	637	-----	-----	636	-----	-----	636	-----	-----	629	-----
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----
Rosgen Classification	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----
Bankfull Discharge (cfs)	5	-----	11	-----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----
Sinuosity	-----	-----	1.02	----	1.10	1.15	1.20	-----	1.03	-----	-----	1.02	-----	-----	1.02	-----	-----	1.02	-----	-----	1.02	-----	-----	1.008013	-----
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.111	-----	-----	0.111	-----	-----	0.114	-----	-----	0.114	-----	-----	0.114	-----	-----	0.112	-----

Note: * Channel length for each year has been corrected as length was not reported correctly in past reports.

Table 13. UT3
Stream Reach Morphology
Data Table

Table 14. Cross-Section Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS #92663

	Sink Hole Creek Reach 1																	
Parameter	Cross Section 1 Pool						Cross Section 2 Riffle						Cross Section 3 Riffle					
	AB	MY1	MY2	MY3*	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	14.1	16.6	13.6	13.8	13.5	14.4	12.9	12.6	10.8	8.1	9.1	12.8	14.2	14.3	14.4	13.5	13.0	13.8
Floodprone Width (ft)	64.0	66.6	64.0	>67.0	>67.0	>65	69.4	69.4	69.3	69.4	>70.0	>69	58.0	56.7	58.0	58.6	60.0	>56
BF Cross Sectional Area (ft2)	18.6	20.3	19.0	25.1	23.3	22.3	12.2	9.8	6.0	5.3	5.5	5.8	17.4	14.5	16.0	14.5	14.4	15.0
BF Mean Depth (ft)	1.31	1.23	1.39	1.83	1.73	1.56	0.95	0.78	0.56	0.65	0.61	0.45	1.23	1.01	1.11	1.07	1.11	1.09
BF Max Depth (ft)	2.51	2.69	2.56	3.40	3.36	3.28	1.48	1.34	1.46	1.42	1.42	1.70	1.96	1.76	1.83	2.05	1.93	1.84
Width/Depth Ratio	10.8	13.5	9.8	7.5	7.8	9.2	13.6	16.2	19.2	12.6	14.8	28.2	11.6	14.1	13.0	12.6	11.8	12.6
Entrenchment Ratio	>4.5	4.0	4.7	4.8	4.9	4.6	>5.4	5.5	6.4	8.5	7.7	5.4	>4.1	4.0	4.0	4.3	4.4	4.2
Wetted Perimeter (ft)	16.8	19.0	16.4	17.4	17.0	17.5	14.8	14.2	11.9	9.4	10.3	13.7	16.7	16.3	16.7	15.6	15.2	15.9
Hydraulic Radius (ft)	1.1	1.1	1.2	1.4	1.4	1.3	0.8	0.7	0.5	0.6	0.5	0.4	1.0	0.9	1.0	0.9	0.9	0.9
Substrate	*Correction of data made during MY4.																	
d50 (mm)																		
d84 (mm)																		

	Sink Hole Creek Reach 2																	
Parameter	Cross Section 4 Pool						Cross Section 5 Riffle						Cross Section 6 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	13.1	13.0	12.6	10.6	15.5	9.6	16.7	16.4	14.1	17.4	20.6	23.7	13.1	12.3	13.9	14.2	13.3	15.0
Floodprone Width (ft)	80.4	80.1	80.0	85.0	83.5	84.0	70.1	67.7	71.8	73.8	74.4	73.6	54.3	51.3	52.2	54.6	55.0	>55.1
BF Cross Sectional Area (ft2)	14.2	13.4	10.8	11.7	10.9	10.5	23.3	21.4	18.8	24.3	27.1	23.7	15.5	12.9	13.8	13.8	11.9	12.6
BF Mean Depth (ft)	1.08	1.02	0.86	0.51	0.70	1.09	1.40	1.31	1.33	1.40	1.32	1.37	1.18	1.04	1.00	0.97	0.90	0.84
BF Max Depth (ft)	1.67	1.71	1.83	2.21	2.16	2.28	2.36	2.14	2.46	2.55	2.64	2.68	1.88	1.65	1.75	1.95	1.88	2.03
Width/Depth Ratio	12.1	12.7	14.7	20.7	22.1	8.9	11.9	12.5	10.6	12.4	15.6	12.7	11.0	11.8	13.9	14.6	14.9	17.9
Entrenchment Ratio	6.1	6.1	6.3	8.0	5.4	8.9	4.2	4.1	5.1	4.3	3.6	4.3	>4.2	4.2	3.8	3.8	4.0	3.7
Wetted Perimeter (ft)	15.3	15.1	14.4	11.6	16.9	11.8	19.5	19.0	16.8	20.2	23.2	26.4	15.4	14.4	15.9	16.1	15.1	16.7
Hydraulic Radius (ft)	0.9	0.9	0.8	1.0	0.6	0.9	1.2	1.1	1.1	1.2	1.2	0.9	1.0	0.9	0.9	0.9	0.8	0.8

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	0	0	0	30	70	51	30	70	51	30	70	51	30	70	51	30	70	51
Radius of Curvature (ft)	0	0	0	32	51	39	32	51	39	32	51	39	32	51	39	32	51	39
Meander Wavelength (ft)	0	0	0	135	331	227	135	331	227	135	331	227	135	331	227	135	331	227
Meander Width Ratio	0.0	0.0	0.0	1.8	5.5	3.8	1.8	5.5	3.8	1.8	5.5	3.8	1.8	5.5	3.8	1.8	5.5	3.8
Profile																		
Riffle length (ft)	9	56	22	9	46	27	9	46	23	10	42	22	7	57	29	9	66	25
Riffle Slope (ft/ft)	0.010	0.050	0.020	0.007	0.046	0.020	0.003	0.052	0.017	0.014	0.041	0.024	0.008	0.108	0.020	0.019	0.052	0.030
Pool Length (ft)	7	21	14	4	17	11	7	25	13	10	27	17	8	55	18	3	48	20
Pool Spacing (ft)	12	66	39	11	62	46	9	77	36	9	64	33	8	93	24	10	66	29
Substrate																		
d50 (mm)	31(R1) / 26(R2)			34(R1) /110(R2)			42(R1) /58(R2)			41(R1) /52(R2)			19(R1) /55.6(R2)			26(R1) /19(R2)		
d84 (mm)	93(R1) / 79(R2)			110(R1) /134(R2)			119(R1) /143(R2)			113(R1) /128(R2)			40(R1) /134(R2)			68(R1) /72(R2)		
Additional Reach Parameters																		
Valley Length (ft)*	2068			2068			2068			2068			2068			2068		
Channel Length (ft)*	2231			2241			2241			2240			2240			2236		
Sinuosity*	1.08			1.08			1.08			1.08			1.08			1.08		
Water Surface Slope (ft/ft)	0.025			0.025			0.025			0.025			0.025			0.025		
BF Slope (ft/ft)	0.025			0.026			0.026			0.026			0.026			0.025		
Rosgen Classification	B/Cb4			Cb4/Eb4			Cb4/Eb4			Cb4/Eb4			Cb4/Eb4			Cb4/Eb4		

*Channel length, Valley Length and Sinuosity for each year has been corrected as length was not reported correctly in past reports.

Table 14. Sink Hole Cr. Cross-Section Morphology Data Table

Table 14. Cross-Section Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS #92663

UT1 Reach 2

Parameter	Cross Section 1 Pool						Cross Section 2 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	12.7	11.9	10.4	9.1	10.5	13.2	9.5	12.5	11.0	10.5	6.2	10.4
Floodprone Width (ft)	44.8	44.0	44.1	42.9	42.6	43.5	36.9	37.3	33.1	38.7	>38.0	>39.1
BF Cross Sectional Area (ft2)	12.3	10.0	7.2	9.4	8.1	8.5	4.3	4.1	1.7	4.0	2.7	3.4
BF Mean Depth (ft)	0.97	0.84	0.69	1.03	0.77	0.64	0.45	0.33	0.15	0.38	0.44	0.33
BF Max Depth (ft)	1.55	1.42	1.49	1.47	1.40	1.38	0.83	0.79	0.41	1.10	1.08	0.87
Width/Depth Ratio	13.1	14.1	15.2	8.8	13.6	20.5	21.1	37.7	72.4	27.4	13.9	32.0
Entrenchment Ratio	3.5	3.7	4.2	4.7	4.1	3.3	3.9	3.0	3.0	3.7	6.2	3.6
Wetted Perimeter (ft)	14.6	13.6	11.8	11.2	12.1	14.5	10.4	13.1	11.3	11.2	7.1	11.1
Hydraulic Radius (ft)	0.8	0.7	0.6	0.8	0.7	0.6	0.4	0.3	0.1	0.4	0.4	0.3
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	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)	5	20	13	5	22	14	5	21	15	13	18	15	3	24	15	8	98	22
Riffle Slope (ft/ft)	0.025	0.062	0.043	0.021	0.073	0.037	0.029	0.083	0.041	0.030	0.063	0.043	0.012	0.077	0.032	0.013	0.144	0.044
Pool Length (ft)	5	11	8	4	13	6	5	10	7	7	13	12	5	17	11	5	13	9
Pool Spacing (ft)	11	34	15	10	37	17	10	34	19	11	32	19	11	40	17	10	33	18
Substrate																		
d50 (mm)		-			-			-			-			-			-	
d84 (mm)		-			-			-			-			-			-	
Additional Reach Parameters																		
Valley Length (ft)*		468			468			468			468			468			468	
Channel Length (ft)*		511			513			510			509			508			510	
Sinuosity*		1.09			1.10			1.09			1.09			1.09			1.09	
Water Surface Slope (ft/ft)		0.040			0.040			0.040			0.040			0.040			0.041	
BF Slope (ft/ft)		0.042			0.040			0.041			0.041			0.041			0.041	
Rosgen Classification		C4			C4			C4			C4			C4			C4	

*Channel length, Valley Length and Sinuosity for each year has been corrected as length was not reported correctly in past reports.

Table 14. UT1 - R2 Cross-Section Morphology Data Table

Table 14. Cross-Section Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS #92663

UT2 Reach 1

Parameter	Cross Section 1 Riffle						Cross Section 2 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	4.2	4.4	5.1	3.8	5.8	6.2	7.0	5.4	5.4	4.6	7.0	8.4
Floodprone Width (ft)	30.6	31.9	19.2	36.5	27.2	27.0	30.2	26.6	24.9	22.9	28.6	29.0
BF Cross Sectional Area (ft2)	1.1	0.9	0.7	0.7	0.8	0.6	5.3	2.9	2.4	2.1	4.3	4.4
BF Mean Depth (ft)	0.26	0.20	0.15	0.18	0.15	0.10	0.75	0.54	0.44	0.45	0.62	0.52
BF Max Depth (ft)	0.53	0.53	0.25	0.64	0.30	0.20	1.40	1.09	0.84	0.93	1.27	1.11
Width/Depth Ratio	16.3	21.5	34.8	20.5	39.8	64.2	9.4	10.1	12.2	10.4	11.4	16.1
Entrenchment Ratio	7.2	7.3	3.8	9.7	4.7	4.2	4.3	4.9	4.6	4.9	4.1	3.5
Wetted Perimeter (ft)	4.7	4.8	5.4	4.1	6.1	6.4	8.5	6.5	6.3	5.5	8.3	9.5
Hydraulic Radius (ft)	0.2	0.2	0.1	0.2	0.1	0.1	0.6	0.4	0.4	0.4	0.5	0.5
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	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)	4	18	11	4	18	12	4	19	13	5	22	14	4	25	15	7	52	22
Riffle Slope (ft/ft)	0.046	0.149	0.123	0.045	0.176	0.121	0.047	0.185	0.118	0.057	0.170	0.123	0.022	0.143	0.093	0.058	0.202	0.124
Pool Length (ft)	3	10	7	3	11	8	7	14	11	8	13	11	3	13	7	3	12	8
Pool Spacing (ft)	10	22	13	7	22	13	9	34	13	11	34	13	9	49	18	9	19	12
Substrate																		
d50 (mm)		-			-			-			-							
d84 (mm)		-			-			-			-							
Additional Reach Parameters																		
Valley Length (ft)*		608			608			608			608			608			608	
Channel Length (ft)*		627			627			626			624			627			625	
Sinuosity*		1.03			1.03			1.03			1.03			1.03			1.03	
Water Surface Slope (ft/ft)		0.107			0.105			0.106			0.106			0.106			0.104	
BF Slope (ft/ft)		0.107			0.107			0.109			0.109			0.109			0.105	
Rosgen Classification		A/B			A/B			A/B			A/B			A/B			A/B	

*Channel length, Valley Length and Sinuosity for each year has been corrected as length was not reported correctly in past reports.

Table 14. UT2 - R1 Cross-Section Morphology Data Table

Table 14. Cross-Section Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS #92663

UT2 Reach 2																		
Parameter	Cross Section 3 Riffle						Cross Section 4 Riffle						Cross Section 5 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	4.9	5.1	5.7	5.3	6.0	5.3	6.0	6.5	6.9	6.9	7.0	7.0	8.4	8.4	8.4	9.0	9.9	9.0
Floodprone Width (ft)	38.3	33.2	39.1	40.9	43.7	>38.2	49.1	48.6	47.5	47.5	52.1	43.0	67.4	67.4	67.5	67.7	>67.4	>56.4
BF Cross Sectional Area (ft2)	2.5	2.2	2.7	2.5	3.1	2.6	4.9	4.7	5.1	4.8	5.1	4.7	8.1	7.3	6.6	6.8	6.4	6.0
BF Mean Depth (ft)	0.52	0.43	0.47	0.47	0.51	0.49	0.81	0.72	0.74	0.70	0.73	0.67	0.96	0.88	0.78	0.76	0.65	0.66
BF Max Depth (ft)	0.86	0.79	0.92	1.10	1.16	0.99	1.50	1.45	1.37	1.55	1.61	1.37	1.67	1.57	1.63	1.70	1.61	1.43
Width/Depth Ratio	9.5	11.9	12.1	11.3	11.7	10.8	7.4	9.0	9.3	9.9	9.6	10.6	8.8	9.6	10.9	11.8	15.2	13.6
Entrenchment Ratio	7.8	6.5	6.9	7.8	7.3	7.1	8.2	7.5	6.9	6.9	7.4	6.2	8.0	8.1	8.0	7.5	6.8	6.3
Wetted Perimeter (ft)	5.9	5.9	6.6	6.2	7.0	6.3	7.6	8.0	8.4	8.3	8.5	8.4	10.3	10.1	10.0	10.5	11.2	10.3
Hydraulic Radius (ft)	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.7	0.7	0.6	0.6	0.6
Substrate																		
d50 (mm)																		
d84 (mm)																		

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	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)	13	27	18	11	27	20	8	27	18	12	27	16	9	39	22	7	25	16
Riffle Slope (ft/ft)	0.052	0.091	0.077	0.025	0.092	0.060	0.034	0.097	0.062	0.041	0.084	0.054	0.011	0.081	0.048	0.026	0.069	0.050
Pool Length (ft)	5	11	8	3	11	7	3	11	9	6	13	10	4	27	10	1	20	11
Pool Spacing (ft)	9	43	26	12	43	32	11	43	31	12	43	31	10	43	22	9	40	21
Substrate																		
d50 (mm)		-			-			-			-							
d84 (mm)		-			-			-			-							
Additional Reach Parameters																		
Valley Length (ft)*		857			857			857			857			857			857	
Channel Length (ft)*		882			882			883			884			881			884	
Sinuosity*		1.03			1.03			1.03			1.03			1.03			1.03	
Water Surface Slope (ft/ft)		0.058			0.058			0.058			0.058			0.058			0.124	
BF Slope (ft/ft)		0.055			0.056			0.055			0.055			0.055			0.055	
Rosgen Classification		A/B			A/B			A/B			A/B			A/B			A/B	

*Channel length, Valley Length and Sinuosity for each year has been corrected as length was not reported correctly in past reports.

Table 14. UT2 - R2 Cross-Section Morphology Data Table

Table 14. Cross-Section Morphology Data Table
Sink Hole Creek Mitigation Project, NCDMS #92663

UT3

Parameter	Cross Section 1 Riffle						Cross Section 2 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	5.2	6.6	6.2	6.9	9.2	8.2	6.2	6.9	6.9	7.48	6.88	7.23
Floodprone Width (ft)	25.2	35.9	29.2	37.8	36.2	37.0	44.5	46.8	47.4	47.54	42.60	38.00
BF Cross Sectional Area (ft2)	2.1	3.9	3.1	3.6	3.9	3.7	4.2	5.6	5.7	6.00	4.40	4.00
BF Mean Depth (ft)	0.41	0.58	0.50	0.53	0.43	0.46	0.69	0.82	0.81	0.80	0.64	0.55
BF Max Depth (ft)	0.76	0.98	0.76	1.01	0.81	0.91	1.28	1.42	1.48	1.60	1.13	0.82
Width/Depth Ratio	12.7	11.5	12.5	13.1	21.4	17.8	9.0	8.4	8.5	9.3	10.7	13.2
Entrenchment Ratio	4.8	5.4	4.7	5.5	3.9	4.5	7.2	6.8	6.8	6.4	6.2	5.3
Wetted Perimeter (ft)	6.0	7.8	7.2	7.9	10.1	9.1	7.6	8.5	8.6	9.1	8.2	8.3
Hydraulic Radius (ft)	0.4	0.5	0.4	0.5	0.4	0.4	0.6	0.7	0.7	0.7	0.5	0.5
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	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)	10	27	14	11	21	19	5	28	17	10	31	17	4	33	13.4	13	28	21.3
Riffle Slope (ft/ft)	0.060	0.168	0.113	0.064	0.169	0.123	0.091	0.158	0.108	0.093	0.168	0.113	0.010	0.232	0.086	0.097	0.214	0.119
Pool Length (ft)	3	6	5	4	9	5	2	7	4	4	7	6	4	14	8	4	18	10
Pool Spacing (ft)	10	21	17	8	23	17	9	24	14	10	22	15	12	26	17	5	23	14
Substrate																		
d50 (mm)	-			-			-			-								
d84 (mm)	-			-			-			-								
Additional Reach Parameters																		
Valley Length (ft)*	624			624			624			624			624			624		
Channel Length (ft)*	638			638			637			636			636			629		
Sinuosity*	1.02			1.02			1.02			1.02			1.02			1.01		
Water Surface Slope (ft/ft)	0.105			0.106			0.106			0.106			0.106			0.110		
BF Slope (ft/ft)	0.111			0.111			0.114			0.114			0.114			0.112		
Rosgen Classification	A/B			A/B			A/B			A/B			A/B			A/B		

*Channel length, Valley Length and Sinuosity for each year has been corrected as length was not reported correctly in past reports.

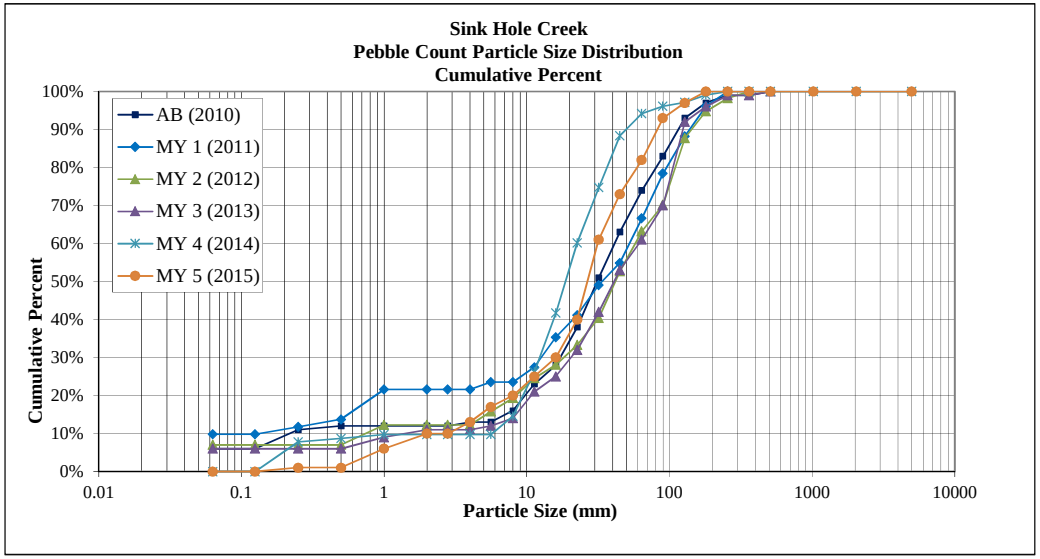
Table 14. UT3
Cross-Section Morphology
Data Table

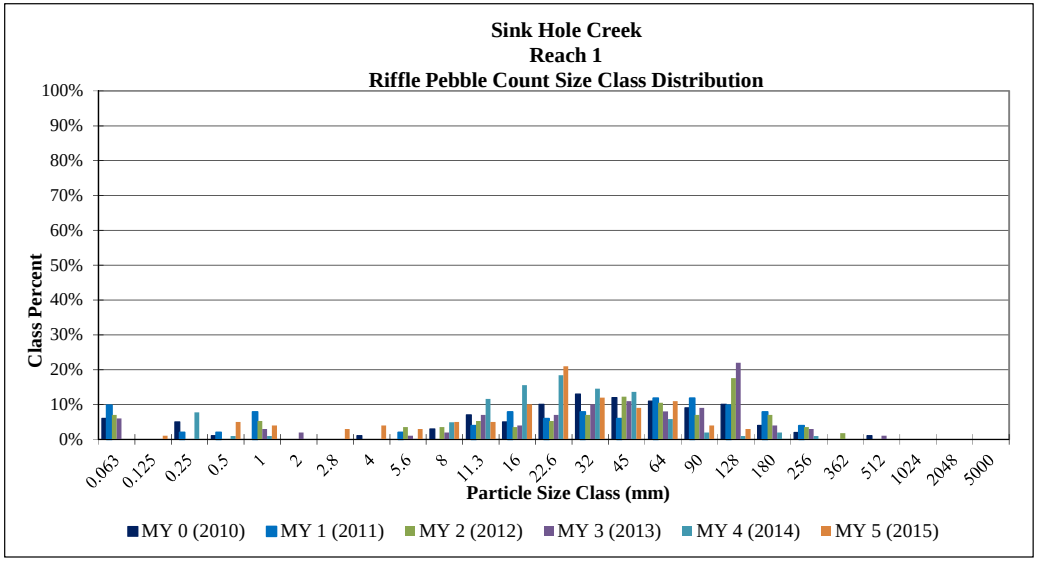
Cross-Section Pebble Count (Sink Hole Creek-Reach 1)
Sink Hole Creek Mitigation Project, DMS# 92663

SITE OR PROJECT:	Sink Hole Creek
REACH/LOCATION:	Reach 1, 1st riffle downstream of VP6
FEATURE:	Riffle

			2015		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt/Clay	Silt / Clay	< .063		0%	0%
Sand	Very Fine	.063 - .125		0%	0%
	Fine	.125 - .25	1	1%	1%
	Medium	.25 - .50		0%	1%
	Coarse	.50 - 1.0	5	5%	6%
	Very Coarse	1.0 - 2.0	4	4%	10%
Gravel	Very Fine	2.0 - 2.8		0%	10%
	Very Fine	2.8 - 4.0	3	3%	13%
	Fine	4.0 - 5.6	4	4%	17%
	Fine	5.6 - 8.0	3	3%	20%
	Medium	8.0 - 11.0	5	5%	25%
	Medium	11.0 - 16.0	5	5%	30%
	Coarse	16 - 22.6	10	10%	40%
	Coarse	22.6 - 32	21	21%	61%
	Very Coarse	32 - 45	12	12%	73%
	Very Coarse	45 - 64	9	9%	82%
Cobble	Small	64 - 90	11	11%	93%
	Small	90 - 128	4	4%	97%
	Large	128 - 180	3	3%	100%
	Large	180 - 256		0%	100%
Boulder	Small	256 - 362		0%	100%
	Small	362 - 512		0%	100%
	Medium	512 - 1024		0%	100%
	Large-Very Large	1024 - 2048		0%	100%
Bedrock	Bedrock	> 2048		0%	100%
Total % of whole count			100	100%	100%

Summary Data	
Channel materials	
D_{16} = 5.2	D_{84} = 68.1
D_{35} = 19.0	D_{95} = 107.3
D_{50} = 26.7	D_{100} = 128 - 180



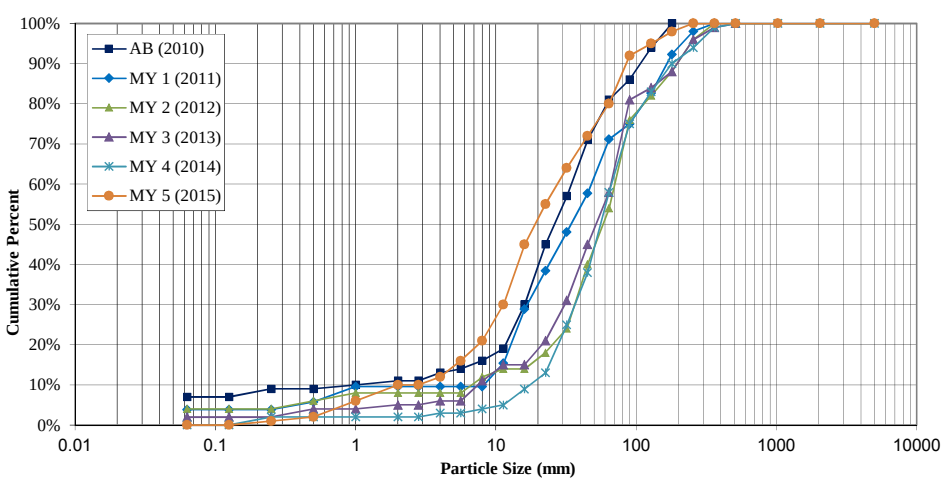


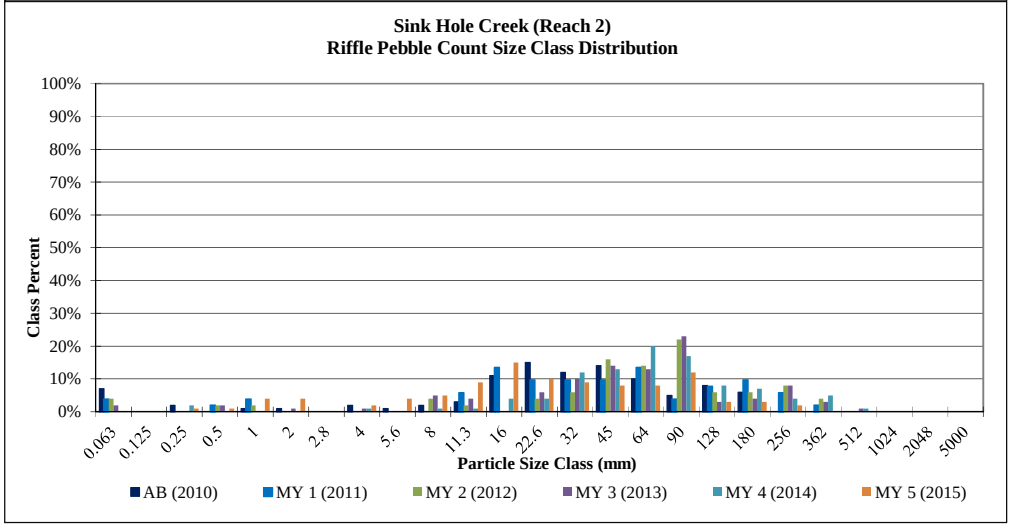
Cross-Section Pebble Count (Sink Hole Creek-Reach 2)
Sink Hole Creek Mitigation Project, DMS# 92663

SITE OR PROJECT:	Sink Hole Creek
REACH/LOCATION:	Reach 2, 1st riff upstream of VP4
FEATURE:	Riffle

			2015		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt/Clay	Silt / Clay	< .063		0%	0%
Sand	Very Fine	.063 - .125		0%	0%
	Fine	.125 - .25	1	1%	1%
	Medium	.25 - .50	1	1%	2%
	Coarse	.50 - 1.0	4	4%	6%
	Very Coarse	1.0 - 2.0	4	4%	10%
Gravel	Very Fine	2.0 - 2.8		0%	10%
	Very Fine	2.8 - 4.0	2	2%	12%
	Fine	4.0 - 5.6	4	4%	16%
	Fine	5.6 - 8.0	5	5%	21%
	Medium	8.0 - 11.0	9	9%	30%
	Medium	11.0 - 16.0	15	15%	45%
	Coarse	16 - 22.6	10	10%	55%
	Coarse	22.6 - 32	9	9%	64%
	Very Coarse	32 - 45	8	8%	72%
	Very Coarse	45 - 64	8	8%	80%
Cobble	Small	64 - 90	12	12%	92%
	Small	90 - 128	3	3%	95%
	Large	128 - 180	3	3%	98%
	Large	180 - 256	2	2%	100%
Boulder	Small	256 - 362		0%	100%
	Small	362 - 512		0%	100%
	Medium	512 - 1024		0%	100%
	Large-Very Large	1024 - 2048		0%	100%
Bedrock	Bedrock	> 2048		0%	100%
Total % of whole count			100	100%	100%

Summary Data	
Channel materials	
D_{16} = 5.6	D_{84} = 71.7
D_{35} = 12.5	D_{95} = 128.0
D_{50} = 19.0	D_{100} = 180 - 256





Sink Hole Creek
Photo Log - Reference Photo Points

Notes: Photos for Sink Hole Creek were taken October 21, 2015.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Photo Point 7: looking upstream

Photo Point 7: looking downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

Photo Point 9: looking upstream

Photo Point 9: looking downstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

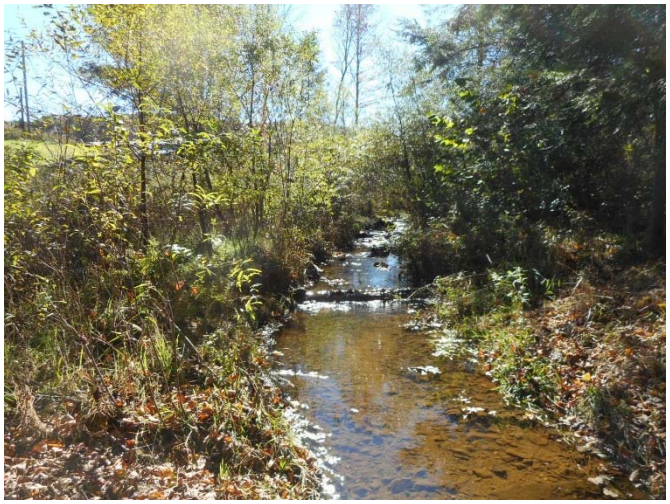


Photo Point 11: looking upstream

Photo Point 11: looking downstream

Photo Point 12: looking upstream

Photo Point 12: looking downstream

Photo Point 13: looking upstream

Photo Point 13: looking downstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Sink Hole Creek – UT1, Reach 1, Preservation Reach
Photo Log - Reference Photo Points

Notes: Photos for UT1, Reach 1 Preservation Reach were taken in October 21, 2015.

1. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking upstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Photo Point 7: looking upstream

Photo Point 7: looking downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

UT 1 to Sink Hole Creek-Reach 2
Photo Log - Reference Photo Points

Notes: Photos for UT1-Reach 2 were taken in October 21, 2015.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

UT1 Photo Point 1: looking upstream

UT1 Photo Point 1: looking downstream

UT1 Photo Point 2: looking upstream

UT1 Photo Point 2: looking downstream

UT1 Photo Point 3: looking upstream

UT1 Photo Point 3: looking downstream

UT1 Photo Point 4: looking upstream

Sink Hole Creek – UT2
Photo Log - Reference Photo Points

Notes: Photos for UT2 were taken October 21, 2015.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Photo Point 7: looking upstream

Photo Point 7: downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

Photo Point 9: looking upstream

Photo Point 9: looking downstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

Photo Point 11: looking upstream

Photo Point 11: looking downstream

Photo Point 12: looking upstream

Photo Point 12: looking downstream

Photo Point 13: looking upstream

Photo Point 13: looking downstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Sink Hole Creek – UT3
Photo Log - Reference Photo Points

Notes: Photos for UT3 were taken October 21, 2015.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream