

**CEDAR CREEK STREAM AND WETLAND RESTORATION  
PROJECT  
MONITORING REPORT  
MONITORING YEAR 5  
FINAL**

SAMPSON COUNTY, NORTH CAROLINA  
CONTRACT No. 005011 - PROJECT No. 95718  
USACE ACTION ID No. 2012-00389 – NCDWR PROJECT No. 2013-0186



Prepared for:

**Division of Mitigation Services**  
North Carolina Department of Environmental Quality  
1652 Mail Service Center  
Raleigh, NC 27699-1652

February 2020

Mitigation Project Name Cedar Creek  
 DMS ID 95718  
 River Basin Cape Fear  
 Cataloging Unit 03030006

County Sampson  
 Date Project Instituted 12/14/2012  
 Date Prepared 6/18/2019

USACE Action ID 2013-00389  
 NCDWR Permit No 2013-0186

Credit Release Milestone	Stream Credits						Wetland Credits							
	Scheduled Releases (Stream)	Warm	Cool	Cold	Anticipated Release Year (Stream)	Actual Release Date (Stream)	Scheduled Releases (Forested)	Riparian Riverine	Riparian Non-riparian	Non-riparian	Scheduled Releases (Coastal)	Coastal	Anticipated Release Year (Wetland)	Actual Release Date (Wetland)
Potential Credits (Mitigation Plan)	5,229.930						13.100							
Potential Credits (As-Built Survey)	5,275.930						13.720							
Potential Credits (IRT Approved)	5,229.933						13.100							
1 (Site Establishment)	N/A				N/A	N/A	N/A				N/A		N/A	N/A
2 (Year 0 / As-Built)	30%	1,582.779			2016	2/19/2016	30%	4.116			30%		2016	2/19/2016
3 (Year 1 Monitoring)	10%	527.593			2016	4/25/2016	10%	1.372			10%		2016	4/25/2016
4 (Year 2 Monitoring)	10%	522.993			2017	8/8/2017	10%	1.310			15%		2017	8/8/2017
IRT Adjustment*		-18.400				8/8/2017		-0.248						8/8/2017
5 (Year 3 Monitoring)** - Resubmitted	10%	522.993			2018	4/26/2019	10%	1.310			20%		2018	4/26/2019
6 (Year 4 Monitoring)	5%	261.497			2019	4/26/2019	10%	1.310			10%		2019	4/26/2019
7 (Year 5 Monitoring)	10%				2020		10%				15%		2020	
8 (Year 6 Monitoring)	5%				2021		10%				N/A		2021	
9 (Year 7 Monitoring)	10%				2022		10%				N/A		2022	
Stream Bankfull Standard	10%	522.993			2019	4/26/2019	N/A				N/A			
Total Credits Released to Date		3,922.449						9.170						

**NOTES:**

8/8/2017: Adjustment required due to IRT concerns on how the as-built credits were calculated  
 5/22/2018: Due to concerns expressed by the IRT, no stream or wetland credits were released from this site for the 2017 monitoring cycle.

**CONTINGENCIES:**

  
 Signature of Wilmington District Office Approving Credit Release

27 Sept 2019

Date

- 1 - For NCDMS, no credits are released during the first milestone
- 2 - For NCDMS projects, the second credit release milestone occurs automatically when the as-built report (baseline monitoring report) has been made available to the NCIRT by posting it to the NCDMS Portal, provided the following criteria have been met:
  - 1) Approval of the final Mitigation Plan
  - 2) Recordation of the preservation mechanism, as well as a title opinion acceptable to the USACE covering the property
  - 3) Completion of all physical and biological improvements to the mitigation site pursuant to the mitigation plan
  - 4) Receipt of necessary DA permit authorization or written DA approval for projects where DA permit issuance is not required
- 3 - A 10% reserve of credits is to be held back until the bankfull event performance standard has been met







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February 4, 2020

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NC DEQ Division of Mitigation Services  
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Raleigh, NC 27604

RE: Cedar Creek Stream and Wetland Restoration Site: MY5 Monitoring Report (NCDMS ID 95718)

Listed below are comments provided by DMS on January 17, 2020 regarding the Cedar Creek Stream and Wetland Restoration Site: Year 5 Monitoring Report and RES' responses.

### 1. Digital files

a. Features for UT1 (44+60 to 53+51), UT2 (3+48 to 9+12), UT3, UT4, and Wetland 1 in geodatabase do not match the values reported in the asset table. DMS needs representative features for these creditable assets.

[GIS shapefiles as well as the design CAD files are attached.](#)

b. Please make note of the gauge type (e.g. transducer, RDS etc.) used in the excel data file for groundwater well and streamflow gages. Please also label any probe or benchmark elevations, the raw and corrected readings of the water elevations and any offsets applied. DMS needs to be able to clearly identify these key elevations before incorporating these into the DMS database permitting independent calculation/verification. The DMS Excel template is an example of what is needed for reference and is required for use as part of RFPS within the last several years. Please include an excel file including the raw precipitation data.

[Done. The raw precipitation data is located in the Well Charts Excel file.](#)

### 2. Appendix B

a. Figure 3b – Please update wetland gauge AW-8 to show that it met success criteria.

[Done.](#)

### 3. Appendix D

a. Table 11 – The BHR for riffle cross section 14 is reported as N/A. Please correct in Table 11 and on the cross-section graph sheet.

[Done.](#)

b. BHRs below 1.0 can be reported as <1.

[Done.](#)

c. Please show on the cross section graphs the line that encompasses the MY0 cross sectional area below the line.

[Done.](#)

### 4. Appendix E

a. Table 13 – Please make table cumulative with prior years' data.

[Done](#)

**Cedar Creek  
Sampson County, North Carolina  
DMS Project ID 95718**

**Cape Fear River Basin  
HUC 3030006090060**

**Prepared by:**



**Resource Environmental Solutions, LLC  
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919-209-1061**

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# 1 PROJECT GOALS, BACKGROUND AND ATTRIBUTES

## 1.1 Location and Setting

The Cedar Creek Stream and Wetland Site is located in Sampson County approximately 3.1 miles southwest of Clinton, NC (**Figure 1**). To access the Site from the town of Clinton, travel west on Highway 24 (Sunset Avenue), take a left onto Airport Road and go 1.3 miles. Turn right onto West Main Street Extension, go approximately 350 feet, and turn left onto a dirt farm path. Follow the farm path along the cultivated field edge to the southwest corner and enter the forest. Follow the dirt path to cultivated fields adjacent to the project below UT2. Turning to the left will take you to UT2. Going to the right will take you to UT3.

## 1.2 Project Goals and Objectives

The Cedar Creek Stream and Wetland Restoration Project has provided numerous ecological and water quality benefits within the Cape Fear River Basin. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality, hydrology, and habitat are outlined below.

### Design Goals and Objectives

<b>Benefits Related to Water Quality</b>	
Nutrient removal	Benefit will be achieved through filtering of runoff from adjacent agricultural fields through buffer areas, the conversion of active farm fields to forested buffers, improved denitrification and nutrient uptake through buffer zones, and installation of BMPs at the headwaters of selected reaches.
Sediment removal	Benefit will be achieved through the stabilization of eroding stream banks and reduction of sediment loss from field areas due to lack of vegetative cover. Channel velocities will also be decreased through a reduction in slope, therefore decreasing erosive forces.
Increase dissolved oxygen concentration	Benefit will be achieved through the construction of instream structures to increase turbulence and dissolved oxygen concentrations and riparian canopy restoration to lower water temperature to increase dissolved oxygen capacity.
Runoff filtration	Benefit will be achieved through the restoration of buffer areas that will receive and filter runoff, thereby reducing nutrients and sediment concentrations reaching water bodies downstream.
<b>Benefits to Flood Attenuation</b>	
Water storage	Benefit will be achieved through the restoration of buffer areas which will infiltrate more water during precipitation events than under current site conditions. Wetland areas will provide additional storage of runoff and flood waters.
Improved groundwater recharge	Benefit will be achieved through the increased storage of precipitation in buffer areas, ephemeral depressions, and reconnection of existing floodplain. Greater storage of water will lead to improved infiltration and groundwater recharge.
Improved/restored hydrologic connections	Benefit will be achieved by restoring the stream to a natural meandering pattern with an appropriately sized channel, such that the channel's floodplain will be flooded more frequently at flows greater than the bankfull stage.
<b>Benefits Related to Ecological Processes</b>	
Restoration of habitats	Benefit will be achieved by restoring riparian buffer habitat to appropriate bottomland hardwood ecosystem. Protected riparian corridors will create contiguous natural areas with uninterrupted migration corridors.
Improved substrate and instream cover	Benefit will be achieved through the construction of instream structures designed to improve bedform diversity and to trap detritus. Stream will be designed with the appropriate channel dimension and will prevent aggradation and sedimentation within the channel. Substrate will become coarser as a result of the stabilization of stream banks and an overall decrease in the amount fine materials deposited in the stream.

Addition of large woody debris	Benefit will be achieved through the addition of wood structures as part of the restoration design. Such structures may include log vanes, root wads, and log weirs.
Reduced temperature of water due to shading	Benefit will be achieved through the restoration of canopy tree species to the stream buffer areas.
Restoration of terrestrial habitat	Benefit will be achieved through the restoration of riparian buffer bottomland hardwood habitats.

The Cedar Creek Stream and Wetland Restoration Project is located in the Great Coharie Creek Watershed (<http://portal.ncdenr.org/web/DMS/priorities-map>). This 14-digit Hydrologic Unit Code (HUC 03003006090060) is identified as a Targeted Local Watershed (TLW) in the Cape Fear River Basin Restoration Priority (RBRP).

The North Carolina Division of Mitigation Services (NCDMS) develops River Basin Restoration Priorities (RBRP) to guide its restoration activities within each of the state's 54 cataloging units. RBRPs delineate specific watersheds that exhibit both the need and opportunity for wetland, stream and riparian buffer restoration. These TLWs receive priority for DMS planning and restoration project funds. Currently, no Local Watershed Plan (LWP) is available for the project area.

The 2009 Cape Fear RBRP identified water quality and agricultural impacts as major stressors within this TLW. The Cedar Creek Stream and Wetland Restoration Project was identified as a Stream and Wetland opportunity to improve water quality, habitat, and hydrology within the TLW.

The project goals addressed stressors identified in the TLW, and include the following:

- Water quality improvements,
- Natural resource protection, and
- Manage agricultural impacts.

The project goals were addressed through the following project objectives:

- Converting active farm fields to forested buffers,
- Stabilization of eroding stream banks,
- Reduction in stream bank slope,
- Restoration of riparian buffer bottomland hardwood habitats, and
- Construction of in-stream structures designed to improve bedform diversity.

### 1.3 Project Structure

Following 2016 monitoring the NCIRT requested a review of the differential between the Approved Mitigation Plan and Baseline Monitoring Report. The table below details the discrepancies by reach. The primary causes of increased baseline SMUs was minor field adjustments during construction along with survey methodology (thalweg vs. centerline). The Mitigation Plan lengths were based on centerline. Wetland credits increased to include restoration of a backfilled pond bed (0.22 acres) that was identified as an opportunity to expand the easement following approval of the Mitigation Plan. RES does not plan on submitting an asset revision and will revert to the Approved Mitigation Plan assets.

**Table 1a. Cedar Creek Site Project Components – Stream Mitigation**

Reach	Mitigation Type*	Proposed Length (LF)	Mitigation Ratio	Proposed SMUs	Baseline SMUs
UT1	Enhancement II	3,064	2.5:1	1,226	1,226
UT1	Enhancement I	415	1.5:1	277	277
UT1	Enhancement II	615	2.5:1	246	246
UT1	Enhancement I	265	1.5:1	177	177
UT1	Enhancement II	827	2.5:1	331	331
UT2	Headwater Valley	337	1:1	337	337
UT2	P1 Restoration	504	1:1	504	518
UT2C	Headwater Valley	190	1:1	190	193
UT3	P1 Restoration	1,912	1:1	1,912	1,941
UT4	Enhancement II	78	2.5:1	31	31
<b>Total</b>		<b>8,207</b>		<b>5,230</b>	<b>5,276</b>

\*P1=Priority 1

\*\*The contracted amount of credits for this Site is 5,000 SMUs

Wetland	Mitigation Type	Mitigation Area (ac)	Mitigation Ratio	Proposed WMUs	Baseline WMUs
W1	Restoration	13.10	1:1	13.10	13.72
<b>Total</b>		<b>13.10</b>		<b>13.10</b>	<b>13.72</b>

\*The contracted amount of credits for this Site is 9.00 WMUs

#### 1.3.1 Restoration Type and Approach

Stream restoration efforts along the unnamed tributaries to Great Coharie Creek were accomplished through analyses of geomorphic conditions and watershed characteristics. The design approach applied a combination of analytical and reference and/or analog reach based design methods that meet objectives commensurate with both ecological and geomorphic improvements. Proposed treatment activities ranged from minor bank grading and planting to re-establishing stable planform and hydraulic geometry. Reaches that required full restoration, natural design concepts have been applied and verified through rigorous engineering analyses and modeling. The objective of this approach was to design a geomorphically stable channel that provides habitat improvements and ties into the existing landscape.

Priority Level I stream restoration, headwater valley restoration, stream Enhancement Levels I and II, and stream buffers throughout the project site have been restored and protected in perpetuity. Priority Level I stream restoration was incorporated into the design of a single-thread meandering channel, with parameters based on data taken from the reference site. Priority 1 stream restoration was proposed on 2,416 linear feet of stream channel. Headwater valley restoration was applied to 527 linear feet of channel. Enhancement Level I was applied to 680 linear feet of channel that required buffer enhancement, bank stabilization and habitat improvements. Enhancement Level II was applied to an additional 4,584 linear feet of channel that required buffer enhancement and/or minimal bank and habitat improvements.

### **UT1**

UT1 flows from southeast to northwest across the project, totaling 5,186 linear feet of Enhancement Level I and II. The upper-most portion of UT1 (reaches UT1A and UT1B) is stable and has a forested buffer along both banks; however, privet was dominant within the right buffer. The downstream portion of UT1 (reaches UT1C, UTD and UT1E) was moderately stable and exhibited some areas of localized erosion prior to mitigation activities. The buffer along this section consisted of a five year old clear-cut along the left bank and cultivated fields along the right bank. A 60-foot easement break is present within the downstream section (UT1E) to account for an existing farm crossing which has been upgraded. 680 linear feet of Enhancement Level I was performed along reach UT1. Selective locations were identified to include streambed structures, minor bank grading, planting a native stream buffer and invasive species control. Primarily, Stabilization/Enhancement II activities included performing minor bank grading, planting the buffer with native vegetation, and invasive species control.

### **UT2**

UT2 is the middle tributary of the project, totaling 337 linear feet of headwater valley restoration along the upstream section and 518 linear feet of Priority 1 restoration through the downstream section. The upper section of the channel was channelized and bordered by cultivated fields to the northwest and a pine stand to the southeast, while the lower portion was a small ditch surrounded by cultivated fields. The headwater valley portion relocated the flow path to the natural valley (to the left of the existing ditch), and the abandoned ditch has been back filled. The performed P1 restoration included relocating the channel to follow the natural valley and emptying into Cedar Creek near STA 25+50. A 60-foot easement break crossing is present at STA 4+66 along UT2. Twin 24" HDPE culverts were installed within the easement break crossing. Restoration activities included constructing a meandering channel, installing habitat and drop structures, filling and plugging the abandoned channel, planting the buffer with native vegetation, and invasive species control.

### **UT2C**

UT2C is also located in the middle of the project (adjacent to UT2), totaling 193 linear feet of headwater valley restoration. The upstream end of the reach begins at an existing wetland that borders a farm path to the north. Flow from the wetland originally had been diverted to a ditch that ran east-west along the farm path before it was conveyed across the path and into UT2 near the upstream end. Restoration activities involved redirecting channel flow to the natural valley and grading out the existing ditch and path such that the area matches existing grade on either side of the path. Additional activities included planting the buffer with native vegetation and invasive species control.

### **UT3**

UT3 is the western most tributary of the project, totaling 1,941 linear feet of Priority 1 restoration. The upper section of the channel was incised/oversized and began at a pond outlet east of the airport and flowed through a wooded area consisting of saplings and some mature hardwoods, while the lower section flowed through a cultivated field. The restored channel has been relocated to the west to follow the natural valley, and now flows through the middle of the wetland restoration area (W1). UT3 now

outlets into Cedar Creek near STA 43+10. Restoration activities included constructing a meandering channel, installing habitat and grade control structures, filling and plugging the abandoned channel, planting the buffer with native vegetation, and invasive species control. Small ditches located adjacent to UT3 and within the conservation easement have also been plugged and filled to redirect and diffuse flow through the wetland restoration area and/or into UT3.

#### **UT4**

UT4 is the eastern most tributary of the project, totaling 78 linear feet of Enhancement Level II. The reach was relatively stable, but had been historically channelized. The buffer along this section consisted of an agricultural field along the right bank, and a forested buffer along the left bank; however, privet was common within the left buffer. Stabilization/Enhancement II activities included performing minor bank grading, cutting a floodplain bench, and planting the buffer with native vegetation, and invasive species control.

#### **Wetland W1**

This 13.72-acre wetland is located along UT3 and where it reaches the confluence of with UT1 Reach E. The pre-restoration land use was sparsely wooded and active cropland. Wetland restoration activities consisted of removing valley fill, filling drainage ditches, removing subsurface drainage tiles, and raising adjacent stream channels to reconnect the floodplain with seasonal and out of bank flows. Raising the stream bed will also reduce the “dry shoulder” effect near the stream channel. Specific wetland restoration activities included: reconnecting low lying areas of hydric soil with the floodplain, plugging agricultural drainage ditches, planting native tree and shrub species commonly found in small stream swamp ecosystems, and surface roughening to increase infiltration and storage. Wetland restoration activities also included the breaching, backfilling, and planting of an old pond (0.22 acres) that was identified after Mitigation Plan approval. The IRT has not approved these additional 0.22 acres therefore RES will revert back to the 13.10 WMUs from the Approved Mitigation Plan. Wetland restoration limits and hydroperiods will be determined by on-site soil investigations and hydrologic modeling in conjunction with pre-construction water table monitoring at the restoration sites and reference wetlands. Combined with the stream restoration, these actions will result in a sufficiently high water table and flood frequency to support hydrophytic vegetation and wetland hydrology, resulting in restored riparian wetlands.

### **1.4 Project History, Contacts and Attribute Data**

#### **1.4.1 Project History**

The Cedar Creek Stream and Wetland Restoration Site was restored by Resource Environmental Solutions, LLC (RES) through a full-delivery contract awarded by NCDMS in 2012. Tables 2, 3, and 4 in **Appendix A** provide a time sequence and information pertaining to the project activities, history, contacts, and baseline information.

#### **1.4.2 Project Watersheds**

The easement totals 42.0 acres and is broken into four tributaries, UT1, UT2, UT3, and UT4. The land use in the 2,778-acre (4.34 mi<sup>2</sup>) project watershed that drains to UT1 consisted of row crop production, livestock production, silviculture, and sand mining areas. Past land use practices caused increased erosion and sedimentation along drainage-ways and stream banks in the watershed.

UT2 has a drainage area of 32 acres (0.05 mi<sup>2</sup>) and flows southwest into UT1. Land use in this small drainage area consisted entirely of row crop production and disturbed hardwood forest. UT2 originated in a disturbed hardwood forest and flows through a cultivated field to its confluence with UT1.

UT3 has a drainage area of 147 acres (0.23 mi<sup>2</sup>) and flows south into UT1. Land use in this drainage area consisted of row crop production, historical and future livestock production, disturbed hardwood forest, maintained open space, and impervious surfaces associated with residential commercial development. Portions of the Sampson County Airport, including parts of the runway, terminal, and apron areas, lie within the UT3 drainage area. UT3 originates at a pond that is adjacent to the airport property. This reach flowed through a disturbed hardwood forest, and then through a cultivated field to its confluence with UT1.

UT4 has a drainage area of 77 acres (0.12 mi<sup>2</sup>), originates within a disturbed hardwood forest, and flows southwest into UT1. Land use in this small drainage area consisted of a mix of row crop production and disturbed hardwood forest located primarily along the drainage way.

UT2, UT3 and UT4 were straightened, dredged, or re-aligned in the past to promote drainage. Soil investigations showed that much of the low-lying landscape adjacent to UT1 and its confluences with UT2 and UT3 exhibited hydric characteristics and a shallow seasonal high water table. The low lying fields in this area were considered prior converted wetlands (PC) that were drained and are currently utilized for row crop and livestock production.

The land use in the watershed is characterized by evergreen forest (47 percent), cultivation (31 percent), woody wetlands (9 percent), open space (8 percent) and shrub/scrub (5 percent).

## **2 Success Criteria**

The success criteria for the Cedar Creek Site stream restoration will follow accepted and approved success criteria presented in the USACE Stream Mitigation Guidelines and subsequent NCDMS and agency guidance. Specific success criteria components are presented below.

### **2.1 Stream Restoration**

#### **2.1.1 Bankfull Events**

Two bankfull flow events must be documented within the seven-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. Bankfull events will be documented using crest gauges, auto-logging crest gauges, photographs, and visual assessments for evidence of debris rack lines.

#### **2.1.2 Cross Sections**

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections are classified using the Rosgen stream classification method, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

#### **2.1.3 Bank Pin Arrays**

Bank pin arrays will be used as a supplemental method to monitor erosion on selected meander bends where there is not a cross section. Bank pin arrays will be installed along the outer bend of the meander. Bank pins will be installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with

the bank. There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

#### **2.1.4 Digital Image Stations**

Digital images are used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal images should not indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral images should not indicate excessive erosion or continuing degradation of the banks over time. A series of images over time should indicate successional maturation of riparian vegetation.

### **2.2 Wetland Restoration**

Success criteria and monitoring for wetland hydrology within the wetland restoration areas on the site follows NCDMS Guidance dated 7 November 2011. The target minimum wetland hydroperiod is 9 percent of the growing season. Stream hydrology and water balance calculations indicate the wetland area will meet jurisdictional criteria (5 percent hydroperiod). However, due to immature vegetation and reduced PET, a longer success criterion is appropriate. Auto recording gauges are used to measure daily groundwater elevations throughout the Sampson County growing season in all seven years of monitoring.

If a hydrology gauge location fails to meet these success criteria in the seven-year monitoring period then monitoring may be extended, remedial actions may be undertaken, or groundwater modeling may be used to demonstrate the limits of wetland restoration.

### **2.3 Vegetation Success Criteria**

Specific and measurable success criteria for plant density within the wetland restoration and riparian buffers on the site will follow NCDMS Guidance dated 7 November 2011. Vegetation monitoring plots are a minimum of 0.02 acres in size, and cover a minimum of two percent of the planted area. The following data is recorded for all trees in the plots: species, height, planting date (or volunteer), and grid location. Monitoring occurs in the fall of Years 1, 2, 3, 5, and 7. The interim measures of vegetative success for the site is the survival of at least 320 three-year old planted trees per acre at the end of Year 3, and 260 planted trees per acre at the end of Year 5. The final vegetative success criteria is the survival of 210 planted trees per acre at the end of Year 7 of the monitoring period.

Invasive and noxious species will be monitored and controlled so that none become dominant or alter the desired community structure of the site. If necessary, RES will develop a species-specific control plan.

### **2.4 Scheduling/Reporting**

The monitoring program will be implemented to document system development and progress toward achieving the success criteria. The restored stream morphology is assessed to determine the success of the mitigation. The monitoring program will be undertaken for seven years or until the final success criteria are achieved, whichever is longer.

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCDMS. The monitoring reports will include all information, and be in the format required by NCDMS in Version 2.0 of the NCDMS Monitoring Report Template (Oct. 2010).

### **3 MONITORING PLAN**

Annual monitoring data will be reported using the NCDMS monitoring template. Annual monitoring shall be conducted for stream, wetland, and vegetation monitoring parameters as noted below.

#### **3.1 Stream Restoration**

##### **3.1.1 As-Built Survey**

An as-built survey was conducted following construction to document channel size, condition, and location. The survey will include a complete profile of thalweg, water surface, bankfull, and top of bank to compare with future geomorphic data. Longitudinal profiles will not be required in annual monitoring reports unless requested by NCDMS or USACE.

##### **3.1.2 Bankfull Events**

Three sets of manual and auto-logging crest gauges were installed on the site, one along UT2, one along UT2C, and one along UT3. The auto logging crest gauges were installed within the channel and will continuously record flow conditions at an hourly interval. Manual crest gauges were installed on the bank at bankfull elevation. Crest gauges will be checked during each site visit to determine if a bankfull event has occurred since the last site visit. Crest gauge readings and debris rack lines will be photographed to document evidence of bankfull events.

##### **3.1.3 Cross Sections**

A total of 27 permanent cross sections were installed to monitor channel dimensions and stability. Cross sections were typically located at representative riffle/shallows and pool sections along each stream reach. Four cross sections were installed along UT1 where enhancement activities were performed. Eight cross sections (three pools, two runs, and three shallows) were installed along UT2. UT2C has one cross section installed throughout its length. Stream reach UT3 has 14 cross sections installed along its length where stream restoration was performed. Each cross section was permanently marked with 3/8 rebar pin to establish a monument location at each end. A marker pole was also installed at both ends of each cross section to allow ease locating during monitoring activities. Cross section surveys will be performed once a year during annual monitoring years 1, 2, 3, 5, and 7 and will include all breaks in slope including top of bank, bottom of bank, streambed, edge of water, and thalweg.

##### **3.1.4 Digital Image Stations**

Digital photographs will be taken at least once a year to visually document stream and vegetation conditions. This monitoring practice will continue for seven years following construction and planting. Permanent photo point locations at cross sections and vegetation plots have been established so that the same directional view and location may be repeated each monitoring year. Monitoring photographs will also be used to document any stream and vegetation problematic areas such as erosion, stream and bank instability, easement encroachment and vegetation damage.

##### **3.1.5 Bank Pin Arrays**

Eight bank pin array sets have been installed at pool cross sections located along UT2 and UT3. These bank pin arrays were installed along the upstream and downstream third of the meander. Bank pins are a minimum of three feet long, and have been installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with the bank.



### **3.1.6 Visual Assessment Monitoring**

Visual monitoring of all mitigation areas is conducted a minimum of twice per monitoring year by qualified individuals. The visual assessments include vegetation density, vigor, invasive species, and easement encroachments. Visual assessments of stream stability include a complete stream walk and structure inspection. Digital images are taken at fixed representative locations to record each monitoring event as well as any noted problem areas or areas of concern. Results of visual monitoring are presented in a plan view exhibit with a brief description of problem areas and digital images. Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal photos should indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the banks over time. A series of photos over time should indicate successional maturation of riparian vegetation.

### **3.1.7 Surface Flow**

The headwater valley restoration reaches on UT2 and UT2C will be monitored to document intermittent or seasonal surface flow. This will be accomplished through direct observation, photo documentation of dye tests, and continuous flow monitoring devices (pressure transducers). An auto logging crest gauges has been installed within the headwater valley channel and will continuously record flow conditions at an hourly interval. This gauge will be downloaded during each site visit to determine if intermittent or seasonal flows conditions are present.

## **3.2 Wetland Hydrology**

Wetland hydrology will be monitored to document hydric conditions in the wetland restoration areas. This will be accomplished with automatic recording pressure transducer gauges installed in representative locations across the restoration areas and reference wetland areas. A total of fourteen automatic recording pressure transducers (Auto-Wells) have been installed on the site. Eleven auto-wells have been installed within the wetland restoration area and three within reference areas. The gauges will be downloaded quarterly and wetland hydroperiods will be calculated during the growing season. Gauge installation followed current regulatory and DMS guidance. Visual observations of primary and secondary wetland hydrology indicators will also be recorded during quarterly site visits.

## **3.3 Vegetation**

A total of 20 vegetation plots were randomly established within the planted stream riparian buffer easement. Vegetation plots measure 10 meters by 10 meters or 5 meters by 20 meters (0.02 acres) and have all four corners marked with metal posts. Planted woody vegetation was assessed within each plot to establish a baseline dataset. Within each vegetation plot, each planted stem was identified for species, “X” and “Y” origin located, and measured for height. Reference digital photographs were also captured to document baseline conditions. Species composition, density, growth patterns, damaged stems, and survival ratios will be measured and reported on an annual basis. Vegetation plot data will be reported for each plot as well as an overall site average.

## **4 MAINTENANCE AND CONTINGENCY PLAN**

All identified problematic areas or areas of concern such as stream bank erosion/instability, aggradation/degradation, lack of targeted vegetation, and invasive/exotic species which prevent the site from meeting performance success criteria will be evaluated on a case by case basis. These areas will be documented and remedial actions will be discussed with NCDMS staff to determine a plan of action. If it is determined remedial action is required, a plan will be provided.

#### 4.1 Stream

No stream problems were identified in MY5.

#### 4.2 Wetlands

One wetland problem area was noted during the Year 5 monitoring period. The ditch between AW8 and AW7 was plugged in October 2018; however, AW7 did not meet success again in 2019. This is the fifth year in a row it did not meet success. If this well does not meet success in MY6, RES will perform a wetland delineation to remove the unsuccessful area from crediting.

#### 4.3 Vegetation

There were no vegetation problems identified in the Year 5 monitoring period.

### 5 YEAR 5 MONITORING CONDITIONS (MY5)

The Cedar Creek Year 5 Monitoring activities were completed in the middle of May 2019, the middle of August 2019 and the middle of November 2019. Year 5 wetland, stream hydrology, cross section monitoring, and vegetation monitoring data is present below and in the appendices. Data presented shows the site has no stream problem areas and no vegetation problem areas. The site is on track to meeting stream, wetland, and vegetation interim success criteria. (**Figure 3**).

#### 5.1 Year 5 Monitoring Data Collection

##### 5.1.1 Morphological State of the Channel

All morphological stream data for the MY5 dimensions were collected during the annual monitoring survey performed during May 2019. **Appendix B** includes summary data tables, morphological parameters, and stream photographs.

##### *Profile*

The baseline (MY-0) profiles closely matches the proposed design profiles. The plotted longitudinal profiles can be found on the As-Built Drawings. Longitudinal profiles will not be performed in annual monitoring reports unless requested by NCDMS or USACE. Morphological summary data tables can be found in **Appendix D**.

##### *Dimension*

The Year 5 (MY-5) cross sectional dimensions closely matches the baseline cross section parameters. Minimal changes were noticed for most Year 5 cross section surveys resulting from stable bed and bank conditions. All cross-section plots and data tables can be found in **Appendix D**.

##### *Sediment Transport*

The Year 5 conditions show that shear stress and velocities have been reduced for all six restoration reaches. Pre-construction conditions documented all six reaches as sand bed channels and remain classified as sand bed channels post-construction. Visual assessments (**Appendix B**) show the channels are transporting sediment as designed and will continue to be monitored for aggradation and degradation.

##### *Bank Pin Arrays*

Eight pool cross section locations with bank pin arrays were observed and measured for bank erosion located on the outside meander bends. If bank pin exposure was noticeable, it was measured, recorded,

photographed, and then driven flush with the bank at each monitoring location. No bank pin arrays recorded any exposure during the Year 5 monitoring season (**Table 12**).

### **5.1.2 Vegetation**

The Year 5 monitoring vegetation survey was completed in mid-August 2019 and resulted in an average of 633 planted stems per acre, well above the interim survival density of 260 stems per acre at the end of Year 5 monitoring. The average stems per vegetation plot was 14 planted stems. The minimum planted stem per plot was eight stems and the maximum was 31 stems per plot. Six volunteer tree species were noted during MY5 activities. The average planted stem height was 7.6 feet. Vegetation summary data tables can be found in **Appendix C** and vegetation plot photos in **Figure 5**.

### **5.1.3 Photo Documentation**

Permanent photo point locations have been established at cross sections, vegetation plots, stream crossings, and stream structures by RES staff. Any additional problem areas or areas of concern will also be documented with a digital photograph during monitoring activities. Stream digital photographs can be found in **Figure 4** and **Figure 5** for vegetation photos.

### **5.1.4 Stream Hydrology**

Three sets of manual and auto-logging crest gauges were installed on the site, one along UT2, one along UT2C, and one along UT3. The auto logging crest gauges were installed within the channel and continuously record flow conditions at hourly intervals. Bankfull events were recorded on one of the three crest gauges in Year 5. Crest Gauge 1 documented three bankfull events in MY5 with the highest reading being 0.8 feet above bankfull elevation. Crest Gauge 2, on the headwater valley restoration reach UT-2C, documented 122 consecutive flow days and 151 cumulative flow days in MY5. Stream hydrology data can be found in **Appendix E**.

### **5.1.5 Wetland Hydrology**

Ten of the eleven wetland gauges achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Groundwater gauge data indicate the hydroperiods being very responsive to rainfall events. Wetland hydrology gauge AW7 fell short of the nine percent success criteria. AW7 documented 5.5 days consecutively (2%) throughout the growing season. REFAW2 and REFAW3 reference gauges documented hydroperiods well above the nine percent success criteria at 37 percent of the growing season. Wetland gauge and rainfall data is presented in **Table 15** and **Figure 8**.

## **6 REFERENCES**

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- Horton, J. Wright Jr. and Victor A. Zullo. 1991. The Geology of the Carolinas, Carolina Geological Society Fiftieth Anniversary Volume. The University of Tennessee Press. Knoxville, TN.
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# **Appendix A**

## **Project Background Data and Maps**

Table 1. Project Components and Mitigation Credits

Table 2. Project Activity and Reporting History

Table 3. Project Contacts

Table 4. Project Information and Attributes

Figure 1. Project Vicinity Map

Figure 2. Project USGS Map

**Table 1. Project Components and Mitigation Credits**

Table 1. Project Components and Mitigation Credits										
Cedar Creek Stream and Wetland Restoration Project/DMS Project # 95718										
Mitigation Credits										
	Stream		Riparian Wetland		Non-riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset	
Type	R	RE	R	RE	R	RE				
Totals	5,230	0	13.10	N/A	N/A	N/A	N/A	N/A	N/A	
Project Components										
Project Component -or- Reach ID	Mitigation Plan Stationing/Location (LF)		Existing Footage/Acreage		Approach (PI, PII etc.)		Restoration or- Restoration Equivalent	Mitigation Plan Restoration Footage or Acreage	Mitigation Ratio	SMUs/ WMUs
UT1	1+01 to 31+65		3,064		Enhancement II		R	3,064	1 : 2.5	1,226
UT1	31+65 to 35+80		415		Enhancement I		R	415	1 : 1.5	277
UT1	35+80 to 41+95		615		Enhancement II		R	615	1 : 2.5	246
UT1	41+95 to 44+60		265		Enhancement I		R	265	1 : 1.5	177
UT1	44+60 to 53+51		891		Enhancement II		R	827	1 : 2.5	331
UT2	0+11 to 3+48		364		Headwater Valley		R	337	1 : 1.0	337
UT2	3+48 to 9+12		587		P1 Restoration		R	504	1 : 1.0	504
UT2C	0+02 to 1+92		NA		Headwater Valley		R	190	1 : 1.0	190
UT3	0+60 to 19+72		1,428		P1 Restoration		R	1,912	1 : 1.0	1,912
UT4	0+36 to 1+14		78		Enhancement II		R	78	1 : 2.5	31
Wetland 1	Adjacent to UT1 & UT3		17.3		Restoration		R	13.10	1 : 1.0	13.1
Component Summation										
Restoration Level	Stream (linear feet)		Riparian Wetland (acres)		Non-riparian Wetland	Buffer (square feet)	Upland (acres)			
			Riverine	Non-Riverine						
Restoration	2,416		13.10							
Headwater Valley	527									
Enhancement I	680									
Enhancement II	4,584									
Creation										
Preservation										
High Quality Preservation										
BMP Elements										
Element	Location		Purpose/Function			Notes				
---	---		---			---				
---	---		---			---				
---	---		---			---				
BMP Elements										
BR = Bioretention Cell; SF = Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; S = Grassed Swale; LS = Level Spreader; NI = Natural Infiltration Area; FB = Forested Buffer										

Credit calculations were originally calculated along the as-built thalweg. For Monitoring Year 3 forward, credits were updated to be calculated along stream centerlines following discussions stemming from the April 3, 2017 Credit Release Meeting

**Table 2. Project Activity and Reporting History**

<b>Project Activity and Reporting History Cedar Creek Stream and Wetland Restoration Project / DMS Project #95718</b>		
<b>Activity or Report</b>	<b>Data Collection Complete</b>	<b>Completion or Delivery</b>
Mitigation Plan	NA	Aug-14
Final Design – Construction Plans	NA	Dec-14
Construction Completed	Mar-15	May-15
Site Planting Completed	May-15	May-15
Baseline Monitoring Document (Year 0 Monitoring – baseline)	Jul-15	Nov-15
Year 1 Monitoring	Dec-15	Feb-16
Year 2 Monitoring	Oct-16	Dec-16
Year 3 Monitoring	XS: July-17 VP: Aug-17	Feb-18
Beaver Management	NA	Sep-17
Year 4 Monitoring	VP: Aug-18	Jan-19
Stream and Wetland Repair	NA	Oct-18
Year 5 Monitoring	XS: May-19 VP: Aug-19	Jan-20
Year 6 Monitoring		
Year 7 Monitoring		

**Table 3. Project Contacts**

<b>Project Contacts Table Cedar Creek Stream and Wetland Restoration Project /DMS Project #95718</b>	
<b>Designer</b>	WK Dickson and Co., Inc. 720 Corporate Center Drive Raleigh, NC 27607 (919) 782-0495 Frasier Mullen, PE
<b>Construction Contractor</b>	Wright Contracting PO Box 545 Siler City, NC 27344 (919) 663-0810 Joseph Wright
<b>Planting Contractor</b>	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 209-1061 David Godley
<b>Seeding Contractor</b>	Wright Contracting PO Box 545 Siler City, NC 27344 (919) 663-0810 Joseph Wright
Seed Mix Sources	Green Resource
Nursery Stock Suppliers	Arbogen, NC Forestry Services Nursery
<b>Full Delivery Provider</b>	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605
Project Manager:	Brad Breslow
<b>Monitoring Performers</b>	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 741-6268
Project Manager:	Ryan Medric



**Table 4. Project Information**

Project Information	
Project Name	Cedar Creek Site
County	Sampson
Project Area (acres)	42
Project Coordinates (latitude and longitude)	34° 57' 59.663" N 78° 22' 0.778" W

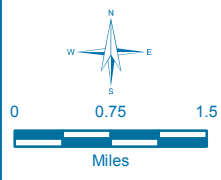
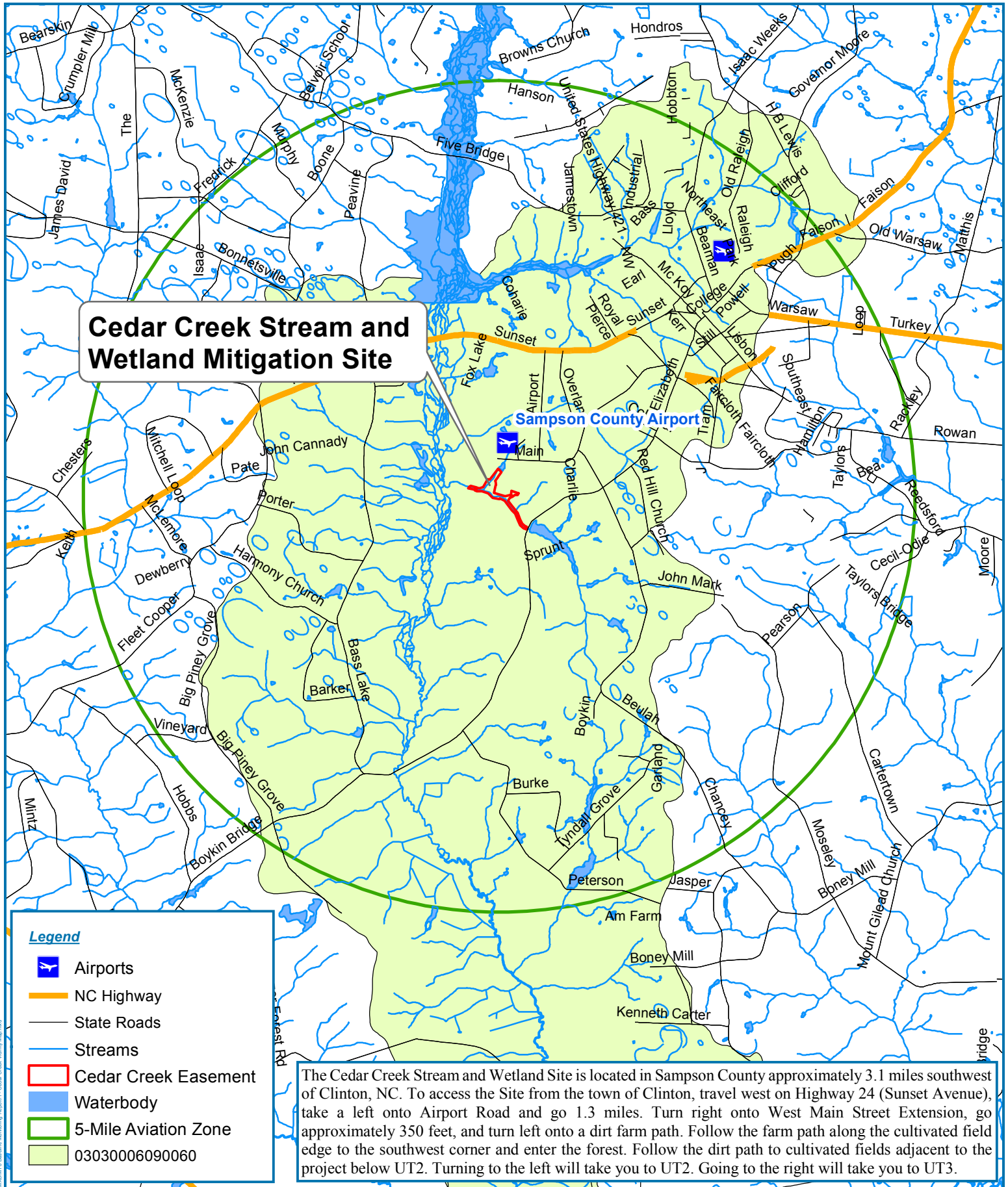
Project Watershed Summary Information	
Physiographic Province	Outer Coastal Plain
River Basin	Cape Fear
USGS Hydrologic Unit 8-digit	03030006
USGS Hydrologic Unit 14-digit	03003006090060
DWQ Sub-basin	03-06-19
Project Drainage Area (acres)	2,890 acres
DA Percentage of Impervious Area	4.50%
CGIA Land Use Classification	Woody wetlands, Shrub/scrub, cultivated crops, evergreen forest

Reach Summary Information (As-Built Conditions)				
Parameters	UT1	UT2	UT3	UT4
Length of reach (linear feet)	5,186	1,048	1,941	78
Valley Classification	X	X	X	X
Drainage area (acres)	2780	35	151	77
NCDWQ stream identification score	50	34.5	40	42.5
NCDWQ Water Quality Classification	N/A	N/A	N/A	N/A
Morphological Description (stream type)	E5	E5	E5	E5
Evolutionary trend	Stage II	Stage II/III	Stage II/III	Stage II/III
Underlying mapped soils	BH	Jo	BH	BH
Drainage class	frequently flooded	undrained	frequently flooded	frequently flooded
Soil Hydric status	Hydric	Hydric	Hydric	Hydric
Slope	0.20%	1.40%	1.10%	1.00%
FEMA classification	N/A	N/A	AE	N/A
Native vegetation community	cultivated, mixed hardwood forest	cultivated, mixed hardwood forest	mixed hardwood forest	mixed hardwood forest
Percent composition of exotic invasive vegetation	<5	0	0	<5

**Table 4 con't. Project Information**

<b>Wetland Summary Information</b>	
<b>Parameters</b>	<b>Wetland 1 UT1/3</b>
Size of Wetland (acres)	13.72
Wetland Type (non-riparian, riparian riverine or riparian non-riverine)	Riparian Riverine
Mapped Soil Series	Bibb/Johnson
Drainage class	Frequently Flooded
Soil Hydric Status	Hydric
Source of Hydrology	Runoff/Groundwater Discharge
Hydrologic Impairment	Incised Channel, Dredging
Native vegetation community	Forested
Percent composition of exotic invasive vegetation	1 – 2%

<b>Regulatory Considerations</b>			
<b>Regulation</b>	<b>Applicable</b>	<b>Resolved</b>	<b>Supporting Documentation</b>
Waters of the United States - Section 404	Yes	Yes	SAW-2013-00389
Waters of the United States - Section 401	Yes	Yes	DWR # 13-0186
Endangered Species Act	Yes	Yes	USFWS (Corr. Letter)
Historic Preservation Act	Yes	Yes	SHPO (Corr. Letter)
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	No	NA	N/A
FEMA Floodplain Compliance	Yes	Yes	EEP Floodplain Requirements Checklist
Essential Fisheries Habitat	No	NA	N/A



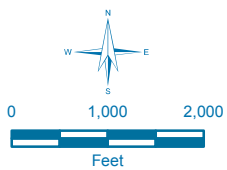
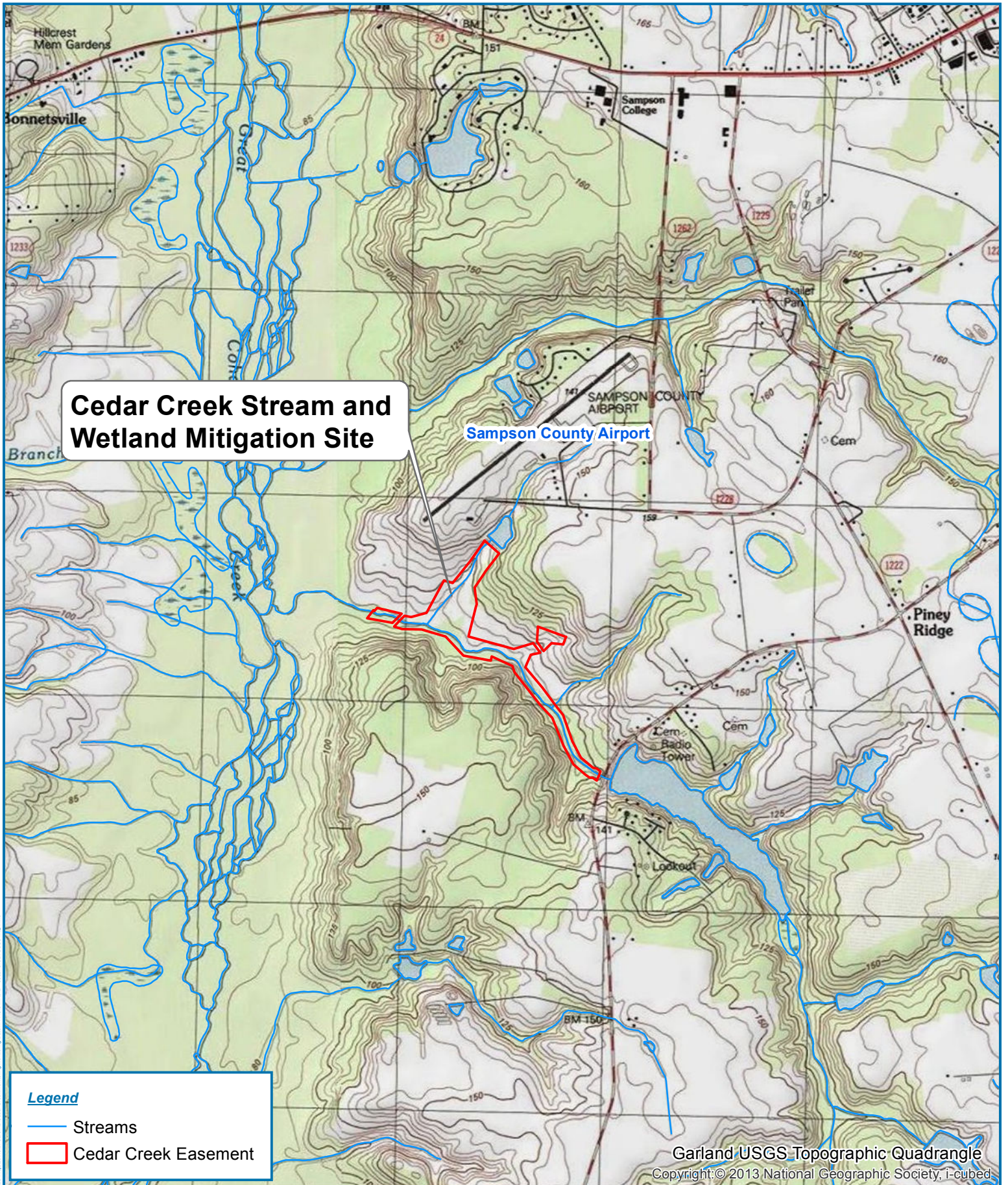
**Figure1**  
**Project Vicinity Map**  
**Cedar Creek Stream and Wetland Restoration Site**  
**Sampson County, North Carolina**

Date: 11/6/2015

Drawn by: BSH



Document Path: E:\RES Files\Cedar\_Creek\CAD\GIS\MXD\03030006090060.mxd; Report: 1\_Cedar\_Creek\_Vicinity\_Map.mxd



**Figure2**  
**Project USGS Map**  
**Cedar Creek Stream and Wetland Restoration Site**  
**Sampson County, North Carolina**

Date: 2/16/2016

Drawn by: BSH



Document Path: C:\Users\shelton\Documents\RES\GIS\ESRI\Projects\North Carolina\Cedar Creek\Map\Map.mxd

# **Appendix B**

## **Visual Assessment Data**

Figure 3. Current Conditions Plan View Map (CCPV)

Table 5. Visual Stream Morphology Stability Assessment

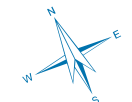
Table 6. Vegetation Condition Assessment

Table 7. Stream Problem Areas

Table 8. Vegetation Problem Areas

Figure 4. Stream and Wetland Photos

Figure 5. Vegetation Plot Photos



0 100 200  
Feet

1 inch = 200 feet

Figure 3b

**Cedar Creek  
Restoration Project  
MY5 2019**

**Current Conditions  
Plan View**

Date: 2/4/2020

Drawn by: GDS

**LEGEND**

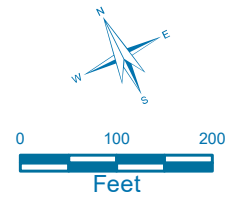
- ▭ Conservation Easement
- ▨ Wetland Restoration Area
- ▭ VP >260 stems/acre
- Cross Sections
- P1 Restoration
- Headwater Valley Restoration
- Enhancement I
- Enhancement II
- Bankpin
- Flow Gauge
- Crest Gauge
- ⊕ >9%
- ⊕ 5-8%
- ⊕ <5%
- ⊕ No Data

**Vegetation Condition Assessment**

		Target Community		
		Present	Marginal	Absent
Invasive Species	Absent	No Fill	No Fill	No Fill
	Present	No Fill	No Fill	No Fill



Source: 2017 NC Onemap Aerial Imagery  
NC Center for Geographic Information & Analysis



1 inch = 200 feet

**Figure 3b**  
**Cedar Creek Restoration Project**  
**MY5 2019**  
**Current Conditions**  
**Plan View**

Date: 2/4/2020 Drawn by: GDS

**LEGEND**

- Conservation Easement
- Wetland Restoration Area
- VP >260 stems/acre
- Cross Sections
- P1 Restoration
- Headwater Valley Restoration
- Enhancement I
- Enhancement II
- Bankpin
- Flow Gauge
- Crest Gauge
- >9%
- 5-8%
- <5%
- No Data

**Vegetation Condition Assessment**

Invasive Species	Target Community		
	Present	Marginal	Absent
Absent	No Fill		
Present			



Source: 2017 NC Onemap Aerial Imagery  
 NC Center for Geographic Information & Analysis

**Table 5** Visual Stream Morphology Stability Assessment  
**Reach ID** UT1  
**Assessed Length** 5186

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does <u>NOT</u> include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
	<b>Totals</b>				0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	5	5			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	5	5			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	5	5			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	5	5			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	5	5			100%			



Table 5 **Visual Stream Morphology Stability Assessment**  
 Reach ID UT2  
 Assessed Length 855

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
<b>Totals</b>					0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	21	21			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	21	21			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	21	21			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	21	21			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	21	21			100%			

Table 5 **Visual Stream Morphology Stability Assessment**  
 Reach ID UT2C  
 Assessed Length 193

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
<b>Totals</b>					0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	3	3			100%			

Table 5 **Visual Stream Morphology Stability Assessment**  
 Reach ID UT3  
 Assessed Length 1941

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
<b>Totals</b>					0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	19	19			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	19	19			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	19	19			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	19	19			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	19	19			100%			

Table 5  
 Reach ID  
 Assessed Length

**Visual Stream Morphology Stability Assessment**  
 UT4  
 78

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%			100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%			100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%			100%
<b>Totals</b>					0	0	100%			100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	0	0			N/A			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	0	0			N/A			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	0	0			N/A			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			N/A			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			N/A			

**Table 6**

**Vegetation Condition Assessment**

Planted Acreage<sup>1</sup>

20

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres	Red Simple Hatch	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	Orange Simple Hatch	0	0.00	0.0%
<b>Total</b>				0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	Orange Simple Hatch	0	0.00	0.0%
<b>Cumulative Total</b>				0	0.00	0.0%

Easement Acreage<sup>2</sup>

37.6

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern <sup>4</sup>	Areas or points (if too small to render as polygons at map scale).	1000 SF	Yellow Crosshatch	0	0.00	0.0%
5. Easement Encroachment Areas <sup>3</sup>	Areas or points (if too small to render as polygons at map scale).	none	Red Simple Hatch	0	0.00	0.0%

<sup>1</sup> = Enter the planted acreage within the easement. This number is calculated as the easement acreage minus any existing mature tree stands that were not subject to supplemental planting of the understory, the channel acreage, crossings or any other elements not directly planted as part of the project effort.

<sup>2</sup> = The acreage within the easement boundaries.

<sup>3</sup> = Encroachment may occur within or outside of planted areas and will therefore be calculated against the overall easement acreage. In the event a polygon is cataloged into items 1, 2 or 3 in the table and is the result of encroachment, the associated acreage should be tallied in the relevant item (i.e., item 1, 2 or 3) as well as a parallel tally in item 5.

<sup>4</sup> = Invasives may occur in or out of planted areas, but still within the easement and will therefore be calculated against the overall easement acreage. Invasives of concern/interest are listed below. The list of high concern species are those with the potential to directly outcompete native, young, woody stems in the short-term (e.g. monitoring period or shortly thereafter) or affect the community structure for existing, more established tree/shrub stands over timeframes that are slightly longer (e.g. 1-2 decades). The low/moderate concern group are those species that generally do not have this capacity over the timeframes discussed and therefore are not expected to be mapped with regularity, but can be mapped, if in the judgement of the observer their coverage, density or distribution is suppressing the viability, density, or growth of planted woody stems. Decisions as to whether remediation will be needed are based on the integration of risk factors by EEP such as species present, their coverage, distribution relative to native biomass, and the practicality of treatment. For example, even modest amounts of Kudzu or Japanese Knotweed early in the projects history will warrant control, but potentially large coverages of Microstegium in the herb layer will not likely trigger control because of the limited capacities to impact tree/shrub layers within the timeframes discussed and the potential impacts of treating extensive amounts of ground cover. Those species with the "watch list" designator in gray shade are of interest as well, but have yet to be observed across the state with any frequency. Those in *red italics* are of particular interest given their extreme risk/threat level for mapping as points where isolated specimens are found, particularly early in a projects monitoring history. However, areas of discreet, dense patches will of course be mapped as polygons. The symbology scheme below was one that was found to be helpful for symbolizing invasives polygons, particularly for situations where the condition for an area is somewhere between isolated specimens and dense, discreet patches. In any case, the point or polygon/area feature can be symbolized to describe things like high or low concern and species can be listed as a map inset, in legend items if the number of species are limited or in the narrative section of the executive summary.

<b>Table 7. Stream Problem Areas</b>			
<b>Cedar Creek Stream and Wetland Restoration Project - Project # 95718</b>			
<b>Feature Issue</b>	<b>Station # / Range</b>	<b>Suspected Cause; Repair</b>	<b>Photo Number</b>

<b>Table 8. Vegetation Problem Areas</b>			
<b>Cedar Creek Stream and Wetland Restoration Project - Project # 95718</b>			
<b>Feature Category</b>	<b>Station Numbers</b>	<b>Suspected Cause; Repair</b>	<b>Photo Number</b>

**Figure 5. MY5 Vegetation Plot Photos**



Vegetation Plot 1



Vegetation Plot 2



Vegetation Plot 3



Vegetation Plot 4



Vegetation Plot 5



Vegetation Plot 6

**Cedar Creek MY5 Vegetation Plot Photos**



Vegetation Plot 7



Vegetation Plot 8



Vegetation Plot 9



Vegetation Plot 10



Vegetation Plot 11



Vegetation Plot 12



**Cedar Creek MY5 Vegetation Plot Photos**



Vegetation Plot 13



Vegetation Plot 14



Vegetation Plot 15



Vegetation Plot 16



Vegetation Plot 17



Vegetation Plot 18

**Cedar Creek MY5 Vegetation Plot Photos**



Vegetation Plot 19



Vegetation Plot 20

# Appendix C

## Vegetation Plot Data

Table 9a. Vegetation Plot Criteria Attainment Summary

Table 9b. CVS Vegetation Plot Metadata

Table 9c. Planted and Total Stem Counts (Species by Plot)

Table 9a. Vegetation Plot Criteria Attainment Summary

Plot #	Planted Stems/Acre	Volunteer Stems/Acre	Total Stems/Acre	Success Criteria Met?	Average Stem Height (ft)
1	971	0	971	Yes	8.4
2	1255	40	1295	Yes	7.2
3	931	2469	3399	Yes	6.3
4	688	7203	7891	Yes	10.7
5	445	1416	1862	Yes	10.2
6	728	2023	2752	Yes	6.4
7	405	769	1174	Yes	3.9
8	607	809	1416	Yes	11.3
9	364	607	971	Yes	9.6
10	486	567	1052	Yes	3.3
11	567	0	567	Yes	8.3
12	688	121	809	Yes	10.2
13	526	0	526	Yes	12.8
14	607	809	1497	Yes	4.2
15	809	769	1578	Yes	11.1
16	486	1457	1942	Yes	6.7
17	445	890	1335	Yes	7.0
18	971	850	1821	Yes	2.0
19	324	0	324	Yes	8.3
20	364	162	526	Yes	7.7
<b>Project Avg</b>	<b>633</b>	<b>1048</b>	<b>1686</b>	<b>Yes</b>	<b>7.6</b>

<b>Table 9b. CVS Vegetation Plot Metadata Cedar Creek Stream and Wetland Restoration Site</b>	
<b>Report Prepared By</b>	Grayson Sanner
<b>Date Prepared</b>	11/18/2019 10:41
<b>database name</b>	Cedar_Creek_MY5_2019.mdb
<b>database location</b>	S:\@RES Projects\North Carolina\0104 - Cedar Creek\Monitoring\Monitoring Data\MY5_2019\Vegetation Data
<b>computer name</b>	DESKTOP-SN39OLO
<b>file size</b>	76546048
<b>DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT</b>	
<b>Metadata</b>	Description of database file, the report worksheets, and a summary of project(s) and project data.
<b>Proj, planted</b>	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
<b>Proj, total stems</b>	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
<b>Plots</b>	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
<b>Vigor</b>	Frequency distribution of vigor classes for stems for all plots.
<b>Vigor by Spp</b>	Frequency distribution of vigor classes listed by species.
<b>Damage</b>	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
<b>Damage by Spp</b>	Damage values tallied by type for each species.
<b>Damage by Plot</b>	Damage values tallied by type for each plot.
<b>Planted Stems by Plot and Spp</b>	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
<b>ALL Stems by Plot and spp</b>	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
<b>PROJECT SUMMARY</b>	
<b>Project Code</b>	95718
<b>project Name</b>	Cedar Creek Restoration Site
<b>Description</b>	
<b>River Basin</b>	Cape Fear
<b>length(ft)</b>	
<b>stream-to-edge width (ft)</b>	
<b>area (sq m)</b>	
<b>Required Plots (calculated)</b>	
<b>Sampled Plots</b>	20





# **Appendix D**

## **Stream Geomorphology Data**

Table 10. Morphological Parameters Summary Data

Table 11. Dimensional Morphology Summary – Cross-Section Data

Table 12. Bank Pin Array Summary Data

Figure 7. Cross Section Plots



**Table 10. Cedar Creek Morphological Parameters**

Feature	Reference Reach			Existing <sup>1</sup>									Design				As-Built				
				UT1 (Upper)		UT1 (Lower)		UT2 Reach A		UT3 Reach A (Upper)	UT3 Reach A (Lower)		UT4	UT2		UT3		UT2		UT3	
	Pool	Run	Shallow	Shallow	Pool	Shallow	Pool	Shallow	Run	Run	Shallow	Run	Shallow	Shallow	Pool	Shallow	Pool	Shallow	Pool	Shallow	Pool
Drainage Area (ac)	81			2514		2780		34		116	150		79	41		146		41		146	
Drainage Area (mi <sup>2</sup> )	0.13			3.93		4.34		0.05		0.18	0.23		0.12	0.06		0.23		0.06		0.23	
NC Regional Curve Discharge (cfs) <sup>2</sup>	---	---	3.7	44.3		47.7		2.0		4.8	5.8		3.7	2.3		5.7		2.3		5.7	
NC Regional Curve Discharge (cfs) <sup>3</sup>	---	---	1.8	24.9		26.8		0.9		2.4	2.9		1.8	1.1		2.9		1.1		2.9	
Design/Calculated Discharge (cfs)	---	---	5	---		---		---		---	---		---	4.0		6.0		4.0		6.0	
<b>Dimension</b>																					
BF Width (ft)	6.3	14.0	6.2	18.2	14.1	11.0	10.9	4.8	5.2	4.0	10.4	7.7	6.2	4.6	5.4	6.0	7.0	7.5	7.1	7.9	7.2
Floodprone Width (ft)	100.0	100.0	100.0	100	100	100	100	100	100	100	100	100	100	>50	>50	>50	>50	>50	>50	>50	>50
BF Cross Sectional Area (ft <sup>2</sup> )	4.0	5.9	2.9	42.1	46.4	32.2	29.2	2.4	3.0	3.4	5.5	4.8	5.6	2.2	3.1	3.6	4.8	2.9	2.9	4.1	4.2
BF Mean Depth (ft)	0.6	0.4	0.5	2.3	3.3	2.9	2.7	0.5	0.6	0.9	0.5	0.6	0.9	0.5	0.6	0.6	0.7	0.4	0.4	0.5	0.6
BF Max Depth (ft)	1.0	0.5	0.8	3.2	4.4	3.7	3.3	0.7	0.9	1.0	0.8	1.1	1.3	0.7	1.0	0.8	1.2	0.9	0.9	1.0	1.2
Width/Depth Ratio	10.2	33.3	13.4	7.9	4.3	3.8	4.1	9.6	10.5	4.7	19.7	12.2	6.9	10.2	9.4	10.2	10.1	20.1	18.1	15.6	13.2
Entrenchment Ratio	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	1.2	1.3	1.6	2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2
Wetted Perimeter (ft)	7.1	14.2	6.7	20.4	18.8	15.8	16.2	5.2	5.9	5.8	10.7	8.2	7.1	4.9	5.9	6.4	7.6	7.7	7.5	8.3	7.7
Hydraulic Radius (ft)	0.6	0.4	0.4	2.1	2.5	2.0	1.8	0.5	0.5	0.6	0.5	0.6	0.8	0.4	0.5	0.6	0.6	0.4	0.4	0.5	0.5
<b>Substrate</b>																					
	Medium/Coarse Sand			Medium/Coarse Sand									Medium/Coarse Sand				Medium/Coarse Sand				
<b>Pattern</b>																					
	<b>Min</b>	<b>Max</b>	<b>Med</b>	---	---	---	---	---	---	---	---	---	---	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>
Channel Beltwidth (ft)	13.0	19.3	13.9	---	---	---	---	---	---	---	---	---	---	10.5	15.7	12.6	18.8	10.3	23.9	14.3	23.3
Radius of Curvature (ft)	5.2	11.7	9.9	---	---	---	---	---	---	---	---	---	---	4.2	9.4	5.1	11.3	8.6	22.0	6.4	20.8
Radius of Curvature Ratio	0.7	1.6	1.3	---	---	---	---	---	---	---	---	---	---	1.0	3.0	1.0	3.0	1.1	2.9	0.8	2.6
Meander Wavelength (ft)	13.3	22.5	21.1	---	---	---	---	---	---	---	---	---	---	4.6	13.8	6.0	18.0	5.0	18.3	6.5	19.5
Meander Width Ratio	2.1	3.1	2.2	---	---	---	---	---	---	---	---	---	---	2.1	3.1	2.1	3.1	1.4	3.2	1.8	2.9
<b>Profile</b>																					
Shallow Length (ft)	2.0	30.9	10.9	---	---	---	---	---	---	---	---	---	---	1.6	24.5	1.9	29.4	2.5	26.2	2.3	33.2
Run Length (ft)	1.0	20.1	6.9	---	---	---	---	---	---	---	---	---	---	0.8	15.9	0.9	19.1	2.1	18.5	2.3	23.2
Pool Length (ft)	2.6	12.1	5.8	---	---	---	---	---	---	---	---	---	---	2.1	9.6	2.5	11.5	3.2	10.2	3.7	12.2
Pool -to-Pool Spacing (ft)	10.1	61.0	28.6	---	---	---	---	---	---	---	---	---	---	8.0	48.3	9.6	57.9	12.5	55.6	10.1	60.7
<b>Additional Reach Parameters</b>																					
Valley Length (ft)	164			3376		1515		255		486	731		78	643		1600		643		1600	
Channel Length (ft)	203			3694		1574		275		496	739		78	724		1912		740		1941	
Sinuosity	1.24			1.09		1.04		1.08		1.02	1.01		1.00	1.13		1.20		1.15		1.21	
Water Surface Slope (ft/ft)	0.009			---		---		---		---	---		---	---		---		---		---	
Channel Slope (ft/ft)	0.009			0.0022		0.0016		0.012		0.0164	0.007		0.010	0.0170		0.0095		0.0202		0.0130	
Rosgen Classification	E/C5			E5		E5		E5		E5	E5		E5	E5		E5		E5		E5	

<sup>1</sup> Bankfull stage was estimated using NC Regional Curve equations and existing conditions data

<sup>2</sup> NC Regional Curve equations source: Doll et al. (2003)

<sup>3</sup> NC Regional Curve equations source: Sweet and Geratz (2003)



**Appendix D. Table 11. - Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)**

**Project Name/Number: Cedar Creek Site/ NCDMS Project # 95718**

Dimension	Cross Section 21 (Pool)							Cross Section 22 (Riffle)							Cross Section 23 (Riffle)							Cross Section 24 (Pool)							Cross Section 25 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	101.8	101.8	101.8	101.8	101.8			101.3	101.3	101.3	101.3	101.4			95.6	95.6	95.6	95.6	95.6			95.4	95.4	95.4	95.4	95.5			91.5	91.5	91.5	91.5	91.6		
Bankfull Width (ft) <sup>1</sup>	8.9	11.1	10.0	9.9	9.9			6.0	5.9	6.7	6.4	6.9			8.3	8.7	7.0	7.5	7.4			5.9	5.7	6.4	6.5	7.4			6.6	6.6	6.8	6.3	8.7		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9			50.0	50.0	50.0	50.0	49.7			50.0	50.0	50.0	50.0	49.8			50.0	50.0	50.0	50.0	49.8			50.0	50.0	50.0	50.0	49.8		
Bankfull Mean Depth (ft)	0.3	0.4	0.3	0.4	-			0.5	0.6	0.4	0.5	-			0.4	0.3	0.5	0.4	-			0.5	0.4	0.5	0.4	-			0.4	0.4	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.9	0.9	0.7	0.9	0.7			0.9	1.0	0.8	0.9	0.5			1.3	1.0	1.4	1.1	1.2			1.1	1.0	1.1	1.1	1.1			0.8	8.0	0.8	0.8	0.9		
Low Bank Elevation (ft)	-	-	-	-	101.6			-	-	-	-	101.2			-	-	-	-	95.6			-	-	-	-	95.4			-	-	-	-	91.5		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.1	4.0	3.3	3.7	1.9			3.1	3.3	2.7	3.2	1.8			3.1	2.9	3.3	3.2	2.6			3.0	2.2	2.9	2.5	2.9			2.6	2.9	2.5	2.5	2.3		
Bankfull Width/Depth Ratio	25.6	30.8	30.6	26.8	-			11.6	10.7	16.8	13.0	-			21.9	26.1	15.0	17.2	-			11.8	14.7	14.1	16.7	-			17.0	15.3	18.8	16.1	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A			>2.2	>2.2	>2.2	>2.2	>2.2			>2.2	>2.2	>2.2	>2.2	>2.2			>2.2	>2.2	>2.2	N/A	N/A			>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A			1.0	1.0	1.0	0.9	<1			1.0	1.0	1.0	0.9	1.0			1.0	1.0	1.0	N/A	N/A			1.0	1.0	1.0	N/A	N/A		
Dimension	Cross Section 26 (Riffle)							Cross Section 27 (Run)																											
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+																					
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	91.3	91.3	91.3	91.3	91.4			105.3	105.3	105.3	105.3	105.5																							
Bankfull Width (ft) <sup>1</sup>	6.8	8.2	6.0	6.8	11.5			6.4	5.7	5.7	6.8	8.6																							
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9			50.0	50.0	50.0	50.0	49.9																							
Bankfull Mean Depth (ft)	0.4	0.3	0.3	0.3	-			0.4	0.4	0.4	0.4	-																							
Bankfull Max Depth (ft) <sup>2</sup>	0.7	0.7	0.6	0.6	0.5			0.9	0.8	0.8	0.9	0.9																							
Low Bank Elevation (ft)	-	-	-	-	91.2			-	-	-	-	105.4																							
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.5	2.4	1.9	2.1	1.4			2.8	2.1	2.1	2.6	2.3																							
Bankfull Width/Depth Ratio	18.1	27.3	18.9	21.8	-			14.8	15.2	15.5	17.9	-																							
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2			>2.2	>2.2	>2.2	>2.2	>2.2																							
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1			1.0	1.0	1.0	1.0	<1																							

**Note:** In MY3, BHR was calculated on riffles using the baseline bankfull elevation. This method was used because the dimension of the channels has not changed enough to alter the bankfull elevation. None of the riffle cross sections exceeded a 1.2 BHR.

**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull elevation. These changes reflect the 2018 guidance that arose from the mitigation technical workgroup consisting of DMS, the IRT, and industry mitigation providers.

**Table 12.Cedar Creek Bank Pin Array Summary**

<b>Cross Section</b>	<b>Location</b>	<b>Position</b>	<b>Year 1 Reading</b>	<b>Year 2 Reading</b>	<b>Year 3 Reading</b>	<b>Year 5 Reading</b>
XS 6 @ Sta. 3+25 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 10 @ Sta. 8+80 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 12 @ Sta. 12+90 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 13 @ Sta. 14+50 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 16 @ Sta. 16+95 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 17 @ Sta. 18+50 Reach UT3	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 24 @ Sta. 6+60 Reach UT2	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
XS 25 @ Sta. 8+25 Reach UT2	US	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0
	DS	Top	0.0	0.0	0.0	0.0
		Bottom	0.0	0.0	0.0	0.0

Notes:

US - Upstream from cross section

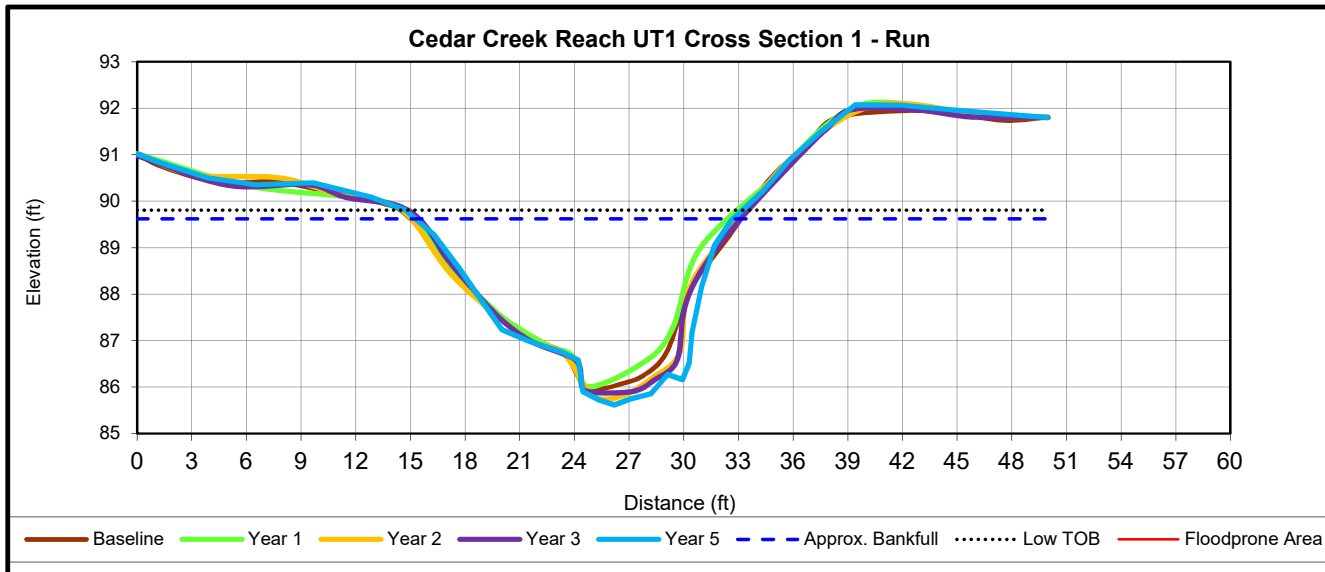
DS - Downstream from cross section



Upstream



Downstream



Dimension	Cross Section 1 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	89.8	89.8	89.8	89.8	89.6		
Bankfull Width (ft) <sup>1</sup>	19.0	18.5	19.0	18.9	17.4		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	2.2	2.1	2.3	2.3	-		
Bankfull Max Depth (ft) <sup>2</sup>	3.8	3.8	4.0	3.9	4.2		
Low Bank Elevation (ft)	-	-	-	-	89.8		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	41.6	38.9	43.6	42.8	45.0		
Bankfull Width/Depth Ratio	8.6	8.8	8.2	8.3	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	1.0		

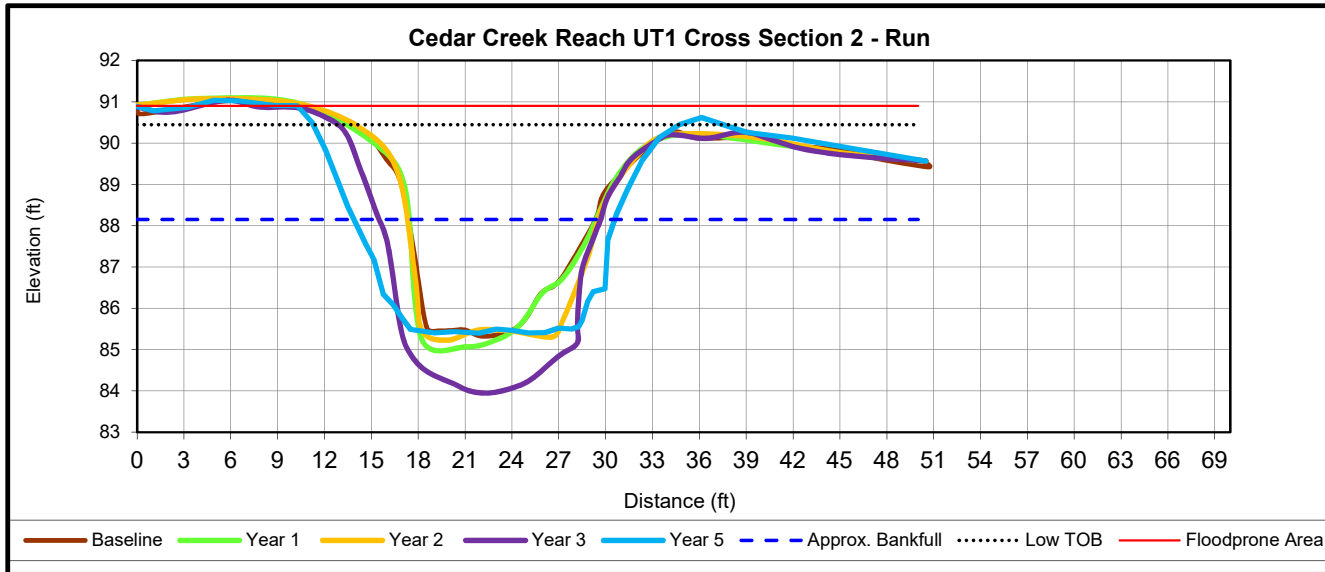
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 2 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	89.2	89.2	89.2	89.2	88.2		
Bankfull Width (ft) <sup>1</sup>	14.3	14.2	14.4	16.5	16.7		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	43.8		
Bankfull Mean Depth (ft)	2.7	2.8	3.0	3.7	-		
Bankfull Max Depth (ft) <sup>2</sup>	3.9	4.1	4.0	5.3	5.1		
Low Bank Elevation (ft)	-	-	-	-	90.4		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	38.0	40.1	43.1	61.3	82.9		
Bankfull Width/Depth Ratio	5.4	5.1	4.8	44.0	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.1	1.8		

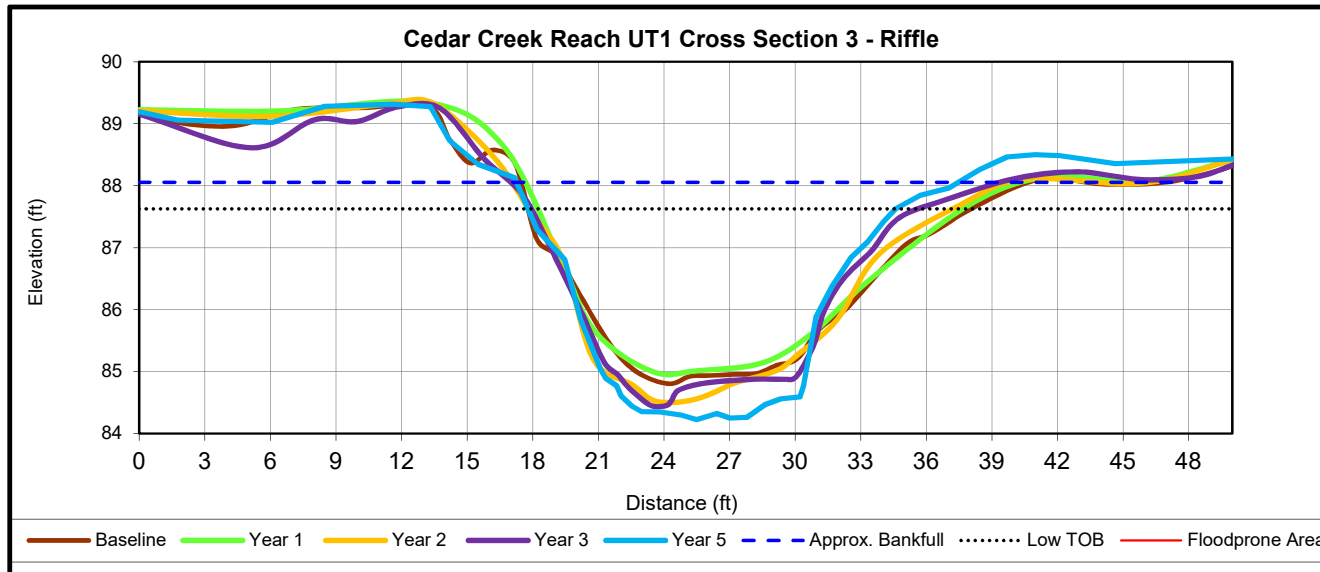
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 3 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	88.1	88.1	88.1	88.1	88.1		
Bankfull Width (ft) <sup>1</sup>	23.8	26.1	23.5	23.1	20.2		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	1.9	1.7	2.0	1.9	-		
Bankfull Max Depth (ft) <sup>2</sup>	3.3	3.1	3.6	3.7	3.4		
Low Bank Elevation (ft)	-	-	-	-	87.6		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	45.5	43.7	46.8	44.6	37.6		
Bankfull Width/Depth Ratio	12.4	15.6	11.8	12.0	-		
Bankfull Entrenchment Ratio <sup>1</sup>	2.1	1.9	2.1	2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.1	<1		

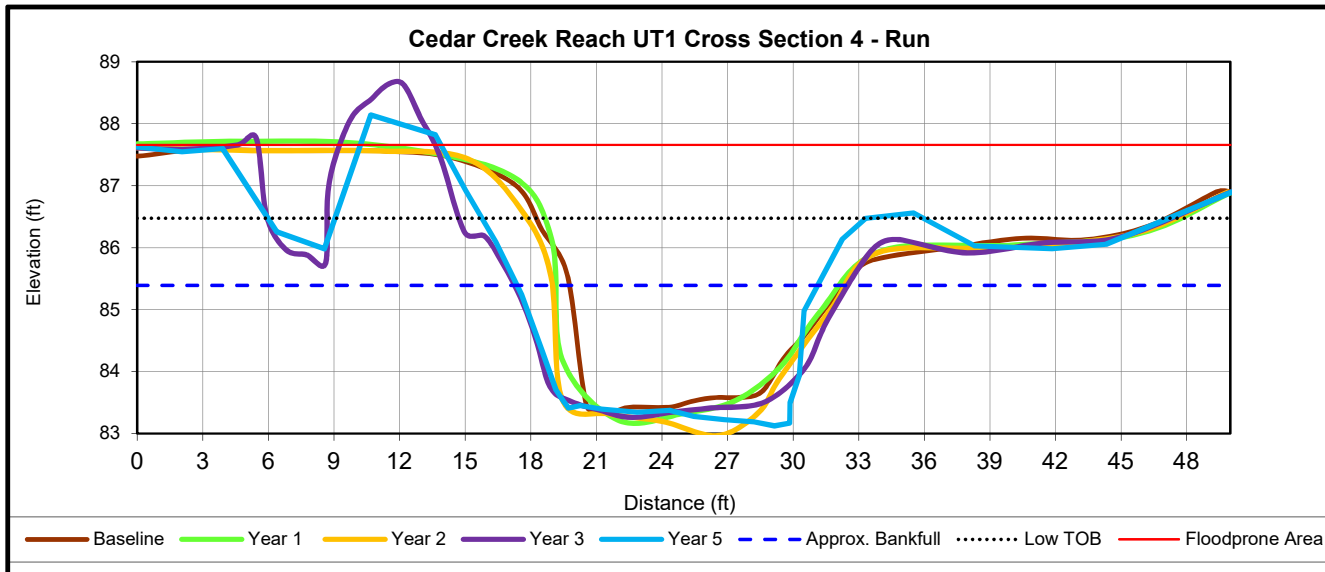
Note: Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Left Bank \*Note Downed Tree



Dimension	Cross Section 4 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	85.8	85.8	85.8	85.8	85.4		
Bankfull Width (ft) <sup>1</sup>	14.4	14.5	15.0	16.7	13.7		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	46.4		
Bankfull Mean Depth (ft)	1.7	1.8	2.0	1.9	-		
Bankfull Max Depth (ft) <sup>2</sup>	2.5	2.6	2.8	2.5	3.3		
Low Bank Elevation (ft)	-	-	-	-	86.5		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	24.7	26.3	29.8	31.4	41.4		
Bankfull Width/Depth Ratio	8.4	8.0	7.5	8.9	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.1	1.5		

**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.

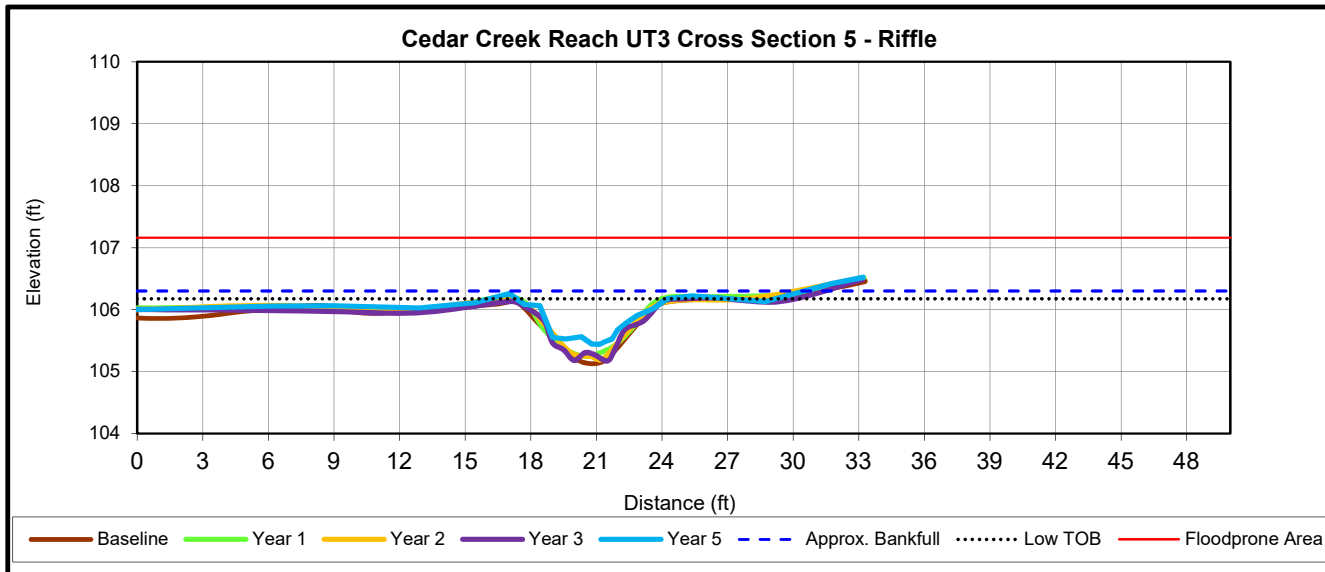




Upstream



Downstream



Dimension	Cross Section 5 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	106.1	106.1	106.1	106.1	106.3		
Bankfull Width (ft) <sup>1</sup>	6.9	6.3	6.9	6.6	7.2		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	33.2		
Bankfull Mean Depth (ft)	0.5	0.5	0.5	0.5	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.0	0.8	0.9	0.9	0.7		
Low Bank Elevation (ft)	-	-	-	-	106.2		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.7	3.2	3.2	3.3	2.8		
Bankfull Width/Depth Ratio	12.8	12.2	14.5	13.1	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1		

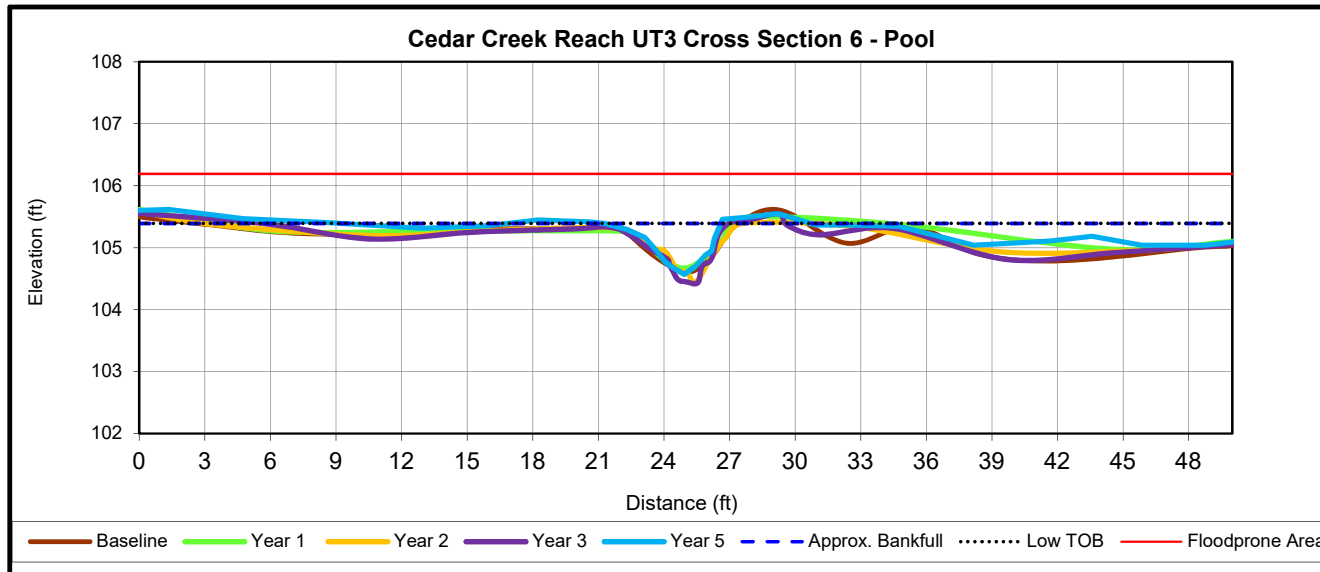
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 6 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	105.3	105.3	105.3	105.3	105.4		
Bankfull Width (ft) <sup>1</sup>	5.9	4.6	5.3	4.9	5.3		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	0.4	0.4	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.7	0.6	0.9	0.9	0.8		
Low Bank Elevation (ft)	-	-	-	-	105.4		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.1	1.6	2.0	2.1	2.1		
Bankfull Width/Depth Ratio	16.0	12.8	13.7	11.2	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

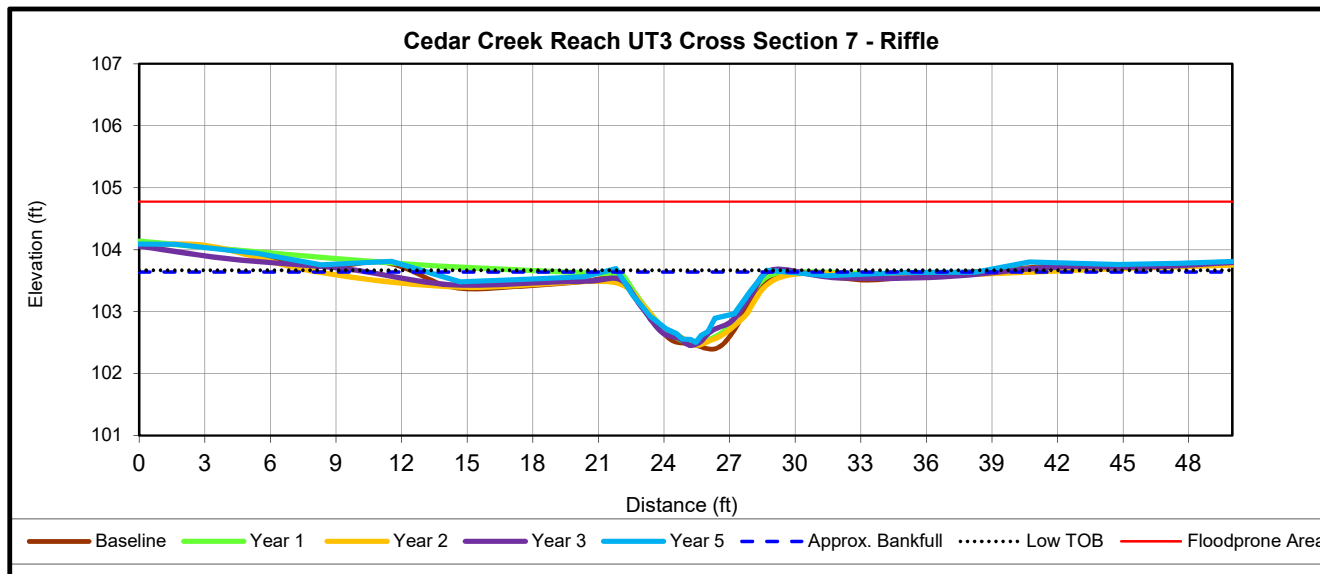
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 7 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	103.5	103.5	103.5	103.5	103.7		
Bankfull Width (ft) <sup>1</sup>	7.3	6.5	7.7	6.5	6.7		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.6	0.6	0.6	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	1.0	1.0	1.0	1.2		
Low Bank Elevation (ft)	-	-	-	-	103.7		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.5	3.9	4.6	4.1	4.7		
Bankfull Width/Depth Ratio	11.8	10.9	12.9	10.5	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	1.0		

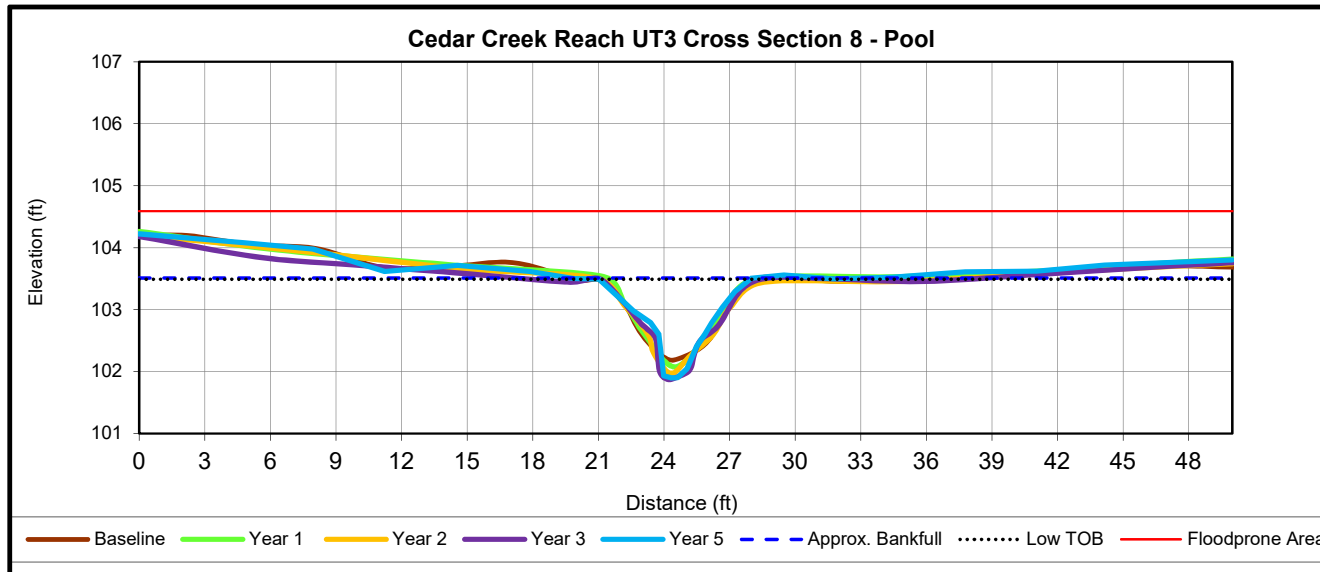
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 8 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	103.5	103.5	103.5	103.5	103.5		
Bankfull Width (ft) <sup>1</sup>	7.1	8.1	7.6	7.8	8.3		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	0.7	0.6	0.7	0.7	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.2	1.4	1.5	1.6	1.6		
Low Bank Elevation (ft)	-	-	-	-	103.5		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	5.0	5.1	5.6	5.5	4.8		
Bankfull Width/Depth Ratio	9.9	13.0	10.3	10.9	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

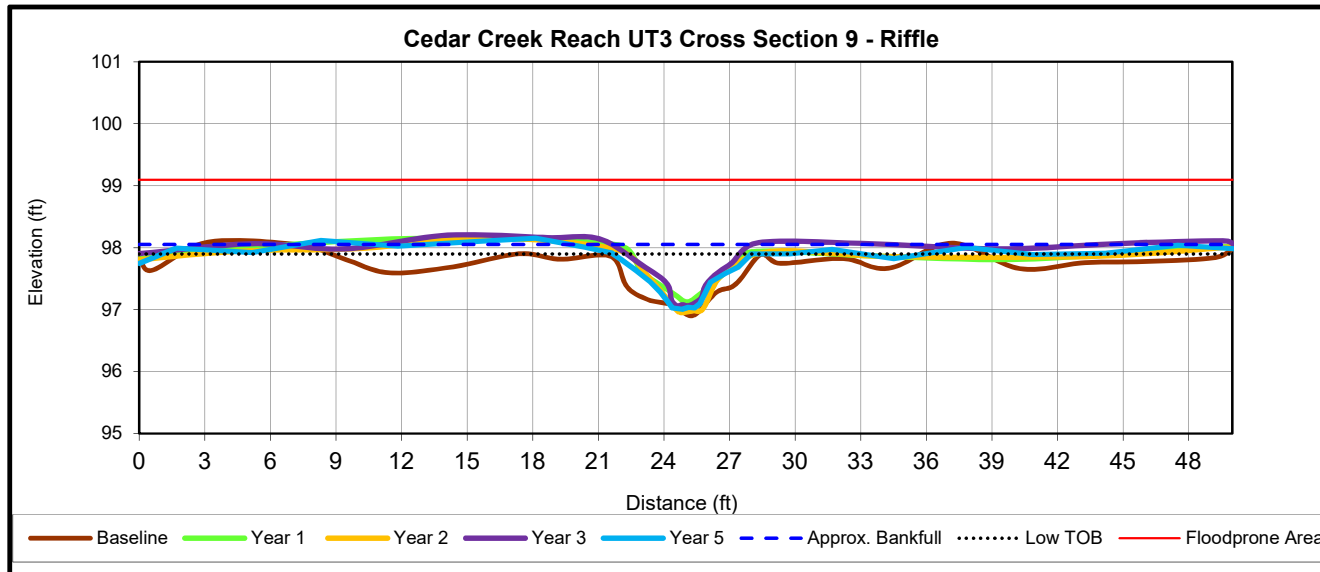
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 9 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	97.9	97.9	97.9	97.9	98.1		
Bankfull Width (ft) <sup>1</sup>	7.5	5.7	6.6	5.5	8.3		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.3		
Bankfull Mean Depth (ft)	0.5	0.4	0.5	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.0	0.8	0.9	0.8	0.9		
Low Bank Elevation (ft)	-	-	-	-	97.9		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.0	2.4	3.0	2.2	2.9		
Bankfull Width/Depth Ratio	14.2	13.5	14.4	13.7	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.2	<1		

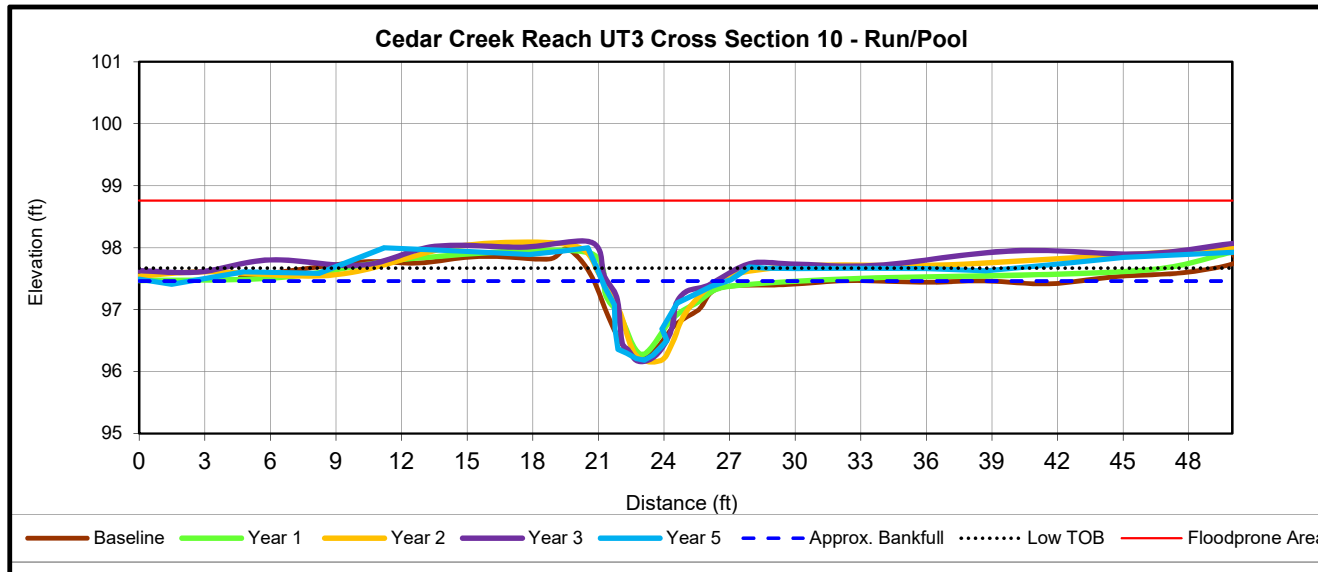
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 10 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	97.4	97.4	97.4	97.4	97.5		
Bankfull Width (ft) <sup>1</sup>	5.7	5.3	4.9	4.6	7.5		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	0.6	0.5	0.7	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	1.0	1.0	1.2	1.5		
Low Bank Elevation (ft)	-	-	-	-	97.7		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.5	2.4	3.3	2.9	5.0		
Bankfull Width/Depth Ratio	9.1	11.7	7.2	7.2	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

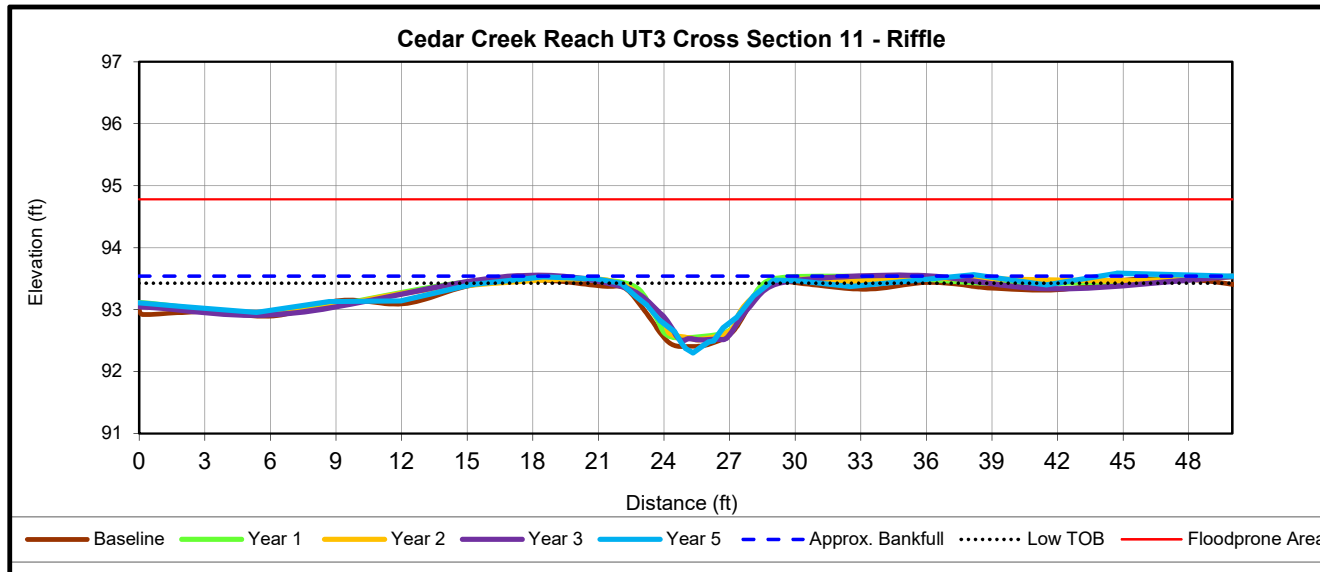
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 11 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	93.5	93.5	93.5	93.5	93.5		
Bankfull Width (ft) <sup>1</sup>	10.4	6.9	9.3	11.7	10.6		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.5	0.6	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	0.9	1.0	1.0	1.1		
Low Bank Elevation (ft)	-	-	-	-	93.4		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.8	4.2	3.6	4.8	3.9		
Bankfull Width/Depth Ratio	22.2	11.1	24.0	28.6	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	0.9	<1		

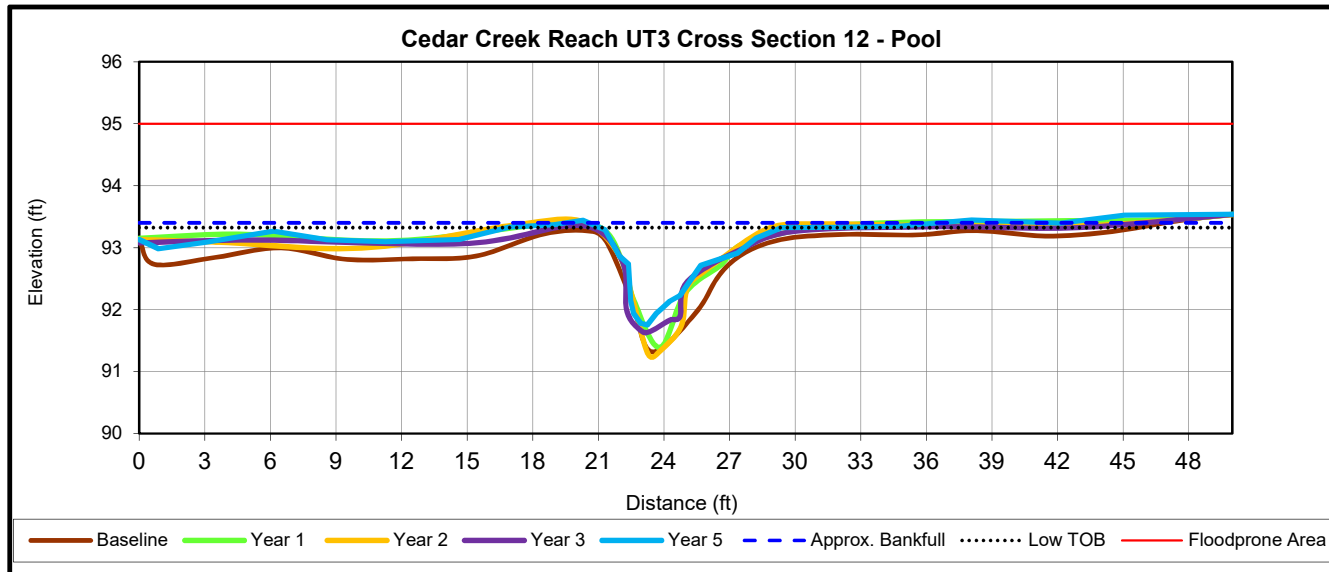
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 12 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	93.1	93.1	93.1	93.1	93.4		
Bankfull Width (ft) <sup>1</sup>	8.1	6.6	6.5	7.6	17.0		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.8	0.7	0.8	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.8	1.7	1.8	1.4	1.6		
Low Bank Elevation (ft)	-	-	-	-	93.3		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	6.6	4.7	5.1	4.9	5.5		
Bankfull Width/Depth Ratio	10.0	9.3	8.3	11.7	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

Note: Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.

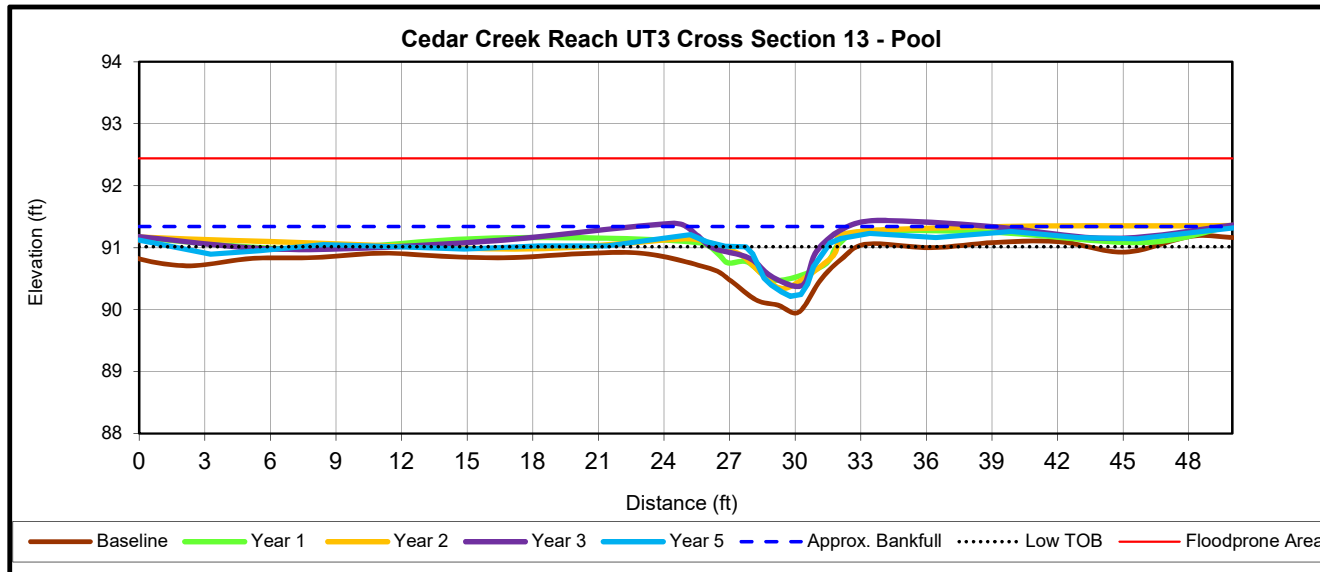




Upstream



Downstream

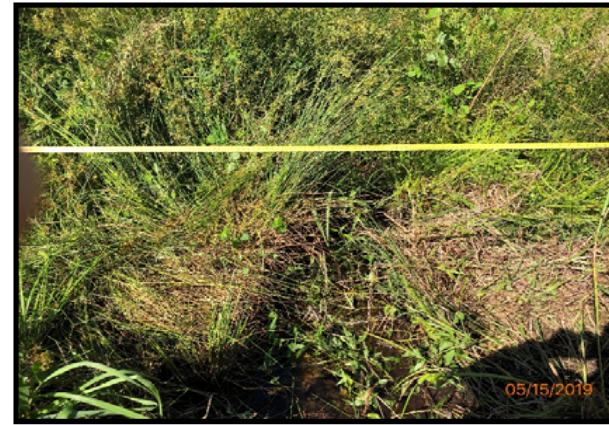


Dimension	Cross Section 13 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	90.9	90.9	90.9	90.9	91.3		
Bankfull Width (ft) <sup>1</sup>	9.3	5.4	7.0	5.9	7.5		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.3		
Bankfull Mean Depth (ft)	0.4	0.2	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.9	0.4	0.8	0.7	0.8		
Low Bank Elevation (ft)					91.0		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.9	1.2	2.6	2.2	1.8		
Bankfull Width/Depth Ratio	22.2	23.2	19.0	15.9	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

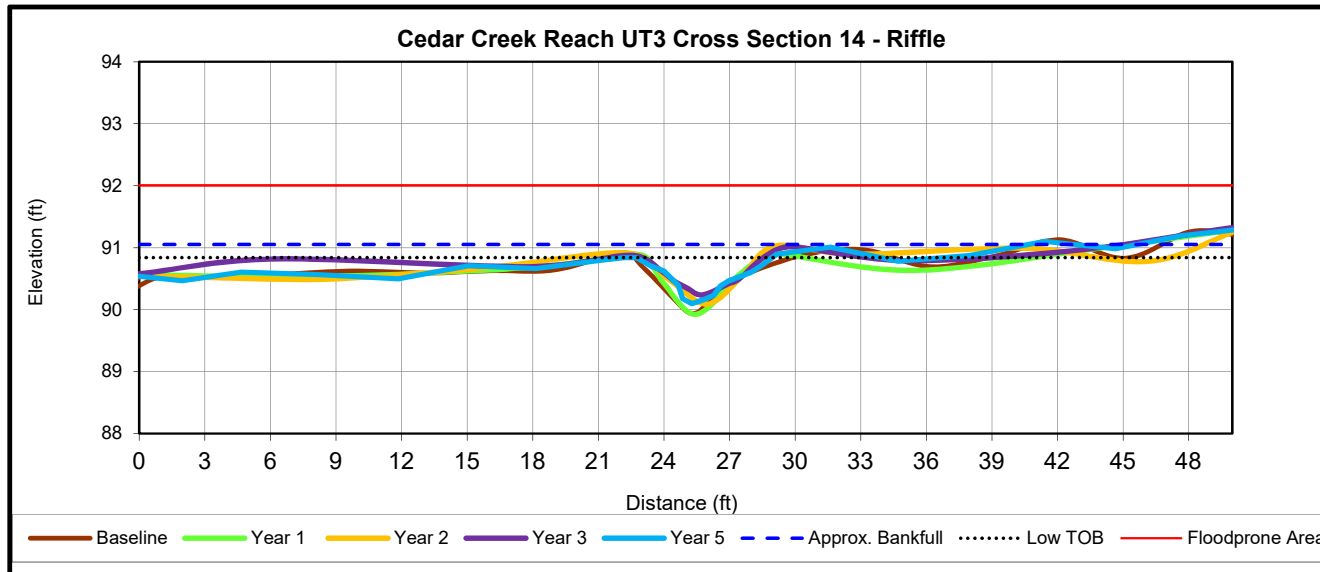
Note: Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 14 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	90.9	90.9	90.9	90.9	91.1		
Bankfull Width (ft) <sup>1</sup>	9.6	6.2	6.4	6.5	7.0		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.4	0.5	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.0	1.0	0.8	0.7	0.7		
Low Bank Elevation (ft)	-	-	-	-	90.8		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.7	2.9	2.7	2.3	2.2		
Bankfull Width/Depth Ratio	25.0	13.4	15.2	18.0	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1		

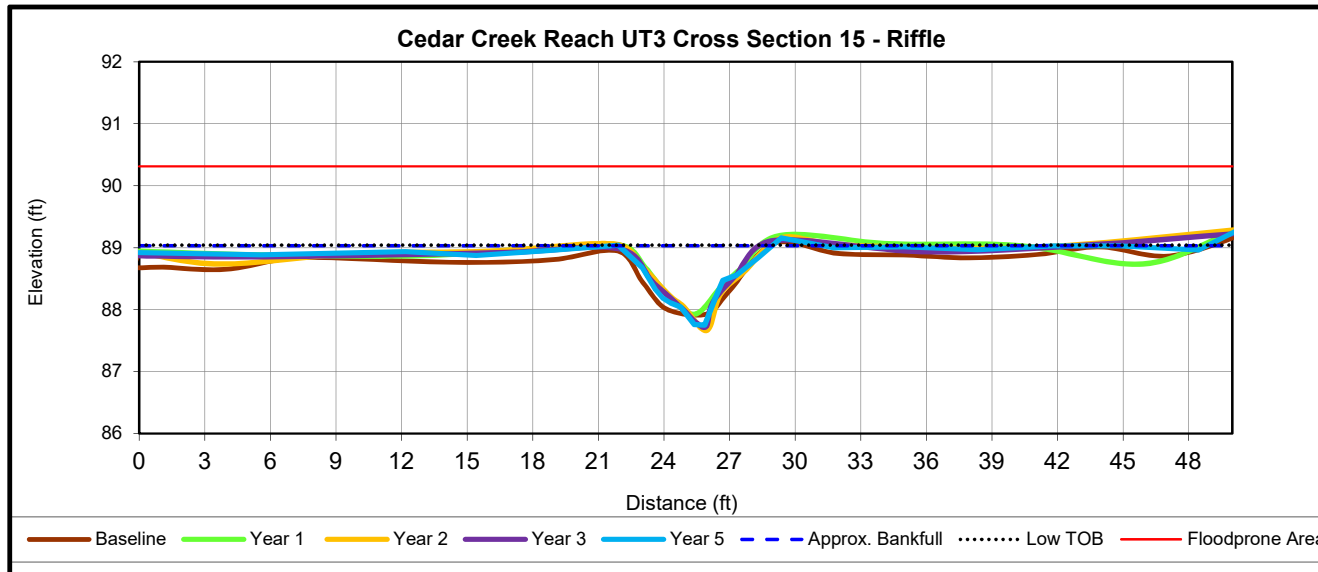
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 15 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	89.0	89.0	89.0	89.0	89.0		
Bankfull Width (ft) <sup>1</sup>	6.8	6.4	6.9	6.7	7.0		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.6	0.5	0.6	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.0	1.1	1.3	1.3	1.3		
Low Bank Elevation (ft)	-	-	-	-	89.0		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.3	3.5	4.1	4.1	4.3		
Bankfull Width/Depth Ratio	10.8	11.9	11.7	11.1	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	1.0		

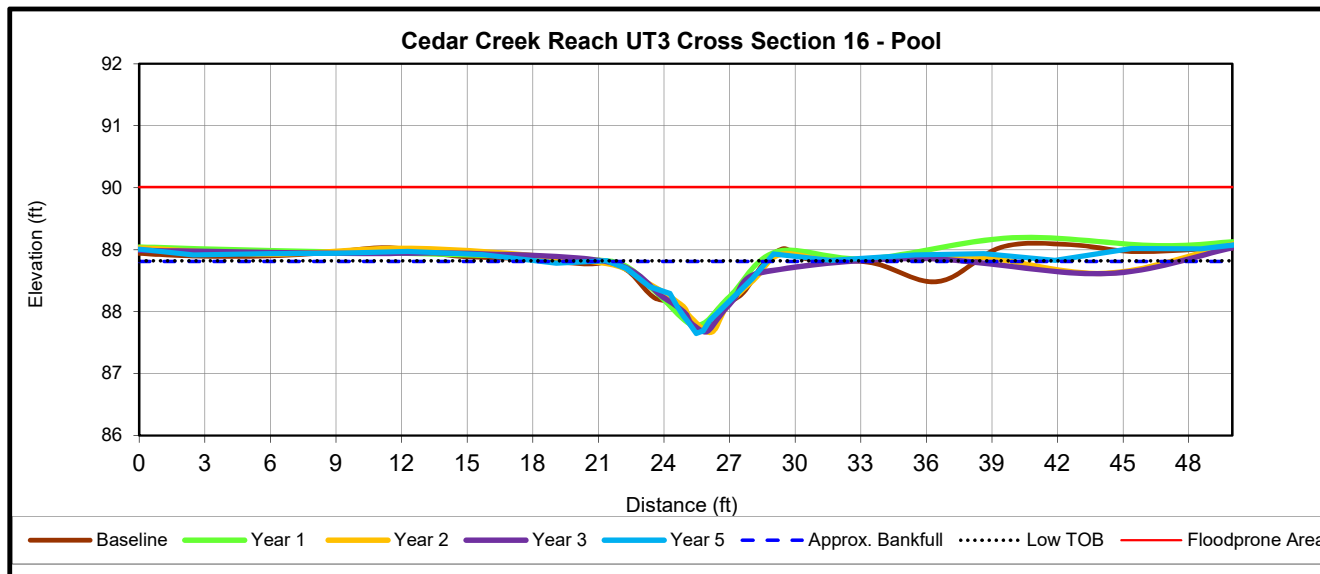
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 16 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	88.8	88.8	88.8	88.8	88.8		
Bankfull Width (ft) <sup>1</sup>	7.1	7.1	8.5	6.6	7.3		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.2		
Bankfull Mean Depth (ft)	0.5	0.5	0.5	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	1.0	1.1	1.1	1.2		
Low Bank Elevation (ft)	-	-	-	-	88.8		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.8	3.5	3.8	3.9	3.8		
Bankfull Width/Depth Ratio	13.1	14.4	18.8	11.4	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

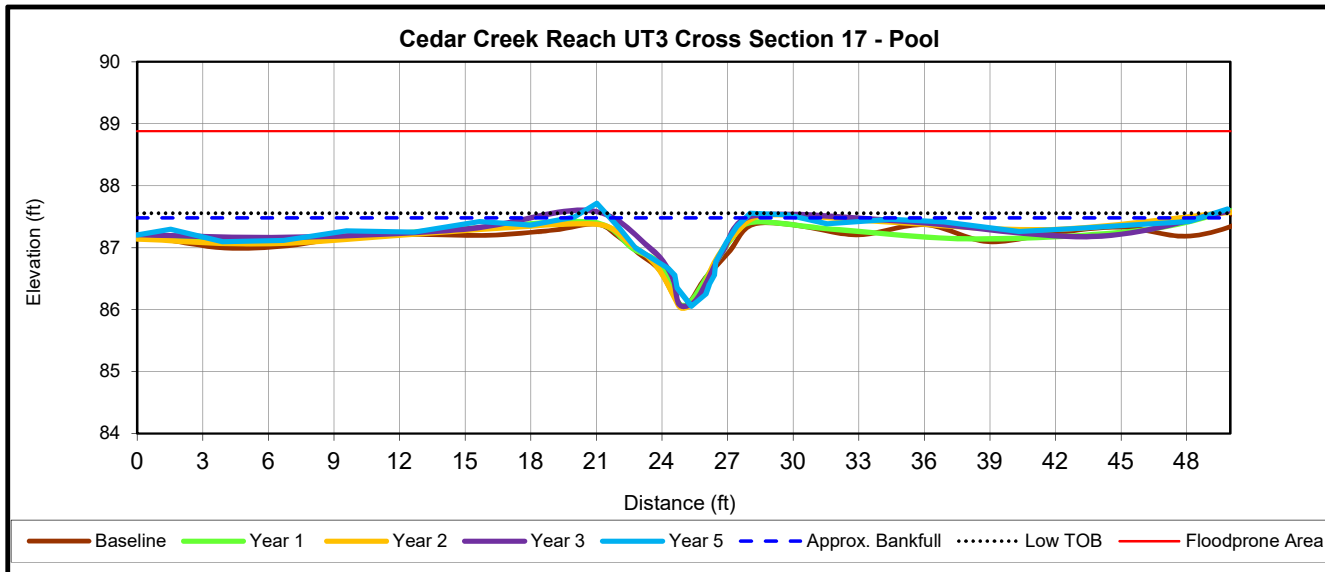
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 17 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	87.4	87.4	87.4	87.4	87.5		
Bankfull Width (ft) <sup>1</sup>	7.1	7.2	7.1	6.3	6.2		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9		
Bankfull Mean Depth (ft)	0.6	0.6	0.6	0.6	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.3	1.3	1.4	1.3	1.5		
Low Bank Elevation (ft)					87.6		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.2	4.0	4.2	3.7	4.7		
Bankfull Width/Depth Ratio	12.0	13.0	12.0	10.8	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

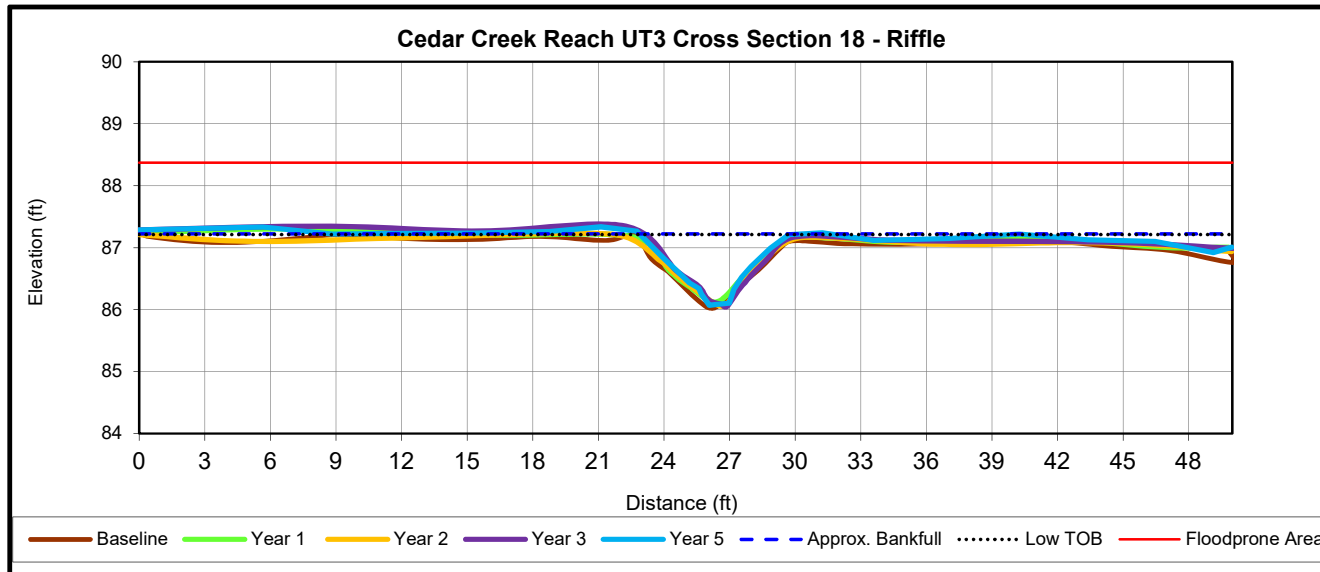
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 18 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	87.1	87.1	87.1	87.1	87.2		
Bankfull Width (ft) <sup>1</sup>	7.0	6.9	7.7	6.7	6.8		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	0.6	0.5	0.5	0.5	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	1.0	1.0	1.0	1.1		
Low Bank Elevation (ft)	-	-	-	-	87.2		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	4.0	3.5	3.7	3.5	3.9		
Bankfull Width/Depth Ratio	12.3	13.7	16.0	12.9	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.1	1.0		

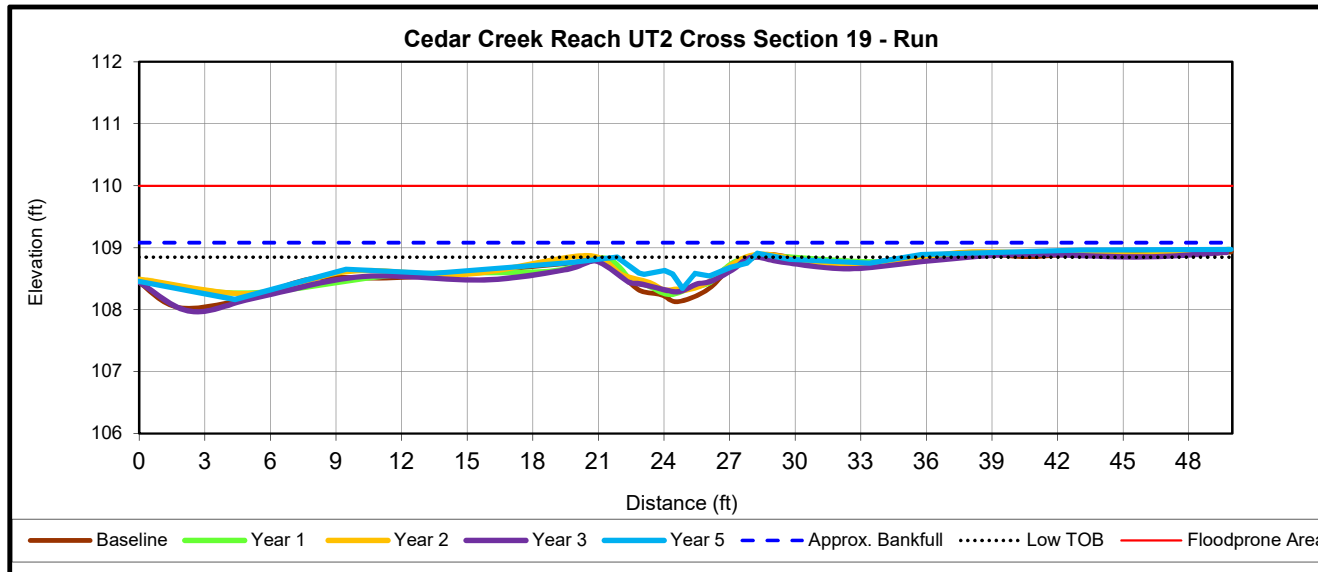
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 19 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	108.8	108.8	108.8	108.8	109.8		
Bankfull Width (ft) <sup>1</sup>	7.5	6.3	6.8	7.2	6.4		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9		
Bankfull Mean Depth (ft)	0.4	0.3	0.3	0.3	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.8	0.6	0.5	0.8	0.7		
Low Bank Elevation (ft)					108.8		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.9	2.1	2.0	2.2	1.4		
Bankfull Width/Depth Ratio	19.6	19.4	23.4	23.5	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1		

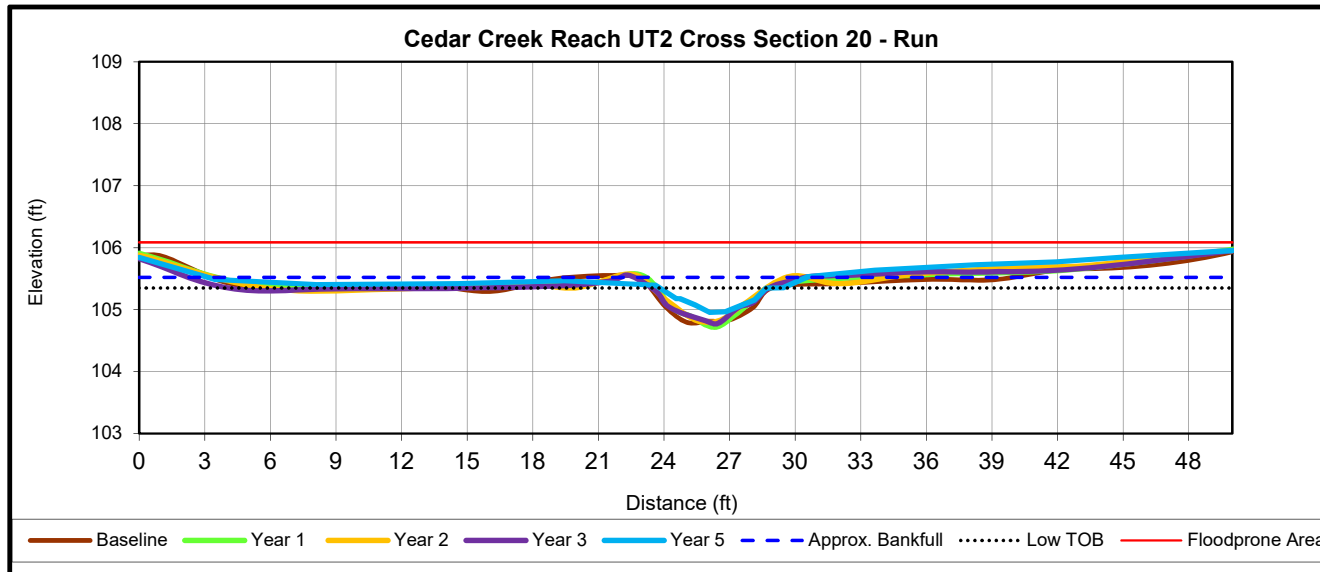
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 20 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	105.4	105.4	105.4	105.4	105.5		
Bankfull Width (ft) <sup>1</sup>	8.8	5.9	5.9	6.1	11.1		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	50.0		
Bankfull Mean Depth (ft)	0.3	0.4	0.3	0.3	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.6	0.7	0.6	0.6	0.4		
Low Bank Elevation (ft)	-	-	-	-	105.3		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.7	2.2	2.0	2.1	1.2		
Bankfull Width/Depth Ratio	29.1	15.7	17.4	17.7	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.2	<1		

**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.

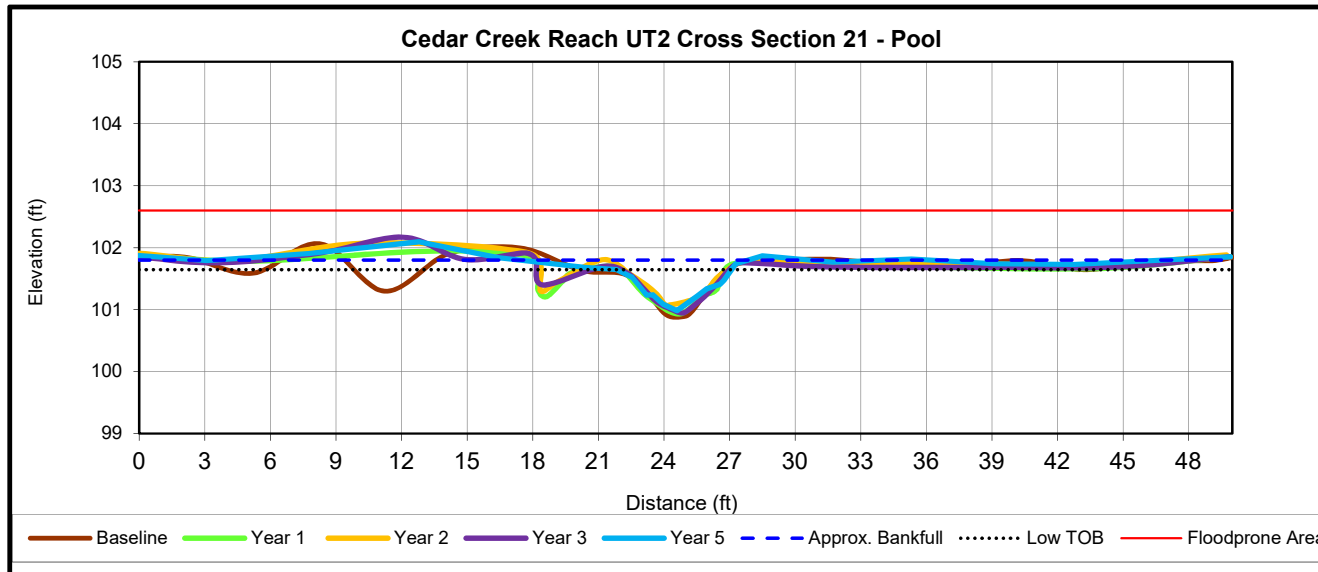




Upstream



Downstream



Dimension	Cross Section 21 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	101.8	101.8	101.8	101.8	101.8		
Bankfull Width (ft) <sup>1</sup>	8.9	11.1	10.0	9.9	9.9		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9		
Bankfull Mean Depth (ft)	0.3	0.4	0.3	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.9	0.9	0.7	0.9	0.7		
Low Bank Elevation (ft)	-	-	-	-	101.6		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.1	4.0	3.3	3.7	1.9		
Bankfull Width/Depth Ratio	25.6	30.8	30.6	26.8	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

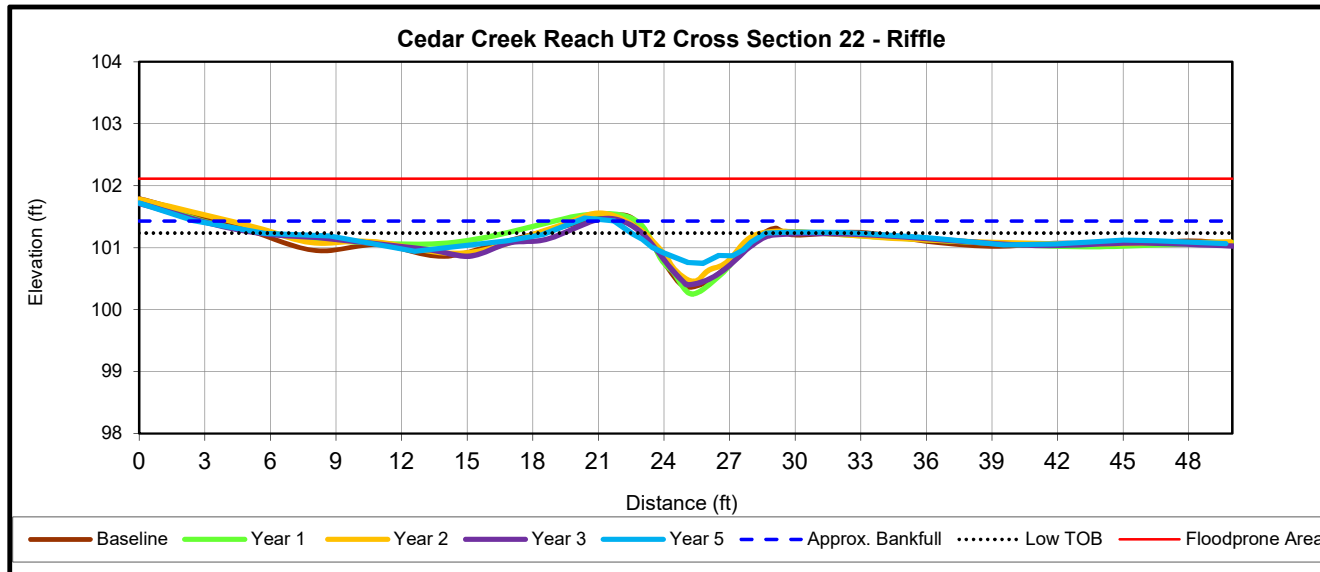
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 22 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	101.3	101.3	101.3	101.3	101.4		
Bankfull Width (ft) <sup>1</sup>	6.0	5.9	6.7	6.4	6.9		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.7		
Bankfull Mean Depth (ft)	0.5	0.6	0.4	0.5	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.9	1.0	0.8	0.9	0.5		
Low Bank Elevation (ft)	-	-	-	-	101.2		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.1	3.3	2.7	3.2	1.8		
Bankfull Width/Depth Ratio	11.6	10.7	16.8	13.0	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	0.9	<1		

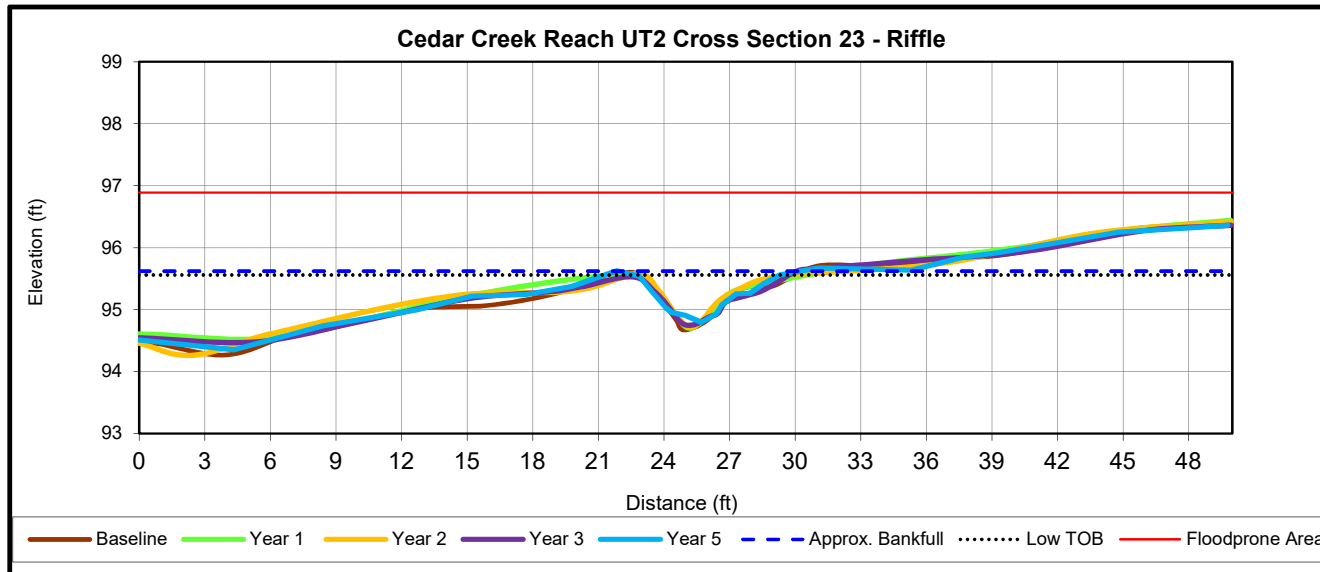
Note: Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Left Bank



Dimension	Cross Section 23 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	95.6	95.6	95.6	95.6	95.6		
Bankfull Width (ft) <sup>1</sup>	8.3	8.7	7.0	7.5	7.4		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.8		
Bankfull Mean Depth (ft)	0.4	0.3	0.5	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.3	1.0	1.4	1.1	1.2		
Low Bank Elevation (ft)					95.6		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.1	2.9	3.3	3.2	2.6		
Bankfull Width/Depth Ratio	21.9	26.1	15.0	17.2	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	0.9	1.0		

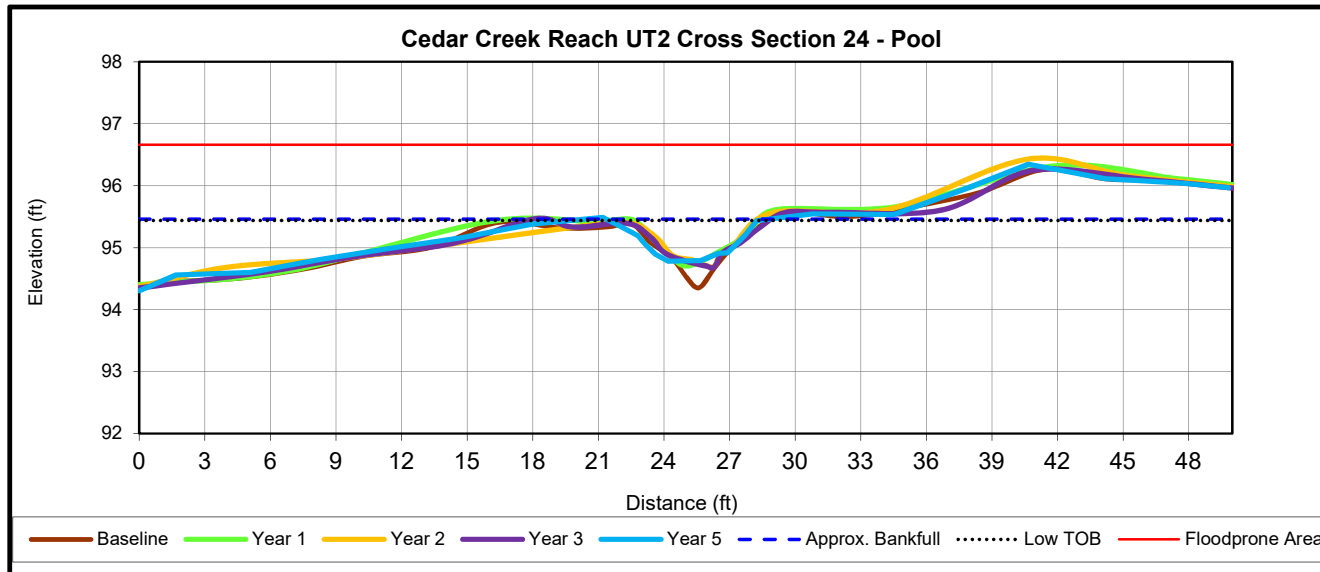
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 24 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	95.4	95.4	95.4	95.4	95.5		
Bankfull Width (ft) <sup>1</sup>	5.9	5.7	6.4	6.5	7.4		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.8		
Bankfull Mean Depth (ft)	0.5	0.4	0.5	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	1.1	1.0	1.1	1.1	1.1		
Low Bank Elevation (ft)	-	-	-	-	95.4		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	3.0	2.2	2.9	2.5	2.9		
Bankfull Width/Depth Ratio	11.8	14.7	14.1	16.7	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

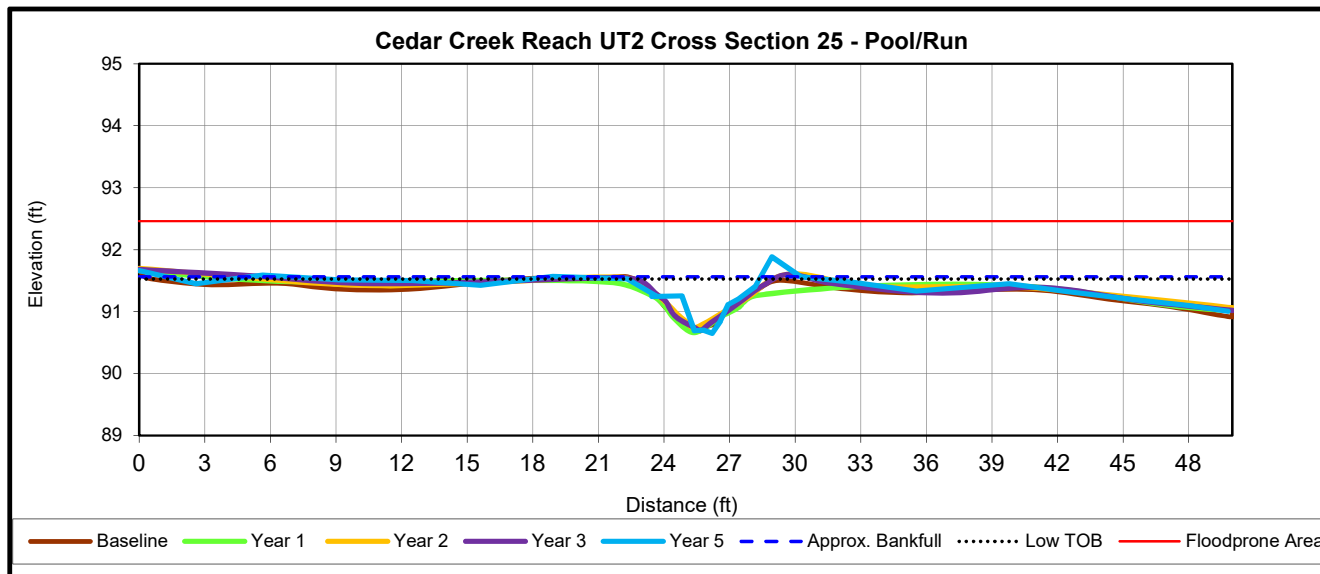
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 25 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	91.5	91.5	91.5	91.5	91.6		
Bankfull Width (ft) <sup>1</sup>	6.6	6.6	6.8	6.3	8.7		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.8		
Bankfull Mean Depth (ft)	0.4	0.4	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.8	8.0	0.8	0.8	0.9		
Low Bank Elevation (ft)	-	-	-	-	91.5		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.6	2.9	2.5	2.5	2.3		
Bankfull Width/Depth Ratio	17.0	15.3	18.8	16.1	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	N/A	N/A		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	N/A	N/A		

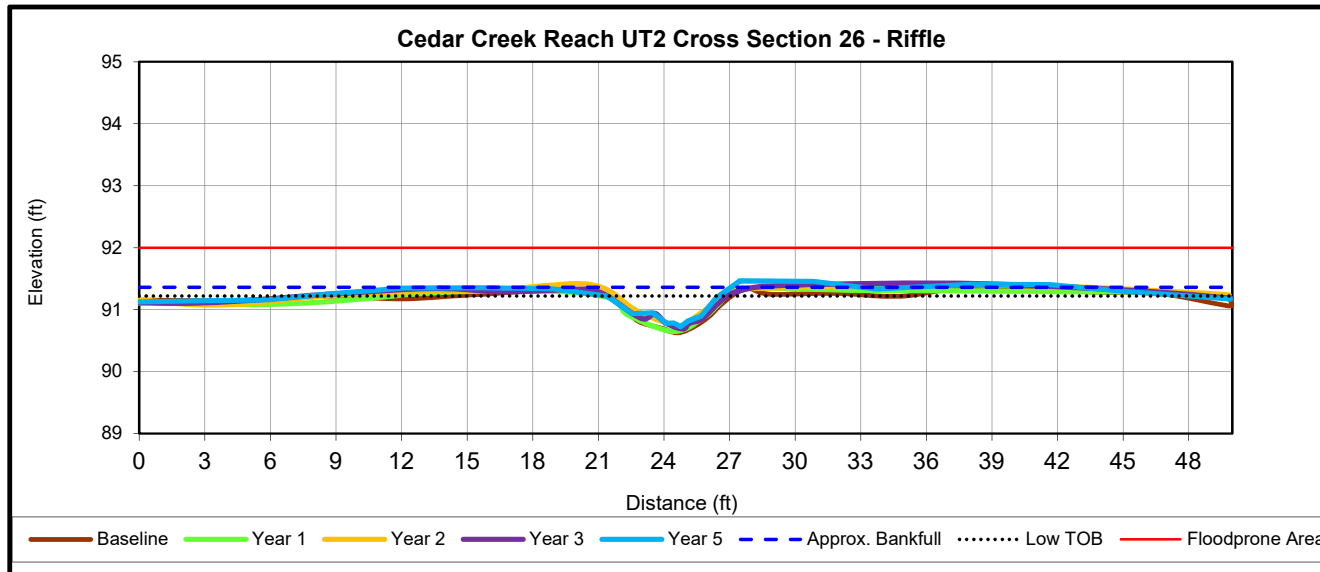
**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 26 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA <sup>1</sup>	91.3	91.3	91.3	91.3	91.4		
Bankfull Width (ft) <sup>1</sup>	6.8	8.2	6.0	6.8	11.5		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9		
Bankfull Mean Depth (ft)	0.4	0.3	0.3	0.3	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.7	0.7	0.6	0.6	0.5		
Low Bank Elevation (ft)					91.2		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.5	2.4	1.9	2.1	1.4		
Bankfull Width/Depth Ratio	18.1	27.3	18.9	21.8	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1		

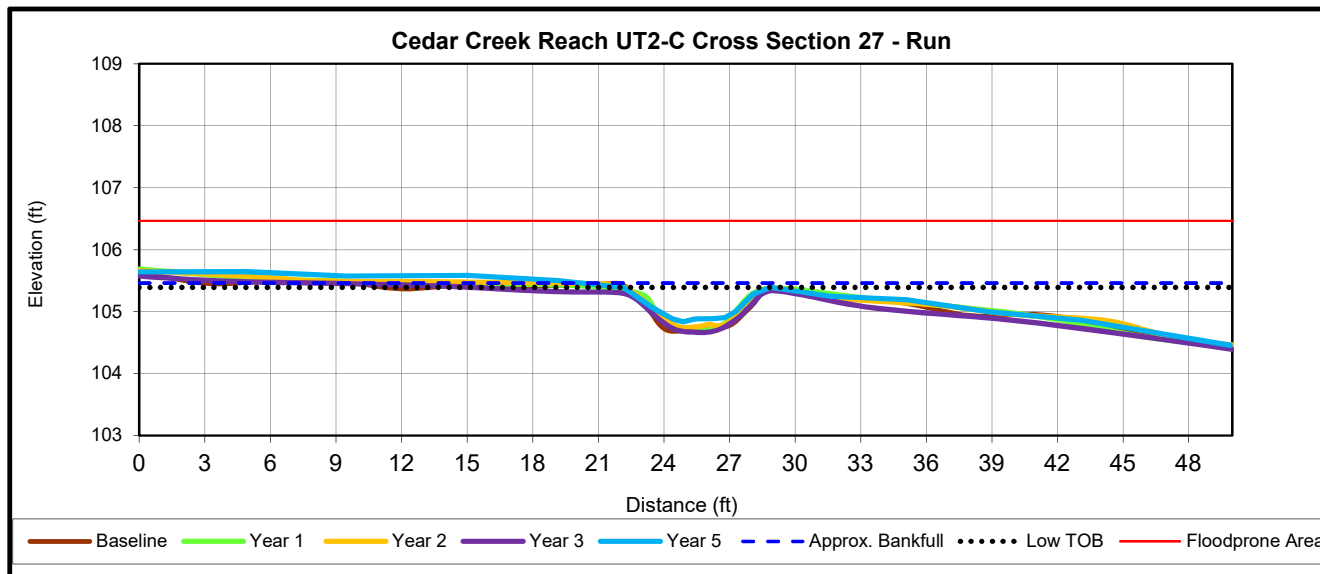
Note: Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.



Upstream



Downstream



Dimension	Cross Section 27 (Run)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+
<b>Bankfull Elevation (ft) - Based on AB-XSA<sup>1</sup></b>	105.3	105.3	105.3	105.3	105.5		
Bankfull Width (ft) <sup>1</sup>	6.4	5.7	5.7	6.8	8.6		
Floodprone Width (ft) <sup>1</sup>	50.0	50.0	50.0	50.0	49.9		
Bankfull Mean Depth (ft)	0.4	0.4	0.4	0.4	-		
Bankfull Max Depth (ft) <sup>2</sup>	0.9	0.8	0.8	0.9	0.9		
Low Bank Elevation (ft)					105.4		
Bankfull Cross Sectional Area (ft <sup>2</sup> ) <sup>2</sup>	2.8	2.1	2.1	2.6	2.3		
Bankfull Width/Depth Ratio	14.8	15.2	15.5	17.9	-		
Bankfull Entrenchment Ratio <sup>1</sup>	>2.2	>2.2	>2.2	>2.2	>2.2		
Bankfull Bank Height Ratio <sup>1</sup>	1.0	1.0	1.0	1.0	<1		

**Note:** Starting in MY5, the parameters denoted with <sup>1</sup> were calculated using the as-built cross sectional area as the basis for adjusting the bankfull elevation and the parameters denoted with <sup>2</sup> were calculated using the current years low top of bank as the bankfull.

# **Appendix E**

## **Hydrology Data**

Table 13. Documentation of Geomorphological Significant Flow Events

Table 14. Rainfall Summary

Table 15. Wetland Hydrology Criteria Attainment

Figure 8. 2019 Groundwater Monitoring Gauge Hydrographs

Figure 9. Headwater Valley Restoration Flow Chart

Crest Gauge Verification Photos



**Table 13. Documentation of Geomorphologically Significant Flow Events**

Crest Gauge	Flow Events	Maximum Consecutive Flow Days	Cumulative Flow Days
Crest Gauge 2 (HWV UT-2C)			
MY2	36	117	186
MY3	36	35	130
MY4	32	57	168
MY5	6	122	151

**Note:** Starting in MY5, flow days were calculated using the height of the downstream riffle

Crest Gauge	Number of Bankfull Events	Maximum Bankfull Height (ft.)
Crest Gauge 1 (UT3)		
MY1	0	NA
MY2	4	1.15
MY3	0	NA
MY4	4	1.05
MY5	3	0.8
Crest Gauge 3 (UT2)		
MY1	0	NA
MY2	1	0.4
MY3	0	NA
MY4	2	0.25
MY5	0	N/A

**Table 14. 2019 Rainfall Summary**

Month	Average	Normal Limits		Clinton Precipitation
		30 Percent	70 Percent	
January	4.33	3.32	5.03	2.60
February	3.23	2.14	3.87	2.45
March	4.50	3.23	5.32	3.34
April	3.16	1.70	3.85	4.67
May	3.68	2.69	4.34	2.22
June	4.49	3.11	5.34	3.81
July	6.06	4.16	7.22	4.96
August	5.40	3.12	6.56	10.34
September	5.00	2.04	6.07	9.44
October	3.21	1.62	3.92	2.87
November	2.89	1.83	3.49	0.03
December	3.24	2.14	3.88	---
Total	49.19	31.10	58.89	46.73

**Table 15a. 2019 Wetland Hydrology Criteria Attainment**

2019 Max Hydroperiod (Growing Season 17-Mar through 14-Nov, 242 days) Success Criterion 9%					
Gauge	Consecutive		Cumulative		Occurrences
	Days	Percent of growing Season	Days	Percent of growing Season	
AW1	243	100	243	100	1
AW2	243	100	243	100	1
AW3	243	100	243	100	1
AW4	133	55	236	97	2
AW5	43	18	124	51	9
AW6	67	27	195	80	13
AW7	6	2	33	13	10
AW8	44	18	74	31	6
AW9	43	18	122	50	8
AW10	43	18	104	43	6
AW11	33	13	85	35	11
RAW1*	---	---	---	---	---
RAW2	90	37	207	85	9
RAW3	90	37	186	77	7

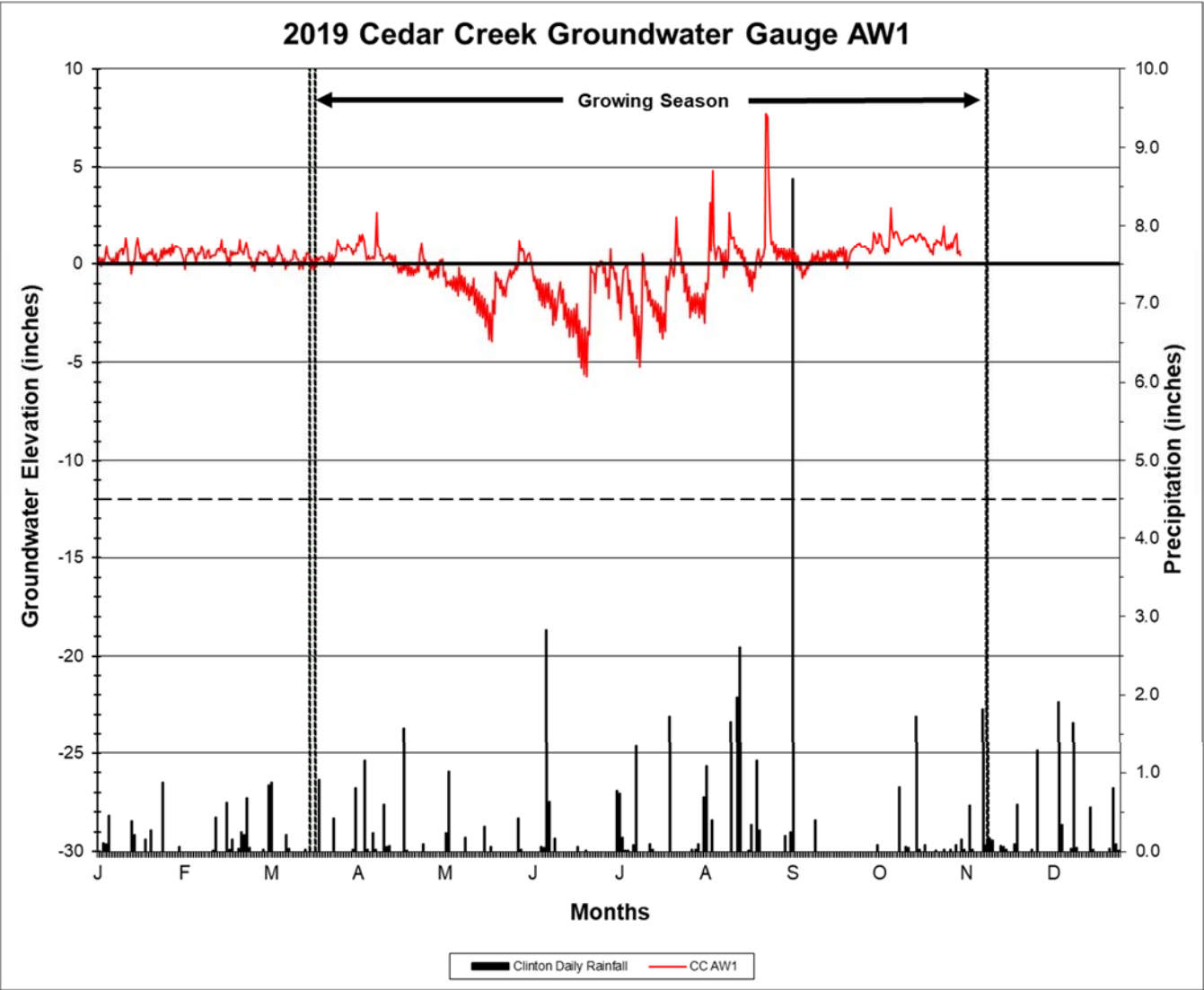
\*Reference Well 1 was destroyed during Hurricane Florence

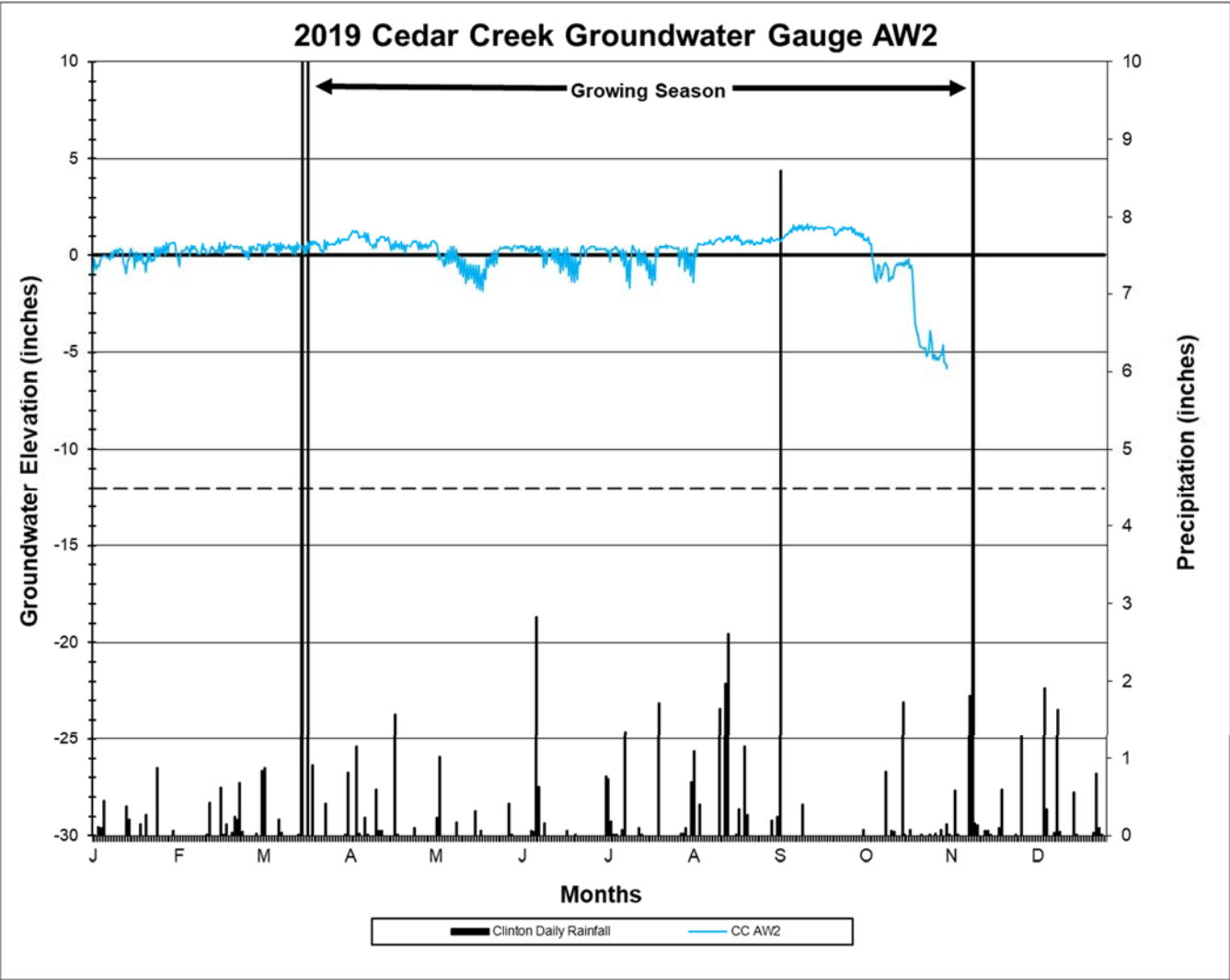
**Table 15b. Wetland Hydrology Gauge Summary**

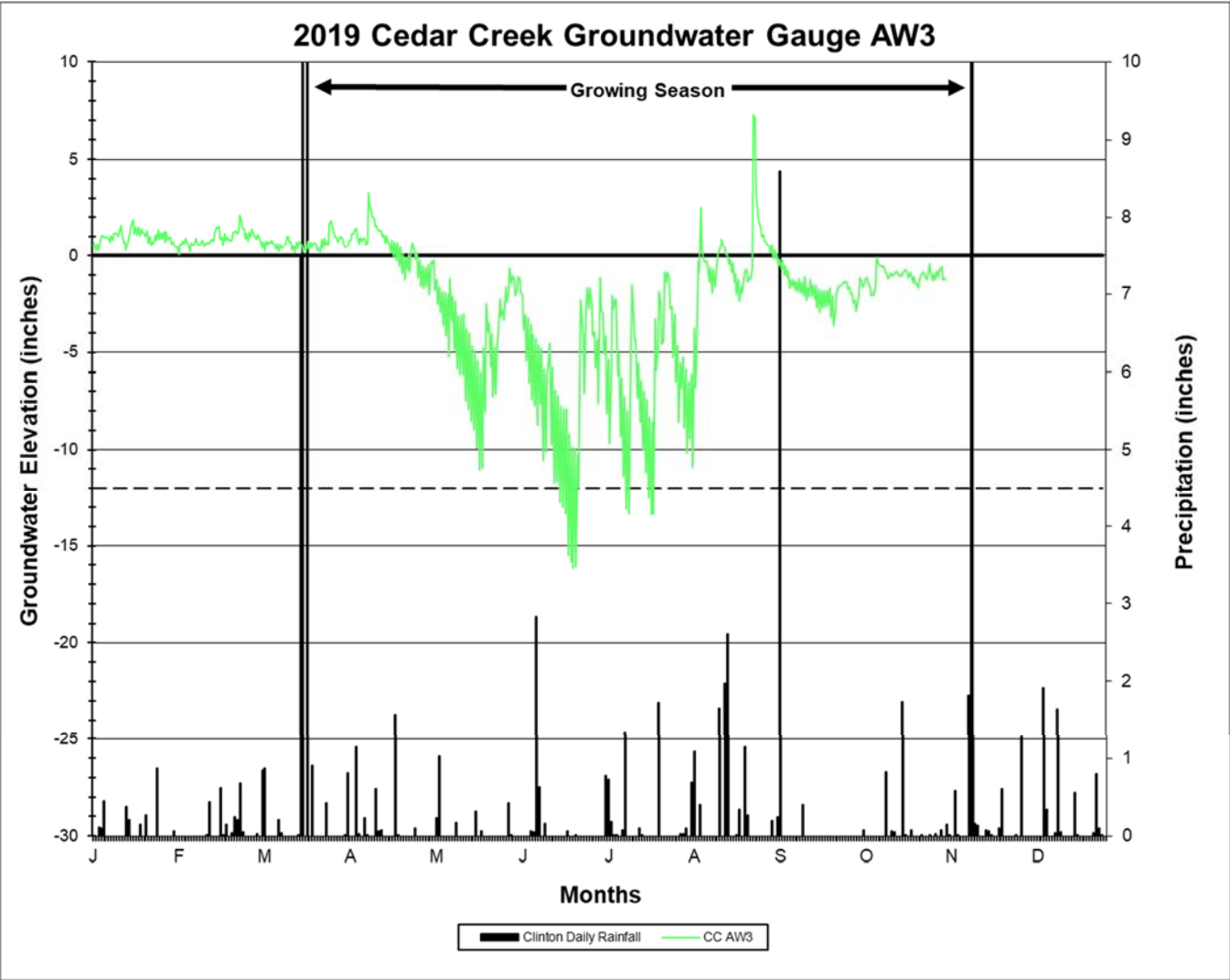
Gauge	MY1 - 2015		MY2 - 2016		MY3 - 2017		MY4 - 2018		MY5 - 2019	
	Consecutive		Consecutive		Consecutive		Consecutive		Consecutive	
	Days	Percent of growing Season	Days	Percent of growing Season	Days	Percent of growing season	Days	Percent of growing season	Days	Percent of growing season
AW1	162	67	229	94	240	99	242	100	243	100
AW2	162	67	229	94	240	99	242	100	243	100
AW3	71	29	134	55	242	100	242	100	243	100
AW4	100	41	229	94	131	54	242	100	133	55
AW5	51	21	60	25	53	22	49	20	43	18
AW6	51	21	96	39	79	32	98	40	67	27
AW7	5	2	4	2	2	1	7	3	6	2
AW8	21	9	34	14	28	12	19	8	44	18
AW9	51	21	33	13	61	25	49	20	43	18
AW10	50	21	35	14	31	13	36	15	43	18
AW11	13	5	6	2	24	10	19	8	33	13
RAW1	23	10	56	23	177	73	36	15	---	---
RAW2	52	21	99	41	191	79	62	25	90	37
RAW3	51	21	88	36	63	26	62	25	90	37

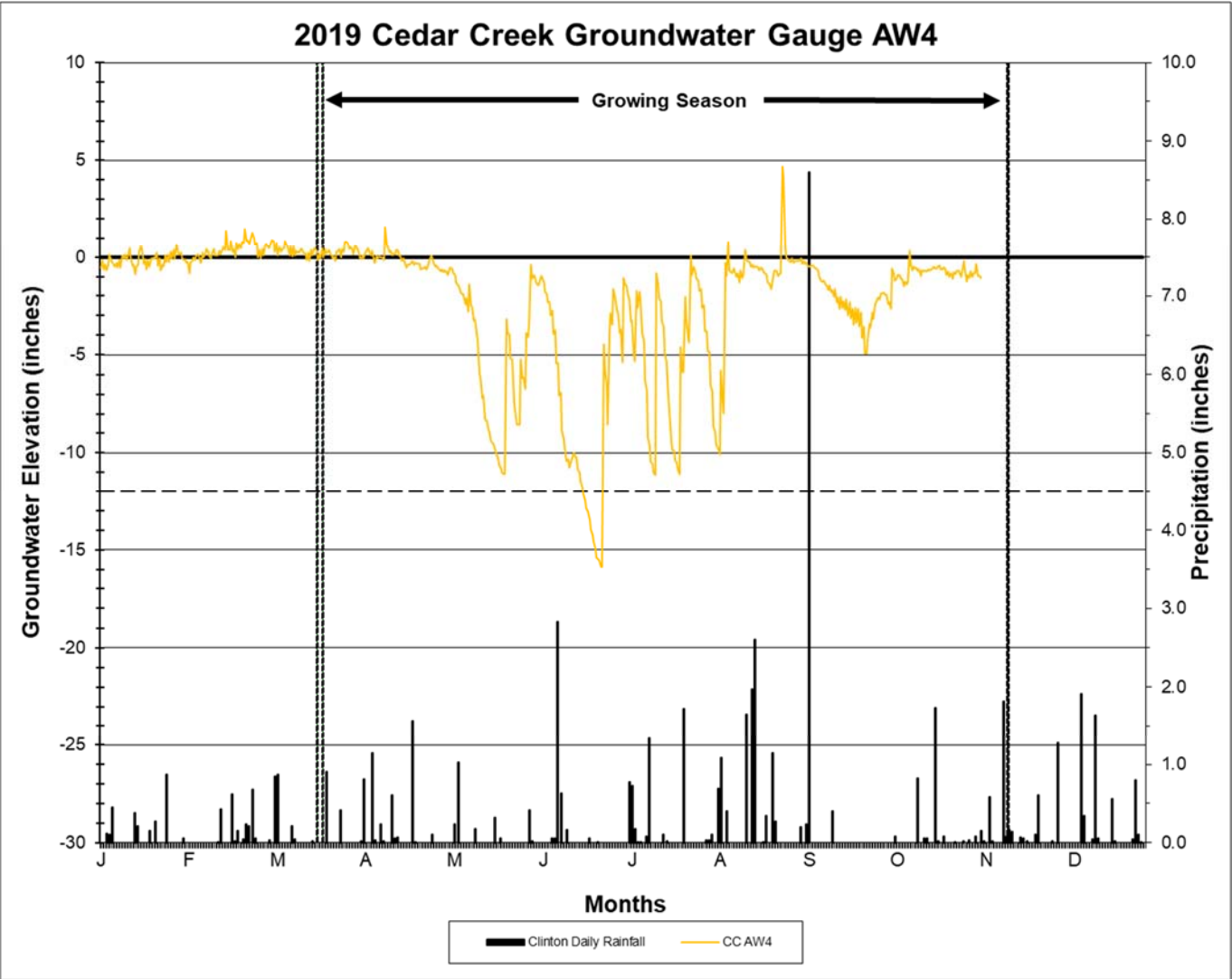
<5%    5-8%    ≥9%

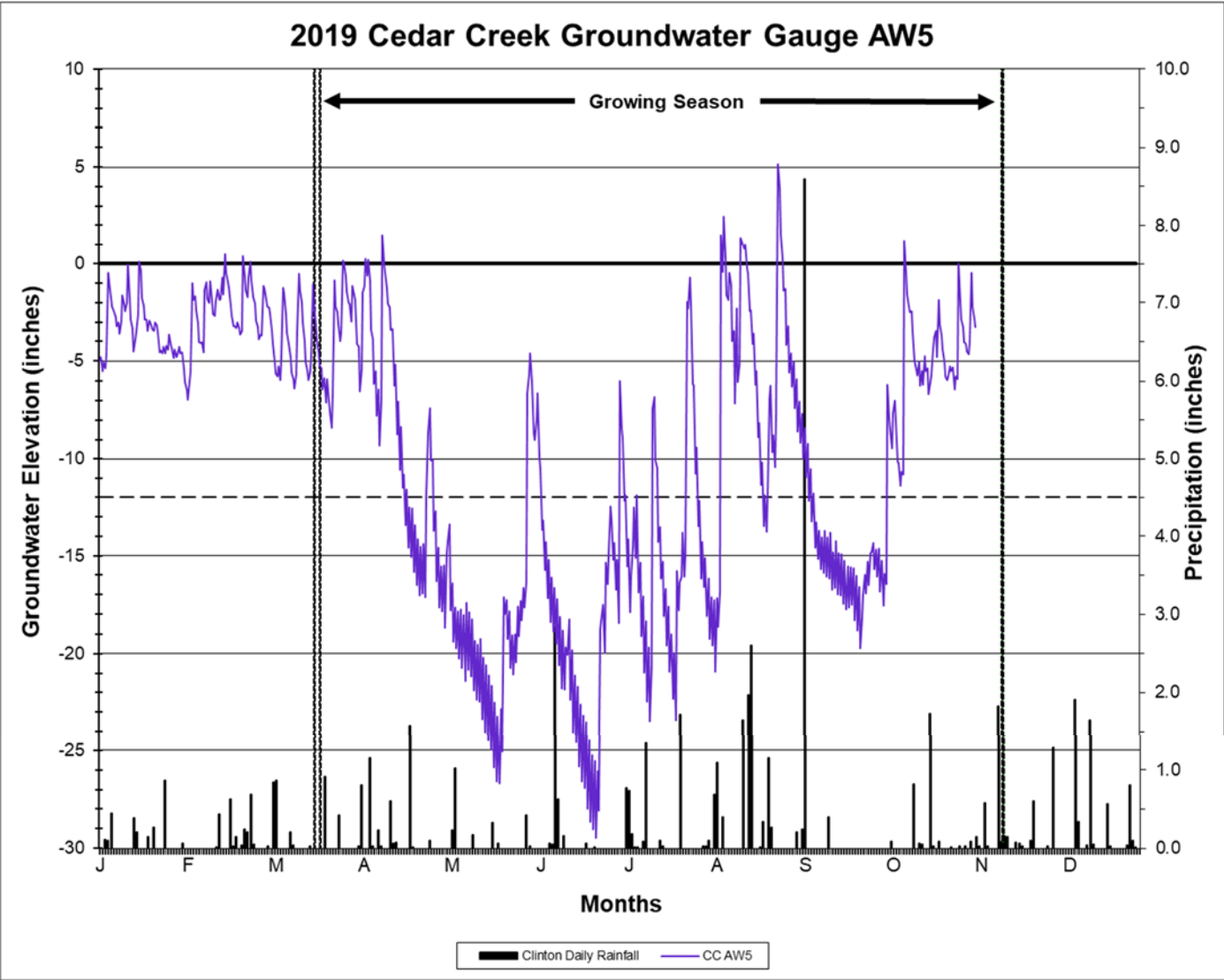
Figure 8. 2019 Cedar Creek Groundwater Monitoring Gauge Hydrographs

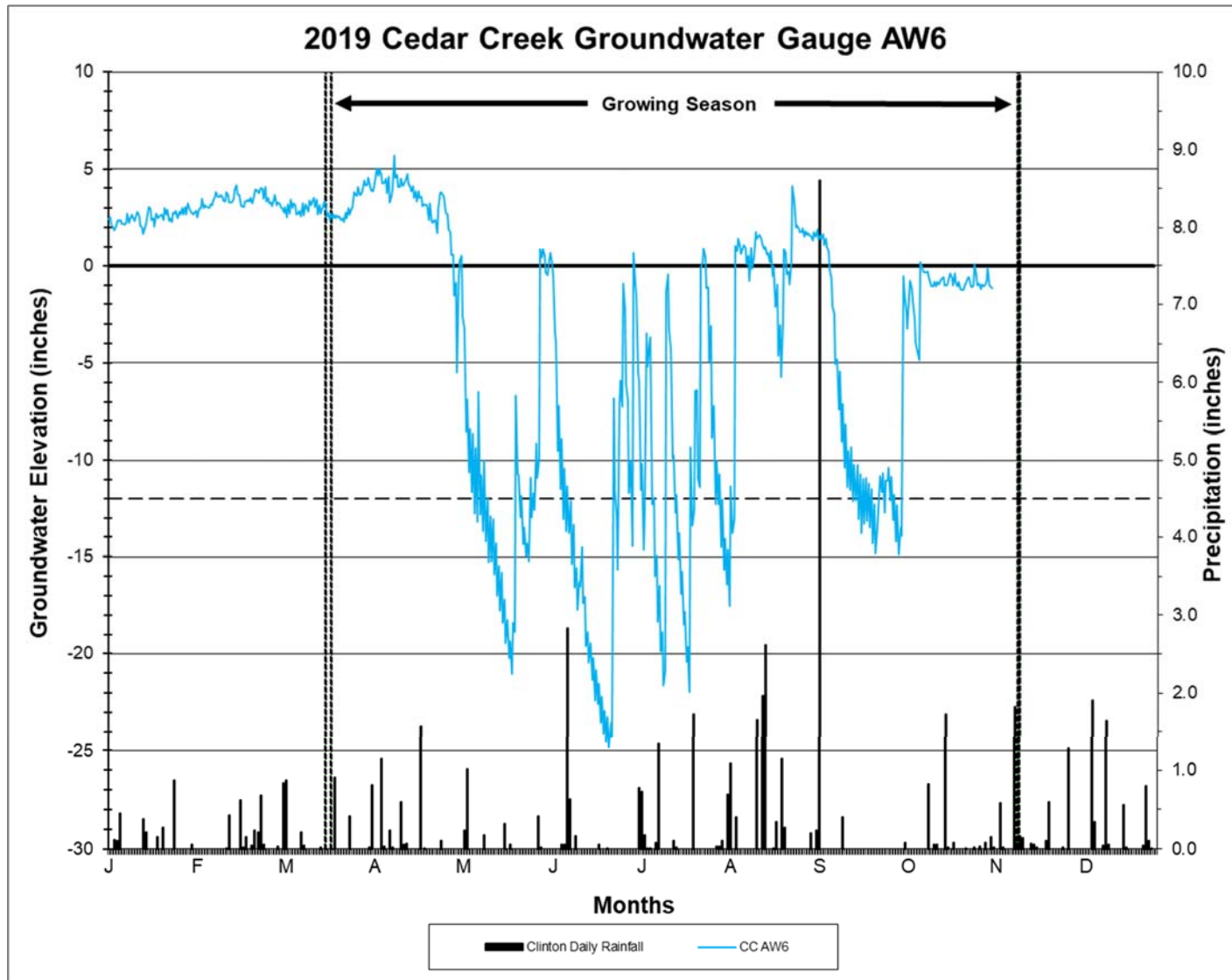




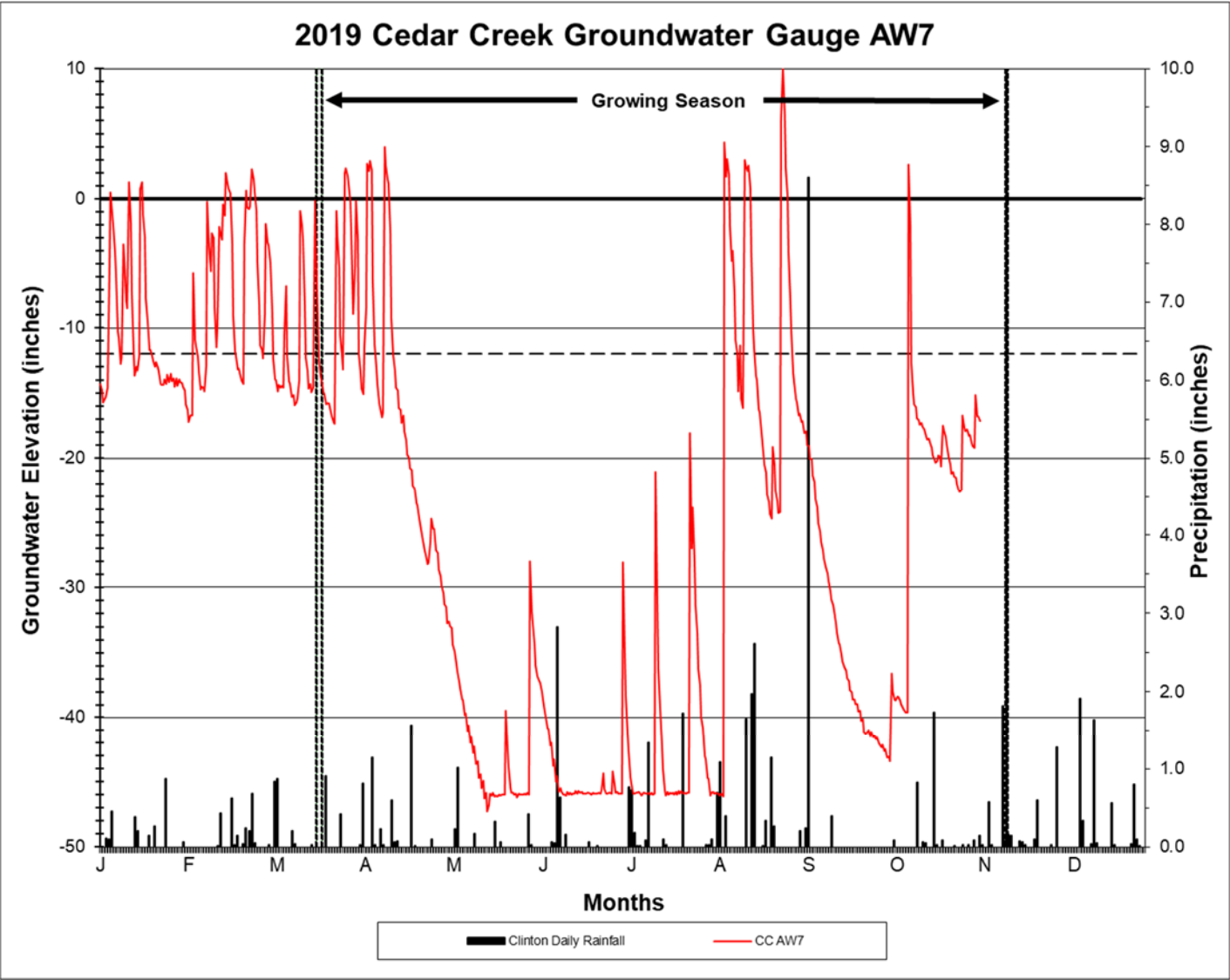


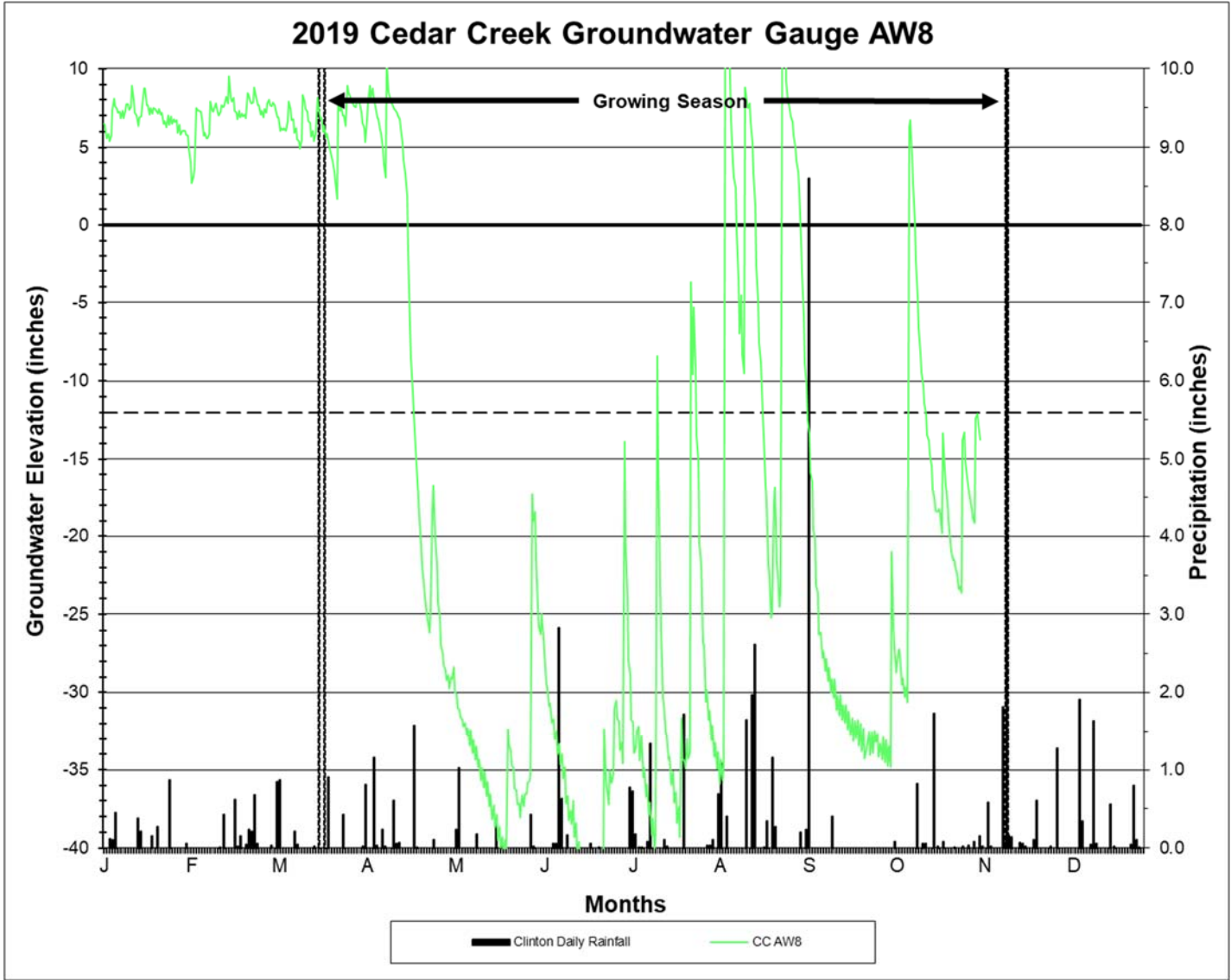


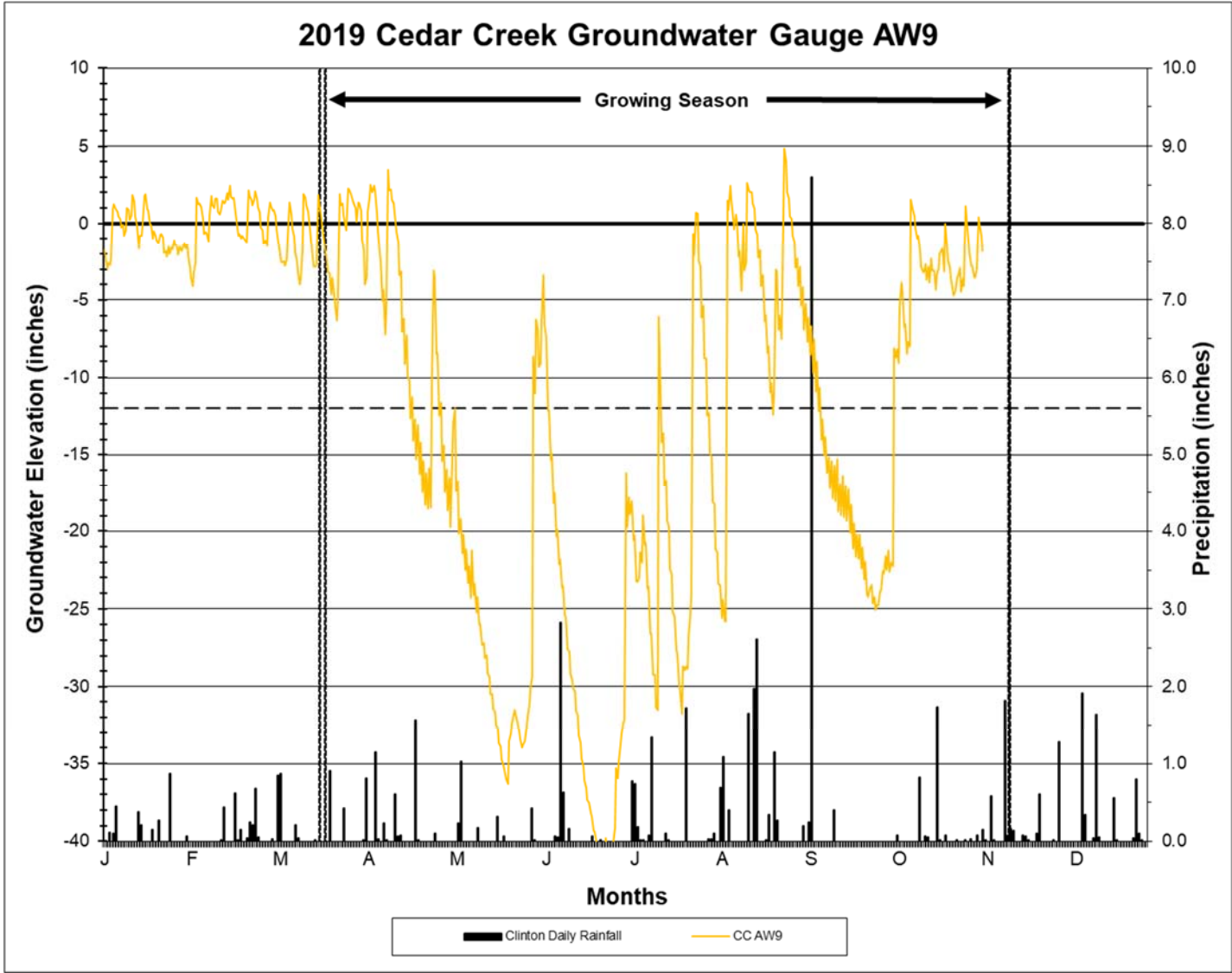


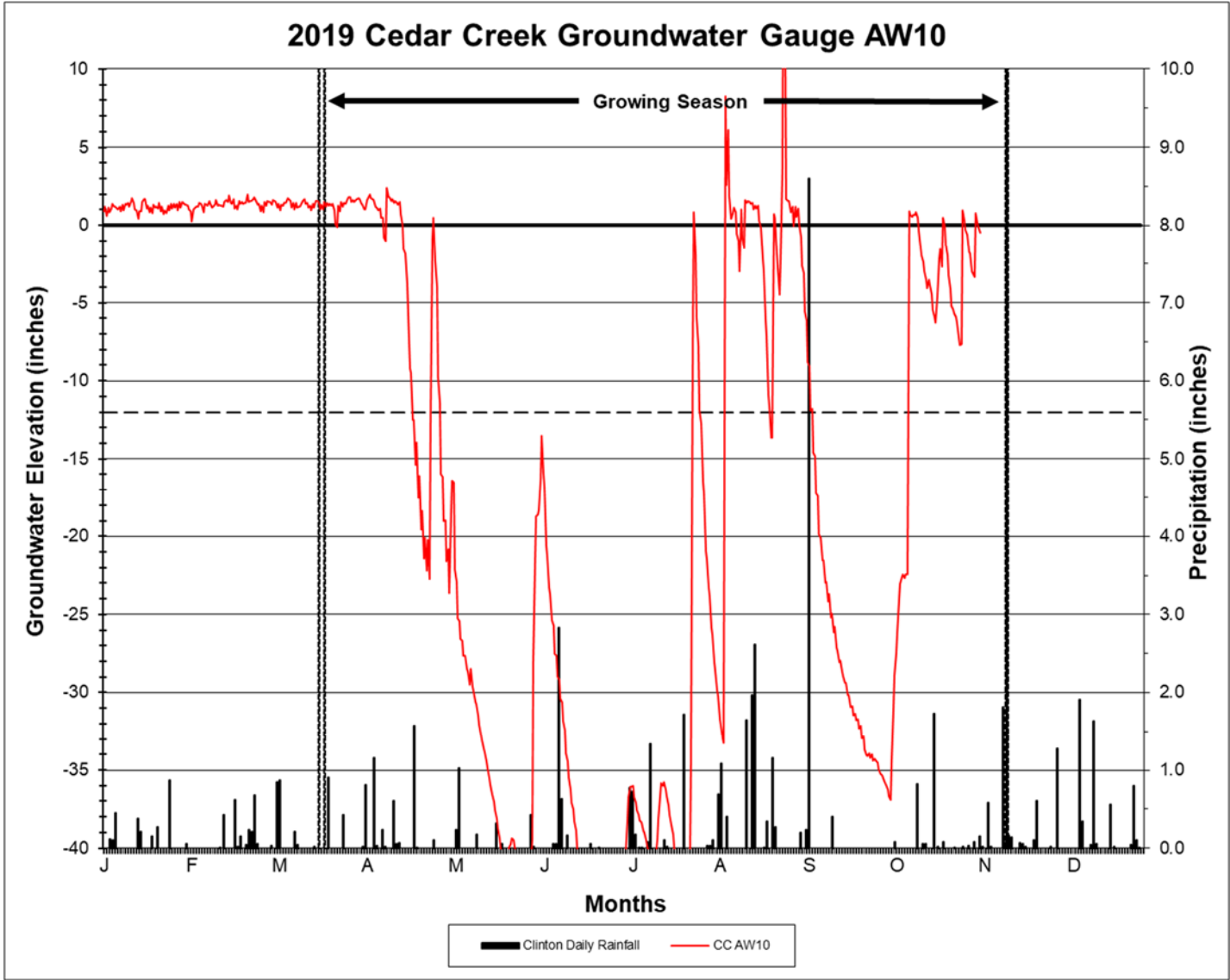


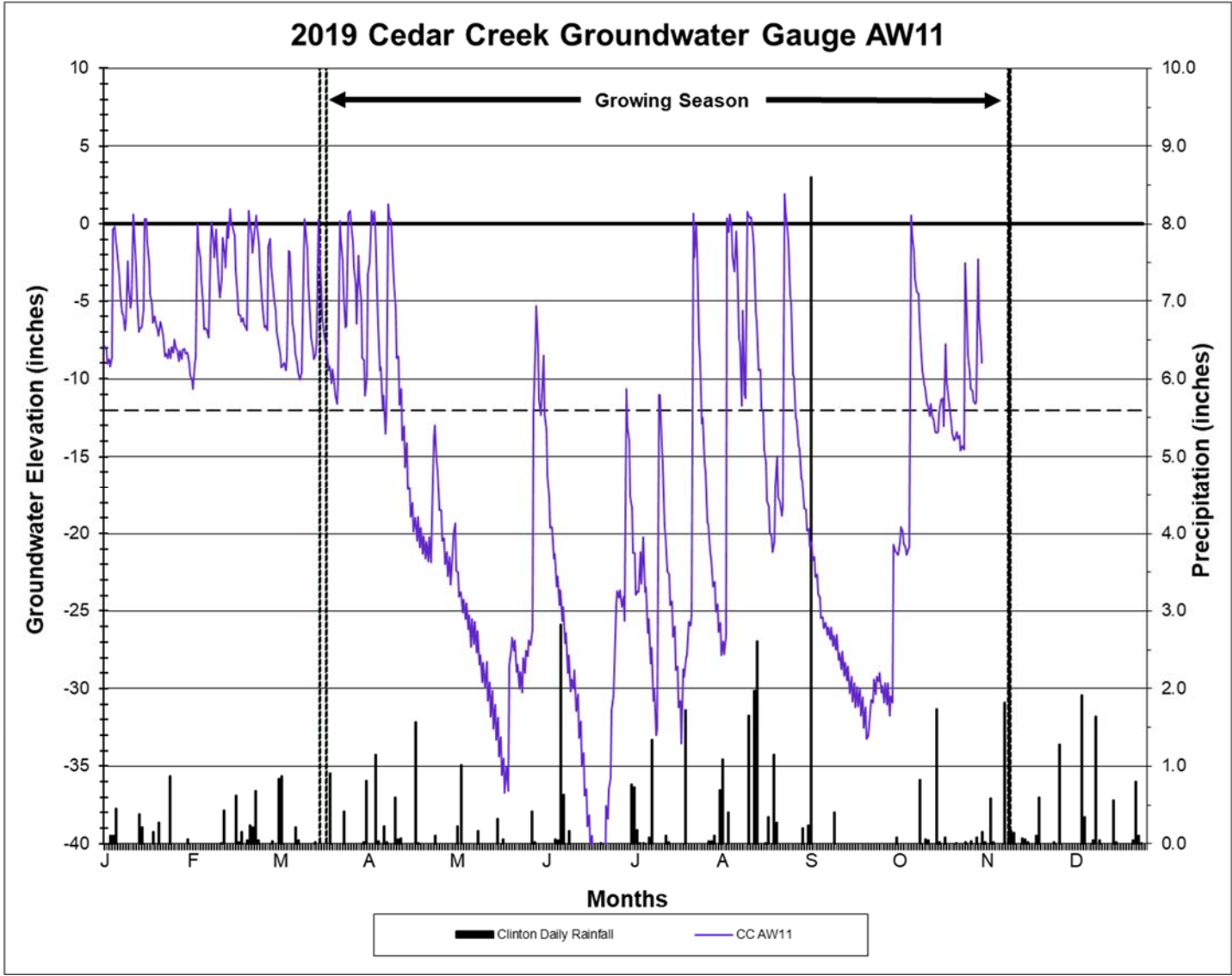


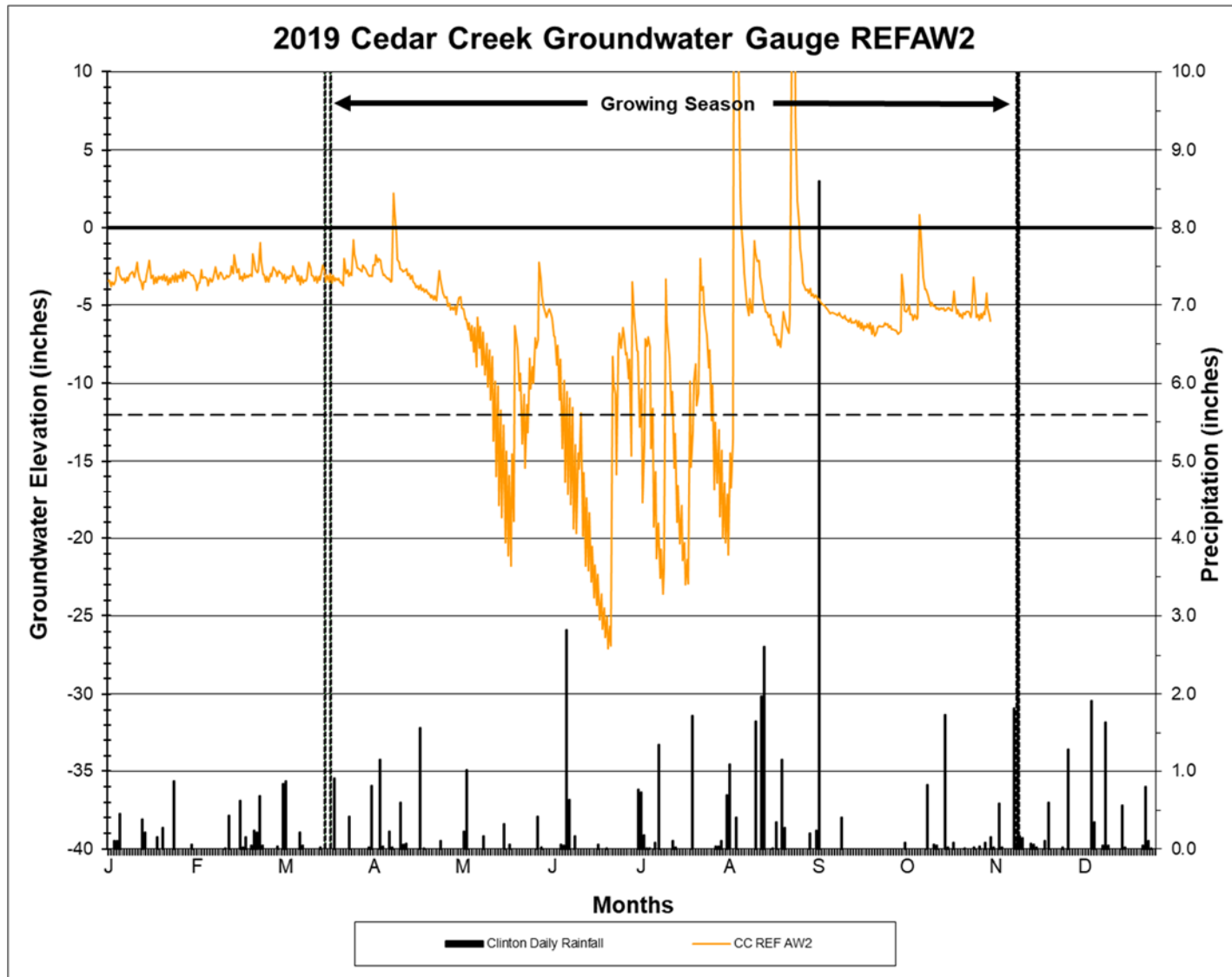












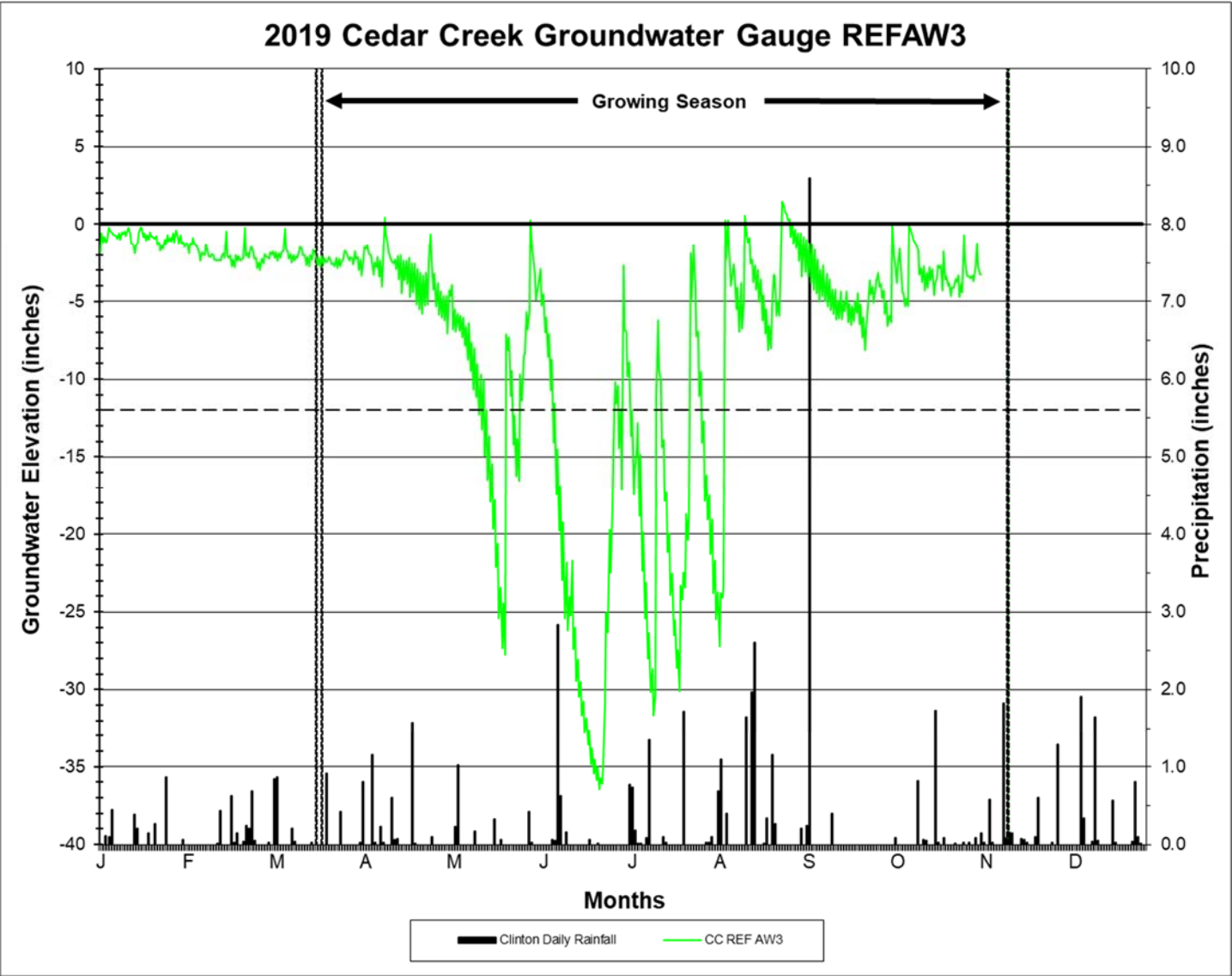
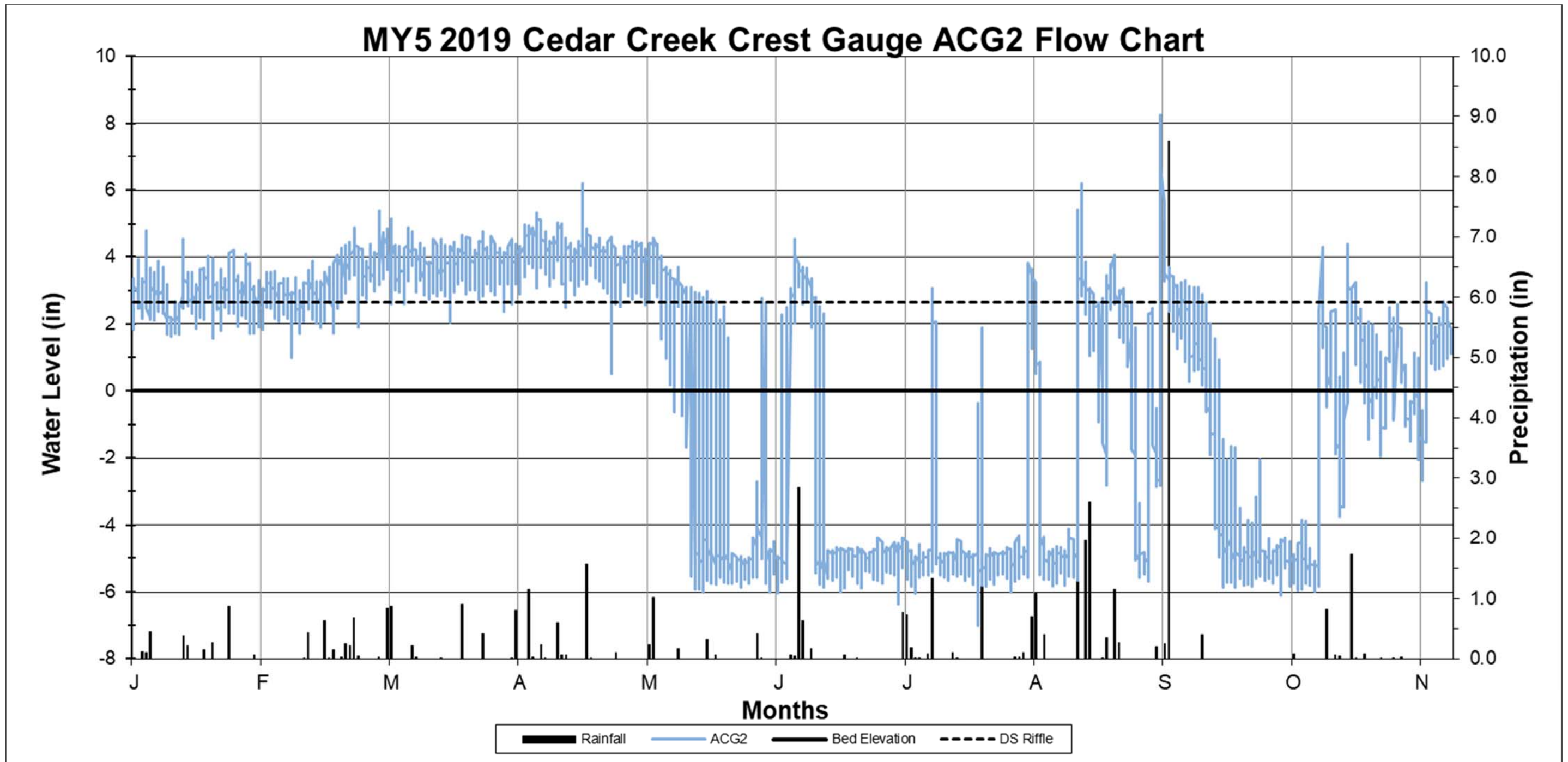


Figure 9. Headwater Valley Restoration Flow Chart





**Appendix E – Crest Gauge Verification Photos**



Crest Gauge 1 Reading 0.8 ft (09/06/2019)