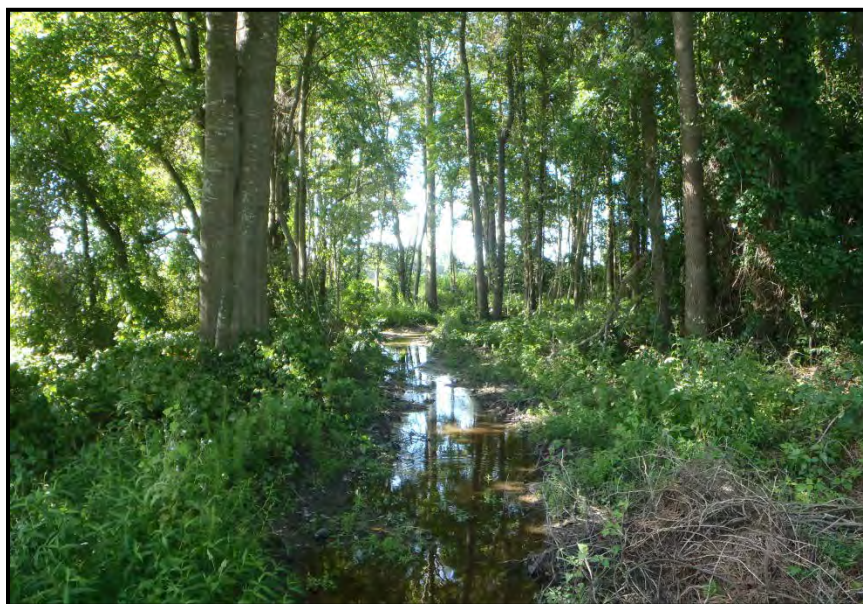


# **MUDDY RUN STREAM RESTORATION PROJECT**

## **MONITORING REPORT**

### **MONITORING YEAR 1**

DUPLIN COUNTY, NORTH CAROLINA, PROJECT # 95018



Prepared for:



## **North Carolina Ecosystem Enhancement Program**

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January 2015

**Muddy Run  
Duplin County, North Carolina  
EEP Project ID 95018**

**Cape Fear River Basin  
HUC 03030007060010**

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## EXECUTIVE SUMMARY

The Muddy Run Stream Restoration Project is located within an agricultural watershed in Duplin County, North Carolina, approximately six miles south of Beulaville. The stream channels were heavily impacted by channelization and agricultural practices. The project involved the restoration and protection of streams in the Muddy Creek watershed. The purpose of this restoration project was to restore and enhance a stream/wetland complex located within the Cape Fear River Basin.

The project lies within USGS Hydrologic Unit Code 03030007060010 (USGS, 1998) and within the North Carolina Division of Water Quality (NCDWQ) Cape Fear River Subbasin 03-06-22 (NCDENR, 2002). The project consists of three unnamed tributaries to Muddy Creek, but the project has been divided into five distinct reaches for design purposes. Reach 1A is the upstream-most portion of Reach 1; it begins approximately 50 feet below an agricultural road crossing, and extends to STA17+25. Reach 1B is the middle reach of the main stem; it begins at STA17+25, and runs through a clear-cut area to STA33+67. Reach 1C is the downstream section of Reach 1; it begins at a culvert crossing (STA33+67) and flows westward to STA47+08. Reach 2 starts on the south side of eight hog houses and flows northwest around two hog lagoons before entering Reach 1C. Reach 3 runs north to south, and flows directly into Reach 1C.

The Muddy Run II Mitigation Project is located upstream of Reach 3 and downstream of Reach 1C. Muddy Run II will also include riparian wetland restoration areas directly adjacent to the Muddy Run Easement on Reach 1B, Reach 1C, Reach 2, and Reach 3. Muddy Run II was constructed immediately following Muddy Run.

This Year 1 Annual Monitoring Report presents the data from 20 vegetation monitoring plots, four manual crest gauges, four auto crest gauges, an auto-logging rain gauge, 39 stream cross sections, 10 sets of bank pins, and photo reference locations, as required by the approved Mitigation Plan for the site.

The Year 1 vegetation monitoring observations for Muddy Run Site are summarized in this report. Planted-stem survival for Monitoring Year 1 for all 20 Vegetation Plots (VP) at Muddy Run was above the interim success criterion of 320 trees per acre at the end of Monitoring Year 3. The average stem density (excluding live stakes) across all vegetation plots was 740 stems per acre. Few volunteer tree species were noted during Monitoring Year 1. Three vegetation problem areas were noted during Monitoring Year 1. Invasive Chinese privet (*Ligustrum sinense*) was observed along a small portion of Reach 1B and two areas within the easement along Reach 2 were sparsely vegetated. These problem areas will continue to be observed during Monitoring Year 2; however, these areas pose no threat to achieving the vegetation success criteria. The Muddy Run Site is on track to meet the Year 3 vegetation survival success criterion of 320 trees per acre as specified in the Mitigation Plan.

Throughout the Year 1 monitoring season, the restored stream channel remained stable and continued to provide the intended habitat and hydrologic functions. All monitored cross sections show little adjustment in stream dimension, and the site remains on track to achieve the stream stability success criteria specified in the Mitigation Plan. A few areas along the restoration stream channel are exhibiting minor erosion that presents no major concerns to the overall stream stability. Multiple crest gauge readings were recorded on each of the four crest gauges.

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## 1 PROJECT GOALS, BACKGROUND AND ATTRIBUTES

### 1.1 Location and Setting

The Muddy Run Stream Site is located in Duplin County approximately 1.4 miles east of Chinquapin, NC (Figure 1). The project is in the Cape Fear River Basin (8-digit USGS HUC 03030007, 14-digit USGS HUC 03030007060010) (USGS, 1998) and the NCDWQ Cape Fear 03-06-22 sub-basin (NCDWQ, 2002). To access the Site from the town of Chinquapin, travel east on Highway 50, take the first left onto Pickett Bay Road (SR 1819), go 1.1 miles, then turn left onto Kenney Crawley Road. This private road is gravel and will split just past the residential house on the right. Keeping to the left will take you to the downstream portion of Reach 1 and Reaches 2 and 3. Going to the right at the split will take you to the upstream limits of Reach 1 at the Headwater Valley restoration portion.

### 1.2 Project Goals and Objectives

The Muddy Run stream mitigation project will provide 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 CAFOs 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 and ditch outlets. |
| 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 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.   |
| 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.   |
| Improved substrate and instream cover           | Benefit will be achieved through the construction of instream structures designed to improve bedform diversity and to trap detritus. Substrate will become more coarse as a result of the stabilization of stream banks and an overall decrease in the amount of 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.  |

### 1.3 Project Structure

**Table 1. Muddy Run Project Components**

| Reach        | Mitigation Type  | Stationing     | Existing Length | As-Built Length | Mitigation Ratio | SMUs         |
|--------------|------------------|----------------|-----------------|-----------------|------------------|--------------|
| Reach 1A     | Headwater Valley | 0+66 to 17+87  | 1,659           | 1,691           | 1:1              | 1,691        |
| Reach 1B     | P1 Restoration   | 17+87 to 33+98 | 1,597           | 1,581           | 1:1              | 1,581        |
| Reach 1C     | P1 Restoration   | 33+98 to 47+73 | 1,317           | 1,345           | 1:1              | 1,330        |
| Reach 2      | P1 Restoration   | 2+00 to 17+10  | 1,448           | 1,510           | 1:1              | 1,493        |
| Reach 3      | P1 Restoration   | 0+94 to 7+01   | 464             | 607             | 1:1              | 607          |
| <b>Total</b> |                  |                | <b>6,485</b>    | <b>6,734</b>    |                  | <b>6,702</b> |

\*As-Built length does not include channel in easement breaks.

\*\* SMUs does not include channel in irrigation access areas inside easement.

#### 1.3.1 Restoration Type and Approach

##### Reach 1A

The principal drainage feature (Reach 1) generally flows northwest to west across the site. It was divided into three reaches (Reach 1A, Reach 1B, and Reach 1C) based on slope, drainage area, and surrounding landscape. Reach 1A flows in a northerly direction adjacent to several hog houses and two large lagoons. The planform of this G-type channel is generally straight and is deeply incised throughout. No large woody debris was observed in the channel. A maintained access path built upon spoil material runs along the channel bank. The channel scored 24 points on the NCDWQ Stream Identification Form (Version 4.11). The natural drainage of this channel was bypassed through a deep, excavated ditch through uplands that connects to Reach 2.

Headwater valley restoration was performed along Reach 1A and continued down to Reach 1B. The existing channel adjacent to the hog houses was backfilled to the extent possible such that cut and fill was balanced along the reach. The existing 18-inch corrugated plastic pipe located under the gravel road was removed and replaced with three 12-inch CMPs at a slightly higher elevation. A sediment trapping pool and level spreader BMP immediately downstream of the road crossing was constructed to provide diffuse flow into the valley and collect sediment from the farm access road. The BMP is located outside the conservation easement to allow for maintenance. The reach was not completely filled so as to prevent hydrologic trespass upstream of the road. Grade control structures were placed along portions of the reach that was filled to provide additional vertical stability. During construction, a drain tile was encountered near STA 7+10. The portion of the tile located within the easement was removed, and a subsurface flow structure was installed per Bulletin Drawing #1 (Appendix D).

A forested buffer approximately 115 feet wide was planted throughout this reach. Where the channel was redirected towards Reach 2 near STA 11+31, a channel plug was constructed, and flow has been redirected back in a northerly direction. A channel plug and grade control structure has also been installed where an existing ditch enters the buffer from the east. Flow was directed along the reach such that it follows along the natural valley from STA 11+31 down to Reach 1B. An existing 30-inch CMP culvert located at STA 11+12 has been removed and replaced with three 12-inch CMPs to allow the landowner access to all areas of his property, as the restoration will bisect his land. The terminus of the headwater valley at STA 17+25 includes a grade control structure at the transition to a stable channel for Reach 1B.

### **Reach 1B**

The middle section (Reach 1B) of this reach was mostly excavated through a forested area. The surrounding riparian forest contains jurisdictional wetlands that are adjacent to Reach 1B. This channel had been dredged to nearly four feet in depth. A farm road that is elevated 0.85 feet above the flood plain was located along the right bank. The planform of this F-type channel was generally straight with occasional bends. The channel was entrenched throughout. The banks were nearly vertical in many locations and had almost no vegetation. No large woody debris was observed in the channel. The channel scored 29 points on the NCDWQ Stream Identification Form (Version 4.11).

Priority Level I restoration was constructed on Reach 1B. For the majority of the reach, the channel has been rerouted to the south of its current location. Relocating the channel did not impact any forested areas because most of the buffer was clear cut in the fall of 2011. However, there is a small, wooded area along the upstream portion of the reach. The restored channel from STA 17+25 to 20+78 meanders along the existing channel footprint in order to minimize impacts to the established buffer to the south. The elevated road bed along the north side of the existing channel has been removed in order to maintain a continuous connection between the proposed channel and its floodplain. A channel plug and grade control structure was installed where an existing ditch entered the buffer from the north near STA 18+08. An existing 42-inch CMP culvert crossing was removed and replaced with two 36-inch CMPs at STA 20+93 to maintain access to all portions of the landowner's property. The downstream section of Reach 1B has been relocated to avoid impacts to two existing wetland areas adjacent to the channel. There are two existing ditches within the proposed easement that cross the wetland to the south. These ditches have been plugged to provide diffuse flow through the wetland and into the restored channel. Structures installed along Reach 1B included log grade controls, root wads, and various woody debris structures to enrich habitat and ensure bank stability and channel integrity.

### **Reach 1C**

The downstream section of Reach 1 (Reach 1C) is located within a cleared hay field. This reach appeared to have been straightened and had been dredged. A farm road that is elevated 0.5 to 1.1 feet above bankfull is located along the right bank. Reach 1C was an F-type channel with a planform that was generally straight with a few minor bends throughout. The entire reach was moderately to severely incised with steep banks due to repeated dredging by the landowner. The dominant bed materials were fine sand and silt. The banks were nearly vertical with sparse vegetation. The channel scored 33 points on the NCDWQ Stream Identification Form (Version 4.11).

Priority Level I restoration was performed on Reach 1C. The restoration approach on this reach included relocating the channel to the north of its current location within the adjacent agricultural field. The relocation also included moving the confluence with Reach 2 to STA 45+27. The existing channel was plugged and filled to prevent continued flow within the ditch. An existing 36-inch CMP culvert crossing located at the upstream end of the reach has been removed and relocated to STA



33+67. Twin 42-inch culverts were placed in-line with the restored stream to maintain access to all portions of the landowner's property.

By rerouting and raising the channel, the restoration will allow the channel frequent access to its floodplain and the opportunity for creating small depressional areas within the buffer to enhance habitat for wildlife and aquatic organisms. Structures along this reach will include log grade controls, root wads, leaf packs, and various woody debris structures that will improve in-stream habitat and bank stability.

The downstream end of Reach 1C terminates at a temporary grade drop structure. The restoration will be continued in a subsequent phase of the project, Muddy Run II.

## **Reach 2**

Flowing into Reach 1C are two smaller tributary reaches (Reach 2 and Reach 3). Reach 2 begins south of Reach 1C at a wetland, and follows a shallow drainage feature to the confluence with Reach 1C. It receives flow through a ditch from Reach 1A. This F-type channel was actively maintained and had been dredged to nearly four feet in depth. The banks were nearly vertical in many locations and had almost no vegetation. No large woody debris was observed in the channel. The channel scored 26.5 points on the NCDWQ Stream Identification Form (Version 4.11).

Priority Level I restoration was performed on Reach 2. The bed elevation at the top of the reach is controlled by a 42-inch CMP culvert. This culvert and the associated farm road were moved approximately 100 feet upstream of its current location. The culvert has been replaced with a 36-inch CMP to maintain access to the adjacent hog houses and lagoons located just north of the upstream end of the reach. The channel now flows in a northwesterly direction to the confluence with Reach 1C.

The majority of the channel has been relocated north and east of the existing ditch towards the lagoons. The lower end meanders through a large spoil area constructed during installation of the lagoons. This area was graded down to match pre-disturbance elevations, and the cut material was used to fill abandoned ditches throughout the project. The restored stream channel can now access its floodplain regularly. Typical in-stream structures along this reach included log grade controls, root wads, leaf packs, and various woody debris structures that will improve habitat and bank stability. All areas within the easement have been planted with native shrub and tree species.

## **Reach 3**

Reach 3, an F-type stream channel, began north of Reach 1C at a wetland ditch and followed a shallow drainage feature to Reach 1C. A hay field is located on the east side, and a scrub community lies to the west. This channel had been dredged and the dominant bed material is fine sand. The banks were nearly vertical in many locations and had almost no vegetation. No large woody debris was observed in the channel. The channel scored 24.5 points on the NCDWQ Stream Identification Form (Version 4.11).

Priority Level I restoration was performed on Reach 3. Its bed elevation was controlled at the top of the reach by a 24-inch CMP culvert. This culvert was removed and replaced with two 42-inch CMPs at a higher elevation to maintain access across the property. The culvert was raised a minimal amount to prevent hydrologic trespass upstream of the project. Restoration began just south of the culvert crossing, and involved relocating the channel to the east of the existing ditch into the adjacent spray field. The reach has been reconnected with the primary channel (Reach 1) approximately 146 feet downstream of the confluence with Reach 1C at STA 5+72. A temporary log ramp has been installed at the downstream end to tie the restored channel into the existing ditch. This structure will be removed when the Muddy Run II Mitigation Project is constructed.

By relocating the channel, the restoration will allow the channel regular access to its floodplain and the opportunity for enhanced wetland habitat throughout the buffer. In-stream structures along this reach included log grade controls, root wads, leaf packs, and various woody debris structures that will provide bed diversity and subsequently improve habitat and bank stability. All areas within the easement were planted with native shrub and tree species.

Reach 3 was designed to reflect a proposed drainage area of 391 acres as opposed to the existing area of 85 acres. This significant increase in watershed size incorporates a drainage area that borders Reach 3 to the north and east, which currently directs flows away from the project site. It appears that the drainage features within this additional area were historically diverted north across a natural divide to promote drainage for agricultural production. The proposed Muddy Run II Stream and Wetland Mitigation Project reconnects this drainage to the Muddy Run project site.

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

### **1.4.1 Project History**

The Muddy Run Restoration Site was restored by Environmental Banc & Exchange, LLC (EBX) through a full-delivery contract awarded by NCEEP in 2011. 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 19.1 acres and is broken into five reaches. Reach 1A has a drainage area of 0.23 square miles (145 acres); it begins at the start of the restoration project (Sta. 0+62) and extends north and west to Sta.17+25. Reach 1B has a drainage area of 0.28 square miles (177 acres); it begins at Sta.17+25 and extends to Sta. 33+67. Reach 1C is the downstream section (Sta. 33+67 to 47+08) of Reach 1 and has a drainage area of 0.37 square miles (238 acres). Reach 2 has a drainage area of 0.1 square miles (60 acres) and flows northwest directly into Reach 1. Reach 3 has a drainage area of 0.13 square miles (85 acres) extending north to south (**Figure 2**). The land use in the project watershed is approximately 49 percent cultivated, 33 percent southern yellow pine, 9 percent bottomland forest/hardwood swamp, 7 percent wooded and shrubland, and 2 percent managed herbaceous cover.

## **2 SUCCESS CRITERIA**

The success criteria for the Muddy Run Site stream restoration will follow accepted and approved success criteria presented in the USACE Stream Mitigation Guidelines and subsequent NCEEP 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 five-year monitoring period. The two bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years. 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 shall be 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 Digital Image Stations**

Digital images will be 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 Vegetation**

Specific and measurable success criteria for plant density within the riparian buffers on the site will follow NCEEP Guidance. Vegetation monitoring plots are 0.02 acres in size, and cover greater than two percent of the planted area. Vegetation monitoring will occur annually in the fall of each year. The interim measures of vegetative success for the site will be the survival of at least 320 three-year-old trees per acre at the end of Year 3, and the final vegetative success criteria will be 260 trees per acre at the end of Year 5. Invasive species on the site will be monitored and controlled if necessary throughout the required vegetation monitoring period.

## **2.3 Scheduling/Reporting**

The monitoring program will be implemented to document system development and progress toward achieving the success criteria. The restored stream morphology will be assessed to determine the success of the mitigation. The monitoring program will be undertaken for five 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 NCEEP. The monitoring reports will include all information, and will be in the format required by NCEEP in Version 2.0 of the NCEEP Monitoring Report Template.

## **3 MONITORING PLAN**

Annual monitoring shall be conducted for stream and vegetation monitoring parameters as noted below for five years prior to completion of construction or until success criteria have been met.

### **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 includes a complete profile of thalweg, top of bank, and in stream channel structures to compare with future geomorphic data. Longitudinal profiles will not be required in annual monitoring reports unless requested by NCEEP or USACE.

### **3.1.2 Bankfull Events**

Four sets of manual and auto-logging crest gauges were installed on the site, one along Reach 1A, one along Reach 1C, one along Reach 2, and one along Reach 3. 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 39 permanent cross sections were installed to monitor channel dimensions and stability. Five cross sections were installed along Reach 1A of the headwater valley restoration section. Ten cross sections (five pools and five shallows) were installed along Reach 1B and four pool and four shallow cross sections were installed along Reach 1C. Reach 2 has a total of 14 cross sections installed throughout its length. Two permanent cross sections were installed along Reach 3. Cross sections were typically located at representative shallow and pool sections along each stream reach. 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 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 five 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**

Ten bank pin arrays have been installed at cross sections located on meander pools. 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 will be conducted a minimum of twice per monitoring year by qualified individuals. The visual assessments will include vegetation density, vigor, invasive species, and easement encroachments. Visual assessments of stream stability will include a complete stream walk and structure inspection. Digital images will be 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 will be 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**

Headwater valley restoration areas will be monitored to document intermittent or seasonal surface flow. This will be accomplished through direct observation, photo documentation of dye tests, and stage recorders. An auto logging stage recorder and crest gauge has been installed within the headwater valley channel and will record stage conditions at hourly intervals. Stage data will be used to determine duration of valley flow. This gauge will be downloaded during each site visit to determine if intermittent or seasonal flow conditions are present.

### **3.2 Vegetation**

A total of 20 vegetation plots were randomly established within the planted stream riparian buffer easement. Each vegetation plot measures 22 feet by 40 feet (0.02 acres) and has all four corners marked with PVC 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 amongst NCEEP staff to determine a plan of action. If it is determined remedial action is required, a plan will be provided.

### **4.1 Stream**

No major stream areas of concern were noted during the Year 1 monitoring period. Five areas of minor erosion were observed and have been mapped on the Current Conditions Plan View (CCPV). At this time, no repairs or remedial actions are anticipated, but these issues will continue to be monitored in subsequent years. These issues are described in more detail in **Appendix B**.

### **4.2 Vegetation**

No major vegetation problem areas were identified during the Year 1 monitoring period. Three minor problem areas were observed and have been mapped on the CCPV. Invasive Chinese privet was observed along a small portion of Reach 1B; continued clearing and stump treatment is recommended for this area. One area along the floodplain of Reach 3 is sparsely vegetated, likely due to low soil fertility; continued monitoring of the area is recommended. The upstream portion of Reach 2 is missing outside rows of trees, which was likely caused by improper planting due to damaged easement signage during construction. It is recommended to plant approximately 200 trees in two rows on the outer edge of the easement. These issues are described in **Appendix B**.

## **5 YEAR 1 MONITORING CONDITIONS (MY1)**

The Muddy Run Year 1 Monitoring activities were completed in November 2014. All Year 1 monitoring data is present below and in the appendices. Data presented shows the site has remained stable and is on track to meeting stream and vegetation interim success criteria.

## 5.1 Year 1 Monitoring Data Collection

### 5.1.1 Morphological State of the Channel

All morphological stream data for the Year 1 survey and dimensions were collected during the annual monitoring survey performed during November 2014. Appendix D includes summary data tables, morphological parameters, and cross section plots.

#### *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 NCEEP or USACE. Morphological summary data tables can be found in Appendix D.

#### *Dimension*

The Year 1 (MY-1) cross sectional dimensions closely matches the baseline cross section parameters. This represents that the stream channels are currently stable and functioning as designed. All cross section plots and data tables can be found in **Appendix D**.

#### *Sediment Transport*

The Year 1 conditions show that shear stress and velocities have been reduced for all three restoration reaches. Pre-construction conditions documented all three 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*

Ten 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. Bank pin array data tables can be found in **Appendix D**.

### 5.1.2 Vegetation

The Year 1 monitoring (MY-1) vegetation survey was completed in mid-November 2014. The Year 1 vegetation monitoring on the Muddy Run Stream Restoration Site resulted in an average of 740 planted stems per acre, which is greater than the required planting density of 680 stems per acre and above the interim survival density of 320 stems per acre at the end of Year 3 monitoring. The average stems per vegetation plot was 14.8 planted stems. The minimum planted stem per plot was 9 stems and the maximum was 18 stems per plot. There was one Sycamore (*Platanus occidentalis*) volunteer in Plot 18. Vegetation summary data tables can be found in **Appendix C** and vegetation plot photos in **Appendix B**.

### 5.1.3 Photo Documentation

Permanent photo point locations have been established at cross sections, vegetation plots, stream crossings, and stream structures by WK Dickson staff. Any additional problem areas or areas of concern have been documented with a digital photograph during monitoring activities. All stream and vegetation digital photographs can be found in **Appendix B**.

### 5.1.4 Hydrology

Multiple bankfull events have been observed during Year 1 monitoring activities on three stream reaches. Four sets of manual and auto-logging crest gauges are installed on the site, one along Reach 1A, one along Reach 1C, one along Reach 2, and one along Reach 3 to document flow conditions. Reach 1A (Headwater Valley) exhibited several significant flows throughout the monitoring year. Crest gauge and rainfall data is presented in **Appendix E**.

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[http://www.bae.ncsu.edu/programs/extension/wqg/srp/2008conference/tweedy\\_paper.pdf](http://www.bae.ncsu.edu/programs/extension/wqg/srp/2008conference/tweedy_paper.pdf)



# **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

**Appendix A. General Tables and Figures**

**Table 1** Project Components and Mitigation Credits  
Monitoring Report Year 1

| <b>Table 1. Project Components and Mitigation Credits</b><br><b>Muddy Run Stream Restoration/NCEEP Project # 95018</b>   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
|--|--------------------------------------|-----------------------------|-----------------------------|---------------------------------|---|--------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Mitigation Credits</b>  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
|  | Stream                               |                             | Riparian Wetland            |                                 | Non-riparian Wetland                          |                                      | Buffer           | Nitrogen<br>Nutrient Offset | Phosphorous<br>Nutrient Offset |
| Type   | R                                    | RE                          | R                           | RE                              | R   | RE                                   |                  |                             |                                |
| Totals   | 6,702                                |                             | N/A                         | N/A                             | N/A   | N/A                                  | N/A              | N/A                         | N/A                            |
| <b>Project Components</b>  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Project Component -or- Reach ID  | As-Built<br>Stationing/Location (LF) |                             | Existing<br>Footage/Acreage | Approach<br>(PI, PII etc.)      | Restoration -or-<br>Restoration<br>Equivalent | Restoration<br>Footage or<br>Acreage | Mitigation Ratio |                             |                                |
| Reach 1A   | 0+66 to 17+87                        |                             | 1,659                       | HWV                             | Restoration                                   | 1,691                                | 1 : 1            |                             |                                |
| Reach 1B   | 17+87 to 33+98                       |                             | 1,597                       | P1                              | Restoration                                   | 1,581                                | 1 : 1            |                             |                                |
| Reach 1C   | 33+98 to 47+73                       |                             | 1,317                       | P1                              | Restoration                                   | 1,330                                | 1 : 1            |                             |                                |
| Reach 2  | 2+00 to 17+10                        |                             | 1,448                       | P1                              | Restoration                                   | 1,493                                | 1 : 1            |                             |                                |
| Reach 3  | 0+94 to 7+01                         |                             | 464                         | P1                              | Restoration                                   | 607                                  | 1 : 1            |                             |                                |
|  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| <b>Component Summation</b>   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Restoration Level  | Stream<br>(linear feet)              | Riparian Wetland<br>(acres) |                             | Non-riparian Wetland<br>(acres) | Buffer<br>(square feet)                       | Upland<br>(acres)                    |                  |                             |                                |
|  |                                      | Riverine                    | Non-Riverine                |                                 |   |                                      |                  |                             |                                |
| Restoration  | 5,011                                |                             |                             |                                 |   |                                      |                  |                             |                                |
| Headwater Valley   | 1,691                                |                             |                             |                                 |   |                                      |                  |                             |                                |
| Enhancement  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Enhancement I  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Enhancement II   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Creation   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Preservation   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| High Quality<br>Preservation   |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| <b>BMP Elements</b>  |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |
| Element  | Location                             | Purpose/Function            |                             |                                 | Notes   |                                      |                  |                             |                                |
| ---  | ---                                  | ---                         |                             |                                 | ---   |                                      |                  |                             |                                |
| ---  | ---                                  | ---                         |                             |                                 | ---   |                                      |                  |                             |                                |
| ---  | ---                                  | ---                         |                             |                                 | ---   |                                      |                  |                             |                                |
| BMP Elements<br>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 |                                      |                             |                             |                                 |   |                                      |                  |                             |                                |

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

| <b>Project Activity and Reporting History<br/>Muddy Run Stream Restoration / EEP Project #95018</b> |                                 |                               |
|---|---------------------------------|-------------------------------|
| <b>Activity or Report</b>   | <b>Data Collection Complete</b> | <b>Completion or Delivery</b> |
| Mitigation Plan   | NA                              | November 2012                 |
| Final Design – Construction Plans   | NA                              | August 2013                   |
| Construction Completed  | NA                              | April 2014                    |
| Site Planting Completed   | NA                              | April 2014                    |
| Baseline Monitoring Document (Year 0 Monitoring – baseline)   | July 2014                       | September 2014                |
| Year 1 Monitoring   | November 2014                   | December 2014                 |
| Year 2 Monitoring   |                                 |                               |
| Year 3 Monitoring   |                                 |                               |
| Year 4 Monitoring   |                                 |                               |
| Year 5 Monitoring   |                                 |                               |

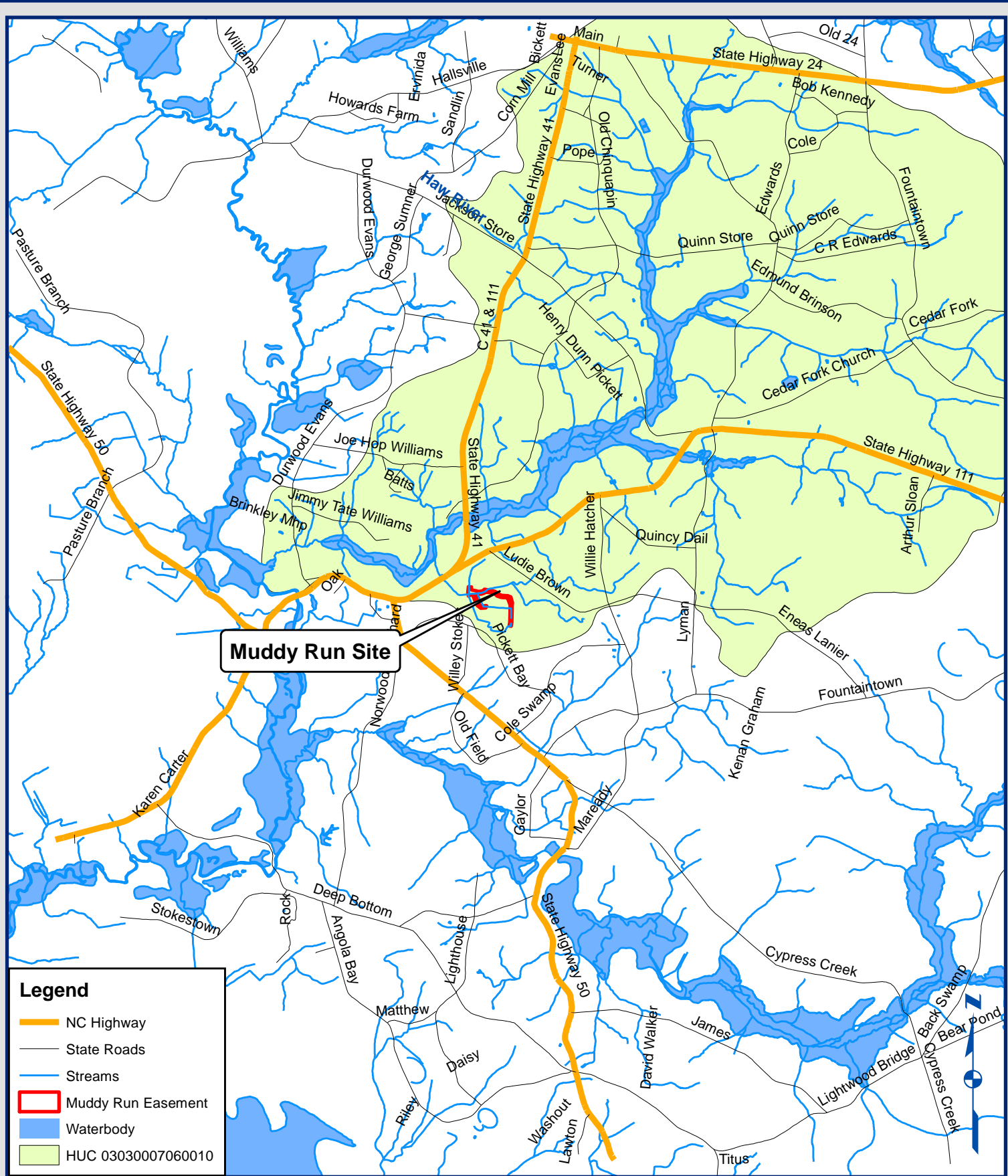
**Table 3. Project Contacts**

| <b>Project Contacts Table<br/>Muddy Run Stream Restoration /EEP Project # 95018</b> |   |
|---|---|
| <b>Designer</b>   | WK Dickson and Co., Inc.<br>720 Corporate Center Drive<br>Raleigh, NC 27607<br>(919) 782-0495<br>Frasier Mullen, PE |
| <b>Construction Contractor</b>  | GP Jenkins<br>6566 HWY 55 W<br>Kinston, NC 28504<br>(252) 569-1222<br>Gary Jenkins                                  |
| <b>Planting Contractor</b>  | H&J Forestry<br>Matt Hitch  |
| <b>Seeding Contractor</b>   | Rain Services, Inc.<br>Lupe Cruz  |
| Seed Mix Sources  | Green Resource  |
| Nursery Stock Suppliers   | Arbogen   |
| <b>Full Delivery Provider</b>   | Environmental Banc & Exchange, LLC<br>909 Capability Drive, Suite 3100<br>Raleigh, NC 27606<br>(919) 829-9909       |
| Project Manager:  | David Godley  |
| <b>Monitoring Performers</b>  | WK Dickson and Co., Inc.<br>720 Corporate Center Drive<br>Raleigh, NC 27607<br>(919) 782-0495                       |
| Project Manager:  | Daniel Ingram   |

**Table 4. Project Information and Attributes**

| Project Information   |                                  |                      |  |                          |                          |
|---|----------------------------------|----------------------|--|--------------------------|--------------------------|
| Project Name  |                                  |                      | Muddy Run Stream Restoration                         |                          |                          |
| County  |                                  |                      | Duplin   |                          |                          |
| Project Area (acres)  |                                  |                      | 19.1   |                          |                          |
| Project Coordinates (latitude and longitude)                            |                                  |                      | 34.830843 <sup>0</sup> N , -77.792838 <sup>0</sup> W |                          |                          |
| Project Watershed Summary Information                                   |                                  |                      |  |                          |                          |
| Physiographic Province  |                                  |                      | Coastal Plain  |                          |                          |
| River Basin   |                                  |                      | Cape Fear  |                          |                          |
| USGS Hydrologic Unit 8-digit  | 03030007                         |                      | USGS Hydrologic Unit 14-digit                        | 0303007060010            |                          |
| DWQ Sub-basin   |                                  |                      | 03-06-22   |                          |                          |
| Project Drainage Area (acres)   |                                  |                      | 391  |                          |                          |
| Project Drainage Area Percentage of Impervious Area                     |                                  |                      | <1%  |                          |                          |
| CGIA Land Use Classification  |                                  |                      |  |                          |                          |
| Reach Summary Information   |                                  |                      |  |                          |                          |
| Parameters  | Reach 1A                         | Reach 1B             | Reach 1C   | Reach 2                  | Reach 3                  |
| Length of Reach (linear feet)   | 1,691                            | 1,581                | 1,330  | 1,510                    | 607                      |
| Valley Classification   |                                  |                      |  |                          |                          |
| Drainage Area (acres)   | 145                              | 177                  | 238  | 60                       | 391                      |
| NCDWQ Stream Identification Score                                       | 24                               | 29                   | 33   | 26.5                     | 24.5                     |
| NCDWQ Water Quality Classification                                      | NA                               | NA                   | NA   | NA                       | NA                       |
| Morphological Description (stream type)                                 |                                  |                      |  |                          |                          |
| Evolutionary Trend  |                                  |                      |  |                          |                          |
| Underlying Mapped Soils   | Foreston /<br>Rains              | Goldsboro /<br>Rains | Goldsboro /<br>Rains                                 | Rains                    | Rains                    |
| Drainage Class  | ---                              | ---                  | ---  | ---                      | ---                      |
| Soil Hydric Status  | Hydric                           | Hydric               | Hydric   | Hydric                   | Hydric                   |
| Slope   | 0.0016                           | 0.0022               | 0.0019   | 0.0023                   | 0.0010                   |
| FEMA Classification   | Zone X                           | Zone X               | Zone X   | Zone X                   | Zone X                   |
| Native Vegetation Community   | Coastal Plain Small Stream Swamp |                      |  |                          |                          |
| Percent Composition of Exotic Invasive Vegetation                       | 0%                               | 0%                   | 0%   | 0%                       | 0%                       |
| Wetland Summary Information   |                                  |                      |  |                          |                          |
| Parameters  | Wetland 1                        | Wetland 2            | Wetland 3  | Wetland 3                | Wetland 3                |
| Size of Wetland (acres)   |                                  |                      |  |                          |                          |
| Wetland Type (non-riparian, riparian riverine or riparian non-riverine) |                                  |                      |  |                          |                          |
| Mapped Soil Series  |                                  |                      |  |                          |                          |
| Drainage class  |                                  |                      |  |                          |                          |
| Soil Hydric Status  |                                  |                      |  |                          |                          |
| Source of Hydrology   |                                  |                      |  |                          |                          |
| Hydrologic Impairment   |                                  |                      |  |                          |                          |
| Native vegetation community   |                                  |                      |  |                          |                          |
| Percent composition of exotic invasive vegetation                       |                                  |                      |  |                          |                          |
| Regulatory Considerations   |                                  |                      |  |                          |                          |
| Regulation  | Applicable?                      | Resolved?            | Supporting Documentation                             | Supporting Documentation | Supporting Documentation |
| Waters of the United States – Section 404                               | X                                | X                    | USACE NWP 27   |                          |                          |
| Waters of the United States – Section 401                               | X                                | X                    | 401 Water Quality Cert.                              |                          |                          |
| Endangered Species Act  | X                                | X                    | USFWS (Corr. Letter)                                 |                          |                          |
| Historic Preservation Act   | X                                | X                    | SHPO (Corr. Letter)                                  |                          |                          |
| Coastal Zone Management Act (CZMA)/ Coastal Area Management Act (CAMA)  | N/A                              | N/A                  | N/A  |                          |                          |
| FEMA Floodplain Compliance  |                                  |                      |  |                          |                          |
| Essential Fisheries Habitat   | N/A                              | N/A                  | N/A  |                          |                          |





**Muddy Run Site**

**Legend**





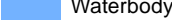
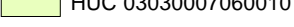
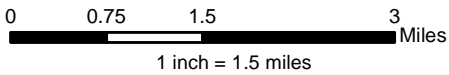
-  NC Highway
-  State Roads
-  Streams
-  Muddy Run Easement
-  Waterbody
-  HUC 03030007060010

Figure 1.  
Project Vicinity Map  
Muddy Run Site





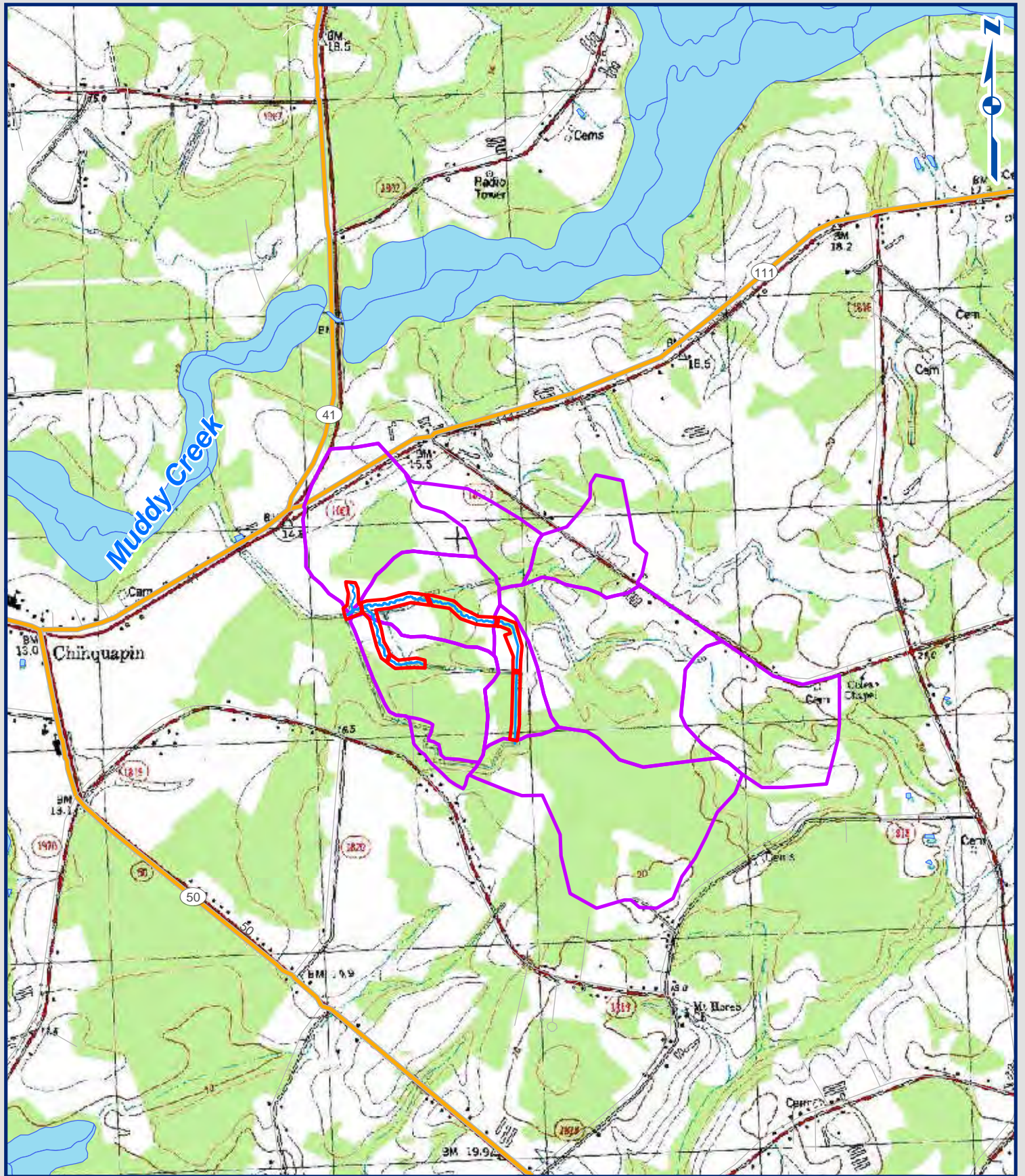


Figure 2.  
USGS/Watershed Map  
Muddy Run Site

0 1,000 2,000 4,000 Feet  
1 inch = 2,000 feet

**Legend**

- Muddy Run Streams
- Drainage Areas
- Muddy Run Easement
- Waterbodies



# **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

Stream Photos

Vegetation Photos

Stream and Vegetation Problem Area Photos



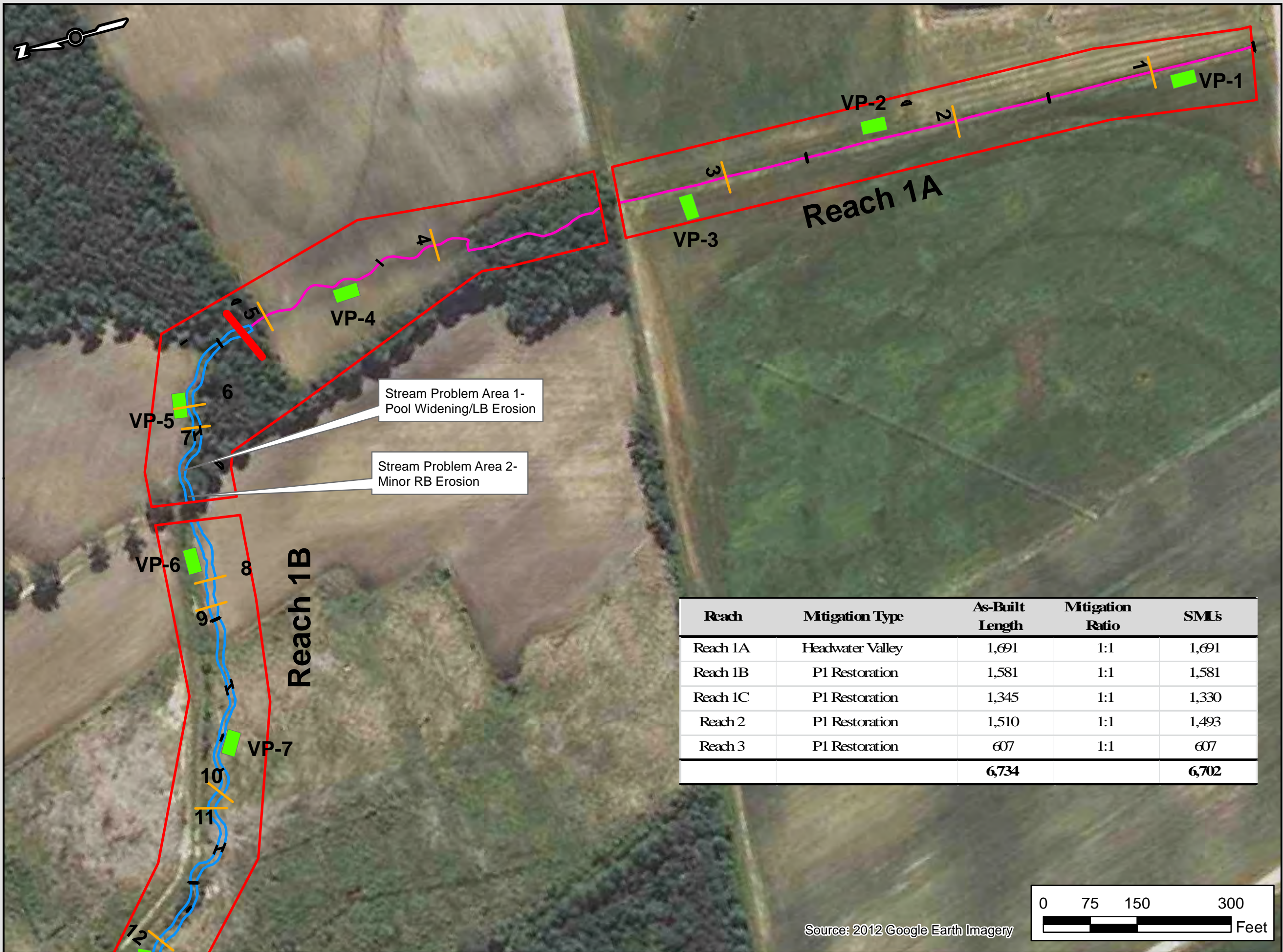


Figure 3a.  
Muddy Run Mitigation Site  
Current Conditions Map  
Duplin County, NC



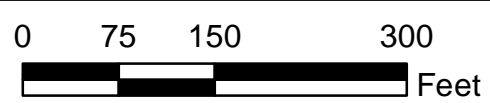
- Legend**
- Restoration
  - HWV Restoration
  - Vegetation Plots
  - Cross Sections
  - Easement Boundary
  - Stream Structures
  - Reach Breaks

| Reach    | Mitigation Type  | As-Built Length | Mitigation Ratio | SMLs         |
|----------|------------------|-----------------|------------------|--------------|
| Reach 1A | Headwater Valley | 1,691           | 1:1              | 1,691        |
| Reach 1B | PI Restoration   | 1,581           | 1:1              | 1,581        |
| Reach 1C | PI Restoration   | 1,345           | 1:1              | 1,330        |
| Reach 2  | PI Restoration   | 1,510           | 1:1              | 1,493        |
| Reach 3  | PI Restoration   | 607             | 1:1              | 607          |
|          |                  | <b>6,734</b>    |                  | <b>6,702</b> |

**Riparian Buffer Conditions**

|                  |         | Target Community |          |        |
|------------------|---------|------------------|----------|--------|
|                  |         | Present          | Marginal | Absent |
| Invasive Species | Absent  | No Fill          |          |        |
|                  | Present |                  |          |        |
|                  | Common  |                  |          |        |

Source: 2012 Google Earth Imagery





| Reach    | Mitigation Type  | As-Built Length | Mitigation Ratio | SMUs         |
|----------|------------------|-----------------|------------------|--------------|
| Reach 1A | Headwater Valley | 1,691           | 1:1              | 1,691        |
| Reach 1B | PI Restoration   | 1,581           | 1:1              | 1,581        |
| Reach 1C | PI Restoration   | 1,345           | 1:1              | 1,330        |
| Reach 2  | PI Restoration   | 1,510           | 1:1              | 1,493        |
| Reach 3  | PI Restoration   | 607             | 1:1              | 607          |
|          |                  | <b>6,734</b>    |                  | <b>6,702</b> |

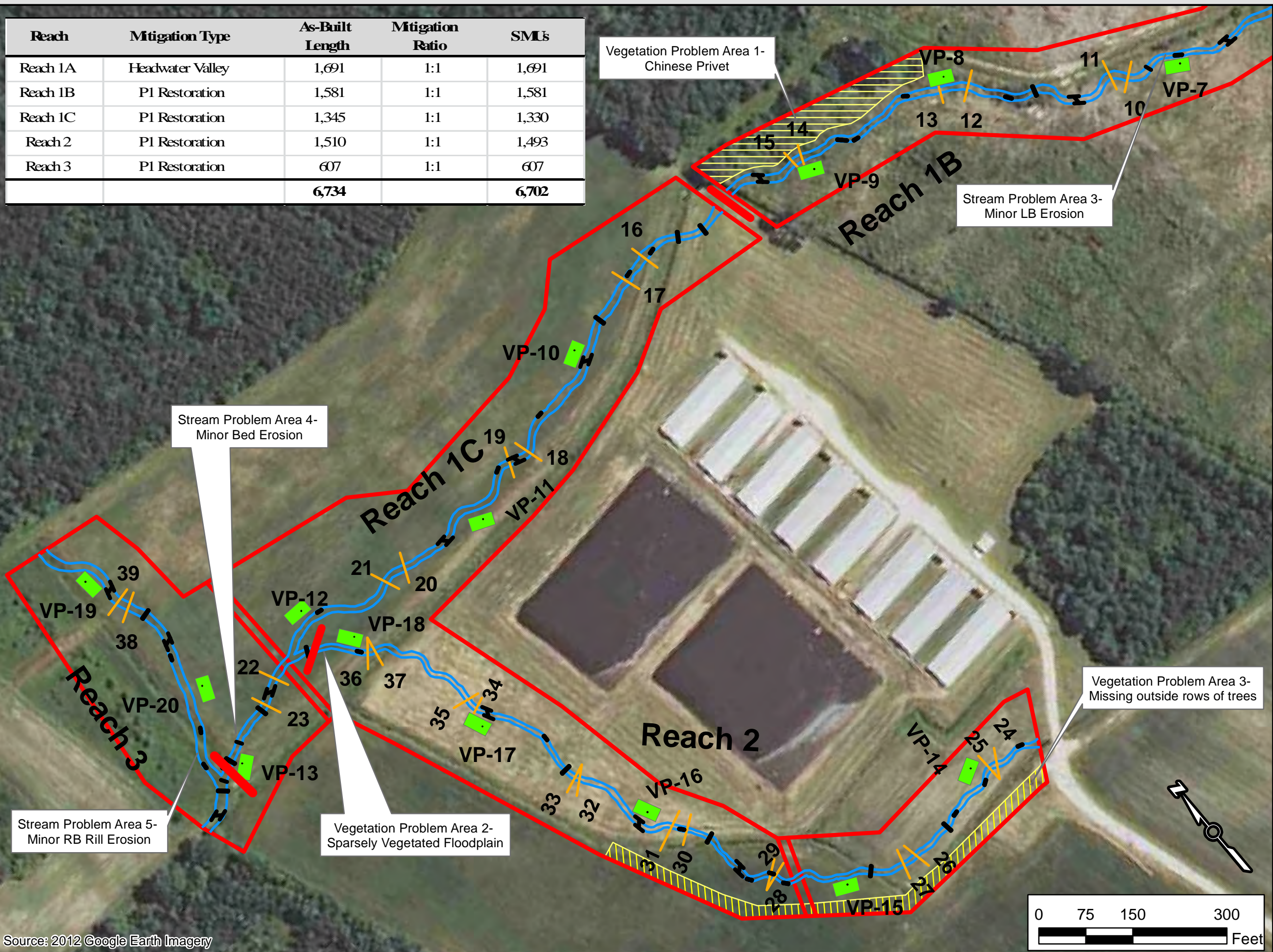


Figure 3b.  
Muddy Run Mitigation Site  
Current Conditions Map  
Duplin County, NC



- Legend**
- Stream Structures
  - Vegetation Plots
  - Cross Sections
  - Restoration
  - Easement Boundary
  - Reach Breaks

| Riparian Buffer Conditions |         |                  |          |        |
|----------------------------|---------|------------------|----------|--------|
|                            |         | Target Community |          |        |
|                            |         | Present          | Marginal | Absent |
| Invasive Species           | Absent  | No Fill          |          |        |
|                            | Present |                  |          |        |
|                            | Common  |                  |          |        |

Source: 2012 Google Earth Imagery



**Table 5a**  
**Reach ID**  
**Assessed Length**

**Visual Stream Morphology Stability Assessment**

**Reach 1A**  
**1691**

| Major Channel Category                                | Channel Sub-Category   | Metric  | Number <sup>1</sup> Stable, Performing as Intended                           | Total <sup>1</sup> Number in As-built | Number of Unstable Segments | Amount of Unstable Footage | % Stable <sup>2</sup> , Performing as Intended | Number with Stabilizing Woody Vegetation | Footage with Stabilizing Woody Vegetation | Adjusted % for Stabilizing Woody Vegetation |      |
|---|--|---|--|---------------------------------------|-----------------------------|----------------------------|--|--|---|---|------|
| 1. Bed  | 1. Vertical Stability (Riffle and Run units)   | 1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)   |  |                                       | 0                           | 0                          | 100%   |  |   |   |      |
|   |  | 2. <u>Degradation</u> - Evidence of downcutting   |  |                                       | 0                           | 0                          | 100%   |  |   |   |      |
|   | 2. Riffle Condition  | 1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate  | *NA  | *NA                                   |                             |                            |  |  |   |   | 100% |
|   |  | 3. Meander Pool Condition   | 1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6) | *NA                                   |                             |                            |  |  |   |   | *NA  |
|   | 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle) |   | *NA  | *NA                                   |                             |                            |  |  |   |   | 100% |
|   | 4. Thalweg Position  | 1. Thalweg centering at upstream of meander bend (Run)  | *NA  | *NA                                   |                             |                            |  |  |   |   | 100% |
| 2. Thalweg centering at downstream of meander (Glide) |  | *NA   | *NA  | 100%                                  |                             |                            |  |  |   |   |      |
| <b>Totals</b>   |  |   |  |                                       |                             |                            |  | 0  | 0   | 100%  | 0    |
| 2. 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 <b>NOT</b> 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%  |      |
| 3. Engineered Structures                              | 1. Overall Integrity   | Structures physically intact with no dislodged boulders or logs.  | 4  | 4                                     |                             |                            |  |  |   |   |      |
|   | 2. Grade Control   | Grade control structures exhibiting maintenance of grade across the sill.   | 4  | 4                                     |                             |                            |  |  |   |   | 100% |
|   | 2a. Piping   | Structures lacking any substantial flow underneath sills or arms.   | 4  | 4                                     |                             |                            |  |  |   |   | 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)                        | **NA   | **NA                                  |                             |                            |  |  |   |   | *NA  |
|   | 4. Habitat   | Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.                                | 2  | 2                                     |                             |                            |  |  |   |   | 100% |

\* NA - Headwater Valley Restoration does not have a riffle/pool sequence.

\*\* NA - No bank protection structures were used in this section.

<sup>1</sup> Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.

<sup>2</sup> Percentage based on visual assessment of channel bed condition.

Table 5b  
 Reach ID  
 Assessed Length

**Visual Stream Morphology Stability Assessment**

Reach 1B

1581

| Major Channel Category   | Channel Sub-Category                         | Metric   | Number <sup>1</sup> Stable, Performing as Intended | Total <sup>1</sup> Number in As-built | Number of Unstable Segments | Amount of Unstable Footage | % Stable <sup>2</sup> , Performing as Intended | Number with Stabilizing Woody Vegetation | Footage with Stabilizing Woody Vegetation | Adjusted % for Stabilizing Woody Vegetation |
|--------------------------|--|--|--|---------------------------------------|-----------------------------|----------------------------|--|--|---|---|
| 1. Bed                   | 1. Vertical Stability (Riffle and Run units) | 1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)                          |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          |  | 2. <u>Degradation</u> - Evidence of downcutting  |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          | 2. Riffle Condition                          | 1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 3. Meander Pool Condition                    | 1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)                             | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 4. Thalweg Position                          | 1. Thalweg centering at upstream of meander bend (Run)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. Thalweg centering at downstream of meander (Glide)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | <b>Totals</b>                                |  |  |                                       |                             | 3                          | 30   | 99%                                      | 1   | 10  |
| 3. Engineered Structures | 1. Overall Integrity                         | Structures physically intact with no dislodged boulders or logs.   | 16   | 16                                    |                             |                            | 100%   |  |   |   |
|                          | 2. Grade Control                             | Grade control structures exhibiting maintenance of grade across the sill.  | 7  | 7                                     |                             |                            | 100%   |  |   |   |
|                          | 2a. Piping                                   | Structures lacking any substantial flow underneath sills or arms.  | 16   | 16                                    |                             |                            | 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.         | 4  | 4                                     |                             |                            | 100%   |  |   |   |

<sup>1</sup> Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.

<sup>2</sup> Percentage based on visual assessment of channel bed condition.

Table 5c  
 Reach ID  
 Assessed Length

**Visual Stream Morphology Stability Assessment**  
 Reach 1C  
 1330

| Major Channel Category   | Channel Sub-Category                         | Metric  | Number <sup>1</sup> Stable, Performing as Intended | Total <sup>1</sup> Number in As-built | Number of Unstable Segments | Amount of Unstable Footage | % Stable <sup>2</sup> , Performing as Intended | Number with Stabilizing Woody Vegetation | Footage with Stabilizing Woody Vegetation | Adjusted % for Stabilizing Woody Vegetation |
|--------------------------|--|---|--|---------------------------------------|-----------------------------|----------------------------|--|--|---|---|
| 1. Bed                   | 1. Vertical Stability (Riffle and Run units) | 1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)   |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          |  | 2. <u>Degradation</u> - Evidence of downcutting   |  |                                       | 1                           | 30                         | 98%  |  |   |   |
|                          | 2. Riffle Condition                          | 1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 3. Meander Pool Condition                    | 1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 4. Thalweg Position                          | 1. Thalweg centering at upstream of meander bend (Run)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. Thalweg centering at downstream of meander (Glide)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | <b>Totals</b>                                |   |  |                                       |                             | 0                          | 0  |  |   |   |
| 2. 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 <b>NOT</b> 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%  |
| 3. Engineered Structures | 1. Overall Integrity                         | Structures physically intact with no dislodged boulders or logs.  | 17   | 17                                    |                             |                            | 100%   |  |   |   |
|                          | 2. Grade Control                             | Grade control structures exhibiting maintenance of grade across the sill.   | 7  | 8                                     |                             |                            | 88%  |  |   |   |
|                          | 2a. Piping                                   | Structures lacking any substantial flow underneath sills or arms.   | 16   | 17                                    |                             |                            | 94%  |  |   |   |
|                          | 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.                                | 4  | 4                                     |                             |                            | 100%   |  |   |   |

<sup>1</sup> Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.

<sup>2</sup> Percentage based on visual assessment of channel bed condition.

Table 5d  
 Reach ID  
 Assessed Length

**Visual Stream Morphology Stability Assessment**

Reach 2

1493

| Major Channel Category   | Channel Sub-Category                         | Metric  | Number <sup>1</sup> Stable, Performing as Intended | Total <sup>1</sup> Number in As-built | Number of Unstable Segments | Amount of Unstable Footage | % Stable <sup>2</sup> , Performing as Intended | Number with Stabilizing Woody Vegetation | Footage with Stabilizing Woody Vegetation | Adjusted % for Stabilizing Woody Vegetation |
|--------------------------|--|---|--|---------------------------------------|-----------------------------|----------------------------|--|--|---|---|
| 1. Bed                   | 1. Vertical Stability (Riffle and Run units) | 1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)   |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          |  | 2. <u>Degradation</u> - Evidence of downcutting   |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          | 2. Riffle Condition                          | 1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 3. Meander Pool Condition                    | 1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 4. Thalweg Position                          | 1. Thalweg centering at upstream of meander bend (Run)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. Thalweg centering at downstream of meander (Glide)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | <b>Totals</b>                                |   |  |                                       |                             | 0                          | 0  | 100%                                     | 0   | 0   |
| 2. 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 <b>NOT</b> 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%  |
| 3. Engineered Structures | 1. Overall Integrity                         | Structures physically intact with no dislodged boulders or logs.  | 17   | 17                                    |                             |                            | 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.   | 17   | 17                                    |                             |                            | 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)                        | 9  | 9                                     |                             |                            | 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%   |  |   |   |

<sup>1</sup> Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.

<sup>2</sup> Percentage based on visual assessment of channel bed condition.

Table 5e  
 Reach ID  
 Assessed Length

**Visual Stream Morphology Stability Assessment**

Reach 3

607




| Major Channel Category   | Channel Sub-Category                         | Metric   | Number <sup>1</sup> Stable, Performing as Intended | Total <sup>1</sup> Number in As-built | Number of Unstable Segments | Amount of Unstable Footage | % Stable <sup>2</sup> , Performing as Intended | Number with Stabilizing Woody Vegetation | Footage with Stabilizing Woody Vegetation | Adjusted % for Stabilizing Woody Vegetation |
|--------------------------|--|--|--|---------------------------------------|-----------------------------|----------------------------|--|--|---|---|
| 1. Bed                   | 1. Vertical Stability (Riffle and Run units) | 1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)                          |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          |  | 2. <u>Degradation</u> - Evidence of downcutting  |  |                                       | 0                           | 0                          | 100%   |  |   |   |
|                          | 2. Riffle Condition                          | 1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 3. Meander Pool Condition                    | 1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)                             | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | 4. Thalweg Position                          | 1. Thalweg centering at upstream of meander bend (Run)   | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          |  | 2. Thalweg centering at downstream of meander (Glide)  | NA   | NA                                    |                             |                            | 100%   |  |   |   |
|                          | <b>Totals</b>                                |  |  |                                       |                             | 1                          | 10   |  |   |   |
| 3. Engineered Structures | 1. Overall Integrity                         | Structures physically intact with no dislodged boulders or logs.   | 8  | 8                                     |                             |                            | 100%   |  |   |   |
|                          | 2. Grade Control                             | Grade control structures exhibiting maintenance of grade across the sill.  | 2  | 2                                     |                             |                            | 100%   |  |   |   |
|                          | 2a. Piping                                   | Structures lacking any substantial flow underneath sills or arms.  | 8  | 8                                     |                             |                            | 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%   |  |   |   |

<sup>1</sup> Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.



<sup>2</sup> Percentage based on visual assessment of channel bed condition.

**Table 6** **Vegetation Condition Assessment**

**Planted Acreage<sup>1</sup>** **17.5**

| 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         |  | 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         |  | 1                  | 0.42             | 2.4%                 |
| <b>Total</b>                           |   |                   |   | <b>1</b>           | <b>0.42</b>      | <b>2.4%</b>          |
| 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        |  | 0                  | 0.00             | 0.0%                 |
| <b>Cumulative Total</b>                |   |                   |   | <b>1</b>           | <b>0.42</b>      | <b>2.4%</b>          |

**Easement Acreage<sup>2</sup>** **19.1**

| 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           |  | 1                  | 0.45             | 2.4%                  |
| 5. Easement Encroachment Areas <sup>3</sup> | Areas or points (if too small to render as polygons at map scale). | none              |  | 0                  | 0.00             | 0.0%                  |

**1** = 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.

**2** = The acreage within the easement boundaries.

**3** = 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.

**4** = 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.



**Table 7. Stream Problem Areas**  
**Muddy Run Stream Restoration Project - Project # 95018**

| <b>Feature Issue</b>                       | <b>Station # / Range</b> | <b>Suspected Cause</b>  | <b>Photo Number</b> |
|--|--------------------------|---|---------------------|
| <b>Pool Widening/ LB Erosion</b>           | 20+90                    | Channel adjustment- does not appear to be worsening; recommend monitoring     | SP1                 |
| <b>Minor RB Erosion</b>                    | 21+50                    | Channel adjustment and sparse bank vegetation; recommend monitoring           | SP2                 |
| <b>Minor LB Erosion</b>                    | 25+70                    | Channel adjustment and sparse bank vegetation; recommend monitoring           | SP3                 |
| <b>Minor Bed Erosion</b>                   | 47+15 - 47+45            | Log weir is undercut, but bed is stable; recommend monitoring                 | SP4                 |
| <b>Minor RB Rill Erosion below matting</b> | 5+60                     | Sparse bank vegetation establishment after construction; recommend monitoring | SP5                 |

**Table 8. Vegetation Problem Areas**  
**Muddy Run Stream Restoration Project - Project # 95018**

| <b>Feature Category</b>              | <b>Station Numbers</b>  | <b>Suspected Cause</b>   | <b>Photo Number</b> |
|--------------------------------------|-------------------------|--|---------------------|
| <b>Invasive/Exotic Populations</b>   | Reach 1B- See Plan View | Ligustrum: encroachment from outside easement. Recommend continued clearing and stump treatment.   | VP1                 |
| <b>Sparsely vegetated floodplain</b> | Sta 16+50               | Seeds sowed in low fertility soil areas. Recommend continued monitoring  | VP2                 |
| <b>Missing outside rows of trees</b> | Sta 2+00 - 10+100       | Improper planting due to damaged easement signage during construction. Recommend planting approximately 200 trees in two rows on outer edge of easement. | VP3                 |

**Appendix B - Stream Photos**



Reach 1A HWV – Looking Downstream - Sta. 2+80 Post- Construction (04/14/2014)



Reach 1A HWV – Looking Downstream - Sta. 2+80 MY 1 (11/10/2014)



Reach 1A Looking Downstream - Sta. 14+80 – Post-Construction (04/14/2014)



Reach 1A Looking Downstream- Sta. 14+80 – MY 1 (11/10/2014)



Reach 1B Looking Downstream Sta. 22+00 - Crossing (12/03/2013)



Reach 1B Looking Downstream Sta. 22+00 – Crossing- MY1 (11/12/2014)





Reach 1B/1C Looking Downstream Sta. 34+00 - Crossing (12/03/2013)



Reach 1B/1C Looking Downstream Sta. 34+00 - Crossing- MY1 (11/12/2014)



Reach 1B Looking Downstream Sta. 26+50 - Post-Construction (04/14/2014)



Reach 1B Looking Downstream Sta. 26+50 - MY1 (11/10/2014)



Reach 1C Looking Downstream Sta. 39+50 - Post-Construction (12/03/2013)



Reach 1C Looking Upstream Sta. 39+50 - MY1 - (11/10/2014)





Reach 2 Looking Downstream Sta. 11+50 - Post-Construction (04/14/2014)



Reach 2 Looking Downstream Sta. 11+50 - Construction (11/11/2014)



Reach 2 Looking Downstream Sta 5+20- Post-Construction (04/15/2014)



Reach 2 Looking Downstream Sta 5+20- MY 1 (11/11/2014)



Reach 3 Looking Upstream Sta. 2+50 - Post-Construction (04/14/2014)

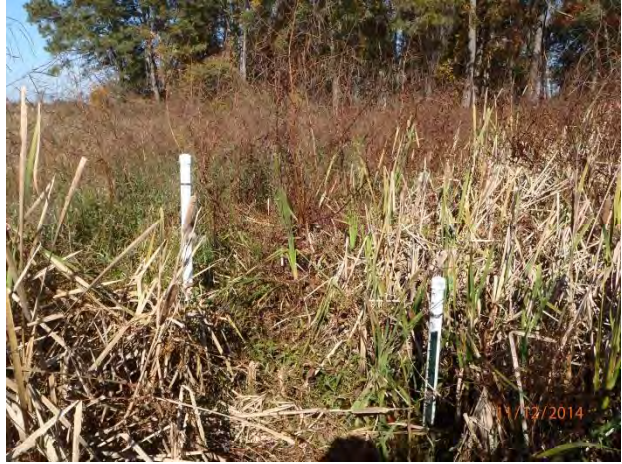


Reach 3 Looking Upstream Sta. 2+50 - MY 1 (11/11/2014)





Crest Gauge 1 Reach 1A (04/15/2014)



Crest Gauge 2 Reach 1A (11/12/2014)



Crest Gauge 3 Reach 2 (04/15/2014)



Crest Gauge 3 Reach 2 (11/12/2014)



**Appendix B - Vegetation Plot Photos**



Vegetation Plot 1 (11/12/2014)



Vegetation Plot 2 (11/12/2014)



Vegetation Plot 3 (11/12/2014)



Vegetation Plot 4 (11/12/2014)



Vegetation Plot 5 (11/12/2014)



Vegetation Plot 6 (11/12/2014)





Vegetation Plot 7 (11/12/2014)



Vegetation Plot 8 (11/12/2014)



Vegetation Plot 9 (11/12/2014)



Vegetation Plot 10 (11/12/2014)



Vegetation Plot 11 (11/12/2014)



Vegetation Plot 12 (04/15/2014)





Vegetation Plot 13 (11/11/2014)



Vegetation Plot 14 (11/12/2014)



Vegetation Plot 15 (11/12/2014)



Vegetation Plot 16 (11/12/2014)



Vegetation Plot 17 (11/12/2014)



Vegetation Plot 18 (11/12/2014)





Vegetation Plot 19 (11/11/2014)



Vegetation Plot 20 (11/11/2014)

## Appendix B - Stream and Vegetation Problem Area Photos



SP1 Pool widening at Sta 20+90



SP2 Minor RB Erosion at STA 21+50



SP3 Minor LB Erosion at STA 25+70



SP4 Minor Bed Erosion at Sta 47+15 - 47+45



SP5 Minor RB Erosion at Sta 5+60





VP1- Invasive population: *Ligustrum* along Reach 1B



VP2 Sparse LB Riparian Vegetation at Sta 16+50



VP3- Missing outside rows of trees at Sta 2+00 – 10+00 (11/11/2014)

# **Appendix C**

## **Vegetation Plot Data**

Table 9a. Planted Stem Count Summary

Table 9b. Planted Species Totals

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

**Table 9a. Monitoring Year 1 Stem Count Summary**

| Vegetation Plot | Baseline      |                     | Year 1       |                   |
|-----------------|---------------|---------------------|--------------|-------------------|
|                 | Stems Planted | Stems/Acre Baseline | Living Stems | Stems/Acre Year 1 |
| 1               | 16            | 800                 | 15           | 750               |
| 2               | 15            | 750                 | 9            | 450               |
| 3               | 17            | 850                 | 16           | 800               |
| 4               | 14            | 700                 | 14           | 700               |
| 5               | 14            | 700                 | 13           | 650               |
| 6               | 15            | 750                 | 15           | 750               |
| 7               | 17            | 850                 | 16           | 800               |
| 8               | 16            | 800                 | 15           | 750               |
| 9               | 13            | 650                 | 12           | 600               |
| 10              | 16            | 800                 | 14           | 700               |
| 11              | 17            | 850                 | 17           | 850               |
| 12              | 14            | 700                 | 14           | 700               |
| 13              | 16            | 800                 | 15           | 750               |
| 14              | 17            | 850                 | 17           | 850               |
| 15              | 18            | 900                 | 17           | 850               |
| 16              | 16            | 800                 | 14           | 700               |
| 17              | 18            | 900                 | 18           | 900               |
| 18              | 16            | 800                 | 16           | 800               |
| 19              | 14            | 700                 | 14           | 700               |
| 20              | 15            | 750                 | 15           | 750               |
| <b>Average</b>  | <b>15.7</b>   | <b>785</b>          | <b>14.8</b>  | <b>740</b>        |
| <b>Min</b>      | <b>13</b>     | <b>650</b>          | <b>9</b>     | <b>450</b>        |
| <b>Max</b>      | <b>18</b>     | <b>900</b>          | <b>18</b>    | <b>900</b>        |

\* One *Plantanus occidentalis* volunteer in plot 18

**Table 9b. Planted Species Totals**

| Species                       | Common Name        | Total Planted |
|-------------------------------|--------------------|---------------|
| <b>Trees - Bare Root</b>      |                    |               |
| <i>Taxodium distichum</i>     | Bald Cypress       | 2,000         |
| <i>Fraxinus pennsylvanica</i> | Green Ash          | 1,900         |
| <i>Quercus lyrata</i>         | Overcup Oak        | 1,600         |
| <i>Betula nigra</i>           | River birch        | 1,600         |
| <i>Quercus michauxii</i>      | Swamp Chestnut Oak | 2,000         |
| <i>Nyssa biflora</i>          | Swamp Tupelo       | 1,800         |
| <i>Plantanus occidentalis</i> | American Sycamore  | 2,000         |
| <i>Quercus laurifolia</i>     | Laurel Oak         | 1,600         |
|                               | <b>Total</b>       | <b>14,500</b> |
| <b>Live Stakes</b>            |                    |               |
| <i>Salix nigra</i>            | Black Willow       | 3,000         |
|                               | <b>Total</b>       | <b>3,000</b>  |

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

| Species                       | Common Name           | Vegetation Plot 1 |            |     |     |     | Vegetation Plot 2 |            |            |     |     | Vegetation Plot 3 |            |            |     |     | Vegetation Plot 4 |     |     |     |     | Vegetation Plot 5 |     |     |            |            |     |     |     |     |
|-------------------------------|-----------------------|-------------------|------------|-----|-----|-----|-------------------|------------|------------|-----|-----|-------------------|------------|------------|-----|-----|-------------------|-----|-----|-----|-----|-------------------|-----|-----|------------|------------|-----|-----|-----|-----|
|                               |                       | MY0               | MY1        | MY2 | MY3 | MY4 | MY5               | MY0        | MY1        | MY2 | MY3 | MY4               | MY5        | MY0        | MY1 | MY2 | MY3               | MY4 | MY5 | MY0 | MY1 | MY2               | MY3 | MY4 | MY5        | MY0        | MY1 | MY2 | MY3 | MY4 |
| <i>Taxodium distichum</i>     | Bald Cypress          | 5                 | 5          |     |     |     |                   |            |            |     |     |                   | 6          | 6          |     |     |                   |     |     |     |     |                   |     |     | 2          | 2          |     |     |     |     |
| <i>Fraxinus pennsylvanica</i> | Green Ash             | 3                 | 3          |     |     |     |                   | 1          | 1          |     |     |                   | 3          | 3          |     |     |                   |     |     |     |     |                   |     |     |            |            |     |     |     |     |
| <i>Quercus sp.</i>            | Unknown Oak sp.       | 1                 |            |     |     |     |                   |            |            |     |     |                   |            |            |     |     |                   |     |     |     |     |                   |     |     | 2          |            |     |     |     |     |
| <i>Quercus lyrata</i>         | Overcup Oak           |                   |            |     |     |     |                   |            |            |     |     |                   |            |            |     |     |                   |     |     |     |     |                   |     |     |            |            |     |     |     |     |
| <i>Betula nigra</i>           | River birch           | 5                 | 5          |     |     |     |                   | 2          | 1          |     |     |                   | 1          | 2          |     |     |                   |     |     |     |     |                   |     |     | 1          | 1          |     |     |     |     |
| <i>Quercus michauxii</i>      | Swamp Chestnut Oak    | 1                 | 1          |     |     |     |                   |            |            |     |     |                   | 3          | 2          |     |     |                   |     |     |     |     |                   |     |     | 6          | 6          |     |     |     |     |
| <i>Nyssa biflora</i>          | Swamp Tupelo          |                   |            |     |     |     |                   | 4          | 2          |     |     |                   | 1          |            |     |     |                   |     |     |     |     |                   |     |     | 2          | 3          |     |     |     |     |
| <i>Plantanus occidentalis</i> | American Sycamore     | 1                 |            |     |     |     |                   | 8          | 5          |     |     |                   | 2          | 2          |     |     |                   |     |     |     |     |                   |     |     | 3          | 2          |     |     |     |     |
| <i>Quercus laurifolia</i>     | Laurel Oak            |                   | 1          |     |     |     |                   |            |            |     |     |                   | 1          | 1          |     |     |                   |     |     |     |     |                   |     |     |            |            |     |     |     |     |
|                               | <b>Species Count</b>  | <b>6</b>          | <b>5</b>   |     |     |     |                   | <b>4</b>   | <b>4</b>   |     |     |                   | <b>7</b>   | <b>6</b>   |     |     |                   |     |     |     |     |                   |     |     | <b>6</b>   | <b>6</b>   |     |     |     |     |
|                               | <b>Stem Count</b>     | <b>16</b>         | <b>15</b>  |     |     |     |                   | <b>15</b>  | <b>9</b>   |     |     |                   | <b>17</b>  | <b>16</b>  |     |     |                   |     |     |     |     |                   |     |     | <b>14</b>  | <b>14</b>  |     |     |     |     |
|                               | <b>Stems per Acre</b> | <b>800</b>        | <b>750</b> |     |     |     |                   | <b>750</b> | <b>450</b> |     |     |                   | <b>850</b> | <b>800</b> |     |     |                   |     |     |     |     |                   |     |     | <b>700</b> | <b>700</b> |     |     |     |     |

| Species                       | Common Name           | Vegetation Plot 6 |            |     |     |     | Vegetation Plot 7 |            |            |     |     | Vegetation Plot 8 |            |            |     |     | Vegetation Plot 9 |     |     |     |     | Vegetation Plot 10 |     |            |            |     |     |     |     |     |
|-------------------------------|-----------------------|-------------------|------------|-----|-----|-----|-------------------|------------|------------|-----|-----|-------------------|------------|------------|-----|-----|-------------------|-----|-----|-----|-----|--------------------|-----|------------|------------|-----|-----|-----|-----|-----|
|                               |                       | MY0               | MY1        | MY2 | MY3 | MY4 | MY5               | MY0        | MY1        | MY2 | MY3 | MY4               | MY5        | MY0        | MY1 | MY2 | MY3               | MY4 | MY5 | MY0 | MY1 | MY2                | MY3 | MY4        | MY5        | MY0 | MY1 | MY2 | MY3 | MY4 |
| <i>Taxodium distichum</i>     | Bald Cypress          | 1                 | 1          |     |     |     |                   | 1          | 1          |     |     |                   |            | 1          | 1   |     |                   |     |     |     |     |                    |     |            | 1          | 1   |     |     |     |     |
| <i>Fraxinus pennsylvanica</i> | Green Ash             | 1                 | 1          |     |     |     |                   |            |            |     |     |                   |            | 5          | 5   |     |                   |     |     |     |     |                    |     |            | 2          | 2   |     |     |     |     |
| <i>Quercus sp.</i>            | Unknown Oak sp.       | 2                 |            |     |     |     |                   |            |            |     |     |                   |            | 1          |     |     |                   |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus lyrata</i>         | Overcup Oak           |                   | 1          |     |     |     |                   | 3          | 3          |     |     |                   | 1          | 1          |     |     |                   |     |     |     |     |                    |     |            |            | 1   |     |     |     |     |
| <i>Betula nigra</i>           | River birch           |                   |            |     |     |     |                   |            |            |     |     |                   |            |            |     |     |                   |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus michauxii</i>      | Swamp Chestnut Oak    | 2                 | 2          |     |     |     |                   | 7          | 7          |     |     |                   | 1          | 2          |     |     |                   |     |     |     |     |                    |     |            | 1          |     |     |     |     |     |
| <i>Nyssa biflora</i>          | Swamp Tupelo          | 1                 | 1          |     |     |     |                   | 4          | 3          |     |     |                   |            | 1          |     |     |                   |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Plantanus occidentalis</i> | American Sycamore     | 1                 | 1          |     |     |     |                   |            |            |     |     |                   | 2          | 2          |     |     |                   |     |     |     |     |                    |     |            | 6          | 6   |     |     |     |     |
| <i>Quercus laurifolia</i>     | Laurel Oak            | 7                 | 8          |     |     |     |                   | 2          | 2          |     |     |                   | 5          | 3          |     |     |                   |     |     |     |     |                    |     |            | 3          | 2   |     |     |     |     |
|                               | <b>Species Count</b>  | <b>7</b>          | <b>7</b>   |     |     |     |                   | <b>5</b>   | <b>5</b>   |     |     |                   | <b>7</b>   | <b>7</b>   |     |     |                   |     |     |     |     |                    |     | <b>5</b>   | <b>5</b>   |     |     |     |     |     |
|                               | <b>Stem Count</b>     | <b>15</b>         | <b>15</b>  |     |     |     |                   | <b>17</b>  | <b>16</b>  |     |     |                   | <b>16</b>  | <b>15</b>  |     |     |                   |     |     |     |     |                    |     | <b>13</b>  | <b>12</b>  |     |     |     |     |     |
|                               | <b>Stems per Acre</b> | <b>750</b>        | <b>750</b> |     |     |     |                   | <b>850</b> | <b>800</b> |     |     |                   | <b>800</b> | <b>750</b> |     |     |                   |     |     |     |     |                    |     | <b>650</b> | <b>600</b> |     |     |     |     |     |

| Species                       | Common Name           | Vegetation Plot 11 |            |     |     |     | Vegetation Plot 12 |            |            |     |     | Vegetation Plot 13 |            |            |     |     | Vegetation Plot 14 |     |     |     |     | Vegetation Plot 15 |     |            |            |     |     |     |     |     |
|-------------------------------|-----------------------|--------------------|------------|-----|-----|-----|--------------------|------------|------------|-----|-----|--------------------|------------|------------|-----|-----|--------------------|-----|-----|-----|-----|--------------------|-----|------------|------------|-----|-----|-----|-----|-----|
|                               |                       | MY0                | MY1        | MY2 | MY3 | MY4 | MY5                | MY0        | MY1        | MY2 | MY3 | MY4                | MY5        | MY0        | MY1 | MY2 | MY3                | MY4 | MY5 | MY0 | MY1 | MY2                | MY3 | MY4        | MY5        | MY0 | MY1 | MY2 | MY3 | MY4 |
| <i>Taxodium distichum</i>     | Bald Cypress          | 4                  | 4          |     |     |     |                    | 5          | 5          |     |     |                    |            | 5          | 5   |     |                    |     |     |     |     |                    |     |            | 5          | 5   |     |     |     |     |
| <i>Fraxinus pennsylvanica</i> | Green Ash             | 2                  | 2          |     |     |     |                    |            |            |     |     |                    |            |            | 1   |     |                    |     |     |     |     |                    |     |            | 1          | 1   |     |     |     |     |
| <i>Quercus sp.</i>            | Unknown Oak sp.       | 1                  |            |     |     |     |                    | 3          |            |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus lyrata</i>         | Overcup Oak           | 1                  | 1          |     |     |     |                    |            |            |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            | 1          |     |     |     |     |     |
| <i>Betula nigra</i>           | River birch           |                    |            |     |     |     |                    | 2          | 2          |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus michauxii</i>      | Swamp Chestnut Oak    | 1                  | 1          |     |     |     |                    | 3          | 6          |     |     |                    | 1          | 1          |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Nyssa biflora</i>          | Swamp Tupelo          | 1                  | 1          |     |     |     |                    | 1          | 1          |     |     |                    | 7          | 5          |     |     |                    |     |     |     |     |                    |     |            | 3          | 3   |     |     |     |     |
| <i>Plantanus occidentalis</i> | American Sycamore     | 5                  | 5          |     |     |     |                    |            |            |     |     |                    | 3          | 3          |     |     |                    |     |     |     |     |                    |     |            | 3          | 3   |     |     |     |     |
| <i>Quercus laurifolia</i>     | Laurel Oak            | 2                  | 3          |     |     |     |                    |            |            |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            | 3          | 5   |     |     |     |     |
|                               | <b>Species Count</b>  | <b>8</b>           | <b>7</b>   |     |     |     |                    | <b>5</b>   | <b>4</b>   |     |     |                    | <b>4</b>   | <b>5</b>   |     |     |                    |     |     |     |     |                    |     | <b>7</b>   | <b>5</b>   |     |     |     |     |     |
|                               | <b>Stem Count</b>     | <b>17</b>          | <b>17</b>  |     |     |     |                    | <b>14</b>  | <b>14</b>  |     |     |                    | <b>16</b>  | <b>15</b>  |     |     |                    |     |     |     |     |                    |     | <b>17</b>  | <b>17</b>  |     |     |     |     |     |
|                               | <b>Stems per Acre</b> | <b>850</b>         | <b>850</b> |     |     |     |                    | <b>700</b> | <b>700</b> |     |     |                    | <b>800</b> | <b>750</b> |     |     |                    |     |     |     |     |                    |     | <b>850</b> | <b>850</b> |     |     |     |     |     |

| Species                       | Common Name           | Vegetation Plot 16 |            |     |     |     | Vegetation Plot 17 |            |            |     |     | Vegetation Plot 18 |            |            |     |     | Vegetation Plot 19 |     |     |     |     | Vegetation Plot 20 |     |            |            |     |     |     |     |     |
|-------------------------------|-----------------------|--------------------|------------|-----|-----|-----|--------------------|------------|------------|-----|-----|--------------------|------------|------------|-----|-----|--------------------|-----|-----|-----|-----|--------------------|-----|------------|------------|-----|-----|-----|-----|-----|
|                               |                       | MY0                | MY1        | MY2 | MY3 | MY4 | MY5                | MY0        | MY1        | MY2 | MY3 | MY4                | MY5        | MY0        | MY1 | MY2 | MY3                | MY4 | MY5 | MY0 | MY1 | MY2                | MY3 | MY4        | MY5        | MY0 | MY1 | MY2 | MY3 | MY4 |
| <i>Taxodium distichum</i>     | Bald Cypress          | 5                  | 5          |     |     |     |                    | 3          | 3          |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            | 6          | 6   |     |     |     |     |
| <i>Fraxinus pennsylvanica</i> | Green Ash             |                    |            |     |     |     |                    |            |            |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus sp.</i>            | Unknown Oak sp.       | 1                  |            |     |     |     |                    | 2          | 1          |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus lyrata</i>         | Overcup Oak           | 1                  | 3          |     |     |     |                    | 1          | 2          |     |     |                    | 1          | 1          |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Betula nigra</i>           | River birch           | 3                  | 3          |     |     |     |                    | 1          | 1          |     |     |                    |            |            |     |     |                    |     |     |     |     |                    |     |            | 1          | 2   |     |     |     |     |
| <i>Quercus michauxii</i>      | Swamp Chestnut Oak    |                    |            |     |     |     |                    |            |            |     |     |                    | 5          | 5          |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Nyssa biflora</i>          | Swamp Tupelo          | 1                  | 1          |     |     |     |                    | 9          | 10         |     |     |                    | 3          | 1          |     |     |                    |     |     |     |     |                    |     |            | 6          | 5   |     |     |     |     |
| <i>Plantanus occidentalis</i> | American Sycamore     | 2                  |            |     |     |     |                    | 1          |            |     |     |                    | 2          | 4          |     |     |                    |     |     |     |     |                    |     |            |            |     |     |     |     |     |
| <i>Quercus laurifolia</i>     | Laurel Oak            | 3                  | 2          |     |     |     |                    | 1          | 1          |     |     |                    | 5          | 5          |     |     |                    |     |     |     |     |                    |     |            | 1          | 1   |     |     |     |     |
|                               | <b>Species Count</b>  | <b>7</b>           | <b>5</b>   |     |     |     |                    | <b>7</b>   | <b>6</b>   |     |     |                    | <b>5</b>   | <b>5</b>   |     |     |                    |     |     |     |     |                    |     | <b>4</b>   | <b>4</b>   |     |     |     |     |     |
|                               | <b>Stem Count</b>     | <b>16</b>          | <b>14</b>  |     |     |     |                    | <b>18</b>  | <b>18</b>  |     |     |                    | <b>16</b>  | <b>16</b>  |     |     |                    |     |     |     |     |                    |     | <b>14</b>  | <b>14</b>  |     |     |     |     |     |
|                               | <b>Stems per Acre</b> | <b>800</b>         | <b>700</b> |     |     |     |                    | <b>900</b> | <b>900</b> |     |     |                    | <b>800</b> | <b>800</b> |     |     |                    |     |     |     |     |                    |     | <b>700</b> | <b>700</b> |     |     |     |     |     |

# **Appendix D**

## **Stream Geomorphology Data**

Table 10. Morphological Parameters Summary Data

Table 11. Dimensional Morphology Summary – Cross Sections Data

Table 12. Bank Pin Array Summary Data

Cross Section Plots

I, Brian S. Hockett, certify that this horizontal and vertical control survey was completed to the Class A standard under my direct and responsible charge from an actual survey performed on November 11<sup>th</sup> 2014. Cross sectional survey plots and morphological parameter tables located in Appendix D of the Muddy Run Stream Restoration Project Year 1 Monitoring Report were drawn and produced under my supervision.

*Brian S. Hockett*

Brian S. Hockett, PLS

L-5165





**Appendix D. Table 10 - Morphological Parameters Summary Data**  
**Project Name/Number: Muddy Run Mitigation Project/95018**

| Feature                                    | Reference Reach |            |            | Existing <sup>1</sup> |        |        |        |        | Design     |            |            |            | As-Built/Baseline |            |            |            |            |            |            |            |            |            |            |            |
|--|-----------------|------------|------------|-----------------------|--------|--------|--------|--------|------------|------------|------------|------------|-------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|  | Pool            | Run        | Shallow    | MR1A                  | MR1B   | MR1C   | MR2    | MR3    | MR1B       | MR1C       | MR2        | MR3        | MR1B              | MR1C       | MR2        | MR3        |            |            |            |            |            |            |            |            |
| Drainage Area (ac)                         | 286             | 286        | 286        | 145                   | 177    | 238    | 60     | 85     | 177        | 238        | 60         | 391        | 177               | 238        | 60         | 391        |            |            |            |            |            |            |            |            |
| NC Regional Curve Discharge (cfs)          |                 |            | 9.3        | 6                     | 7      | 8      | 3      | 4      | 7          | 8          | 3          | 12         | 7                 | 8          | 3          | 12         |            |            |            |            |            |            |            |            |
| Design/Calculated Discharge (cfs)          | ---             | ---        | 13         | ---                   | ---    | ---    | ---    | ---    | 9          | 13         | 4          | 19         | 12.1              | 13.8       | 5.4        | 13.5       |            |            |            |            |            |            |            |            |
| <b>Dimension</b>                           |                 |            |            |                       |        |        |        |        |            |            |            |            |                   |            |            |            |            |            |            |            |            |            |            |            |
| BF Width (ft)                              | 10.9            | 8.9        | 7.0        | 6.6                   | 7.3    | 9.7    | 6.9    | 7.2    | 8.2        | 9.5        | 5.6        | 11.4       | 11.6              | 11.5       | 9.9        | 11.9       |            |            |            |            |            |            |            |            |
| Floodprone Width (ft)                      | 100             | 100        | 100        | 9.9                   | 10.3   | 15.3   | 10.3   | 10.7   | > 50       | > 50       | > 50       | > 50       | > 50              | > 50       | > 50       | > 50       |            |            |            |            |            |            |            |            |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 11.4            | 8.4        | 5          | 5                     | 4.4    | 5.6    | 3.6    | 3.3    | 6.6        | 8.9        | 3.1        | 13.1       | 7.4               | 8.3        | 4.8        | 9.3        |            |            |            |            |            |            |            |            |
| BF Mean Depth (ft)                         | 1.0             | 0.9        | 0.8        | 0.8                   | 0.6    | 0.6    | 0.5    | 0.5    | 0.8        | 0.9        | 0.6        | 1.1        | 0.6               | 0.7        | 0.5        | 0.8        |            |            |            |            |            |            |            |            |
| BF Max Depth (ft)                          | 2.1             | 1.7        | 1.3        | 1.1                   | 0.9    | 1.3    | 1.0    | 0.8    | 1.3        | 1.5        | 0.9        | 1.7        | 1.4               | 1.5        | 1          | 1.6        |            |            |            |            |            |            |            |            |
| Width/Depth Ratio                          | 10.4            | 9.5        | 8.8        | 8.7                   | 12.2   | 17.1   | 13.2   | 15.8   | 10         | 10         | 10         | 10         | 18.6              | 15.7       | 21.2       | 15.1       |            |            |            |            |            |            |            |            |
| Entrenchment Ratio                         | 9.2             | 11.2       | 15.1       | 1.5                   | 1.4    | 1.5    | 1.5    | 10.5   | > 2.2      | > 2.2      | > 2.2      | > 2.2      | > 2.2             | > 2.2      | > 2.2      | > 2.2      |            |            |            |            |            |            |            |            |
| Wetted Perimeter (ft)                      | 12.8            | 9.7        | 7.4        | 6.9                   | 7.7    | 10.3   | 7.2    | 7.4    | 8.7        | 10.1       | 5.9        | 12.1       | 12.2              | 11.9       | 10.3       | 12.4       |            |            |            |            |            |            |            |            |
| Hydraulic Radius (ft)                      | 0.9             | 0.9        | 0.7        | 0.7                   | 0.6    | 0.5    | 0.5    | 0.4    | 0.8        | 0.9        | 0.5        | 1.1        | 0.6               | 0.7        | 0.5        | 0.8        |            |            |            |            |            |            |            |            |
| <b>Substrate</b>                           |                 |            |            |                       |        |        |        |        |            |            |            |            |                   |            |            |            |            |            |            |            |            |            |            |            |
|  | Fine Sand       |            |            | Fine Sand             |        |        |        |        | Fine Sand  | Fine Sand  | Fine Sand  | Fine Sand  | Fine Sand         | Fine Sand  | Fine Sand  | Fine Sand  | Fine 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> | <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)                     | 13.6            | 31.8       | 23.1       | ---                   | ---    | ---    | ---    | ---    | 13.3       | 40.0       | 18.0       | 37.2       | 10.2              | 26.8       | 20.6       | 40.3       | 17.9       | 45.3       | 14.9       | 40.3       | 12.1       | 27.5       | 17.3       | 45.8       |
| Radius of Curvature (ft)                   | 11.0            | 27.6       | 17.6       | ---                   | ---    | ---    | ---    | ---    | 11.4       | 40.4       | 14.8       | 40.8       | 8.9               | 21.7       | 22.8       | 46.5       | 14.5       | 48.7       | 16.8       | 54.9       | 11.1       | 29.4       | 33.8       | 74.9       |
| Radius of Curvature Ratio                  | 1.5             | 3.7        | 2.3        | ---                   | ---    | ---    | ---    | ---    | 1.4        | 4.9        | 1.6        | 3.5        | 1.6               | 3.4        | 2.0        | 4.1        | 1.3        | 4.2        | 1.5        | 4.8        | 1.1        | 3.0        | 2.8        | 6.3        |
| Meander Wavelength (ft)                    | 34.9            | 68.3       | 54.5       | ---                   | ---    | ---    | ---    | ---    | 23.2       | 89.9       | 33.2       | 71.2       | 16.2              | 48.6       | 56.5       | 144        | 44.9       | 99.2       | 37.3       | 94.9       | 20.6       | 44.0       | 41.88      | 88.7       |
| Meander Width Ratio                        | 1.8             | 4.2        | 3.1        | ---                   | ---    | ---    | ---    | ---    | 1.6        | 4.9        | 1.9        | 3.9        | 1.8               | 4.8        | 1.8        | 3.5        | 1.5        | 3.9        | 1.3        | 3.5        | 1.2        | 2.8        | 1.5        | 3.8        |
| <b>Profile</b>                             |                 |            |            |                       |        |        |        |        |            |            |            |            |                   |            |            |            |            |            |            |            |            |            |            |            |
| Shallow Length (ft)                        | 3.1             | 30.7       | 12.6       | ---                   | ---    | ---    | ---    | ---    | 5          | 72         | 10         | 72         | 4                 | 62         | 25.9       | 39.9       | 8          | 27         | 18         | 35         | 7.1        | 24.3       | 6.0        | 27.0       |
| Run Length (ft)                            | 2.2             | 33.2       | 11.3       | ---                   | ---    | ---    | ---    | ---    | ---        | ---        | ---        | ---        | ---               | ---        | ---        | ---        | ---        | ---        | ---        | ---        | ---        | ---        | ---        | ---        |
| Pool Length (ft)                           | 4.2             | 9.5        | 5.8        | ---                   | ---    | ---    | ---    | ---    | 17         | 36         | 20         | 34         | 9                 | 20         | 18.2       | 49.0       | 12         | 28         | 14         | 30         | 11.6       | 20.2       | 9.0        | 28.0       |
| Pool -to-Pool Spacing (ft)                 | 17.5            | 59.8       | 36.3       | ---                   | ---    | ---    | ---    | ---    | 23         | 95         | 25         | 97         | 16                | 78         | 37.0       | 90.0       | 20         | 82         | 25         | 69         | 22         | 75         | 16.0       | 90.0       |
| <b>Additional Reach Parameters</b>         |                 |            |            |                       |        |        |        |        |            |            |            |            |                   |            |            |            |            |            |            |            |            |            |            |            |
| Valley Length (ft)                         | 274             |            |            | ---                   | ---    | ---    | ---    | ---    | 1485       | 1194       | 1560       | 554        | 1485              | 1194       | 1560       | 554        |            |            |            |            |            |            |            |            |
| Channel Length (ft)                        | 309             |            |            | 1638                  | 1590   | 1324   | 1448   | 464    | 1652       | 1386       | 1533       | 613        | 1584              | 1344       | 1510       | 607        |            |            |            |            |            |            |            |            |
| Sinuosity                                  | 1.1             |            |            | 1.0                   | 1.0    | 1.0    | 1.0    | 1.0    | 1.1        | 1.2        | 1.0        | 1.1        | 1.1               | 1.1        | 1.0        | 1.1        |            |            |            |            |            |            |            |            |
| Water Surface Slope (ft/ft)                | 0.004           |            |            | ---                   | ---    | ---    | ---    | ---    | ---        | ---        | ---        | ---        | ---               | ---        | ---        | ---        |            |            |            |            |            |            |            |            |
| Channel Slope (ft/ft)                      | 0.003           |            |            | 0.0016                | 0.0033 | 0.0035 | 0.0032 | 0.0055 | 0.0022     | 0.0019     | 0.0023     | 0.0008     | 0.0036            | 0.0031     | 0.0024     | 0.0022     |            |            |            |            |            |            |            |            |
| Rosgen Classification                      | E5              |            |            | G5c                   | F5     | F5     | F5     | F5     | E5         | E5         | E5         | E5         | E5                | E5         | E5         | E5         |            |            |            |            |            |            |            |            |
| *Habitat Index                             |                 |            |            |                       |        |        |        |        |            |            |            |            |                   |            |            |            |            |            |            |            |            |            |            |            |

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

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

**Project Name/Number: Muddy Run Mitigation Project/95018**

|   | Cross Section 1 (HWV)  |      |     |     |     |     |     | Cross Section 2 (HWV)  |      |     |     |     |     |     | Cross Section 3 (HWV)  |      |     |     |     |     |     | Cross Section 4 (HWV)  |      |     |     |     |     |     | Cross Section 5 (HWV)  |      |     |     |     |     |     |
|---|--|------|-----|-----|-----|-----|-----|--|------|-----|-----|-----|-----|-----|--|------|-----|-----|-----|-----|-----|--|------|-----|-----|-----|-----|-----|--|------|-----|-----|-----|-----|-----|
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ |
| <b>Record elevation (datum) used</b>                    | (Headwater Valley Restoration)                               |      |     |     |     |     |     | (Headwater Valley Restoration)                               |      |     |     |     |     |     | (Headwater Valley Restoration)                               |      |     |     |     |     |     | (Headwater Valley Restoration)                               |      |     |     |     |     |     | (Headwater Valley Restoration)                               |      |     |     |     |     |     |
| Bankfull Width (ft)                                     | No Morphological Parameters were determined for HWV Reaches. |      |     |     |     |     |     | No Morphological Parameters were determined for HWV Reaches. |      |     |     |     |     |     | No Morphological Parameters were determined for HWV Reaches. |      |     |     |     |     |     | No Morphological Parameters were determined for HWV Reaches. |      |     |     |     |     |     | No Morphological Parameters were determined for HWV Reaches. |      |     |     |     |     |     |
| Floodprone Width (ft)                                   |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Mean Depth (ft)                                |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Max Depth (ft)                                 |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Width/Depth Ratio                              |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Entrenchment Ratio                             |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
| Bankfull Bank Height Ratio                              |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |  |      |     |     |     |     |     |
|   | Cross Section 6 (Pool)                                       |      |     |     |     |     |     | Cross Section 7 (Shallow)                                    |      |     |     |     |     |     | Cross Section 8 (Shallow)                                    |      |     |     |     |     |     | Cross Section 9 (Pool)                                       |      |     |     |     |     |     | Cross Section 10 (Shallow)                                   |      |     |     |     |     |     |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ |
| <b>Record elevation (datum) used</b>                    | 49.5   | 49.5 |     |     |     |     |     | 49.5   | 49.5 |     |     |     |     |     | 48.5   | 48.5 |     |     |     |     |     | 48.3   | 48.3 |     |     |     |     |     | 46.5   | 46.5 |     |     |     |     |     |
| Bankfull Width (ft)                                     | 9.0  | 8.4  |     |     |     |     |     | 10.7   | 10.7 |     |     |     |     |     | 9.6  | 8.9  |     |     |     |     |     | 8.8  | 8.1  |     |     |     |     |     | 14.3   | 14.4 |     |     |     |     |     |
| Floodprone Width (ft)                                   | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     |
| Bankfull Mean Depth (ft)                                | 1.1  | 1.0  |     |     |     |     |     | 0.7  | 0.7  |     |     |     |     |     | 0.7  | 0.6  |     |     |     |     |     | 0.9  | 0.8  |     |     |     |     |     | 0.5  | 0.4  |     |     |     |     |     |
| Bankfull Max Depth (ft)                                 | 2.2  | 2.1  |     |     |     |     |     | 1.7  | 1.7  |     |     |     |     |     | 1.4  | 1.4  |     |     |     |     |     | 1.7  | 1.5  |     |     |     |     |     | 1.3  | 1.1  |     |     |     |     |     |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 9.4  | 8.5  |     |     |     |     |     | 8.0  | 8.0  |     |     |     |     |     | 6.4  | 5.7  |     |     |     |     |     | 7.5  | 6.7  |     |     |     |     |     | 6.8  | 6.1  |     |     |     |     |     |
| Bankfull Width/Depth Ratio                              | 8.5  | 8.3  |     |     |     |     |     | 14.4   | 14.4 |     |     |     |     |     | 14.4   | 14.0 |     |     |     |     |     | 10.3   | 9.8  |     |     |     |     |     | 29.9   | 34.2 |     |     |     |     |     |
| Bankfull Entrenchment Ratio                             | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     |
| Bankfull Bank Height Ratio                              | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     |
|   | Cross Section 11 (Pool)                                      |      |     |     |     |     |     | Cross Section 12 (Shallow)                                   |      |     |     |     |     |     | Cross Section 13 (Pool)                                      |      |     |     |     |     |     | Cross Section 14 (Shallow)                                   |      |     |     |     |     |     | Cross Section 15 (Pool)                                      |      |     |     |     |     |     |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ |
| <b>Record elevation (datum) used</b>                    | 46.4   | 46.4 |     |     |     |     |     | 45.6   | 45.6 |     |     |     |     |     | 45.5   | 45.5 |     |     |     |     |     | 45.0   | 45.0 |     |     |     |     |     | 44.4   | 44.4 |     |     |     |     |     |
| Bankfull Width (ft)                                     | 14.7   | 14.4 |     |     |     |     |     | 11.4   | 11.4 |     |     |     |     |     | 13.2   | 12.3 |     |     |     |     |     | 12.0   | 12.3 |     |     |     |     |     | 10.0   | 9.9  |     |     |     |     |     |
| Floodprone Width (ft)                                   | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     |
| Bankfull Mean Depth (ft)                                | 0.6  | 0.6  |     |     |     |     |     | 0.6  | 0.6  |     |     |     |     |     | 0.6  | 0.6  |     |     |     |     |     | 0.7  | 0.7  |     |     |     |     |     | 0.9  | 0.9  |     |     |     |     |     |
| Bankfull Max Depth (ft)                                 | 1.8  | 1.5  |     |     |     |     |     | 1.2  | 1.2  |     |     |     |     |     | 1.4  | 1.3  |     |     |     |     |     | 1.4  | 1.5  |     |     |     |     |     | 1.9  | 1.8  |     |     |     |     |     |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 9.1  | 7.9  |     |     |     |     |     | 7.1  | 6.3  |     |     |     |     |     | 8.4  | 7.2  |     |     |     |     |     | 8.7  | 8.4  |     |     |     |     |     | 9.1  | 8.8  |     |     |     |     |     |
| Bankfull Width/Depth Ratio                              | 23.9   | 26.1 |     |     |     |     |     | 18.2   | 20.7 |     |     |     |     |     | 20.7   | 21.1 |     |     |     |     |     | 16.4   | 17.8 |     |     |     |     |     | 11.1   | 11.1 |     |     |     |     |     |
| Bankfull Entrenchment Ratio                             | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     |
| Bankfull Bank Height Ratio                              | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     |
|   | Cross Section 16 (Shallow)                                   |      |     |     |     |     |     | Cross Section 17 (Pool)                                      |      |     |     |     |     |     | Cross Section 18 (Pool)                                      |      |     |     |     |     |     | Cross Section 19 (Shallow)                                   |      |     |     |     |     |     | Cross Section 20 (Shallow)                                   |      |     |     |     |     |     |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base   | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ |
| <b>Record elevation (datum) used</b>                    | 44.0   | 44.0 |     |     |     |     |     | 43.7   | 43.7 |     |     |     |     |     | 42.8   | 42.8 |     |     |     |     |     | 43.0   | 43.0 |     |     |     |     |     | 42.6   | 42.6 |     |     |     |     |     |
| Bankfull Width (ft)                                     | 13.3   | 14.0 |     |     |     |     |     | 13.0   | 12.3 |     |     |     |     |     | 8.9  | 8.7  |     |     |     |     |     | 11.9   | 11.6 |     |     |     |     |     | 10.8   | 10.8 |     |     |     |     |     |
| Floodprone Width (ft)                                   | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     | 50.0   | 50.0 |     |     |     |     |     |
| Bankfull Mean Depth (ft)                                | 0.8  | 0.7  |     |     |     |     |     | 0.9  | 0.8  |     |     |     |     |     | 1.1  | 1.1  |     |     |     |     |     | 0.7  | 0.7  |     |     |     |     |     | 0.7  | 0.7  |     |     |     |     |     |
| Bankfull Max Depth (ft)                                 | 1.4  | 1.4  |     |     |     |     |     | 1.5  | 1.7  |     |     |     |     |     | 2.0  | 1.9  |     |     |     |     |     | 1.5  | 1.5  |     |     |     |     |     | 1.6  | 1.5  |     |     |     |     |     |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 10.0   | 9.8  |     |     |     |     |     | 11.3   | 10.4 |     |     |     |     |     | 10.2   | 9.4  |     |     |     |     |     | 8.1  | 7.8  |     |     |     |     |     | 8.0  | 7.3  |     |     |     |     |     |
| Bankfull Width/Depth Ratio                              | 17.6   | 20.1 |     |     |     |     |     | 15.0   | 14.5 |     |     |     |     |     | 7.7  | 8.1  |     |     |     |     |     | 17.4   | 17.1 |     |     |     |     |     | 14.5   | 16.1 |     |     |     |     |     |
| Bankfull Entrenchment Ratio                             | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     | >2.2   | >2.2 |     |     |     |     |     |
| Bankfull Bank Height Ratio                              | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     | 1.0  | 1.0  |     |     |     |     |     |

<sup>1</sup> = Widths and depths for annual measurements will be based on the baseline bankfull datum regardless of dimensional/depositional development. Input the elevation used as the datum, which should be consistent and based on the baseline datum established. If the performer has inherited the project and cannot acquire the datum used for prior years this must be discussed with EEP. If this cannot be resolved in time for a given years report submission a footnote in this should be included that states: "It is uncertain if the monitoring datum has been consistent over the monitoring history, which may influence calculated values. Additional data from a prior performer is being acquired to provide confirmation. Values will be recalculated in a future submission based on a consistent datum if determined to be necessary."

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

**Project Name/Number: Muddy Run Mitigation Project/95018**

|   | Cross Section 21 (Pool)    |      |     |     |     |     |     | Cross Section 22 (Shallow) |      |     |     |     |     |     | Cross Section 23 (Pool)    |      |     |     |     |     |     | Cross Section 24 (Shallow) |      |      |     |     |     |     | Cross Section 25 (Pool) |      |      |     |     |     |     |  |
|---|----------------------------|------|-----|-----|-----|-----|-----|----------------------------|------|-----|-----|-----|-----|-----|----------------------------|------|-----|-----|-----|-----|-----|----------------------------|------|------|-----|-----|-----|-----|-------------------------|------|------|-----|-----|-----|-----|--|
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ | Base                    | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ |  |
| Record elevation (datum) used                           | 42.3                       | 42.3 |     |     |     |     |     | 41.8                       | 41.8 |     |     |     |     |     | 41.5                       | 41.5 |     |     |     |     |     |                            | 45.2 | 45.2 |     |     |     |     |                         | 45.2 | 45.2 |     |     |     |     |  |
| Bankfull Width (ft)                                     | 10.6                       | 10.5 |     |     |     |     |     | 9.8                        | 11.4 |     |     |     |     |     | 10.6                       | 11.7 |     |     |     |     |     |                            | 9.1  | 9.9  |     |     |     |     |                         | 8.6  | 8.2  |     |     |     |     |  |
| Floodprone Width (ft)                                   | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     |                            | 50.0 | 50.0 |     |     |     |     |                         | 50.0 | 50.0 |     |     |     |     |  |
| Bankfull Mean Depth (ft)                                | 1.1                        | 1.1  |     |     |     |     |     | 0.7                        | 0.6  |     |     |     |     |     | 0.7                        | 0.6  |     |     |     |     |     |                            | 0.5  | 0.5  |     |     |     |     |                         | 0.6  | 0.6  |     |     |     |     |  |
| Bankfull Max Depth (ft)                                 | 2.2                        | 2.2  |     |     |     |     |     | 1.4                        | 1.5  |     |     |     |     |     | 1.2                        | 1.3  |     |     |     |     |     |                            | 1.0  | 0.9  |     |     |     |     |                         | 1.3  | 1.2  |     |     |     |     |  |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 11.5                       | 11.5 |     |     |     |     |     | 7.2                        | 7.1  |     |     |     |     |     | 7.0                        | 7.3  |     |     |     |     |     |                            | 4.6  | 4.5  |     |     |     |     |                         | 5.3  | 4.9  |     |     |     |     |  |
| Bankfull Width/Depth Ratio                              | 9.8                        | 9.6  |     |     |     |     |     | 13.3                       | 18.2 |     |     |     |     |     | 16.3                       | 18.7 |     |     |     |     |     |                            | 18.2 | 21.5 |     |     |     |     |                         | 13.9 | 13.8 |     |     |     |     |  |
| Bankfull Entrenchment Ratio                             | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     |                            | >2.2 | >2.2 |     |     |     |     |                         | >2.2 | >2.2 |     |     |     |     |  |
| Bankfull Bank Height Ratio                              | 1.0                        | 10.0 |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     |                            | 1.0  | 1.0  |     |     |     |     |                         | 1.0  | 1.0  |     |     |     |     |  |
|   | Cross Section 26 (Shallow) |      |     |     |     |     |     | Cross Section 27 (Pool)    |      |     |     |     |     |     | Cross Section 28 (Shallow) |      |     |     |     |     |     | Cross Section 29 (Pool)    |      |      |     |     |     |     | Cross Section 30 (Pool) |      |      |     |     |     |     |  |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ | Base                    | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ |  |
| Record elevation (datum) used                           | 44.6                       | 44.6 |     |     |     |     |     | 44.5                       | 44.5 |     |     |     |     |     | 44.0                       | 44.0 |     |     |     |     |     |                            | 43.6 | 43.6 |     |     |     |     |                         | 42.7 | 42.7 |     |     |     |     |  |
| Bankfull Width (ft)                                     | 7.3                        | 9.1  |     |     |     |     |     | 7.0                        | 7.6  |     |     |     |     |     | 19.6                       | 20.1 |     |     |     |     |     |                            | 9.7  | 10.1 |     |     |     |     |                         | 7.4  | 7.3  |     |     |     |     |  |
| Floodprone Width (ft)                                   | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     |                            | 50.0 | 50.0 |     |     |     |     |                         | 50.0 | 50.0 |     |     |     |     |  |
| Bankfull Mean Depth (ft)                                | 0.6                        | 0.5  |     |     |     |     |     | 0.7                        | 0.6  |     |     |     |     |     | 0.4                        | 0.4  |     |     |     |     |     |                            | 0.7  | 0.6  |     |     |     |     |                         | 0.5  | 0.5  |     |     |     |     |  |
| Bankfull Max Depth (ft)                                 | 1.1                        | 1.1  |     |     |     |     |     | 1.4                        | 1.4  |     |     |     |     |     | 1.2                        | 1.3  |     |     |     |     |     |                            | 1.5  | 1.3  |     |     |     |     |                         | 1.1  | 0.9  |     |     |     |     |  |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 4.3                        | 4.1  |     |     |     |     |     | 5.1                        | 5.1  |     |     |     |     |     | 8.2                        | 8.7  |     |     |     |     |     |                            | 6.4  | 6.2  |     |     |     |     |                         | 4.0  | 3.6  |     |     |     |     |  |
| Bankfull Width/Depth Ratio                              | 12.2                       | 20.1 |     |     |     |     |     | 9.5                        | 11.2 |     |     |     |     |     | 47.1                       | 46.3 |     |     |     |     |     |                            | 14.7 | 16.5 |     |     |     |     |                         | 13.6 | 15.0 |     |     |     |     |  |
| Bankfull Entrenchment Ratio                             | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     |                            | >2.2 | >2.2 |     |     |     |     |                         | >2.2 | >2.2 |     |     |     |     |  |
| Bankfull Bank Height Ratio                              | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     |                            | 1.0  | 1.0  |     |     |     |     |                         | 1.0  | 1.0  |     |     |     |     |  |
|   | Cross Section 31 (Shallow) |      |     |     |     |     |     | Cross Section 32 (Shallow) |      |     |     |     |     |     | Cross Section 33 (Pool)    |      |     |     |     |     |     | Cross Section 34 (Shallow) |      |      |     |     |     |     | Cross Section 35 (Pool) |      |      |     |     |     |     |  |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ | Base                    | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ |  |
| Record elevation (datum) used                           | 42.9                       | 42.9 |     |     |     |     |     | 42.6                       | 42.6 |     |     |     |     |     | 42.4                       | 42.4 |     |     |     |     |     |                            | 42.2 | 42.2 |     |     |     |     |                         | 42.1 | 42.1 |     |     |     |     |  |
| Bankfull Width (ft)                                     | 11.3                       | 12.3 |     |     |     |     |     | 6.8                        | 7.2  |     |     |     |     |     | 7.1                        | 7.4  |     |     |     |     |     |                            | 8.4  | 7.8  |     |     |     |     |                         | 7.7  | 7.8  |     |     |     |     |  |
| Floodprone Width (ft)                                   | 70.0                       | 70.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     |                            | 50.0 | 50.0 |     |     |     |     |                         | 50.0 | 50.0 |     |     |     |     |  |
| Bankfull Mean Depth (ft)                                | 0.4                        | 0.4  |     |     |     |     |     | 0.5                        | 0.5  |     |     |     |     |     | 0.6                        | 0.6  |     |     |     |     |     |                            | 0.5  | 0.5  |     |     |     |     |                         | 0.7  | 0.7  |     |     |     |     |  |
| Bankfull Max Depth (ft)                                 | 0.9                        | 0.9  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     | 1.1                        | 1.0  |     |     |     |     |     |                            | 0.9  | 0.9  |     |     |     |     |                         | 1.4  | 1.4  |     |     |     |     |  |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 4.6                        | 4.5  |     |     |     |     |     | 3.7                        | 3.8  |     |     |     |     |     | 4.3                        | 4.3  |     |     |     |     |     |                            | 3.9  | 3.6  |     |     |     |     |                         | 5.6  | 5.3  |     |     |     |     |  |
| Bankfull Width/Depth Ratio                              | 28.3                       | 33.7 |     |     |     |     |     | 12.4                       | 13.4 |     |     |     |     |     | 11.5                       | 12.9 |     |     |     |     |     |                            | 18.1 | 16.5 |     |     |     |     |                         | 10.5 | 11.3 |     |     |     |     |  |
| Bankfull Entrenchment Ratio                             | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     |                            | >2.2 | >2.2 |     |     |     |     |                         | >2.2 | >2.2 |     |     |     |     |  |
| Bankfull Bank Height Ratio                              | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     |                            | 1.0  | 1.0  |     |     |     |     |                         | 1.0  | 1.0  |     |     |     |     |  |
|   | Cross Section 36 (Shallow) |      |     |     |     |     |     | Cross Section 37 (Pool)    |      |     |     |     |     |     | Cross Section 38 (Pool)    |      |     |     |     |     |     | Cross Section 39 (Shallow) |      |      |     |     |     |     |                         |      |      |     |     |     |     |  |
| Based on fixed baseline bankfull elevation <sup>1</sup> | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2 | MY3 | MY4 | MY5 | MY+ | Base                       | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ | Base                    | MY1  | MY2  | MY3 | MY4 | MY5 | MY+ |  |
| Record elevation (datum) used                           | 41.8                       | 41.8 |     |     |     |     |     | 41.8                       | 41.8 |     |     |     |     |     | 41.1                       | 41.1 |     |     |     |     |     |                            | 41.1 | 41.1 |     |     |     |     |                         | 41.1 | 41.1 |     |     |     |     |  |
| Bankfull Width (ft)                                     | 7.4                        | 7.8  |     |     |     |     |     | 9.6                        | 10.0 |     |     |     |     |     | 15.6                       | 15.5 |     |     |     |     |     |                            | 11.9 | 11.6 |     |     |     |     |                         | 11.9 | 11.6 |     |     |     |     |  |
| Floodprone Width (ft)                                   | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     | 50.0                       | 50.0 |     |     |     |     |     |                            | 50.0 | 50.0 |     |     |     |     |                         | 50.0 | 50.0 |     |     |     |     |  |
| Bankfull Mean Depth (ft)                                | 0.6                        | 0.6  |     |     |     |     |     | 0.5                        | 0.4  |     |     |     |     |     | 1.2                        | 1.1  |     |     |     |     |     |                            | 0.8  | 0.7  |     |     |     |     |                         | 0.8  | 0.7  |     |     |     |     |  |
| Bankfull Max Depth (ft)                                 | 1.0                        | 1.0  |     |     |     |     |     | 1.3                        | 1.1  |     |     |     |     |     | 2.5                        | 2.2  |     |     |     |     |     |                            | 1.6  | 1.5  |     |     |     |     |                         | 1.6  | 1.5  |     |     |     |     |  |
| Bankfull Cross Sectional Area (ft <sup>2</sup> )        | 4.4                        | 4.3  |     |     |     |     |     | 5.1                        | 4.4  |     |     |     |     |     | 18.6                       | 17.3 |     |     |     |     |     |                            | 9.3  | 8.1  |     |     |     |     |                         | 9.3  | 8.1  |     |     |     |     |  |
| Bankfull Width/Depth Ratio                              | 12.2                       | 14.2 |     |     |     |     |     | 18.2                       | 22.9 |     |     |     |     |     | 13.0                       | 14.0 |     |     |     |     |     |                            | 15.1 | 16.6 |     |     |     |     |                         | 15.1 | 16.6 |     |     |     |     |  |
| Bankfull Entrenchment Ratio                             | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     | >2.2                       | >2.2 |     |     |     |     |     |                            | >2.2 | >2.2 |     |     |     |     |                         | >2.2 | >2.2 |     |     |     |     |  |
| Bankfull Bank Height Ratio                              | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     | 1.0                        | 1.0  |     |     |     |     |     |                            | 1.0  | 1.0  |     |     |     |     |                         | 1.0  | 1.0  |     |     |     |     |  |

<sup>1</sup> = Widths and depths for annual measurements will be based on the baseline bankfull datum regardless of dimensional/depositional development. Input the elevation used as the datum, which should be consistent and based on the baseline datum established. If the performer has inherited the project and cannot acquire the datum used for prior years this must be discussed with EEP. If this cannot be resolved in time for a given years report submission a footnote in this should be included that states: "It is uncertain if the monitoring datum has been consistent over the monitoring history, which may influence calculated values. Additional data from a prior performer is being acquired to provide confirmation. Values will be recalculated in a future submission based on a consistent datum if determined to be necessary."

**Table 12.Muddy Run Bank Pin Array Summary**

| Cross Section                 | Location | Position | Year 1  |
|-------------------------------|----------|----------|---------|
|                               |          |          | Reading |
| XS 6 @ Sta.<br>19+70 Reach 1  | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 11 @ Sta.<br>26+70 Reach 1 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 15 @ Sta.<br>32+75 Reach 1 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 18 @ Sta.<br>39+70 Reach 1 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 23 @ Sta.<br>46+30 Reach 1 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 25 @ Sta.<br>2+90 Reach 2  | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 29 @ Sta.<br>7+60 Reach 2  | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 33 @ Sta.<br>11+45 Reach 2 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 37 @ Sta.<br>15+80 Reach 2 | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
| XS 38 @ Sta.<br>2+55 Reach 3  | US       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |
|                               | DS       | Top      | 0.0     |
|                               |          | Bottom   | 0.0     |

Notes:

US - Upstream from cross section

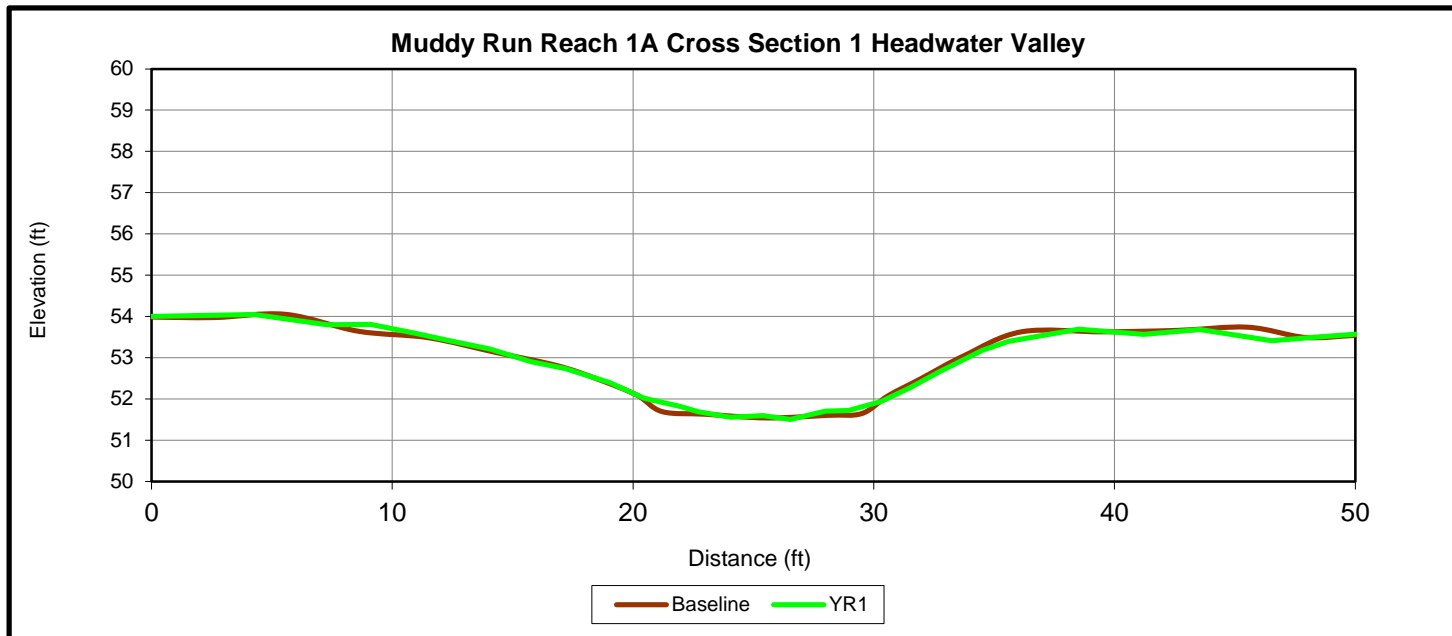
DS - Downstream from cross section



Upstream



Downstream

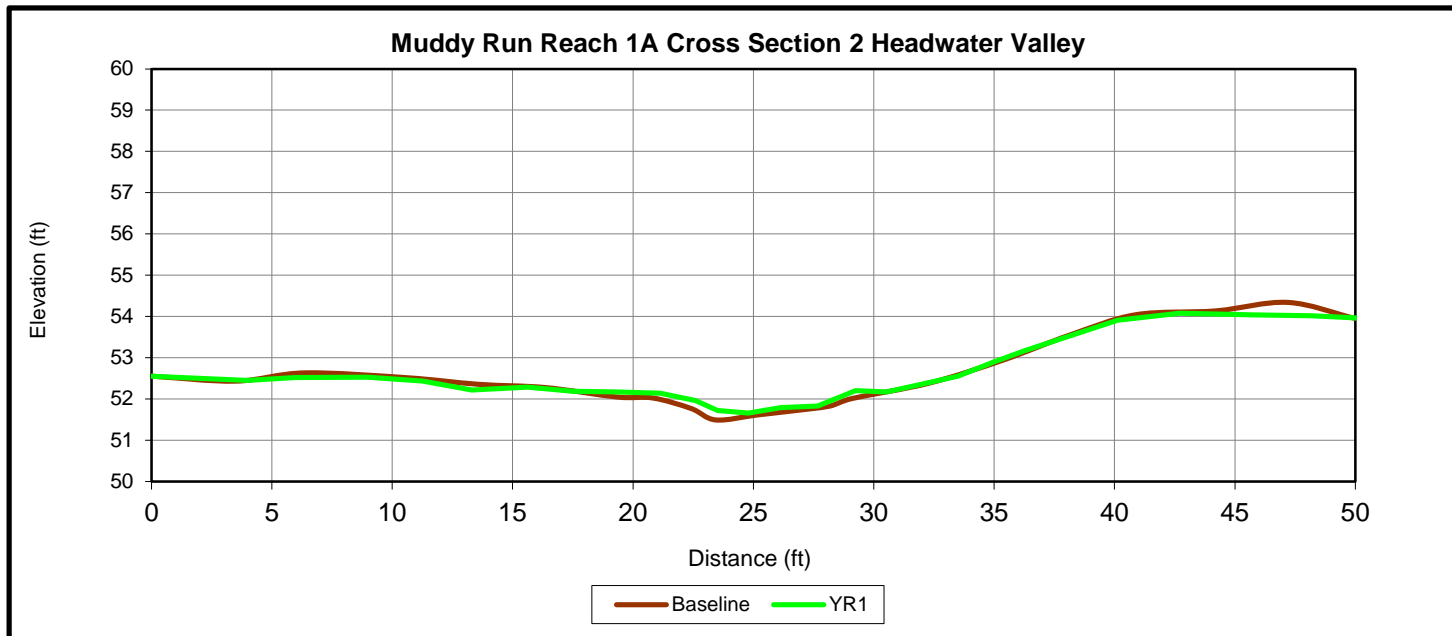




Upstream



Downstream



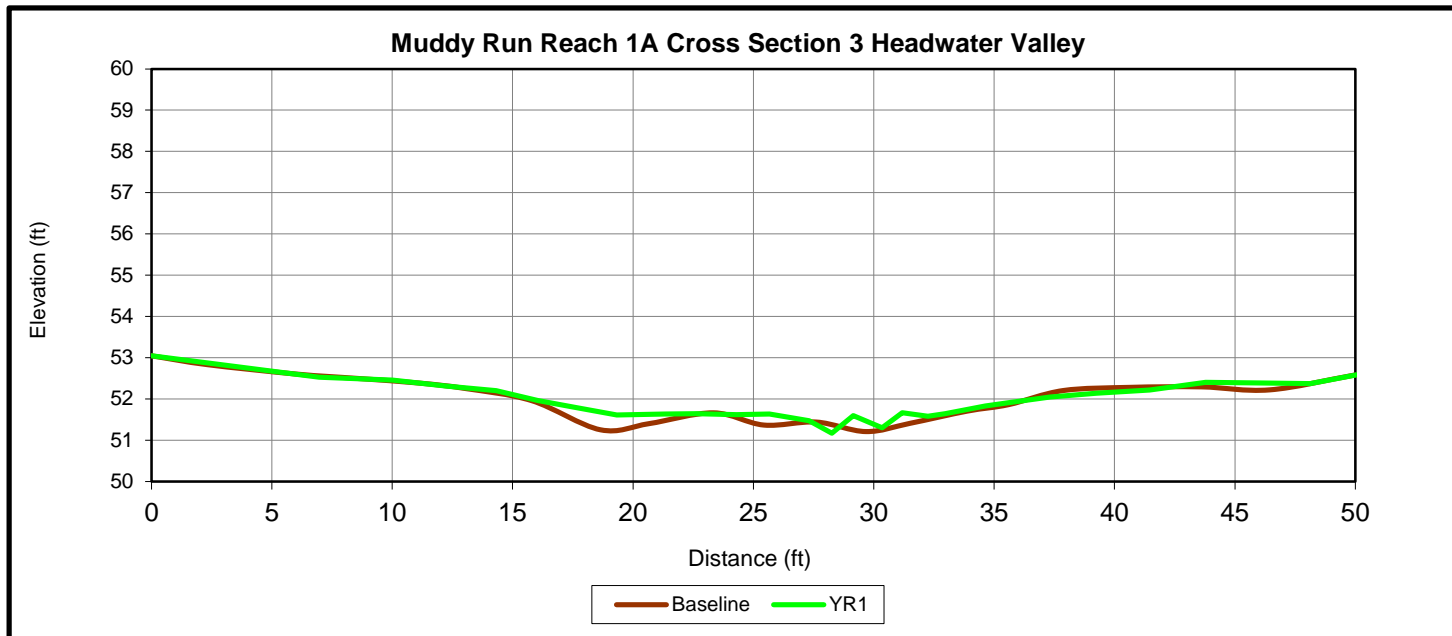




Upstream



Downstream

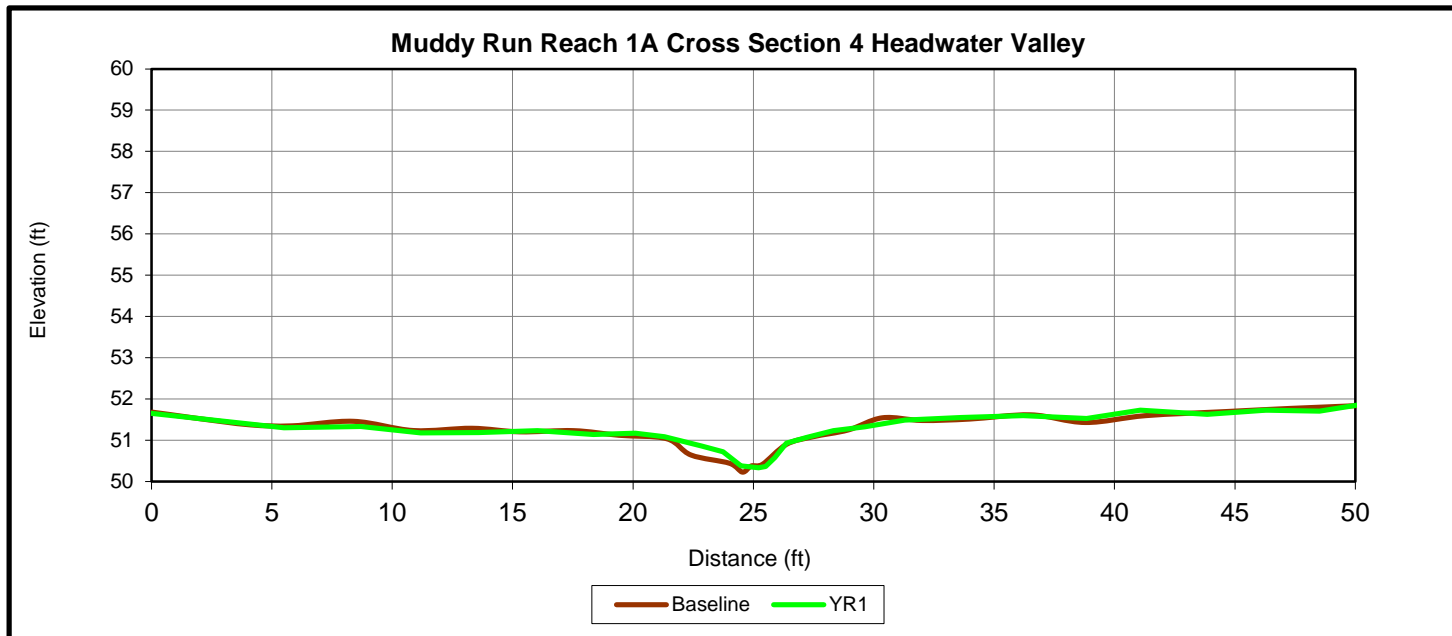




Upstream



Downstream

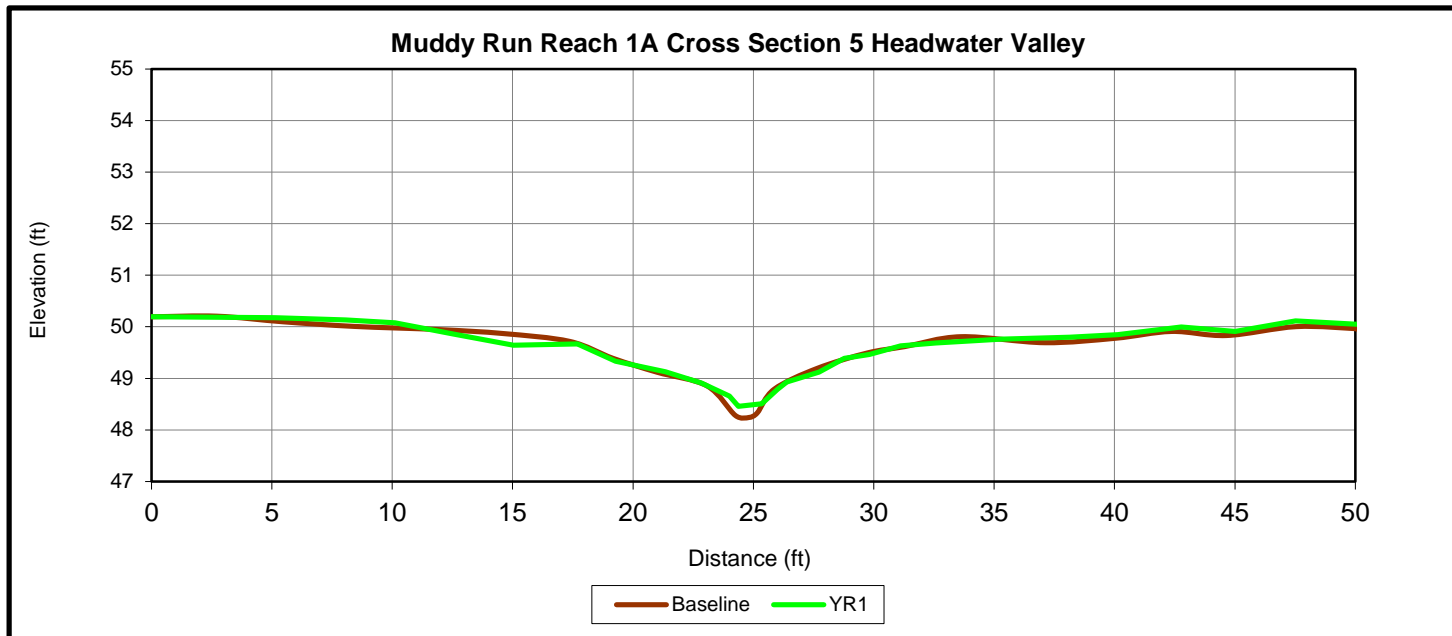




Upstream



Downstream



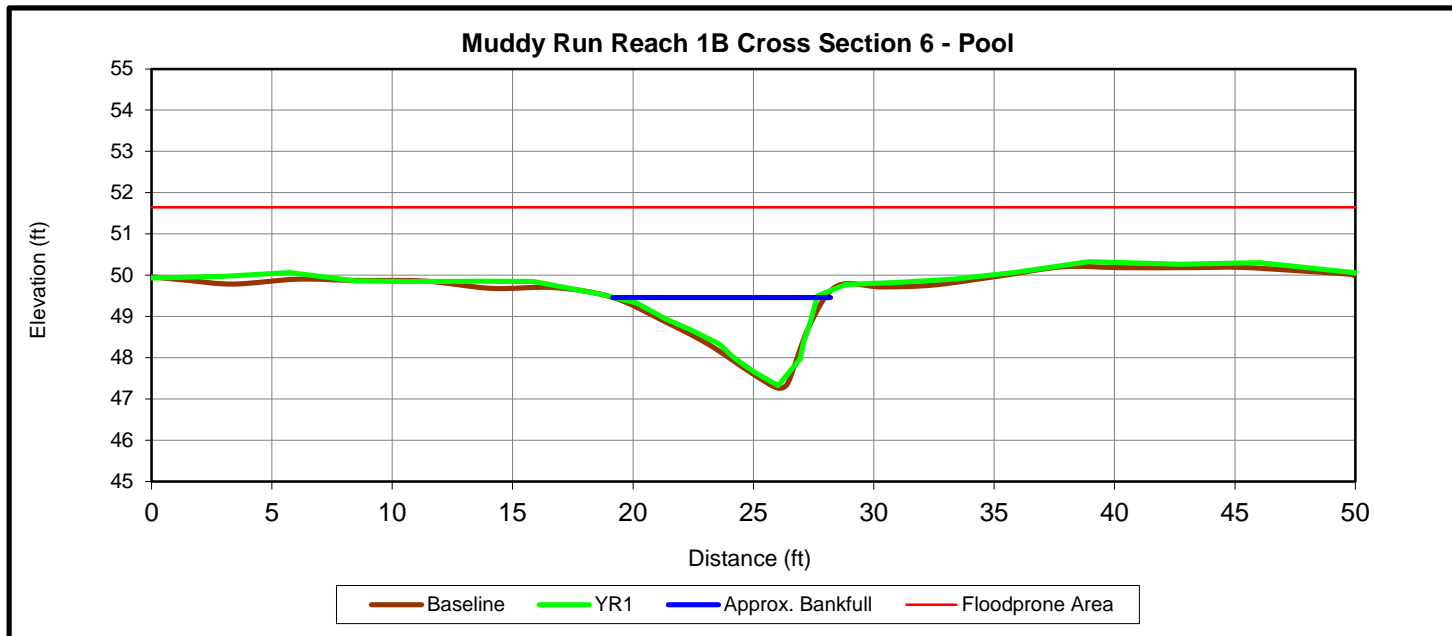




Upstream



Downstream

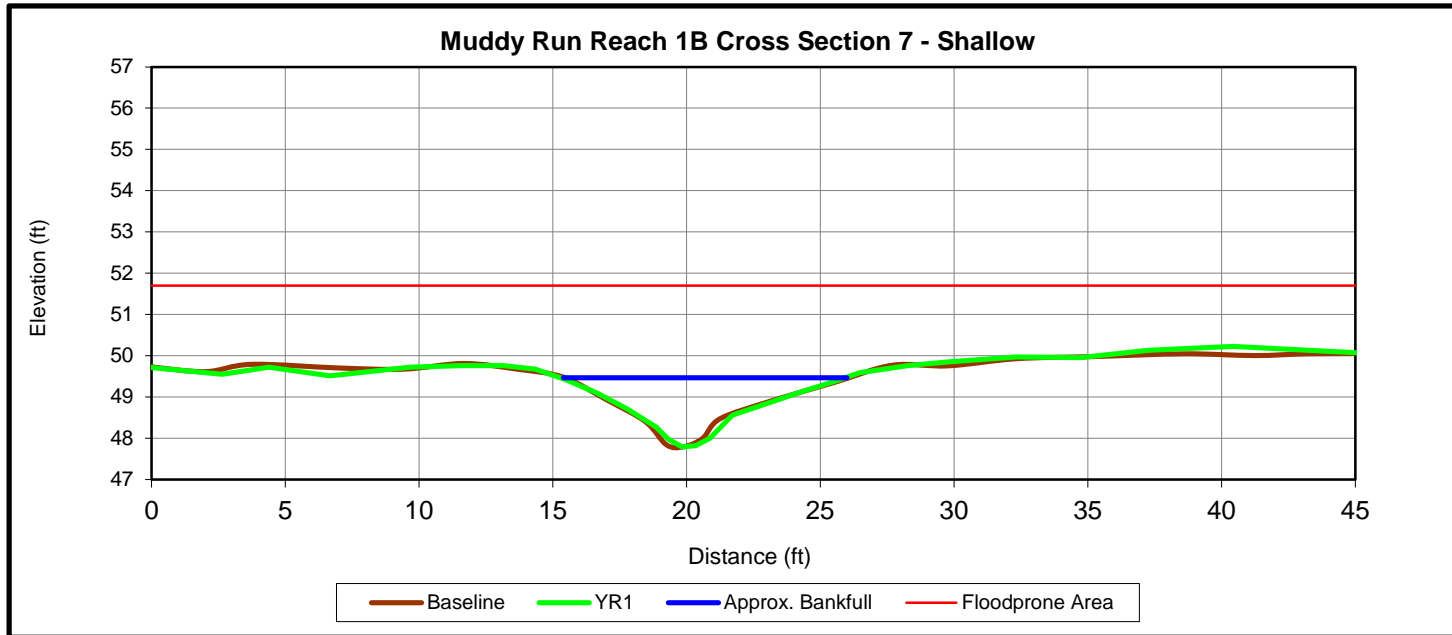




Upstream



Downstream

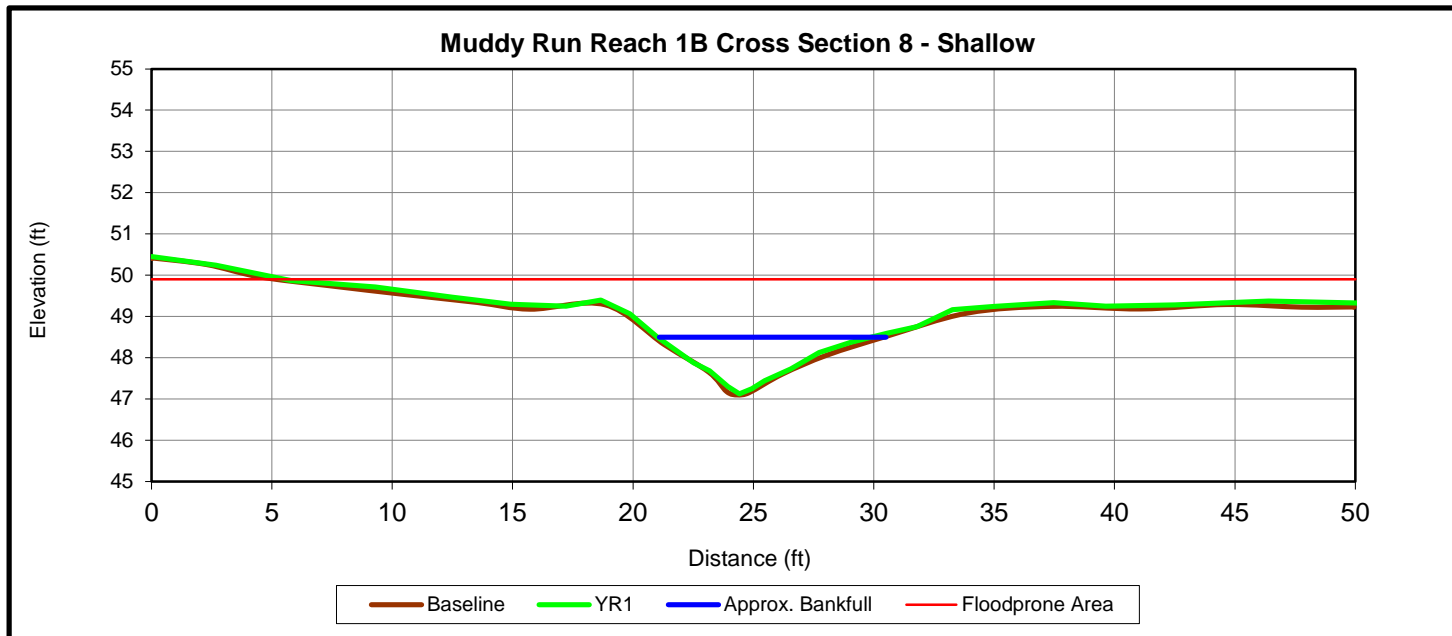




Upstream



Downstream



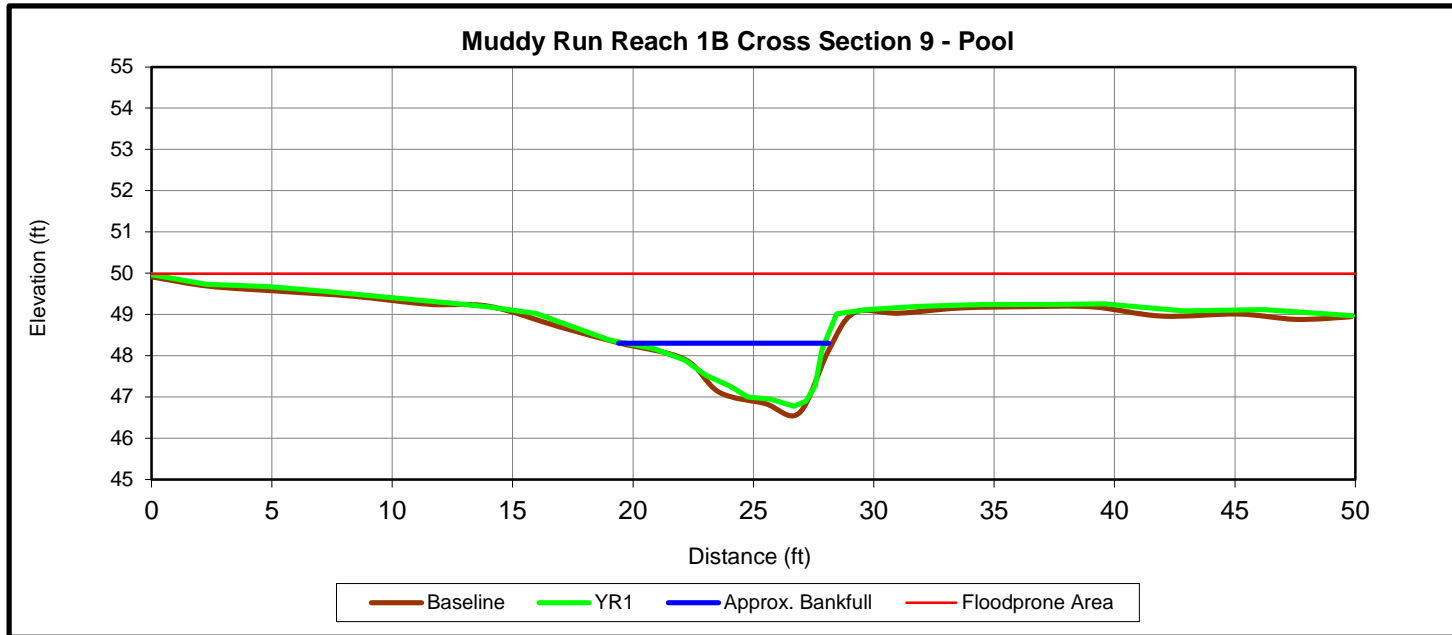




Upstream



Downstream

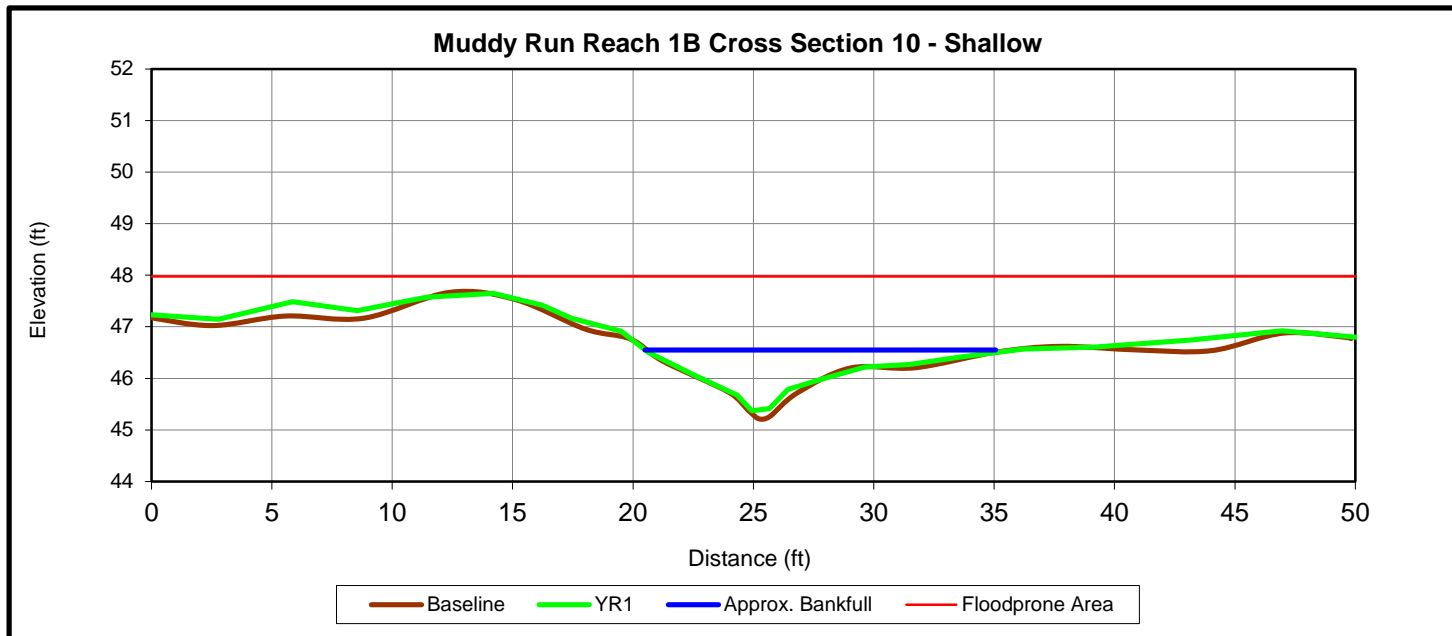


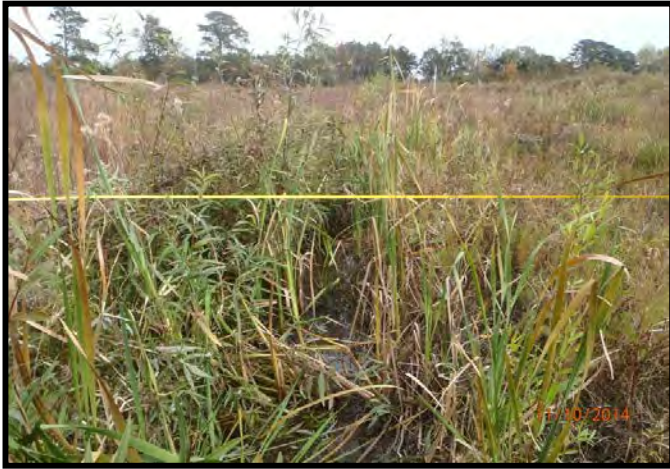


Upstream



Downstream

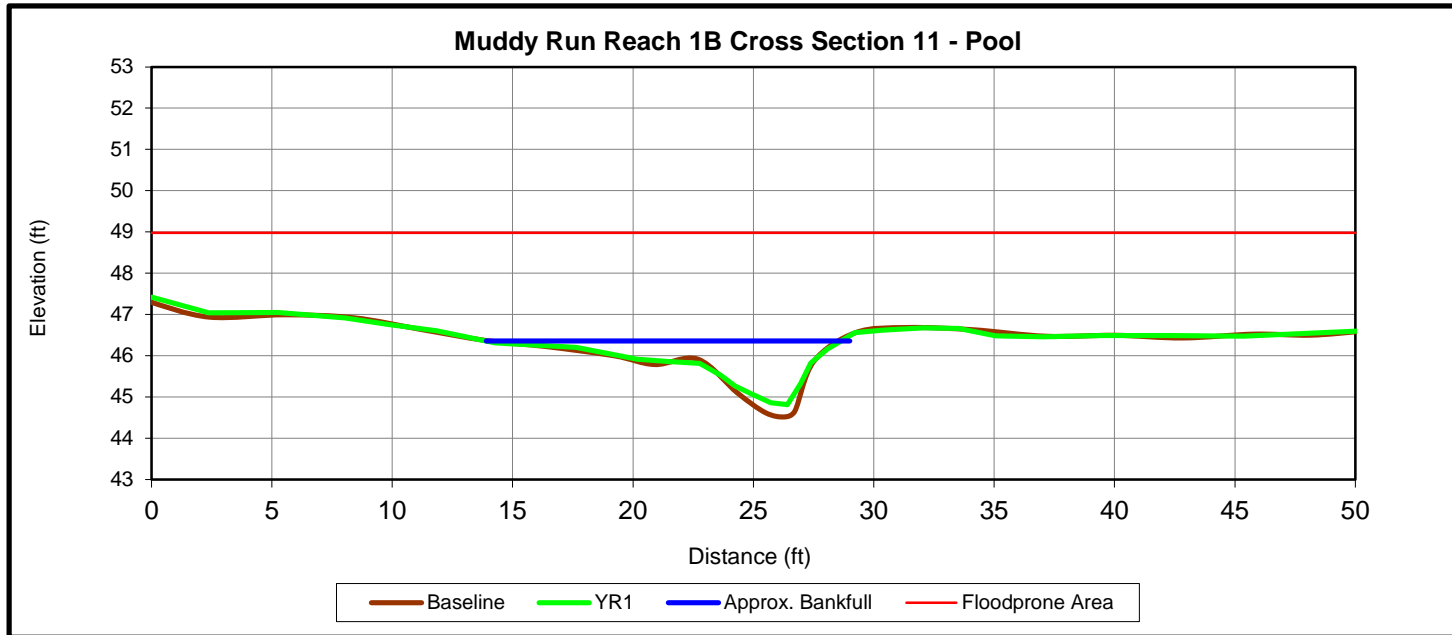




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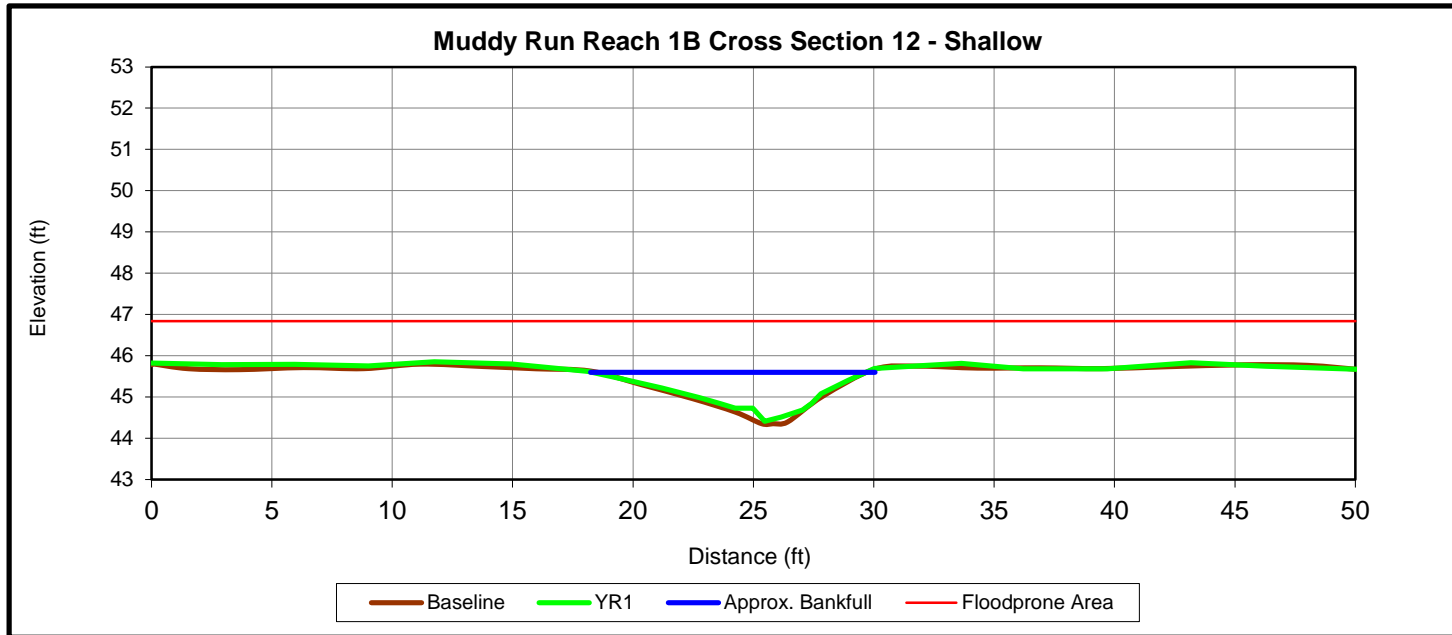




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Downstream



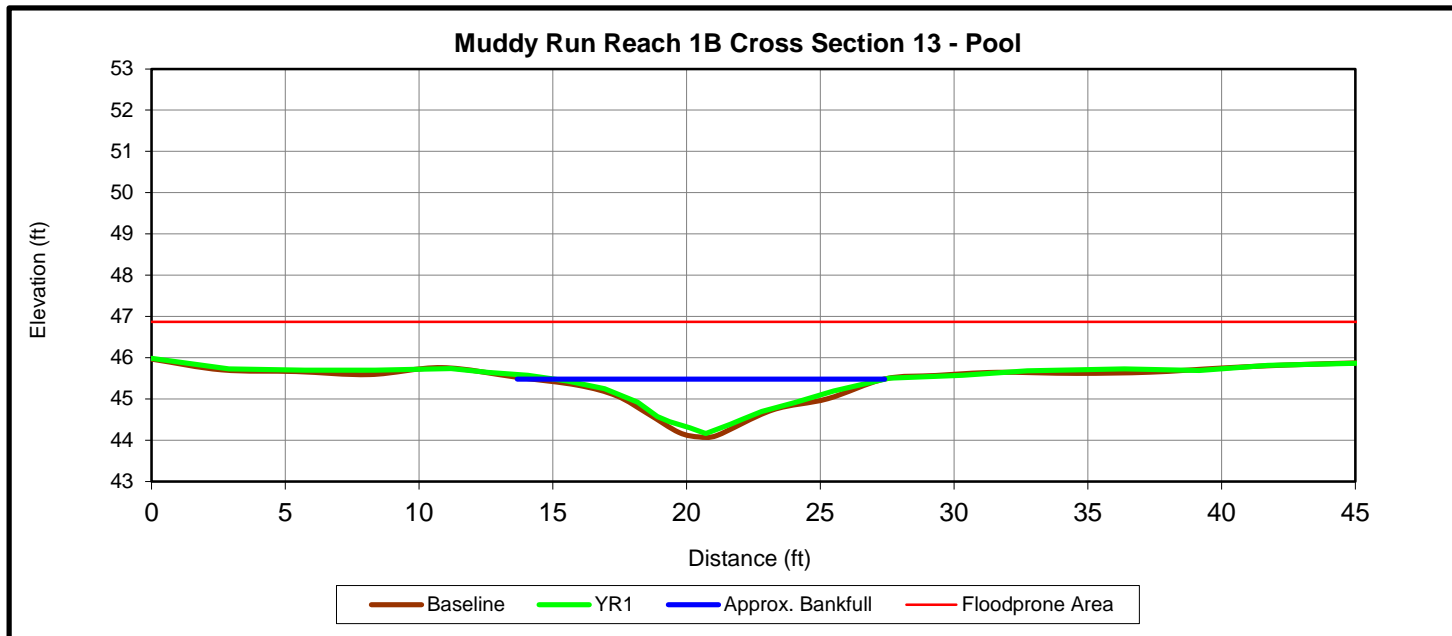




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Downstream

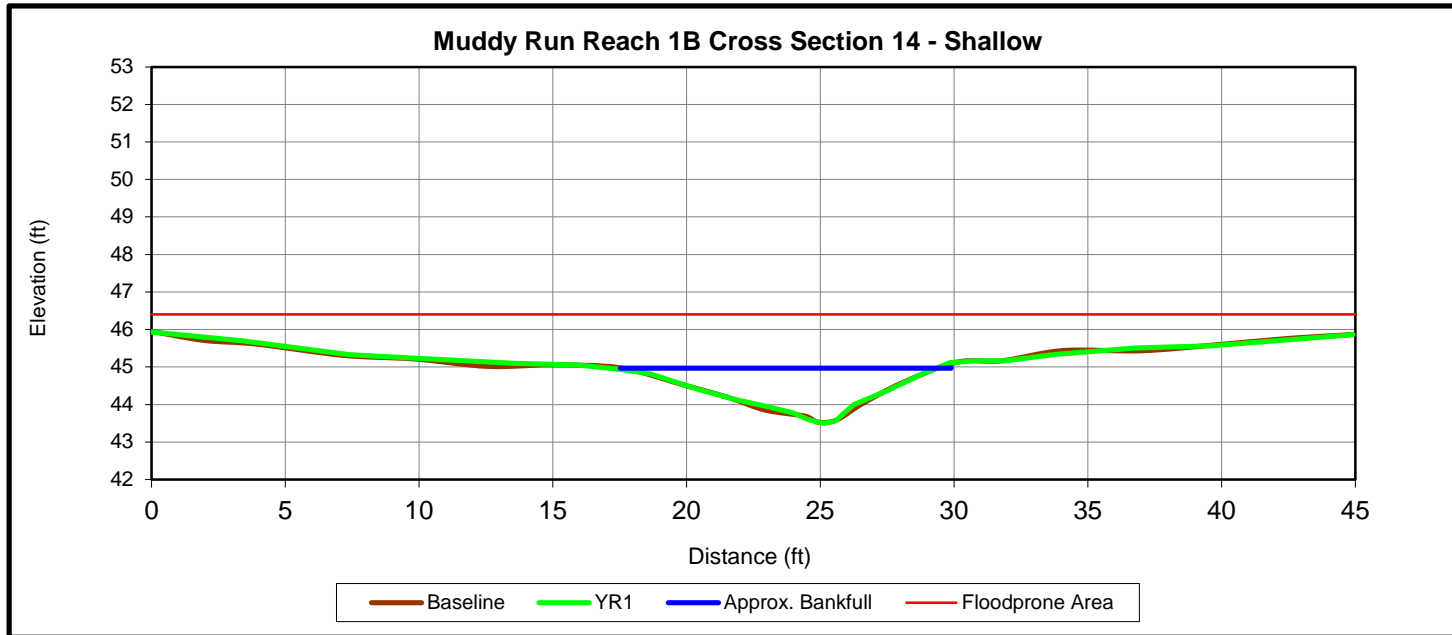




Upstream



Downstream

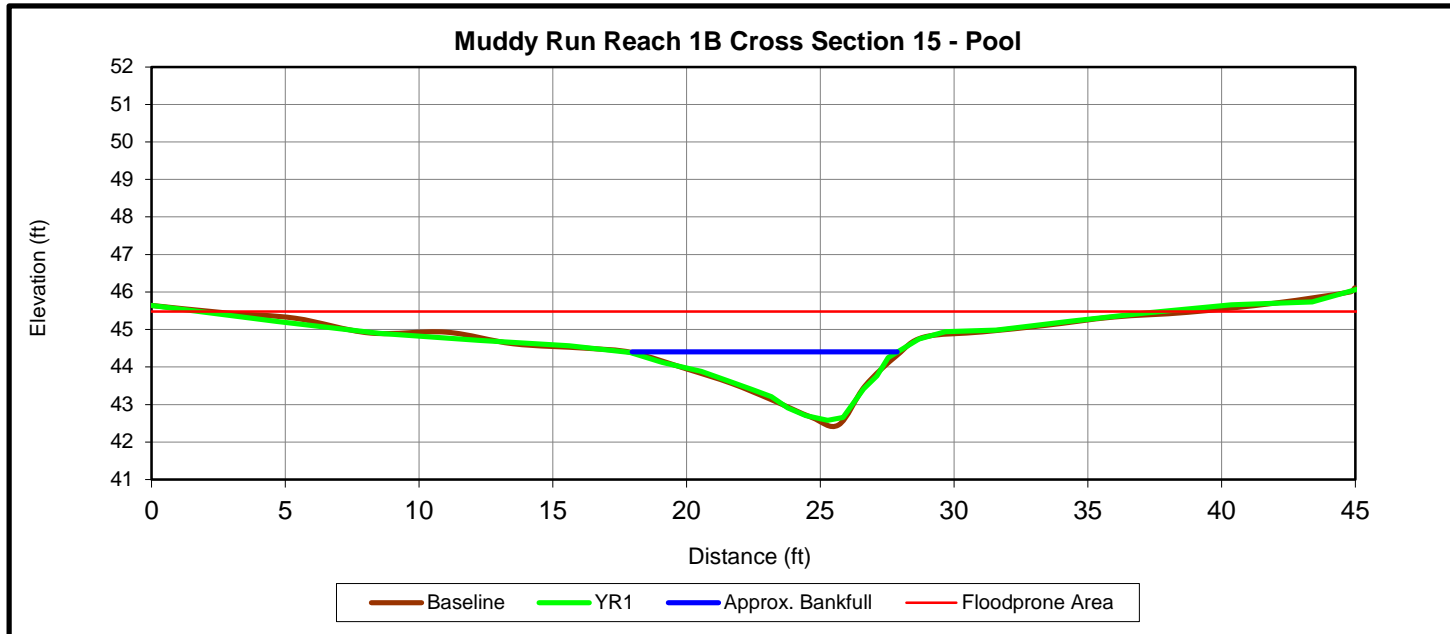




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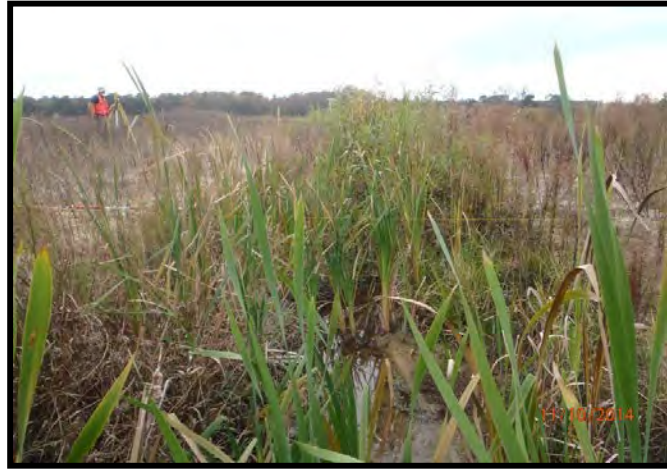
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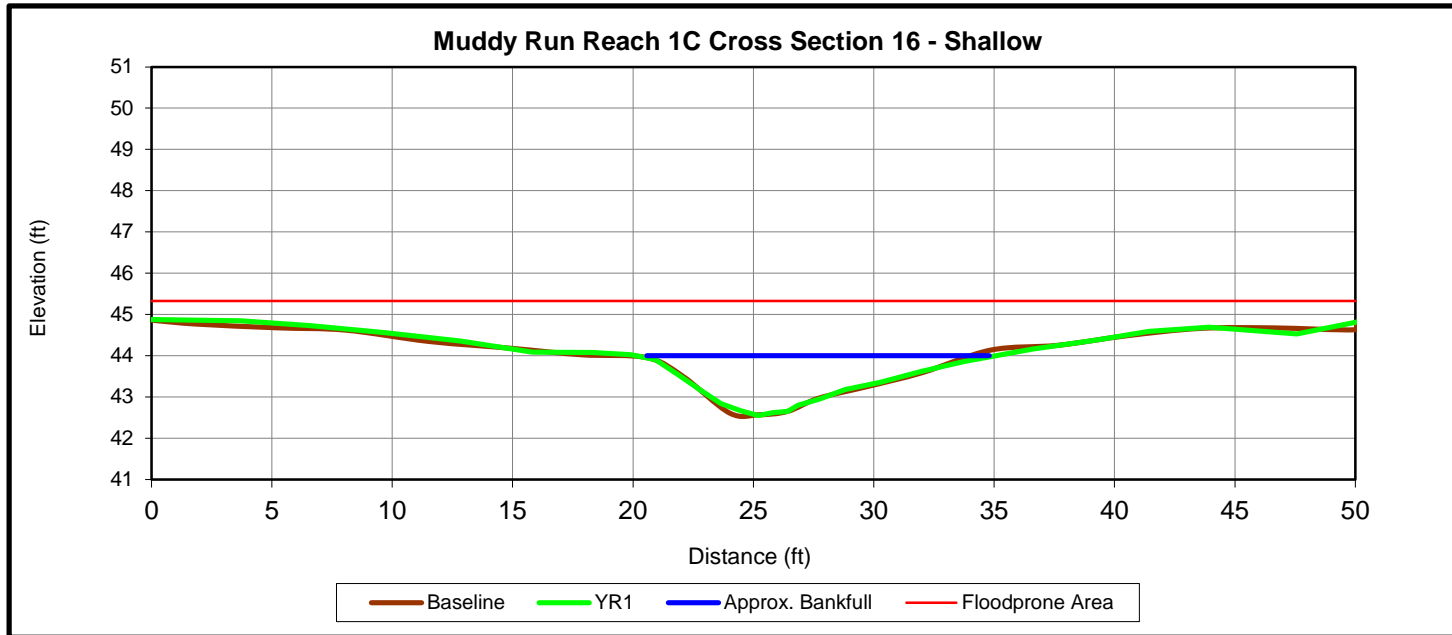




Upstream



Downstream



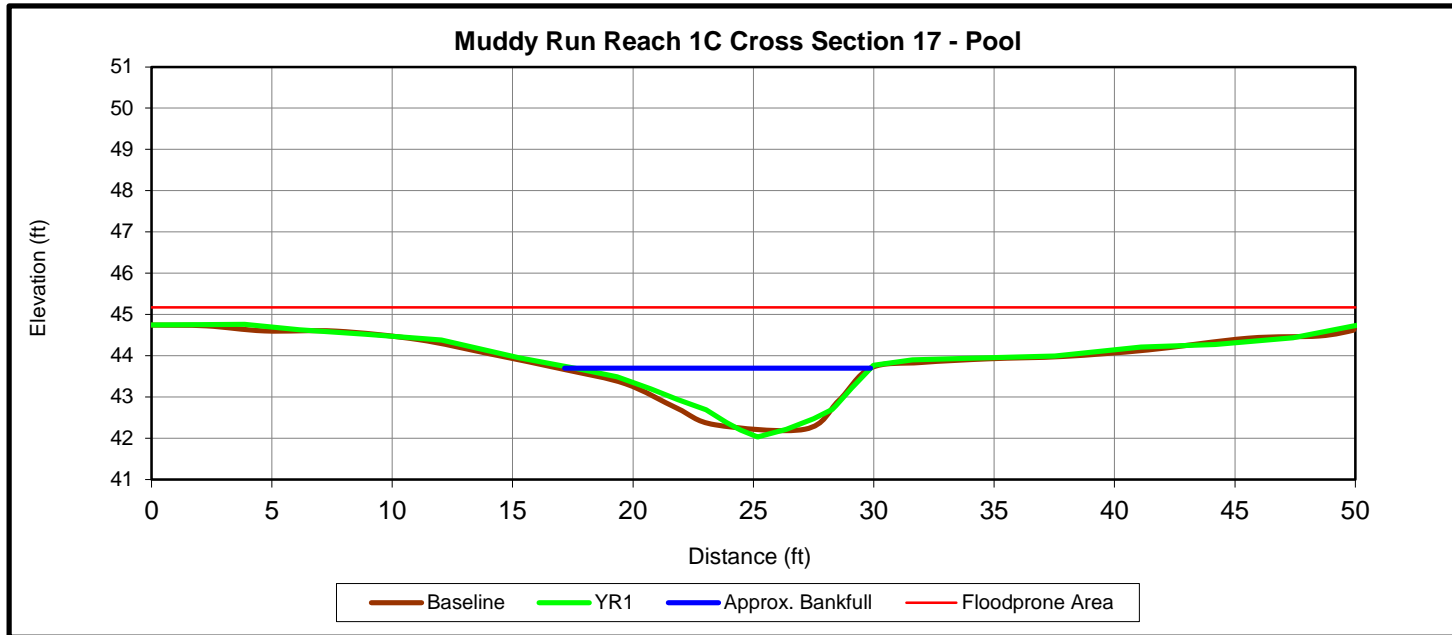




Upstream



Downstream

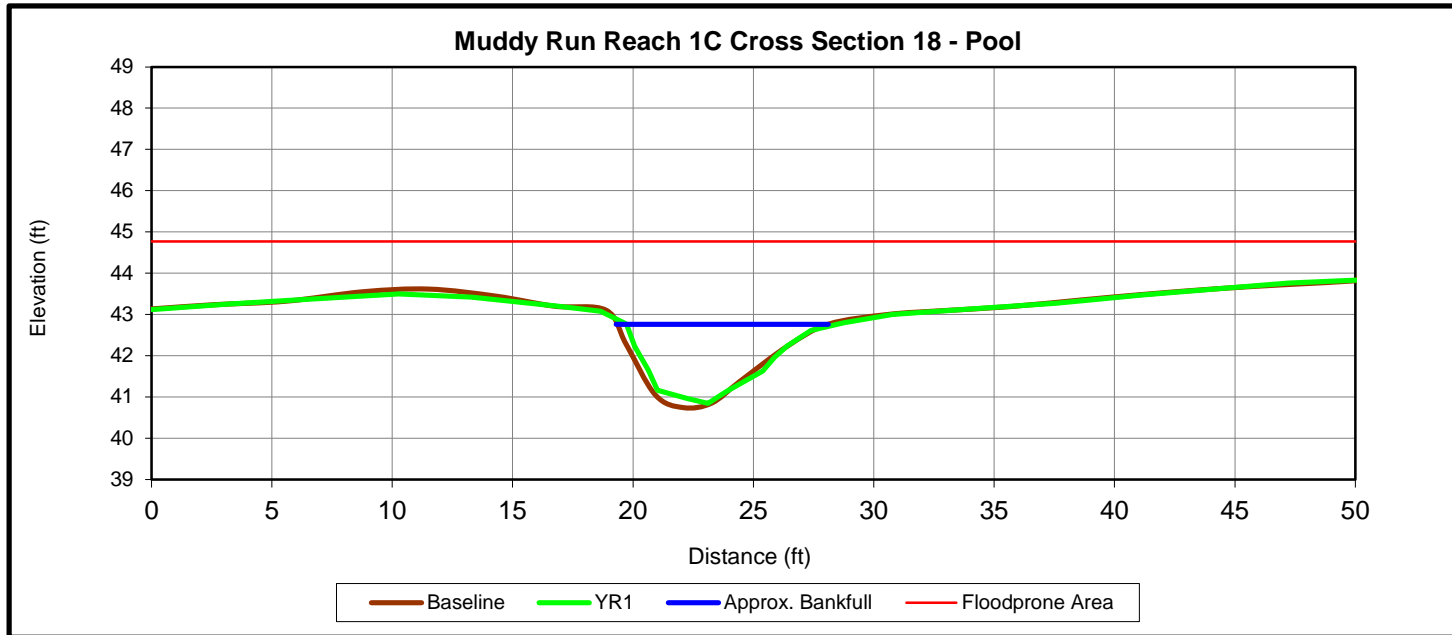




Upstream



Downstream

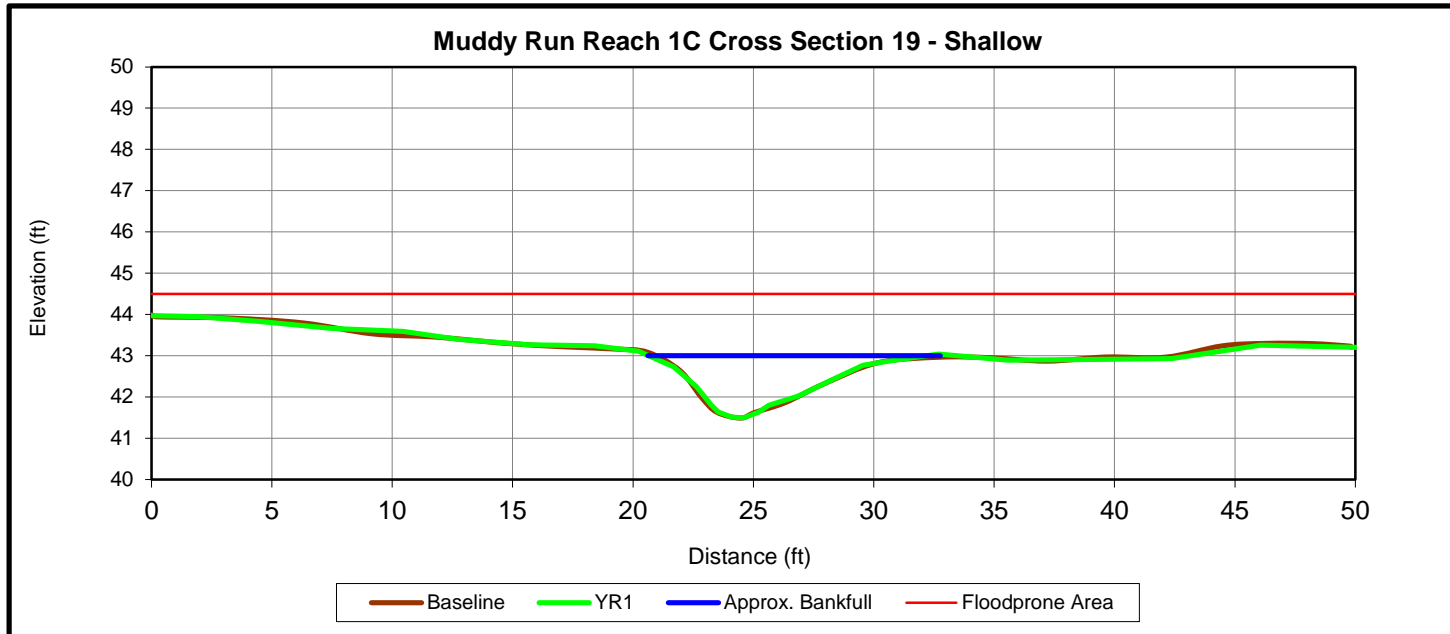




Upstream



Downstream



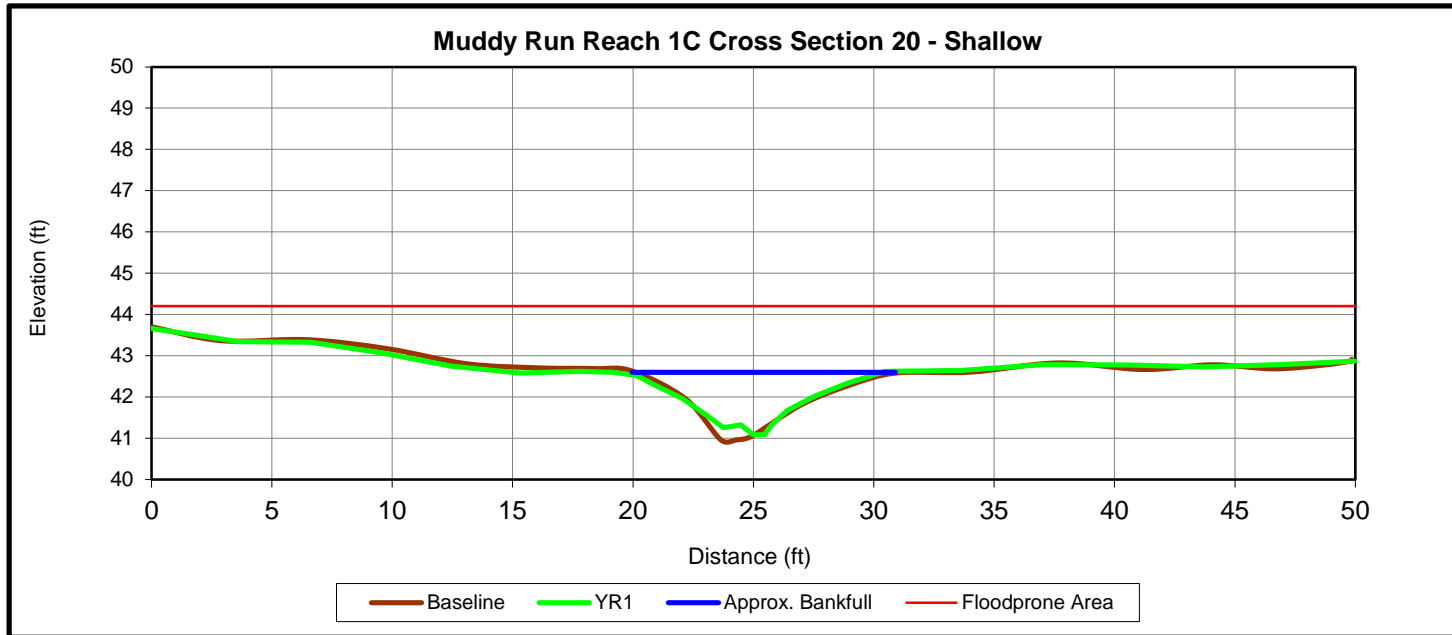




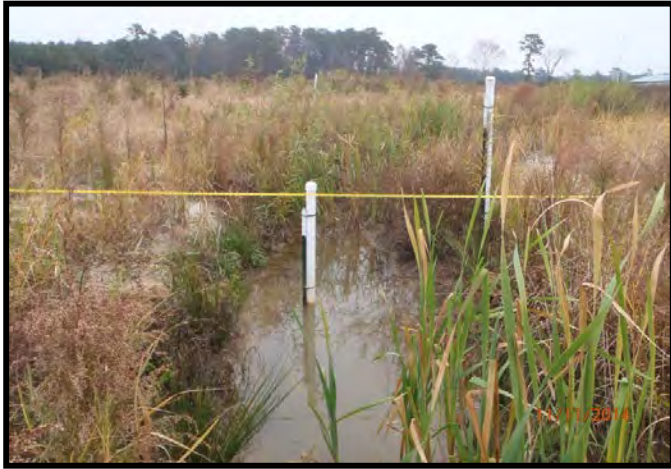
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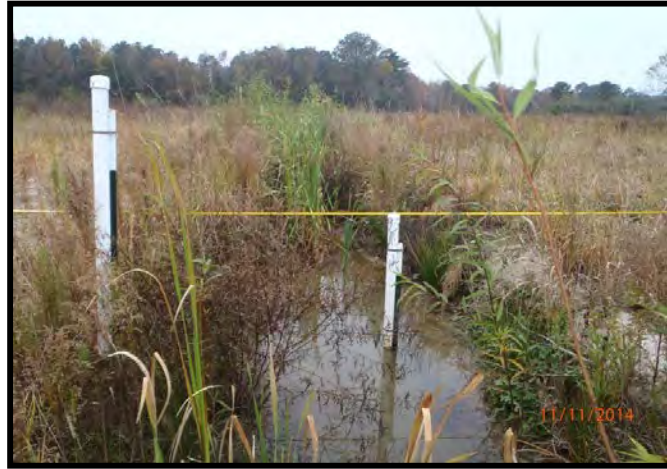
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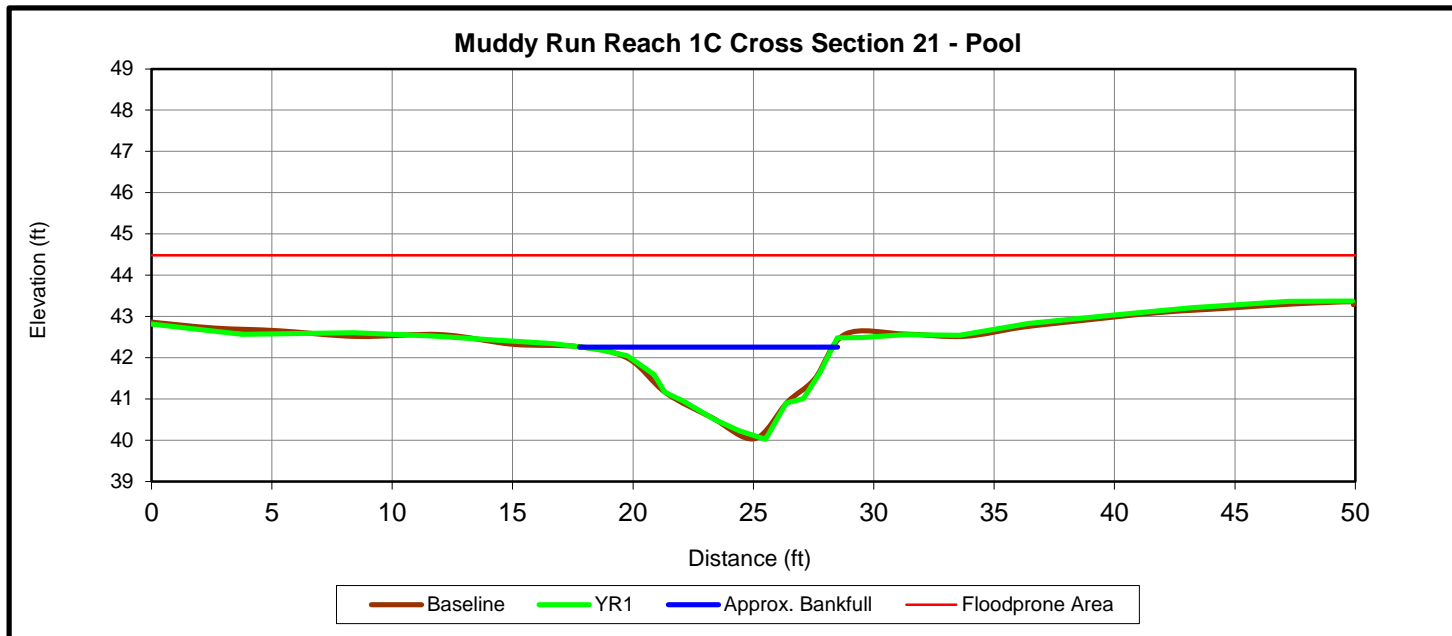




Upstream



Downstream

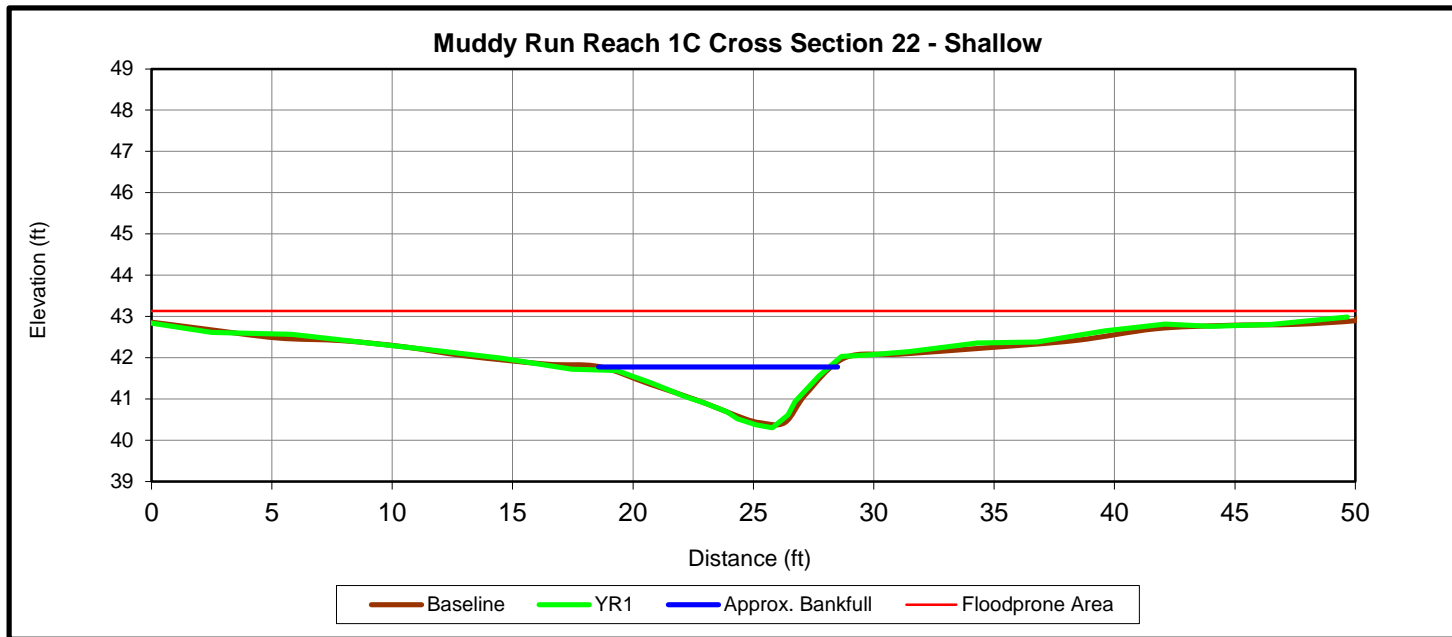




Upstream



Downstream

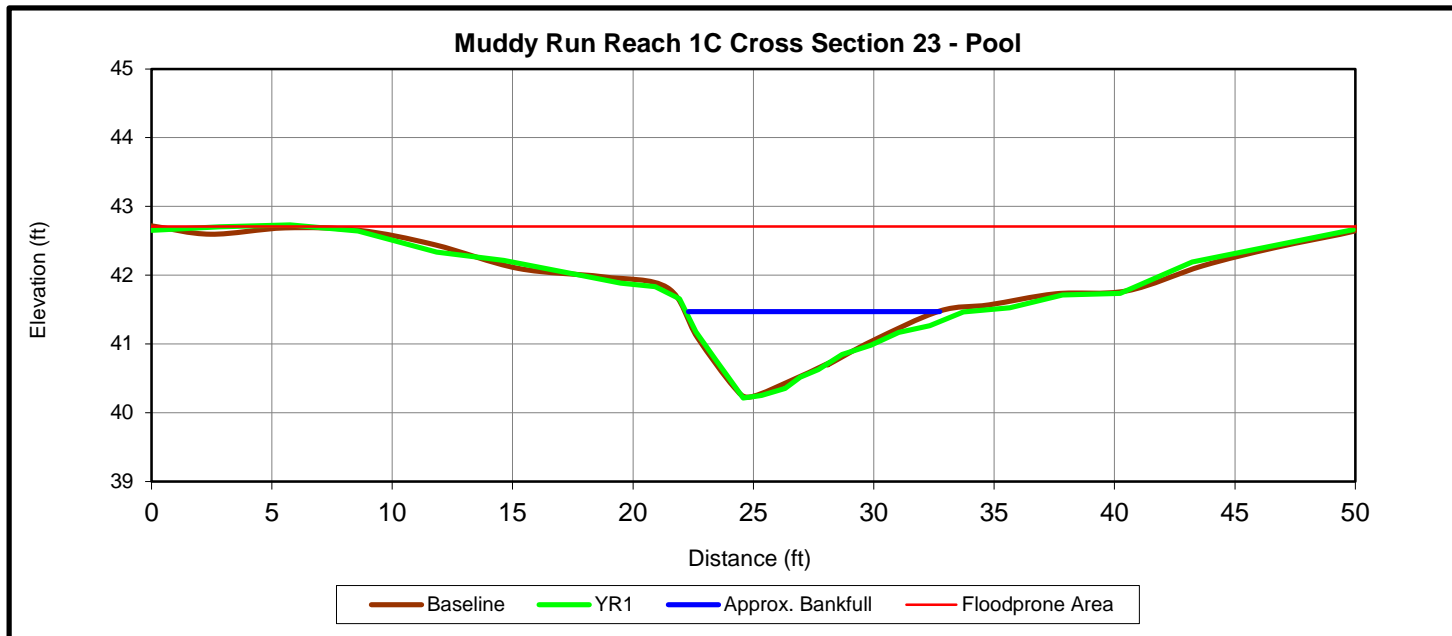




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Downstream



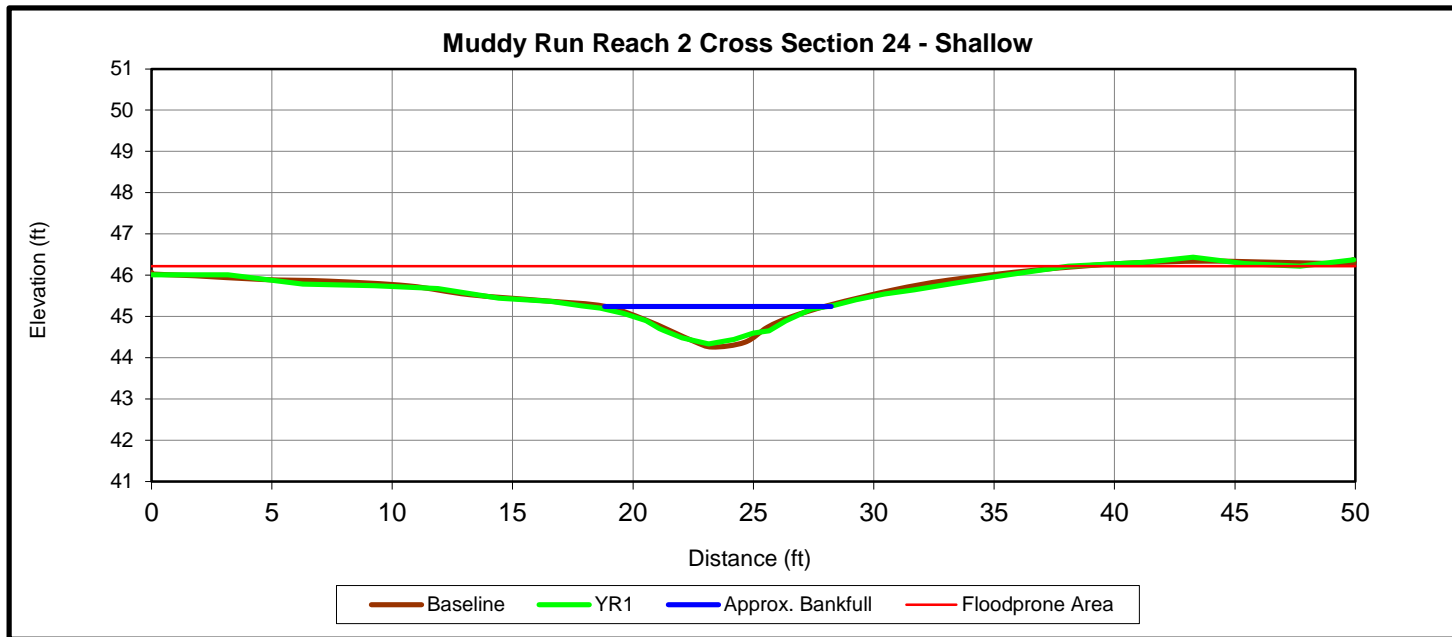




Upstream



Downstream



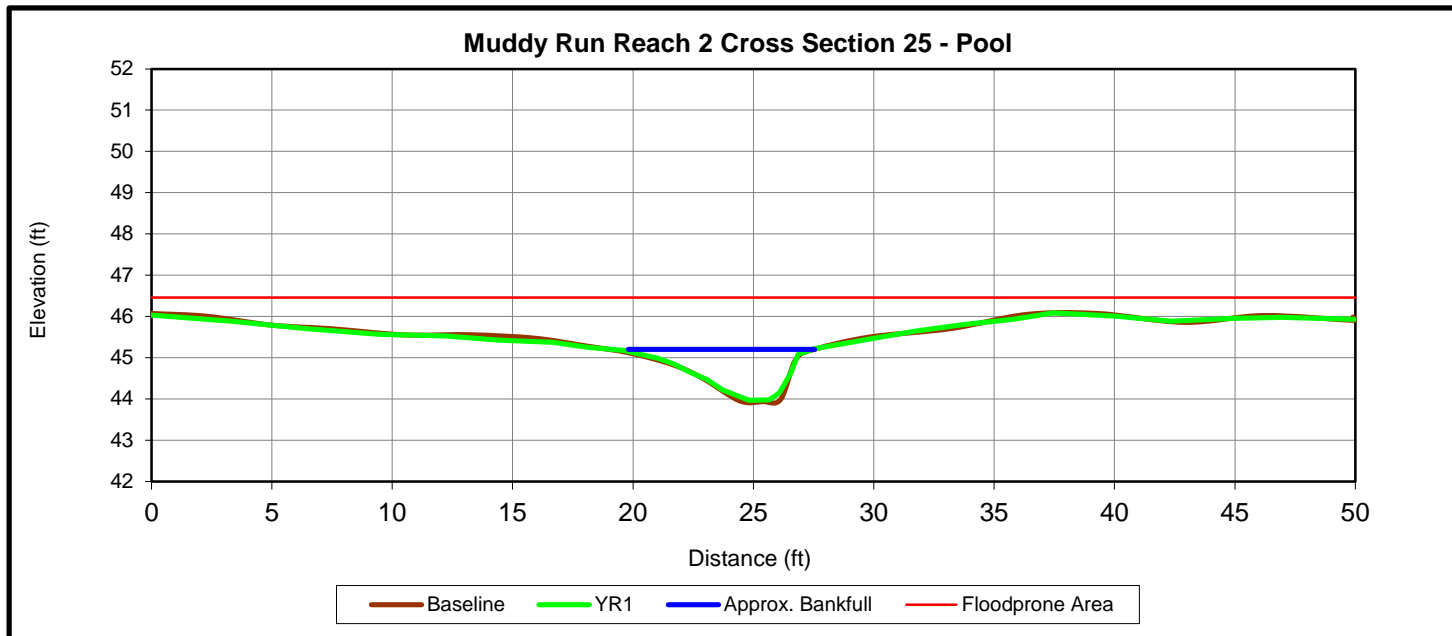




Upstream



Downstream

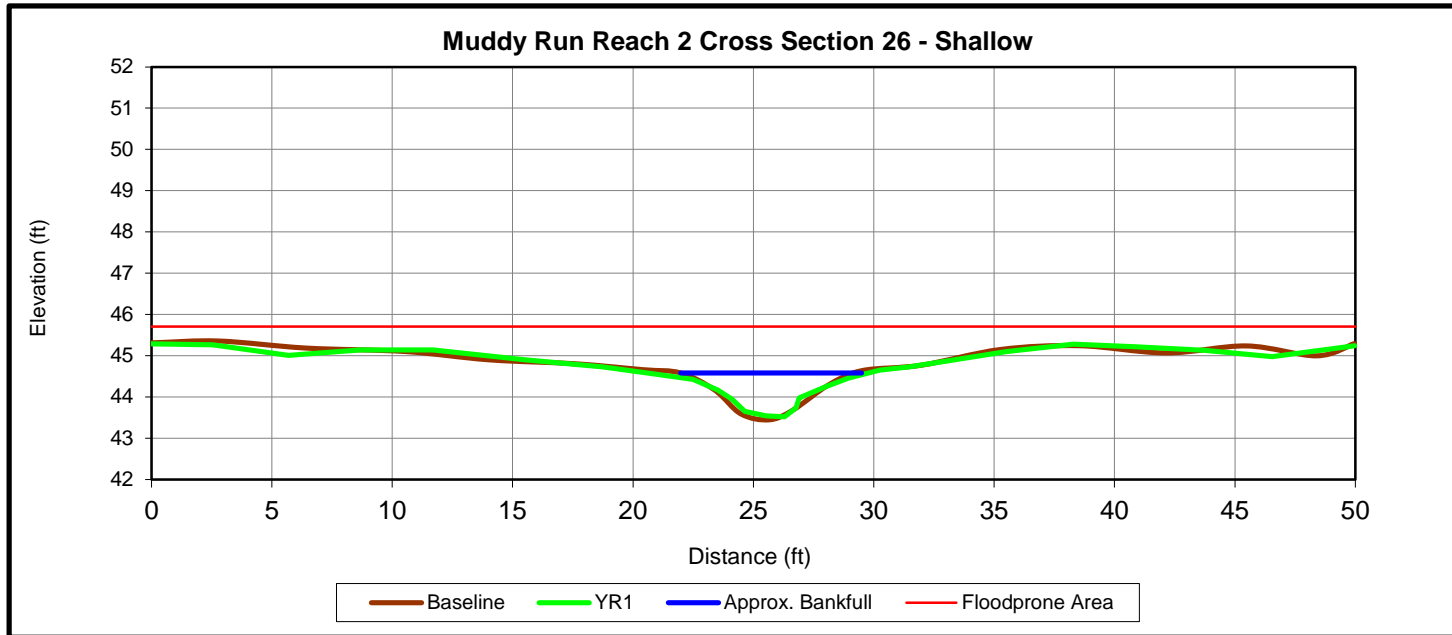




Upstream



Downstream

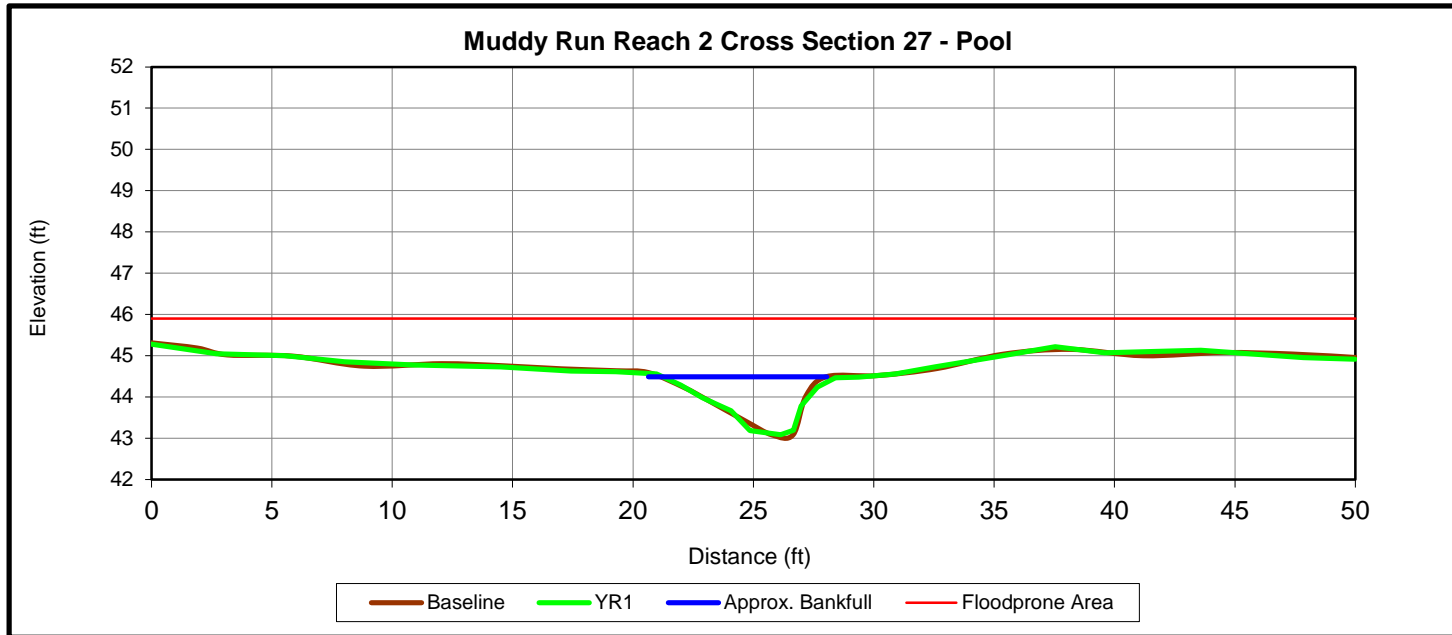




Upstream



Downstream



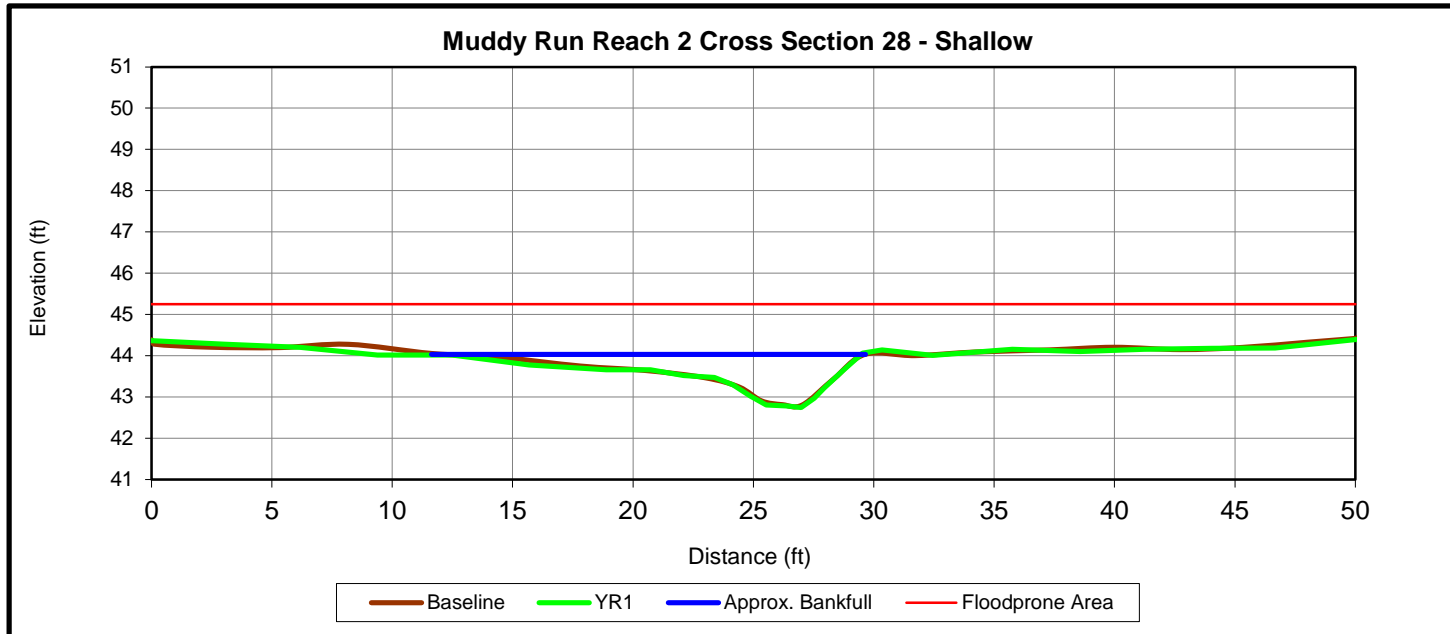




Upstream



Downstream



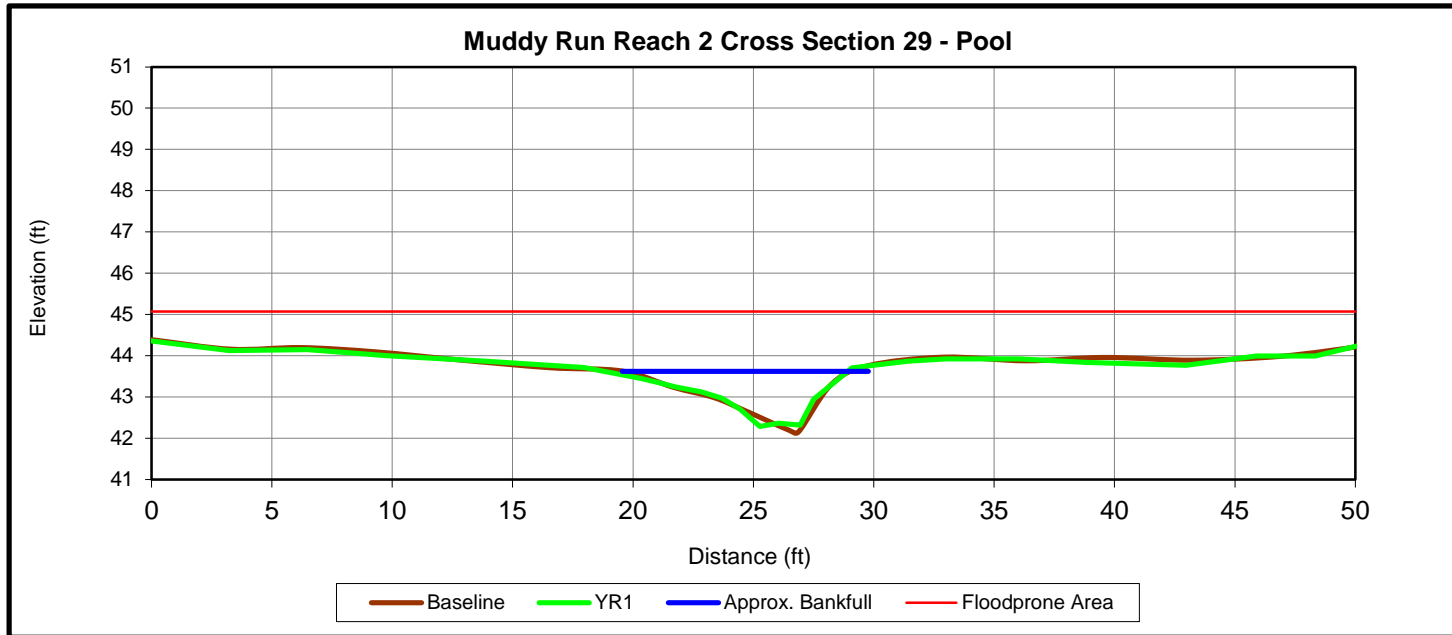




Upstream



Downstream

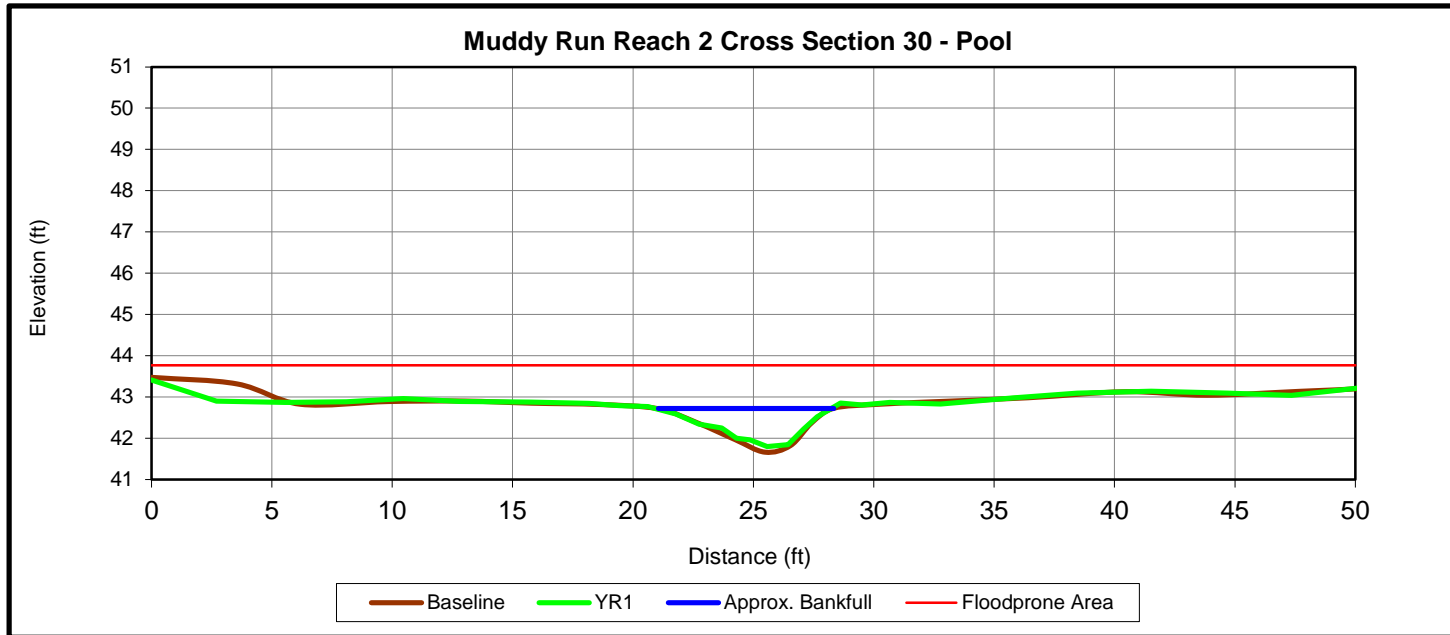




Upstream



Downstream

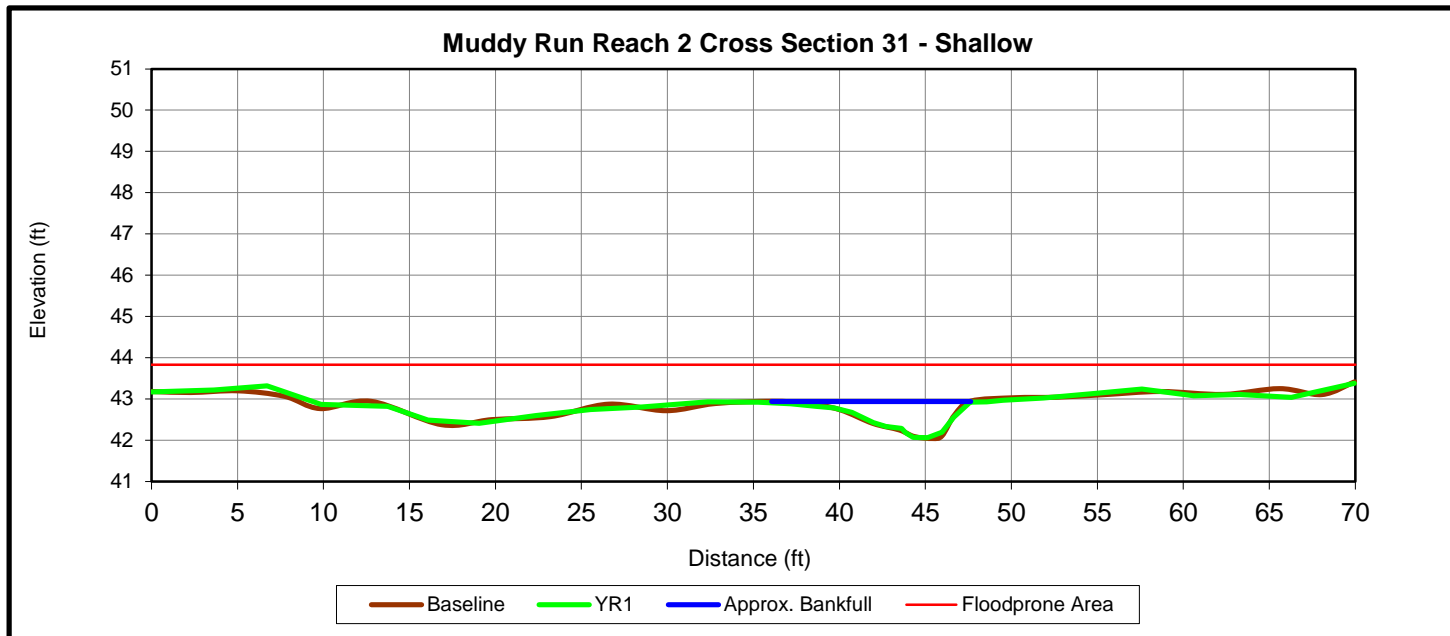




Upstream



Downstream



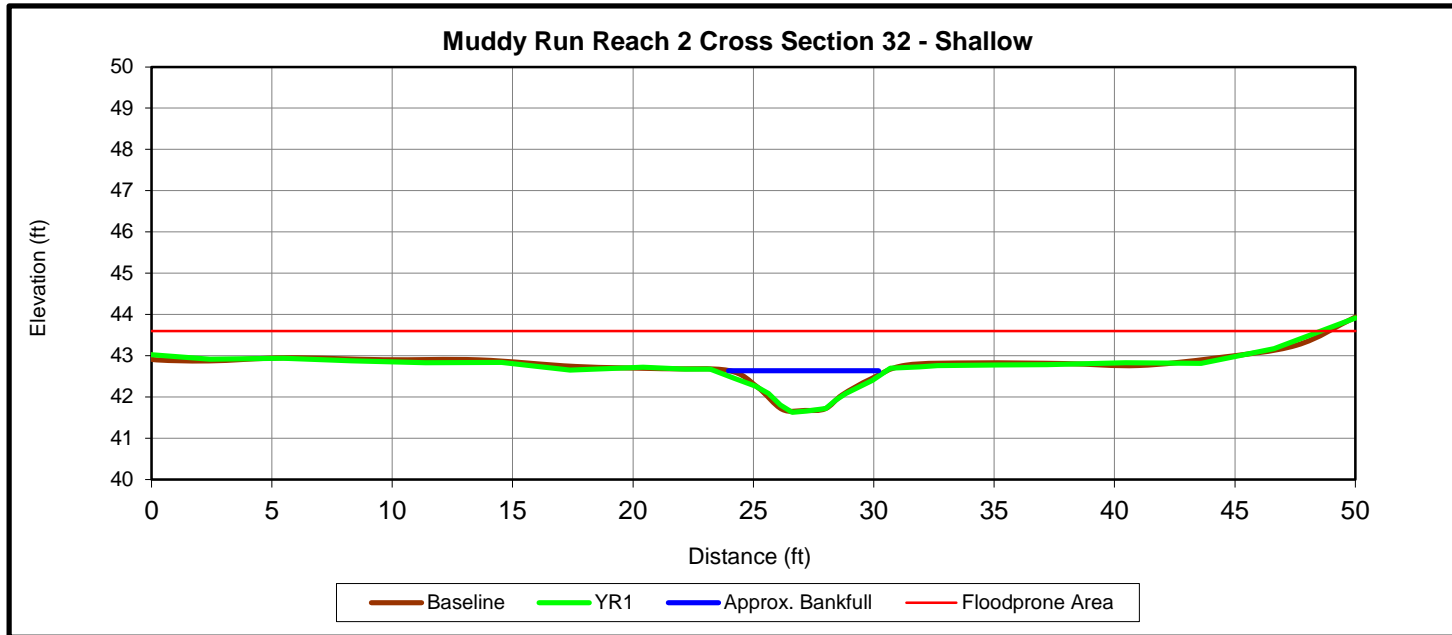




Upstream



Downstream



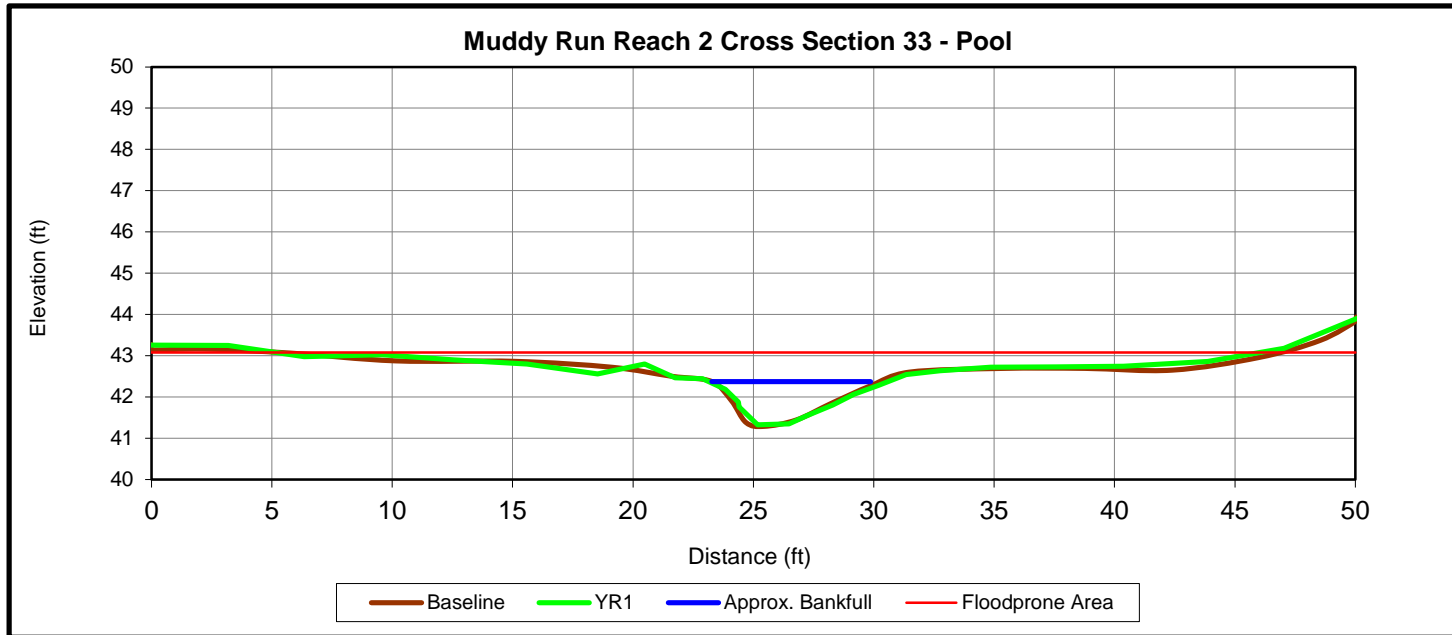




Upstream



Downstream

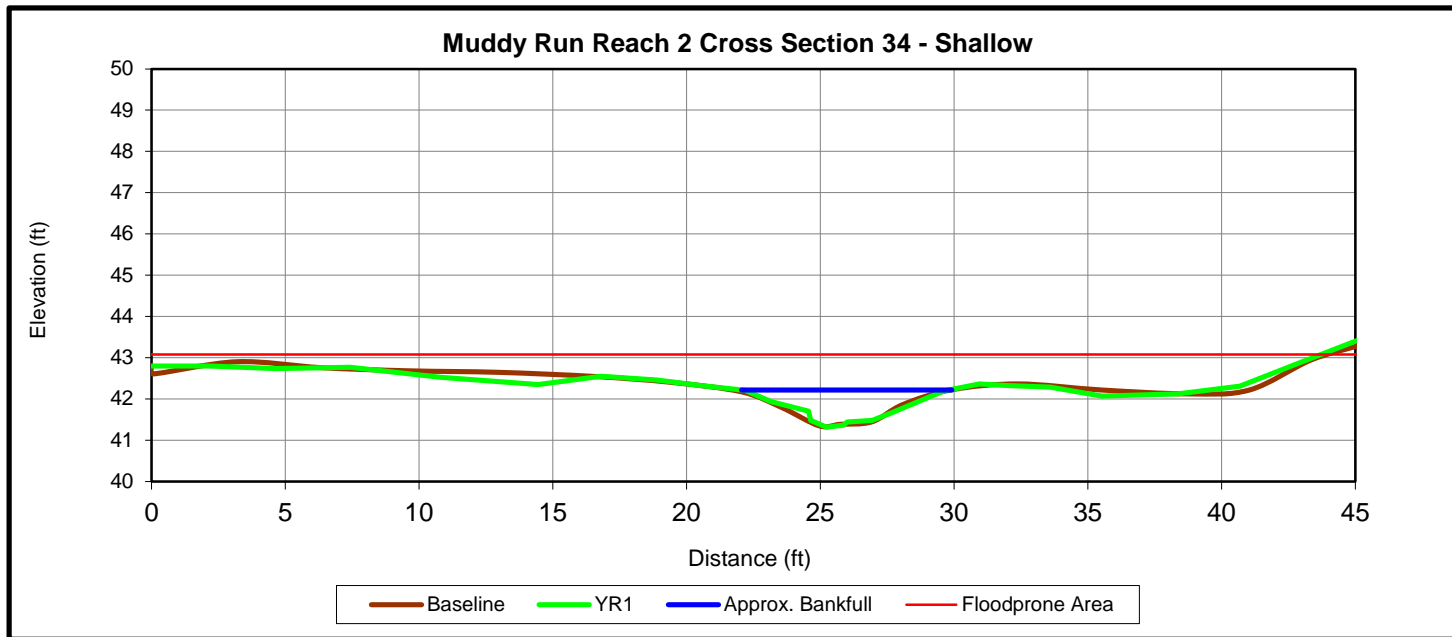




Upstream



Downstream

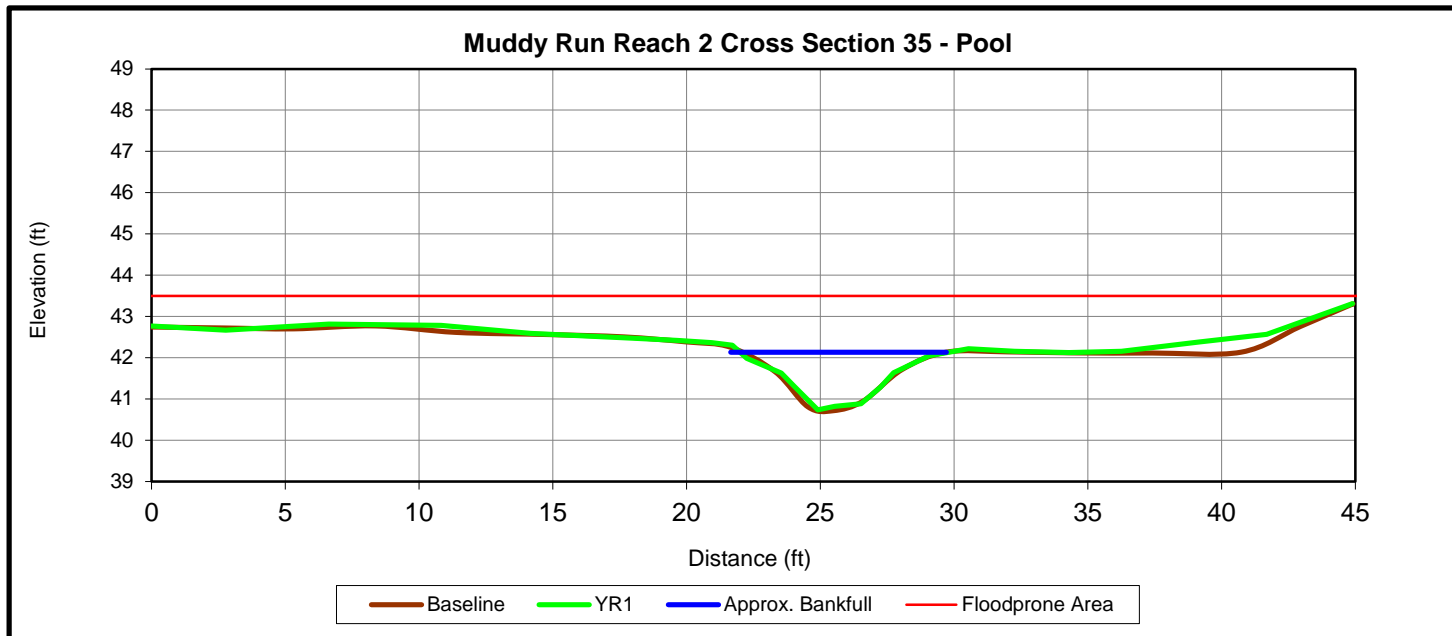




Upstream



Downstream



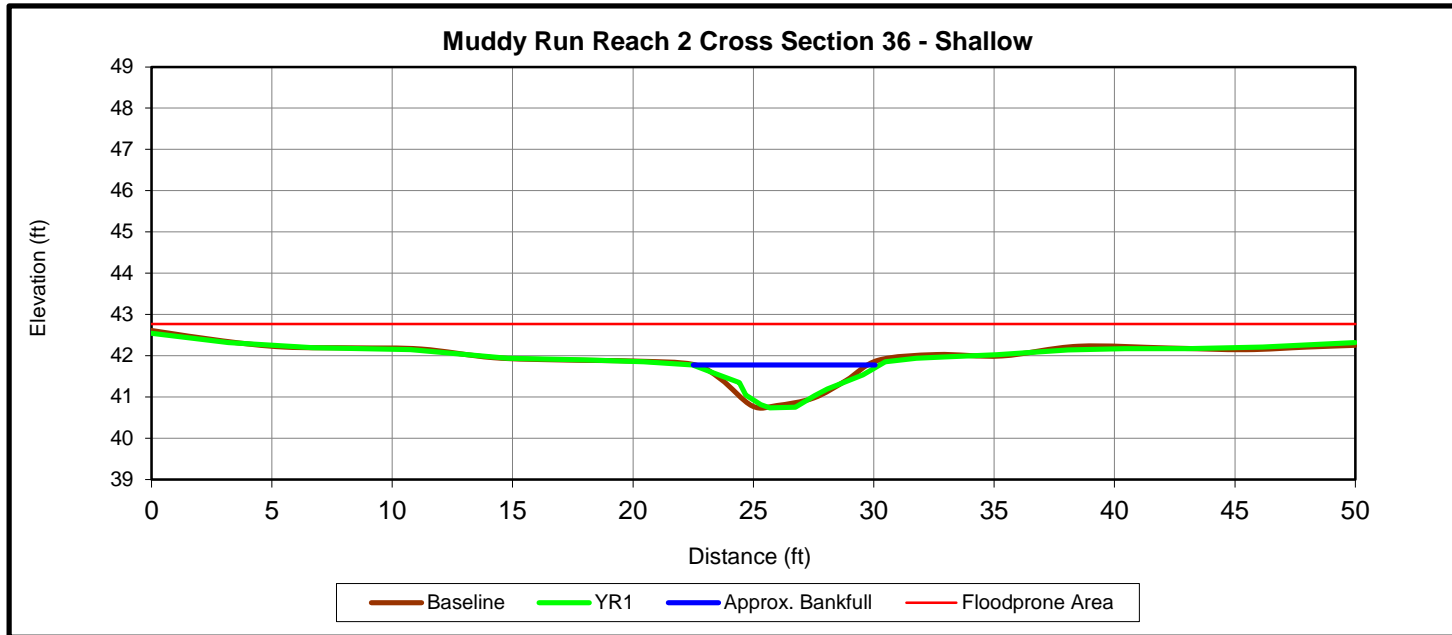




Upstream



Downstream



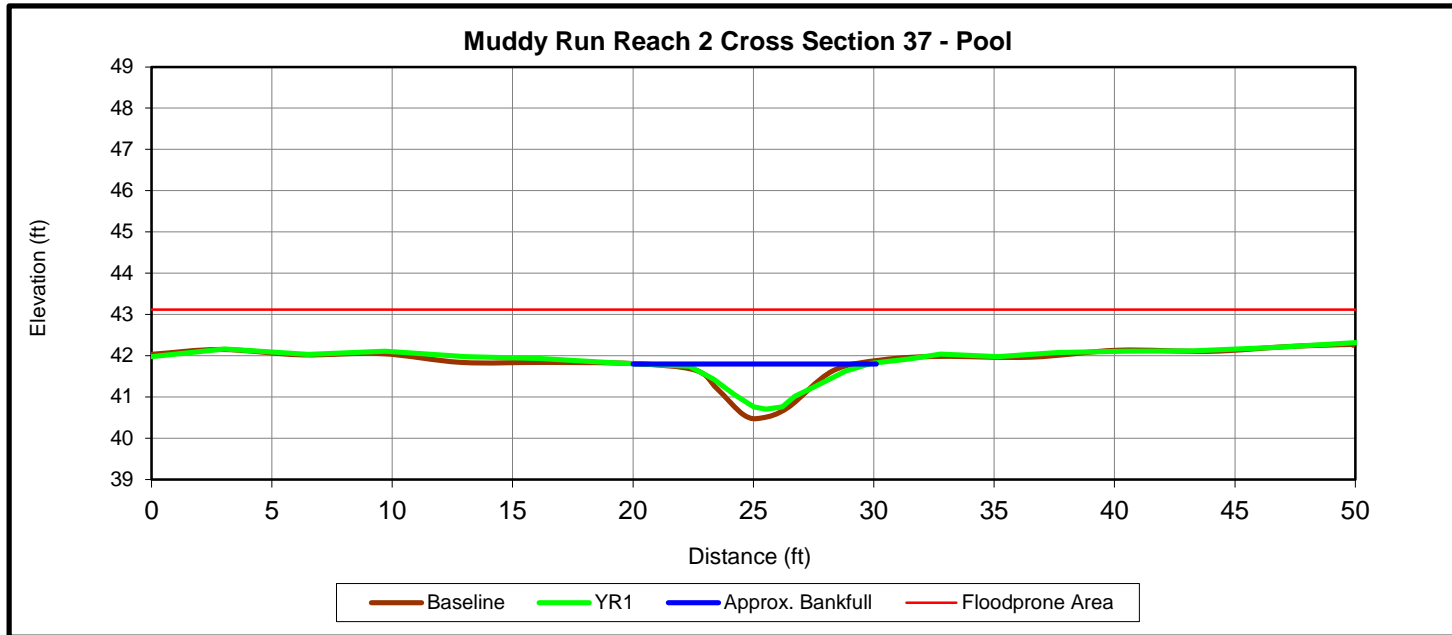




Upstream



Downstream

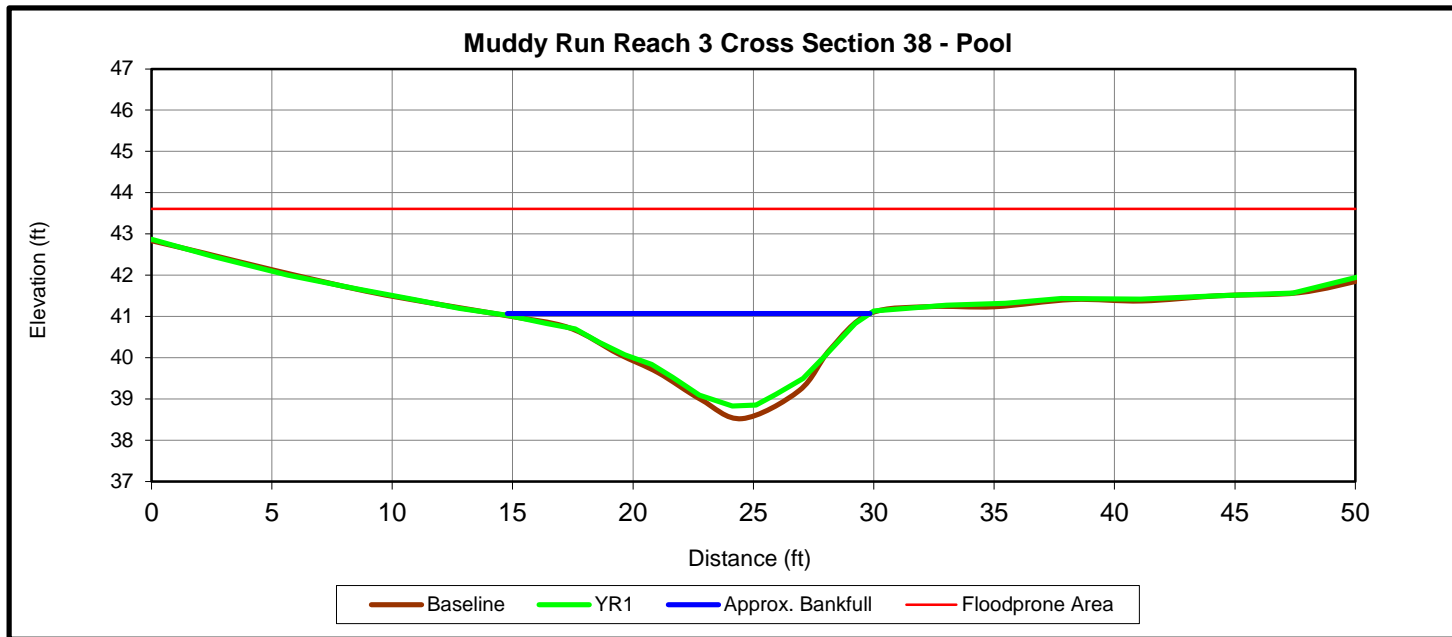




Upstream



Downstream

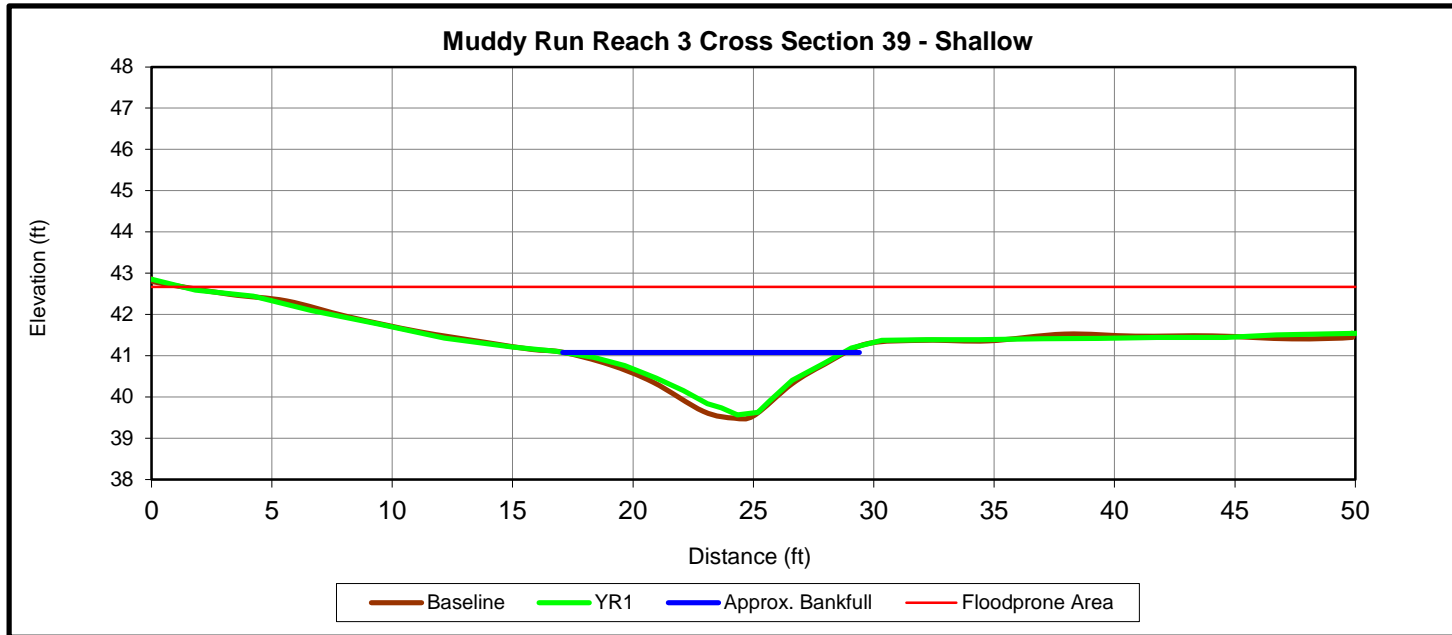




Upstream



Downstream



# **Appendix E**

## Hydrology Data

Table 13. Documentation of Geomorphologically Significant Flow Events

Table 14. Rainfall Summary

Chart 1. 2014 Precipitation Data for Muddy Run Site



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

| <b>Crest Gauge</b>  | <b>Headwater Valley Flow Events</b> | <b>Maximum Consecutive Flow Days</b> | <b>Cumulative Flow Days</b> |
|---------------------|-------------------------------------|--------------------------------------|-----------------------------|
| Crest Gauge 1 (HWV) | 16                                  | 7.6                                  | 37.1                        |
| <b>Crest Gauge</b>  | <b>Number of Bankfull Events</b>    | <b>Maximum Bankfull Height (ft.)</b> |                             |
| Crest Gauge 1 (HWV) | NA                                  | 1.1                                  |                             |
| Crest Gauge 2       | 9                                   | 0.85                                 |                             |
| Crest Gauge 3       | 10                                  | 0.90                                 |                             |
| Crest Gauge 4       | 4                                   | 1.05                                 |                             |

**Table 14. Rainfall Summary**

| <b>Month</b> | <b>Average</b> | <b>Normal Limits</b> |                   | <b>Wallace Station Precipitation</b> | <b>On-Site Auto Rain Gauge</b> |
|--------------|----------------|----------------------|-------------------|--------------------------------------|--------------------------------|
|              |                | <b>30 Percent</b>    | <b>70 Percent</b> |                                      |                                |
| January      | 4.33           | 3.32                 | 5.03              | 1.68                                 | ---                            |
| February     | 3.23           | 2.14                 | 3.87              | 1.89                                 | ---                            |
| March        | 4.50           | 3.23                 | 5.32              | 5.68                                 | ---                            |
| April        | 3.16           | 1.70                 | 3.85              | 5.23                                 | 4.11                           |
| May          | 3.68           | 2.69                 | 4.34              | 2.10                                 | 2.85                           |
| June         | 4.49           | 3.11                 | 5.34              | 6.96                                 | 3.73                           |
| July         | 6.06           | 4.16                 | 7.22              | 4.31                                 | 10.50                          |
| August       | 5.40           | 3.12                 | 6.56              | 6.69                                 | 9.35                           |
| September    | 5.00           | 2.04                 | 6.07              | 7.27                                 | 7.24                           |
| October      | 3.21           | 1.62                 | 3.92              | 1.49                                 | 1.64                           |
| November     | 2.89           | 1.83                 | 3.49              | 3.45                                 | 4.85                           |
| December     | 3.24           | 2.14                 | 3.88              |                                      |                                |
| <b>Total</b> | <b>49.19</b>   | <b>31.10</b>         | <b>58.89</b>      | <b>46.75</b>                         | <b>44.27</b>                   |

Chart 1. 2014 Precipitation Data for Muddy Run Site

