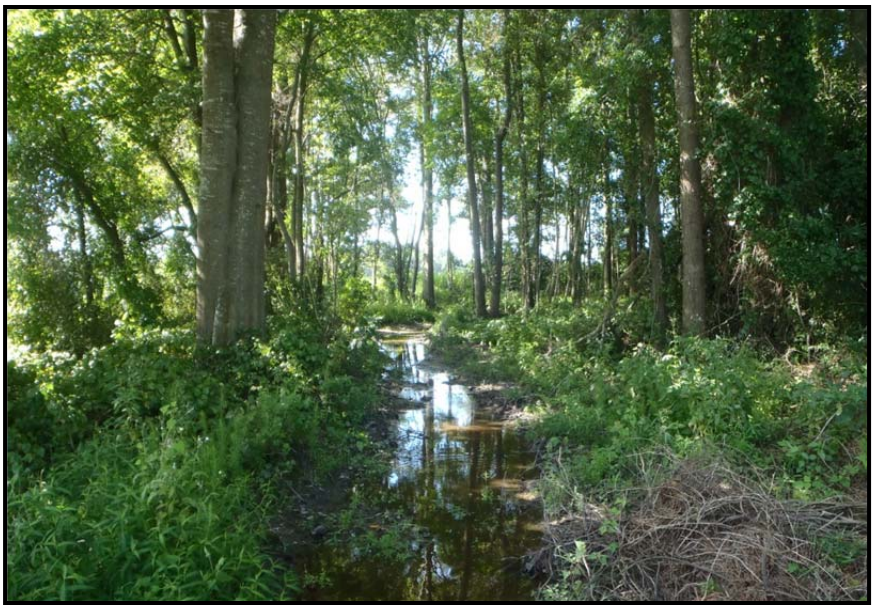
MUDDY RUN II STREAM AND WETLAND RESTORATION PROJECT
FINAL-MONITORING REPORT
MONITORING YEAR 1

DUPLIN COUNTY, NORTH CAROLINA, PROJECT # 95354



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Muddy Run II
Duplin County, North Carolina
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Cape Fear River Basin
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EXECUTIVE SUMMARY

The Muddy Run II Stream and Wetland 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 six unnamed tributaries to Muddy Creek, but the project has been divided into nine distinct reaches for design purposes. Reach 1 is one of the upstream-most portions of the project; it begins on the edge of an existing agricultural field and extends to STA 04+48. Similarly, Reach 2 is one of the upper-most portions of the stream project. It begins in a disturbed forest corridor between several agricultural fields and extends to STA 19+14. Reach 3a starts at the confluence of Reaches 1 and 2 (STA 00+00) and flows north north-west through a disturbed hardwood buffer and several agricultural fields before being partially diverted to enter Reach 3b near STA 37+23. Reach 3b flows to the north and west where it flows into Reach 3c at STA 57+92. Reach 3c flows through a pine plantation to STA 65+30, where it flows into Reach 3 of the Muddy Run project. Reach 4 is a perennial channel that flows through a forested area from a ditch draining an agricultural field. Reach 4 flows into Reach 3A at STA 18+76. Reach 5a consists of the main stem beginning at STA 00+00 where it adjoins with Reach 1C of the Muddy Run project. Reach 5a flows north and flows into Reach 5b at STA 19+59. Reach 5b is the most downstream reach of the project, ending at the right-of-way for State Highway 41. Reach 6 begins in a forested area south of Reach 5 and flows in a northerly direction to the confluence with Reach 5a near STA 9+20. Two areas containing drained hydric soil were identified for restoration, located along Reach 3b and Reach 5a.

This Year 1 Annual Monitoring Report presents the data from 28 vegetation monitoring plots, four manual crest gauges, four auto crest gauges, an auto-logging rain gauge, seven wetland restoration groundwater gauges, three reference groundwater gauges, 59 stream cross sections, 20 sets of bank pins, and photo reference locations, as required by the approved Mitigation Plan for the site.

The Muddy Run II Year 1 Monitoring activities were completed in December 2014. All Year 1 monitoring data is present below and in the appendices. Data presented shows the site has localized areas of bed and bank erosion; however, the site is on track to meeting stream, wetland and vegetation interim success criteria.

Throughout the Year 1 monitoring season, the majority of restored stream channel remained stable and continued to provide the intended habitat and hydrologic functions. Minimal changes were noticed for most Year 1 cross section surveys resulting from stable bed and bank conditions. Six out of 59 cross sections showed noticeable changes resulting from aggradation or degradation. Multiple bankfull events have been observed during Year 1 monitoring activities on three of the four crest gauges. During several site visits throughout Year 1, each stream reach was noted to be flowing during normal conditions.

Eight stream problem areas were observed during the Year 1 monitoring period. The problem areas observed during Year 1 monitoring activities consist of bank erosion due to structure failure and unstable bed and banks. Each stream problem area is addressed in this report detailing the severity of the problem and recommended adaptive management.

Four of the seven wetland gauges (AW1, AW2, AW4, and AW6) achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Since wetland hydrology was only monitored for the last half of the growing season, it is difficult to determine success of the remaining three gauges. Groundwater gauge data indicate the hydroperiods being very responsive to rainfall events. Year 2 wetland hydrology monitoring data will represent the first full growing season.

The Year 1 vegetation monitoring observations for Muddy Run II Site are summarized in this report. Planted-stem survival for Monitoring Year 1 for all 28 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 616 stems per acre. Few volunteer tree species were noted during Monitoring Year 1. Vegetation problem areas noted during Monitoring Year 1 include Chinese privet (*Ligustrum sinense*) along portions of Reach 2, Reach 3a, Reach 3c, and Reach 5b and three areas that had sparse tree cover due to lack of planting or mortality due to low soil fertility. There was also tree mortality and evidence of vehicles accessing the easement in two areas; these issues are being addressed by restricting vehicle access and replanting these areas in January/February. These problem areas will continue to be observed during Monitoring Year 2; however, these areas pose little threat to achieving the vegetation success criteria. The Muddy Run II Site is on track to meet the Year 3 vegetation survival success criterion of 320 trees per acre as specified in the Mitigation Plan.

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APPENDICES

1 PROJECT GOALS, BACKGROUND AND ATTRIBUTES

1.1 Location and Setting

The Muddy Run II Stream and Wetland Restoration 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 0303007060010) (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 Reaches 3b, 3c, 5b, and 6. Going to the right at the split will take you to Reaches 1, 2, 3a, and 4.

1.2 Project Goals and Objectives

The Muddy Run II stream and wetland 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

Benefits Related to Water Quality	
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.
Benefits to Flood Attenuation	
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.
Benefits Related to Ecological Processes	
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 II Project Components- Stream Mitigation

Reach	Mitigation Type	As-Built Stationing	Existing Length (LF)	As-Built Length (LF)	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	0+00 to 4+48	438	398	1:1	398
Reach 2	Headwater Valley	0+00 to 5+04	504	504	1:1	504
Reach 2	P1 Restoration	5+04 to 19+14	1,223	1,410	1:1	1,410
Reach 3a	P1 Restoration	0+00 to 37+23	3,301	3,586	1:1	3,586
Reach 3b	P1 Restoration	37+23 to 57+92	NA	1,979	1:1	1,979
Reach 3c	Enhancement I	57+92 to 65+30	737	708	1:1.5	472
Reach 4	P1 Restoration	0+44 to 2+17	120	173	1:1	173
Reach 5a	P1 Restoration	0+00 to 19+59	1,602	1,926	1:1	1,926
Reach 5b	Enhancement II	19+59 to 23+68	401	409	1:2.5	164
Reach 6	Enhancement II	9+02 to 12+19	317	318	1:2.5	127
			8,643	**11,411**		**10,739**

Table 2. Muddy Run II Project Components – Wetland Mitigation

Wetland	Mitigation Type	Mitigation Area (ac)	Mitigation Ratio	WMUs
WA	Restoration	3.60	1:1	3.60
WB	Restoration	1.32	1:1	1.32
	Total	**4.92**		**4.92**

1.3.1 Restoration Type and Approach

Reach 1

Headwater valley restoration approach was performed along Reach 1. The existing channel/ditch was backfilled, and flow has been directed from its current position along the tree line back to within the historic valley location down to the confluence with Reaches 2 and 3a. A 100 foot wide forested buffer has been planted throughout the reach. The upstream limit of Reach 1 ties into an existing headwater valley system comprised of intermittent sections of single and multiple channels. This

system will be used as a reference site for incorporating a small baseflow channel into the headwater valley restoration design.

Reach 2
Similar to Reach 1, headwater valley restoration was performed along the upper section of Reach 2. The existing channel was backfilled with existing spoil material located along the channel, a result of previous dredging activities. Areas within the 100 foot buffer that were disturbed or lack riparian vegetation were planted. Grade control structures were installed along three ditches that enter Reach 2 at the upstream end of the project. These structures raised the upstream channel bed elevations slightly to tie into existing ditches to the project reach. An existing CMP culvert located along the upstream section was removed and replaced outside the easement (upstream) to continue to allow the landowner access to all areas of his property. Priority 1 restoration was performed for the majority of Reach 2. Restoration activities involved relocating the channel to the north through an existing wooded area consisting primarily of pines and a few hardwoods. Existing spoil piles located along the channel banks were removed and used to fill the existing ditch. Diffuse flow structures have been installed along several ditches that outlet to the reach from both the north and south. The structures will attenuate and disperse flows as the existing ditches enter the proposed easement.

Reach 3a
Priority Level I restoration was performed on Reach 3a. The restoration approach on this reach included relocating the channel on either side of its current location to follow the natural valley and removing the adjacent roadbed to allow continuous access to the floodplain. Two existing 36" CMP culvert crossings were located along this reach. Each culvert was removed and replaced in-line with the proposed stream to allow the landowners to access portions of their respective properties to the west of the project site. Reach 3a now flows in a northwesterly direction until it reaches a property line. At this point, the existing ditch that continued to flow in a northerly direction was plugged and a diversion structure was installed. The structure is designed to pass 100 percent of baseflow and small storms through the project, and divert up to 70 percent of storms larger than the 25-yr storm to the existing ditch and offsite. See Section 7.3.1.1 (Stream Hydrologic Analysis) for hydraulic analysis details.

Just downstream of the diversion structure, the channel was relocated south of several turkey houses, and now flows in a westerly direction as Reach 3b. The network of ditches surrounding the turkey houses appear to cross a small ridge, directing flow away from the project area. An additional culvert crossing was constructed where flow will be diverted to the west at the turkey houses. Priority I restoration is appropriate for this channel because it is the only mitigation approach that addresses bed and bank instability, establishes a forested riparian buffer, and significantly enhances aquatic habitat. Diffuse flow structures were constructed where existing agricultural ditches enter the easement area.

The diversion structure was constructed at the downstream end of Reach 3a to alleviate and prevent flooding caused by rerouting flow and increased drainage areas, to provide continued flow through the existing ditch for storms larger than bankfull (design) events, and to reduce impacts from proposed grading activities. Per discussions with Mr. Lanier (owner of parcel northwest of proposed structure), larger storm events overtop the existing ditch flowing to the north. This flooding may be attributed to inefficiencies with existing structures and ditch alignments in conjunction with low gradients. The culvert associated with the gravel access road that leads from Ludie Brown Road to the turkey houses outlets perpendicular to the receiving ditch that flows to the northeast and under Ludie Brown Road. This ditch continues to the northeast and crosses Route 111, where it flows to the north into Muddy Creek. By diverting up to 70 percent of higher flows through the existing ditch and offsite, existing flooding issues will be reduced adjacent to the turkey houses. This diversion also decreases potential flooding impacts that would occur if 100 percent of storm events were passed

through the proposed channel, Reach 3b. There are several residential parcels within zero to 200 feet of the proposed easement along Reach 3b. Because the topography is very flat through this area, the flooding associated with the majority of storm events greater than bankfull would negatively impact these parcels.

Finally, by diverting a percentage of the proposed higher flows, flooding impacts will also be reduced along Reaches 5a and 5b and at the existing HWY 41culvert at the downstream end of the project. Currently, agricultural fields are present along the north side of Reach 5a. By reducing high flows, the flooding extent and duration will be reduced; thus, preventing adverse impacts to crops. If 100 percent of higher storm events were allowed to pass through the project, significant grading would be required to cut floodplain terraces/benches to relieve flooding of the adjacent agricultural fields.

Approximately 1,611 LF of the existing ditch that flows to the north from the Reach 3a/3b diversion structure will be impacted (dewatered). This length includes the segment of the ditch from the diversion structure downstream to the Muddy Creek floodplain. The channel impacts resulting from the proposed channel relocation will be addressed in the ensuing NWP application.

Reach 3b
Priority Level I restoration was performed on Reach 3b. The restoration approach on this reach included relocating the channel in a westerly direction through an open pasture. The pasture area has been extensively modified and substantial grading was required. The design then moves the channel to a historic drainage way as observed on LiDAR and historical aerial photographs.The flow path is now connected to a small relic channel identified in the forested area west of the pasture. Subsequent topographic survey confirmed positive drainage along the relic channel which follows a low lying feature observed on LiDAR. The restoration approach included some minor grading to enlarge the existing channel and to create a diverse bed habitat by constructing pools. Log grade control structures were installed at the confluence with Reach 3c and at the connection to the relic channel. Small, mechanical equipment and hand tools were used to minimize damage to the existing forested buffer. A livestock protected culvert crossing was constructed near the existing pasture along an existing farm path to allow the landowner uninterrupted access to his property.

Reach 3c
Enhancement I was performed on Reach 3c as it flows through a forested area downstream from Reach 3b to Reach 3 of the Muddy Run Stream Mitigation Project. A grade control structure was installed at the upstream end to stabilize the transition from an existing agricultural ditch to the stable channel. A crossing was constructed along the upper section to allow the landowner access to both sides of his property. Enhancement activities included removing portions of exising spoil piles located along top of banks, cutting floodplain benches and laying back banks, and installing woody debris habitat structures. Diffuse flow structures were also constructed at the downstream limit where existing agricultural ditches enter the easement area. Invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 4
Priority 1 restoration was performed on the downstream end of Reach 4 as it flows through a forested area below a ditch draining an agricultural field. A grade control structure was installed at the upstream end to transition from the existing ditch to a stable channel. The lower section of the reach was constructed into an E-type channel before its confluence with Reach 3a. Invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 5a

Priority Level I restoration was performed on Reach 5a. The channel was relocated north of its current location into the adjacent agricultural field. The existing ditch was backfilled and plugged at any locations that may cross the proposed channel. The upstream end of the reach ties into Reach 1C of the Muddy Run Stream Mitigation Project. The single-thread channel will flows through proposed wetland WB beginning approximately 300 feet downstream of the Muddy Run project. A CMP culvert crossing was installed in-line with the proposed design near the middle of the reach to allow the landowners access to the adjacent parcels. Priority I restoration is appropriate for this channel because it is the only mitigation approach that addresses bed and bank instability, establishes a forested riparian buffer, and significantly enhances aquatic habitat.

Reach 5b
Enhancement Level II was performed on Reach 5b. Several log grade controls and woody debris structures were installed along the bed to increase aquatic habitat and bed diversity. The right bank along the reach was laid back and spoil piles along the tops of banks were removed using small equipment to minimize impacts to the existing buffer. Additionally, invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 6
Enhancement Level II was performed on the downstream section of Reach 6 (STA 9+02 to STA 12+19). The right and left banks were laid back, and the channel was backfilled using spoil located adjacent to the channel such that positive drainage is maintained throughout the reach down to the confluence with Reach 5a. Invasive species management was performed throughout the buffer where enhancement took place, and any bare or disturbed areas were planted with native riparian vegetation. A 50 foot wide buffer was provided along the upper section of Reach 6 (STA 0+00 to STA 9+02); however, no enhancement activities were performed through this section other than filling portions of the channel. This additional easement was provided to account for any hydrologic impacts that may occur as a result of the proposed enhancement activities.

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 37.6 acres and is broken into nine reaches. Reach 1 has a drainage area of 68 acres; it begins at the start of the restoration project (STA 0+00) and extends west to STA 4+48. Reach 2 has a drainage area of 114 acres; it begins at STA 0+00 and extends to STA 19+14. Reach 3a (Sta. 0+00 to 37+23) begins at the confluence of Reaches 1 and 2 and has a drainage area of 227 acres. Reach 3b has a drainage area of 333 acres and flows west into Reach 3c; it begins at STA 37+23 and extends to STA 57+92. Reach 3c has a drainage area of 370 acres extending north to south and flows into Reach 3 of the Muddy Run project; it begins at STA 57+92 and extends to STA 65+30. Reach 4 has a drainage area of 46 acres and flows from the east into Reach 3a; it begins at STA 0+44 and extends to STA STA 2+17. Reach 5a begins at the downstream limit of the Muddy Run project, flows into Reach 5b, and has a drainage area of 774 acres; it begins at STA 0+00 and extends to STA 19+59. Reach 5b has a drainage area of 908 acres; it starts at STA 19+59 and extends

to STA 23+68. Reach 6 has a drainage area of 318 acres and flows from the south into Reach 5a; it starts at STA 9+02 and extends to STA 12+19 **(Figure 2).** The land use in the project watershed is approximately 38 percent cultivated, 32 percent evergreen forest, 15 percent shrub/scrub, 6 percent bottomland forest/hardwood swamp, 5 percent mixed forest, 2 percent developed, 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 Wetland Restoration

The NRCS does not have a current WETs table for Duplin County upon which to base a normal rainfall amount and average growing season. The closest comparable data was determined to be from Sampson County. The growing season for Sampson County is 242 days long, extending from March 17 to November 14, and is based on a daily minimum temperature greater than 28 degrees Fahrenheit occurring in five of ten years.

Because of the surface roughing and shallow depressions, a range of hydroperiods are expected. The water balance indicates that the site will have a positive water balance in the early part of the growing season for four to five weeks, on average. The hydrology success criterion for the site is to restore the water table at the site so that it will remain continuously within 12 inches of the soil surface for at

least nine percent of the growing season (approximately 22 days) at each groundwater gauge location during normal rainfall years. Overbank flooding events will provide additional inputs that may extend the hydroperiod in some years.

Gauge data will be compared to reference wetland well data in growing seasons with less than normal rainfall. In periods of low rainfall, if a restoration gauge hydroperiod exceeds the reference gauge hydroperiod, and both exceed five percent of the growing season, then the gauge will be deemed successful. If a gauge location fails to meet these success criteria in the five year monitoring period, then monitoring may be extended, remedial actions may be undertaken, or the limits of wetland restoration will be determined.

2.3 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.

2.4 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, wetland, 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 2, one along Reach 3a, one along Reach 3b, and one along Reach 5a. 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 59 permanent cross sections were installed to monitor channel dimensions and stability. Four cross sections were installed along Reach 1 and ten cross sections were installed along Reach 2. There were 21 cross sections (nine runs, nine pools, and three riffles) installed along Reach 3A and six cross sections installed along Reach 3B. Four cross sections were installed along Reach 3C and two cross sections were installed along Reach 4. Reach 5A had eight cross sections installed, while Reach 5B and 6 each had two cross sections installed. 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

Twenty 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 hydrology conditions, and dye tests if necessary.

3.2 Wetland Hydrology

Wetland hydrology will be monitored to document hydric conditions in the wetland restoration areas. Seven automatic recording pressure transducer gauges were installed in representative locations across the restoration areas and an additional three gauges were installed in reference wetlands. The gauges will be downloaded quarterly and wetland hydroperiods will be calculated during the growing season. Gauge installation followed current regulatory and EEP guidance. Visual observations of primary and secondary wetland hydrology indicators will also be recorded during quarterly site visits.

3.3 Vegetation

A total of 28 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 adaptive management will be discussed with NCEEP staff. If it is determined remedial action is required, a plan will be provided.

4.1 Stream

Eight stream problem areas were noted during the Year 1 monitoring period. The problem areas observed during Year 1 monitoring activities consist of minor bank erosion to failing structures with unstable bed and banks. These problem areas have been mapped on the Current Conditions Plan View (CCPV). Reach 1 had one problem with a loose grade control toe log at station 3+25 which has become undercut; however, the bed is stable and it will continue to be monitored. Reach 3A has one problem at the very upstream log grade control structure. Concentrated flow has created bank erosion around the left toe log. The structure is stable; however, the scour will be repaired and a coir log will be installed to divert flow around the structure. Two stream problem areas are located on Reach 3B. At station 37+22, concentrated flow has eroded a gully on the left bank behind the diversion structure. The scour pool will be graded on the left floodplain with a level spreader or stable swale to redirect overland flow. The area will be livestaked once the erosion is repaired. The second problem area on Reach 3B is located at the downstream portion from station 57+30 to 57+80. This area has five log structures that have failed due to improper installation. Both bed and banks in this area need to be repaired. Bed and banks will be repaired, new log grade control structures will be installed, livestakes will be planted along the banks. This area may also benefit from a floodplain bench to reduce high energy flow within the channel for larger flow events. Reach 3C has one stream problem area with

minor left bank erosion located at stations 60+00 and 61+00. These areas consist of two headcuts forming on the left bank and will be repaired by installing a coir log to divert concentrated flow from these areas. Reach 5A has the remaining three stream problem areas. Stream problem area six (SPA6) is a segment from station 13+25 to 16+50 where stream structures have failed and become unstable due to improper installation. This area has localized areas of bank erosion on both sides. To repair problem area 6, new rock/log structures will be installed and a floodplain bench will be created. After all repair work is completed, the area will be replanted and livestaked. Stream problem area 7 (SPA7) is an area with minor bank erosion located on the right bank at station 14+00. This stream problem is a small scour and will be repaired by installing a coir log to divert concentrated flow from this area. The last stream problem area (SPA8) on Reach 5A is a segment from station 16+50 to 19+50. Log structures along this portion are unstable and have failed due to improper installation. Both streambed and banks are eroding at a rapid pace due to sandy soil cohesion in this problem area. Repair work for problem area 8 will include installing new rock/log structures and re-grading the bed and banks. A floodplain bench will be created along with replanting and livestaking the banks. All stream problem areas have been mapped on the Current Conditions Plan View (CCPV) along with a table and photos for each area that are described in more detail in **Appendix B**. Stream problem areas requiring adaptive management occupy less than five percent of the total channel length. Overall the system is performing as designed and no systematic problems exist.

4.2 Wetlands

No wetland problem areas were noted during the Year 1 monitoring period. Wetland hydrology and vegetation represent typical conditions of a site in Year 1 post construction monitoring. If any wetland problem areas are identified during post construction monitoring activities in the future, they will be documented and mapped on the Current Conditions Plan View (CCPV) as part of the annual stream and wetland monitoring report. Wetland hydrology gauges were installed in early July and documented hydrology conditions for approximately 55 percent of the total growing season. Four of the seven wetland gauges achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Since wetland construction occurred in the early growing season and wetland hydrology was only monitored for the last half of the growing season, it is difficult to determine success of the remaining three gauges. Year 2 wetland hydrology monitoring data will represent the first full growing season.

4.3 Vegetation

Ten vegetation problem areas were identified during the Year 1 monitoring period and have been mapped on the CCPV. Invasive Chinese privet was observed along portions of Reach 2, Reach 3a, Reach 3c, and Reach 5b (VPA1, VPA2, VPA3, VPA8, and VPA10); management will consist of continued clearing and stump treatment for these areas. One area along the right bank floodplain of Reach 3a is sparsely vegetated and has evidence of vehicles driving through the easement (VPA4); it approximately 80 trees will be planted in two rows in this area and vehicle access to the easement will be restricted. One area along Reach 3a was never planted (VPA5); approximately 400 trees will be planted in this area. One area along Reach 3b is sparsely vegetated, likely due to low soil fertility and compaction (VPA6); approximately 300 trees will be planted in this area; preferably fast growing species. Another area along Reach 3b is sparsely vegetated, likely due to low planting density (VPA7); approximately 250 trees will be planted in this area. The last problem area is along the right bank floodplain of Reach 5a. This area is sparsely vegetated and has evidence of vehicles driving through the easement (VPA9); approximately 80 trees will be planted in two rows in this area and vehicle access to the easement will be restricted. Landowners will be communicated with to aid in the prevention of future easement encroachment issues. These issues are described in **Appendix B**.

5 YEAR 1 MONITORING CONDITIONS (MY1)

The Muddy Run II Year 1 Monitoring activities were completed in December 2014. All Year 1 monitoring data is present below and in the appendices. Data presented shows the site has localized areas of bed and bank erosion; however, the site is on track to meeting stream, wetland 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 and December 2014. Appendix D includes summary data tables, morphological parameters, cross section plots, and bank pin array tables.

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. Minimal changes were noticed for most Year 1 cross section surveys resulting from stable bed and bank conditions. Only six out of 59 cross sections showed noticeable changes resulting from aggradation or degradation. Cross sections 43 (Reach 3C), 56 and 57 (Reach 5B) showed evidence of slight-aggradation. Cross sections 52, 54, and 55 all located on Reach 5A, exhibited down cutting and/or widening. 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 six restoration reaches. Pre-construction conditions documented all six reaches as sand bed channels and remain classified as sand bed channels post-construction. Visual assessments (**Appendix B**) show the channels are transporting sediment as designed and will continue to be monitored for aggradation and degradation. Areas of excessive erosion appear due to improper structure installation and unstable soil conditions.

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. Three bank pin array locations had measurable readings during annual Year 1 monitoring activities. Bank pins located at cross sections 40 and 49 showed minimal erosion with readings of 0.2 and 0.6 feet; cross section 54 had a reading of 1.0 feet on the bottom downstream bank pin. 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 early December 2014. The Year 1 vegetation monitoring on the Muddy Run Stream Restoration Site resulted in an average of 616 planted stems per acre, which is above the interim survival density of 320 stems per acre at the end of Year 3 monitoring. The average stems per vegetation plot was 12.3 planted stems. The minimum

planted stem per plot was 7 stems and the maximum was 17 stems per plot. There was one tulip poplar (*Liriodendron tulipidera)* volunteer in Plot 22. 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 Stream Hydrology

Multiple bankfull events have been observed during Year 1 monitoring activities on three of the four crest gauges. Four sets of manual and auto-logging crest gauges are installed on the site, one along Reach 2, one along Reach 3A, one along Reach 3B, and one along Reach 5A to document flow conditions. Crest gauges 1 and 2 both recorded their maximum bankfull flow event on August 1st; however, crest gauge 4 recorded its maximum reading on September 12th. During several site visits throughout Year 1, each stream reach was noted to be flowing during normal conditions. Crest gauge and rainfall data is presented in **Appendix E**.

5.1.5 Wetland Hydrology

Seven wetland hydrology gauges were installed in early July 2014 and documented hydrology conditions for approximately 55 percent of the total growing season. Four of the seven wetland gauges (AW1, AW2, AW4, and AW6) achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Since wetland hydrology was only monitored for the last half of the growing season, it is difficult to determine if the remaining three gauges were successful. Groundwater gauge data indicate the hydroperiods being responsive to rainfall events. One reference gauge (RAW1) met the nine percent success criteria while the remaining two (RAW2 and RAW3) had hydroperiods of four and eight percent of the growing season. Year 2 wetland hydrology monitoring data will represent the first full growing season. Wetland gauge and rainfall data is presented in **Appendix E**.

6 REFERENCES

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Appendix A

Project Background Data and Maps

Appendix A. **General Tables and Figures**
Table 1 Project Components and Mitigation Credits
Monitoring Report Year 1

Table 1. Project Components and Mitigation Credits
Muddy Run II Stream and Wetland Restoration/NCEEP Project # NC-95354

Mitigation Credits

	Stream		Riparian Wetland		Non-riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	10,739		4.92	N/A	N/A	N/A	N/A	N/A	N/A

Project Components

Project Component -or- Reach ID	As-Built Stationing/Location (LF)	Existing Footage/Acreage	Approach (PI, PII etc.)	Restoration -or- Restoration Equivalent	Restoration Footage or Acreage	Mitigation Ratio
Reach 1	0+00 – 4+48	438	HWV	Restoration	398	1 : 1
Reach 2	0+00 – 5+04	504	HWV	Restoration	504	1 : 1
Reach 2	5+04 – 19+14	1,223	P1	Restoration	1,410	1 : 1
Reach 3A	0+00 – 37+23	3,301	P1	Restoration	3,586	1 : 1
Reach 3B	37+23 – 57+92	NA	P1	Restoration	1,979	1 : 1
Reach 3C	57+92 – 65+30	737	Enh. I	Rest. Equivalent	708	1 : 1.5
Reach 4	0+44 – 2+17	120	P1	Restoration	173	1 : 1
Reach 5A	0+00 – 19+59	1,602	P1	Restoration	1,926	1 : 1
Reach 5B	19+59 – 23+68	401	Enh. II	Rest. Equivalent	409	1 : 2.5
Reach 6	9+02 – 12+19	317	Enh. II	Rest. Equivalent	318	1 : 2.5

Component Summation

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	9,074	4.92				
Headwater Valley	902					
Enhancement						
Enhancement I	708					
Enhancement II	727					
Creation						
Preservation						
High Quality Preservation						

BMP Elements

Element	Location	Purpose/Function	Notes
---	---	---	---
---	---	---	---
---	---	---	---

BMP Elements
BR = Bioretention Cell; SF = Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; S = Grassed Swale; LS = Level Spreader; NI = Natural Infiltration Area; FB = Forested Buffer

Table 2. Project Activity and Reporting History

Project Activity and Reporting History Muddy Run II Stream and Wetland Restoration / EEP Project #NC-95354		
Activity or Report	**Data Collection Complete**	**Completion or Delivery**
Mitigation Plan	NA	January 2014
Final Design – Construction Plans	NA	March 2014
Construction Completed	NA	May 2014
Site Planting Completed	NA	May 2014
Baseline Monitoring Document (Year 0 Monitoring – baseline)	June 2014	August 2014
Year 1 Monitoring	December 2014	December 2014
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contacts

Project Contacts Table Muddy Run Stream Restoration /EEP Project # 95354	
Designer	WK Dickson and Co., Inc. 720 Corporate Center Drive Raleigh, NC 27607 (919) 782-0495 Frasier Mullen, PE
Construction Contractor	GP Jenkins 6566 HWY 55 W Kinston, NC 28504 (252) 569-1222 Gary Jenkins
Planting Contractor	H&J Forestry Matt Hitch
Seeding Contractor	Rain Services, Inc. Lupe Cruz
Seed Mix Sources	Green Resource
Nursery Stock Suppliers	Arbogen
Full Delivery Provider Project Manager:	Environmental Banc & Exchange, LLC 909 Capability Drive, Suite 3100 Raleigh, NC 27606 (919) 829-9909 David Godley
Monitoring Performers Project Manager:	WK Dickson and Co., Inc. 720 Corporate Center Drive Raleigh, NC 27607 (919) 782-0495 Daniel Ingram

Table 4. Project Information

Project Information			
Project Name	Muddy Run II Stream and Wetland Restoration		
County	Duplin		
Project Area (acres)	37.6		
Project Coordinates (latitude and longitude)	34.830843^0 N , -77.792838 ^{0} 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)	908		
Project Drainage Area Percentage of Impervious Area	<1%		
CGIA Land Use Classification			

Reach Summary Information

Parameters	Reach 1	Reach 2	Reach 3a	Reach 3b	Reach 3c	Reach 4	Reach 5a	Reach 5b	Reach 6
Length of Reach (linear feet)	398	1914	3586	1979	708	173	1926	409	318
Valley Classification									
Drainage Area (acres)	68	114	227	333	370	46	774	908	77
NCDWQ Stream Identification	24.75	24.75	36.5	NA	40.5	32.0	35.5	37.5	20.75
NCDWQ Water Quality	NA	NA	NA	NA	NA	NA	NA	NA	NA
Morphological Description (stream									
Evolutionary Trend									
Underlying Mapped Soils	Rains	Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro / Rains	Goldsboro	Goldsboro / Rains
Drainage Class	---	---	---	---	---				
Soil Hydric Status	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric
Slope	0.0043	0.0021	0.0016	0.0023	0.0022	0.0034	0.0024	0.0015	0.0024
FEMA Classification	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X
Native Vegetation Community	Coastal Plain Small Stream Swamp								
Percent Composition of Exotic	0%	0%	0%	0%	0%	0%	0%	0%	0%

Wetland Summary Information

Parameters	Wetland A	Wetland B
Size of Wetland (acres)	3.60	1.32
Wetland Type (non-riparian, riparian riverine or riparian	Riparian	Riparian
Mapped Soil Series	Goldsboro	Rains
Drainage class	Moderately Well	Poorly
Soil Hydric Status	Yes	Yes
Source of Hydrology	Runoff/Overbank Flows	Runoff/Overbank Flows
Hydrologic Impairment	Ditched/Incised Channel	Ditched/Incised Channel
Native vegetation community	Cultivated	Cultivated
Percent composition of exotic invasive vegetation	NA	NA

Regulatory Considerations

Regulation	Applicable?	Resolved?	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

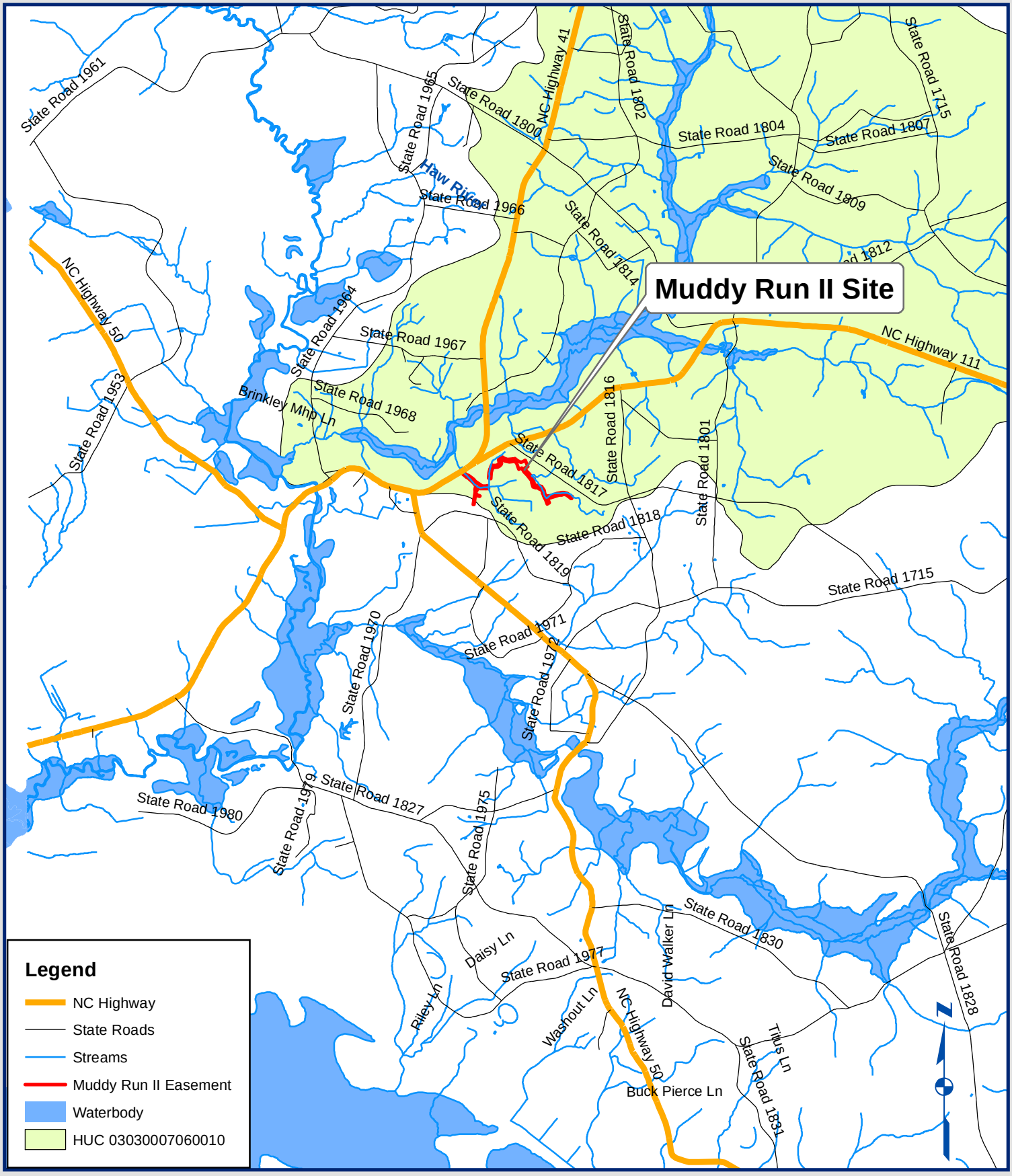


Figure 1.
Project Vicinity Map
Muddy Run II Mitigation Site

0 0.75 1.5 3 Miles

1 inch = 1.5 miles

DUPLIN COUNTY
Scale: NTS

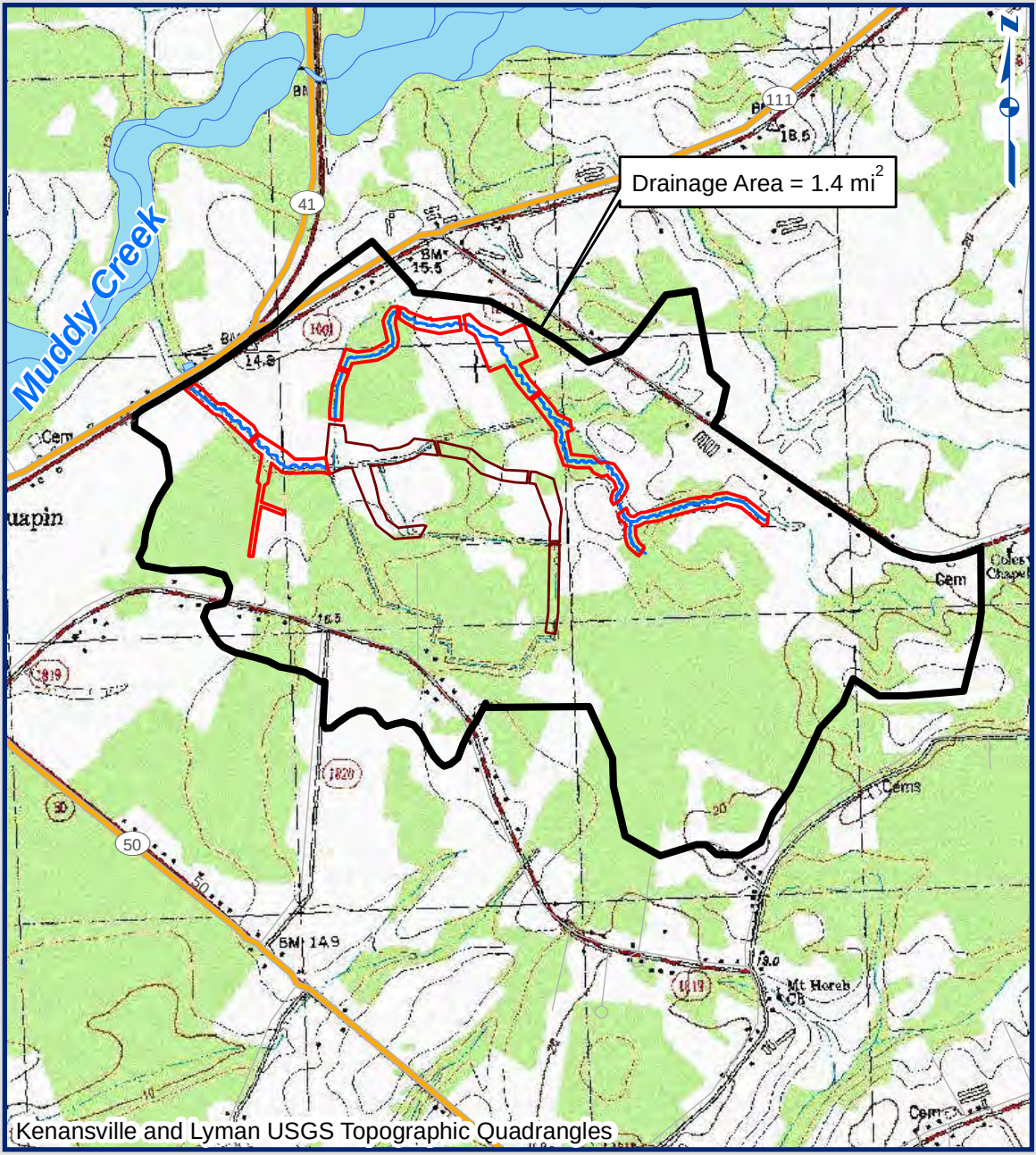


Exhibit 2.
USGS/Watershed Map
Muddy Run II Site

0 1,000 2,000 4,000 Feet

1 inch = 2,000 feet

- Proposed Streams
- Waterbodies
- Muddy Run II Easement
- Muddy Run Easement
- Drainage Area

Appendix B

Visual Assessment Data

Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

S-21
XS-20
VP-8
XS-18
XS-19
XS-17
VP-7
XS-16
Reach 3A
XS-15
SPA2
VP-6
VP-5
XS-12
CG 1
XS-10
XS-9
XS-8
XS-7
VP-3
XS-13
XS-11
VP-4
XS-6
XS-14
XS-4
XS-3
Reach 2
SPA1
Reach 1
VP-2
XS-5
VP-1
XS-2
XS-1
VPA1

0 75 150 300 Feet

Source: 2012 Google Earth Imagery

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

Legend

- Easement Boundary
- Cross Sections
- Stream Structures
- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Vegetation Plots
- Reach Breaks
- Crest Gauges

Riparian Buffer Conditions

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

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

Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

SPA3
VPA5
VPA4
VPA3
VPA2
VP-17
VP-15
VP-16
VP-13
VP-14
VP-12
VP-11
VP-10
VP-9
VP-8
AW3
AW2
AW1
AW4
CG 2
XS-31
XS-30
XS-29
XS-28
XS-27
XS-26
XS-25
XS-24
XS-46
XS-47
XS-23
XS-22
XS-21
XS-20
Reach 3A
Reach 4

0 75 150 300 Feet

Source: 2012 Google Earth Imagery

NC OneMap, NC Center for Geographic Information and /

Legend

- Easement Boundary
- Cross Sections
- Stream Structures
- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Vegetation Plots
- Wetland Restoration
- Encroachment Area
- Reach Breaks
- Crest Gauges

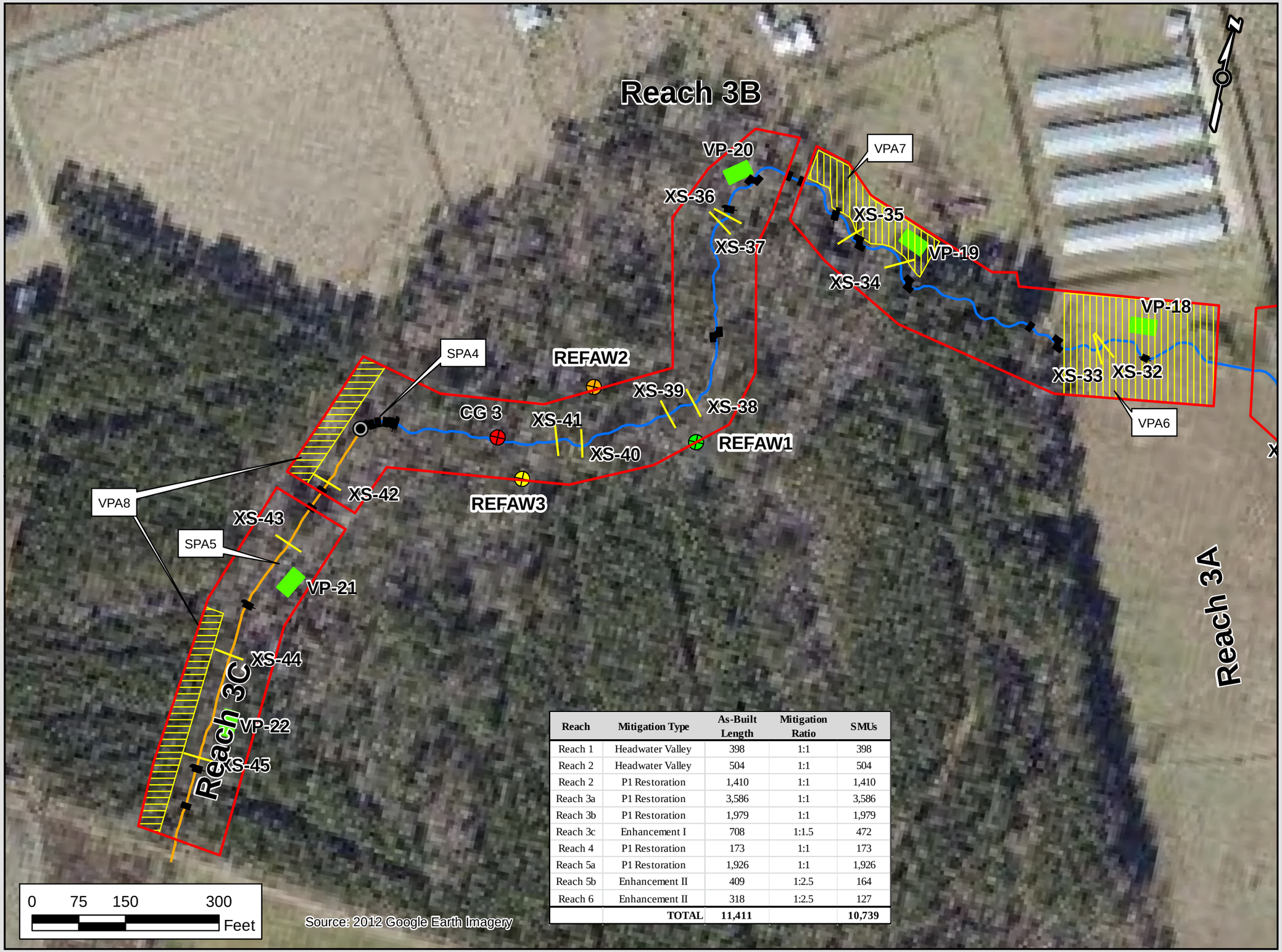
Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions

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

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



Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

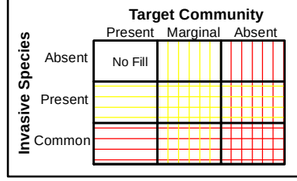
Legend

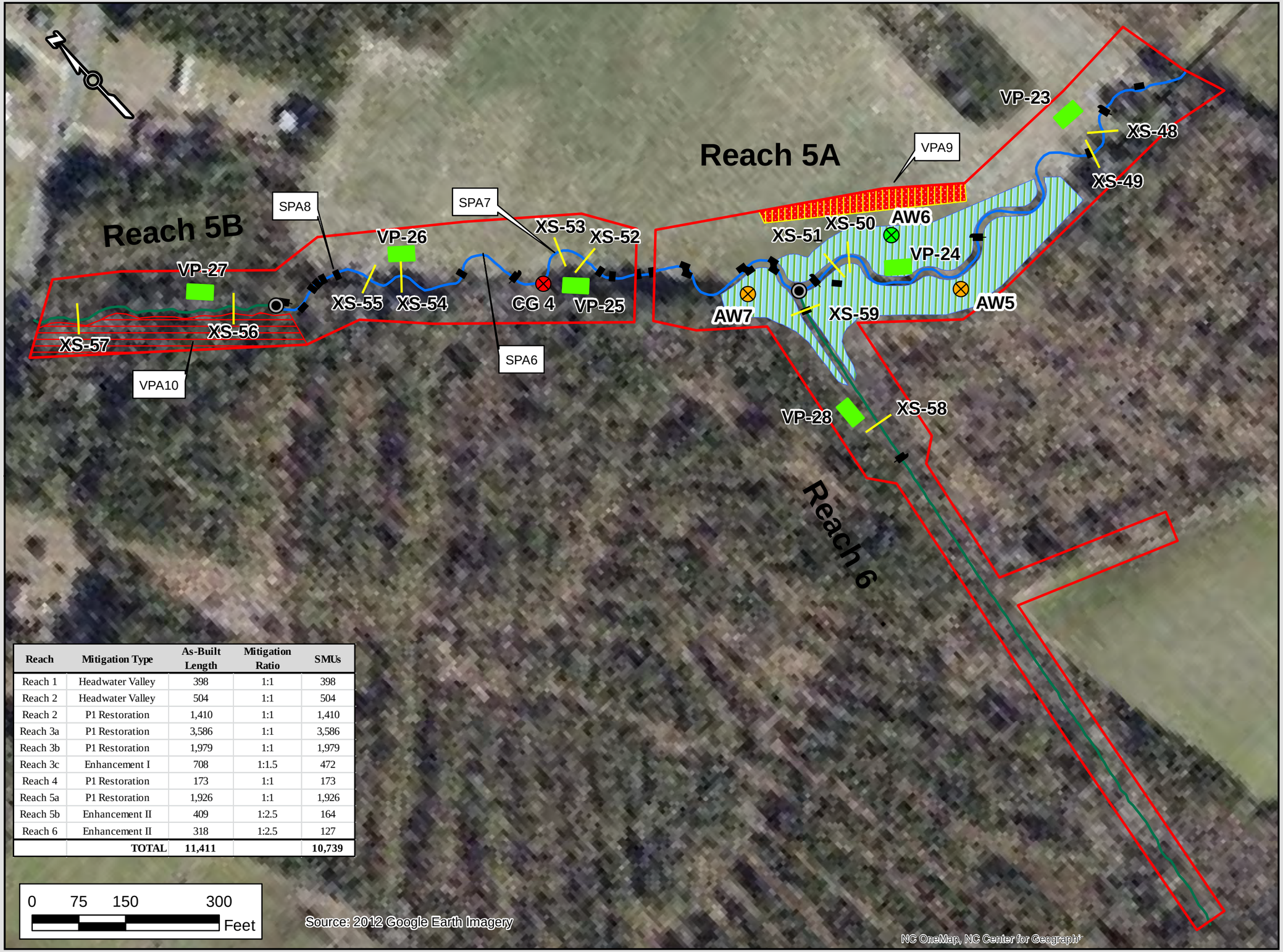
- Easement Boundary
- Cross Sections
- Stream Structures
- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Vegetation Plots
- Wetland Restoration
- Reach Breaks
- Crest Gauges

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions





Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
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Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

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

EBX

Legend

- Easement Boundary
- Cross Sections
- Stream Structures
- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Vegetation Plots
- Wetland Restoration
- Encroachment Area
- Crest Gauges
- Reach Breaks

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions

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

Table 5a **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 1**
Assessed Length **398**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
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 NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	3	4			75%			
	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 not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5b **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 2**
Assessed Length **1914**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
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 NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	14	14			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	13	13			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	14	14			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5c **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3A**
Assessed Length **3586**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			2	15	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	2	15	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	21	21			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	11	11			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	19	21			90%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	10	10			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5d **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3B**
Assessed Length **1979**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			1	50	97%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	50	99%	0	0	99%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			1	30	99%	0	0	99%
				Totals	2	80	98%	0	0	98%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	12	17			71%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	4	9			44%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	12	17			71%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	7	7			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5e **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3C**
Assessed Length **708**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			2	15	99%	2	10	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	2	15	99%	2	10	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	5	5			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	5	5			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	2	2			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5f **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 4**
Assessed Length **173**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
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 NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	2	2			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5g **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 5A**
Assessed Length **1926**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			1	550	71%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	10	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			1	250	94%	0	0	94%
				Totals	2	260	93%	0	0	93%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	14	22			64%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	9	16			56%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	13	22			59%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	4	6			67%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

Table 5h **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 5B**
Assessed Length **409**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
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 NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	1	1			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	1	1			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

[1] 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.
[2] Percentage based on visual assessment of channel bed condition.

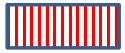
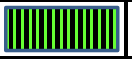
Table 5a **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 6**
Assessed Length **318**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], 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. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem 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%			
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 NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	2	2			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.	2	2			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

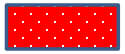
[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 6 Vegetation Condition Assessment

Planted Acreage[1] **17**

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		5	2.42	14.2%
			Total	5	2.42	14.2%
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%
			Cumulative Total	5	2.42	14.2%

Easement Acreage[2] **37.6**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern[4]	Areas or points (if too small to render as polygons at map scale).	1000 SF	 	7	1.56	4.1%
5. Easement Encroachment Areas[3]	Areas or points (if too small to render as polygons at map scale).	none		2	0.38	2.2%

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 spcies 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 likley 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 ealry 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 symbolzing invasives polygons, particularly for situations where the conditon 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 II Stream and Wetland Restoration Project - Project # 95354

Feature Issue	Station # / Range	Suspected Cause; Repair	Photo Number
Loose grade control toe log structure	Reach 1 @ 3+25	Concentrated flow; Log toe is undercut, but bed is stable; Will continue to monitor	SPA1
Erosion around grade control toe log	Reach 3A @ 0+25	Concentrated flow; Repair scour on left bank around log structure and install coir log to divert concentrated flow from left bank.	SPA2
Left bank erosion behind flow diversion structure	Reach 3B @ 37+22	Concentrated flow; Grade scour pool on left floodplain with level spreader or stable swale to channel, repair bank, livestake	SPA3
Failed grade control structures at 3C confluence	Reach 3B @ 57+30 to 57+80	Improper installation; Bed/bank repair, install new grade controls , bench floodplain, livestake	SPA4
Minor left bank erosion (Head cut forming)	Reach 3C @ 60+00 and 61+00	Concentrated flow; Repair scour on left bank and install coir log to divert concentrated flow from left bank.	SPA5
Failed grade control structures and bank erosion	Reach 5A @ Sta 13+25-16+50	Improper installation; Install rock/log structures and repair banks, bench floodplain, livestake, replant	SPA6
Minor right bank erosion	Reach 5A @ Sta 14+00	Concentrated flow; Repair scour on right bank and install coir log to divert concentrated flow from right bank.	SPA7
Failed grade control structures; bed and banks unstable	Reach 5A @ Sta 16+50-19+50	Improper installation; Install rock/log structures and repair banks, bench floodplain, livestake, replant	SPA8

Table 8. Vegetation Problem Areas
Muddy Run II Stream and Wetland Restoration Project - Project # 95354

Feature Category	Station Numbers	Suspected Cause; Repair	Photo Number
Invasive/Exotic Populations	Reach 2 @ Sta 0+50 - 3+00	Ligustrum: encroachment from outside easement; Continued clearing and stump treatment.	VPA1
Invasive/Exotic Populations	Reach 3A @ Sta 11+00 - 16+00	Ligustrum: encroachment from outside easement; Continued clearing and stump treatment.	VPA2
Invasive/Exotic Populations	Reach 3A- localized areas- see plan view	Ligustrum; Continued clearing and stump treatment.	VPA3
Sparse vegetation/ Easement encroachment	Reach 3A @ Sta 19+00 - Sta 23+00	Vehicles driving in the easement; Plant approximately 80 trees in 2 rows and restrict vehicle access to the easement.	VPA4
Missing rows of trees	Reach 3A @ Sta 28+50 - 33+75	Trees were never planted; Plant approximately 400 trees.	VPA5
Sparse target community	Reach 3B @ Sta 38+50 - 42+00	Mortality due to low soil fertility, possibly due to compaction; Plant approximately 300 trees.	VPA6
Missing rows of trees	Reach 3B @ Sta 44+50 - 47+12	Low planting density; Plant approximately 250 trees.	VPA7
Invasive/Exotic Populations	Reach 3C- localized areas- see plan view	Ligustrum: encroachment from outside easement; Continued clearing and stump treatment.	VPA8
Sparse vegetation/ Easement encroachment	Reach 5A @ Sta 4+50 - 9+25	Vehicles driving in the easement; Plant approximately 80 trees in 2 rows and restrict vehicle access to the easement.	VPA9
Invasive/Exotic Populations	Reach 5B @ Sta 19+60 - 23+68	Ligustrum: encroachment from outside easement; Continued clearing and stump treatment.	VPA10

Appendix B - Stream Photos

Reach 1– Looking Downstream - Sta.1+25 - MY1 (06/02/2014)

Reach 1– Looking Downstream - Sta.1+25 – MY1 (12/02/2014)

Reach 2 Looking Downstream Sta. 16+35 Post-Construction (05/22/2014)

Reach 2 Looking Downstream Sta. 16+35- MY1 (12/02/2014)

Reach 3A Looking Downstream Sta. 19+80 Post-Construction (06/02/2014)

Reach 3A Looking Downstream Sta. 19+80- MY1 (11/13/2014)

Reach 3A Looking Downstream Sta. 7+50 During Construction (06/02/2014)


Reach 3A Looking Downstream Sta. 7+50- MY1 (12/02/2014)


Reach 3B Sta. 44+75 Looking Downstream During Construction (04/03/2014)

Reach 3B Sta. 44+75 Looking Downstream- MY1 (12/03/2014)

Reach 3B Looking Upstream Sta. 48+70 Post-Construction (06/18/2014)


Reach 3B Looking Downstream Sta. 48+70-MY1 (11/13/2014)

Reach 3C Looking Downstream Sta. 64+00 Construction (05/22/2014)

Reach 3C Looking Downstream Sta. 64+00- MY1 (12/03/2014)

Reach 4 Looking Downstream Sta. 0+65- Post Construction (06/02/2014)

Reach 4 Looking Downstream Sta. 0+50- MY1 (12/03/2014)

Reach 5a Looking Upstream Sta. 13+50- Post Construction (06/04/2014)

Reach 5a Looking Upstream Sta. 13+50 - MY1- (11/12/2014)

Reach 5A Looking Downstream Sta. 17+80 Post-Construction (06/18/2014)

Reach 5A Looking Downstream Sta. 17+80 – MY1 Post-Construction (12/02/2014)

Reach 5B Looking Downstream Sta. 20+05 During Construction (04/23/2014)

Reach 5B Looking Downstream Sta. 20+05- MY1 (12/03/2014)

Reach 5B Looking Upstream Sta. 23+10 Post-Construction (06/02/2014)

Reach 5B Looking Upstream Sta. 23+10 –MY1 (12/03/2014)

Reach 6 Looking downstream Sta. 8+00 During Construction (03/12/2014)

Reach 6 Looking downstream Sta. 8+00- MY1 During Construction (12/03/2014)

Crest Gauge 1- Reach 2 (12/04/2014)

Crest Gauge 2- Reach 3A (12/03/2014)

Crest Gauge 3- Reach 3B (12/03/2014)

Crest Gauge 4 – Reach 5B (12/03/2014)

Appendix B- Vegetation Plot Photos

Vegetation Plot 1 (12/04/2014)

Vegetation Plot 2 (12/04/2014)

Vegetation Plot 3 (12/04/2014)

Vegetation Plot 4 (12/04/2014)

Vegetation Plot 5 (12/04/2014)

Vegetation Plot 6 (12/04/2014)

Vegetation Plot 7 (12/03/2014)

Vegetation Plot 8 (12/03/2014)

Vegetation Plot 9 (12/03/2014)

Vegetation Plot 10 (12/03/2014)

Vegetation Plot 11 (12/03/2014)

Vegetation Plot 12 (12/03/2014)

Vegetation Plot 13 (12/03/2014)

Vegetation Plot 14 (12/03/2014)

Vegetation Plot 15 (12/03/2014)

Vegetation Plot 16 (12/03/2014)

Vegetation Plot 17 (12/03/2014)

Vegetation Plot 18 (07/03/2014)

Vegetation Plot 19 (12/03/2014)

Vegetation Plot 20 (12/03/2014)

Vegetation Plot 21 (12/03/2014)

Vegetation Plot 22 (12/03/2014)

Vegetation Plot 23 (12/03/2014)

Vegetation Plot 24 (07/03/2014)

Vegetation Plot 25 (12/03/2014)

Vegetation Plot 26 (12/03/2014)

Vegetation Plot 27 (12/03/2014)

Vegetation Plot 28 (12/03/2014)

Appendix B - Stream Problem Area Photos

SPA1- Loose grade control toe log structure - Reach 2 @ Sta 3+25

SPA2- Erosion around grade control log - Reach 3A @ Sta 0+25

SPA3- Left bank erosion behind flow diversion structure - Reach 3b @ Sta 37+22

SPA4- Failed grade control structures- Reach 3B @ Sta 57+30 – 57+80

SPA5- Minor left bank erosion – Reach 3C @ Sta 60+00 and 61+00

SPA6- Failed grade control structures and bank erosion- Reach 5A @ Sta 13+25- Sta 16+50

SPA7- Minor right bank erosion- Reach 5A @ Sta 14+00

SPA8- Failed grade control structures, bed/bank erosion- Reach 5A @ Sta 16+50- 19+50

Appendix B - Vegetation Problem Area Photos

VPA1- Invasive population: *Ligustrum* along Reach 2 @ Sta 0+50 – Sta 3+00.

VPA2- Invasive population: *Ligustrum* along Reach 3a @ Sta 11+00 – Sta 16+00.

VPA3- Localized invasive populations: *Ligustrum* along Reach 3a

VPA4- Missing rows of trees and vehicles through easement along Reach 3a @ Sta 19+00 - Sta 23+00

VPA5- Missing rows of trees along Reach 3a @ Sta 28+50 – Sta 33+75.

VPA6- Missing trees along Reach 3b @ Sta 38+50- Sta 42+00.

VPA7- Missing trees along Reach 3b @ Sta 44+50- Sta 47+12.

VPA8- Localized invasive populations: *Ligustrum* along Reach 3c

VPA9- Missing trees and vehicles through easement along Reach 5a @ Sta 4+50 – Sta 9+25.

VPA10- Invasive population: *Ligustrum* along Reach 5b @ Sta 19+60 – Sta 23+68.

Appendix C

Vegetation Plot Data

Table 9a. Baseline 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

	Baseline		Year 1	
Vegetation Plot	**Stems Planted**	**Stems/Acre Baseline**	**Living Stems**	**Stems/Acre Year 1**
1	16	800	16	800
2	17	850	14	700
3	15	750	13	650
4	14	700	12	600
5	16	800	12	600
6	17	850	14	700
7	15	750	13	650
8	16	800	14	700
9	17	850	11	550
10	14	700	9	450
11	13	650	13	650
12	15	750	9	450
13	16	800	14	700
14	14	700	10	500
15	15	750	13	650
16	16	800	15	750
17	15	750	10	500
18	14	700	14	700
19	9	450	8	400
20	10	500	7	350
21	18	900	16	800
22	16	800	13	650
23	13	650	11	550
24	17	850	11	550
25	16	800	12	600
26	11	550	7	350
27	19	950	17	850
28	17	850	17	850
Average	**15.0**	**752**	**12.3**	**616**
Min	**9**	**450**	**7**	**350**
Max	**19**	**950**	**17**	**850**

* One *Liriodendeon tulipifera* volunteer in Plot 22.

Table 9b. Planted Species Totals

Species	Common Name	Total Planted
Trees - Bare Root		
Taxodium distichum	Bald Cypress	1,800
Fraxinus pennsylvanica	Green Ash	1,900
Quercus lyrata	Overcup Oak	1,800
Betula nigra	River birch	1,800
Quercus michauxii	Swamp Chestnut Oak	2,200
Nyssa biflora	Swamp Tupelo	2,000
Plantanus occidentalis	American Sycamore	2,200
Quercus laurifolia	Laurel Oak	1,800
	Total	**15,500**

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

		Vegetation Plot 1						Vegetation Plot 2						Vegetation Plot 3						Vegetation Plot 4						Vegetation Plot 5					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress	3	3																	1	1					1	1				
Fraxinus pennsylvanica	Green Ash																			5	5					1	1				
Quercus sp.	Unknown Oak sp.							2						2	1					1						1	1				
Quercus lyrata	Overcup Oak							8	8					4	4											8	7				
Betula nigra	River birch	6	6											2												2	1				
Quercus michauxii	Swamp Chestnut Oak	2	2					2	2					1	1											1	1				
Nyssa biflora	Swamp Tupelo							4	4					3	3					2	1										
Plantanus occidentalis	American Sycamore	1	1											3	3					5	5										
Quercus laurifolia	Laurel Oak	4	4					1	0						1											2					
	Species Count	**5**	**5**					**5**	**4**					**6**	**6**					**5**	**4**					**7**	**6**				
	Stem Count	**16**	**16**					**17**	**14**					**15**	**13**					**14**	**12**					**16**	**12**				
	Stems per Acre	**800**	**800**					**850**	**700**					**750**	**650**					**700**	**600**					**800**	**600**				

		Vegetation Plot 6						Vegetation Plot 7						Vegetation Plot 8						Vegetation Plot 9						Vegetation Plot 10					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress	6	6					5	5					5	5																
Fraxinus pennsylvanica	Green Ash							2	2																						
Quercus sp.	Unknown Oak sp.							1						1						1											
Quercus lyrata	Overcup Oak	2	1					3	3					2	2											3	2				
Betula nigra	River birch	3	3					3	2											10	6					3	1				
Quercus michauxii	Swamp Chestnut Oak																														
Nyssa biflora	Swamp Tupelo							1	1					3	3											4	2				
Plantanus occidentalis	American Sycamore	1	1											2	2					2	1					1	1				
Quercus laurifolia	Laurel Oak	5	3											3	2					4	4					3	3				
	Species Count	**5**	**5**					**6**	**5**					**6**	**5**					**4**	**3**					**5**	**5**				
	Stem Count	**17**	**14**					**15**	**13**					**16**	**14**					**17**	**11**					**14**	**9**				
	Stems per Acre	**850**	**700**					**750**	**650**					**800**	**700**					**850**	**550**					**700**	**450**				

		Vegetation Plot 11						Vegetation Plot 12						Vegetation Plot 13						Vegetation Plot 14						Vegetation Plot 15					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress	2	2											1	1					1	1					2	2				
Fraxinus pennsylvanica	Green Ash	2	2					1	1					2	2					3	3					1	1				
Quercus sp.	Unknown Oak sp.							2						1																	
Quercus lyrata	Overcup Oak							2	2																						
Betula nigra	River birch	1	1					3						1	1					1						1	1				
Quercus michauxii	Swamp Chestnut Oak							5	5					7	6											6	5				
Nyssa biflora	Swamp Tupelo	4	4											4	4					9	6					3	3				
Plantanus occidentalis	American Sycamore	1	1					2	1																	1	1				
Quercus laurifolia	Laurel Oak	3	3																							1					
	Species Count	**6**	**6**					**6**	**4**					**6**	**5**					**4**	**3**					**7**	**6**				
	Stem Count	**13**	**13**					**15**	**9**					**16**	**14**					**14**	**10**					**15**	**13**				
	Stems per Acre	**650**	**650**					**750**	**450**					**800**	**700**					**700**	**500**					**750**	**650**				

		Vegetation Plot 16						Vegetation Plot 17						Vegetation Plot 18						Vegetation Plot 19						Vegetation Plot 20					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress																			1	1										
Fraxinus pennsylvanica	Green Ash													6	6					1											
Quercus sp.	Unknown Oak sp.							1																							
Quercus lyrata	Overcup Oak													3	3					1	1										
Betula nigra	River birch							6	4					1	1					1	1										
Quercus michauxii	Swamp Chestnut Oak	7	7					1	1																	2	3				
Nyssa biflora	Swamp Tupelo	8	8					4	2					4	4											6	3				
Plantanus occidentalis	American Sycamore							3	3											5	5					2	1				
Quercus laurifolia	Laurel Oak	1																													
	Species Count	**3**	**2**					**5**	**4**					**4**	**4**					**5**	**4**					**3**	**3**				
	Stem Count	**16**	**15**					**15**	**10**					**14**	**14**					**9**	**8**					**10**	**7**				
	Stems per Acre	**800**	**750**					**750**	**500**					**700**	**700**					**450**	**400**					**500**	**350**				

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

		Vegetation Plot 16						Vegetation Plot 17						Vegetation Plot 18						Vegetation Plot 19						Vegetation Plot 20					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress																			1	1										
Fraxinus pennsylvanica	Green Ash													6	6					1											
Quercus sp.	Unknown Oak sp.							1																							
Quercus lyrata	Overcup Oak													3	3					1	1										
Betula nigra	River birch							6	4					1	1					1	1										
Quercus michauxii	Swamp Chestnut Oak	7	7					1	1																	2	3				
Nyssa biflora	Swamp Tupelo	8	8					4	2					4	4											6	3				
Plantanus occidentalis	American Sycamore							3	3											5	5					2	1				
Quercus laurifolia	Laurel Oak	1																													
	Species Count	**3**	**2**					**5**	**4**					**4**	**4**					**5**	**4**					**3**	**3**				
	Stem Count	**16**	**15**					**15**	**10**					**14**	**14**					**9**	**8**					**10**	**7**				
	Stems per Acre	**800**	**750**					**750**	**500**					**700**	**700**					**450**	**400**					**500**	**350**				

		Vegetation Plot 21						Vegetation Plot 22						Vegetation Plot 23						Vegetation Plot 24						Vegetation Plot 25					
Species	**Common Name**	**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**	**MY5**
Taxodium distichum	Bald Cypress	2	3					8	8					2	2					1	1										
Fraxinus pennsylvanica	Green Ash	6	6											7	6																
Quercus sp.	Unknown Oak sp.	1												1																	
Quercus lyrata	Overcup Oak	3	4											1	2						1										
Betula nigra	River birch							3	3											6	3					4	3				
Quercus michauxii	Swamp Chestnut Oak	2	2																							5	4				
Nyssa biflora	Swamp Tupelo																			3	3					6	5				
Plantanus occidentalis	American Sycamore																			1											
Quercus laurifolia	Laurel Oak	4	1					5	2					2	1					6	3					1					
	Species Count	**6**	**5**					**3**	**3**					**5**	**4**					**5**	**5**					**4**	**3**				
	Stem Count	**18**	**16**					**16**	**13**					**13**	**11**					**17**	**11**					**16**	**12**				
	Stems per Acre	**900**	**800**					**800**	**650**					**650**	**550**					**850**	**550**					**800**	**600**				

		Vegetation Plot 26						Vegetation Plot 27						Vegetation Plot 28					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress																		
Fraxinus pennsylvanica	Green Ash							9	9										
Quercus sp.	Unknown Oak sp.																		
Quercus lyrata	Overcup Oak	4	4					1						4	4				
Betula nigra	River birch	1												1	1				
Quercus michauxii	Swamp Chestnut Oak	2	2					1	1					1	1				
Nyssa biflora	Swamp Tupelo	3	1																
Plantanus occidentalis	American Sycamore	1						1	1					7	7				
Quercus laurifolia	Laurel Oak							7	6					4	4				
	Species Count	**5**	**3**					**5**	**4**					**5**	**5**				
	Stem Count	**11**	**7**					**19**	**17**					**17**	**17**				
	Stems per Acre	**550**	**350**					**950**	**850**					**850**	**850**				

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 December 2nd 2014. Cross sectional survey plots and morphological parameter tables located in Appendix D of the Muddy Run II Stream and Wetland Restoration Project Year 1Monitoring Report were drawn and produced under my supervision.

Brian S. Hockett

Brian S. Hockett, PLS L-5165

Appendix D. Table 10 - Morphological Paramters Summary Data
Project Name/Number: Muddy Run II Mitigation Project/95354

	Reference Reach			Existing[1,2]									Design						As-Built/Baseline											
				MRII 1	MRII 2	MRII 3A	MRII 3B	MRII 3C	MRII 4	MRII 5A	MRII 5B	MRII 6	MRII 2	MRII 3A (U/S)	MRII 3A (D/S)	MRII 3B	MRII 4	MRII 5A	MRII 1	MRII 2	MRII 3A (U/S)	MRII 3A (D/S)	MRII 3B	MRII 4	MRII 5A						
Feature	Pool	Run	Shallow	Run	Run	Run	Run	Run	Run	Run	Run	Run	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow						
Drainage Area (ac)	286	286	286	68	115	227	NA/313	74/360	45	424/774	583/909	77	115	209	254	333	45	774	68	115	209	254	333	45	774						
NC Regional Curve Discharge (cfs)			9.3	3	5	8	NA/10	4/11	2	13/18	16/21	4	---	---	---	---	---	---	---	---	---	---	---	---	---						
Design/Calculated Discharge (cfs)	---	---	13	---	---	---	---	---	---	---	---	---	7	14	16	10	5	40	5	7	14	16	10	5	40						
Dimension																															
BF Width (ft)	10.9	8.9	7.0	4.8	8.1	6.9	7.1	8.0	4.2	6.7	9.9	6.9	7.6	9.2	12.4	9	5.6	15	9.7	11.28	10.4	11.9	9.8	8.4	14.7						
Floodprone Width (ft)	100	100	100	8.7	10.2	8.1	>50	12.9	6.1	11.9	11.6	10.0	>40	>30	>30	>30	>30	>40	>30	>50	>50	>50	>50	>40	>50						
BF Cross Sectional Area (ft^2)	11.4	8.4	5.0	2.3	4.1	2.8	2.4	3.9	2.1	6.6	11.1	6.2	5.9	8.7	15.7	8.3	3.3	22.7	3.7	10.2	11.6	16.5	8.0	6.3	23.9						
BF Mean Depth (ft)	1.0	0.9	0.8	0.5	0.5	0.4	0.3	0.5	0.5	1.0	1.1	0.9	0.78	0.9	1.3	0.9	0.6	1.5	0.4	0.9	1.1	1.4	0.9	0.8	1.6						
BF Max Depth (ft)	2.1	1.7	1.3	0.8	0.8	0.6	0.8	0.9	0.7	1.5	1.5	1.3	1.3	1.5	2.0	1.5	0.9	2.4	1.0	1.6	1.8	2.1	1.4	1.5	2.6						
Width/Depth Ratio	10.4	9.5	8.8	9.6	16.2	17.3	20.9	16.0	8.4	6.7	9.0	7.7	9.7	9.8	9.8	9.7	9.3	9.9	25.8	12.9	9.4	8.7	13.9	11.1	9.1						
Entrenchment Ratio	9.2	11.2	15.1	1.8	1.3	1.2	>2.2	1.6	1.5	1.8	1.2	1.4	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2						
Wetted Perimeter (ft)	12.8	9.7	7.4	5.2	8.3	7.1	7.4	8.3	4.6	7.6	11.4	7.8	8.1	9.8	13.2	9.6	6.0	15.9	10.1	11.9	11.2	13.1	10.4	9.1	15.9						
Hydraulic Radius (ft)	0.9	0.9	0.7	0.4	0.5	0.4	0.3	0.5	0.4	0.9	1.0	0.8	0.7	0.9	1.2	0.9	0.5	1.4	0.4	0.8	1.0	1.2	0.9	0.7	1.4						
Substrate																															
	Fine Sand			Fine Sand									Fine Sand		Fine Sand		Fine Sand		Fine Sand		Fine Sand		Fine Sand		Fine Sand						
Pattern																															
	Min	**Max**	**Med**	---	---	---	---	---	---	---	---	---	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Channel Beltwidth (ft)	13.6	31.8	23.1	---	---	---	---	---	---	---	---	---	14	32	17	39	22	53	16	38	10	24	27	64	7	17	14	39	16	52	21	44	18	36	8	24	19	68
Radius of Curvature (ft)	11.0	27.6	17.6	---	---	---	---	---	---	---	---	---	11	28	13	34	18	46	13	33	8	21	22	55	10	31	7	28	15	44	12	29	15	45	13	19	23	38
Radius of Curvature Ratio	1.5	3.7	2.3	---	---	---	---	---	---	---	---	---	1.5	3.7	1.5	3.7	1.5	3.7	1.5	3.7	1.5	3.7	1.5	3.7	1.0	3.2	0.6	2.5	1.4	4.2	1.0	2.4	1.6	4.5	1.5	2.3	1.6	2.6
Meander Wavelength (ft)	34.9	68.3	54.5	---	---	---	---	---	---	---	---	---	35	69	43	84	58	113	42	82	26	51	70	137	17	38	13	53	31	81	23	53	33	65	23	33	41	77
Meander Width Ratio	1.8	4.2	3.1	---	---	---	---	---	---	---	---	---	1.8	4.2	1.8	4.2	1.8	4.2	1.8	4.2	1.8	4.2	1.8	4.2	0.7	1.8	1.2	3.5	1.5	5.0	1.7	3.7	1.9	3.7	0.9	2.8	1.3	4.6
Profile																															
Shallow Length (ft)	3.1	30.7	12.6	---	---	---	---	---	---	---	---	---	3	31	4	38	5	51	4	37	2	23	6	61	8	12	7	22	7	20	5	45	6	25	6	23	6	35
Run Length (ft)	2.2	33.2	11.3	---	---	---	---	---	---	---	---	---	2	34	3	41	4	55	3	40	2	25	4	66	8	9	5	16	8	25	5	56	5	20	4	15	8	27
Pool Length (ft)	4.2	9.5	5.8	---	---	---	---	---	---	---	---	---	4	10	5	12	7	16	5	11	3	7	8	19	8	10	14	29	10	28	13	30	13	25	12	15	8	23
Pool -to-Pool Spacing (ft)	17.5	59.8	36.3	---	---	---	---	---	---	---	---	---	18	60	22	74	29	99	21	72	13	45	35	120	15	42	36	60	18	63	25	100	17	56	43	75	15	104
Additional Reach Parameters																															
Valley Length (ft)	274			382	1678	3301	908	745	90	1620	383	1172	1682		1524		1648		1693		175		1530		376		1682		1524		1648		1693		175		1530	
Channel Length (ft)	309			382	1678	3301	908	745	90	1620	383	1172	1828		1738		1890		1849		202		1790		398		1914		1796		1790		1979		173		1926	
Sinuosity	1.1			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.09		1.14		1.15		1.09		1.15		1.17		1.1		1.14		1.18		1.09		1.17		0.99		1.26	
Water Surface Slope (ft/ft)	0.004			---	---	---	---	---	---	---	---	---	---		---		---		---		---		---		---		---		---		---		---		---		---		---	
Channel Slope (ft/ft)	0.003			0.0043	0.0021	0.0016	0.0023	0.0022	0.0034	0.0024	0.0015	0.002427	0.0017		0.0026		0.0005		0.0014		0.0049		0.0017		0.0037		0.0022		0.0038		0.001		0.003		0.008		0.0030	
Rosgen Classification	E5			G5c	F5	F5	C5	F5	G5c	G5c	G5c	G5c	E5		E5		E5		E5		E5		E5		E5		E5		E5		E5		E5		E5		E5	
*Habitat Index																																						

[1] 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 II Mitigation Project/95354

	Cross Section 1 (Riffle)							Cross Section 2 (Pool)							Cross Section 3 (Pool)							Cross Section 4 (Riffle)							Cross Section 5 (Run)						
Based on fixed baseline bankfull elevation[1]	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	53.7	53.7						54.1	54.1						53.3	53.3						53.3	53.3						58.0	58.0					
Bankfull Width (ft)	6.3	4.9						6.4	5.6						6.3	6.2						6.9	6.7						14.8	14.5					
Floodprone Width (ft)	30.0	30.0						50.0	50.0						50.0	50.0						35.0	35.0						45.0	45.0					
Bankfull Mean Depth (ft)	0.4	0.4						0.7	0.6						0.8	0.6						0.6	0.6						1.1	1.0					
Bankfull Max Depth (ft)	0.8	0.7						1.3	1.1						1.4	1.2						1.1	1.1						2.0	1.8					
Bankfull Cross Sectional Area (ft^2)	2.7	2.0						4.7	3.5						5.0	4.0						4.6	4.3						15.6	14.5					
Bankfull Width/Depth Ratio	14.4	12.2						8.8	8.7						7.9	9.6						10.7	10.4						14.0	13.7					
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 6 (Run)							Cross Section 7 (Riffle)							Cross Section 8 (Pool)							Cross Section 9 (Riffle)							Cross Section 10 (Pool)						
Based on fixed baseline bankfull elevation[1]	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	56.6	56.6						55.8	55.8						55.5	55.5						55.3	55.3						54.8	54.8					
Bankfull Width (ft)	13.5	13.4						8.4	7.6						9.4	8.8						9.8	9.5						7.0	6.7					
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)	0.9	0.9						0.7	0.7						1.0	0.9						1.2	1.1						1.1	1.1					
Bankfull Max Depth (ft)	1.6	1.5						1.3	1.2						1.6	1.4						1.9	1.8						1.9	1.8					
Bankfull Cross Sectional Area (ft^2)	12.7	11.5						6.1	5.6						9.7	7.8						11.3	10.2						8.0	7.1					
Bankfull Width/Depth Ratio	14.5	15.7						11.5	10.2						9.0	10.0						8.5	8.8						6.1	6.3					
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 11 (Riffle)							Cross Section 12 (Pool)							Cross Section 13 (Riffle)							Cross Section 14 (Pool)							Cross Section 15 (Run)						
Based on fixed baseline bankfull elevation[1]	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	53.9	53.9						54.3	54.3						53.3	53.3						52.8	52.8						53.0	53.0					
Bankfull Width (ft)	9.0	7.2						11.3	10.2						12.1	10.2						9.0	7.8						11.8	11.9					
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)	0.7	0.8						1.4	1.2						0.7	0.8						1.0	0.9						1.2	1.1					
Bankfull Max Depth (ft)	1.3	1.2						2.6	2.3						1.5	1.5						2.0	1.8						1.8	1.8					
Bankfull Cross Sectional Area (ft^2)	6.7	5.6						15.5	12.7						8.7	8.2						8.9	7.8						13.7	12.9					
Bankfull Width/Depth Ratio	12.2	9.4						8.3	8.2						17.0	12.8						9.2	9.9						10.2	10.9					
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 (Run)							Cross Section 17 (Run)							Cross Section 18 (Pool)							Cross Section 19 (Run)							Cross Section 20 (Riffle)						
Based on fixed baseline bankfull elevation[1]	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	52.3	52.3						50.8	50.8						50.1	50.1						50.5	50.5						50.5	50.5					
Bankfull Width (ft)	11.3	11.6						10.5	10.5						10.6	9.9						11.4	11.1						9.3	8.9					
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)	0.9	0.9						1.2	1.2						1.3	1.1						1.3	1.0						1.2	1.2					
Bankfull Max Depth (ft)	1.9	1.7						1.8	2.0						2.0	1.8						2.0	1.7						2.0	2.0					
Bankfull Cross Sectional Area (ft^2)	9.8	9.9						12.4	12.7						14.2	11.3						14.2	11.1						11.3	10.3					
Bankfull Width/Depth Ratio	13.0	13.6						8.9	8.6						7.9	8.7						9.1	11.1						7.7	7.7					
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					

1 = 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 II Mitigation Project/95354

	Cross Section 21 (Pool)							Cross Section 22 (Pool)							Cross Section 23 (Riffle)							Cross Section 24 (Riffle)							Cross Section 25 (Pool)						
Based on fixed baseline bankfull elevation[1]	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	50.3	50.3						49.0	49.0						49.3	49.3						48.8	48.8						48.7	48.7					
Bankfull Width (ft)	11.7	9.1						9.3	9.3						7.8	7.7						11.7	11.8						14.1	13.9					
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)	0.7	0.9						1.3	1.6						1.1	1.0						1.5	1.4						1.8	1.7					
Bankfull Max Depth (ft)	1.7	1.7						2.2	2.4						1.7	1.8						2.1	2.0						3.1	2.8					
Bankfull Cross Sectional Area (ft^2)	8.6	8.1						12.3	14.5						8.3	7.9						18.0	17.1						25.0	24.3					
Bankfull Width/Depth Ratio	16.0	10.2						7.0	6.0						7.4	7.5						7.6	8.2						7.9	8.0					
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 26 (Pool)							Cross Section 27 (Run)							Cross Section 28 (Pool)							Cross Section 29 (Run)							Cross Section 30 (Pool)						
Based on fixed baseline bankfull elevation[1]	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	48.6	48.6						48.8	48.8						48.4	48.4						48.3	48.3						47.4	47.4					
Bankfull Width (ft)	14.9	15.7						12.7	12.4						13.4	13.3						13.4	13.7						12.9	13.1					
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)	1.7	1.6						1.5	1.5						1.8	1.7						1.5	1.4						1.4	1.3					
Bankfull Max Depth (ft)	3.2	3.1						2.3	2.3						2.9	2.9						2.1	2.3						2.3	2.2					
Bankfull Cross Sectional Area (ft^2)	24.9	25.7						19.4	18.9						24.6	23.2						19.8	19.7						18.4	17.4					
Bankfull Width/Depth Ratio	8.9	9.6						8.3	8.1						7.3	7.6						9.1	9.5						9.1	9.8					
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	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 31 (Run)							Cross Section 32 (Run)							Cross Section 33 (Pool)							Cross Section 34 (Pool)							Cross Section 35 (Run)						
Based on fixed baseline bankfull elevation[1]	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	47.5	47.5						47.7	47.7						47.7	47.7						47.2	47.2						46.9	46.9					
Bankfull Width (ft)	13.7	14.2						10.5	10.7						11.5	12.0						10.4	10.5						9.5	8.8					
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)	1.2	1.0						1.3	1.3						1.7	1.6						2.1	1.9						1.3	1.3					
Bankfull Max Depth (ft)	2.1	1.9						2.2	2.0						3.1	2.9						3.1	3.0						2.0	1.9					
Bankfull Cross Sectional Area (ft^2)	15.8	14.6						13.8	13.4						19.5	19.0						21.4	20.5						12.1	11.7					
Bankfull Width/Depth Ratio	11.9	13.8						8.0	8.5						6.8	7.6						5.0	5.4						7.4	6.7					
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 (Pool)							Cross Section 37 (Run)							Cross Section 38 (Pool)							Cross Section 39 (Run)							Cross Section 40 (Pool)						
Based on fixed baseline bankfull elevation[1]	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	45.6	45.6						45.5	45.5						45.4	45.4						45.2	45.2						45.0	45.0					
Bankfull Width (ft)	9.3	9.0						12.4	11.9						10.0	8.8						8.2	7.2						10.3	10.3					
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)	0.9	0.9						0.5	0.5						1.3	1.1						0.9	0.9						1.4	1.1					
Bankfull Max Depth (ft)	1.7	1.5						1.0	1.1						2.0	1.8						1.5	1.5						2.5	2.0					
Bankfull Cross Sectional Area (ft^2)	8.7	8.1						6.1	5.8						12.6	9.2						7.6	6.5						14.3	11.7					
Bankfull Width/Depth Ratio	9.9	10.1						25.4	24.4						7.9	8.4						8.7	7.9						7.4	9.0					
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					

1 = 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 II Mitigation Project/95354

	Cross Section 41 (Run)							Cross Section 42 (Run)							Cross Section 43 (Run)							Cross Section 44 (Run)							Cross Section 45 (Run)						
Based on fixed baseline bankfull elevation[1]	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	45.1	45.1						44.0	44.0						41.3	41.3						41.5	41.5						41.4	41.4					
Bankfull Width (ft)	8.9	8.5						23.5	24.1						9.4	9.2						13.72	13.5						11.8	11.5					
Floodprone Width (ft)	50.0	50.0						50.0	50.0						29.0	29.0						22.0	22.0						35.3	35.3					
Bankfull Mean Depth (ft)	1.1	1.1						1.7	1.5						1.4	0.7						1.4	1.3						1.2	1.2					
Bankfull Max Depth (ft)	1.9	1.8						3.8	3.7						2.2	0.9						2.0	2.0						1.9	2.0					
Bankfull Cross Sectional Area (ft^2)	10.2	9.0						39.7	35.7						13.2	6.5						19.6	18.0						14.6	13.8					
Bankfull Width/Depth Ratio	7.8	8.0						13.9	16.2						6.7	13.2						9.6	10.1						9.5	9.6					
Bankfull Entrenchment Ratio	>2.2	>2.2						2.1	2.1						>2.2	>2.2						1.6	1.6						>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 46 (Run)							Cross Section 47 (Pool)							Cross Section 48 (Riffle)							Cross Section 49 (Pool)							Cross Section 50 (Pool)						
Based on fixed baseline bankfull elevation[1]	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	49.3	49.3						48.2	48.2						41.0	41.0						40.5	40.5						40.0	40.0					
Bankfull Width (ft)	8.4	7.2						6.7	6.3						15.1	15.0						16.6	17.0						18.5	17.7					
Floodprone Width (ft)	42.5	42.5						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						1.7	1.7						1.7	1.7						1.8	1.7					
Bankfull Max Depth (ft)	1.5	1.2						1.8	1.5						2.6	2.7						3.1	3.1						3.2	3.1					
Bankfull Cross Sectional Area (ft^2)	6.3	5.1						6.0	5.3						25.3	24.8						27.4	28.5						32.9	30.7					
Bankfull Width/Depth Ratio	11.1	10.2						7.3	7.4						9.0	9.1						10.0	10.2						10.4	10.2					
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 51 (Riffle)							Cross Section 52 (Run)							Cross Section 53 (Pool)							Cross Section 54 (Pool)							Cross Section 55 (Riffle)						
Based on fixed baseline bankfull elevation[1]	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	40.0	40.0						39.8	39.8						39.7	39.7						38.8	38.8						38.0	38.0					
Bankfull Width (ft)	16.2	16.1						17.7	17.8						17.4	17.9						15.7	16.7						9.7	14.8					
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)	1.5	1.4						1.8	2.1						1.9	2.1						1.7	2.0						1.4	2.2					
Bankfull Max Depth (ft)	2.4	2.3						3.1	4.5						3.5	3.8						2.9	4.0						2.2	3.0					
Bankfull Cross Sectional Area (ft^2)	24.7	23.2						31.8	36.9						33.8	37.1						26.1	32.7						13.6	33.3					
Bankfull Width/Depth Ratio	10.6	11.2						9.9	8.6						9.0	8.6						9.5	8.5						7.0	6.6					
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					

	Cross Section 56 (Run)							Cross Section 57 (Run)							Cross Section 58 (Run)							Cross Section 59 (Run)													
Based on fixed baseline bankfull elevation[1]	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	37.3	37.3						35.7	35.7						41.0	41.0						39.5	39.5												
Bankfull Width (ft)	17.6	17.0						17.0	16.8						14.2	13.7						13.5	12.5												
Floodprone Width (ft)	50.0	50.0						37.5	37.5						50.0	50.0						50.0	50.0												
Bankfull Mean Depth (ft)	2.6	2.2						1.8	1.3						2.4	2.3						1.1	0.9												
Bankfull Max Depth (ft)	3.7	3.2						2.6	2.1						3.4	3.3						2.2	1.8												
Bankfull Cross Sectional Area (ft^2)	45.3	38.0						30.7	22.4						33.9	31.7						15.2	11.3												
Bankfull Width/Depth Ratio	6.9	7.6						9.4	12.5						6.0	6.0						11.9	13.8												
Bankfull Entrenchment Ratio	>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 = 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 II Bank Pin Array Summary

Cross Section	Location	Position	Year 1 Reading
XS 2 @ Sta. 1+35 Reach 1	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 3 @ Sta. 3+45 Reach 1	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 8 @ Sta. 8+55 Reach 2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 10 @ Sta. 11+70 Reach 2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 12 @ Sta. 16+40 Reach 2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 18 @ Sta. 8+40 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 21 @ Sta. 11+20 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 25 @ Sta. 19+80 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 26 @ Sta. 25+90 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 28 @ Sta. 31+40 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0

Cross Section	Location	Position	Year 1 Reading
XS 30 @ Sta. 35+60 Reach 3A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 33 @ Sta. 40+90 Reach 3B	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 36 @ Sta. 48+90 Reach 3B	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 38 @ Sta. 52+10 Reach 3B	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 40 @ Sta. 54+15 Reach 3B	US	Top	0.0
		Bottom	0.0
	DS	Top	0.2
		Bottom	0.0
XS 47 @ Sta. 1+90 Reach 4	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 49 @ Sta. 2+40 Reach 5A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.6
		Bottom	0.0
XS 50 @ Sta. 8+20 Reach 5A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 53 @ Sta. 13+90 Reach 5A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 54 @ Sta. 17+35 Reach 5A	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	1.0

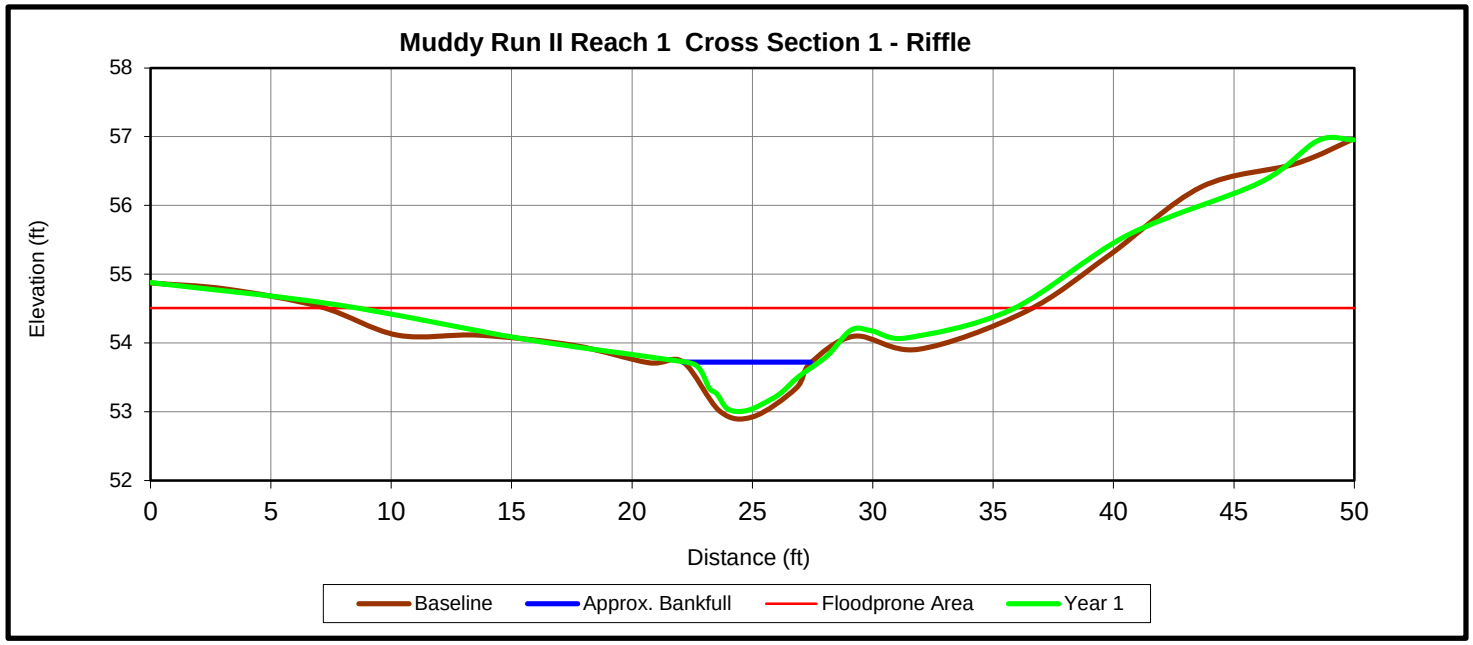
Notes:

US - Upstream from cross section

DS - Downstream from cross section

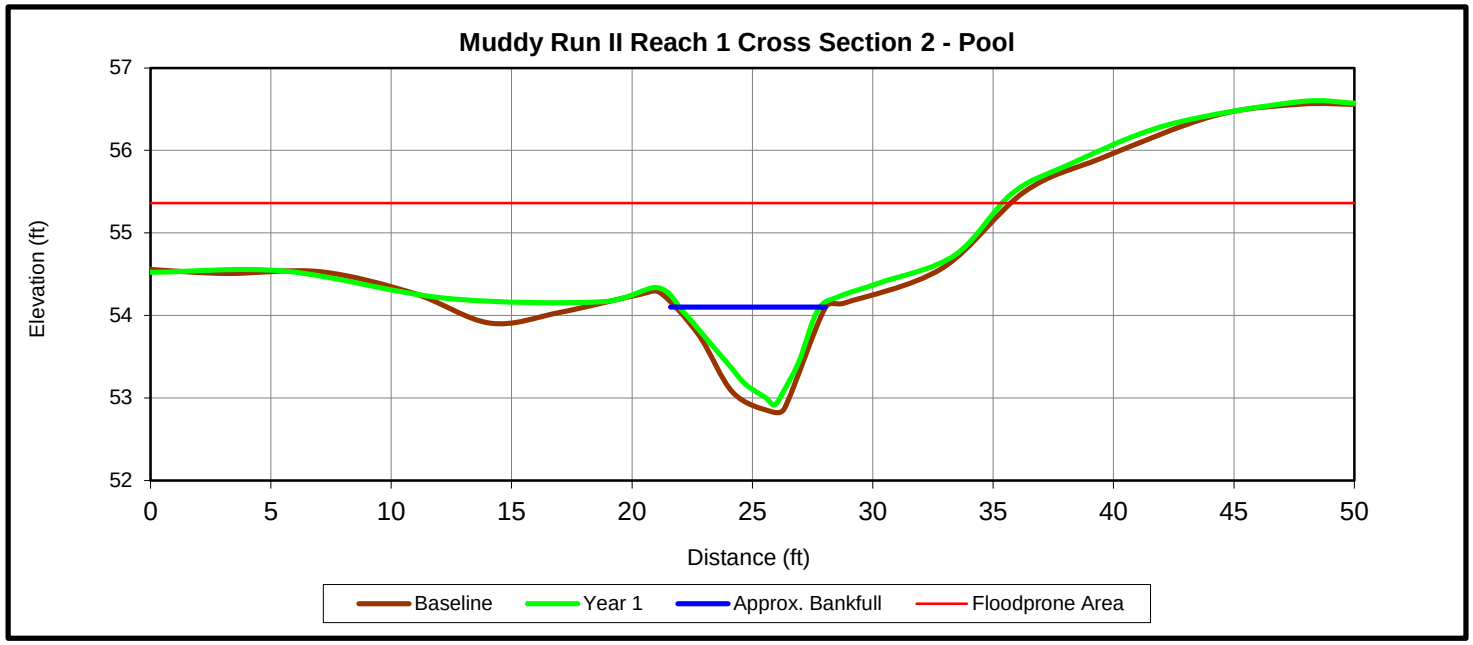
Upstream

Downstream



Upstream

Downstream



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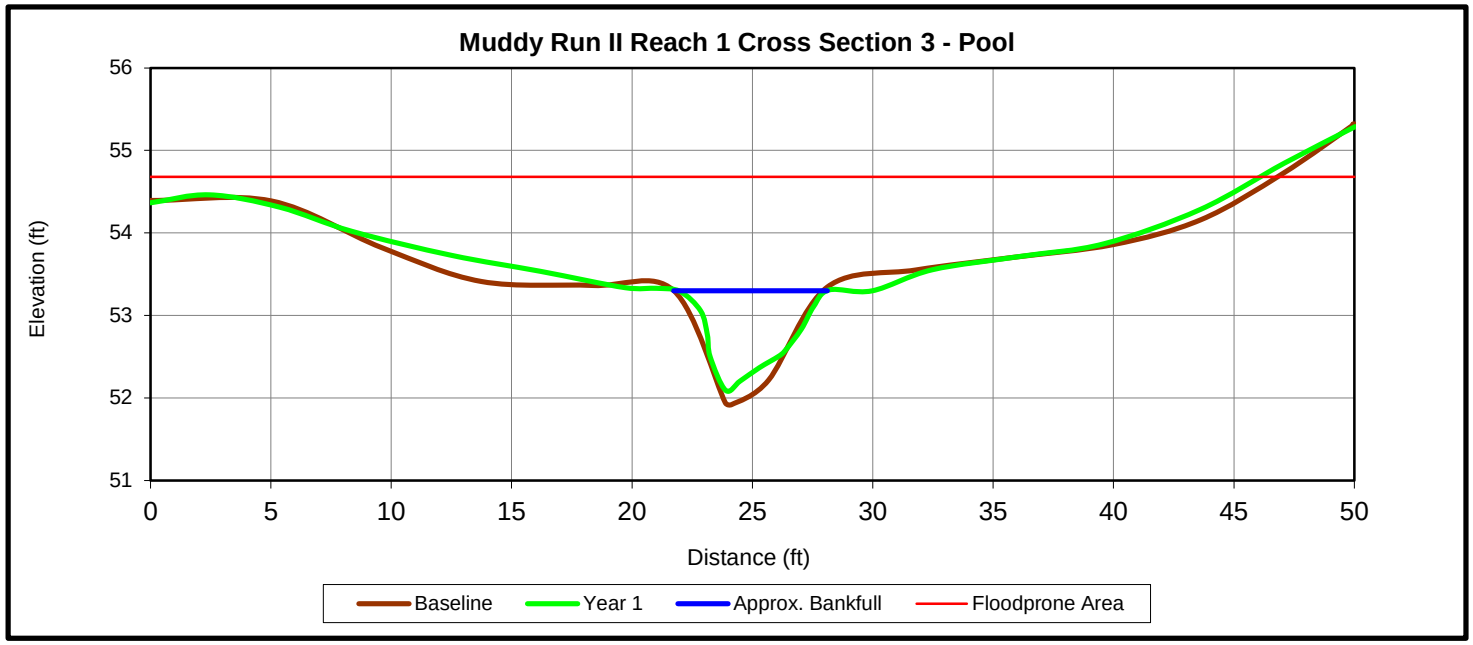
Downstream



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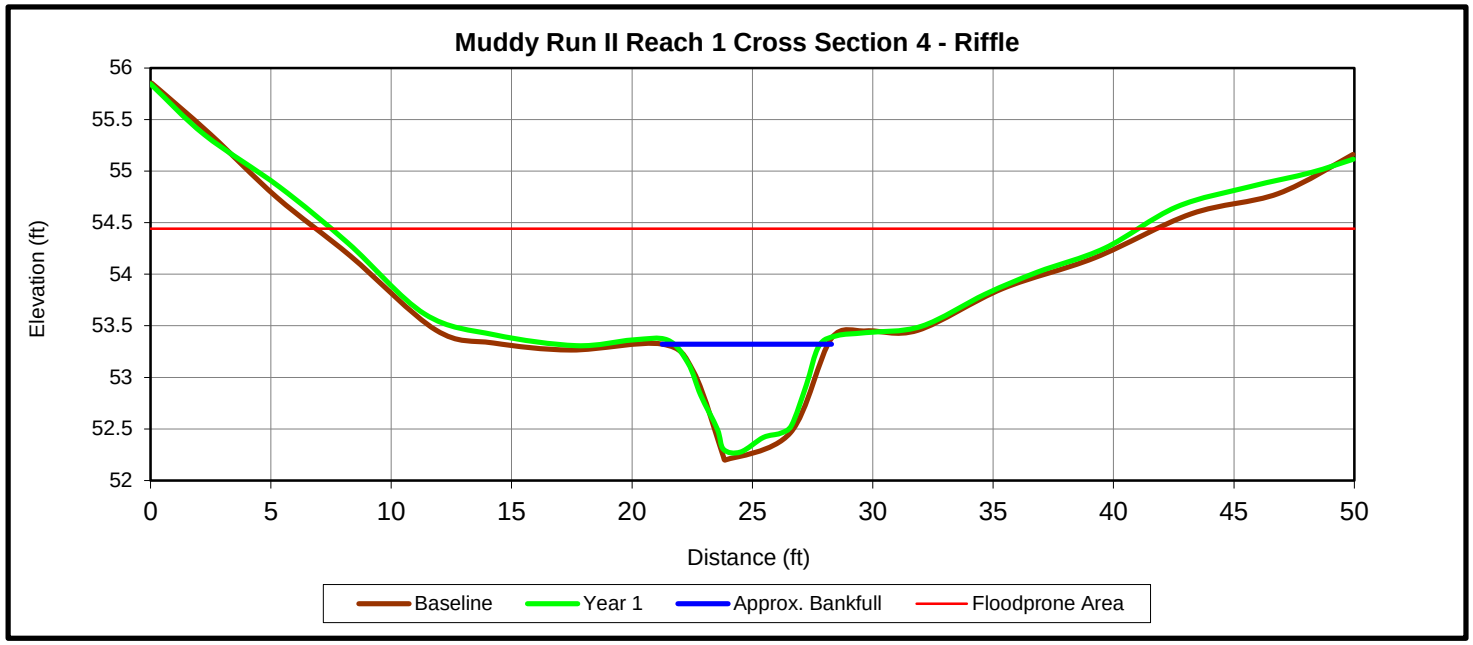
Downstream



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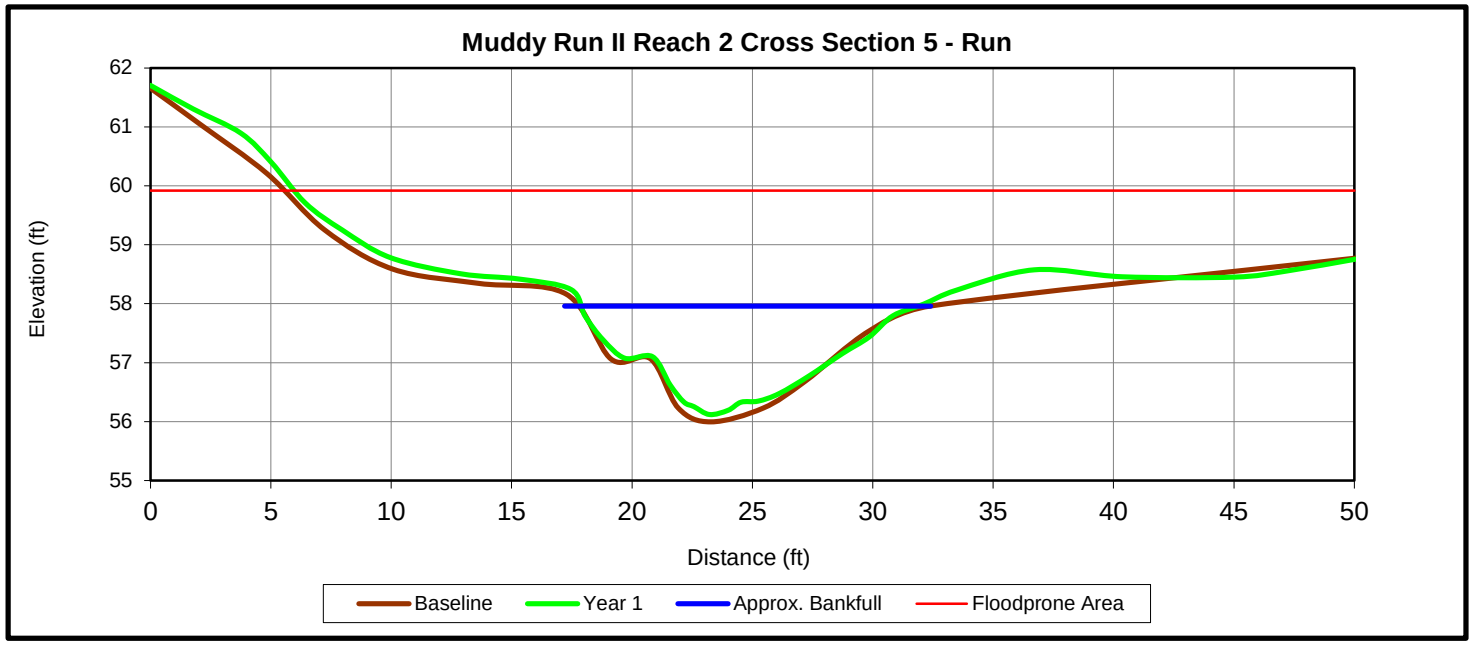

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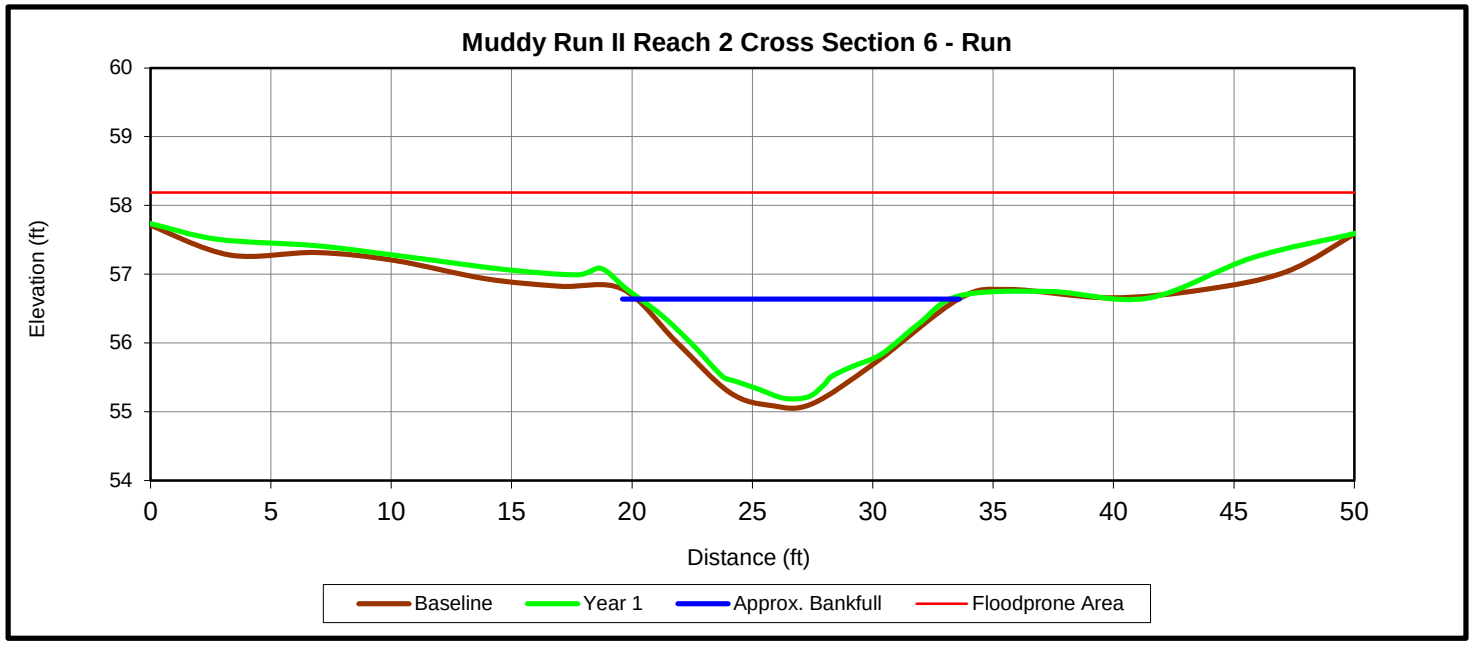

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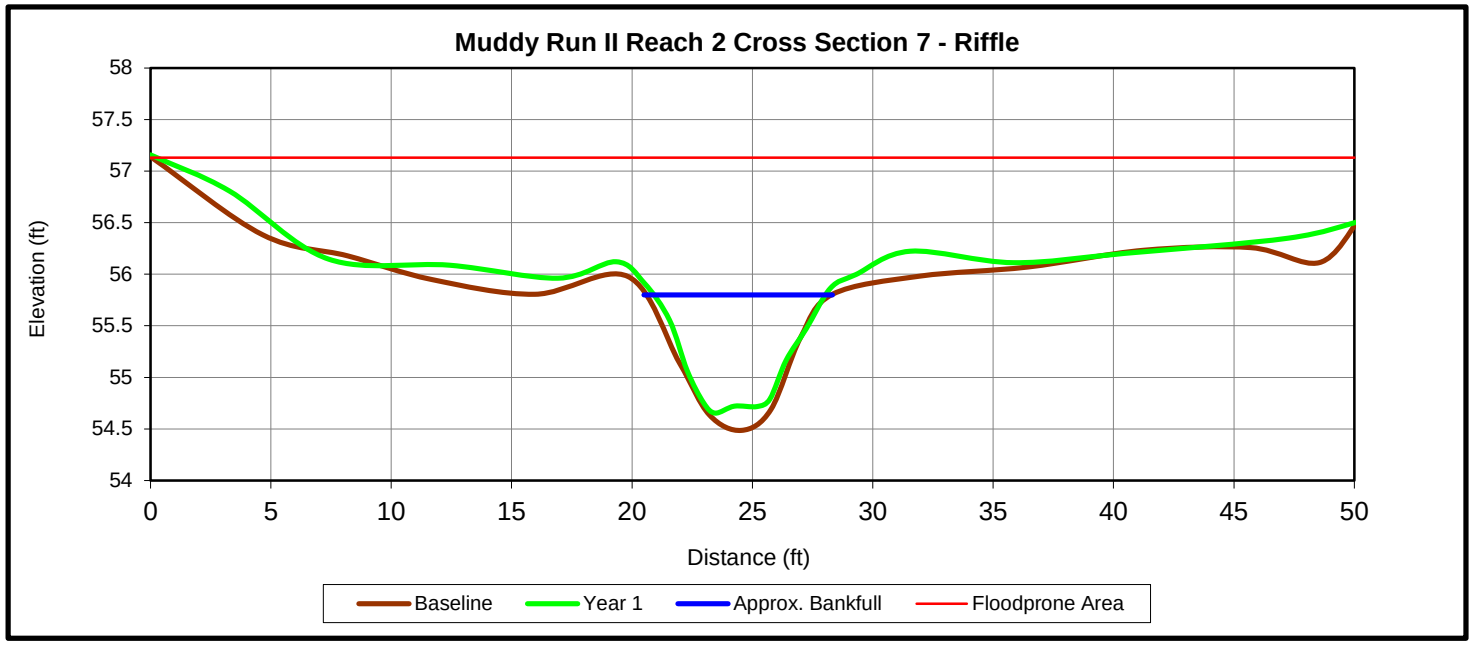

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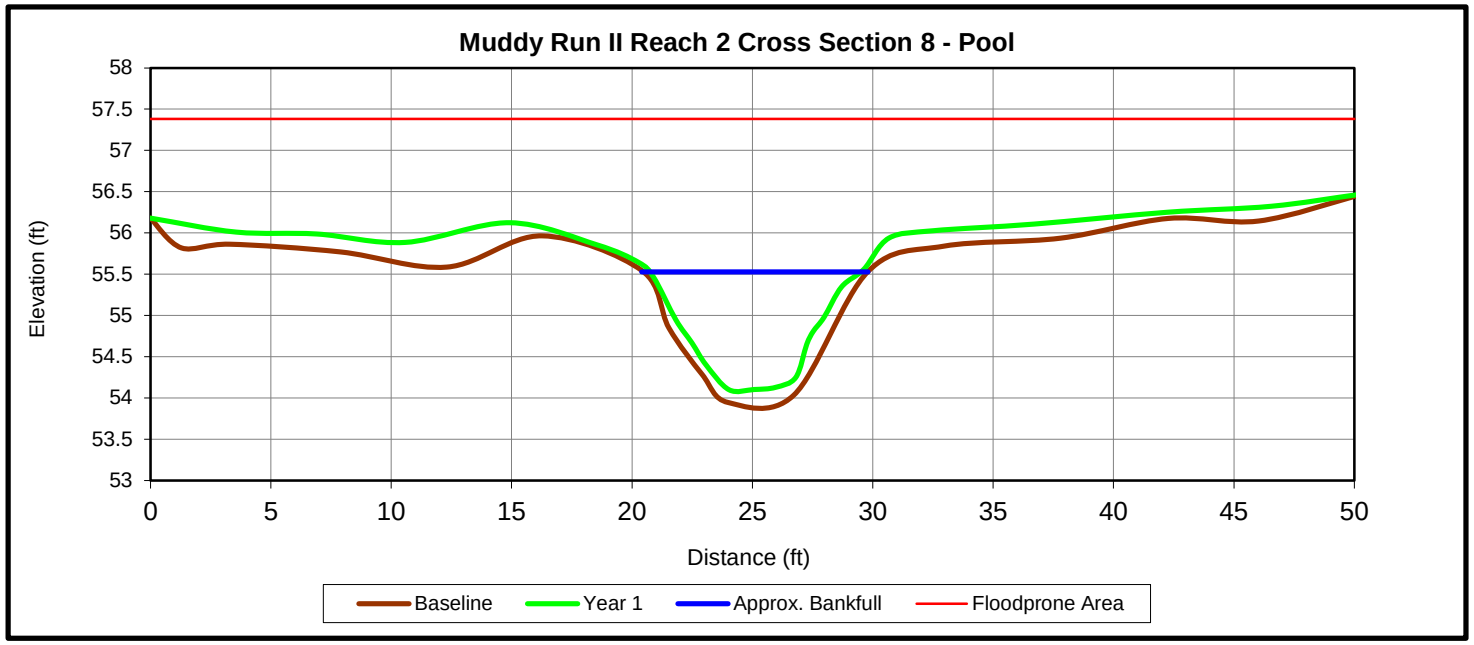

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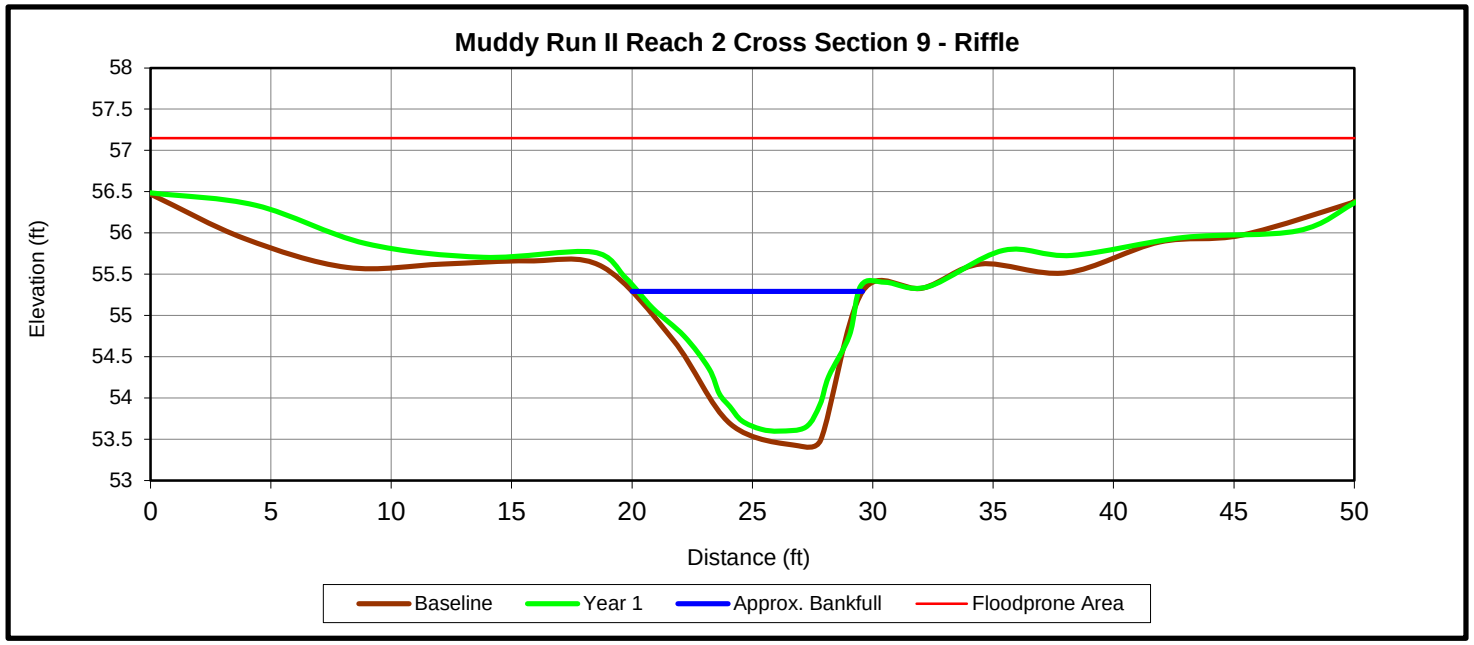

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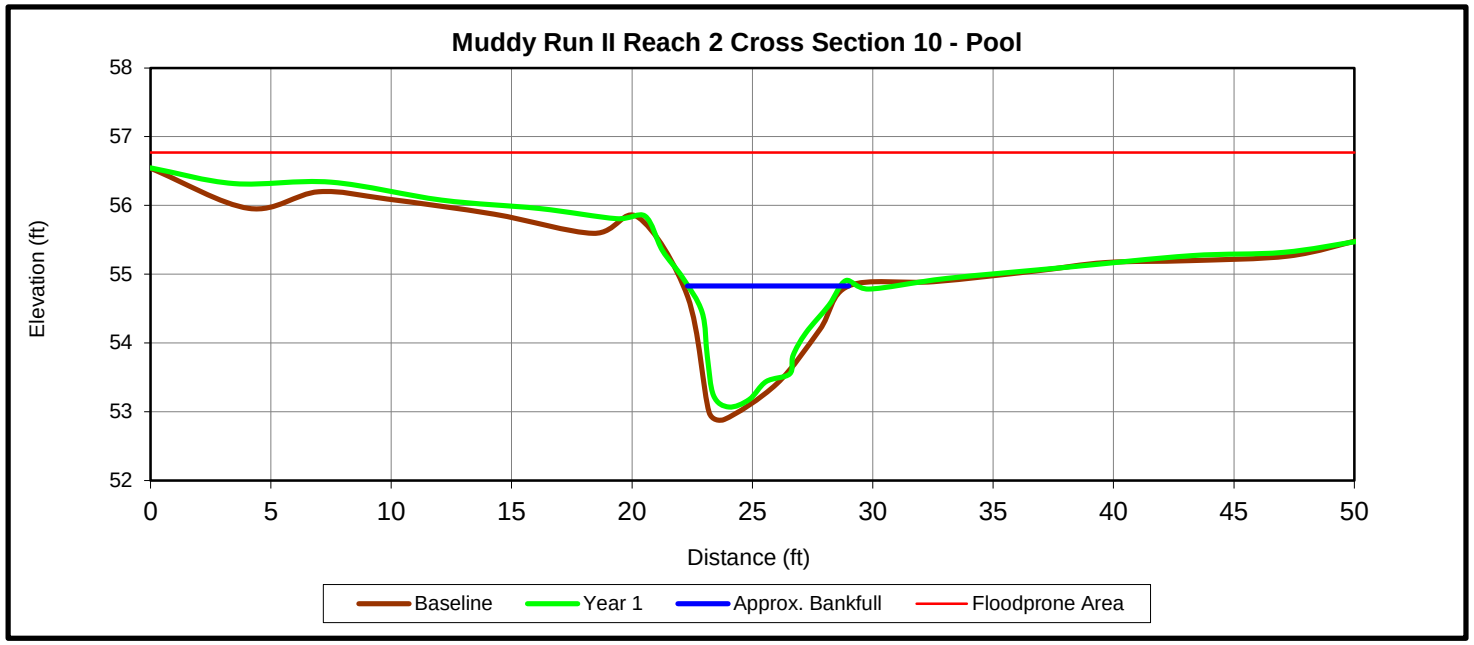

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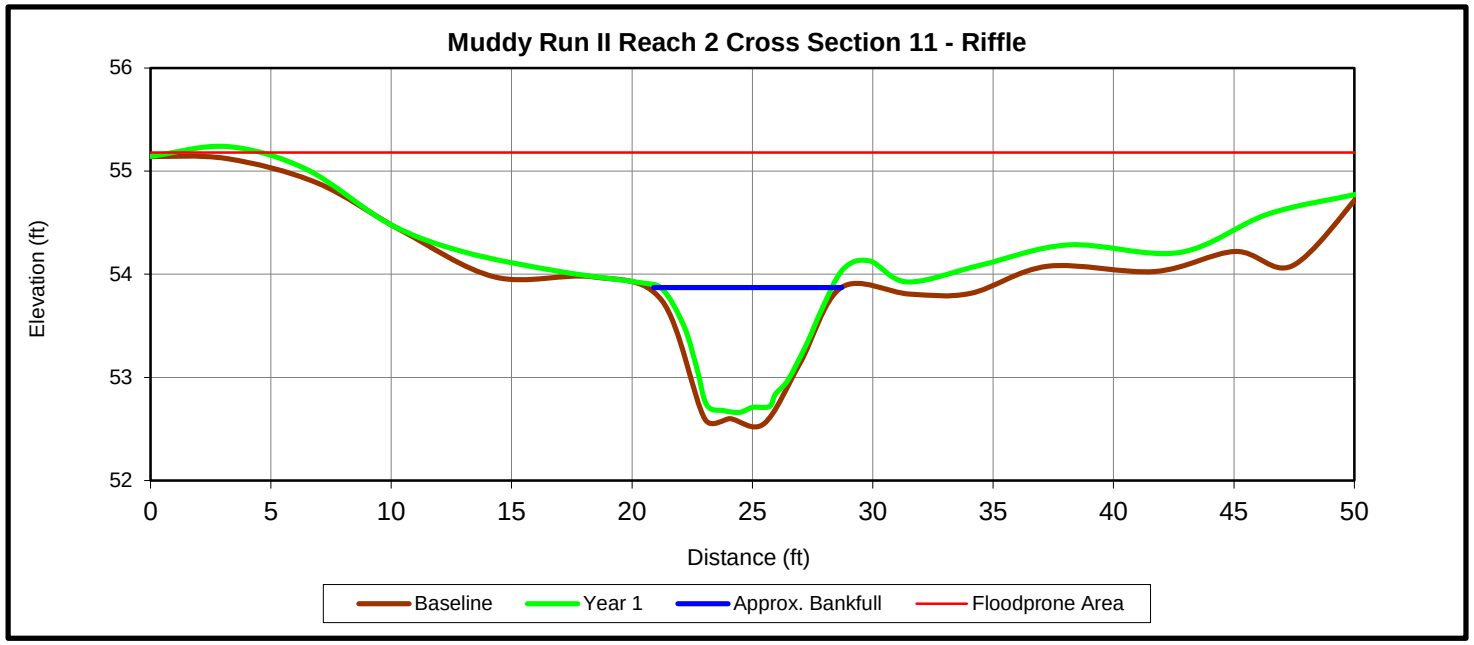
Downstream



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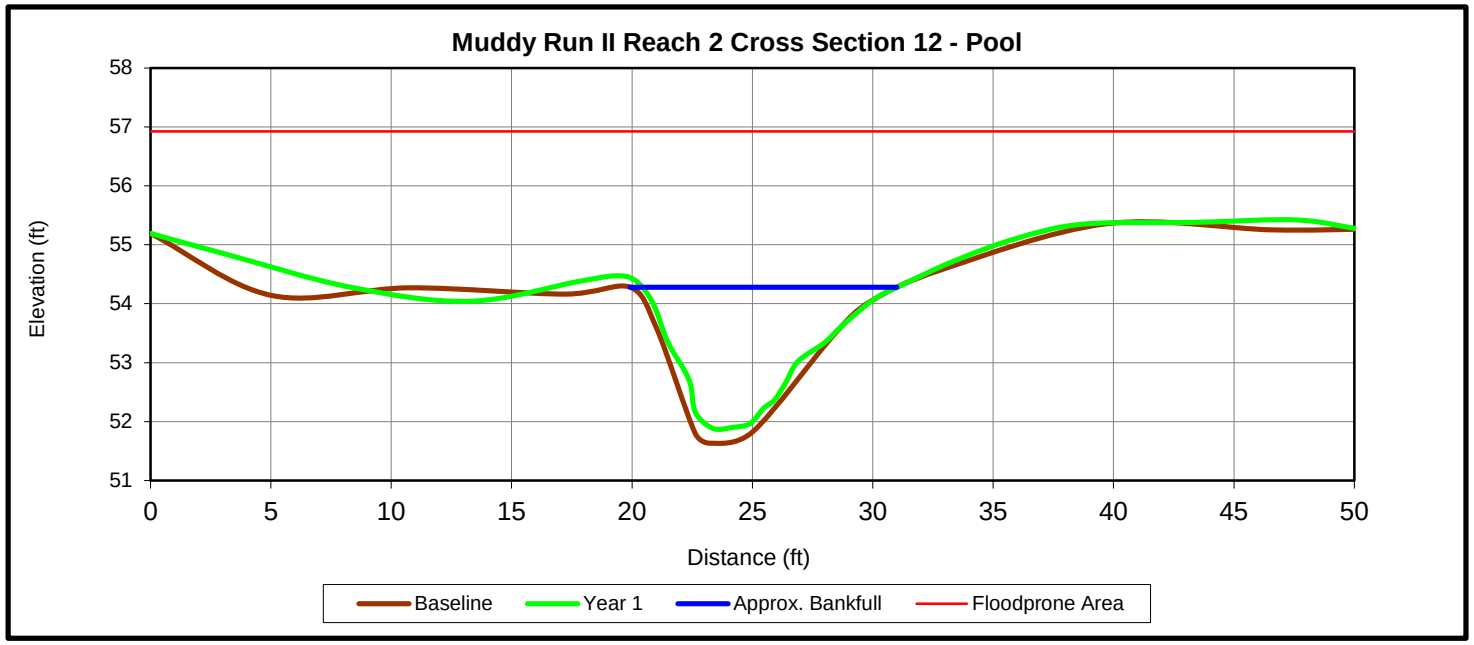

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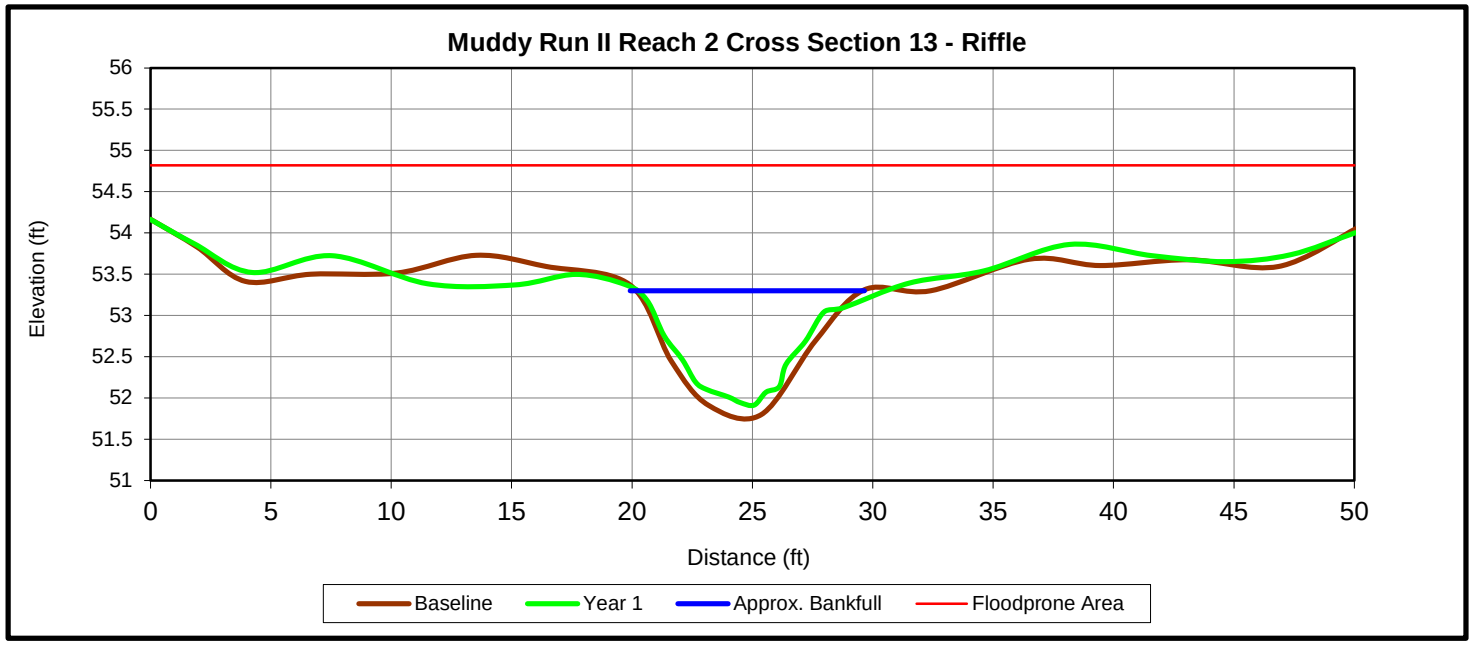
Downstream



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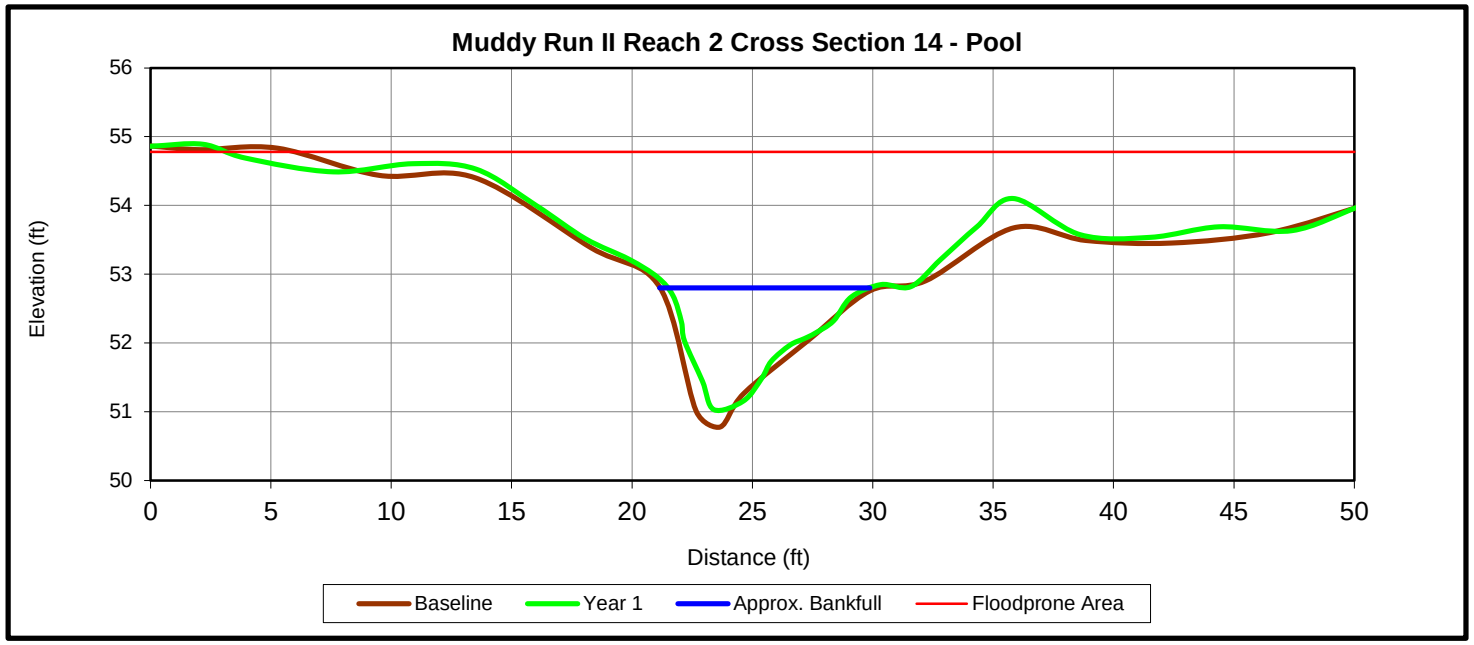
Downstream



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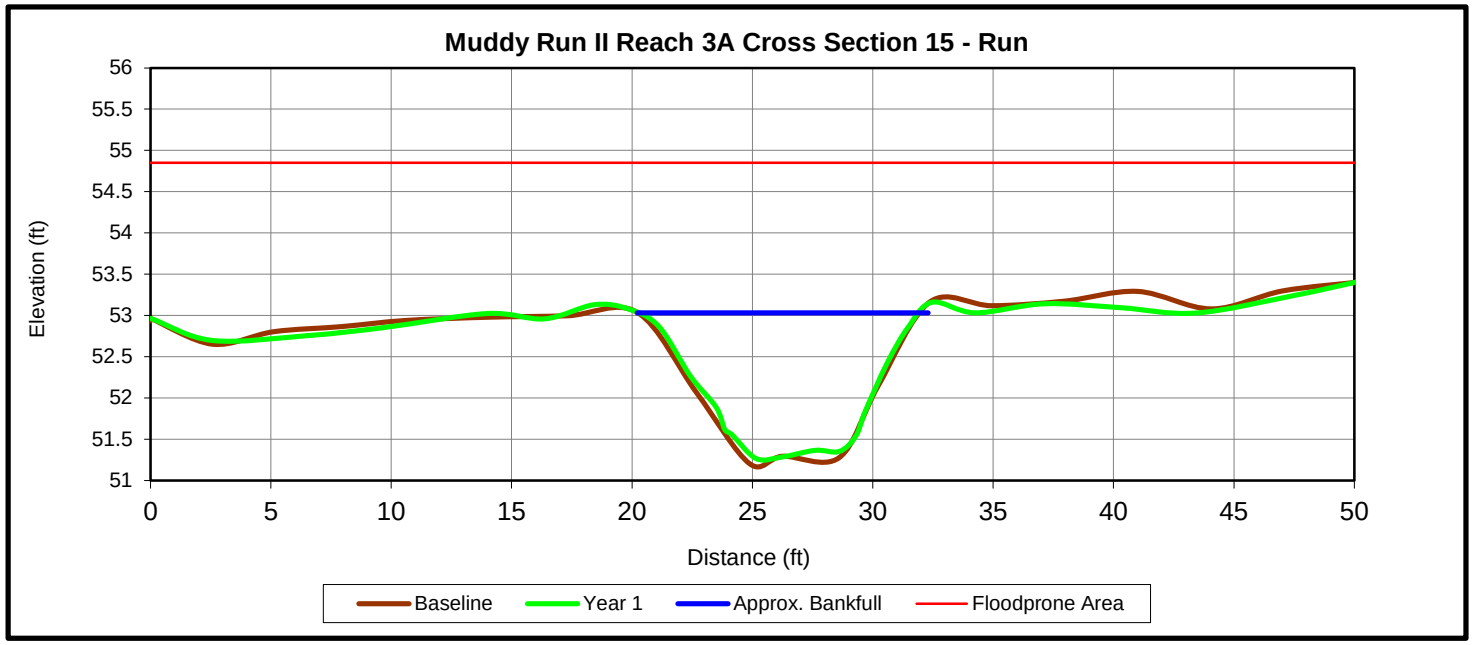
Downstream



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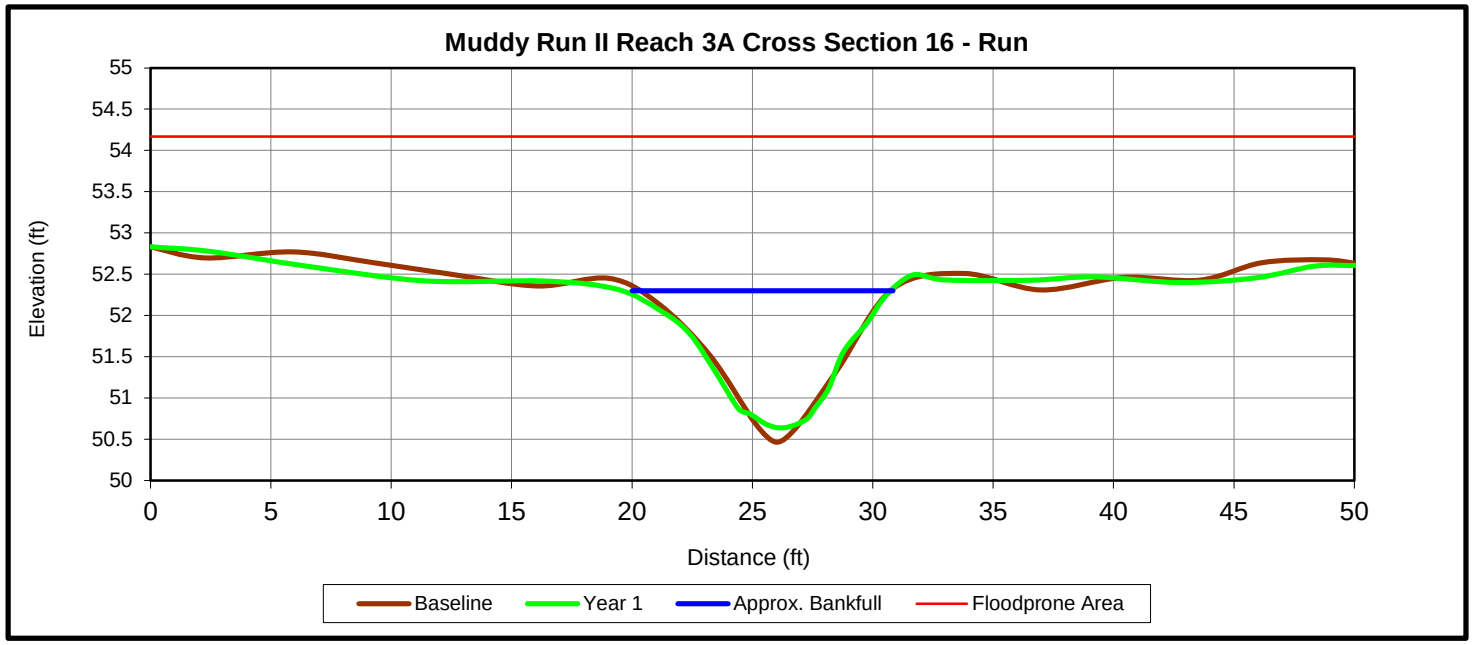

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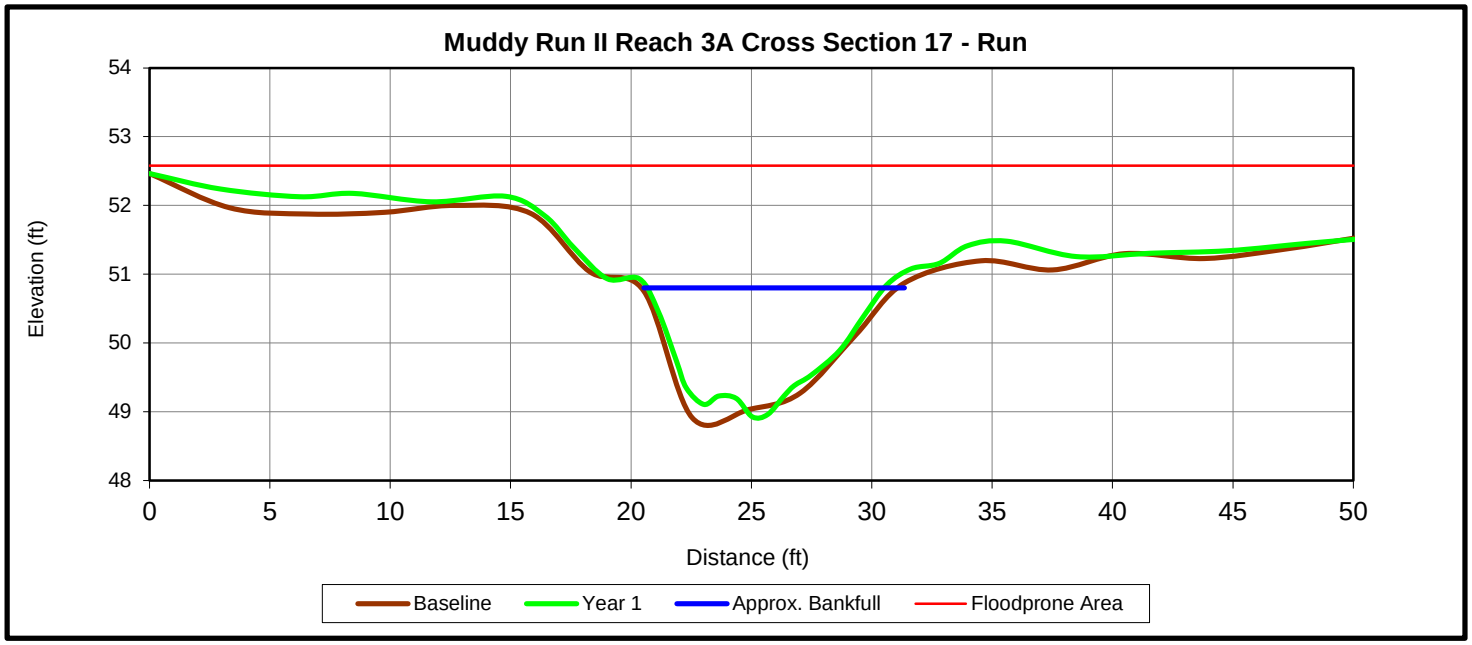
Downstream



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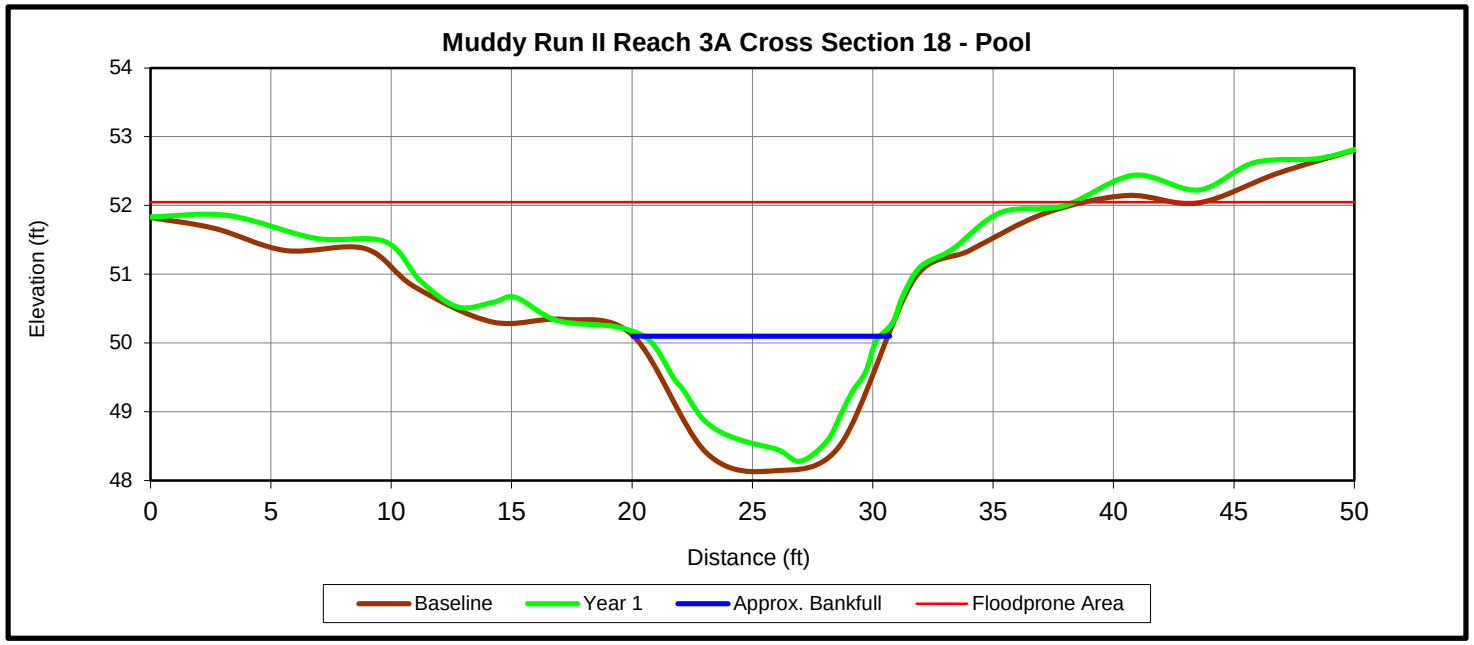
Downstream



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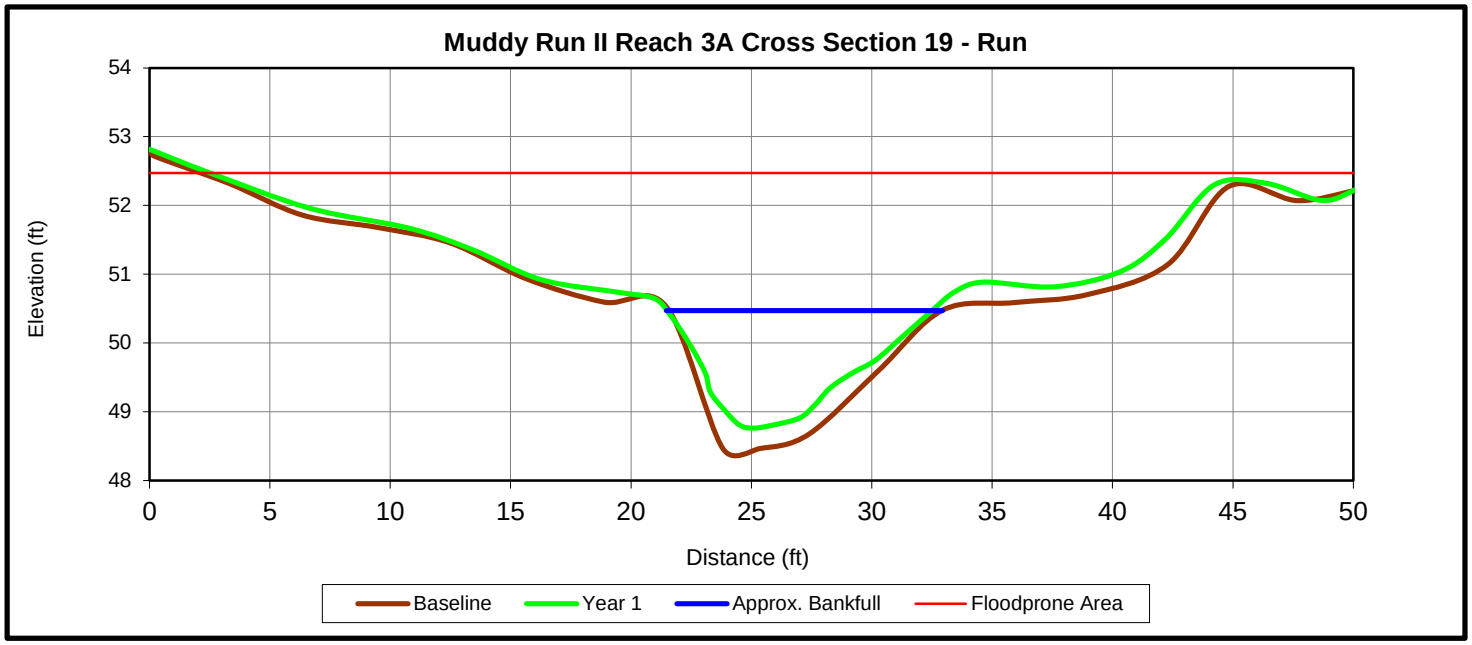
Downstream



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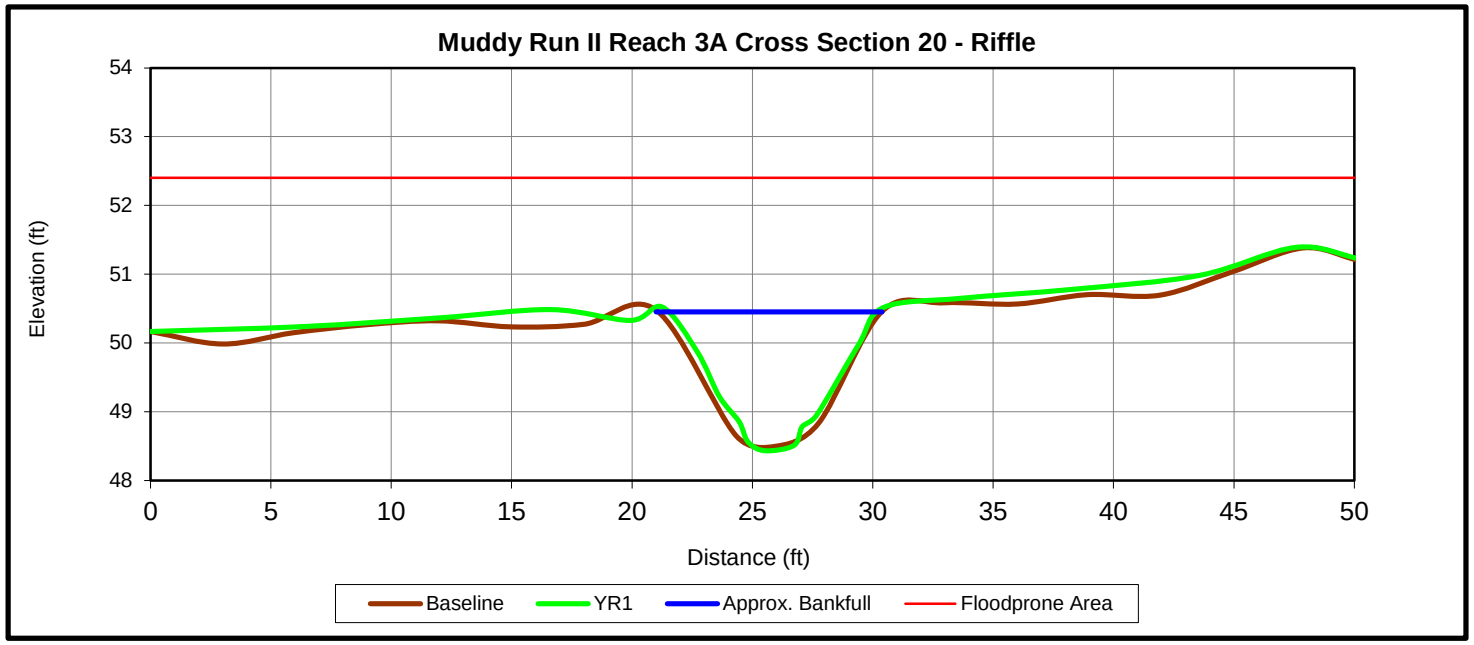
Downstream



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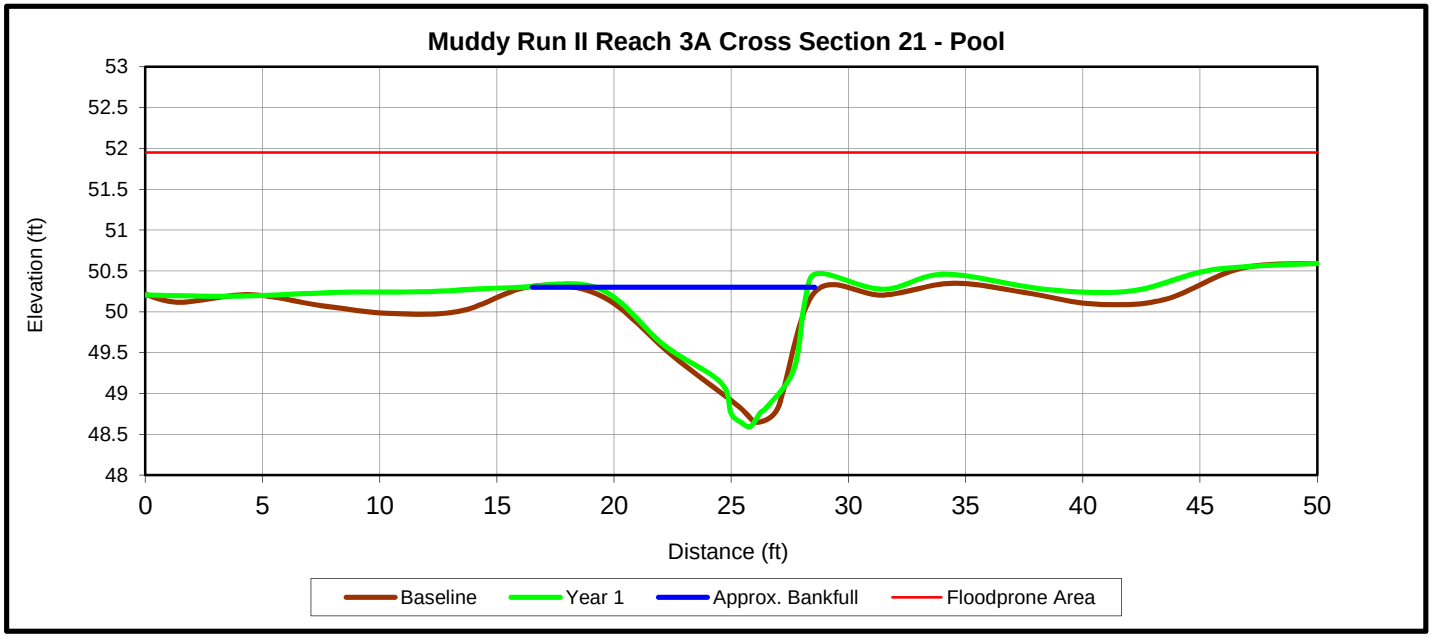

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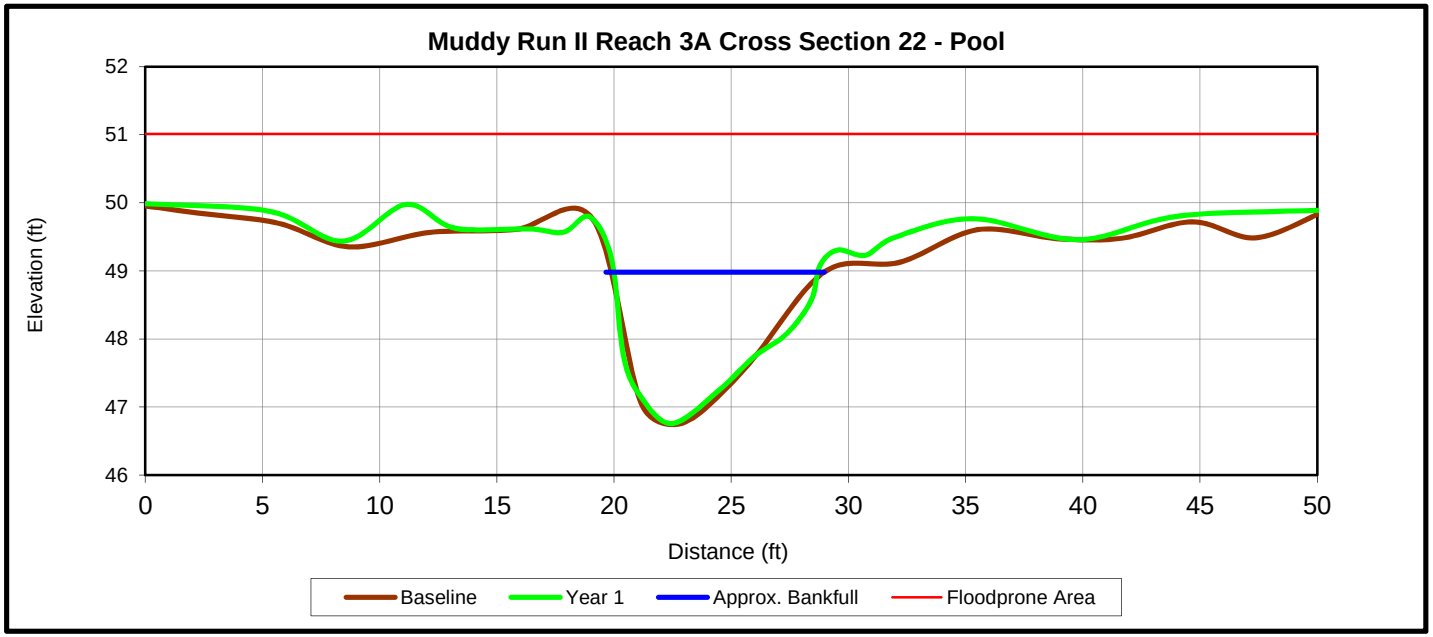
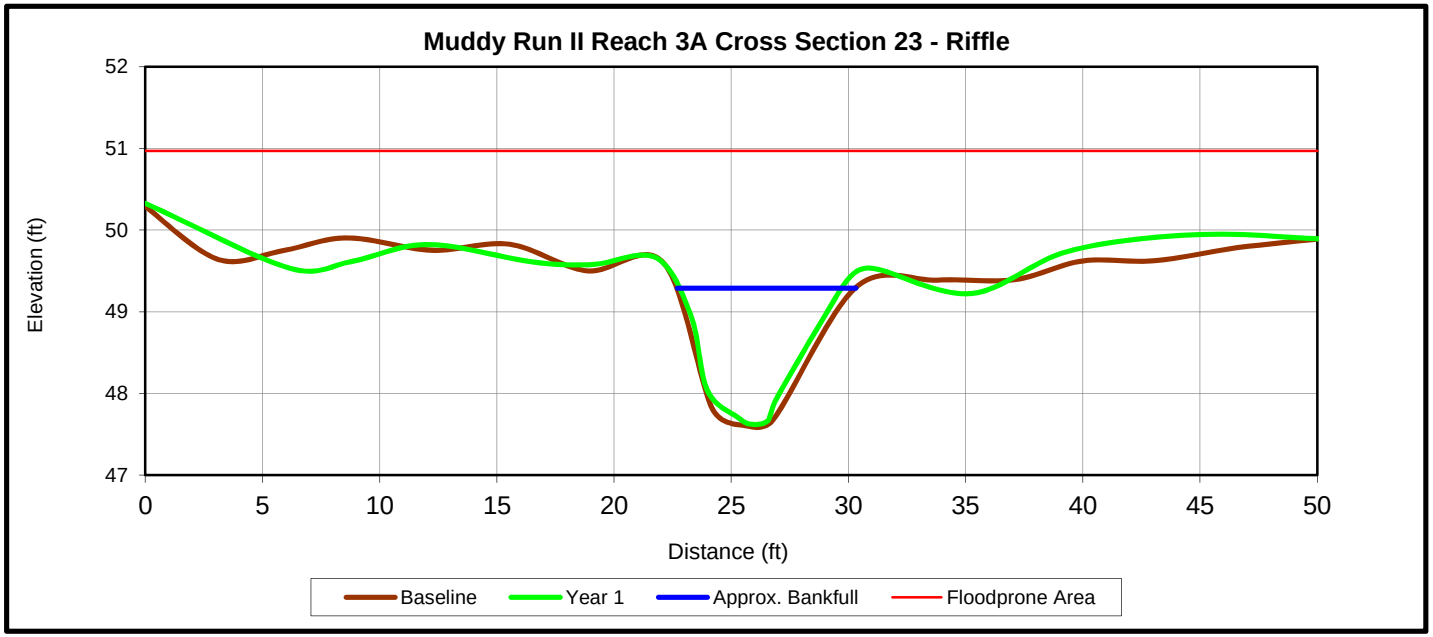


Upstream

Downstream



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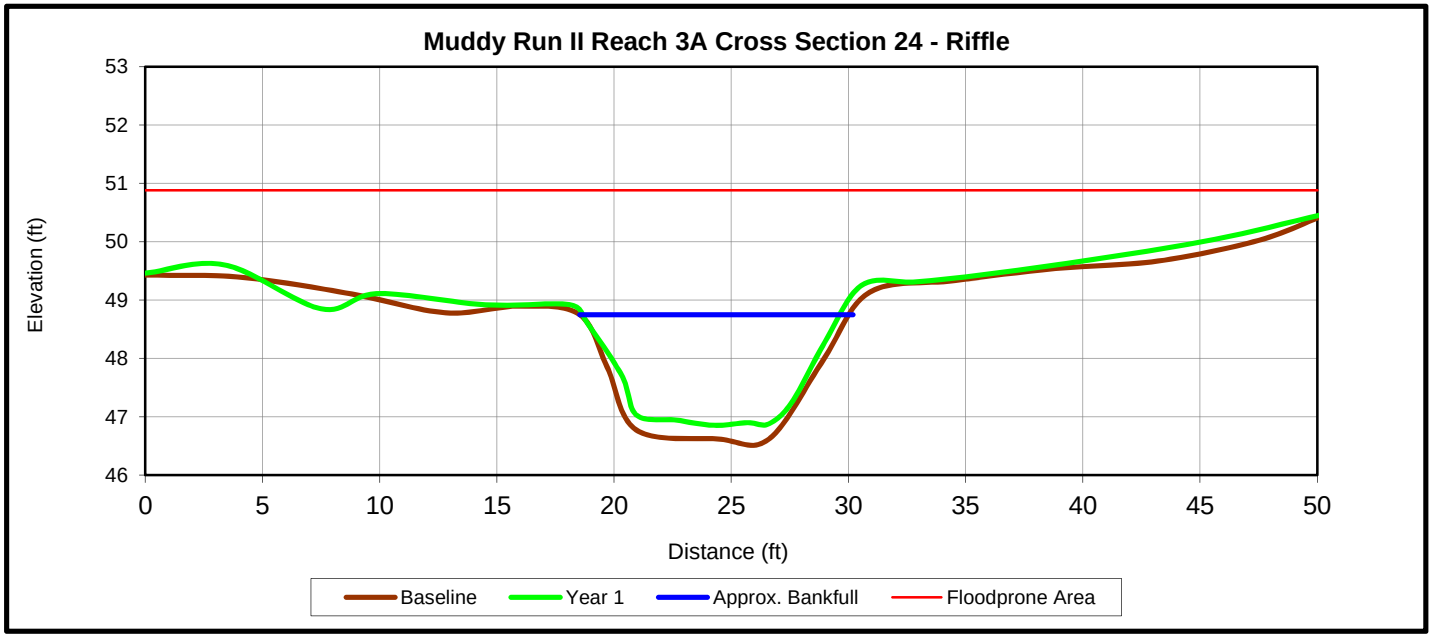
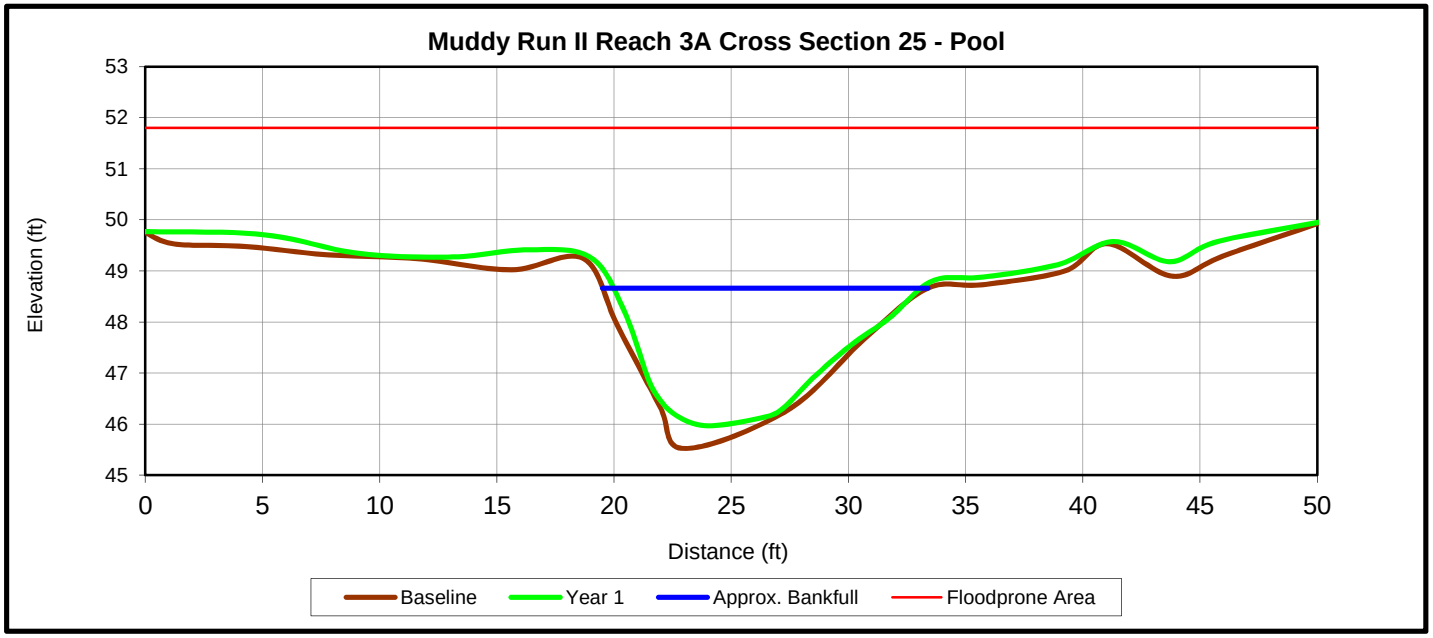
Downstream



Upstream

Downstream



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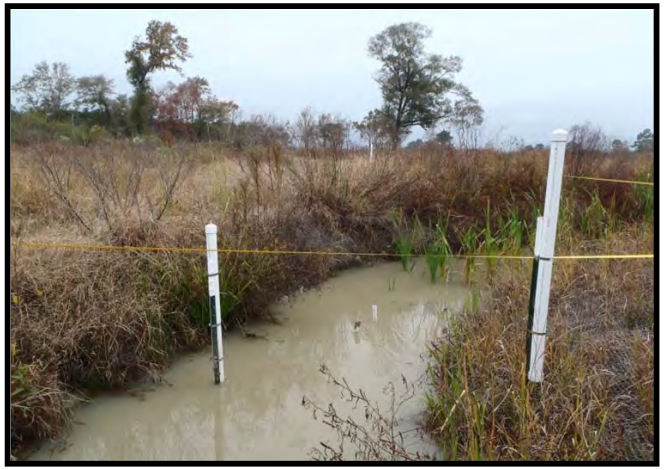

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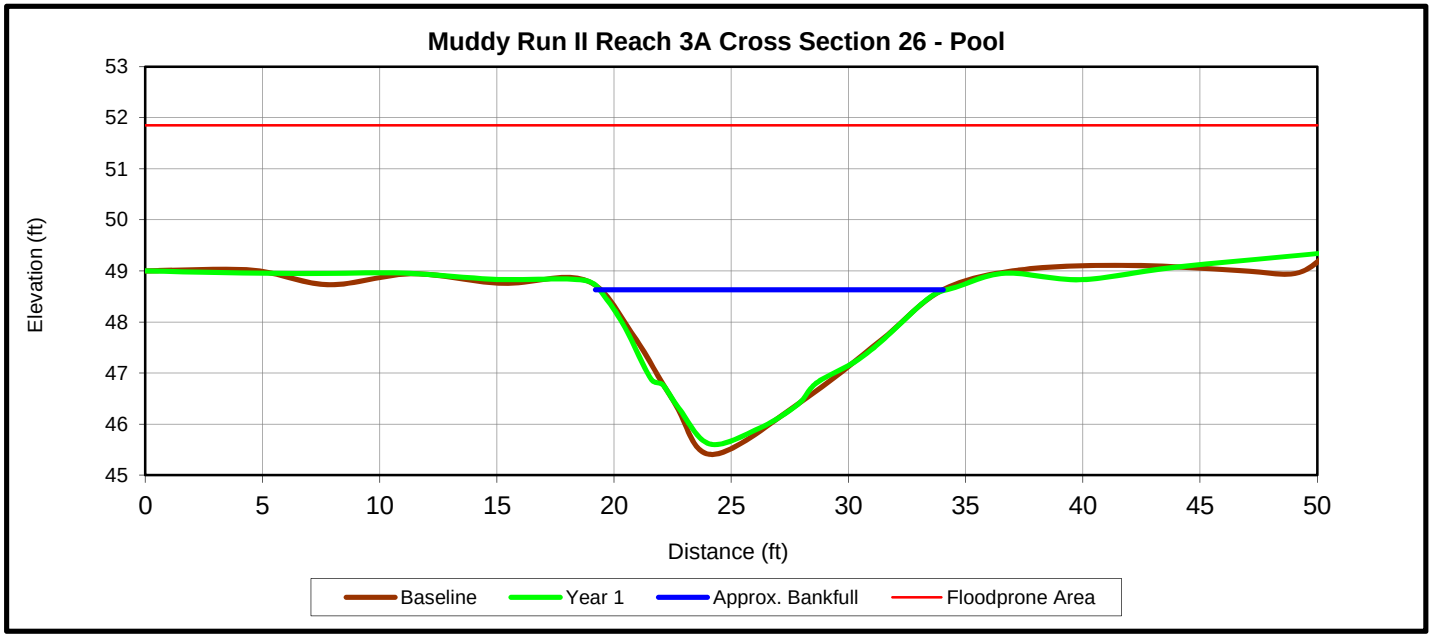

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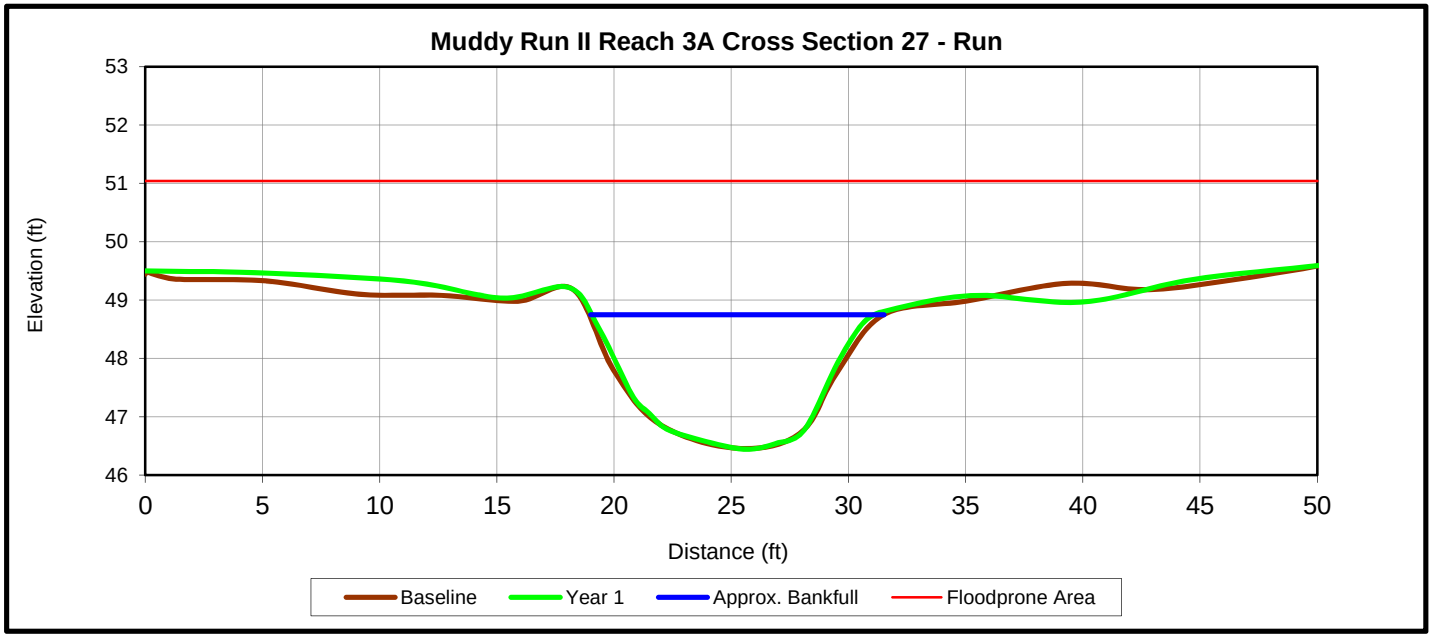

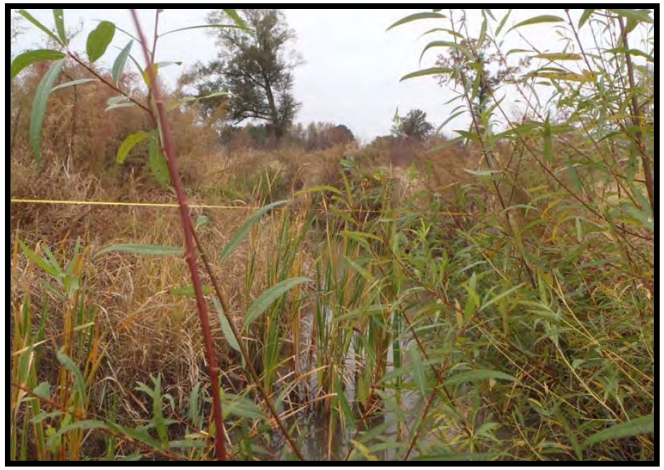

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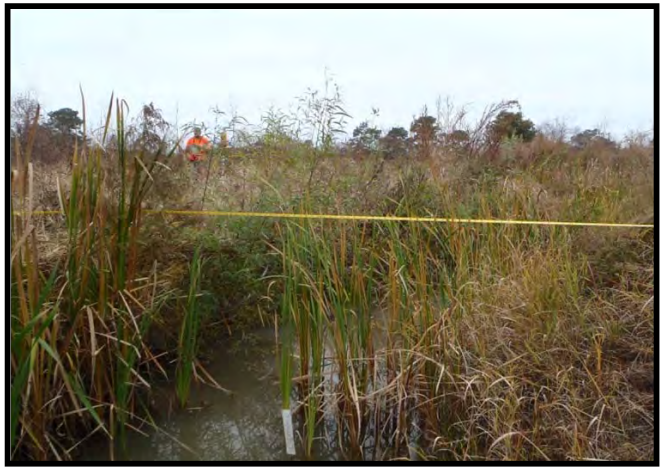

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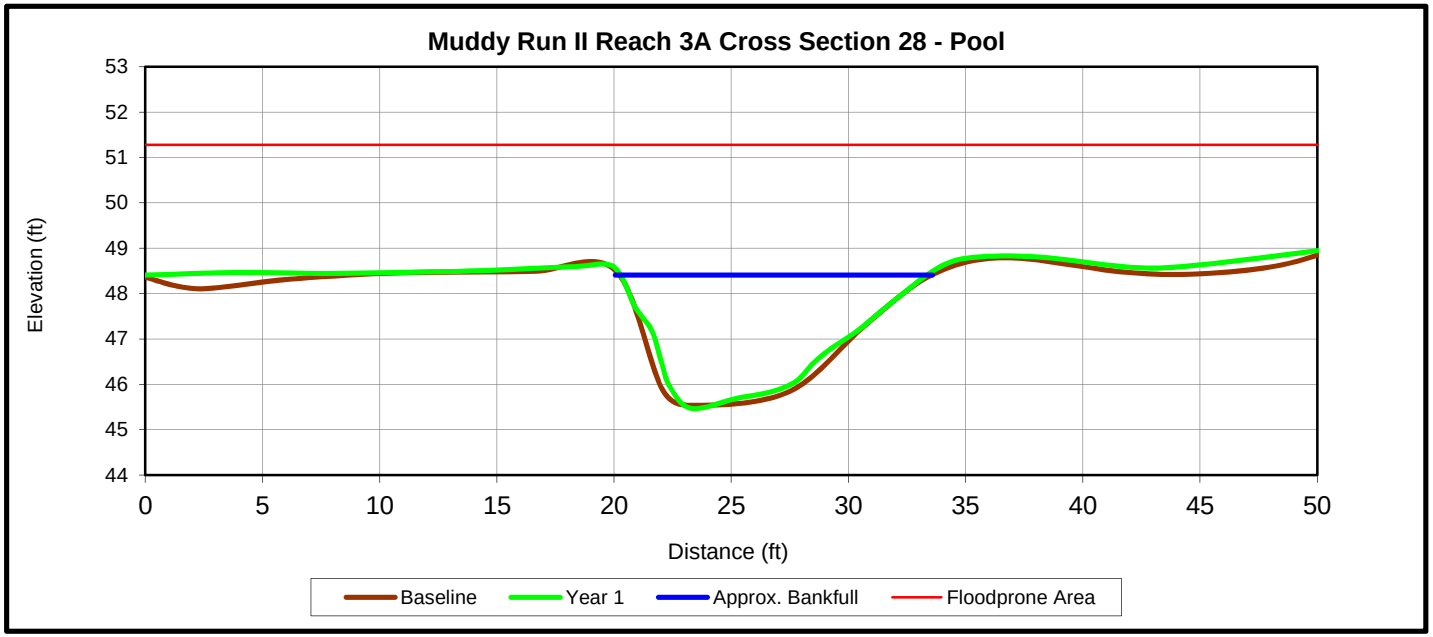

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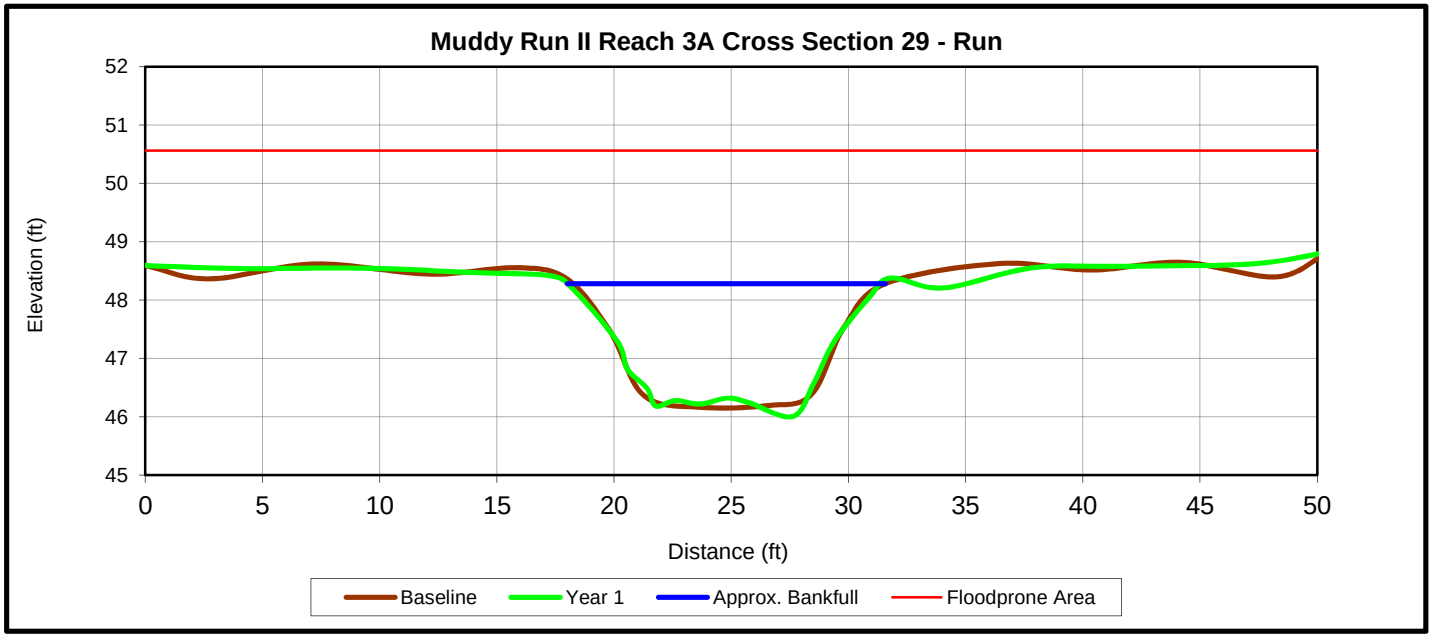

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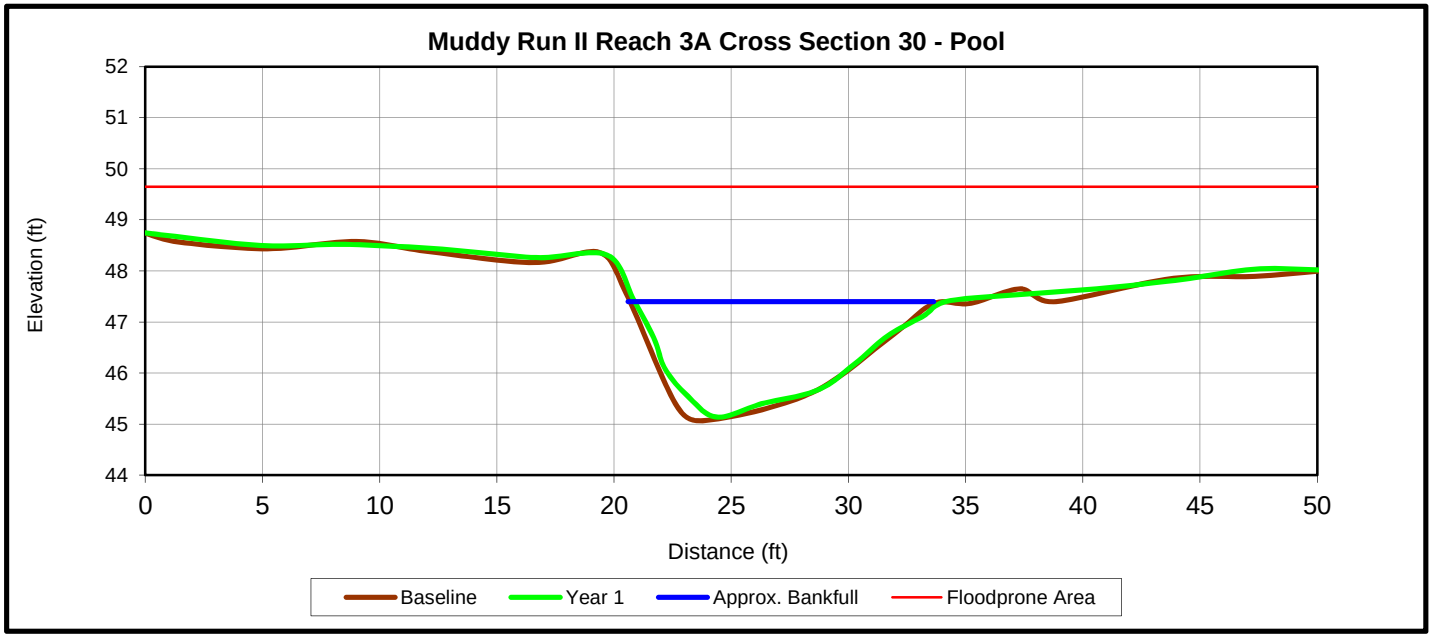

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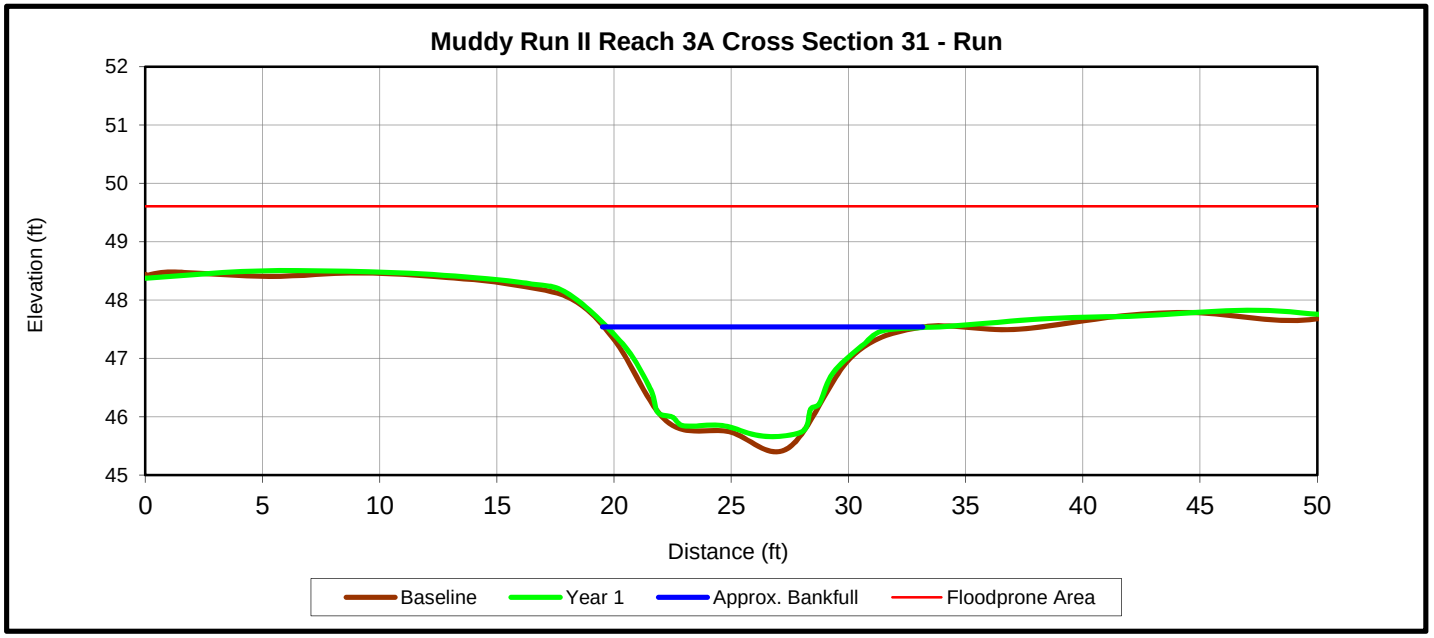

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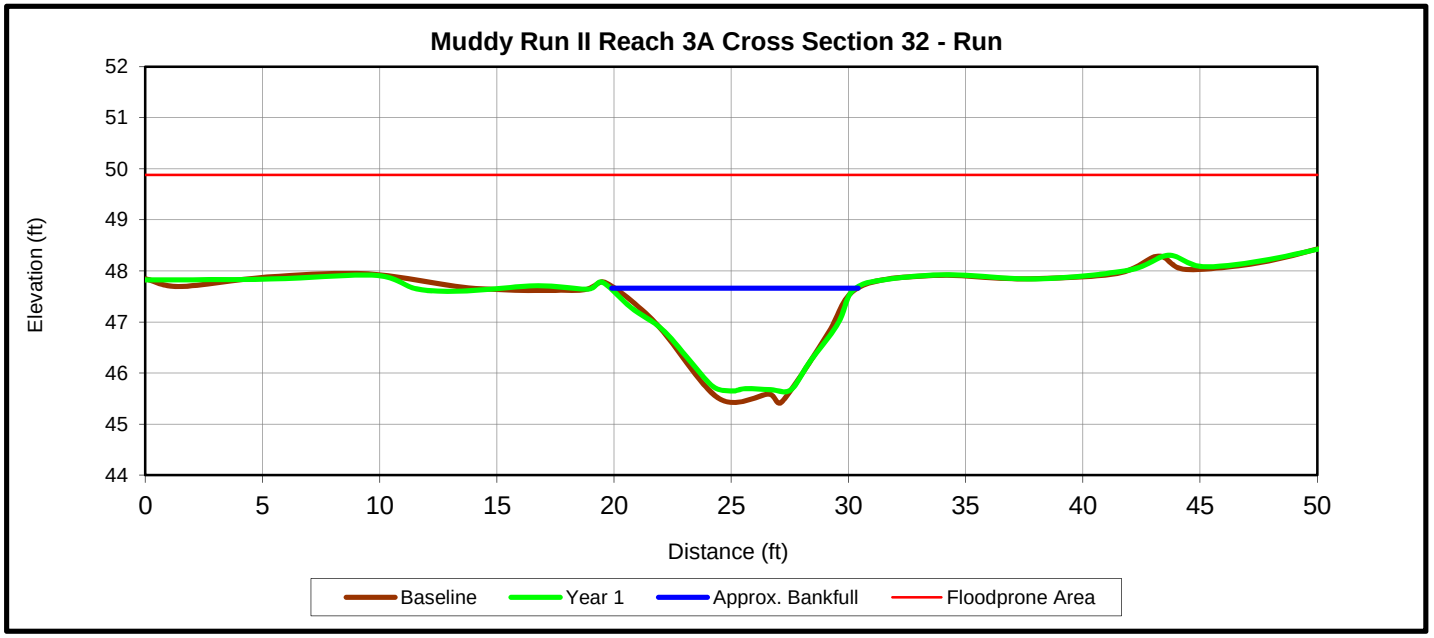

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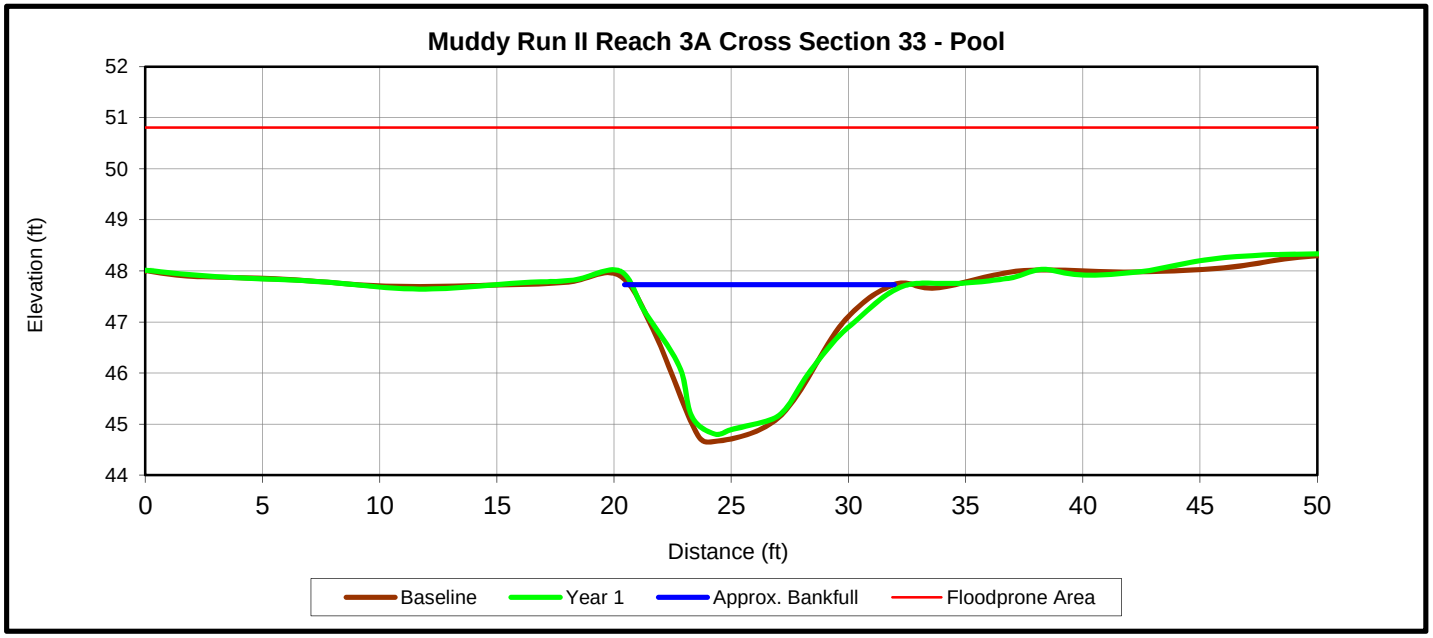

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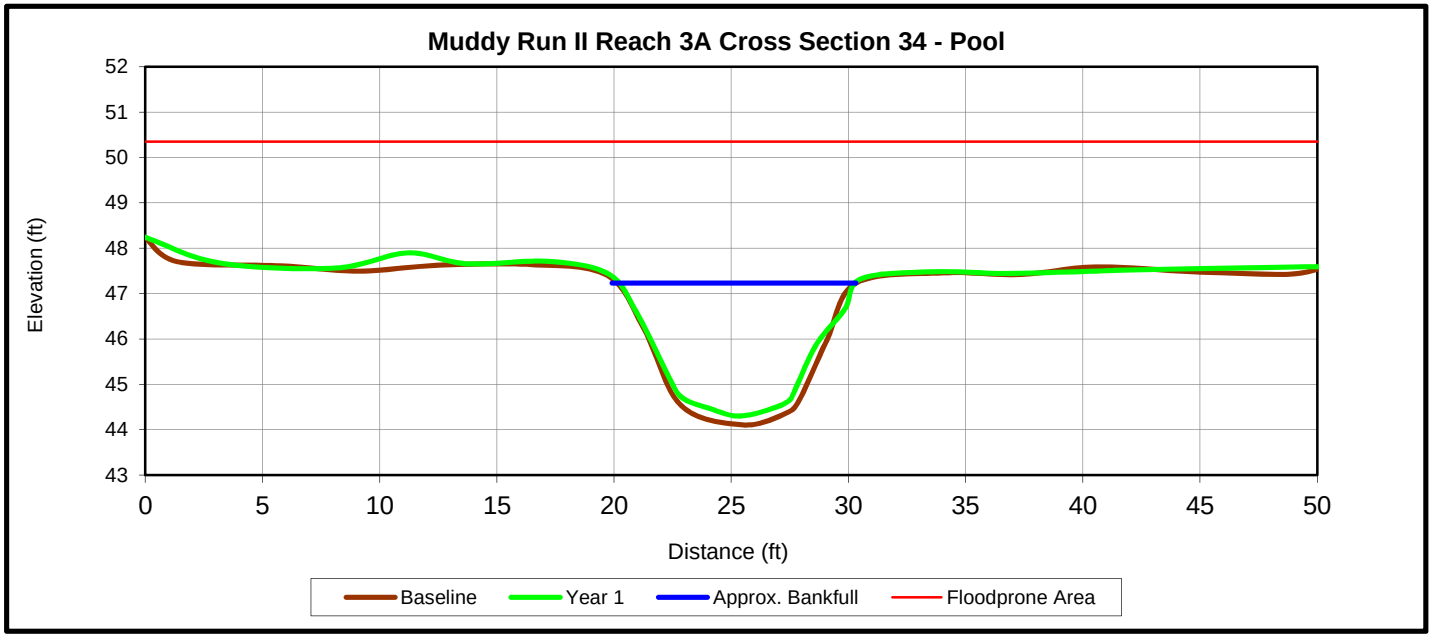

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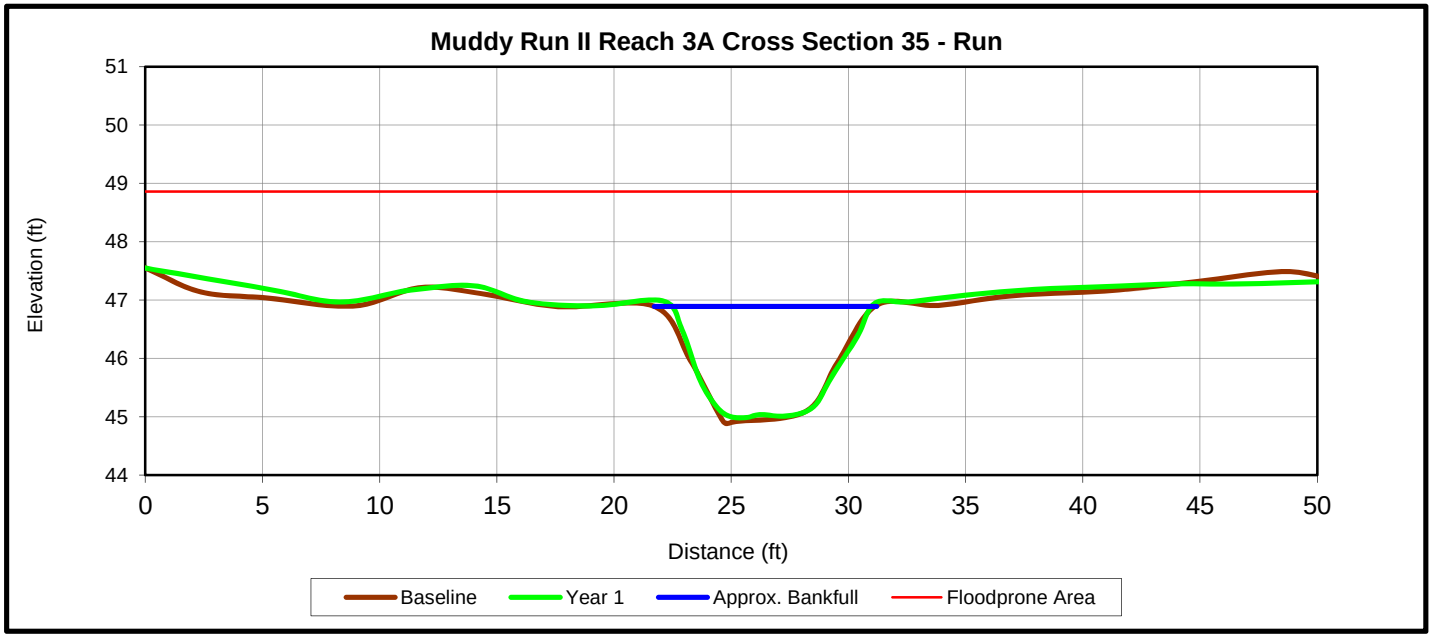

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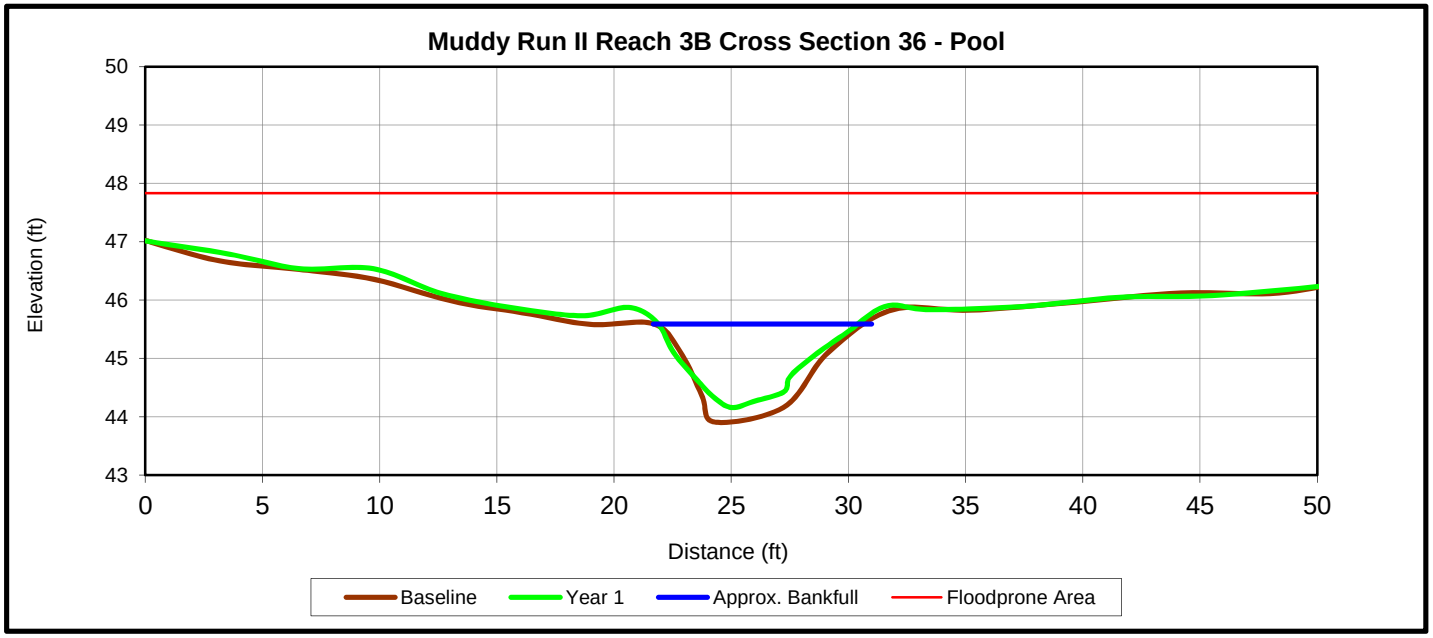

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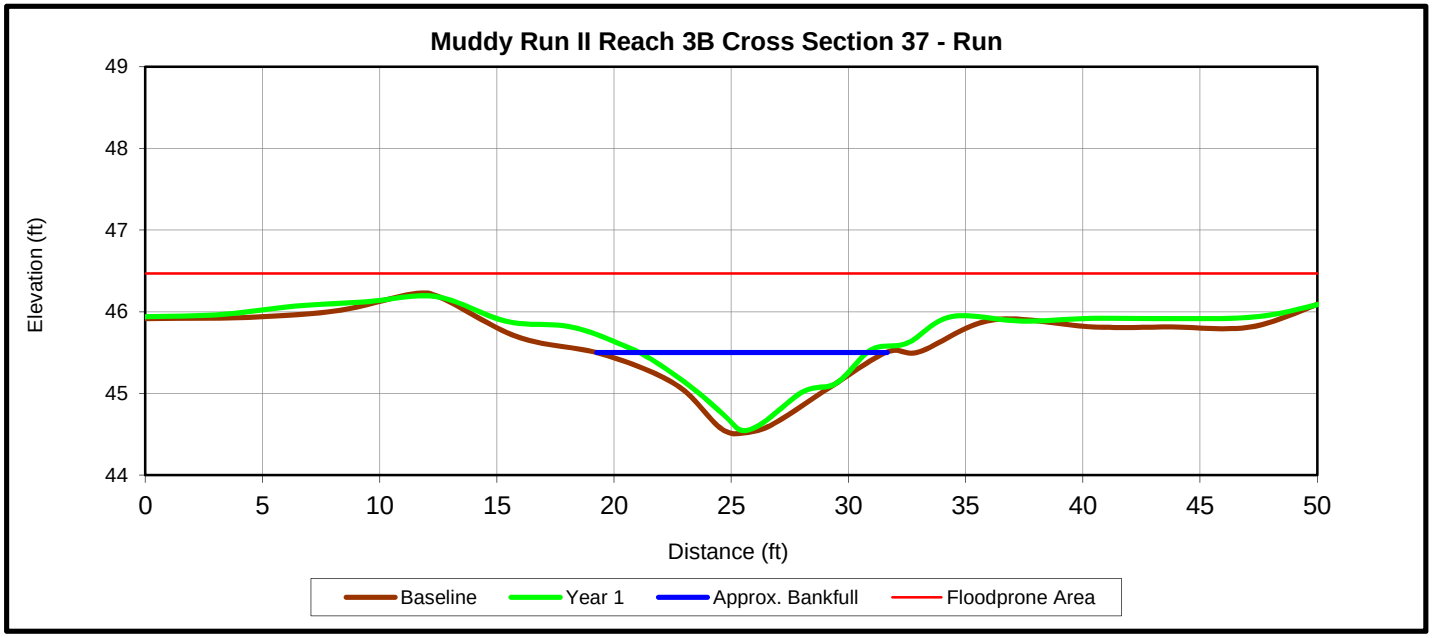

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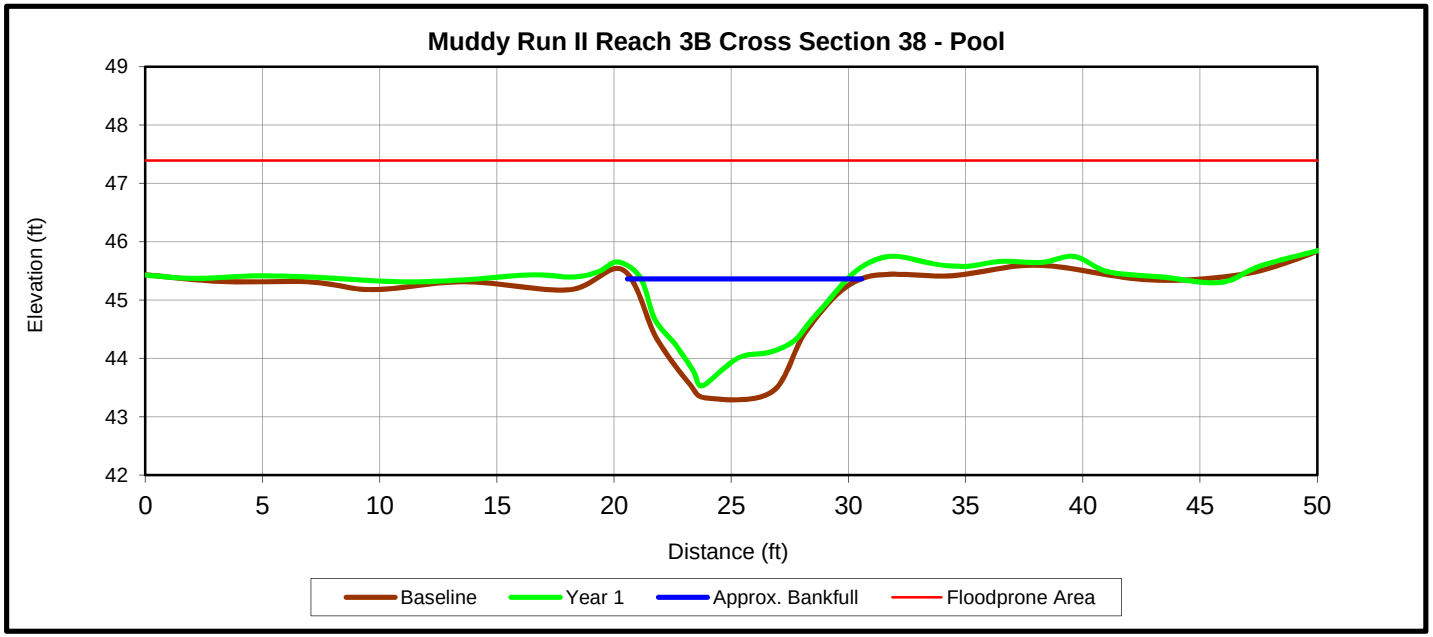

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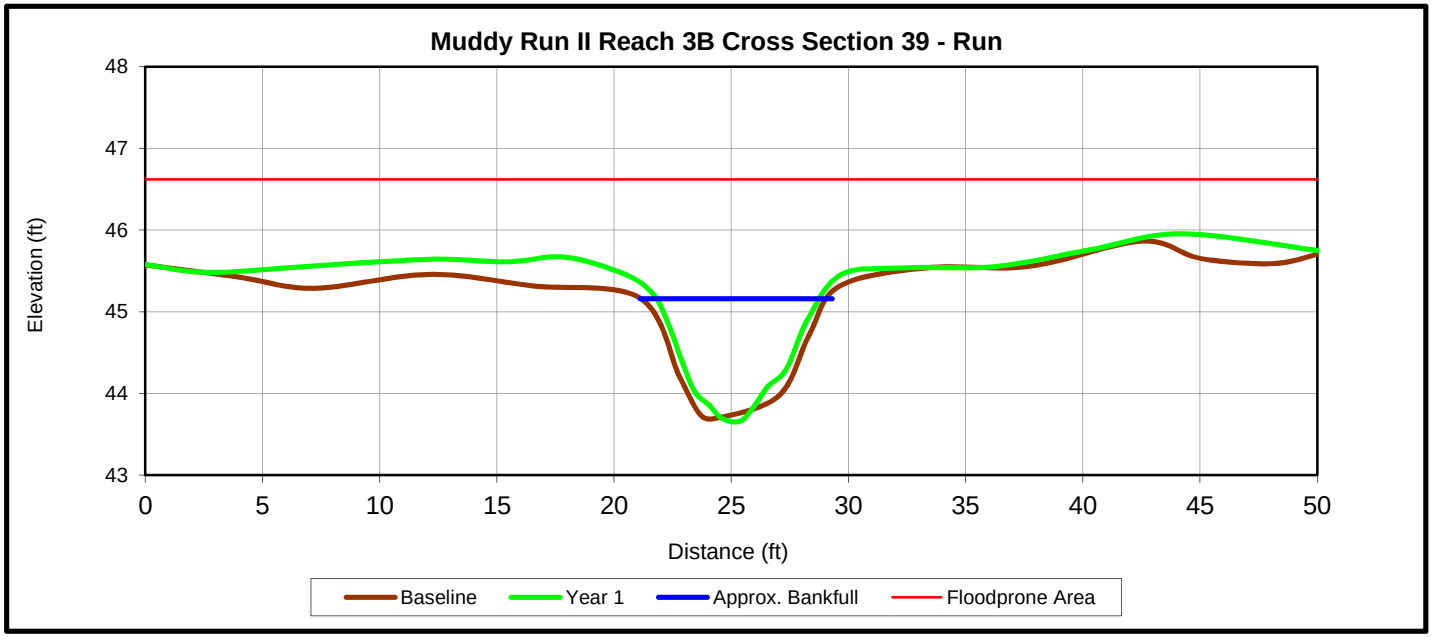

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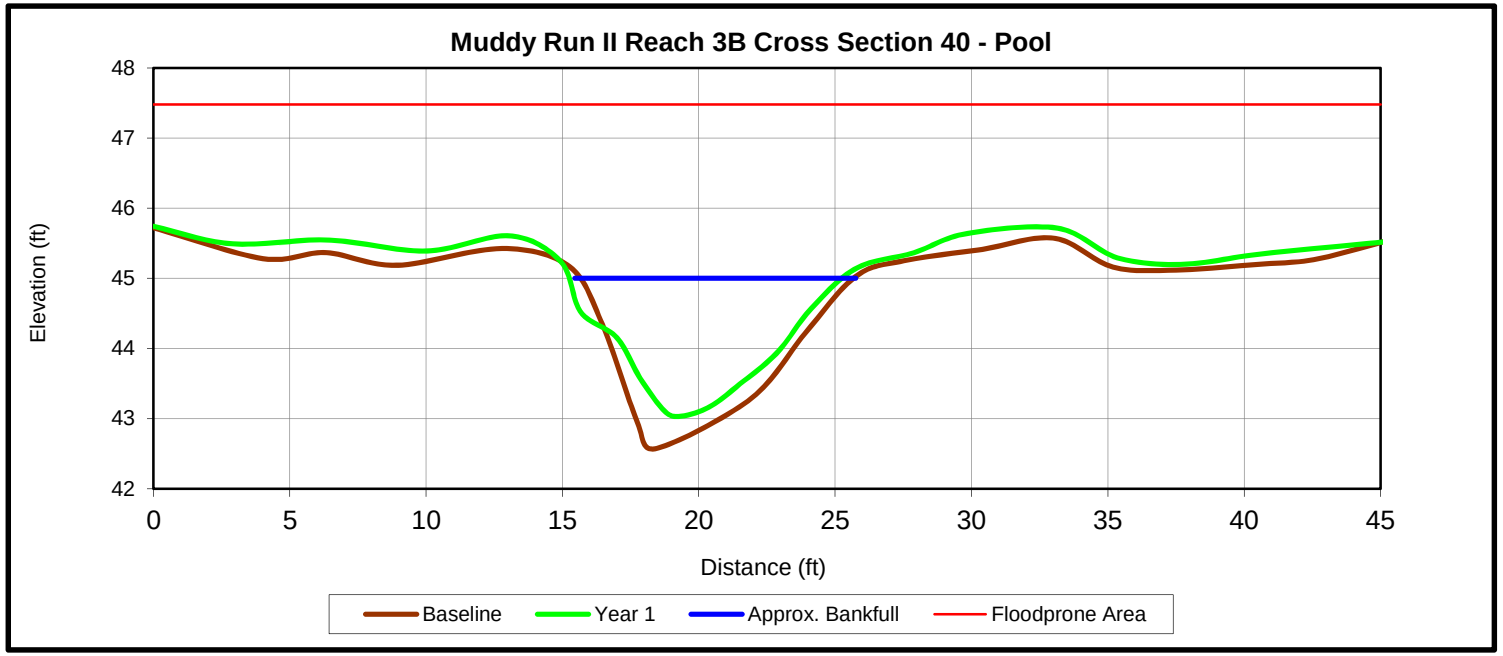

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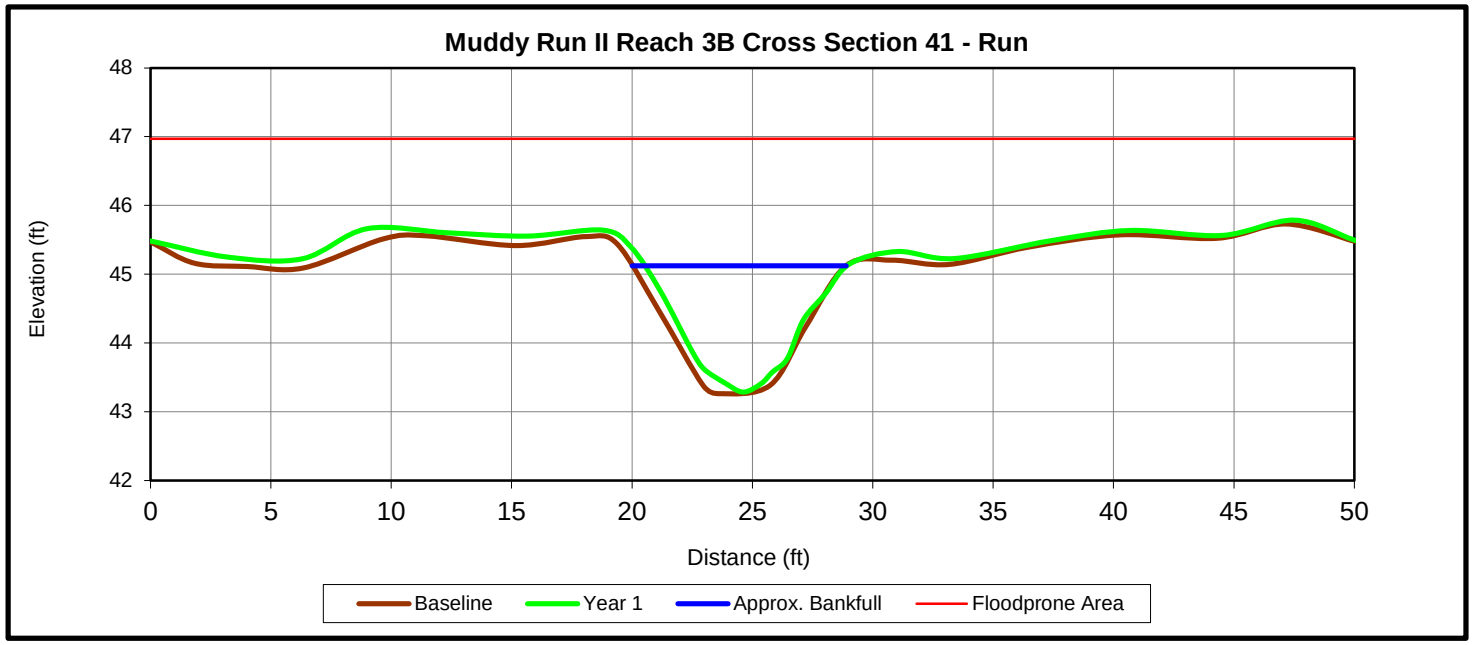

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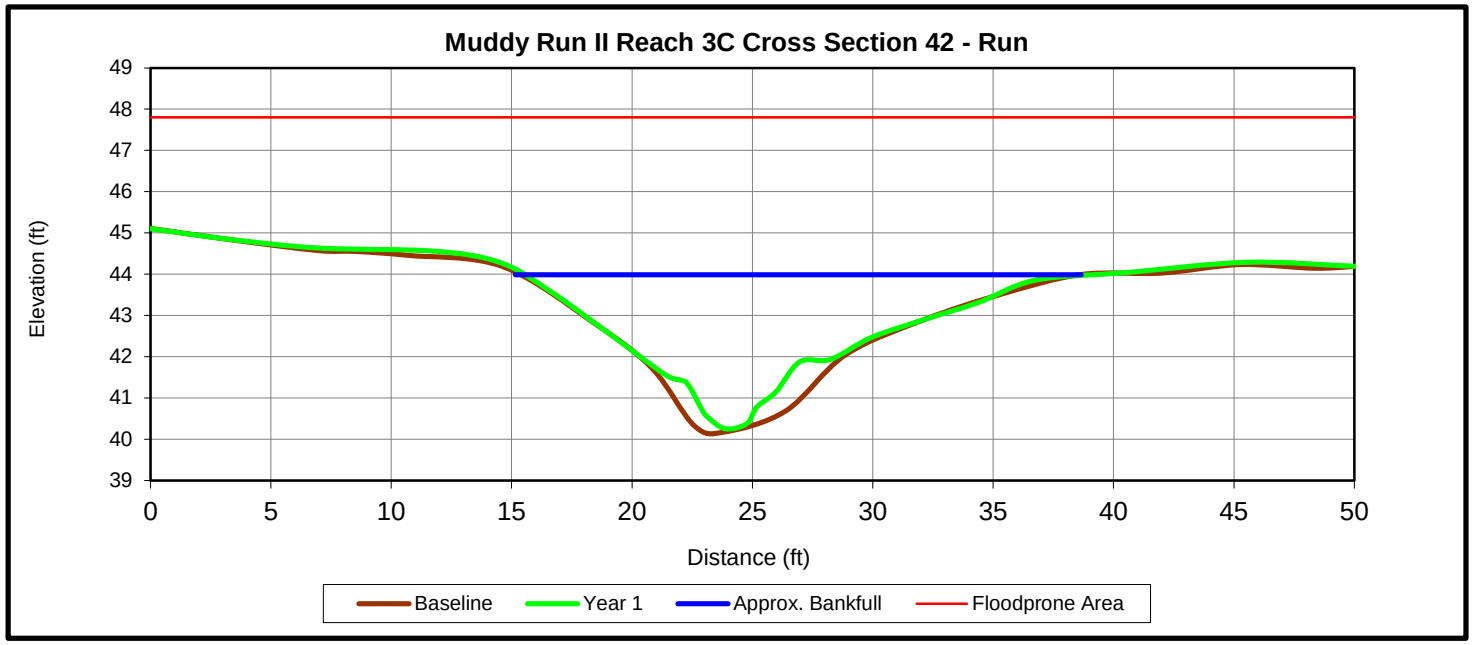

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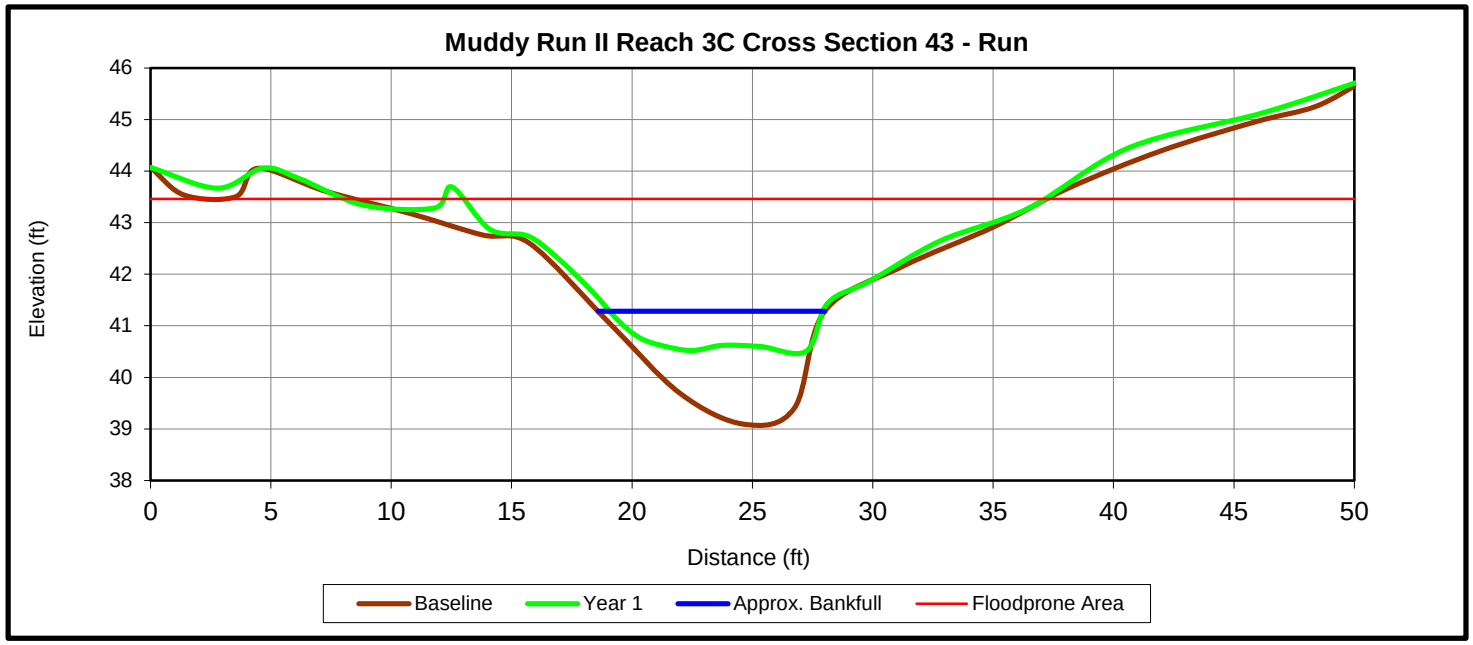

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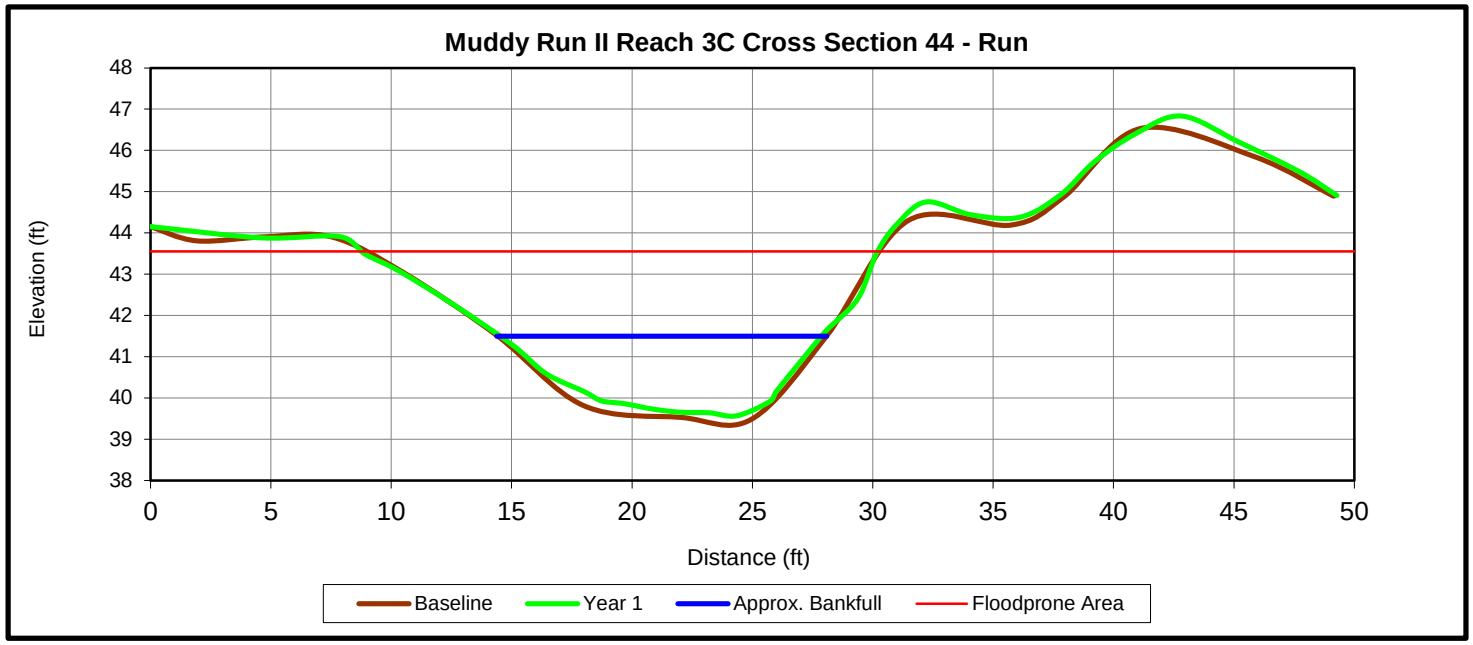

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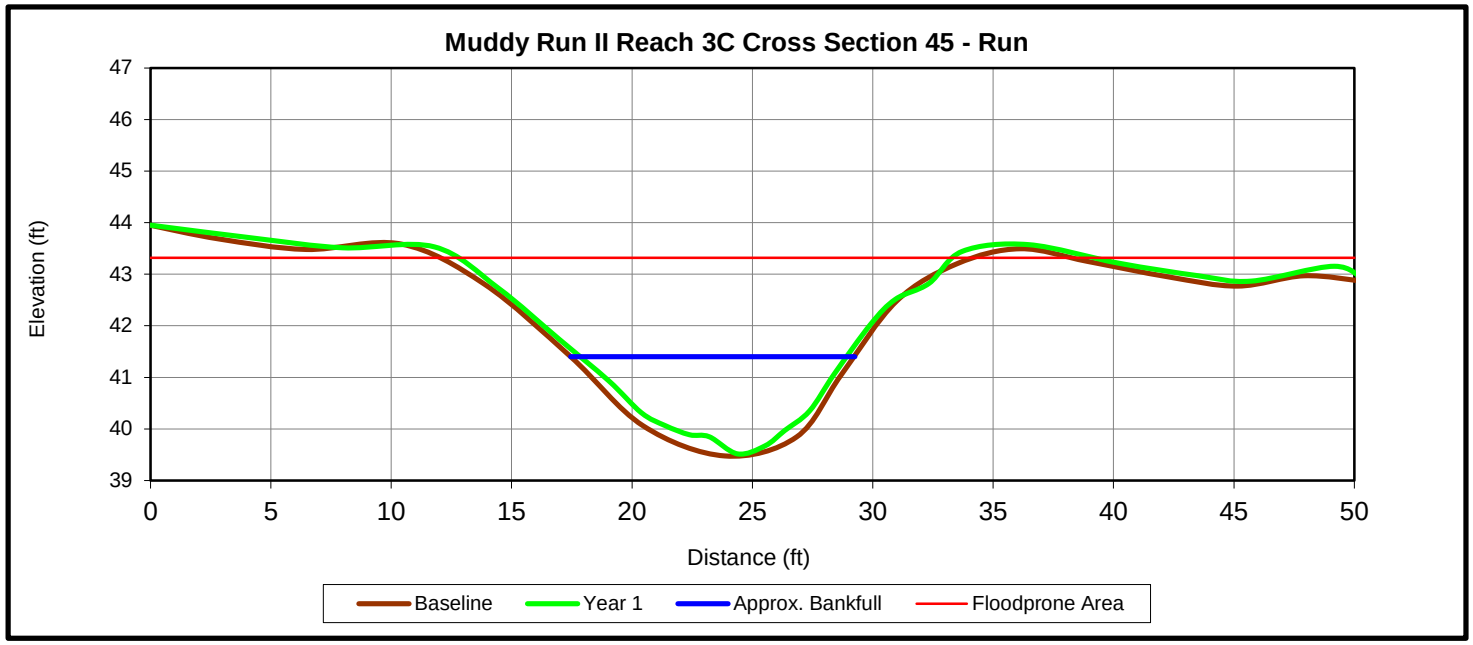

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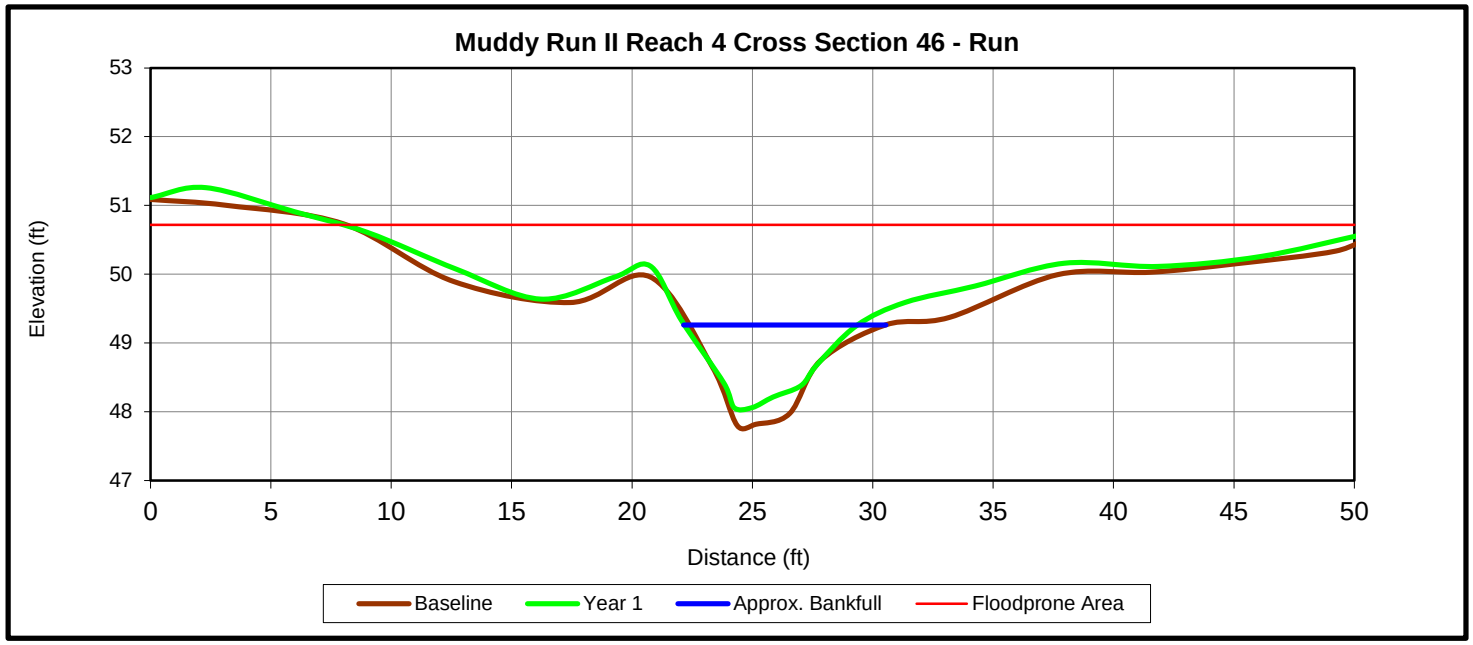

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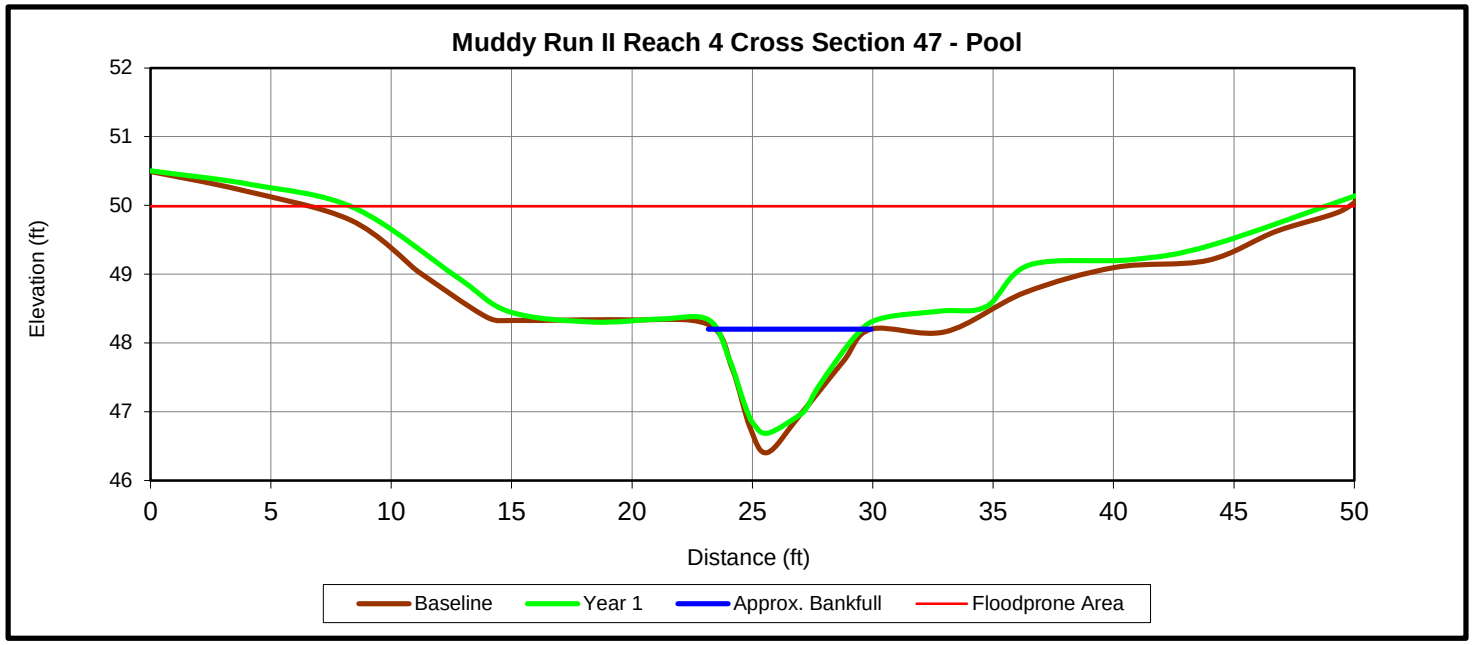

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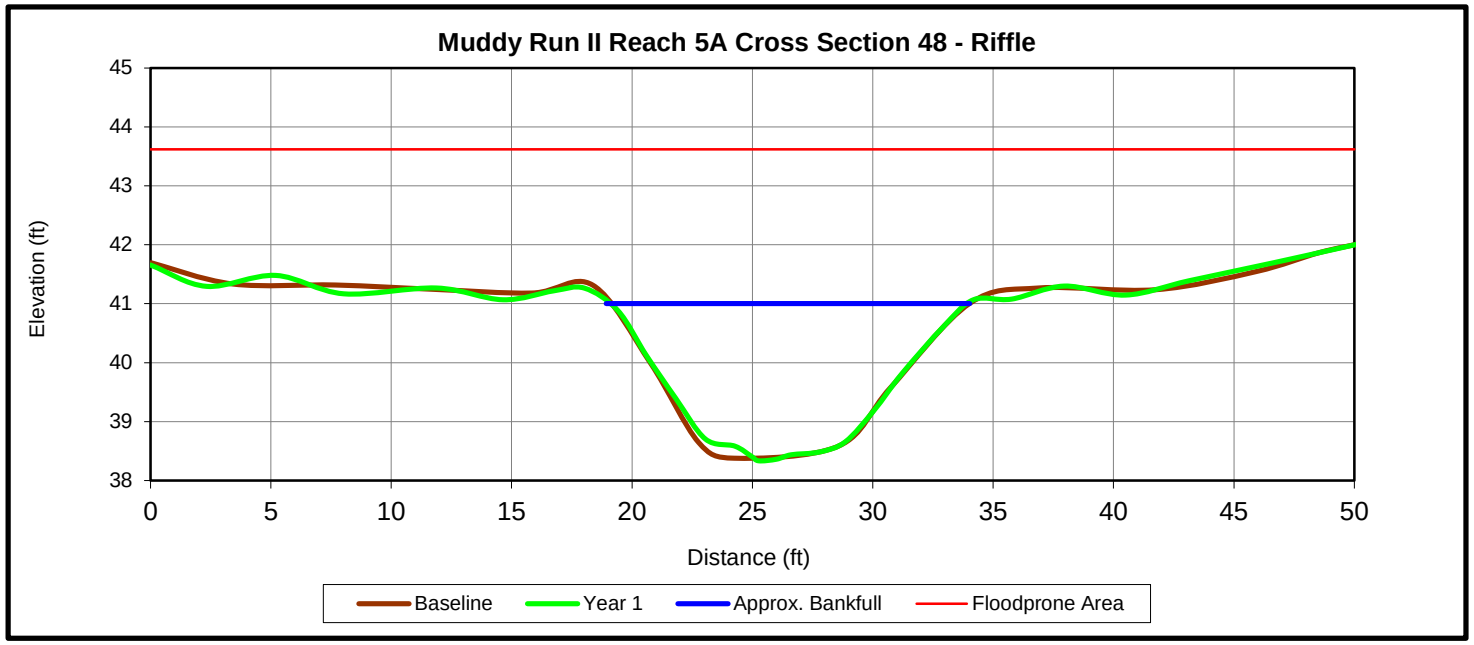

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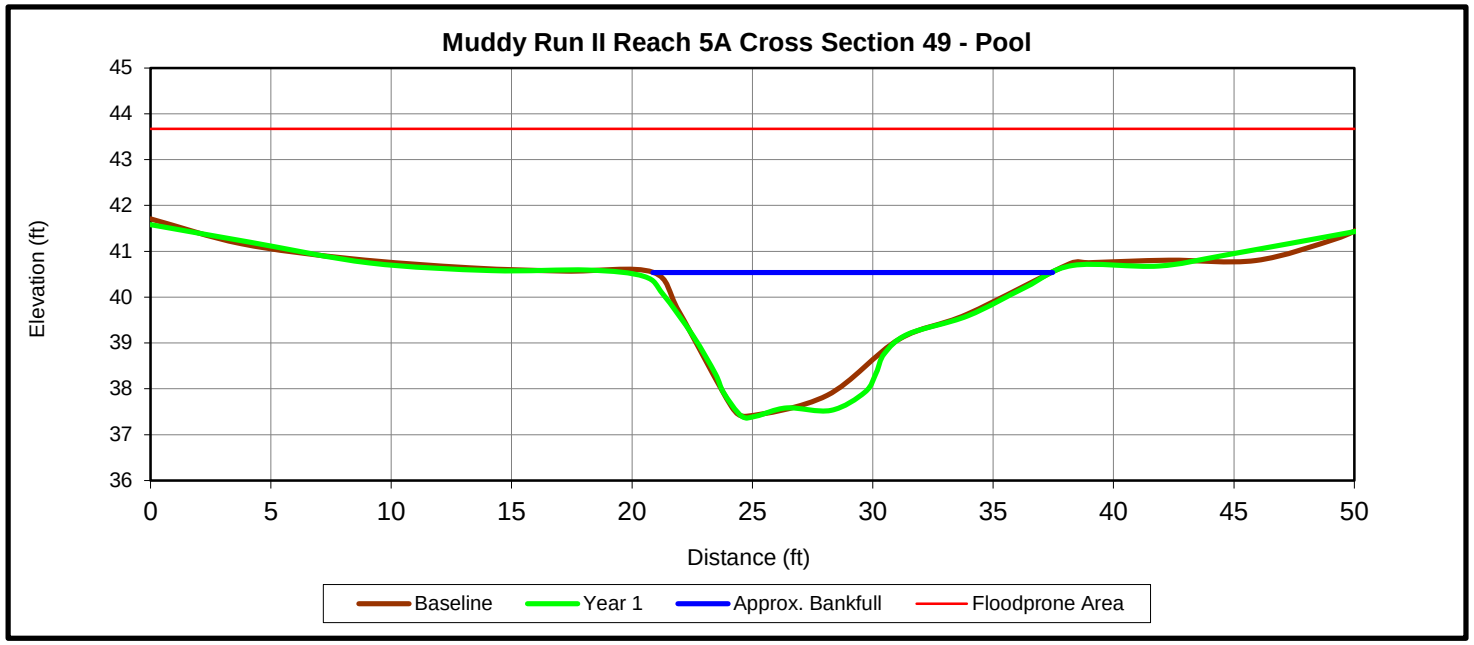

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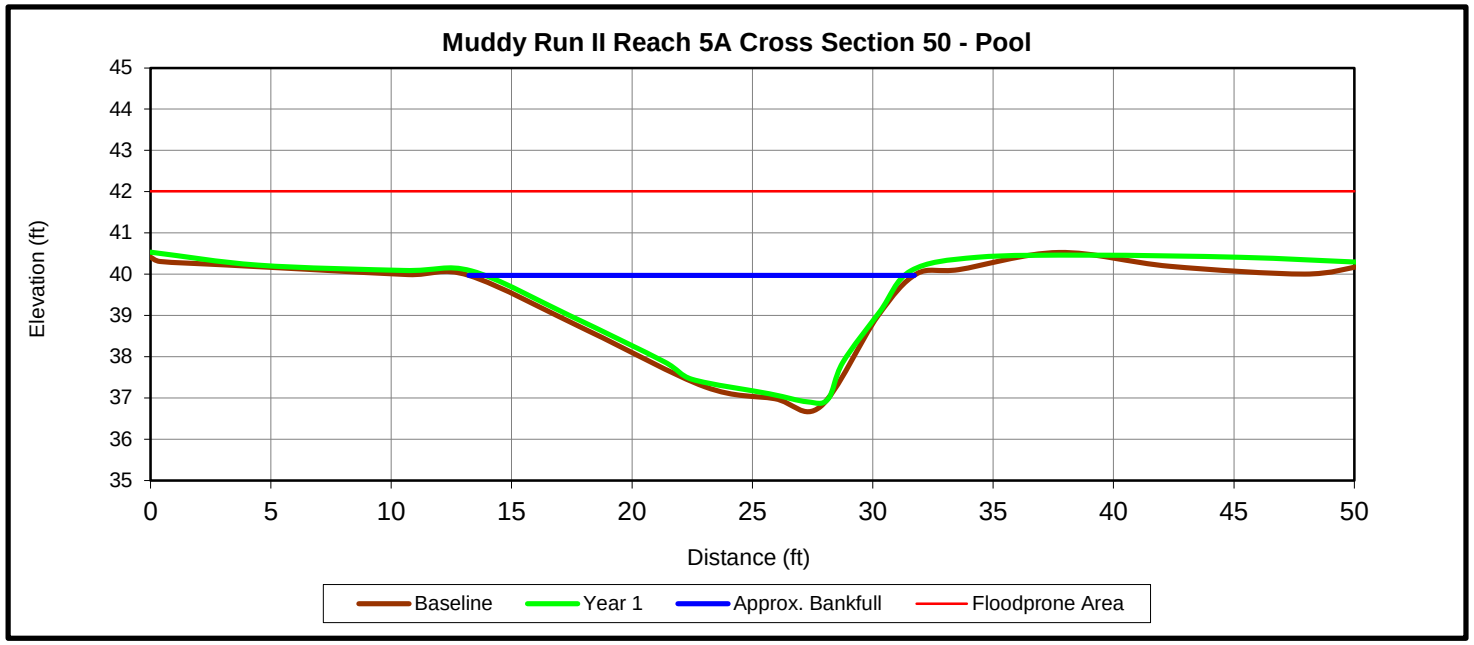

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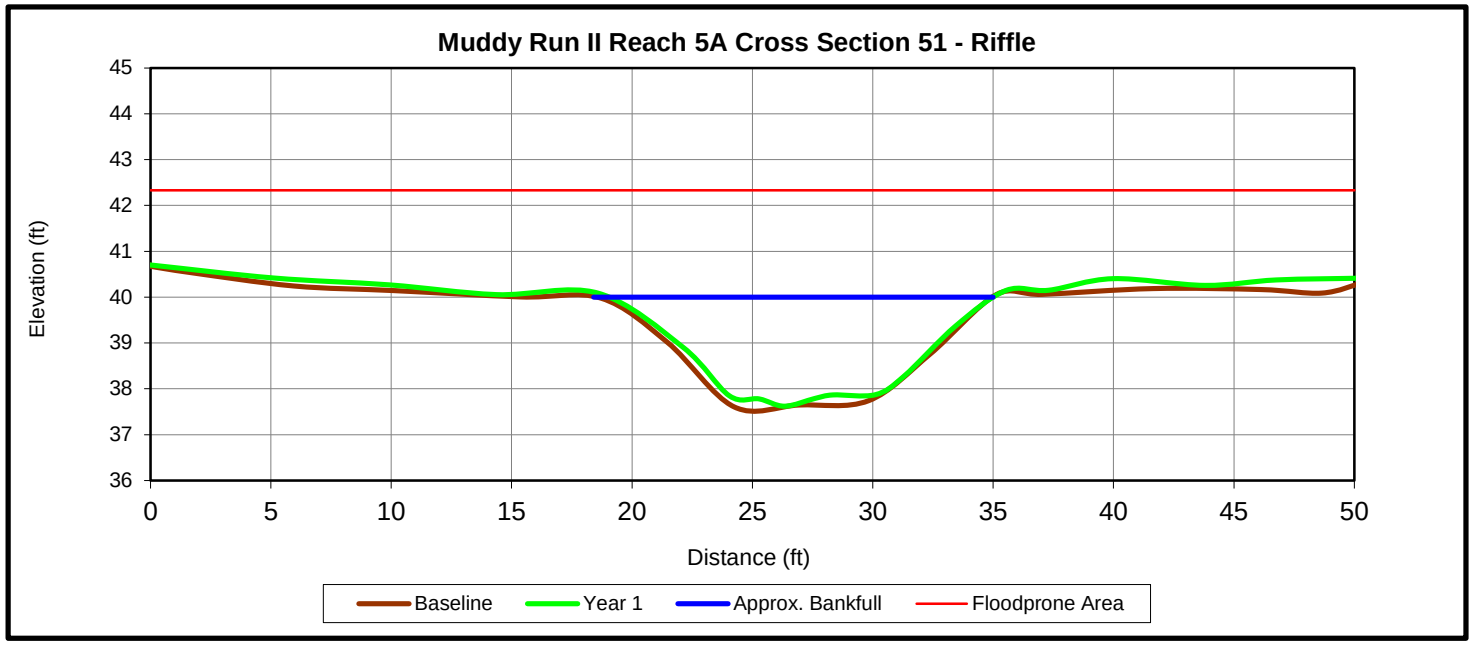

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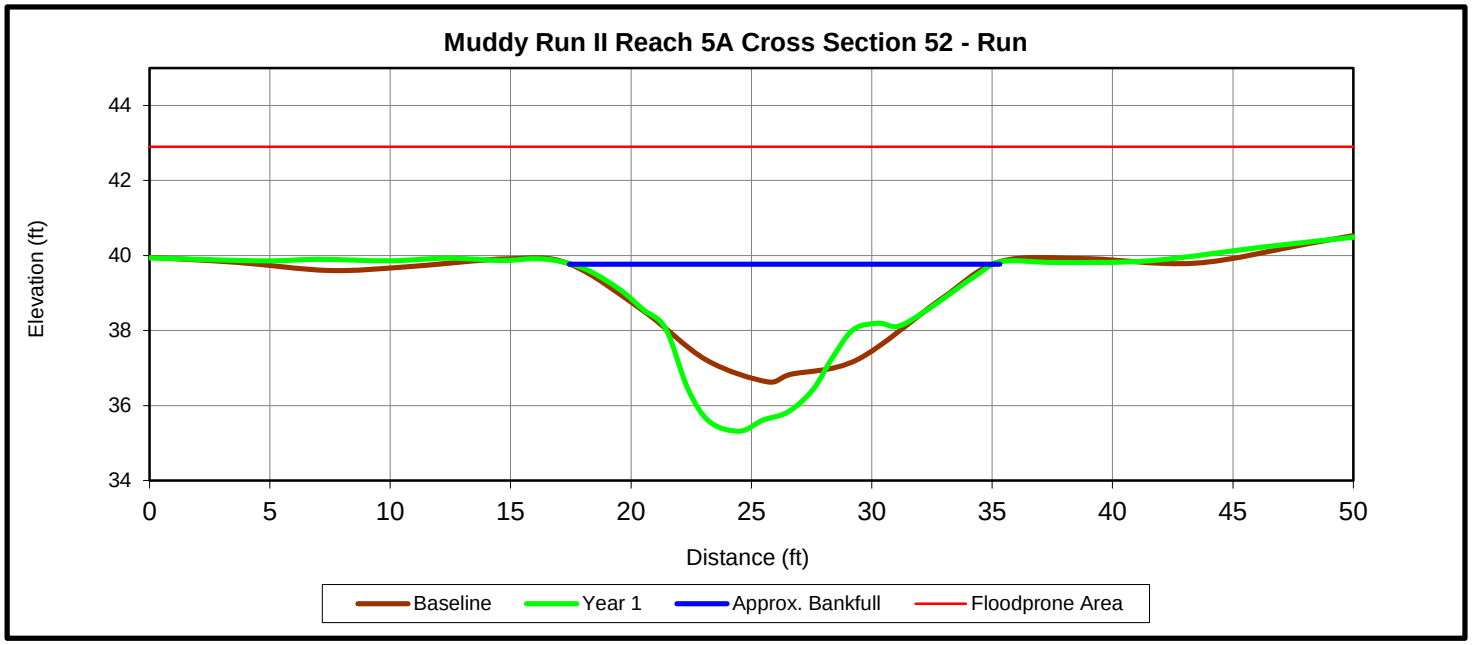

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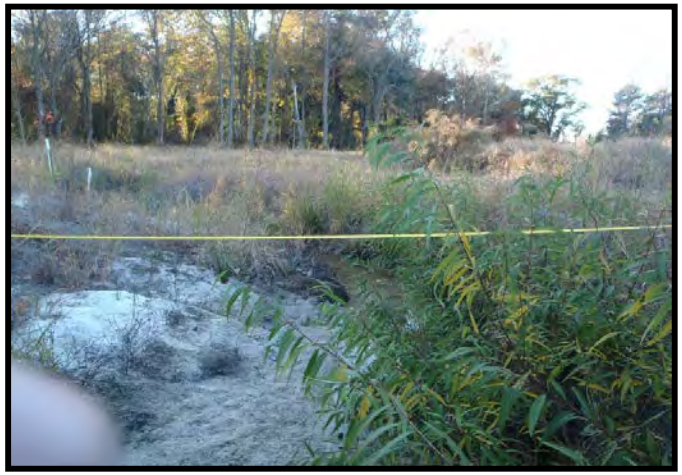

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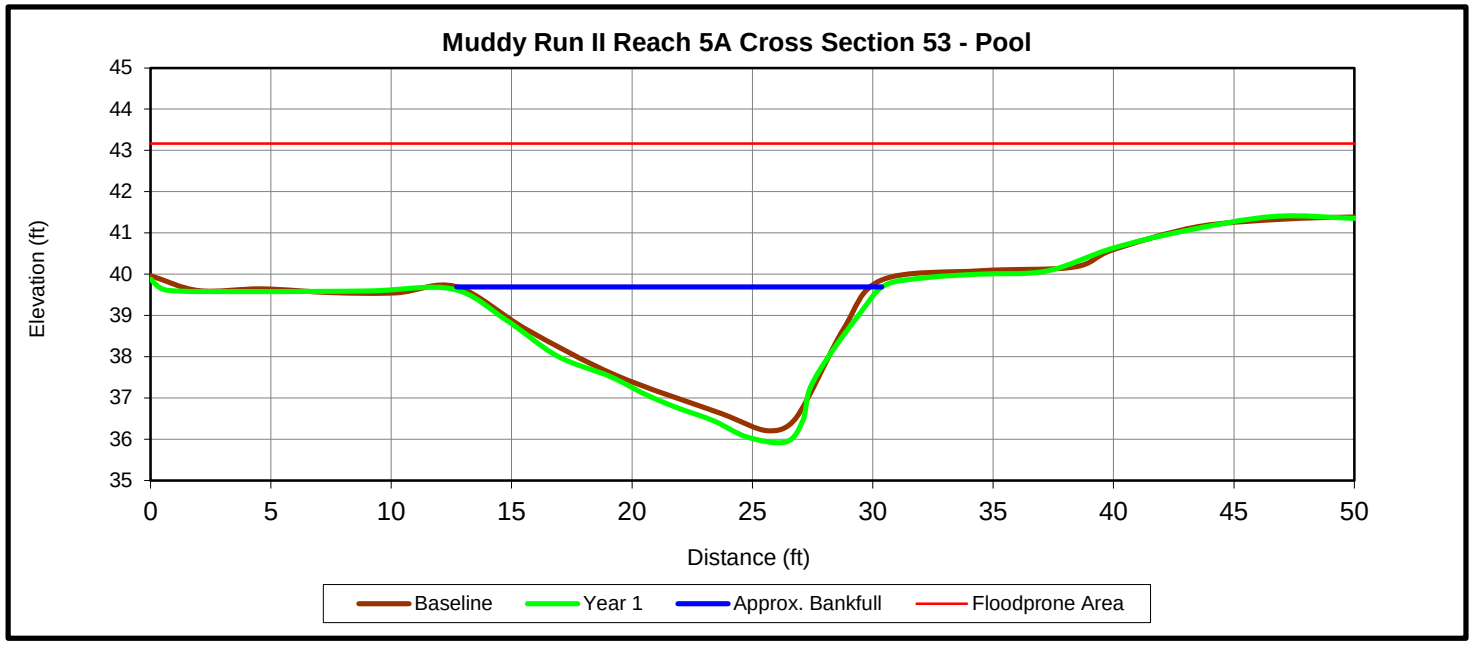

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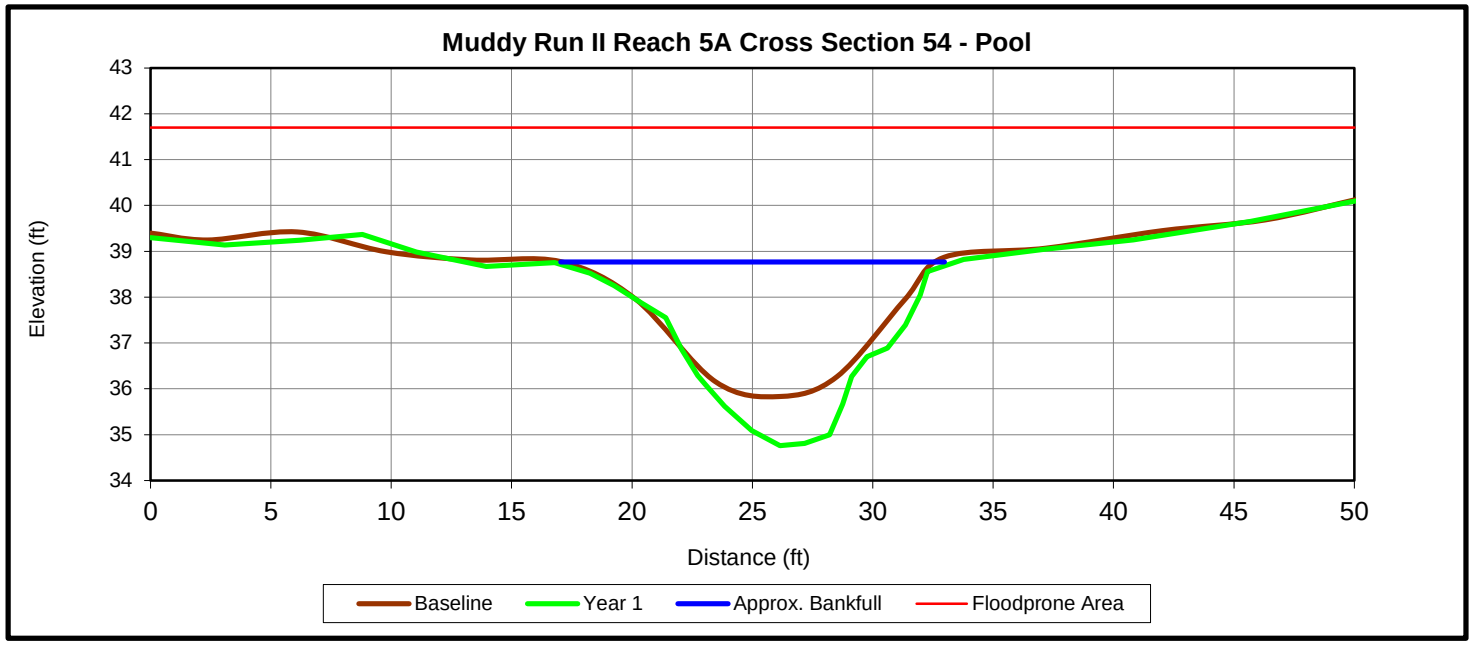

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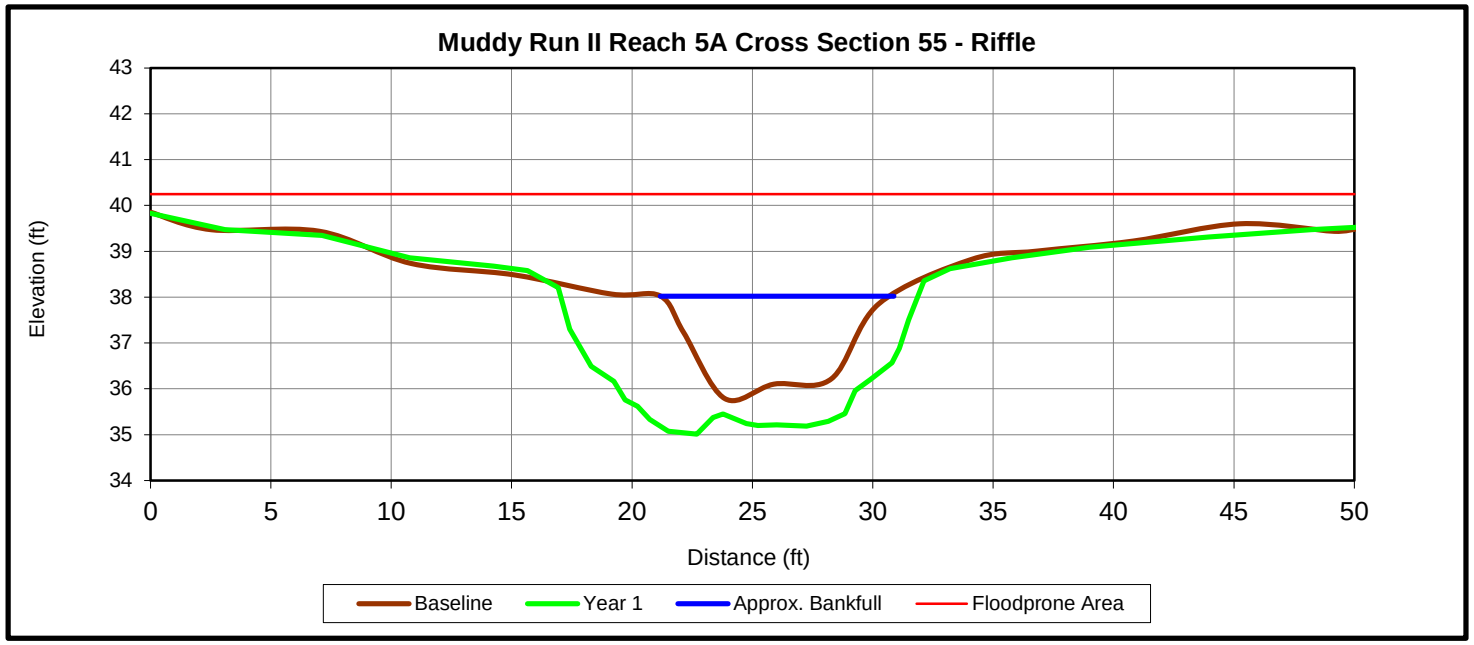

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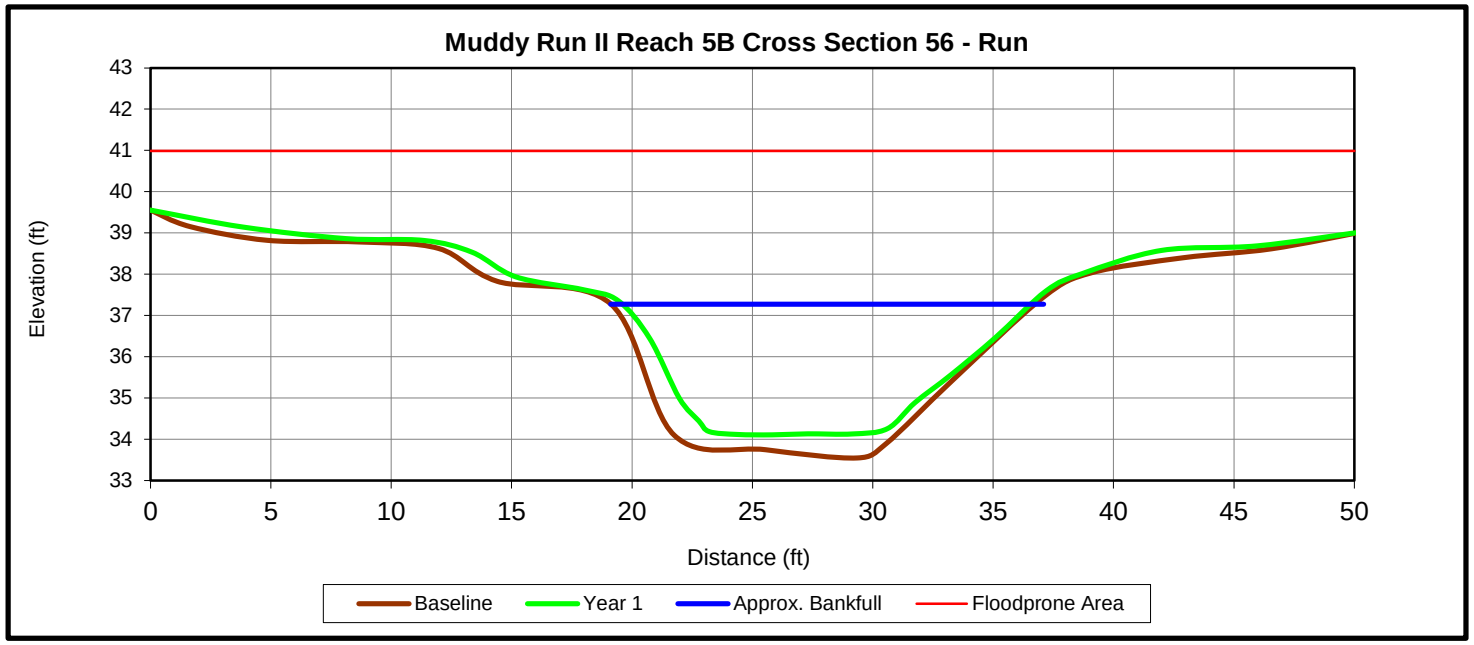

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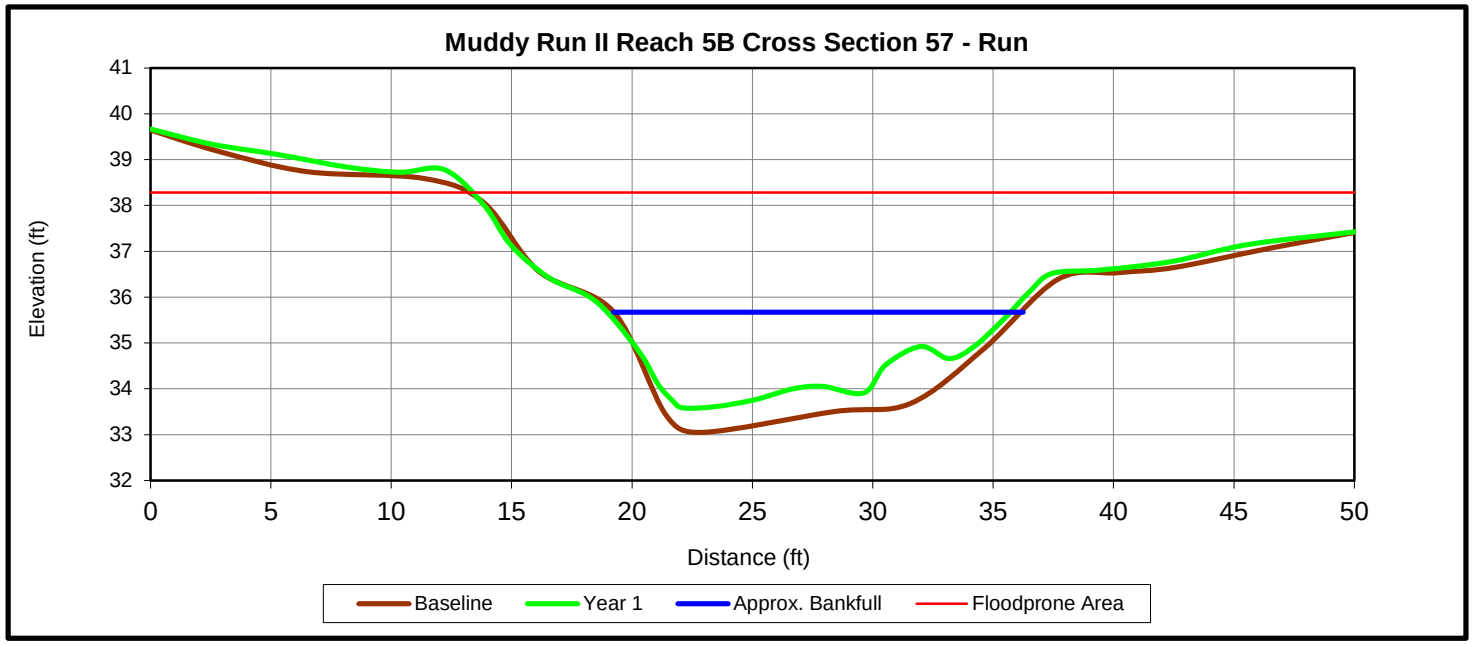

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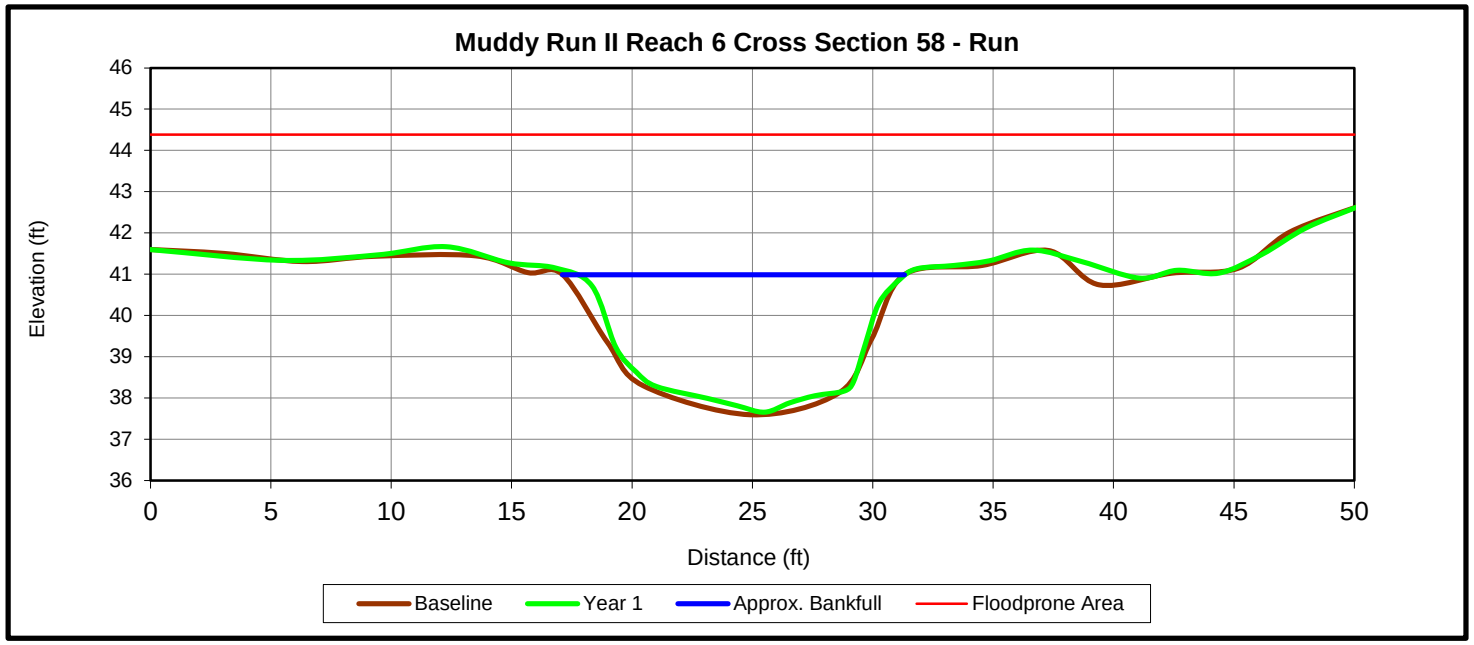
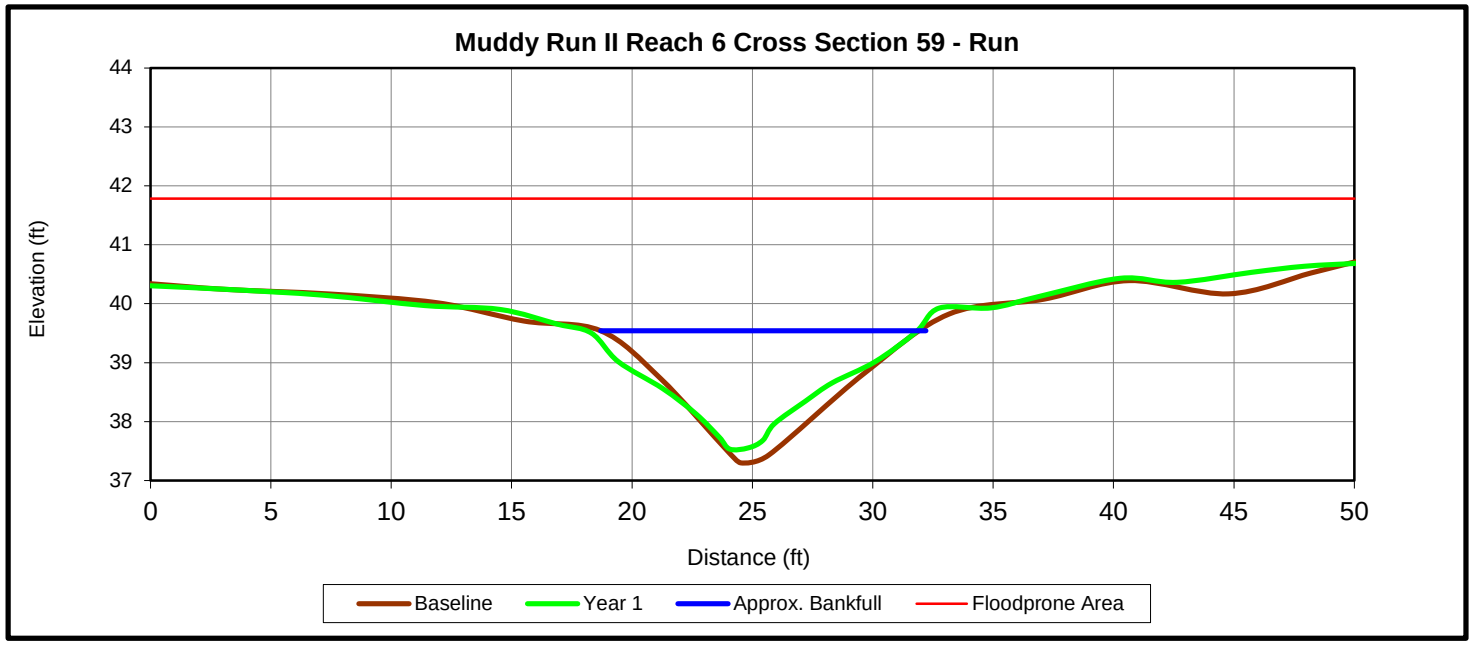


Upstream

Downstream



Appendix E

Hydrology Data

Table 13. Documentation of Geomorphologically Significant Flow Events

Crest Gauge	Number of Bankfull Events	Date of Highest Bankfull Event	Maximum Bankfull Height (ft.)	Photo Number
Crest Gauge 1	1	8/1/2014	0.4	1
Crest Gauge 2	8	8/1/2014	1.5	2
Crest Gauge 3	0	NA	NA	NA
Crest Gauge 4	2	9/12/2014	0.45	3

Table 14. Rainfall Summary

Month	Average	Normal Limits		Wallace Station Precipitation	On-Site Auto Rain Gauge
		30 Percent	70 Percent		
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		
Total	**49.19**	**31.10**	**58.89**	**46.75**	**44.27**

Table 15. Wetland Hydrology Criteria Attainment

2014 Max Hydroperiod (Growing Season 17-Mar through 14-Nov, 242 days) Well Data for 3-July through 14-November Success Criterion 9% = 22 Consecutive Days					
	Consecutive		Cumulative		
Gauge	Days	Percent of growing Season	Days	Percent of growing Season	Occurrences
AW1	22	9	75	31	10
AW2	22	9	72	30	10
AW3	13	5	60	25	11
AW4	67	28	129	53	2
AW5	7	3	26	11	14
AW6	43	18	92	38	6
AW7	5	2	8	3	4
RAW1	22	9	56	23	7
RAW2	10	4	25	10	4
RAW3	20	8	42	17	8

* Well data represents only 134 days (~55%) during the total growing season from July 3rd to November 14th.

Chart 1. 2014 Precipitation Data for Muddy Run II Site

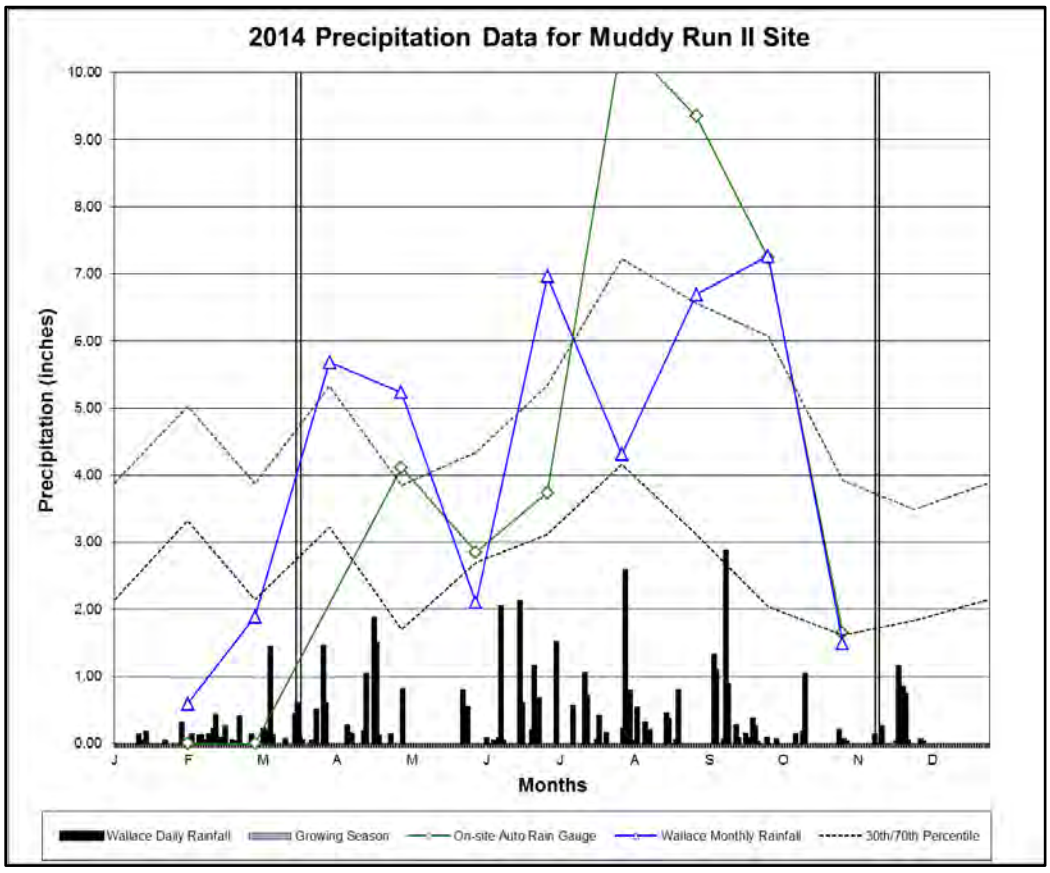
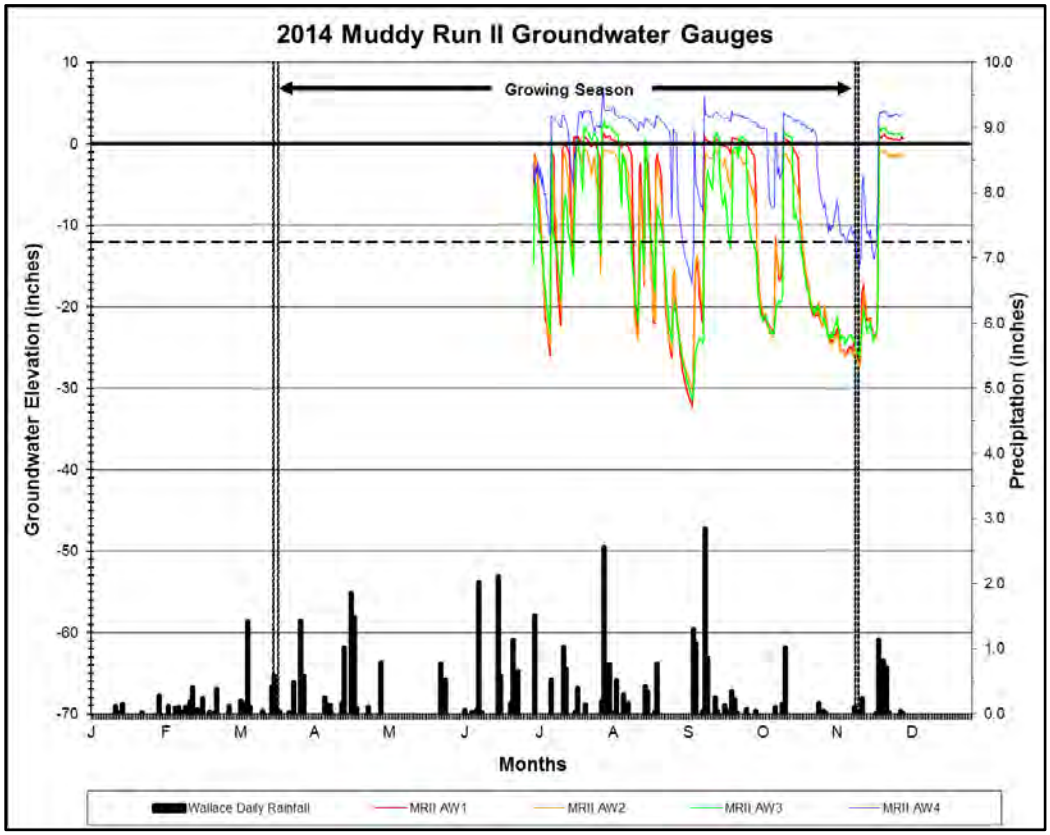
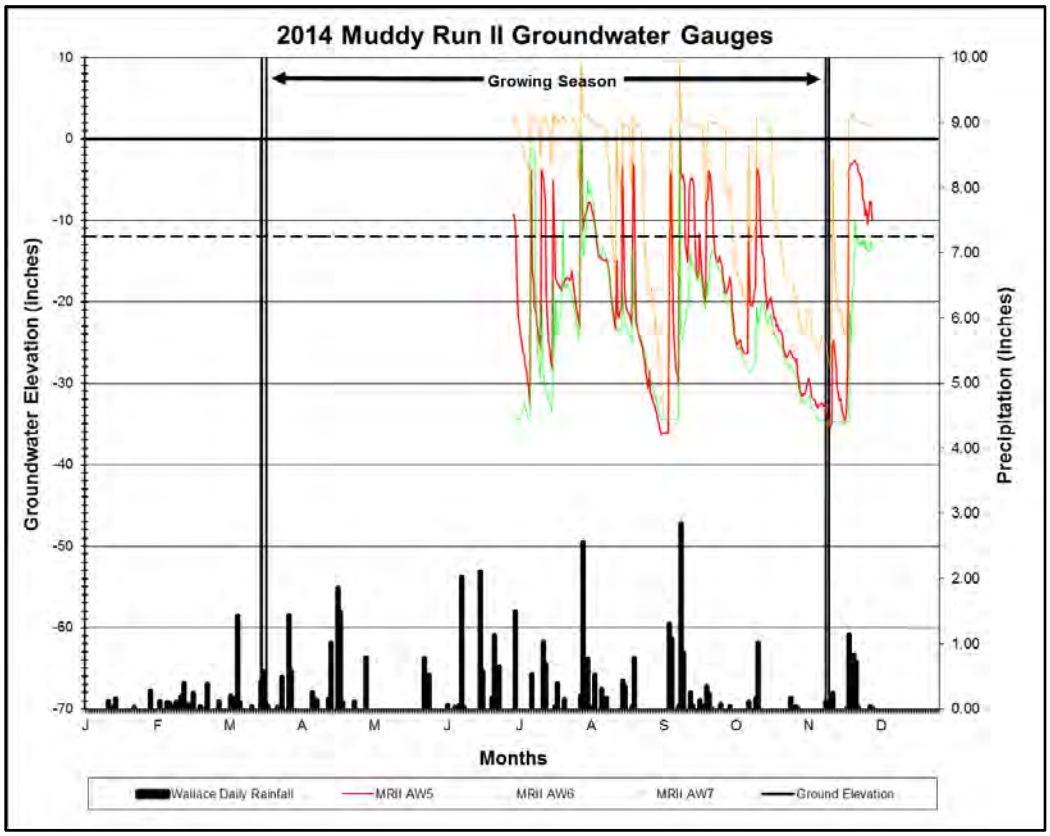
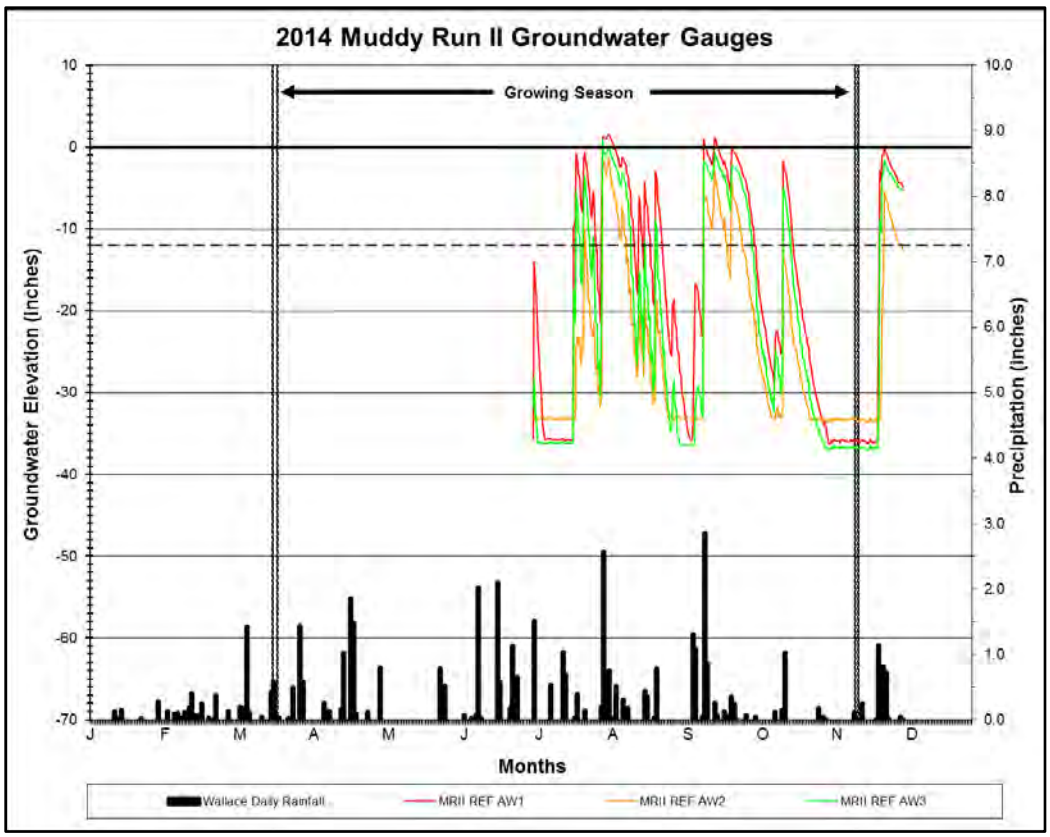


Chart 2. 2014 Muddy Run II Site Groundwater Monitoring Gauge Hydrographs






2014 Muddy Run II Groundwater Gauges
Growing Season
Groundwater Elevation (Inches)
Precipitation (Inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII REF AW1
MRII REF AW2
MRII REF AW3

Appendix E – Crest Gauge Verification Photos

Photo 1. Crest Gauge 1 (Reach 2 - 0.4 ft. – 8/1/2014)

Photo 2a. Crest Gauge 2 (Reach 3A - 1.5 ft. – 8/1/2014)

Photo 2b. Crest Gauge 2 (Reach 3A - 1.3 ft. – 11/26/2014)

Photo 3. Crest Gauge 4 (Reach 5A - 0.45 ft. – 9/12/2014)