ANALYSIS OF THREE DELTA HEADWATERS PROJECT (DHP) STREAMS USING THE SEDIMENT IMPACT ANALYSIS METHOD (SIAM) MODEL

Michelle Martin, Hydraulic Engineer, Anderson Consulting Engineers, Inc, Fort Collins, CO, mlmartin@acewater.com; David S. Biedenharn, Hydraulic Engineer, Biedenharn Group, LLC, Vicksburg, MS, biedenharngroup@yahoo.com; Charles Little, Research Hyd Engineer, USACE ERDC, Vicksburg, MS, Charles.D.Little@usace.army.mil; Kendall Smith, Hydraulic Engineer, USACE, Vicksburg District, Vicksburg, MS, Kendall.H.Smith@usace.army.mil; and Chester C. Watson, Hyd Engineer, Biedenharn Group, LLC, Vicksburg, MS, chester@chestercwatson.com.

Abstract A key component of the DHP is to provide channel stability and to reduce the delivery of sediments to downstream reservoirs, flood control channels, and wetlands. Several years ago, the Sediment Impact Analysis Method (SIAM) model was developed through the DHP as a screening level tool to assist in the assessment of erosion and sedimentation trends in these watersheds. Through the DHP, hundreds of miles of channel surveys (thalweg and cross sections) have been conducted. For this study, three watersheds were selected and the surveys incorporated into SIAM models for the pre- and post construction conditions. The streams selected for this task were Hickahala Creek, Long and Caney Creeks, and Harland Creek. This analysis involved three interrelated tasks. The first task involved searching the Vicksburg District files to obtain the original channel surveys that were made as part of the initial DHP investigations of the watersheds. These surveys would represent the pre-project conditions for these streams. The next step involved scanning and digitizing these surveys, and creating HEC-RAS data files. In the final step, SIAM models for these stream systems for both the pre- and post DHP project (DHP) conditions were developed and an assessment of the impacts of the DHP features was made. Typical DHP features in these watersheds included bank stabilization structures, grade control structures, riser pipes for gully control, flood water retarding structures, and land treatments. According to the SIAM results, the DHP features reduced the fine sediment (fine sands and finer) delivery out of the Hickahala, Long and Caney, and Harland Creek Watersheds by 35%, 44%, and 30%, respectively. Considerable uncertainty in sediment modeling results is typical and these numbers should not be considered as absolute. However, the results do provide a reasonable estimate of the relative magnitude of the sediment delivery reduction. The reduction in fine sediment delivery is expected to occur within a relatively short period following construction, perhaps 1 to 5 years. Long term impacts that require sediment routing of materials cannot be assessed in SIAM. Many of the recommended DHP features will reduce the delivery of medium sands and greater to the channel system. However, the time required for the impacts of these upstream coarse sediment reductions to be realized at the mouth of these streams may be measured in decades. Therefore, the 30 to 44% reductions indicated by the SIAM model reflect the short term response. Long term reduction in sediment supply could be much greater.

INTRODUCTION

The Delta Headwaters Project (DHP), formerly known as the Demonstration Erosion Control (DEC) Project was initiated in 1985 with the primary goals to provide channel stability and reduce the delivery of sediments to downstream reservoirs, flood control channels, and wetlands

(Hudson, 1997 and Watson, et. al. 1997). Another goal of the project is to develop innovative approaches to providing control of erosion, sedimentation, and flooding on a watershed basis. A monitoring program was implemented to document the performance of the implemented features and to develop improved tools for channel design. Through the DHP, hundreds of miles of stream surveys have been conducted. Unfortunately most of these exist only in hard copy form. For this study, three watersheds were selected and the surveys incorporated into SIAM models for the pre- and post construction conditions. The SIAM results document the channel response (particularly the sediment yields) resulting from the implementation of the DHP features.

The stream watersheds selected for this task were Hickahala, Long and Caney, and Harland. The location of these three watersheds is shown in Figure 1. This analysis involved three interrelated tasks. The first task involved searching the Vicksburg District files to obtain the original channel surveys that were made as part of the initial investigations of the watersheds. These surveys would represent the pre-project conditions for these streams. The next step involved scanning and digitizing these surveys, and then bringing them into HEC-RAS. The final step involved setting up the SIAM models for these stream systems for both the pre- and post project (DHP) conditions and assessing the impacts of the DHP features.

SIAM ANALYSIS

The Sediment Impact Analysis Method (SIAM) model was developed through the DHP to assist in the assessment of erosion and sedimentation trends in these watersheds. SIAM is viewed as a screening tool for the assessment of multiple rehabilitation alternatives, particularly in the reconnaissance and feasibility phases of a project. It provides a framework to combine sediment sources and computed sediment transport capacities into a model that can evaluate sediment imbalances and downstream sediment yields for different alternatives. A summary of SIAM capabilities, applications, and limitations is provided in these proceedings by Jonas and Little (2010). The results of the SIAM analysis for the Hickahala, Long and Caney, and Harland Creeks are discussed in this section.

Hickahala Creek SIAM Analysis The Hickahala Creek Watershed is located about 30 miles south of Memphis TN and has a drainage area of approximately 230 square miles. The primary erosion and sediment control features in the Hickahala Watershed are bank stabilization, grade control structures, and land treatments. A channel improvement project was also constructed in the early 1990s along the lower reaches of Hickahala and Senatobia Creeks. The original DHP surveys were conducted in 1985. Using these surveys, the SIAM model was developed for the following streams: Hickahala, Senatobia, Basket, Beards, Billy's, Cathey's, James Wolf, Martin Dale, Mattic, Nelson, South Fork Hickahala, Steamill, Thornton, Tolbert Jones, West Ditch, and Whites.

The existing conditions SIAM model was developed using estimates of pre-project hydrology, hydraulics, sediment supply and bed material gradations. The Hickahala Watershed was divided into 68 SIAM sediment reaches. These reaches are shown in Figure 2. The existing conditions model was set up and calibrated based on observed geomorphic processes. The next step was to modify the existing conditions SIAM model to reflect the construction of the DHP features. These features included 94,700 feet of bank stabilization, 97 riser pipes, and 19 grade control structures. Figure 3 shows the location of the bank stabilization and grade control structures. Surface erosion from the watershed was estimated to be reduced by 25% due to land treatment measures. With all the DHP features in place, the SIAM results indicated that there would be a reduction in fine sediment (silts, clay, and very fine sands) delivery at the mouth of Hickahala Creek of about 35% (Figure 4).

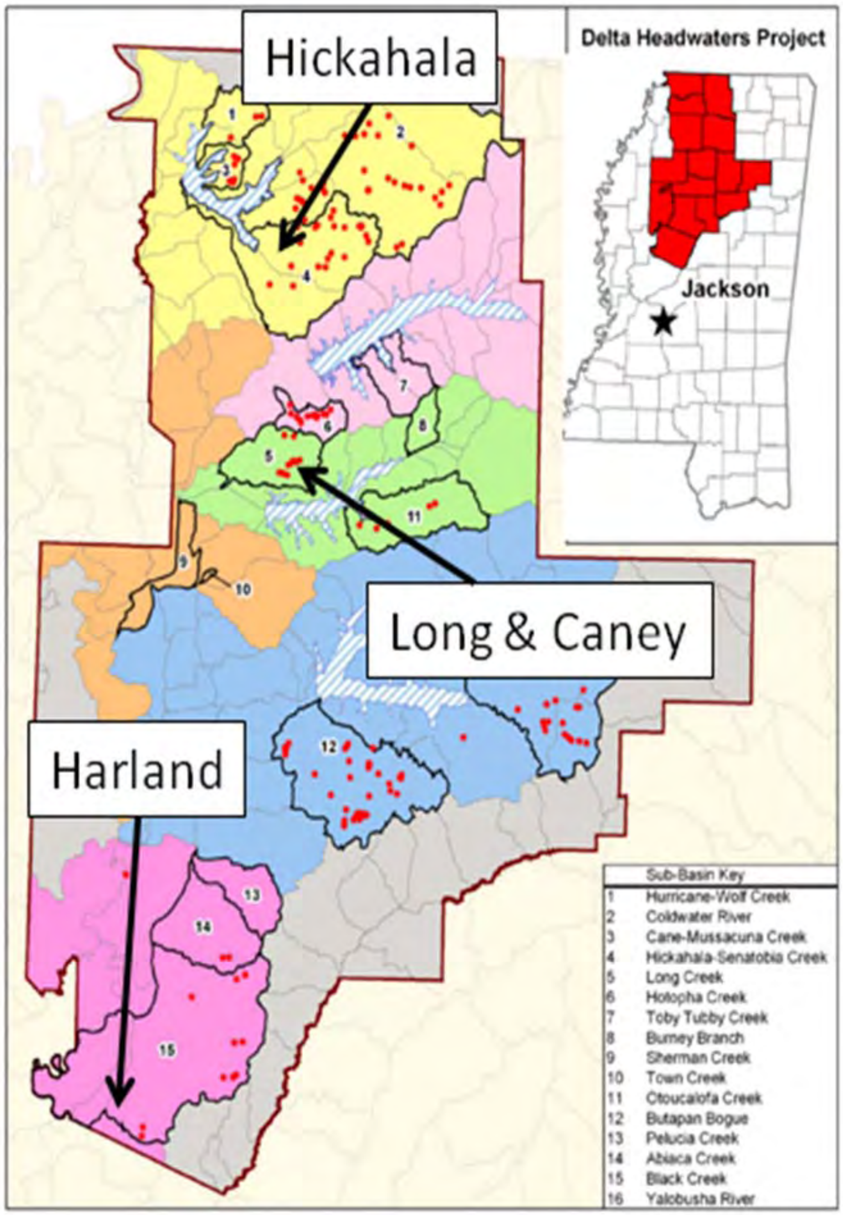

Figure 1 Location of the Hickahala, Long and Harland Watersheds.

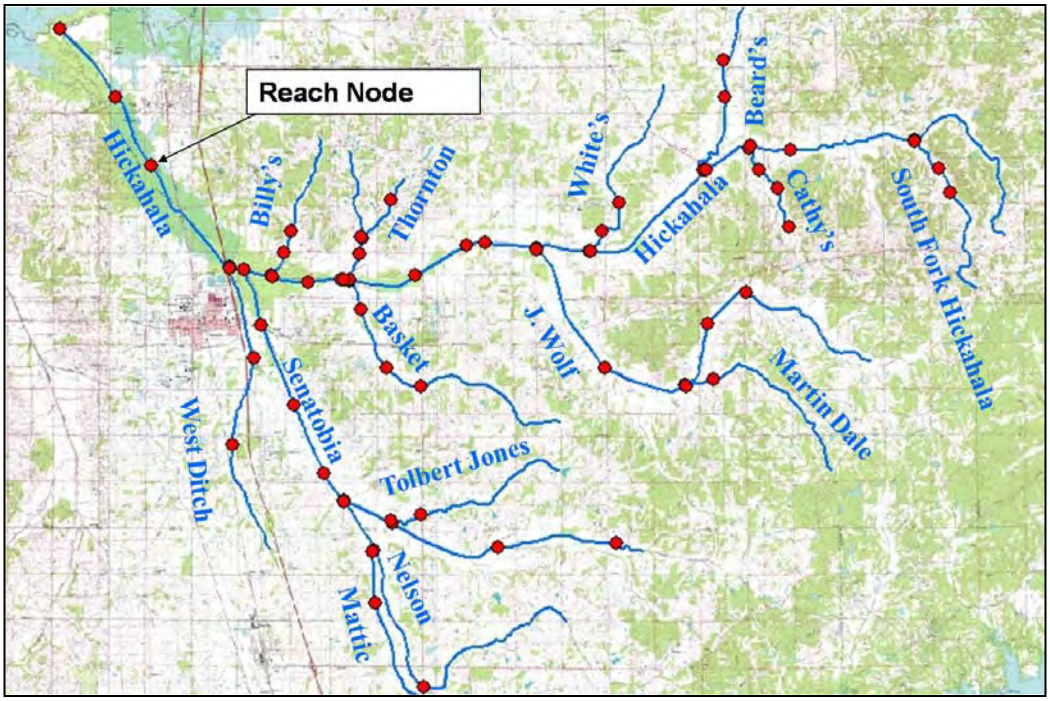

Figure 2 SIAM sediment reaches for the Hickahala Watershed. The red circles define the upstream and downstream limits of each reach.

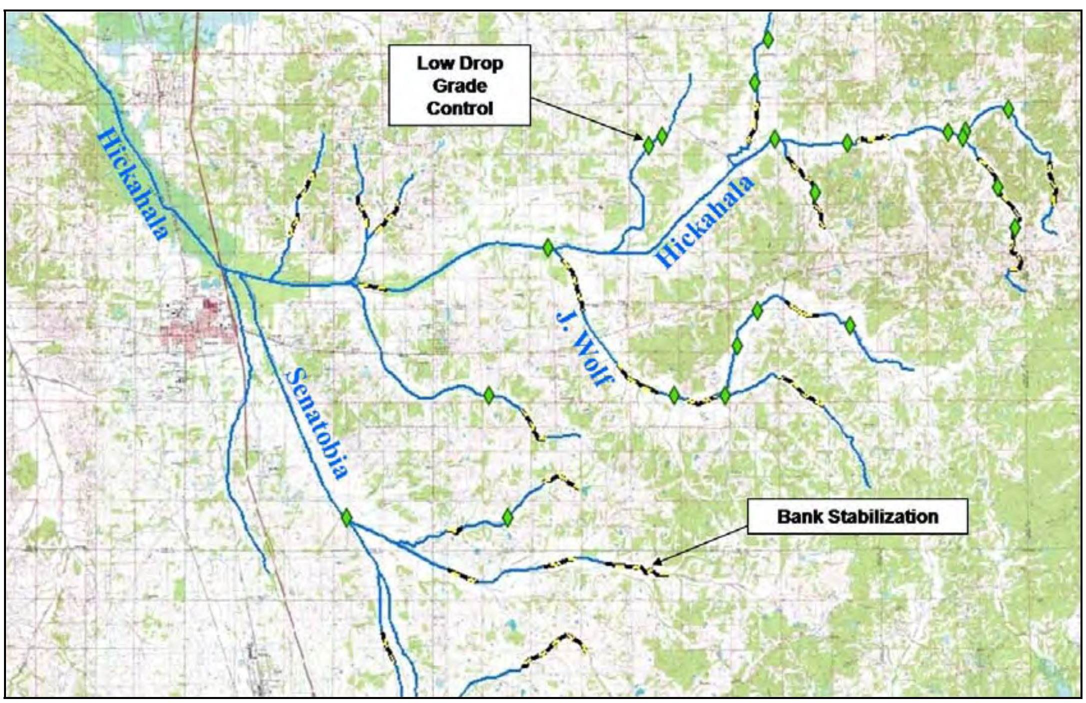

Figure 3 Location of bank stabilization and grade control structures in the Hickahala Watershed.

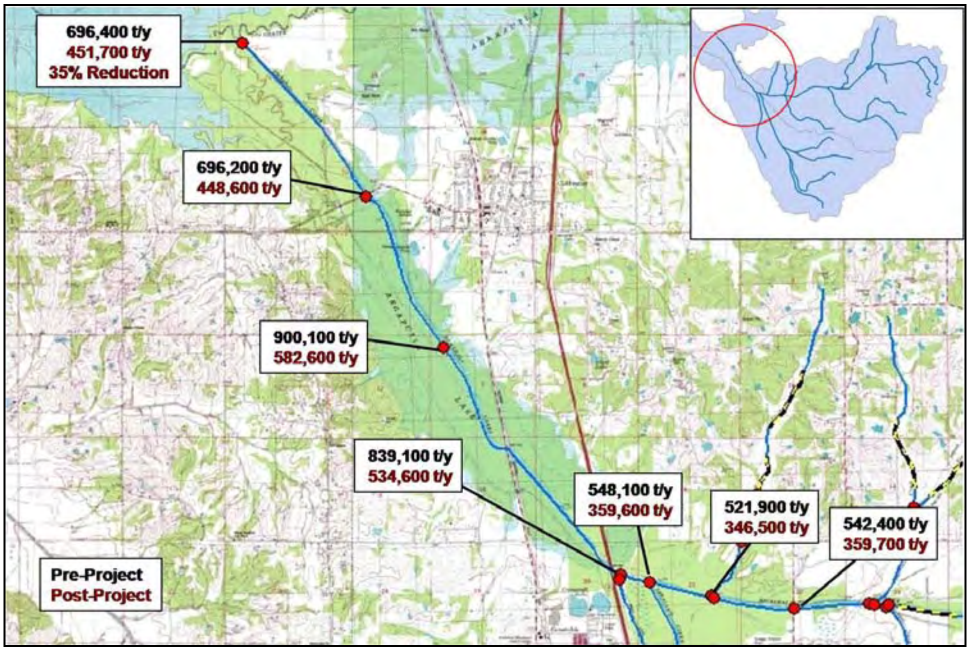

Figure 4 Reductions in sediment supply in the lower reaches of Hickahala Creek as a result of the DHP features.

Long and Caney Creek SIAM Analysis The SIAM analysis was conducted for the Long and Caney Creek Watershed to assess the impacts of the DHP features on sediment reductions (Figure 5). The drainage area of this stream system is 39.7 square miles. The original DHP surveys of this system were conducted in 1985. These original surveys were used to develop the pre-project SIAM model. The existing conditions SIAM model was developed using estimates of pre-project hydrology, hydraulics, sediment supply and bed material gradations. Figure 6 shows the SIAM sediment reaches for Long and Caney Creeks.

The SIAM model was modified to include the constructed DHP features. These features included 29,800 feet of bank stabilization, and six grade control structures. Figure 7 shows the location of the bank stabilization and grade control structures. Surface erosion from the watershed was estimated to be reduced by 25% due to land treatment measures. As shown in Figure 8, the DHP features have reduced the fine sediment load (silts, clay, and very fine sands) at the most downstream reach on Long creek by about 44%.

Harland Creek SIAM Analysis Harland Creek is a tributary to Black Creek just upstream from the Hillside Floodway (Figure 9). Harland Creek is somewhat unique among the DHP watersheds because it has not been extensively channelized, and as a consequent, it has been subject to only moderate amounts of channel incision. Historically, it has been an extremely active meandering stream with high erosion rates. As a result, the primary treatment in the watershed has been bank stabilization. A flood water retarding structure was also built on the upper end of Harland in 1996. The 1985 original survey of Harland and Black Creeks was used in the development of the pre-project SIAM model. The existing conditions SIAM model was developed using estimates of pre-project hydrology, hydraulics, sediment supply and bed material gradations. Figure 10 shows the SIAM sediment reaches for Harland Creek. As shown in Figure 10, the SIAM model covers all of Harland Creek up to the newly constructed floodway retarding structure, as well as the lower 4 miles of Black Creek.

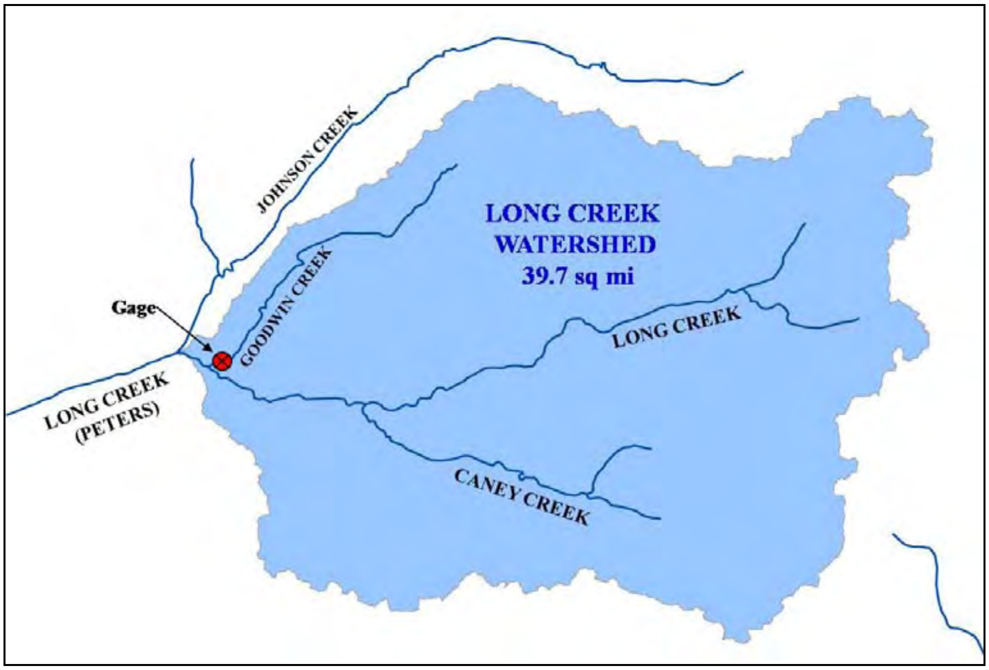

Figure 5 Long and Caney Creek Watershed.

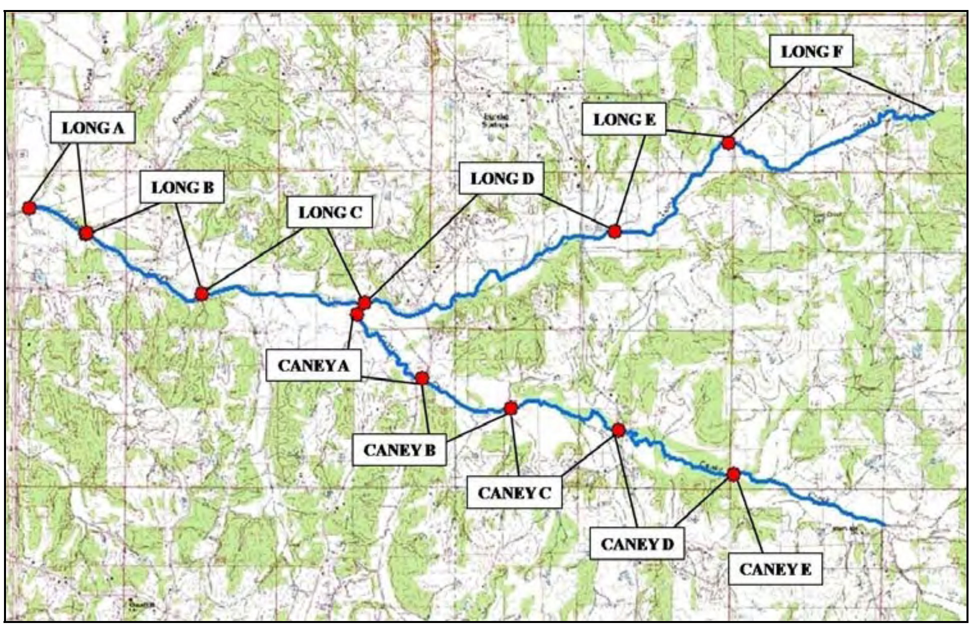

Figure 6 SIAM sediment reaches for Long and Caney Creeks.

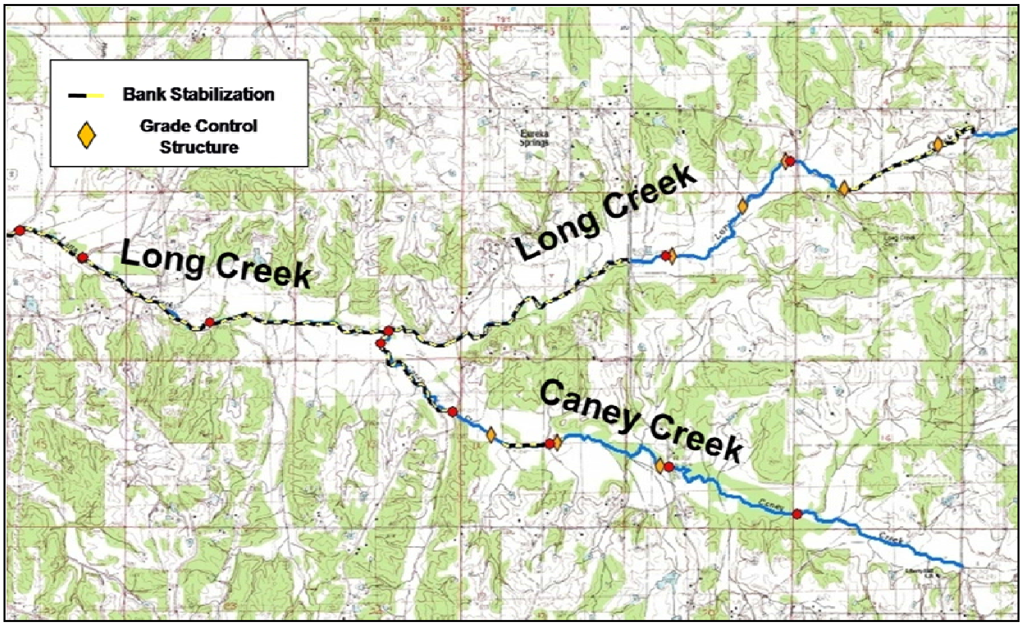

Figure 7 Location of bank stabilization and grade control structures in the Long and Caney Creek Watersheds.

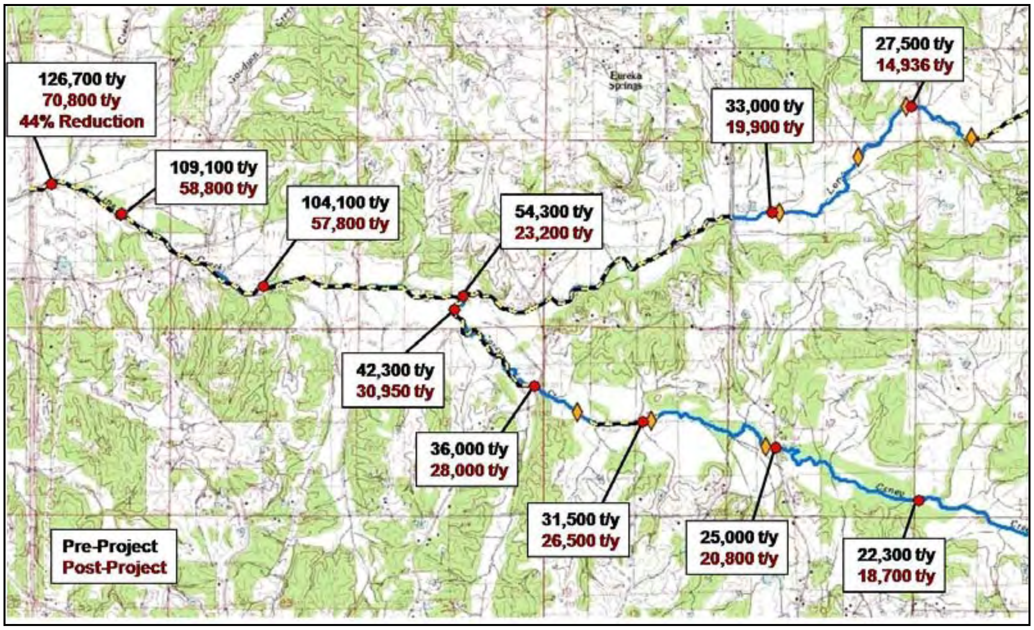

Figure 8 Reductions in fine sediment supply along Long and Caney Creeks as a result of the DHP features.

The SIAM model was modified to include the constructed DHP features, which included 46,200 feet of bank stabilization, and a floodwater retarding structure. As shown in Figure 11 bank stabilization has been almost continuous along Harland Creek. As shown in Figure 12, the DHP features have reduced the fine sediment load (silts, clay, and very fine sands) at the most downstream reach on Black Creek by about 30%.

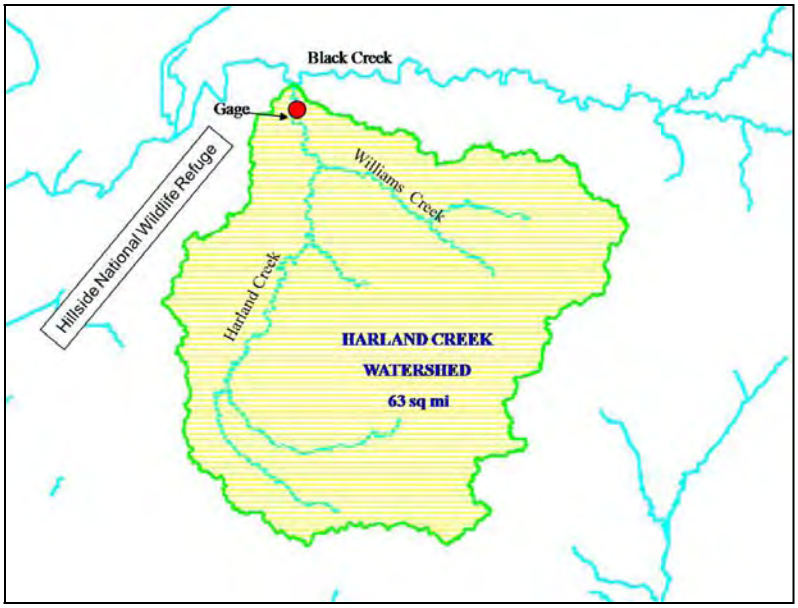

Figure 9 Location of the Harland Creek Watershed.

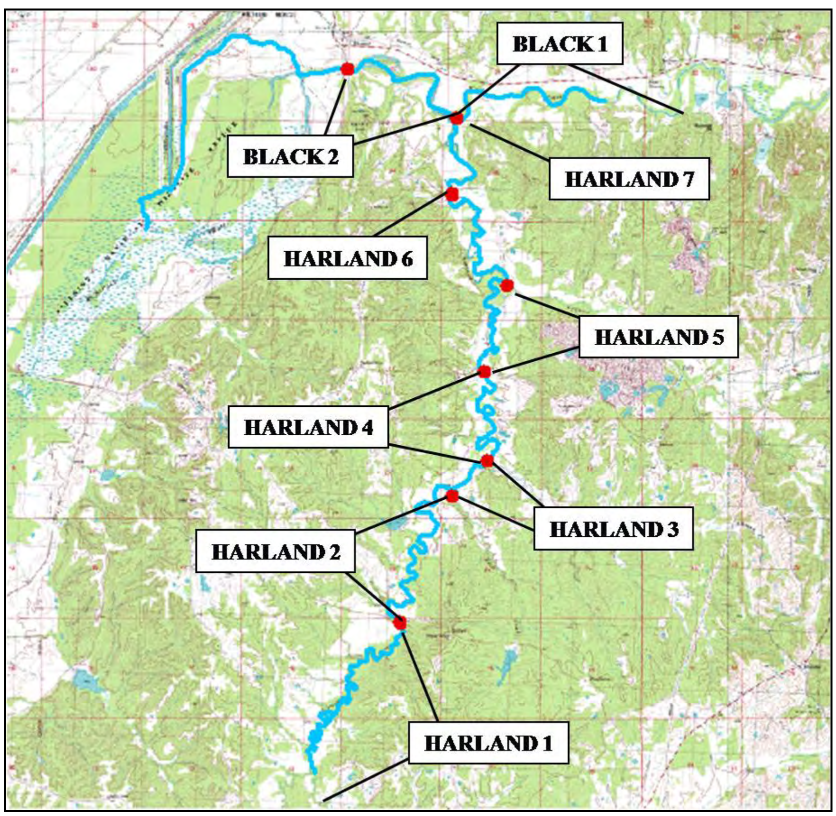

Figure 10 SIAM sediment reaches on Harland and lower Black Creeks.

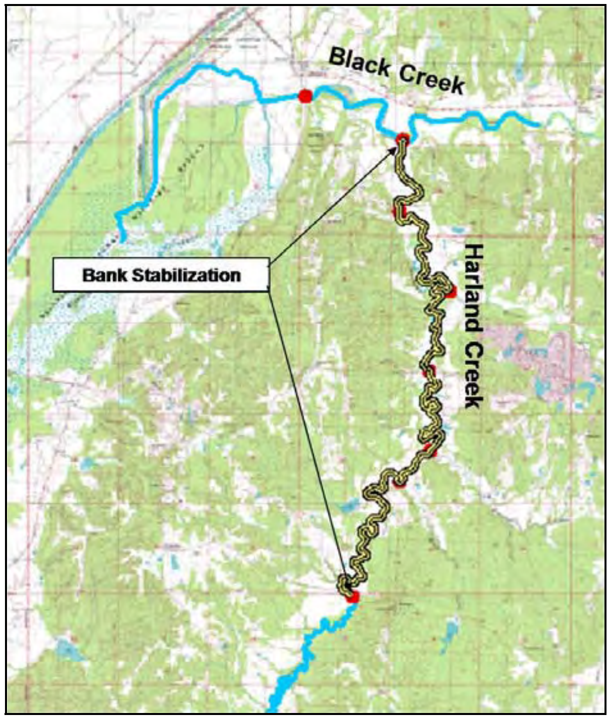

Figure.11 Bank stabilization along Harland Creek.

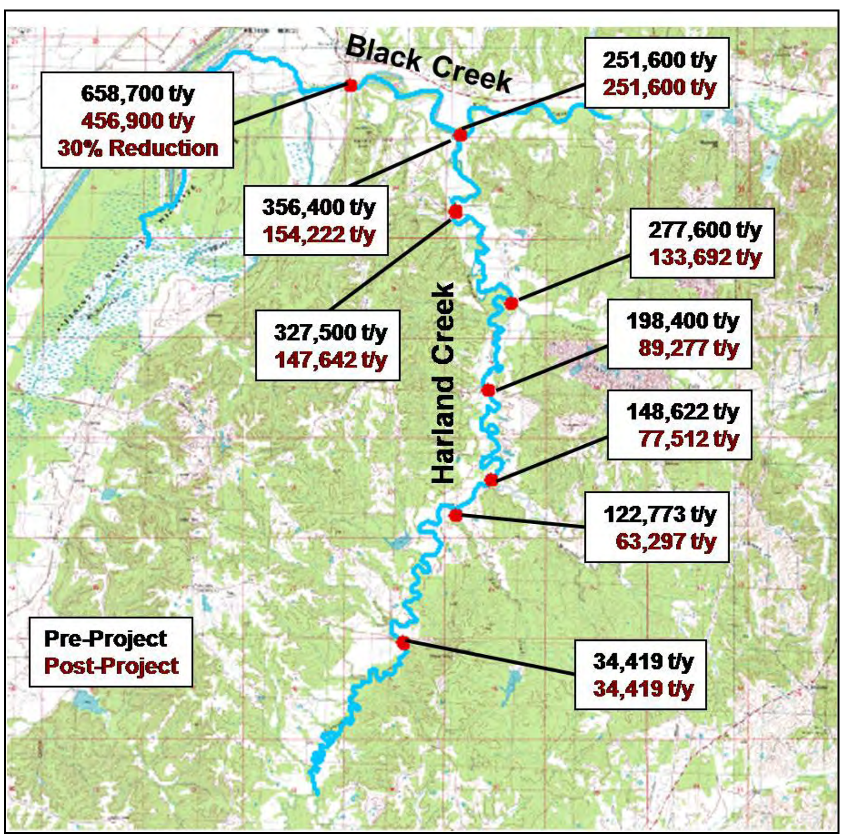

Figure 12 Reductions in fine sediment supply along Harland and Lower Black Creeks as a result of the DHP features.

SUMMARY

One of the goals of the DHP is the reduction in sediment supply from the watersheds. The erosion control features implemented in the DHP not only provide protection to local infrastructure, riparian lands, and wetlands, but also reduce the amount of sediment delivered to the channel systems. Developing a reasonable estimate of the reduction in sediment delivered to the channel as a result of stabilization features such as bank stabilization and riser pipes is relatively straight forward. However, documenting the impacts in the downstream reaches is much more difficult. Direct measurement of the sediment reductions have proven problematic. For this reason, the SIAM model was used to make estimates of the reductions in sediment supply in the Hickahala, Long and Caney, and Harland Watersheds. According to the SIAM results, the DHP features reduced the fine sediment delivery out of the Hickahala, Long and Caney, and Harland Creek Watersheds by 35%, 44%, and 30%, respectively. Obviously, there is always considerable uncertainty in any type of sediment modeling, and these numbers should not be considered as absolute. However, a reasonable estimate of the relative magnitude of the sediment delivery reduction can be made. The reduction in fine sediment delivery is expected to occur within a relatively short period following construction, perhaps 1 to 5 years. However, long term impacts that require sediment routing cannot be assessed using SIAM. Many of the recommended DHP features will reduce the delivery of medium sands and greater to the channel system. However, the time required for the impacts of these upstream coarse sediment reductions to be realized at the mouth may be measured in decades. Therefore, the 30 to 44% reductions indicated by the SIAM model reflect the short term response. Estimates of long term reduction in sediment supply could be much greater.

REFERENCES

Hudson, Frank, E., (1997), "Project Formulation of the Demonstration Erosion Control Project," Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision, S.S.Y. Wang, E.J. Langendoen, and F.D. Shields, Jr. (eds), The University of Mississippi, University, MS.

Jonas, M., and C.D. Little, 2010, "Sediment Impact Analysis Method (SIAM): Overview of Model Capabilities, Applications, and Limitations," 2nd Joint Federal Interagency Conference on Sedimentation and hydrologic Modeling, Riviera Hotel, Las Vegas, NV.

Watson, C.C., N.K. Raphelt, and D.S. Biedenharn, 1997, "Historical Background of Erosion Problems in the Yazoo Basin," Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision, S.S.Y. Wang, E.J. Langendoen, and F.D. Shields, Jr. (eds), The University of Mississippi, University, MS.