Turkey Creek Rehabilitation Project: NRCS, The City of Sumter, and SCDOT Join Forces to Improve a Degraded Urban Waterway

Joshua Robinson, PE\textsuperscript{1}, Stephen Henry, PE\textsuperscript{2}

\textbf{AUTHORS}  
\textsuperscript{1}Principal Engineer, BurnsRobinson, PC, 214 West Liberty Street, Sumter, SC, 29150  
\textsuperscript{2}Assistant State Conservation Engineer, USDA-NRCS, 1835 Assembly Street, Columbia, SC, 29201

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\textbf{ABSTRACT.} The Turkey Creek Canal Rehabilitation Project, completed in 2011, is the first of its kind in South Carolina. Local leadership by the City of Sumter, active cooperation and funding by federal, state, and local agencies, and innovative engineering design resulted in a successful project to protect property and infrastructure.

The Turkey Creek Canal is one of two major waterways flowing through the City of Sumter. Flooding and channel stability have been significant challenges in this municipal sand-bed canal for several generations, and watershed urbanization has further complicated these issues along the channel corridor. Most of Turkey Creek is managed through an agreement with the US Army Corps of Engineers (USACE), with ongoing maintenance activities including dredging, bank stabilization, and vegetation removal.

In July 2009, two high-intensity, short-duration storm events severely eroded channel banks. A 900-foot reach of channel adjacent to the SCDOT office and equipment yard was threatened by severe bank sloughing. Previous attempts to stabilize the banks in this reach were undermined by high-energy storm flows. Following this damage, the City of Sumter and the SCDOT reached out to the USDA-Natural Resources Conservation Service (NRCS), and the NRCS offered Emergency Watershed Protection (EWP) funding and assistance for the repair efforts. The EWP funding required a 25\% match, and the City and SCDOT worked together to provide this match through in-kind contributions such as raw construction materials, construction administration, and regulatory assistance. BurnsRobinson, PC, a Sumter-based firm, was selected by the City of Sumter to provide engineering analysis, channel stabilization design, and regulatory coordination for the project, with the goals of restoring the flow capacity of the channel and protecting adjacent properties.

The innovative engineering design utilized traditional stabilization techniques, such as riprap revetment design, combined with forward-thinking bio-engineering techniques, such as fabric-encapsulated soil lifts and live-staking. Hydraulic and geomorphic analyses included rigorous one-dimensional and two-dimensional hydraulic modeling and hydrologic gauge data assessment.

One of the most challenging aspects of the project was coordinating requirements of three Federal agencies – USACE, NRCS, and FEMA - as the lower 450 feet of the project reach are within the USACE-managed section, and the entire project area is in a regulatory floodplain.

From the perspectives of funding, management, and design, this project is truly unique among environmental water resource efforts. This successful project has attracted attention locally and across the state from agencies, governments, and the public. The project has also brought attention to the waterway, helping residents see Turkey Creek as a community resource and bringing energy to future plans for a greenway, floodplain remapping efforts, and other water quality improvement projects.

\textbf{INTRODUCTION}  
Managing urban streams is a challenging responsibility for many municipalities. Technical, financial, and regulatory constraints often prevent effective management of these waterways, and as a result, channels become increasingly unstable, property is damaged, water quality degrades, and flooding increases. The downstream effects of watershed urbanization and the resultant hydrologic modification are well-documented (Debo and Reese 2003; NCDWQ 2007), and numerous approaches to management, stabilization, and restoration of urban streams have been presented in the last twenty years (Shields et al. 2003; Federal Interagency Stream Restoration Working Group
Urban streams in the South Carolina Midlands and Coastal Plain are particularly difficult to manage due to frequent, intense rainfall events coupled with fine-grained channel boundary sediments. As a result, stream stabilization and restoration projects are expensive and prone to failure if not monitored, designed, and constructed properly (Copeland et al. 2001), and successful projects typically require years of observation and on-going adaptive management. Furthermore, working within active waterways requires extensive coordination and approvals through USACE and FEMA to comply with the Clean Water Act and National Flood Insurance Program.

The Turkey Creek Rehabilitation Project team, including the City of Sumter, NRCS, SCDOT, and consulting engineers of BurnsRobinson, PC, navigated these technical, financial, and regulatory constraints to successfully stabilize and rehabilitate more than 900 linear feet of urban stream in Sumter. The lessons learned from this project are valuable for practitioners, municipalities, and agencies working to manage and improve South Carolina's urban waterways.

Turkey Creek has been intensively managed by the Sumter community since at least 1870. Public records indicate on-going cycles of channel cleaning, dredging, and straightening, punctuated by flood events, droughts, and severe water contamination. In the late 1960's and early 1970's, Turkey Creek was channelized by USACE under the provisions of the Flood Control Act of 1948. Since then, USACE has inspected the canal annually and has provided technical guidance for the on-going channel dredging required to maintain its capacity for flood waters.

The Turkey Creek Canal corridor is fully urbanized and is tightly constrained by adjacent properties, utility crossings, and road crossings. The urban watershed delivers flashy, high-intensity storm flows and large quantities of sandy sediment from upstream sources. Whereas Turkey Creek was originally a wide, shallow, meandering, multi-thread, and swampy backwater creek, Turkey Creek is presently a deep and narrow trapezoid, and the planform is single-threaded and straight. The native sandy soil forms the bank material and bed material, and the banks have been cleared of most woody vegetation. Water quality, habitat value, and recreational value are very poor, as the singular function of the canal for the last 100 years has been flood control.

In the northern, upstream portion of the City, the Turkey Creek Canal flows directly adjacent to the SCDOT office and equipment yard property for approximately 900 linear feet. The highly-erosive sandy banks along the SCDOT property have been susceptible to erosion and mass wasting for many years, and previous stabilization efforts such as sheet-pile bulkheads had been undermined by storm flows. In July 2009, two large storm events severely eroded channel banks, causing further loss of property.

PROJECT FUNDING

Following the damage, the SCDOT reached out to local officials for assistance. The NRCS identified the site as a candidate for its Emergency Watershed Protection (EWP) program, which exists to undertake emergency measures to prevent soil erosion and safeguard lives and property from the effects of erosion when a natural occurrence has caused a sudden impairment of the watershed. The EWP program enables the NRCS to partner with a local sponsor and provide technical and financial assistance; the sponsor, in turn, provides in-kind services, materials, and/or technical, financial, and administrative support. The urgent nature of EWP projects requires a compressed project timeline, and typically enables streamlining of permitting and regulatory approvals. For this project, the City of Sumter agreed to serve as the project sponsor, and the SCDOT agreed to work with the City to provide in-kind materials and services.

REGULATORY CONSTRAINTS

Unlike most EWP projects, this project required extensive regulatory review and approvals. Typically, permit approvals are streamlined due to the “emergency” nature of EWP projects. Furthermore, since the goal of EWP is to restore the project area to pre-damage conditions, the proposed conditions are usually very similar to the pre-damage conditions. Accordingly, EWP projects follow a rapid timeline; the total project timeframe for this project was 220 days. As the project team soon learned, however, Turkey Creek was unique due to the severe bank erosion and the tightly-constrained urban environment. Proposed stabilization measures would require mass-grading along the channel corridor, which, in turn required coordination with FEMA and the USACE.

Turkey Creek is a flooding source for a major Special Flood Hazard Area within the City of Sumter, and any proposed manipulation of the channel requires a hydraulic study to ensure the work will not adversely affect flooding upstream or downstream. Because the
The selected design alternative involved excavating the channel bed and banks and rebuilding the channel bottom and bank toe with riprap stone. Riprap stone was selected because 1) the SCDOT could provide the stone as part of its in-kind contribution, 2) riprap revetment design and construction methods are widely published (Lagasse et al. 2006), and 3) standard riprap enables greater quality control over stone size, shape, and material, compared to other types of quarry stone. The riprap channel was designed to be a threshold channel, such that the expected velocity and shear stresses in the channel could not move the stones (Sturm 2001). A bioengineering approach was used to reconstruct the upper portion of the stream banks. Fabric-encapsulated, compacted, vegetated soil lifts were designed to create a stable soil matrix that would strengthen over time. Live stakes and bare root woody riparian species were planted within and along the soil lifts, and herbaceous seed and plugs were planted along the bottom soil lift. The root system of these plants, particularly the woody species, will grow into the banks, creating a sustainable, low-maintenance stream bank that also provides ecological benefits of shade, cover, refuge habitat, and organic input.

The computer model HEC-RAS (USACE 1998) was used to size the channel, estimate the forces imposed by the flowing water, and consider the performance of the channel under the full range of flow conditions (USACE 1993). These models were also used to assess sediment

### DESIGN AND CONSTRUCTION

The proposed channel would not tolerate natural adjustment of the channel boundaries, since even minor natural adjustments to the channel section or plan would threaten water lines, sewer lines, a road, and several buildings. The design team thus adopted the “threshold channel” design concept, in which the channel boundaries are designed to be immobile throughout the range of probable storm flows. Rather than referring to the effort as “restoration”, the design team sought to “rehabilitate” the stream – to extract the highest possible degree of natural function within the constraints of the site (Watson et al. 1999). This approach would require a watershed-based, geomorphic approach coupled with experienced design engineering.

### APPROACH

The Turkey Creek project reach is tightly constrained, with the SCDOT equipment yard at the top of the right bank, and a sewer line and public road at the top of the left bank. The team explored options for acquiring additional land to gain floodplain area, but determined that this option was infeasible due to constraints imposed by funding, time, and property ownership. Piping the channel was also infeasible due to the very large pipe size that would be required to contain channel flows, and regulatory constraints imposed by FEMA and USACE.

As the first step, the project team performed a thorough review of similar projects and the literature. Successful “soft” stabilization approaches in similar situations have included floodplain benching, channel widening, bioengineering, and channel re-meandering. Similarly, “hard” stabilization approaches such as channel armoring and grade control structures have been implemented successfully. Many practitioners have followed a purely form-based approach where nearby natural, undisturbed stream systems are used as a template or analog for restoring stream channels. (FISRWG 1998). However, because the fully-urbanized Turkey Creek watershed could never be returned to its natural state, comparison of a natural watershed to an urban one would be a tenuous proposition. Therefore, the design team determined that the unstable urban stream must be rehabilitated and transformed into a new geomorphic form capable of transporting the water and sediment discharges imposed upon it by its existing, urbanized watershed (Robinson and Sturm 2001).
transport potential through the reach in relation to the upstream sediment supply. USACE reviewed the models to ensure the proposed work would not adversely impact flow or sediment transport along the reach or in the downstream reach. The design team also used the two-dimensional hydraulic model CCHE2D (Zang 2006) to analyze geomorphic tendencies in the channel such as meander bend scour pool development, tributary scour, and deposition (Robert 2003). The model was used to iteratively design fixed-bed “scour pools” in key locations along the reach where these pools would naturally develop in a mobile bed system. Modeling runs demonstrated that the naturally-occurring scour pools are an important component of rapid energy dissipation through turbulent mixing in the scour zones, particularly in a section of the reach where a small tributary joins the main channel.

CONCLUSIONS

The rapid project timeline required by EWP funding, coupled with regulatory and technical constraints, nearly prevented this project from moving forward. A turning point in the project was a day-long, on-site meeting of all stakeholders and project representatives where all regulatory requirements were discussed and a plan to navigate these various requirements was developed by the group. This cooperative effort among the NRCS, USACE, SCDNR, SCDOT, Sumter County, The City of Sumter, and private consultants serves as a great example of how federal, state, local, and private entities can work together to achieve a great project that overcomes hurdles imposed by funding, regulatory, and technical constraints.

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LITERATURE CITED


