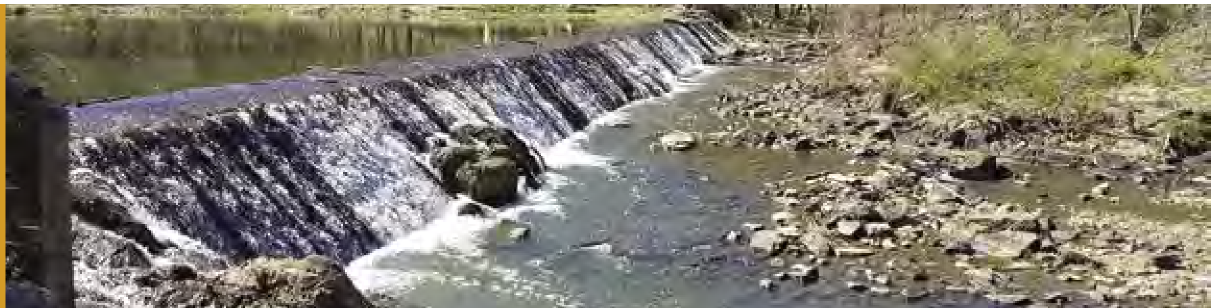
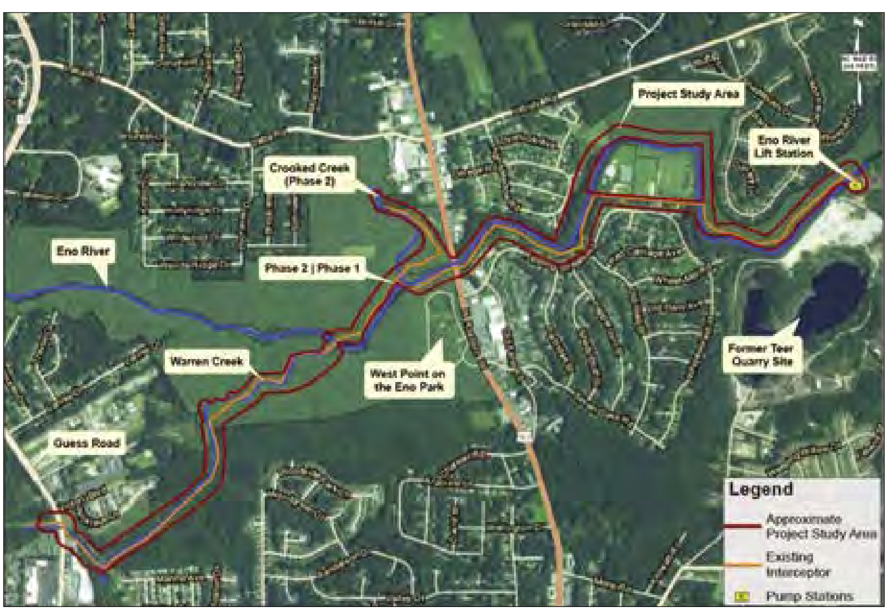


Shown here is the Eno River as it flows over a dam in the City of Durham's West Point Park. This river draws a lot of attention and interest from a variety of groups, including neighborhoods, environmental organizations, recreational users, and regulators. The team dealt with most of these groups while undertaking a major upsize to a section of key infrastructure in the City of Durham's collection system.

Durham's Eno River Outfall Replacement: Not Your Typical Outfall Project

By Jim Harding, PE, Principal Engineer, City of Durham and Jacob Bowes, PE, Project Engineer, McKim & Creed

By definition, a sanitary sewer outfall is any pipe or conduit that is used to carry raw sewage or treated effluent into a final point of discharge. A "typical" new construction sanitary sewer outfall includes mainline sanitary sewer piping of varying size and material that traverses through low-lying areas along with precast concrete manhole structures. Outfall projects also usually include the addition, demolition, or rehabilitation of a lift station. Durham's Eno River Outfall Replacement project had all the ingredients for a typical outfall project, but there's always more to a recipe than what you can taste.



This shows the 3-mile-long project area. On the east end is the Eno River Lift Station, the City's largest. This station collects sewer generated by about 35 square miles of land, and ultimately pumps to the North Durham Water Reclamation Facility. Going west, upriver, the corridor goes through three different neighborhoods, crosses US Highway 501, then traverses mostly through parkland before crossing NC Highway 157 at the westernmost end.

THE BACKGROUND

The City of Durham Department of Water Management provides sanitary sewer service to the entire Eno River sewer shed in Durham County, as well as limited portions of Orange County. For more than 25 years, the City has experienced sustained and substantial growth in development and population, expanding primarily to the north and south. Much of the area to the north drains into the Eno River basin, and numerous developments, primarily residential, have been built with sewer lift stations. All of these lift stations ultimately flow into a large outfall adjacent to the Eno River itself.

Several years ago, a hydraulic analysis of the basin revealed the outfall was surcharging in moderate rainfalls. A significant amount of the clay sewer system had been installed in the 1960s, '70s, and '80s, and rainfall-derived infiltration and inflow (I&I) was a major contributor to the excess flow. The capacity of the existing 24-inch outfall, located primarily along the south side of the Eno River, was simply no longer adequate.

With limited land along the Eno River and few routes for a new large outfall, the City realized this would likely be the last opportunity to upsize this section of sewer.

Click Here
to return to Table of Contents

After evaluating options, the Department of Water Management elected to upsize the outfall sewer to 48 inches, as well as eliminate known/easily identified sources of I&I. With the larger, new outfall, the City could also feel confident in the pipe and joint integrity. The age of the existing outfall was unknown, but records showed it was lined in the early 1990s and its condition was suspect.

DETERMINING A NEW ALIGNMENT

The existing corridor was much too narrow to perform adequate blasting for removal of rock and did not provide room for the deep excavations necessary to accommodate the new pipe construction. The current pipeline alignment was close to the river, and proximity of residences along most of the southern riverbank created additional complications, especially if the new pipeline were aligned parallel to the existing outfall. Hilly terrain, large boulders, mixed face conditions, and a shallow river bed only complicated matters when choosing a feasible alignment for the new outfall pipe.

Ultimately, the north side of the river was determined to be the most feasible and constructible corridor for the majority of the future alignment of this larger outfall pipe. Although this alignment was preferred, it presented many unique and challenging hurdles that required teamwork and collaboration to ensure a successful outcome. Right away, we knew this was not going to be a typical outfall project.

SELECTING PIPE MATERIAL

When dealing with a large-diameter gravity sanitary sewer outfall, anticipated life of material, cost to the owner, and installation time play key roles in final material selection. This project involved the installation of approximately 8,000 feet of 48-inch fiberglass reinforced polymer (FRP) pipe and approximately 800 feet of 36-inch FRP pipe. The City of Durham had never used FRP in its collection system, but considered it for the following benefits:

At the 36-inch to 48-inch diameter size, FRP has better unit pricing than other commonly used sanitary sewer pipe materials like polyvinyl chloride (PVC) and ductile iron pipe (DIP).

This is one of the three Eno River crossings shown halfway complete with recently poured concrete encasement.

The polymer mortar interior lining in FRP provides a longer maintenance-free service life than the ceramic epoxy liners typically used in DIP for corrosion resistance.

FRP can be installed in a variety of applications, which proved valuable for this project. The average depth of installation ranged from 18 to 20 feet below grade in soil conditions consisting mainly of silt, clay, and partially-weathered rock.

FRP performs well for required pipe thickness in deep direct bury installation with varying soil conditions and as a carrier pipe for large microtunnel installations.

Last and certainly not least, construction of FRP pipe is not out of the ordinary, has a reasonable lead time, and requires typical installation methods as compared to other, more common pipeline materials.

POLYMER CONCRETE VS. TRADITIONAL CONCRETE STRUCTURES

In critical locations along the new outfall, the City wanted manhole and junction box structures that would last forever, or as close to forever as possible. Polymer concrete is known around the industry for its exceptional corrosion resistance and 50+ year life expectancy. As with the FRP pipe, the City did not have polymer concrete structures elsewhere in its collection system.

On this project, two key areas were identified where hydrogen sulfide (H_2S) gas would be the greatest problem, thus requiring an additional layer of interior protection for manholes. To counteract structural degradation from turbulent wastewater flows, three cylindrical polymer

Shown here is the microtunnel boring machine and casing pipe contained in the tunnel's launching shaft near the outfall crossing at US Highway 501. This marked another first for the City of Durham and the NCDOT's Durham District.

concrete manholes were incorporated near the tie-in of an existing 18-inch force main, as well as one cylindrical polymer concrete manhole at the final tie-in point just outside of the Eno River Lift Station. In addition, to minimize the need to work near the river on future structural repairs, two rectangular polymer concrete junction boxes were constructed on both sides of each river crossing. In total, six junction boxes were constructed. Each box contained removable stop logs that acted as weirs to control flow through incoming and outgoing outfall piping during times of high- or low-flow conditions.

CROSSING THE ENO RIVER… THREE TIMES

In the early stages of design, we knew the outfall pipe was going to have to be sized for at least 48 inches in diameter for all three crossings of the Eno River. It would have been easy to provide a continuous diameter across the entire outfall segment traversing each river crossing, but this was not your typical outfall project.

Traversing each river crossing with a 48-inch pipe was not an option because a pipe that size would have protruded from the river bed. Such intrusive impact on the Eno River would have created significant project delays in terms of hydrologic modeling and permitting. A jack and bore or other trenchless means would provide the needed room to allow construction of a new pipe to pass under the river without collapse of a bore or tunnel, yet we were limited to a fixed invert elevation at the downstream connection into the Eno River Lift Station, ultimately making this option unfeasible as well since increasing depth under the river crossings was not possible.

Click Here
to return to Table of Contents

Instead, McKim & Creed proposed the hydraulic equivalent of a 48-inch pipeline: three 24-inch pipelines. With the junction boxes, we were able to take incoming gravity flow from one pipe and split it into three pipes within a rectangular junction box, and vice versa, at both the upstream and downstream ends of each river crossing. A 24-inch line provided sufficient cover between the top of the pipe and the bottom of the river bed, which allowed the team to avoid costly and timely permitting and modeling efforts.

However, the task at hand still involved an open cut of a river that ultimately feeds into the Falls Lake Reservoir and Neuse River, so additional permitting efforts had to be considered. McKim & Creed obtained Section 401 and Section 404 approval from the North Carolina Department of Environmental Quality and the US Army Corps of Engineers. As part of this approval process, an endangered species survey was performed at each river crossing, which considered safeguarding impacts to endangered species through maintaining critical habitats. Upon completion of each river crossing, all native river bed soil and rock removed during excavation went back into the river as backfill, in order to mimic – as closely as possible – the condition of the river bed prior to construction. This provided the habitats required for spawning and egg-laying of endangered species in the native materials after construction was complete.

CREATING A COFFERDAM AND PROVIDING LONG-LASTING PIPELINE PROTECTION

Thinking about crossing a river is one thing, but actually doing it is another. To cross the Eno River, damming a portion of the river was necessary to temporarily bypass river flow and provide for flood protection during excavation. The general contractor, JF Wilkerson, utilized an Aqua-Barrier cofferdam that is held in place by its own weight when inflated with water. Submersible sump pumps controlled the water that naturally seeped in under the Aqua-Barrier.

To create a river crossing that is protected from settlement as well as possible damage caused by future scouring or erosion of the river bed, the contractor used "caged reinforcement." This type of reinforcement involved longitudinal rebar that hugged and reinforced the outside of each outfall pipe. In addition, concrete encasements were poured around all the pipes. Caged reinforcement protected the pipe from future scour and erosion impacts and helped counteract buoyancy forces acting on the pipes spanning these crossings. All three crossings of the Eno River – totaling approximately 465 linear feet – were completed successfully and safely in a little over three months.

SOIL NAIL WALL TO STABILIZE SLOPES

For approximately 300 feet, the gravity sewer main had to be installed through an area of extremely steep slopes; approximately 15 feet from the top of the trench to the top of the slope. The deepest point of excavation along this alignment, at approximately 28 feet, occurred in this location. JF Wilkerson proposed using a soil nail wall to prevent future settlement and slope instability above the trenched areas, as well as to protect against collapse of these steep side slopes into the pipe trench during construction. Soil nail wall installation is permanent, so impacts to neighboring residential properties at the tops of these slopes had to be carefully considered. The soil nail wall was designed and installed to ensure rebar did not cross over into private property adjacent to the project work area.

MICROTUNNELING UNDER HIGHWAY 501

Unlike the river crossings, a design decision was made early in the project schedule that an open-cut installation across US Highway 501 – a major NCDOT four-lane arterial through Durham – was not feasible. However, at 255 linear feet, a 70+ inch diameter casing pipe starts to push the limits of a traditional jack and bore installation, especially considering the possibility of encountering mixed-faced rock and other mixtures of fill materials along the entire bore path. Additionally, launching and receiving pits would have to be located very close to the Eno River, and the risk of the river overtopping its banks and flooding out these pits, thereby damaging jack and bore equipment, was very real. Ultimately, when considering the length of the crossing, potential of mixed-face rock getting bound up in the jack and bore augers, and the flooding concerns, the microtunnel installation option became the clear-cut design choice.

The microtunneling operation occurred approximately 1,100 feet from the most upstream point of the project site. Due to fixed invert limitations at the final connection point of this outfall into the lift station, along with the need to provide adequate cover over the piping at each river crossing, a 0.10%

This is one of three Eno River crossings. It included cofferdam installation, riverbed removal, and installation of three 24-inch diameter ductile iron pipes which are the hydraulic equivalent of a single 48-inch outfall.

Click Here
to return to Table of Contents

Trenching for the new outfall pipe involved the use of an excavator that was shipped to the site and assembled prior to mobilization. Trenching also included drilling and blasting of rock for removal, and installation depths in some places of up to 28 feet below grade.

slope was designed for the majority of this pipeline up to the microtunnel operations. Consequently, this allowed for a steeper slope of 1.00% to be designed across the microtunnel's profile, providing for additional tolerance should the slope need to be adjusted during the tunnel installation. The design originally called for a 72-inch diameter casing to span this crossing, but to allow for further adjustment of the slope of the carrier pipe, a 75-inch diameter steel casing was proposed and accepted by the team. Bradshaw Construction Corporation completed the microtunnel under US Highway 501 accurately and safely in about 30 days, working 24/7 shifts. As this was another first for the City of Durham as well as the Durham District of the North Carolina Department of Transportation, additional monitoring of the microtunnel operations was performed. McKim & Creed provided 24-hour construction observation, and frequent surveys along the tunnel's path were conducted to verify if the roadbed was being impacted by the tunneling operation.

COMMUNICATE, COMMUNICATE, COMMUNICATE

Finally, what better way to engage and coordinate with project stakeholders and neighbors than through substantial tree and brush clearing, followed by several weeks of drilling and blasting? A critical component to the success of this project was neighborhood information meetings hosted by our owner-engineer-construction team. We explained the reasons, locations, and impacts of the project and discussed homeowner concerns. The three river crossings impacted three different neighborhoods, each with unique concerns and preconceived ideas about large construction projects, environmental impacts to a beloved river that provides scenic hiking and swimming areas, and various other concerns related to a new sewer outfall construction project. We were able to address these concerns well ahead of construction, mitigate negative impacts, and inform affected residents about what to expect and when to expect it.

CONCLUSION

The overall construction cost was $14.4 million, with about $2.5 million of that invested in lift station upgrades. Through this project, the City of Durham increased its sanitary sewer capacity at the Eno River Lift Station from 15.8 mgd to 24.3 mgd. The next phase of this outfall replacement project is expected to begin construction in 2021 and will extend further upstream an additional 8,000 feet to near NC Highway 157. This next phase will involve project design components similar to the phase just completed.

When the project team was able to digest the results of such an important project for the City of Durham, one thing was clear. It may not have been a typical sanitary sewer outfall project, but it was definitely a successful one.

ABOUT THE AUTHORS

Jim Harding, PE, is a principal engineer with the City of Durham Department of Water Management and served as the project manager for the City. **Jacob Bowes**, PE, Project Engineer with McKim & Creed, was the full-time construction observer. They can be reached at *jim.harding@durhamnc.gov* and *jbowes@mckimcreed.com*.

Click Here to return to Table of Contents