1. ABSTRACT

The City of Solon, OH is progressing with its City-Wide Sanitary Sewer Improvement Program, a program designed not only to replace an aging infrastructure, but to upgrade the system as a whole to better regulate sewer flows during storm events. The Miles Road Sanitary Sewer Replacement Project is a key component of the overall program, located on a major artery of a residential neighborhood. Of the approximately 4,600 lineal feet of 8-inch and 10-inch sanitary sewer to be replaced, over 3,200 lineal feet was determined to be appropriate for installation via traditional open-cut methods. However, nearly 1,400 lineal feet was to be installed near adjacent ponds and retention basins. In order to ensure protection of these local resources, minimize the need for extensive shoring and dewatering, and minimize the project’s disturbance impact to the local residents, Solon elected to use a trenchless construction method they had utilized once in their history: Pipe Bursting.

General Contractor Trax Construction teamed with subcontractor Utilicon with help from TT Technologies to perform the Pipe Bursting, accomplished in three separate runs using 10-inch diameter heat-fused PVC pipe. The operation was not without challenges. Bedrock elevation was found to be less than 1 foot below the pipe invert in several areas along the alignment. This coupled with the 1% slope of the sanitary sewer raised concerns of maintaining grade and positive gravity flow. This paper discusses how the Project Team including the City of Solon, H.R. Gray, and the Contractor faced these challenges to deliver the Miles Road Sanitary Sewer Project.

2. INTRODUCTION

Settled in the early 1800s and officially established as a city in 1960, the City of Solon is one of Northeast Ohio’s most reputable suburbs. It resides approximately midway between the cities of Cleveland and Akron, allowing for quick access to both cities (See Figure 1). Home to large manufacturing hubs for companies such as Nestle and Swagelok, Solon has a healthy mix of industry to accompany the ever-growing residential population, currently estimated at over 25,000 citizens. Combine this with the abundance of natural resources including parks, trails, and bodies of water within the City, there is good reason the residents willingly pay higher than average property taxes. With high taxes come high expectations for excellent public services. The City of Solon places a high priority on asset management and improvement to ensure stakeholders receive the expected level of service; this includes the efforts of the City’s Engineering and Construction Departments which manage the municipal construction within the City.

The typical construction season for the City of Solon consists of projects ranging from asphalt and concrete road improvements, water main upgrades, culvert replacements and storm and sanitary sewer replacements. The Miles
Road Sanitary Sewer Replacement was one of the largest construction projects in the City’s 2017 Infrastructure Improvement program. At a contract bid price of nearly $1 Million, it represented approximately 10% of the estimated $10 Million in the originally-planned infrastructure improvement expenditures for 2017. Specifically, it was a key part of the City-Wide Sanitary Sewer Improvement Program, an ongoing multi-year program designed to not only replace an aging infrastructure, but to upgrade the system as a whole to better regulate sewer flows during storm events.

2. SEWER DESIGN AND PIPE INSTALLATION METHODOLOGIES

The city engineer made the Miles Road Sanitary Sewer Replacement project a priority due to failing pipe joints, as the existing sewer was experiencing constant infiltration of groundwater during rain events. Because of this, the City’s Water Reclamation plant was experiencing continued capacity issues. The scope of the Miles Road Sanitary Sewer Replacement included full-replacement of approximately 4,600 LF of 8-inch and 10-inch mainline sanitary sewer. In conjunction with the sewer replacement was the associated ancillary work including sanitary lateral tie-ins, concrete curb, sidewalk, and drive apron restoration in areas disturbed by the proposed construction.

Located on Miles Road between Boulder Creek Drive and Harper Road, the sewer alignment was constrained by several factors including but not limited to Right-of-Way boundaries, existing third-party utilities, both overhead and underground utilities, and various natural resources including two adjacent ponds (See Figure 2). Protection of these features proved to be a major driver in the project’s design completed by Burgess & Niple, a consultant engineering firm based in Columbus, OH. Specifically there was concern that traditional open-cut sewer installation near the two existing ponds (distance to the sewer alignment was as close as 10 feet in some areas) could compromise the ponds’ banks. In an effort to mitigate risk to these natural resources, the City of Solon in conjunction with the construction design team began to consider trenchless options for the sewer installation.
Existing geotechnical conditions consisted of soft to stiff Clay, moist to wet, brown to gray, and lean Clay, with little sand and trace Gravel. Further to these very diverse soil conditions was the element of sandstone bedrock, which was determined to be at an elevation within 1-foot of the planned bottom-of-pipe in some areas. Any construction method proposed would need to take these conditions into account. Sewer depths ranged anywhere from 8-feet to 12-feet deep, necessitating use of a trench box should any open-cut methods be considered.

Weighing the issues of cost, mitigation of disturbance to the traffic, and protection of the adjacent natural resources, the City of Solon considered a combination of sewer installation methods. To mitigate costs, Open-cut methods were to be performed for a majority of the project; allocated for approximately 3,200 lineal feet of sewer in the low-risk areas away from the two ponds. To minimize the risk of compromising the integrity of the adjacent ponds, the project’s remaining 1,400 lineal feet, comprised of three separate runs of 374 feet, 650 feet, and 350 feet were to be installed via trenchless methods. Though several renewal construction methods were considered, including sewer grouting, sewer lining, and directional boring, the final decision was to utilize static pipe bursting. The City of Solon had one previous experience with pipe bursting technique on a small project and it proved to be a success. Despite the limited case history, the previous success bred confidence in the method. The existing pipe was generally small diameter, varying between 8 inches and 10 inches, and the assumption was that the displacement of the existing pipe through the bursting process would be minimal. Therefore it was assumed that the close proximity to the sandstone bedrock (again, within 1 foot of planned bottom of pipe) would not pose an issue to the line and grade of the new sewer installation, or to the bursting operation itself. Being able to install these constrained sewer
runs without physically removing the existing sewer would mitigate the risk of an open-cut sewer installation operation in a sensitive area. This proved to be the deciding factor for the methodology.

Material selection for the pipe bursting operation consisted of two options: Flexible High-Density Polyethylene (HDPE) Pipe or the rigid Heat-Fused Polyvinyl Chloride (FPVC) Pipe. Both were viable options that the consultant and city engineers had at their disposal. The HDPE had the benefits of flexibility and seamlessness, however there was a manufacturer-recommended 24-hour post-installation pipe relaxation time which would delay the lateral tie-in process. FPVC required no post-installation relaxation time, so laterals could be installed immediately after mainline pipe installation. The rigidity of the FPVC was assumed to more readily show any required post-construction punch list repairs that would be visible with the acceptance CCTV video inspection. In order to allow for immediate lateral tie-ins, the consultant engineer and City of Solon elected to use the rigid FPVC pipe for the pipe bursting runs. Incidentally, SDR 35 PVC pipe was utilized for the open-cut sewer installation.

As the existing Miles Road sanitary sewer was comprised of aged vitrified clay pipe, bursting the existing pipe was assumed to be feasible. However, as is often the case with underground work, a multitude of factors presented challenges that would need to be overcome during construction.

4. GENERAL CONSTRUCTION CONSIDERATIONS

For quality assurance and control, H.R. Gray (A Haskell Company), based in Columbus, OH with branch offices in Akron, OH, Cleveland, OH, and Pittsburgh, PA teamed with the City of Solon to provide inspection services on Miles Road Sanitary Sewer Replacement Project. The project itself was awarded to Trax Construction (Trax), based out of Wickliffe, OH (east of Cleveland, OH), in the amount of $968,474.50 on April 3, 2017. Construction commenced May 10, 2017. Trax self-performed all open-cut sewer installation and restoration activities. For the portions of the sewer slated for pipe bursting, Trax elected to use subcontractor Utilicon who in turn utilized TT Technologies to supply specialty equipment and act as an advisory consultant during the installation process.

In any City of Solon project, communication is of high importance. As this project affected the main east/west artery along the northern border of the City of Solon, effective communication was not just important, it was demanded by the affected residents. The City produced informational fliers to pass out to residents in the area. As the construction progressed, the Contractor alerted affected residents with notices in the form of door hangers and verbal communication. Keeping communication at the forefront of this project allowed the work to advance while keeping all stakeholders in the loop. Previous project experience had shown that if the affected residents are not kept informed, the potential for complaints and inquiries to the City of Solon would be high. By being proactive and getting the communication out ahead of the work, many resident questions were apparently answered as the complaint traffic was reportedly low.
Prior to performing any sewer installation or even sticking a shovel in the ground, Trax Construction needed to prepare the work-site for long-term (Multi-month) use. Maintenance of traffic was of key importance during the full duration of this project. For a majority of the construction, Miles Road, a major 2-lane arterial street that serves as the northern border of the City of Solon, was reduced to a single lane. Traffic was maintained by use of temporary single-lane traffic signals and corresponding traffic barrel configurations. Brief localized closures were executed with flaggers from the contractor’s work force. At times, side streets branching off of Miles Rd. had to be temporarily closed. This was due to several factors including the intersection’s proximity to the construction, as well as assembly of the FPVC pipe sections for the Pipe Bursting operation. Closure of side streets was coordinated with carefully designed detours. All of these items were proposed by the contractor pre-construction and approved by the City of Solon prior to implementation. Anytime there is a road closure or an alteration to a typical traffic pattern, there is inconvenience experienced by the traveling public. However, through a concerted effort of the contractor in conjunction with the City of Solon, the traffic was maintained throughout the project duration so as to minimize the inconvenience and maximize safety for the residents.

Covering nearly one full mile, there was plenty of linear right-of-way to work in. All material and equipment staging was located within the right-of-way, generally between the Miles Road pavement and the existing sidewalk which was approximately 12 feet to 15 feet from edge of pavement. The construction work was largely kept off of private property, except for when reconnecting laterals that had to be chased back to viable pipe behind the right-of-way. As a general rule, work was to be maintained within the right-of-way to the extent possible.

5. OPEN-CUT SEWER INSTALLATION

Open-cut sewer installation, comprising approximately 3,200 lineal feet of the total 4,600 total sewer replacement length, was performed in phases. Trax Construction was tasked with maintaining existing residential sanitary laterals while replacing the existing mainline sewer in-place. They decided it would not be wise to perform the mainline installation all at once, as this would necessitate long-term lateral maintenance. So the open-cut sewer installation was broken into manageable sections averaging 20 lineal feet. This allowed Trax to fall back and reconnect the laterals as they went which yielded multiple benefits including reduced time of inconvenience to the affected residents and minimization of temporary bypass flow maintenance costs incurred by Trax.

The open-cut sewer installation was able to be performed utilizing traditional trenching methods. A track-mounted excavator performed the excavation, loading trucks that were staged along the closed lane of Miles Road. With an average depth of sewer at approximately 9 feet to 11 feet deep, Trax was well within the 20-foot maximum depth criteria as laid out by OSHA. Had the depth been greater, the temporary excavation support method would need to
be signed and stamped by a registered professional engineer. Being less than 20-feet-deep, Trax elected to use a simple trench-box setup to support the pipe trenching (See Figures 4a and 4b).

![Figure 4a (Left) and 4b (Right). Photos of Open-Cut Sewer Installation](image)

One significant challenge to the open-cut sewer installation was the sandstone bedrock elevation. It appears that the existing sewer had been installed almost directly on top-of bedrock in some areas. Recall that the pre-design geotechnical investigation reflected bedrock elevations within 1 foot of bottom of pipe elevation. This proved to be an estimate as there were areas of anomaly that the rock elevation jogged upward to an elevation at or near bottom of pipe. There was concern that if the new sewer was installed in the same fashion, essentially in contact with the bedrock, the SDR 35 PVC pipe would be point-loaded and may be subject to premature damage. To avoid this situation, the City of Solon directed the contractor to abide by the specified typical pipe bedding detail. This required bedrock to be removed in several locations up to a depth of 6 inches to allow for the specified depth of limestone pipe bedding material to be installed. By doing this, the newly installed PVC pipe would have bedding as the design intended so as to maximize the sewer’s longevity.

The open-cut sewer installation commenced on 5/18/17 and was completed by 8/22/17 however this sewer installation was not a continuous operation. When considering actual time worked trenching and installing the mainline sewer via open-cut methods, the total duration to install the 3,200 lineal feet was approximately 35 working days. This yields a total average production rate of 91.4 lineal feet of open-cut sewer pipe per day.

6. STATIC PIPE BURSTING SEWER INSTALLATION

To perform pipe bursting, an entry point and exit point for the bursting head and pipe need to be established. In the case of this project, the contractor elected to excavate the entry and receiving shafts to facilitate the work. At depths of 10 feet the excavation work was relatively minor. The entry shaft had approximate dimensions of 20 feet by 5 feet, and the far bank of the shaft was sloped at an approximate 2:1 grade to allow for the long stretch of FPVC pipe to be fully pre-fabricated and staged at the entry point. Despite being a fairly rigid pipe, there was enough flex in the FPVC to navigate the slope from surface to entry point. The Exit shaft dimensions were approximately 20 feet by 5 feet, based on the required dimensions to house the hydraulic unit of the pipe bursting equipment, along with the retrieval area for the winch link segments (See Figures 5a – Launch Pit and 5b – Receiving Pit).
The Pipe Bursting operation was performed utilizing a TT Technologies Grundoburst system, which hydraulically pulled the ram/cutter-head and new pipe through the existing vitrified clay pipe, bursting the existing pipe as it progressed. Unlike Pneumatic Pipe Bursting, Static Pipe Bursting uses no percussive action to aid in the advancement of the cutter-head. Due to the relatively short length of each run (374-ft., 650-ft., and 350-ft.), along with the small diameters and brittle nature of the existing clay pipe, TT Technologies was able to recommend Static Pipe Bursting to satisfy the project requirements.

For portions of the Pipe Bursting runs, the contractor had to utilize existing pipelines with manholes along the alignment as points of access. Many of these access manholes had to be modified to accommodate the work, which typically involved removal of the existing manhole inverts to allow the oversized bursting head to pass through. Construction crews did note some resistance through the existing pipe openings in the manhole, but in the end the new sewer was able to be installed without damage during the pipe bursting process.

The pipe bursting construction was fairly straightforward with each of the three runs installed within single shifts. Utilicon commenced the first Pipe Bursting run on 6/12/17. This was a 374 lineal foot run of 10-inch diameter pipe. The total time to complete the run was approximately 3 hours, yielding a production rate of approximately 125 lineal feet per hour. The second Pipe Bursting run commenced on 6/27/17. This was a 650 lineal foot run of 8-inch diameter pipe. The total time to complete the run was approximately 7 hours, yielding a production rate of approximately 93 lineal feet per hour. Utilicon commenced the third and final Pipe Bursting run on 7/07/17. This was a 350 lineal foot run of 8-inch diameter pipe. The total time to complete the run was approximately 3 hours, yielding a production rate of approximately 117 lineal feet per hour.

Prior to installing the mainline sewer via Pipe Bursting, the contractor verbally coordinated with the adjacent homeowners to alert them of the work and to tell them their sanitary laterals would be temporarily out of service. Because the chosen pipe material was the FPVC, lateral reconnection could commence immediately following the installation of the mainline pipe. The intent was to limit the sanitary lateral outages to a single day. For the most part this approach worked as planned. However, the lateral installation did expose a potential drawback to utilizing FPVC: its rigidity.
Lateral reconnection was performed by excavating down to the existing lateral, coring the newly installed mainline sewer and connecting the lateral pipe via a rubber booted connection. During the coring operation for one such lateral, the FPVC mainline pipe shattered. It appears there was significant bending pressure on the installed pipe, so much so that when the coring provided a pressure relief, the pipe essentially shattered several feet in each direction. Further investigation showed that this was in an area immediately following an existing manhole on the pipe bursting run. The inside of the manhole had been modified to accommodate the bursting operation, however there was a previously installed concrete collar on the existing pipe on the outside of the manhole that was not able to be seen pre-construction. This concrete collar caused resistance to the pipe bursting progress and may have forced the alignment off-line enough to create substantial bending pressure on the pipe. Thus when the pipe was cored, the pressure was relieved with the shattering of the pipe. Had a more flexible pipe material, such as HDPE been utilized, this ‘pipe shattering’ probably would not have occurred. Regardless, the damaged FPVC pipe was able to be repaired in-place and the lateral reconnection was made to restore service to the affected resident (See Figure 6).

Figure 6. Lateral Installation

In all, a total of 33 lateral reconnections were made, including those performed on the open-cut portions of the installed sewer. Throughout the lateral installation process the contractor was able to maintain sanitary sewer service to each affected resident. Over-land bypass pumping was utilized to maintain flow (sometimes overnight). Efforts were made to minimize time of lateral construction as temporary flow control is costly and often difficult to work around and maintain.

An additional drawback to the FPVC was found in the areas of fused pipe welds. These welds produced an approximate 0.25-inch raised area. Effect on flow was negligible according to the design engineer, however the protrusion was to such an extent that it prevented use of a mandrel for acceptance-testing of the pipe runs.

7. **RESTORATION AND COMPLETION OF THE PROJECT**

Providing a finished product required restoration of all disturbed surface areas along the 4,600 lineal foot alignment. The sewer installation crossed 33 residential lots, of which 12 were affected by open-cut operations. This resulted in the replacement of numerous concrete driveway aprons, as well as significant stretches of concrete sidewalk and concrete curb. In addition to the hardscape repair, lawn restoration was performed in all disturbed areas. In addition to the areas that required restoration, there was the intangible cost of losing several mature trees that were removed as they were within the sewer installation footprint. The replacement of the trees will be part of a tree planting program in the City’s 2018 infrastructure improvement program.
In areas of trenchless sewer installation, disturbance to hardscape and landscape was generally limited to the Pipe Bursting Launch Pits and Receiving Pits, as well as the lateral tie-in locations. Though detailed comparative data was not obtained for this paper, the surface disturbance caused by the Pipe Bursting operation was observed to be significantly less than what was incurred for the open-cut sewer construction. Further study of this comparison should be performed to quantify the tangible restoration benefit resulting from utilizing trenchless construction methods.

8. SUMMARY AND CONCLUSIONS

With all 4,600 lineal feet of the 10-inch mainline sanitary sewer installed, all the residential sanitary laterals reconnected, and all surface restoration finished, the City of Solon’s nearly $1 Million Miles Road Sanitary Sewer Replacement Project was completed. By designing this project to combine open-cut and trenchless sewer installation techniques, the City of Solon was able to realize multiple benefits. Project costs were mitigated by performing a majority of the project via traditional open-cut methods in locations that warranted use of trenched construction. The integrity of adjacent ponds was preserved by utilizing trenchless methodology in localized portions of the sewer run. Finally, the City of Solon gained additional experience with the trenchless construction method of using Static Pipe Bursting, a method only used once previously on a municipal project in this area.
The Miles Road Sanitary Sewer Replacement Project was not without its share of challenges. A sandstone bedrock elevation that was interfering with the sewer alignment could have caused significant issues with the Pipe Bursting operation. However there was no apparent negative effect on line and/or grade, and the displacement of the existing vitrified clay pipe during the bursting process was generally effective. One major lesson that was reinforced during this project was that when performing trenchless underground work, there may be unforeseen obstructions to consider. This project was affected by an undocumented pre-existing concrete pipe collar on an existing manhole that led to bending pressure on the newly installed pipe, eventually causing localized pipe damage. This experience brought into question the pipe material selection. Was the selected rigid Fused Polyvinyl-Chloride (FPVC) pipe the appropriate pipe material for this application? Would the project have been better suited using a flexible High-Density Polyethylene pipe to mitigate the effect of variable pressures? Ultimately the localized FPVC pipe damage was readily fixed, and the use of the rigid pipe allowed for immediate reconnection of sanitary laterals, thus reducing the impact to the adjacent residents. Thus the City of Solon has not disqualified use of FPVC on future similar applications, but will have a heightened awareness of the potential obstructions when selecting materials during future project designs.

Every project is different, and variables such as geotechnical conditions, existing utilities, and constraints will warrant different methodologies. In the case of the Miles Road Sanitary Sewer Replacement Project, there were surface features that needed to be protected, warranting trenchless methods in specified areas. Static Pipe Bursting was selected as the trenchless technique as it allowed for reduced excavation footprint, and the sewer was small enough and the runs were short enough for the Static operation to accomplish the work. The presence of a high bedrock elevation gave initial pause to the methodology decision, but ultimately the benefits outweighed the assumed risks in the eyes of the designer. In the case of this project, despite the shallow bedrock, the pipe bursting operation worked well. The City of Solon will take this information forward and use it on future projects, but not to say that ‘one method fits all’. The real takeaway for the City of Solon is that there is great benefit to being open to new methods, different techniques, and creatively combining ideas to produce a best-fit solution for a given set of conditions. Trenchless, including Pipe Bursting, will be part of the City of Solon’s planning toolbox for future projects.
ACKNOWLEDGEMENTS

The authors thank the following individuals who contributed to the development of this paper: Chris Valetto of Trax Construction, Daniel O’Day and Timothy Leap of Utilicon, Scott Redman of TT Technologies, John Busch of the City of Solon, Dan Driscoll of the City of Solon, Bill Jakovcic of the City of Solon, Andrea Neal of the City of Solon, Marci Rizzo of the City of Solon, Laura Fuchik of the City of Solon, and Andrew Horning of H.R. Gray.