THE CHALLENGES OF REPLACING A FAILING SANITARY FORCEMAIN THROUGH A FORMER LANDFILL

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ABSTRACT: The City of Elmhurst had experienced numerous breaks on an 8" diameter 6,500 foot sanitary forcemain adjacent to Salt Creek, a major tributary of the Des Plaines River. All the breaks were concentrated in an area of a former landfill. With enforcement action from Illinois Environmental Protection Agency (IEPA), the City was faced with the task of replacing the forcemain within two years. Additionally, Bureau of Land rules require that any material removed from the site is disposed of in another landfill. It was therefore desirable to accomplish the replacement while minimizing excavation.

This paper examines the alternate techniques that were evaluated, the method that was ultimately chosen, and the procedures that were set in place to mitigate any adverse effects of directionally drilling adjacent to a waterway in the floodplain. The area is also a City park so the Contractor had to be mindful of maintaining access for pedestrians, preserving memorial trees, and potential damage to footpaths and soccer fields. With limited access for large equipment, significant effort was required in the pre-planning of the excavations and the drill itself. Measures were in place should the drill head encounter landfill obstructions, and most importantly, an emergency frac-out plan was required from the Contractor that would prevent any drilling mud from reaching the Creek.

1. INTRODUCTION

Eldridge Park is a former landfill in the southern part of the city of Elmhurst. An 8 inch sanitary forcemain had been in the area since the 1950s. Salt Creek was re-routed in the 1960s which changed the profile of the landfill, and then additional soil was added in the1980s due to settlement. Breaks were occurring along portions of the forcemain, and although 6,500 feet in length, all the breaks were occurring in the Eldridge Park area. It was surmised that the leachates were corroding the iron forcemain.

2. CONSTRUCTION OPTIONS

Owing to the number of breaks, the IEPA issued a violation notice to the City requiring that they construct a replacement within two years. Given that much of the route was through a heavily wooded area behind a berm, it was decided only to replace 1,350 feet within the park where all the breaks had occurred.

Much of the area adjacent to the existing forcemain was within the floodplain. In addition, any excavated soil that could not be replaced would have to go to a landfill that could receive household waste, and the closest was almost 50 miles away. So although much of the forcemain would be shallow, with less than six feet of cover, it was decided that trenchless options would be preferable. The site is shown in Figure 1.
The site was ideally suited to pipe bursting or lining, as the diameter was not being upsized. However, it soon became apparent that bypass pumping would be extremely difficult, with Butterfield Road, a 4-lane State road, (Fig. 1), between the park and the pump station. The only possible routing for the bypass would be to hang it off the Salt Creek bridge for which permitting would be very difficult because of the risk of contamination of river waters.

It was therefore determined to attempt to directionally drill a new alignment (Fig. 2). The main items that then had to be considered were the following:

- Routing away from the existing forcemain but not too intrusive in the park
- Out of the flood plain if possible

Figure 1 – Location Plan
3. GEOTECHNICAL DATA

The soil borings indicated a mixture of topsoil and silty clay with landfill debris (wood, trace glass, etc). None of the boreholes showed a clear demarcation between the landfill material, the clay cap, and final topsoil. They all indicated the soils as having very low bearing strengths. While the northernmost boring encountered landfill debris at a depth of only 2.5 feet, it was hoped that this was an anomaly and that the profiles of the other two borings, where debris was not encountered until depths greater than six and nine feet, would be more indicative of the ground condition.

Figure 2 – Detailed Site Plan
4. **ALIGNMENT**

An initial alignment was proposed with most of the new forcemain being east of the footpath along the creek. This would have the advantage of not only reducing the potential for encountering the existing main (whose location was not completely defined) but also keeping much of the final pipe out of the floodplain.

The Park District also identified trees that had been donated in memory of loved ones. Specific “memorial” trees had to be protected, and their location dictated the placement of the boring pits.

A distinct advantage of working within a park was the small number of existing utilities that would require potholing – although one 12” storm sewer did present a complication during the drill process.

5. **PRE-CONSTRUCTION PLANNING**

Once the alignment had been determined, the main issues involved the precautions that had to be taken to protect the environment and the park during the drilling activities. The main concerns were the following:

- Construction Vehicle access
- Access to water
- Protection of spoil piles
- Park user signage
- Park user safety
- Frac-out plan
- Restoration
- Topsoil depth

Vehicular access to the park is very limited. It was recognized that there would be some damage to the footpath (it was not designed for heavy vehicles) and the side grass margins. This would be in addition to the damage adjacent to the pits and the drilling rig. The specifications were written such that only rubber tired or track vehicles would be permitted in the park.

The construction plan divided the project into two drills – one about 700 feet from the northern end and the other about 500 feet drilled from the southern end. It was apparent that while there was a hydrant close to the northern drill set-up, there was no hydrant near the southern drill pit. There was also no access for an additional vehicle to bring water to the site. In the end, the project was bid with the Contractors being aware that over 500 feet of hose would be required when re-filling the water truck for the southern drill.

Spoil piles had to be situated outside the flood plain and protected with double rows of silt fence. The Park District – who were very cooperative throughout the planning and construction of the project – were most concerned about residents safety, it is a very popular park. The decision was made that construction would not begin until schools had resumed. In addition notices were placed at entrances to the park if portions of the footpath were closed. The Park District also posted information on their website, explaining the project.

A major concern of the construction, being in the floodplain and so close to Salt Creek, was the potential for damage to the environment from frac-outs. A pre-approved frac-out plan was required from the Contractor. Fortunately the implementation of this plan was only required on one occasion, and the plan worked well.

Much of the park, particularly along the paths is native planting which is a mix of grasses and wildflowers. These plantings require a significant topsoil depth (up to two feet). However, the project was also trying to minimize material removal from site because, as a former landfill any material which could not be returned to an excavation would have to be transported to another landfill, the closest of which was almost 50 miles away. After discussions with the Park District, it was agreed to the placement of 9” of topsoil over any excavated area and 2” along the footpath margins where the grass had been “churned” by the vehicles.
6. CONSTRUCTION

Work began on the project site towards the end of September 2012. The first step was to locate and pothole the existing utilities to ensure that there would be no conflict with the planned alignment of the new pipe. Next the existing forcemain was excavated at the locations where the new directionally drilled force main would tie into it. In the northern most excavation, it was discovered that the existing forcemain was actually a 12” pipe and not an 8” pipe as originally expected.

After verifying the proposed alignment, the pipe was ordered and delivered to the jobsite. The forcemain pipe material specified was a 10” High Density Polyethylene (HDPE) (DR11). The contractor suggested using an 8” Fusible Polyvinyl Chloride (PVC) (DR18 or DR25) as an alternative for a number of reasons. (Refer to Figure 3)

First, the equivalent size PVC pipe was a lighter pipe, by more than half (6.7 lbs/ft for the PVC compared to 14.0 lbs/ft for the HDPE), which allowed the contractor to handle the material with equipment that had much less impact to the project site. For example, while preassembling the pipe, an 8” PVC pipe could be lifted by hand and placed into the fusion machine whereas a 10” equivalent size HDPE pipe would likely require some type of machine (crane or forklift) to perform the same task. This allowed for a less congested site and addressed the Owner’s concern for maintaining the usability of the park throughout construction.

Next, the use of a smaller and lighter pipe allowed the contractor to utilize slightly smaller drilling equipment since the borehole would not need to be as large and the force required to pull the product pipe back would be reduced. The smaller drill rig also helped to reduce the contractor’s footprint on the job site. Additionally, since the borehole size was reduced, the amount of drilling fluid necessary to complete the bore was also reduced, which would help address the environmental concern of having a frac-out.

The plan was to install the pipe in two separate segments, tie them together in the middle of the project (approx. STA 15+50) and then connect either end to the existing forcemain. The horizontal directional drilled installation of either the fusible PVC or the HDPE pipe would require the preassembly of the pipe into one continuous pipe string prior to its installation. This requirement is because it takes about 15-30 minutes of cure time (depending on ambient temperatures) to correctly fuse the joints of the pipe together. Once the pullback of a pipe begins, it is essential that the operation continue uninterrupted so the borehole does not begin to collapse and the drilling fluid remains in a fluid state, otherwise there is a risk that the pipe could get stuck in the borehole during installation. With the stability of the soil within the landfill being a major concern, this was an important consideration.

For this project, the pipe was fused together into two separate lengths, approximately 700 ft. and 500 ft. each. The pipe was then staged within the limits of the project such that when the preparation of the borehole was complete, the pipe was attached to the swivel, reamer and drill string and pulled back through the bore hole. It was also crucial that the pipe did not interfere with or restrict in any way the local residents’ use of the park. (Refer to Figure 4)
The contractor utilized wheeled equipment with rubber flotation tires (Refer to Figure 5) to minimize the ground disturbance while handling the material on the project. A rubber tracked mini-excavator was utilized for potholing and small excavation work. (Refer to Figure 6)

The next stage of work was to set up the drill rig and drill the pilot hole. On this project, the contractor utilized a Ditch Witch JetTrac 2720 Horizontal Directional Drill Rig, which is capable of approximately 27,000 lbs of thrust/pullback force and 2,000 ft-lbs of rotary force. Pullback forces were estimated to be well within the capabilities of this particular machine. The mud mixing/delivery system consisted of a truck-mounted 1,000 gal capacity bentonite mixing system and a 35 gpm on-board mud pump for delivery of the drilling fluid down the drill string into the bore hole. The first bore attempt had the drill set up on the north end of the project and drilled south to the connection point at approximately STA15+50. The second bore set up the drill on the south side of the site and drilled north to the same connection point.

As many contractors are aware, the type of ground conditions anticipated on a project can dictate decisions such as the type and size of drill rig and tooling (drill bits, reamers, etc.) to be utilized, the composition and amount of the drilling fluids used, and what type of productivity rates can be expected. As much of this bore could take place in a layer of buried landfill trash and not soil, the contractor gave special consideration to this particular installation. It was anticipated that the majority of soil conditions would be "jettable" which is to say that the drill bit would be able to achieve penetration by jetting the formation in front of it with drilling fluid and sliding the rod through the hole with an angled clay bit (refer to Figure 7), the angle of which is oriented in the direction desired to maintain horizontal and vertical control of the drill bit.

During the first bore the driller indicated that the ground conditions were varied, changing from pockets of competent soil where penetration rates were good and steering control was adequate, to soft spongy areas where there existed no directional control over the drill bit but penetration was very easy, to very hard areas where penetration could only be achieved through rotation. It is estimated that the ground was a composite mixture of both soil and trash, but without uncovering the work and physically examining the soil, it is difficult to say for certain the exact composition of material drilled through.

The locating system employed on this job was a DCI Eclipse In-Ground Positioning system. Accurate locating of the bore was also a concern due to possible interference of various metals or magnetic fields that may be present from whatever combination of materials may exist in the landfill area. Fortunately, the ability to locate remained accurate throughout the boring except for the one instance, as noted below.

Approximately 300 ft. from the entry of the first bore; a very hard pocket of ground was encountered that precluded us from obtaining any directional control for approximately 70 ft. At one point, the locating system was no longer able to pick up the signal from the drill head so the contractor had to cease drilling. The drill head was dug up and it was determined that the obstruction was a large chuck of reinforced concrete (refer to Figure 8).
The rotation of the angled bit against the rock-like formation generated a considerable amount of vibration and heat within the drill head and damaged the locating probe (damage was sustained to the probes internal antenna which precluded transmission of the locating signal). The probe was repaired, a new rock bit (refer to Figure 9) was installed on the drill head, and the concrete chuck was removed from the bore path. While the use of a rock bit was considered in the original selection of our tooling, it was decided to attempt the bore first with the clay bit because while the rock bit will achieve better penetration rates in more aggressive soils, it is generally less responsive and harder to maintain directional control than with a more conventional clay bit.

The bore progressed from this point 350 more feet to the center pit. Upon reaching the pit it was discovered that the 12” Reinforced Concrete Storm Sewer pipe that would be crossed had only 5ft. of cover which precluded the force main going on top of the line and still maintaining the required 6 ft. of cover. A typical 12” RCP has an OD of approximately 16” (approx. 2” wall thickness), and this particular line had a very thick wall (in excess of 18” OD), which consequently meant that installing the force main under the storm sewer would require substantial depth at the point where the two pipes would be connected to each other. The project team conferred over the situation and it was determined that the existing storm line could be replaced with a 12” PVC line, thus reducing the thickness of the pipe and allowing the force main to be installed on top of it. Additionally, the finished surface could be re-graded to add cover over the top of the force main and conform to the cover requirement.

Once in the pit, the bore hole was reamed to approximately 16”, and drill rods were trailed behind the reamer to mitigate the risk of losing the borehole should it collapse before finishing the ream and being able to push the drill rods back down the hole and pull back the pipe. Penetration rates for both the ream and the pullback were not notably different than those that would be expected in typical soil conditions for the area. There was no ground heave and no frac-outs, and it took approximately 7 hours to install the 700 ft. of pipe once the pullback began.

The second bore utilized the same drill rig and equipment configuration. The original source of water (a fire hydrant located at the north end of the park) was no longer near the drill as was the case on the first crossing, so to deliver water to the site, hoses were stretched out approximately 500 ft to the next closest fire hydrant. The second bore encountered difficulty maintaining its alignment with the planned bore path. The drill rig was set up in a confined area between a ditch, the excavation on the existing force main, and the walking path. This set-up location was chosen to maximize the amount of force main installed by HDD and minimize the disturbance created by open trench methods. At this location, due to the topography of the ground and the need to drill under the existing utilities that crossed the bore path, the drill penetrated the surface at a severe angle (approximately 32%). It was soon discovered that this severe entry angle placed the bore in the “landfill proper”, where there was no significant bearing strength to the soil formation being drilled. This lack of bearing strength precluded the driller from being able to maintain directional control of the drill head. Drilling continued forward with the hope that directional control would soon be regained, but at a depth of approximately 38 ft, it was determined that the as-drilled bore path deviated too far from the planned alignment, so the first boring attempt was abandoned.

The amount of room needed for an HDD drill rig to set back, punch into the surface, and drill down to the desired grade is always an important consideration with any crossing. Given the limited set-back room for this bore, attempts at crossing under the existing utilities would have continued placing the bore lower than planned depth and into the “landfill proper” where the ability to maintain directional control was severely hampered. The project team conferred and determined that the best course of action would be to re-grade the surface where the drill was set up and enable a punch in angle at a more common 20%, which allowed the bore path to remain at the planned depth of about 6 ft. It was also determined that open trench methods could be utilized through the walkway to address the fact that the bore would not have sufficient cover in the utility crossing area. This resulted in slightly more open trench excavation than planned (approx. 60 ft) but allowed the drilling of the force main to be made in a layer of much more competent soil.
The reaming and pullback of the second bore yielded similar results to that of the first. It took a little over 5 hours to complete the approximately 500 ft installation. The pipe was pulled in from the central pit and appeared at the drill rig with no visible signs of any damage. There were no surface heaves but there was one location where drilling fluid “fraced-out” to the surface (refer to Figure 10). The frac-out was immediately contained with bales of hay and silt fence to prevent spreading of the material. The drilling fluid that escaped to the surface was allowed to dry out and was disposed of with the rest of the spoils from this project. The owner required that no “heavy equipment” be allowed to operate in the park, and this precluded having a vacuum truck available to clean up any inadvertent returns. The ability to use erosion and sedimentation control devices to contain any frac-outs allowed the contractor to continue with his work while abiding by the owner’s equipment restriction.

7. LESSONS LEARNED

- Consideration of the material specification and how it can impact construction operations – in this case a smaller, lighter pipe still met the project requirements and allowed the contractor to reduce his footprint and not impact the area as much.

The ability to directionally drill through landfill trash with conventional tooling and equipment can be successful, with proper planning and a willingness to accept that conditions may change throughout construction. Locating can be done successfully and penetration rates can be relatively productive but the ability to maintain directional control over the alignment of the bore path can be inconsistent.

- If you can keep the bore path above or even in the clay cap, you have a good chance of getting the pipe successfully installed. If you pierce the clay cap and are drilling through a formation of landfill debris (refer to Figure 11) there is no significant bearing strength to the soil formation and the driller’s ability to maintain directional control of the drill bit is drastically reduced.

- It is important to allow for emergency excavations – and not just one (there were ten allowed for in this bid – we used one), especially when ground conditions are so unknown. Concrete, rock and debris could all disturb the drill head. Besides the encounter with the reinforced concrete slab, which needed to be removed to install the pipe, the lack of ability to steer on some occasions was of the greatest concern.

8. CONCLUSIONS

In conclusion, while there were times throughout the project when it was questioned whether the appropriate method was chosen, in the end, the HDD process worked enabling the installation of a new forcemain through the landfill while eliminating the very expensive requirement to transport and properly dispose of landfill waste that would have been generated through conventional open trench methods.

Construction on this project was successful in large part due to the effort spent in the planning and design phases of the project. As is the case with any type of trenchless construction method, the importance of a thorough subsurface condition examination cannot be overstated. Soil borings were taken, as-built information was gathered and a good profile was developed allowing the project team to proceed with a high level of confidence that they would be drilling in a competent soil and be able to effectively manage the various risks on this project.
On a general construction note, having all of the decision makers at the table from Day 1 cannot be emphasized enough. Although this is a City owned force main, it goes through Park District property, and the involvement of Park District officials during all parts of the planning, design, and construction process made for a very cooperative working environment.