Die Draw:

Trunk Mains Lining Technology

Thames Water Lane Rental Industry Publication

TRANSPORT
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Introduction

On 19 October 2019, a 36” cast iron trunk water main burst in Queen's Drive, near Finsbury Park, flooding over 100 properties and causing millions of pounds worth of damage. This main along with two others of the same size were laid in Victorian times to meet the growing demands of London’s population. These mains originally took water from the former treatment works at Stoke Newington to a reservoir on higher ground off Dartmouth Park Hill. Two of these key strategic trunk mains still supply water to the same reservoir as before, but the treatment works are long gone, having been replaced by a ring main shaft in the early 1990s. Water from the ring main supplies areas of Islington, Camden and the West End.

Following the burst in 2019 and further investigations of all three trunk mains by Thames Water, multiple small leaks were identified indicating that the joints on these mains had deteriorated, increasing the risk of future bursts.

The trunk main running along Seven Sisters Road was found to have 19 leaks in total, over a 600metre section. As a result, Thames Water committed to re-lining 610metres of pipework in Seven Sisters Road and into Finsbury Park Road to improve the resilience of the pipework for the next 100 years.

The Project

Thames Water were challenged with reducing the work site as much as possible, to minimise disruption to road users, residents and businesses in the area. Main replacement is typically carried out using the following methodologies:

- Open cut - the road is excavated along the length of the existing main and replaced with steel or plastic
- Conventional slip-lining - several excavations are made, and a plastic lining is pushed through the old main.

These methods were considered and were rejected for the following reasons:

- The open cut method was rejected as it would be too disruptive to the road network, causing significant disruption to local businesses and would be a long process due to the need to move or safeguard other utility services.
- The slip-lining method would require a reduction in diameter of the main by approximately 200mm. This was extensively modelled and rejected due to meeting current and future demand for water in the northeast of London.

Thames Water looked at multiple innovative technologies that would deliver the required solution with less impact on the road network and customers, as well as maintaining the required pipe diameter. After careful consideration of several options, Die Draw was selected for the trial due to its suitability for large diameter mains.

Die Draw Process:

- There were two long excavations at the start and the end of the pipeline section to be relined. The first excavation ("launch pit") is where the new plastic pipe was assembled and inserted. At the end excavation ("receiving pit") there was a large winch that pulled the new pipe through the host pipe using a steel cable.
- The new plastic pipe was similar in size to the host cast iron and is pulled through the die drawing machine under tension situated in the "launch" excavation. This machine squeezed the pipe and reduced its diameter sufficiently so that it could be pulled through the existing pipe.
- Tension was held throughout to ensure the reduced shape was kept; once the pipeline had been pulled completely through, tension was released in a controlled manner. Over the course of a few days the new pipe was allowed to expand, filling the host cast iron main.
- Once the pipe had expanded to fit, the excess at either end was removed. The new pipe was reconnected to the network and the main was returned to full service.

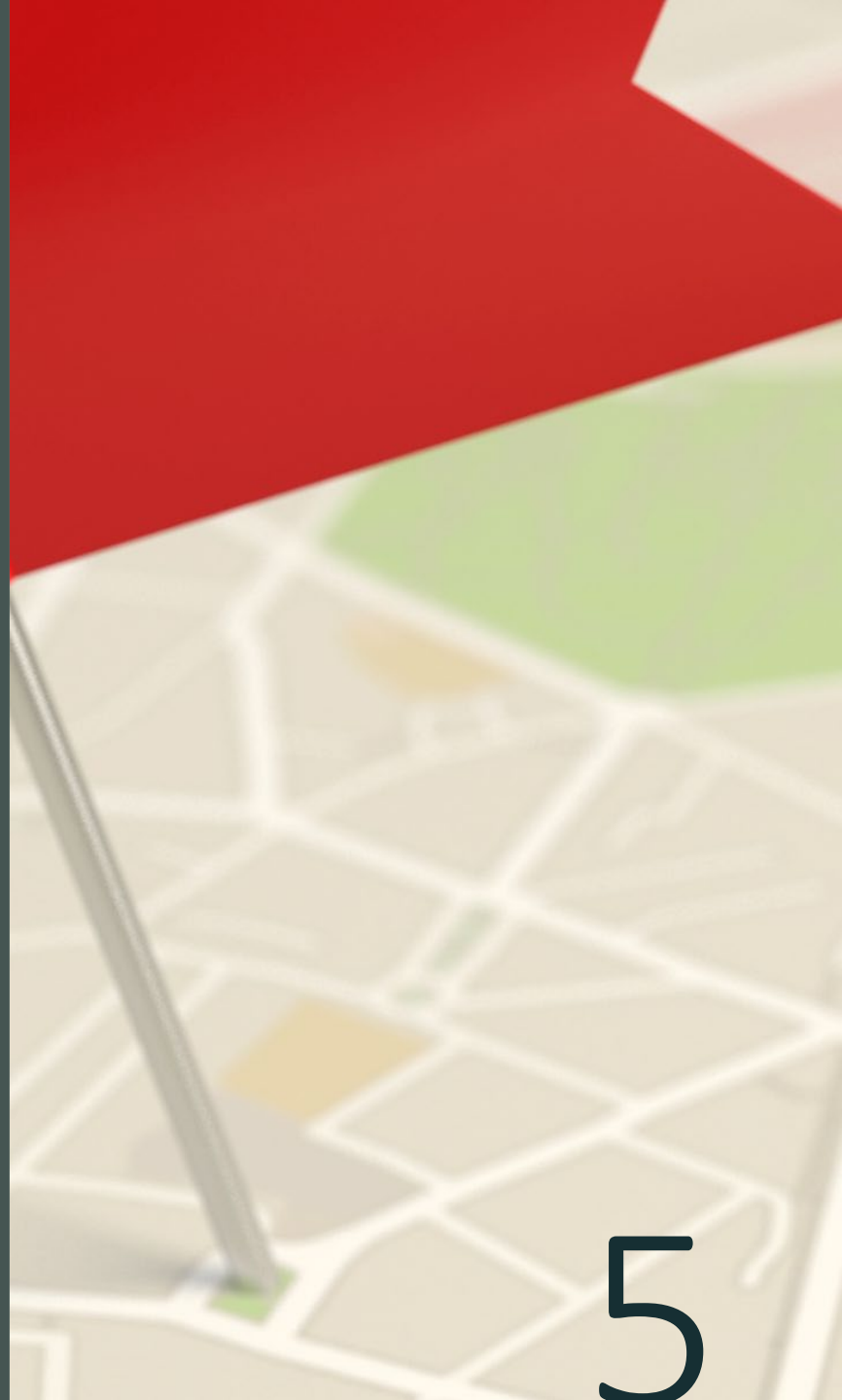
Initially the duration of the trial was estimated to take six months. The "launch" pit was located near the junction of Yonge Park and Seven Sisters Road, with the "receiving" pit in Finsbury Park Road. During initial surveys, three locations were identified which would require a small excavation to be undertaken at each to remove an obstruction and ensuring the successful implementation of the new pipe. Several disconnections of smaller distribution pipes were also required.

Outcomes

The main objectives of the project were to repair all the leaks identified, increase the longevity of the ageing asset, prove the Die Draw technology for use on larger diameter mains and limit the amount of disruption caused to the road network so that it could be assessed for future use if similar situations arise.
There were several challenges encountered through the delivery of this project, which required a change in the way the project was delivered. Along Seven Sisters Road, there are three 36” cast iron water mains of similar age and condition, with a space of less than 300mm between each, with the mains sitting on top of one another in some locations, rather than beside each other.

To complete work, the other mains needed to be protected in order to maintain supply, as resilience of the network was reduced while works were undertaken, necessitating contingency plans to be drawn up to maintain water supply to the area should a second main fail.

Of the proposed 610metres to be lined, 450metres were successfully completed eliminating 17 out of the 19 known leaks, with the remaining remedied through alternative means. At the junction of Seven Sisters Road and Blackstock Road, the pipe bends around the junction and continues under Finsbury Park Road. As the inserted pipe approached the bend near this junction it was observed to have stopped moving. The pulling force required to successfully take the pipe through was modelled and designed as 100 tonnes of force applied by the winch. With the maximum load being reached and no further movement possible, a cyclical, rather than static, load had to be used to move the pipe forward.



The change in load applied was not sufficient to complete the pull around the bend and some fatigue in the bolts holding the winch frame in place were noted. In the interest of safety the works were paused to allow for a redesign of the pulling loads and winch frame to be completed. Upon restarting the process to complete the remaining 100metres, the towing head attached to the pipe was also fatigued and snapped on initiation of higher loads.

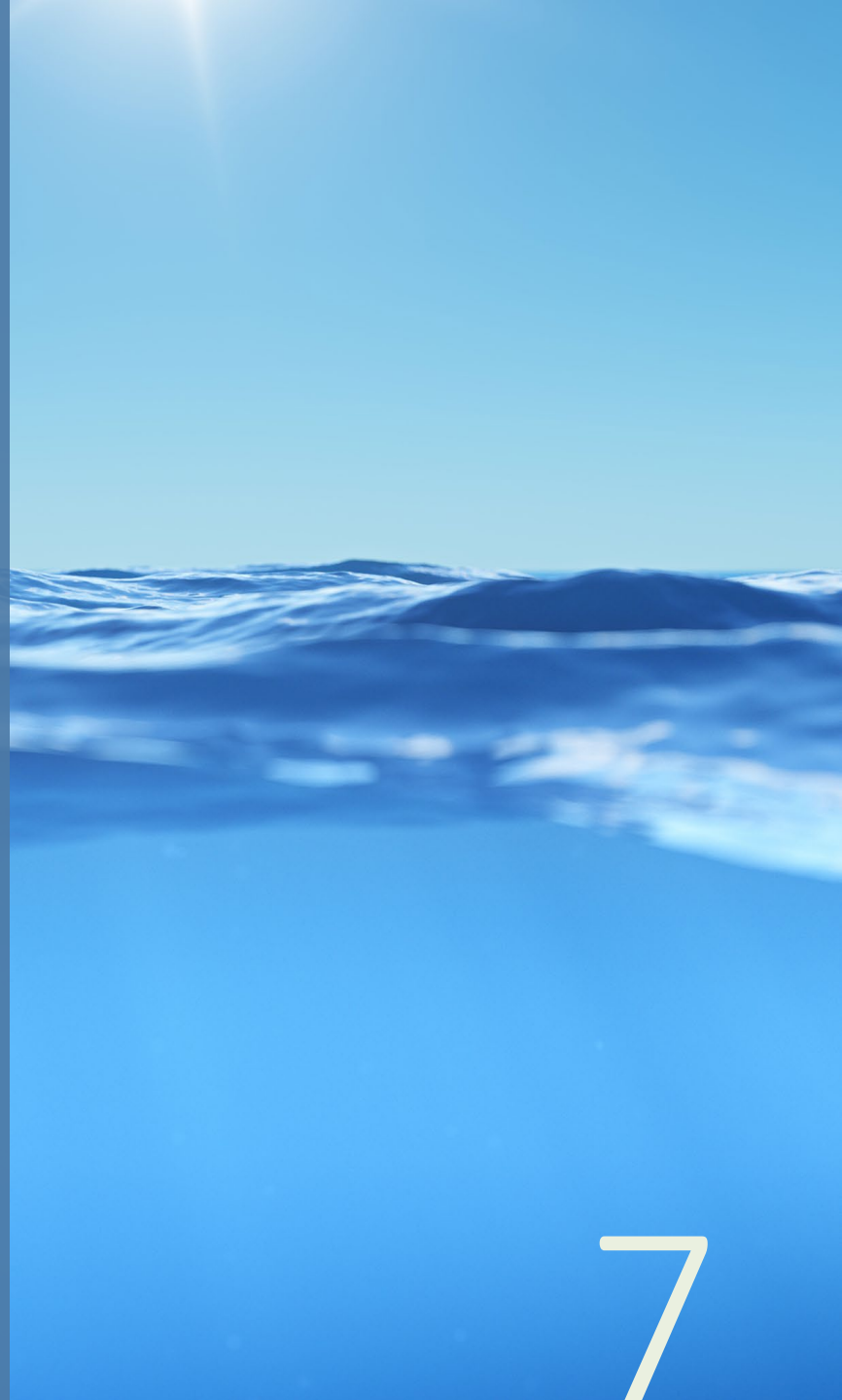
The new liner was consequently terminated on Seven Sisters Road at 450metres and the remaining 160metres was repaired using a pipe joint repair system in combination with a 36metres stainless-steel liner.

Despite this setback, Thames Water successfully completed 75% of the proposed length reducing the number of excavations needed under a busy road, with excavations at a limited number of locations proving the effective use of the Die Draw technology, along with some invaluable lessons learnt, which can be used on future phases of the Seven Sisters main.

Lessons Learnt

Following the completion of the project, detailed analysis and review was undertaken and are detailed as follows:

1. Detailed surveying using a variety of techniques are essential to identify all potential obstructions within the host pipe and treated in advance of commencing towing works. In this instance, LiDAR and CCTV surveys identified some anomalies, however they were not sufficient to identify diametric deformity (oval pipe shape), which contributed to the inability of the pipe traversing the bend at the applied force.
2. Friction between the plastic and cast iron pipes were greater than anticipated, with cable tension reaching maximum force around 500metres into installation rather than the full expected length of 610metres. Another contributing factor was water ingress in the new pipeline through the towing head causing additional resistance. The tow head design, construction and manufacturing control require review in future implementations so that the tow head will have a sealed design to prevent water ingress.
3. The winch and frame set-up should be designed to improve safety. The temporary works to support the winching was designed independently from the overall permanent works. This change from static to cyclic loading impacted the temporary works causing fatigue in the frame. All elements of design would be coordinated by the Principal Designer in future to ensure there's no conflict in design.



4. In this instance, the liner was designed to withstand both hydraulic loads internally and the traffic associated to the road, which was thicker than desired. For future projects, a thinner liner would be more flexible and require less loading, increasing success rates.
5. Several delays occurred due to restricting works to daytime only. This allowed the pipe to contract and expand slightly, making it more difficult to restart. In future, it is recommended that delays during the pipe pull be minimised, overnight working be utilised and the winch has adequate contingency against breakdown. At each stop, a five tonne increase in load to get restarted was observed.
6. Delays in sourcing specialist parts to resolve winch issues may have contributed to the stoppage. Future projects will address the plant and winching equipment used and have sufficient resource and spares available to deal with issues.
7. The pulling cable was observed scoring the cast iron pipe on the inside of the bend causing a 50% loss of section in parts. To avoid this issue in future, bends should be avoided as this will minimise the loading and increase success.

Conclusion

The project has demonstrated the successful installation of the Die Draw technology, delivering the required operational pipe bore to maintain the same level of supply. It also minimises the number of excavations needed to execute, reducing overall highway occupation compare with traditional methods.

This project did encounter problems during its execution which have been treated as a learning opportunity for the design and implementation of this methodology. Extensive lessons learned reviews have been carried out and proposals to mitigate risks are already underway for the next phases of this trunk main renewal in the area.

The outcomes of the project will be shared with project partners and the wider water and pipeline industries, to outline the challenges and benefits associated with using the technology.

TfL Lane Rental Scheme

Optimising customer journeys through the delivery of safer, innovative and sustainable roadworks

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