AQUALINER PIPE LINING TECHNOLOGY

Trial Report

March 2021

Authors: Jamie Perry

Severn Trent

Aqualiner Trial Report

Report Author: Jamie Perry **Business Lead: Matt Lewis**

Executive Summary

Severn Trent has a vast network of pipes that supplies water & waste to its four million customers. A network on this scale needs continual repair and maintenance, to make sure it can deliver a reliable and high-quality product to customers, as well as minimising leakage.

However, this level of maintenance has significant cost, which ultimately is passed on to customer bills. There is also a direct impact on the customer, via disruption from traffic management and interruptions to supply. Pipe renewal options are currently limited to costly open cut replacement, pipe bursting or slip lining. They all have an impact on the customer or on the capacity of the network.

We have joined forces with two other UK water companies to generate innovation in this area. After several years of research and development, a novel structural liner has been developed by Aqualiner with support Severn Trent, Anglian & Yorkshire.

This report summarises the findings of trials of the Aqualiner process, which was found to be very successful, and makes recommendations for it's future use, alongside the existing technologies.

It should also be noted that this technology can also be used to line waste water infrastructure, including rising mains.

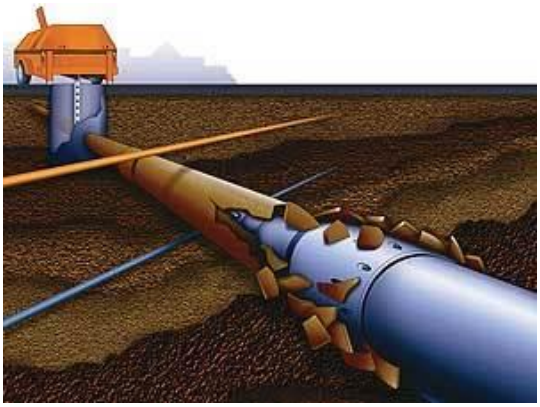
The project was partially funded by a Horizon 2020 EU funded project.

Current processes

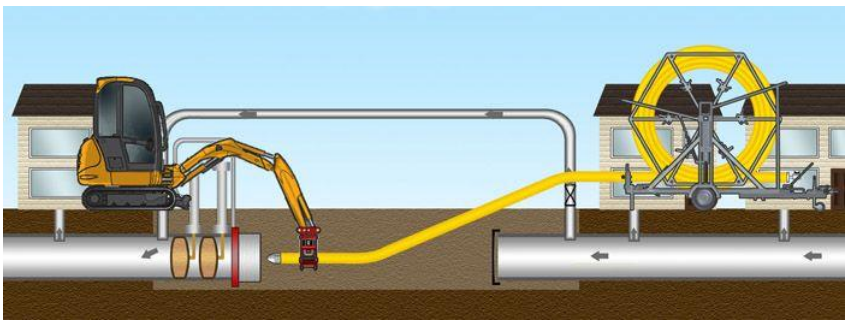
Our current preferred options for dealing with infrastructure that has reached the end of its life are:

- Complete renewal with full excavation

- Pipe bursting



- Slip lining



These techniques are costly and impact our customers greatly, they also carry a high risk to our operatives with likelihood of utility strikes increasing with multiple excavations. Full open cut excavation is a time hungry process often creating huge impact for our customers and road users., Although offering reduced excavations, pipe bursting is a disruptive noisy process that disrupts customers and surrounding apparatus, and slip lining reduces the overall diameter of the host pipe meaning hydraulically its often not a feasible solution. There is also the carbon footprint considerations with these methods.

Benchmark costs for each of these processes are:

- Open cut: £150 per metre of pipe
- Pipe bursting: £120 per metre
- Slip lining: £100 per metre

The Project

Severn Trent Innovation Team began work with an external company, Aqualiner, who had developed an innovative lining material that can be installed with very little disruption. The lining material is a glass-reinforced polypropylene; and is currently the only Regulation 31 approved, fully structural lining available to the industry.

Advantages of Aqualiner:

- The system is 40% lower in cost than open-cut and is cost competitive with slip lining techniques.
- Can line any material and does not require the host pipe to be structurally sound.
- Smaller reduction in pipe volume than slip lining. Aqualiner reduced the capacity of the pipe by ~5% compared to ~25% for slip lining.
- The installation process requires a smaller footprint in the carriageway than slip lining techniques. This results in less traffic disruption. The system does this by avoiding the need the join lengths of pipe before they are inserted into the host pipe.
- Aqualiner also has a smaller installation footprint and creates less noise and vibration than pipe bursting. It also avoids issues with repair collars that can occur during pipe bursting.
- Avoidance of the need for heating and extended curing times associated with epoxy lining. The installation process can also be completed within one hour.

Fig 1: Aqualiner winch to pull liner

Fig 2: Aqualiner inversion bag to drive pig

The REWAISE (Resilient Water Innovation For A Smart Economy) part funded project looked at identifying a piece of 9-inch pipe that was at the end of its workable life to trial the lining material. Working with our partners in Hafey Dyfrdwy a suitable pipe was identified in Rhostyllen in Wrexham.

Fig 3: Route of cast iron pipe in Rhostyllen

The cast iron main had been recently taken out of supply due to its poor internal condition generating significant water quality complaints. As can be visibly seen from the below photographs the pipe's internal condition was very poor and had internally reached the end of its workable life.

Fig 4: photographs of the inside of the cast iron pipe showing severe corrosion

It was agreed by the project team that this pipe would be the perfect host for Aqualiner, and work commenced planning the installation works. A 30-metre section was identified and the planned installation day of the Aqualiner material was Thursday 4th February 2021.

Trial Process

1. *Chemical samples*
2. *Scrape and swab host pipe*
3. *Pre CCTV survey*
4. *Install lining material*
5. *Post CCTV survey*
6. *Recharge, Flush and Reinstate*
7. *Post Chemical samples*

1. Chemical samples

Pre- samples of the main's existing condition were taken by our laboratory team to give us a baseline of the condition, and the cause of the water quality issues were being experienced.

Parameter	Before
Iron total (ug Fe/l)	1243
Manganese filtrate (ug Mn/l)	461
Manganese total (ug Mn/l)	341.5
Aluminium total (ug Al/l)	237
Aluminium filtrate (ug Al/l)	95
Zinc total (ug Zn/l)	51.5
Iron filtrate (ug Fe/l)	8
Zinc filtrate (ug Zn/l)	5.6
Chromium filtrate (ug Cr/l)	2.1
Nickel total (ug Ni/l)	1.9
Cadmium total (ug Cd/l)	1.22
Lead total (ug Pb/l)	1
Nickel filtrate (ug Ni/l)	0.6
Chromium total (ug Cr/l)	0.3
Cadmium filtrate (ug Cd/l)	0.15
Lead filtrate (ug Pb/l)	0.07
Copper total (ug Cu/l)	0.0033
Copper filtrate (ug Cu/l)	0.0022

2. Scrape and swab host pipe

To ensure we had a workable host pipe wall, the section of main was scraped and swabbed.



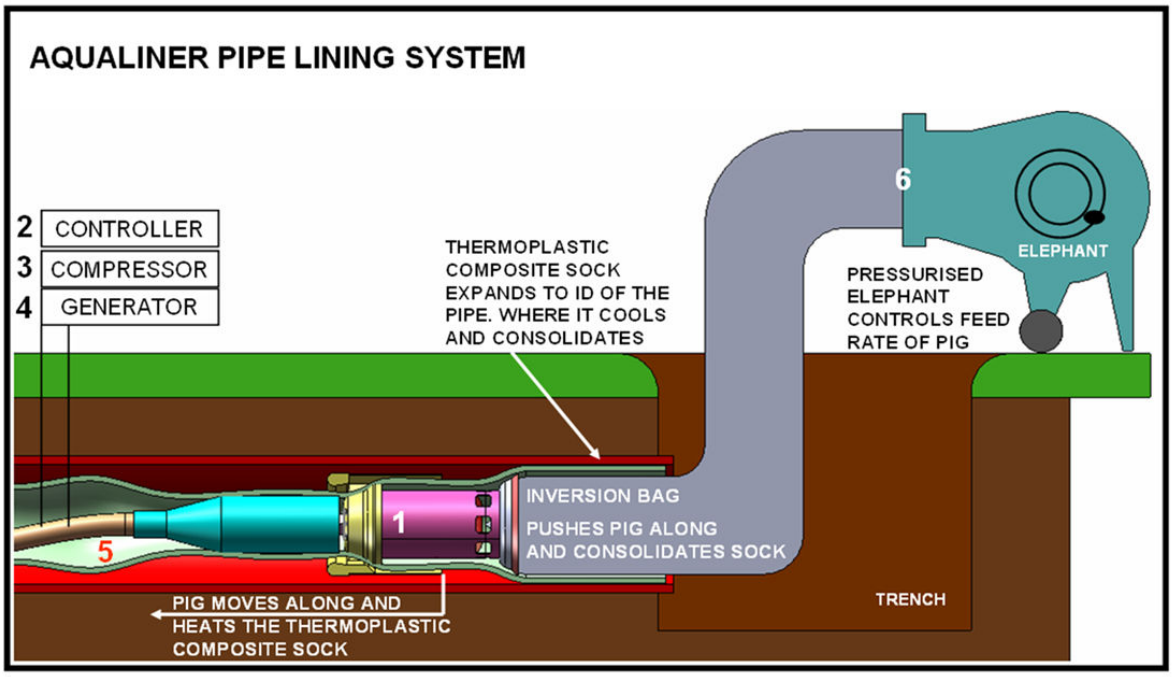
3. Pre CCTV-Survey

To ensure we had a good host, and no damage could occur to the lining sleeve, a pre-CCTV survey was carried out. To reduce costs this was very kindly supported by our internal Customer Operations team from Staffordshire.

Photo from pre-CCTV survey

4. Install Lining Material

The Aqualiner process is undertaken by pulling the new liner through the old pipe and heating it to 200°C with an electrical heating element built into a pig. The pig is moved along the pipe at a controlled speed by an inversion bag, which also moulds the new liner against the wall of the host pipe. Because the heating element does not meet the wall of the host pipe, it can line any material including plastic pipes.



The lining sock being pulled through the host pipe

Severn Trent

Aqualiner Trial Report

Report Author: Jamie Perry **Business Lead: Matt Lewis**

The heating pig which is pushed through the inside of the Aqualiner sock to melt the lining material to the shape of the internal wall of the host pipe

The finished heated liner now in situ close fit to the wall of the host pipe

The machine used to operate the Aqualiner heating pig

To line the 30 metres of host pipe took around 3 hours, however this would not dramatically increase if the length of the line increased. The substantial part of the process is setting up the launch apparatus and pulling the sock between the two pits.

Actual on site speed was 0.3 metres per minute. It is envisaged that this will be closer to 1 metre per minute once fully operational as a service.

5. Post CCTV Survey

To validate a successful line of the Aqualiner a post CCTV survey occurred. The results are below, clearly showing the lining material bonded in-situ.

6. Recharge, Flush and Reinstate

Upon completion of the successful line, the main was re-pieced back up, flushed and brought back into commission along with the required reinstatement of the surrounding area.

As the lining material became fully bonded to the host pipe and the team onsite deemed the ends to be structurally sound, standard Viking Johnson mains couplers were used to re-connect. The end of the lining material was installed slightly longer than the host pipe and cut to size and sanded so it was flush; standard couplers from RDC's were then used to connect to the stub flange.

Installers also have the option of connecting directly to the lining material if required, this has been fully tested up to 100 metres operating pressure. The Aqualiner can be moulded to suit the standard range of couplers available to the business.

Further development is underway to pressure test the liner to >160 metres. In other tests the Aqualiner has been tested to > 500 metres.

A double washout closed valve setup was installed so we could re-commission the section of pipe we had lined. It is worth noting this pipe had previously been out of commission due to the water quality risk, but due to the successful lining process is now in commission.

7. Post chemical samples

Post-chemical samples were then taken by our laboratory team to demonstrate the affect the lining material had made upon the overall mains condition and water quality risk.

The results are below, showing a significant improvement in actual water quality.

Parameter	Before	After	Difference	% Change
Aluminium filtrate (ug Al/l)	95	14	81	85%
Aluminium total (ug Al/l)	237	14	223	94%
Cadmium total (ug Cd/l)	1.22	0.1	1.12	92%
Cadmium filtrate (ug Cd/l)	0.15	0.09	0.21	70%
Chromium total (ug Cr/l)	0.3	0.4	-0.25	-167%
Chromium filtrate(ug Cr/l)	2.1	0.4	1.7	81%
Copper total (ug Cu/l)	0.0033	0.0016	0.0017	52%
Copper filtrate (ug Cu/l)	0.0022	0.0016	0.0006	27%
Iron total (ug Fe/l)	1243	15	1228	99%
Iron filtrate (ug Fe/l)	8	8	0	0%
Lead total (ug Pb/l)	1	0.13	0.87	87%
Lead filtrate (ug Pb/l)	0.07	0.13	-0.06	-86%
Manganese total (ug Mn/l)	341.5	107.2	234.3	69%
Manganese filtrate (ug Mn/l)	461	123.3	337.7	73%
Nickel total (ug Ni/l)	1.9	0.5	1.4	74%
Nickel filtrate (ug Ni/l)	0.6	0.6	0	0%
Zinc total (ug Zn/l)	51.5	7.7	43.8	85%
Zinc filtrate (ug Zn/l)	5.6	7.6	-2	-36%

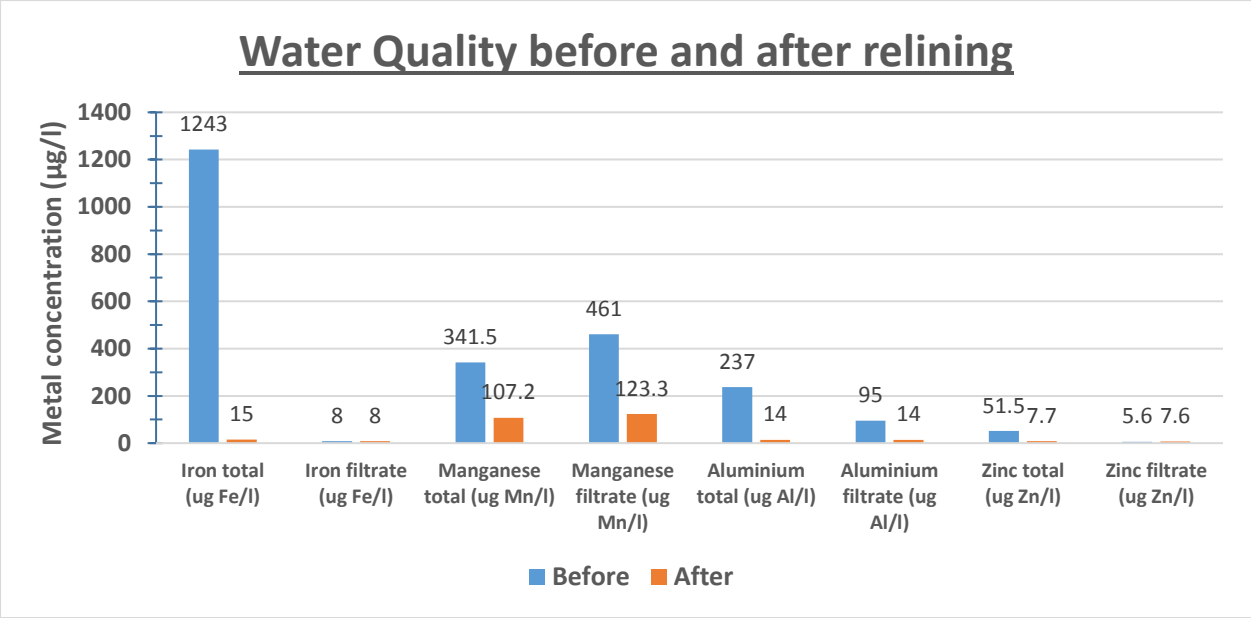
- Iron and manganese are often the largest contributors to turbidity. In this study we see a reduction in total iron of 99% (from 1243 ug/L to 15 ug/L) and total manganese of 73% (from 341.5 to 107.2 ug/L). Filtered iron remains the same. The PCV for manganese is 50 ug/L and for iron 200 ug/L therefore indicating a significant contribution to improving water quality against the regulatory PCVs using Aqualiner.
- Residual Disinfection: free chlorine increase is > 100% and total chlorine 85%. This indicates that organic matter and other chemicals that exert a chlorine demand are reduced. This is also consistent with the reduction of Taste and Odour to zero.
- Total PAH is below the limit of 0.1ug/L at the customer tap and were not seen to change after the introduction of Aqualiner.
- No conclusions can be drawn from the bacteriological data. It is recommended that future surveys include flow cytometry analysis for a more accurate evaluation of the bacterial population in water.
- Turbidity was reduced from 5.97 to 0.27 NTU. This is a significant reduction and will reduce risk of turbidity failure at the customer tap where the limit is 4NTU.
- The data also shows a reduction in aluminium from a total of 237ug/L to 14ug/L (against a standard of 200ug/L at the customer tap).

Severn Trent

Aqualiner Trial Report

Report Author: Jamie Perry

Business Lead: Matt Lewis



Conclusions

The trial of the AquaLiner was 100% successful and has now meant that a redundant part of our water infrastructure network previously removed from commission due to the risk imposed, has now been re-commissioned to supply. Feedback from the Network Operations team was overall positive, and the installation technique is significantly less invasive and cost efficient than current methods available on the market.

We have also seen significant water quality improvements meaning the product we supply to our customers has improved, as well as rehabilitating an existing asset to full structural stability.

Further work is required by Aqualiner to create a broader size range available outside of the current 9-inch range. This is expected to be ready for full launch by a service provider by Q2 2022.

Recommendations

1. Continue to work with Aqualiner to develop a process and system of work for the product.
2. Once available as a service, fully consider Aqualiner internally as an option for mains rehabilitation schemes taking into account the benefits of costs, speed, and carbon footprint.

Appendix

i. Sampling Raw Data

Date & Time Sample Taken	Sample Desc	Aluminium (total) as Al (ug/l) (ug Al/l)	Aluminium in filtrate as Al (ug Al/l)	Benzo (b) Fluoranthene (ug/l)	Benzo (ghi) Perylene (ug/l)	Benzo (k) Fluoranthene (ug/l)	Benzo 3;4 pyrene (ug/l)	Cadmium (total) as Cd (ug/l) (ug Cd/l)	Cadmium in filtrate as Cd (ug/l) (ug Cd/l)	Chromium (total) as Cr (ug/l) (ug Cr/l)	Chromium in filtrate as Cr (ug/l) (ug Cr/l)	Conductivity field (uS/cm)	Copper (total) as Cu (mg/l) (mg Cu/l)	Copper in filtrate as Cu (mg/l) (mg Cu/l)	Indeno (123-cd) pyrene (ug/l)	Iron (total) as Fe (ug Fe/l)	Iron in filtrate as Fe (ug Fe/l)	Lead (Total) as Pb ug/l (ug Pb/l)	Lead in filtrate as Pb (ug Pb/l)	Manganese in filtrate as Mn (ug Mn/l)	Manganese (total) as Mn (ug Mn/l)	Nickel (total) as Ni (ug/l) (ug Ni/l)	Nickel in filtrate as Ni (ug Ni/l)	Qualitative Odour Intensity ()	Quantitative Odour ()	Residual Disinfectant - Free (mg/l)	Residual Disinfectant - Total (mg/l)	Temperature (deg_C)	Turbidity (Field det) (NTU)	Zinc (total) as Zn (ug/l) (ug Zn/l)	Zinc in filtrate as Zn (ug Zn/l)
13/01/2021 08:58	Aqualiner trial - pre work samples	237	95	<0.00097	<0.0012	<0.00074	<0.00074	1.22	<0.15	<0.3	<2.1	166	0.0033	<0.0022	<0.0021	1243	<8	1	<0.07	341.5	461	1.9	0.6	3	10	0.12	0.18	6.1	5.97	51.5	<5.6
18/02/2021 14:07	Aqualiner trial - post work samples	<14	<14	<0.00097	<0.0012	<0.00074	<0.00074	0.1	0.09	<0.4	<0.4	185	<0.0016	<0.0016	<0.0021	15	<8	<0.13	<0.13	107.2	123.3	<0.5	0.6	0	0	0.28	0.33	7.1	0.27	7.7	7.6

ii. Regulation 31 Approval Certificate

REGULATION 31(4)(A) OF THE WATER SUPPLY (WATER QUALITY) REGULATIONS 2016 SI No 614
& THE WATER SUPPLY (WATER QUALITY) REGULATIONS 2010 SI No 994 (W.99)

APPROVAL CONFIRMATION

Product name/designation	Water Pipe Lining
Approval Category(ies)	C.1 In-situ Installed (tubular) pipe linings
Approval Holder (Name & Address)	Aqualiner Ltd Unit 10, Charnwood Business Park North Road Loughborough United Kingdom LE11 1QJ
Instructions for Use	IFU, Version 5, Oct 2010
DWI Ref Number	DWI 56.4.910

The Secretary of State for Environment, Food and Rural Affairs in respect of relevant water[1] suppliers whose area of supply is wholly or mainly in England, and the Welsh Ministers in respect of relevant water suppliers whose area of supply is wholly or mainly in Wales, in exercise of their powers under Regulation 31(4)(a) of the Water Supply (Water Quality) Regulations 2016 and Regulation 31(4)(a) of the Water Supply (Water Quality) Regulations 2010 (as amended) (Wales) respectively hereby approve the introduction or application of the product detailed above, in accordance with the following Conditions:

CONDITIONS OF APPROVAL

The above named product is approved for application in England and Wales[2] by a relevant water supplier for public water supply purposes subject to the following conditions:

1. Relevant water suppliers shall be provided with a copy of the Instructions for Use (IFU) detailed above and use of the product must be in accordance with the IFU.

2. The Drinking Water Inspectorate (DWI) must be notified, in advance and in writing, by the approval holder detailed above, in respect of any change in –
   a) The Instructions for Use
   b) The formulation of the approved product, including change in source or identity of raw materials
   c) The manufacturing process, including location of manufacture
   d) The designation of the approved product
   e) The name, address or ownership of the organisation holding the approval

   Failure to notify such changes will result in approval being withdrawn.

3. The approval holder shall ensure that the product is tested for conformity with its formulation, and the source or identity of its raw materials, at such intervals and by such persons, as may be determined by the DWI and the results of such testing shall be sent to DWI.

4. The use of the Drinking Water Inspectorate, DEFRA or Welsh Government logos, in respect of any approved product (including on the product or in editorial or advertising/trade copy) is not permitted.

5. The following product specific condition(s) apply – *None*

Signed by authority of the Secretary of State and the Welsh Ministers

Date of Issue: 07 November 2016

Date of Expiry: 06 November 2021

Marcus Rink
Chief Inspector of Drinking Water
England and Wales

[1] Relevant water suppliers shall include water undertakers, water supply licensees and inset appointees.
[2] Separate approval arrangements apply in Scotland and Northern Ireland