IMPROVING RESILIENCE THROUGH INNOVATIVE WATERMAIN & DRAINAGE REHABILITATION TECHNIQUES

Leigh John (Aquatech Solutions)

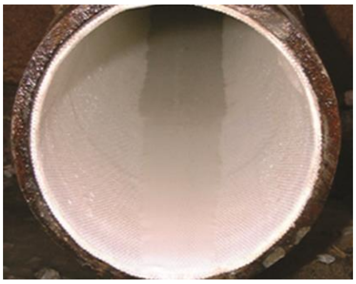
ABSTRACT

An introduction to techniques that have been pioneered in Northern America, that are new to not only New Zealand but pretty much the rest of the world. These techniques will improve pipeline resilience, allow assets life to be drastically extended, with considerable reductions in disruption and safety related claims & risks.

The main focus is on water-main pressure pipeline relining / rehabilitation and gives and explanation of the system, its benefits, development, how it is designed and installed. Comparison between traditional methods & pipeline rehabilitation, New Zealand and International case studies & learnings are also reviewed.

The second part of the presentation is on pipeline sleeve repair systems for both pressure and non-pressure applications. These systems provide a full structural repair in all pipe materials and can be installed in live drains, even with severe infiltration. They can work in conjunction with CIPP lining providing a more robust solution. The diameter range that can be repaired is from 100mm to 3150mm including box and irregular shaped pipes & culverts.

Lastly new techniques to rehabilitate manholes and pipelines to prevent Inflow & Infiltration are reviewed and discussed.



KEYWORDS

Relining, CIPP, rehabilitation, spot repairs, watermain, renewal, pipe bursts, pipe breaks, pipe leaks, liner, trenchless, drainage, resilience, safety risk reduction, extending asset life, I&I

1 INTRODUCTION

The importance of safe drinking water to public health is undisputed. However, as we enter the 21st Century, water utilities are faced with aging buried infrastructures. Underground pipes delivering safe drinking water have exceeded their design life. The various pipes installed during different periods in history have different life expectancies, and thousands of kilometres of potable water pipes that were buried 50 or more years ago will need to be replaced within the next 30 years. In the last 30 years, CIPP (Cured-in-Place-Pipe) technologies have become a standard in rebuilding buried gravity pipeline systems.

Municipalities and Water Authorities are turning to innovative technologies provided by the trenchless rehabilitation industry to help solve the economic burden related to the renewal of drinking water infrastructure.

Canada was faced with this problem in the 90’s with water pipelines that are 4m deep. Traditional replacement methods were not affordable or tolerable in terms of disruption in urban areas. Aquapipe was developed by Sanexen Environmental Services in collaboration with the National Research Council of Canada, the Urban Infrastructure Research & Expertise Centre as an affordable solution to this looming problem.

Over 1000km’s with 60,000 service connections have now been installed in over 500 towns and cities throughout North America and Australasia and is now the preferred (first choice) option for the renewal of watermains in Canada. This has resulted in million dollar savings for tax payers/water utility users through the following economic benefits:

- Rehabilitation is up to 70% quicker and less expensive than traditional methods
- Prevents water main breaks
- Reduced treatment and pumping costs
- No further intervention required on rehabilitated water mains
- Reduction of social costs

2 CIPP WATERMAIN REHABILITATION

The ability to rehabilitate pressure pipelines has until recently not been available in New Zealand or to the rest of world (outside of North America). The first New Zealand has now been successfully completed in Porirua with considerable savings in design, installation and social costs (see Appendix).

This technology differs from traditional CIPP drainage rehabilitation methods as it must act in tension rather than compression to resist the very high structural & pressure loads in pressure pipelines. The inherent benefits of this are as follows:

- Ability to line pipes that are difficult to access (underneath structures, highways, etc.) and through bends, sluice valves, hydrants, different pipe materials & diameters
- Rapid installation with less disruption, with minimal impact on traffic & complaints from community during work
- Little excavation when compared to traditional open cut methods, with adjacent infrastructures not disturbed by work
- Increased pressure, flow capacity & life span of infrastructure
- Regained structural capacity & improved Corrosion resistance
- Capable of withstanding lateral deflections up to 50% of pipe diameter
- Suitable for lining firefighting water lines in areas prone to seismic activity
- Over 80% reduction of Greenhouse Gas Emissions (GHG)

2.1 Liner Properties

- The liner consists of woven textile jackets with epoxy and an internal polymeric membrane for water tightness
- Any pipe internal diameter can be lined from 100mm to 630mm
- Fully Structural liner, designed to ASTM F1216
- Design life of 50 years and expected life of 100 years
- Maximum burst pressure >50 bar
- Certified drinking water safe to AS/NZS 4020, BS 6920 & ANSI 61
- Hazen-Williams Coefficient > 120
- Mechanical interlock with host pipe of up to 8.8T/m2

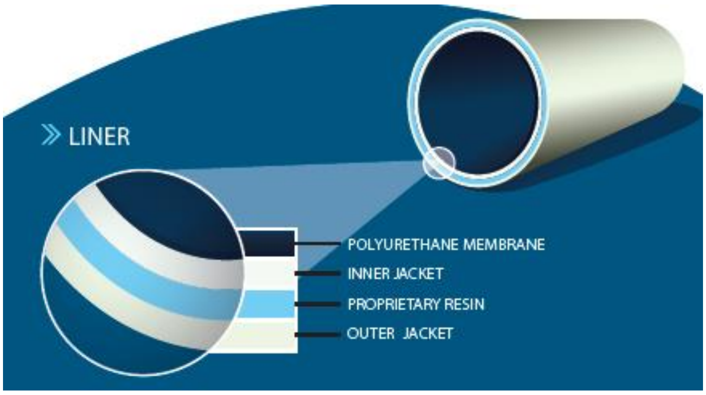


Figure 1: Liner details

2.2 Typical Project Steps

1. Locate and inspect pipeline
2. Accurately determine access pit locations and liner lengths
3. Install temporary bypass to maintain water supply
4. Excavate access pits at each end of the pipe section
5. Clean pipeline
6. Closed-Circuit Television (CCTV) inspect pipeline to identify service connections
7. Insert plugs with specialised robotic equipment into service connection from inside the pipeline
8. Inject epoxy between the two liners whilst pulling the liner into place, in a purpose built refrigerated mobile truck
9. Form the liner by sending swabs from one end to the other
10. Circulate hot water for curing
11. Perform hydrostatic pressure test
12. Reinstate service connections by drilling with specialised robotic equipment from inside the pipeline
13. Disinfect pipeline
14. Reconnect water distribution systems
15. Remove temporary bypass
16. Restore site

2.3 Locating the Pipe

Unlike sewer mains, water mains are not visible from the surface via manholes. Locating the pipe to precisely determine the position of hydrants, valves and intersections (T connections), service connections as well as elbows and services (occasionally not identified in the plans and often unknown to the water utility) is necessary.

It is also important to be aware of any other utilities (gas, telecom, etc.) that may be found in the path of the water main to prevent damaging such utilities or infrastructures during the excavation of the access pits. The location of the water main will dictate the actual location of each access pit on the job site.

2.4 Temporary Water Supply

The temporary water supply (bypass) is installed on the surface and ensures uninterrupted water service to the residents during the project.

The houses are connected to the bypass system using a hose connected to the outdoor spigot or meter box. If required, plumbing may have to be modified to allow feeding the house with drinking water from the garden spigot.

As the host pipe must be isolated from the surrounding houses, cut-off valves from the house are shut and the main stop is turned closed. If required, the main stops will have to be repaired or replaced in order to close them.

The temporary water supply work may be installed by the utility owner and not be included in the scope of work.

Figure 2: Temporary water supply

2.5 Access Pit Excavations

The water mains are accessed through standard excavated and shored access pits. Access pits are used as entry and exit points for the liner during insertion as indicated in Figure 3. The liner is pulled inside the existing pipe with the use of a winch located above the exit pit.

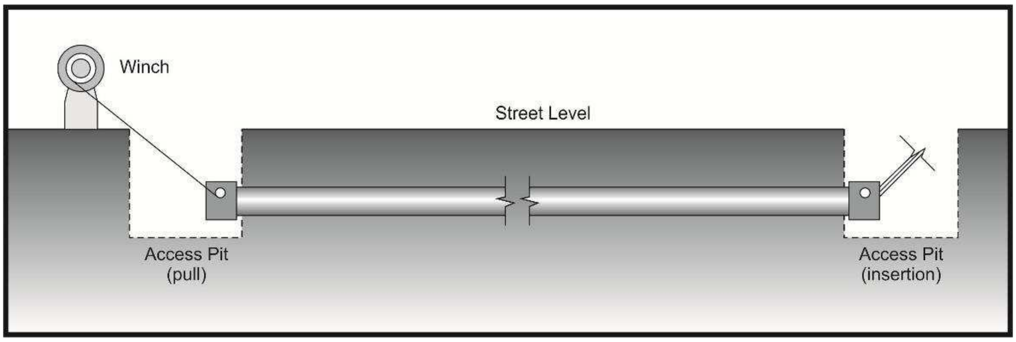


Figure 3: Access pits

The location of access pits will be selected to minimize excavation. Typically, the pits will be placed at water main intersections (tees, crosses, valves, hydrants, etc.) or the pits will be spaced to maximize the length of the sections to be rehabilitated, up to 300m, whichever occurs first.

The pits are fitted with a trench box to ensure a safe work environment and proper signage is required for optimal traffic control. As this is a trenchless technique, streets are kept opened to traffic during the project.

As can be seen in the following figures, a typical access pit requires an excavation of 2.7m x 1.8m (9ft x 6ft) and a depth of 300mm (12 inches) below the pipe.

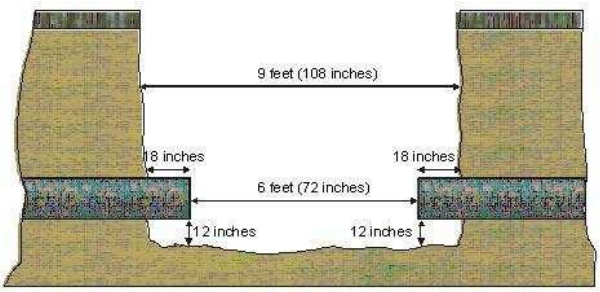


Figure 4: Access pit — side view

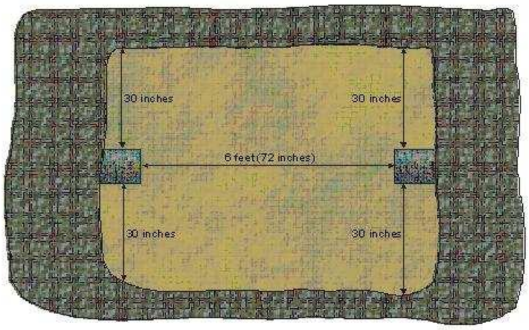


Figure 5: Access pit — top view

Figure 6: Trench box and fencing **Figure 7: Little or no impact on traffic**

2.6 Pipe Cleaning

The cleaning of the pipe is a critical step in the rehabilitation of a water main with AQUAPIPE®. The rust and scale is removed to allow the new composite liner to adhere to the host pipe and restore the flow capacity of the pipe.

After cleaning, the pipe is inspected with a closed circuit television camera (CCTV) to verify that the rust and deposits have been adequately removed.

Cleaning is accomplished using a variety of cleaning tools. Existing repair clamps do not affect the rehabilitation process since all work is carried out from inside the existing pipe.

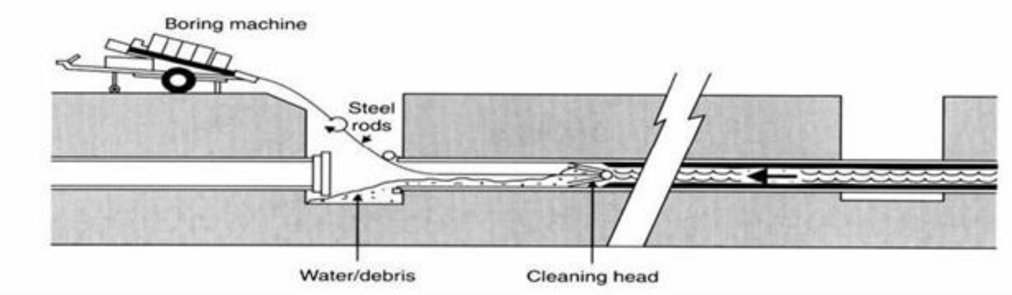


Figure 8: Pipe Cleaning

Figure 9: Water Main Before Cleaning

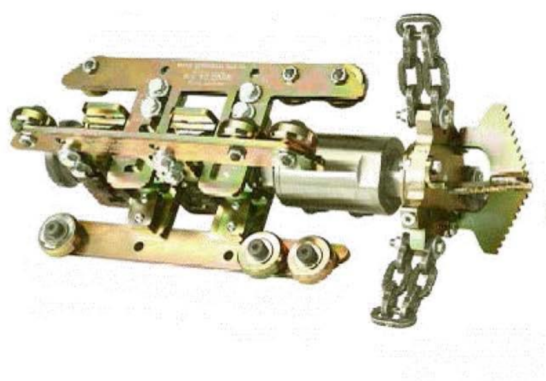


Figure 10: Cleaning Head

2.7 Inspection and Plugging

Rehabilitation of a water main with starts with the camera inspection and the insertion of plugs inside the service connections. These plugs incorporate a diode which is activated by a coil on the robot head as it approaches the service connection, the diode starts to flash red ensuring that all connections are located.

The plugs are inserted in the service connections to prevent the migration of epoxy resin into the service line and potentially blocking the boundary control valve.

As the service connections are plugged, a video inspection of the line is carried out. Each service connection is located and compiled in a log to be used at the end of the rehabilitation process when these same service connections have to be opened.

Finally, the video inspection allows the technicians to check for any major pipe leaks / leaking service connections and provides the client with a preconstruction video. Major pipe leaks must first be sealed off using Link-Pipe structural repair systems.

Figure 11: Control panel for CCTV inspection

Figure 12: Plugging service connections

2.8 Impregnation, Insertion and Curing

Lining involves three main activities: impregnation of the liner; insertion into the host pipe and curing the liner inside the host pipe.

AQUAPIPE® is made of two circular woven (seamless) polyester jackets with a watertight polymeric membrane fused to the inner jacket.

The idea is to have an absorbent fibrous matrix (polyester) that will allow the epoxy to penetrate the material and harden in place. The combined effect of polyester with a hardened epoxy makes the composite liner. The mechanical properties of the resulting composite liner will exceed the requirements of ASTM F1216.

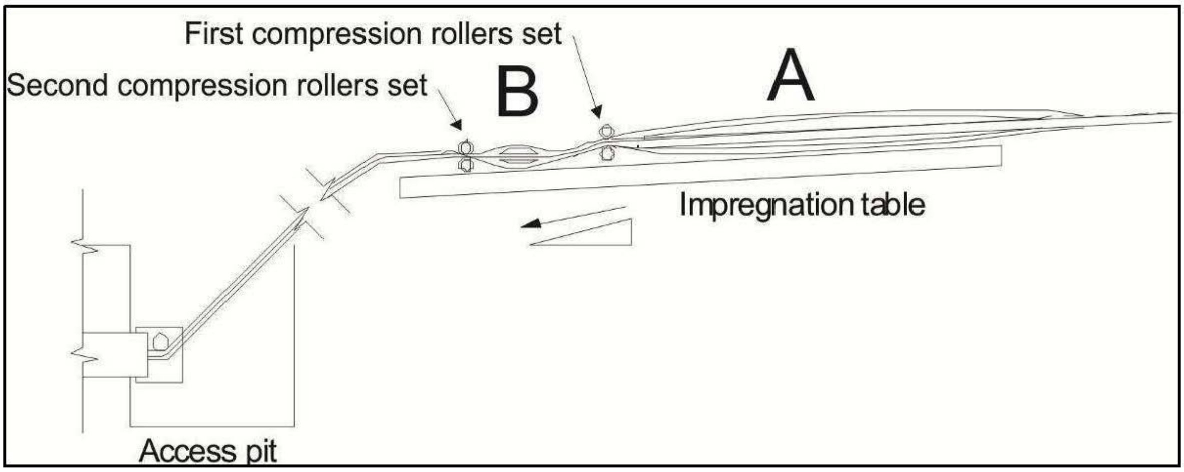


Figure 13: Arrangement of impregnation table

The impregnation of the material (or wet out) is achieved on-site in a refrigerated environment. The low temperature delays the reaction of the mixture that ensures the adhesion.

The liner is impregnated with a two part epoxy system. Figure 14 shows the table arrangement for the impregnation process.

Figure 14: Impregnation of the liner

The liner is pulled inside the host pipe with the help of a winch at the receiving access pit. Pulling can be performed in small spaces. The impregnation and pulling actions are carried out simultaneously (see Figures 15 and 16).

Once pulled into place, the liner rests flat inside the host pipe and needs to be formed or inflated (see Figure 17). The liner is pushed against the inside walls of the host pipe with the help of a swab (pig) and water pressure. In the process, any trapped air located between the liner and the pipe is evacuated and all voids and cracks are filled with epoxy. These actions allow the liner to fit tightly against the inside walls of the existing pipe and provide a watertight environment after the liner has cured.

Curing involves heating the impregnated liner to accelerate the reaction between the components of the polymeric resin. The reaction will cause the polymeric resin to reticulate and harden to confer mechanical rigidity to the liner. Heat is supplied and transported by water. At the end of these three steps (total time of approximately 16 hours), the liner has become a solid structural pipe, inside the host pipe.

Figure 15: Insertion of the liner

Figure 16: Insertion of the liner

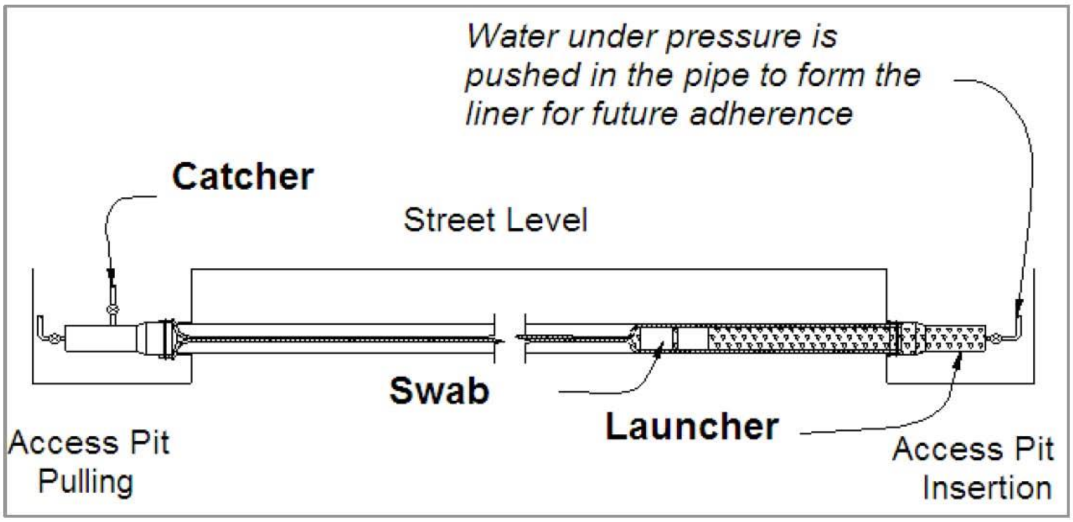


Figure 17: Pulling and forming process

Figure 18: Curing with hot water

Figure 19: Pipe rehabilitated with AQUA-PIPE®

2.9 Hydrostatic Pressure Test

If required by the water authority, the watermain will be subjected to a hydrostatic pressure test before the reinstatement of the service connections. The pressure test and the allowable leakage will be carried out as indicated in Section 8.3 of the ASTM F1743 standard.

2.10 Opening of the Service Connections

The AQUAPIPE® trenchless technology allows for the services to be robotically reinstated from the inside of the renewed pipe. A remote controlled robot is used to open the service connections.

The remote controlled robot is water tolerant and small enough to fit in a 150mm diameter pipe and still allow for the freedom of movement necessary to reach and open the service connection (see Figure 20).

Equipment to reinstate service connections is combined with video viewing and recording equipment for final inspection of the lined water main.

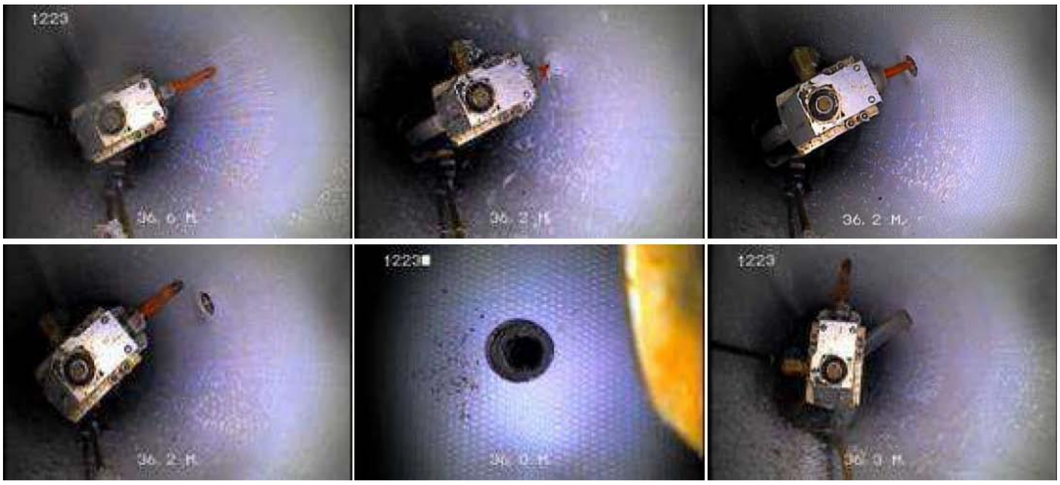


Figure 20: Opening of the service connections

The reinstatement of the service connections does not affect water tightness. Water tightness is maintained by the epoxy which fills all voids around the threads of the service connection (see Figure 21).

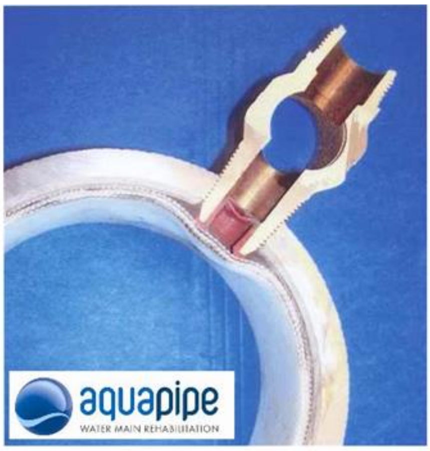


Figure 21: Water tightness at the service connection

2.11 Fitting Installation and Civil Works

Following the reinstatement of all service connections, the required fittings and accessories are installed in the access pits and the rehabilitated pipe is rinsed, disinfected and returned to service. Figure 22 shows a typical re-connection in an access pit. Regular pipe and fittings readily available in the market place and as specified by the utility are used for these connections to the rehabilitated pipe.

Figure 22: Typical reconnection in an insertion pit

Most utility owners will take advantage of the rehabilitation work and replace the old valves and hydrants. In addition, valves and hydrants may be installed or abandoned because of changes in codes and regulations. The replacement and addition of new valves and hydrants is carried out through local excavations which, when possible, are used as access pits.

Furthermore, restoration of the roadway infrastructure is done after the rehabilitation in order to leave the environment as it was before the work began. Restoration involves pavement, curbs, sidewalks and any other infrastructure that was removed to access the water main.

2.12 Future Maintenance, Tapping and Connections

The new lining will not require maintenance once it has been installed into the old pipe. The corrosion free lining will not allow deposits to attach or form on the inside wall of the pipe.

The new lining can be easily dry or pressure tapped. The only precaution would be to make sure that the utility workers use a saddle or tapping sleeve and a sharp shell cutter, and make sure that they have cut through the walls of both the existing pipe and the liner.

If a cut must be performed on a section of rehabilitated pipe, the same procedure as regular pipe can be used. The pipe should be cut with a circular saw equipped with a sharp diamond blade, removed and replaced with a new section of pipe and fittings along with a coupling. No special end seals are required at the pipe extremities. Written procedures are available for these operations and are submitted as part of the work report for an AQUAPIPE® project.

Figure 23: Typical pressure tap equipment

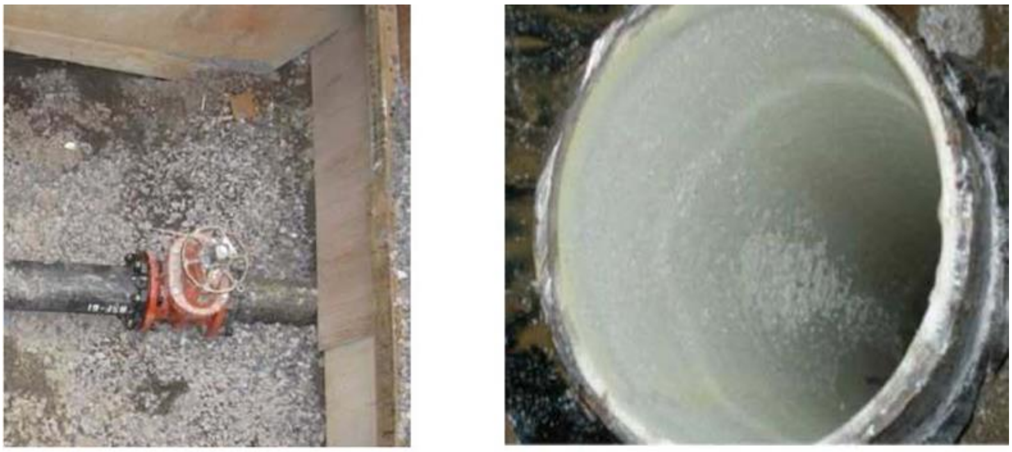


Figure 24: Typical pipe cut

3 CONCLUSION

It is well known that Water Authorities throughout the world are facing looming problems with the replacement of worn out pipelines. The cost and disruption of replacing these pipelines in urban areas is neither, affordable or tolerable. CIPP rehabilitation of watermains is now one option to help solve this problem. It is a proven, sustainable technology, available in New Zealand, installed only by licensed contractors.

It is now up to water authorities to understand and embrace these types of technologies to ensure that our renewals spend can go further and at least maintain the service levels that our community expects.

APPENDIX A - CASE STUDY

Southern Watermain Renewal Project
Porirua City

Adopting the Future - More for Less

Introduction

Porirua City Council like many Councils, has had the renewal of core infrastructure at the heart of its decision making, and it will be a continuing focus for the foreseeable future. In terms of renewing infrastructure, Capacity as network managers for water services, need to ensure it is at the forefront of technology and that it is getting the best value for rate payer's dollar.

This has resulted in Capacity, who manage the Water Assets for Porirua City, being the first in NZ to introduce a Structural water main re-liner. The product was Aquapipe installed by ANZEL Ltd (Aqua Pipe New Zealand Environment Limited).

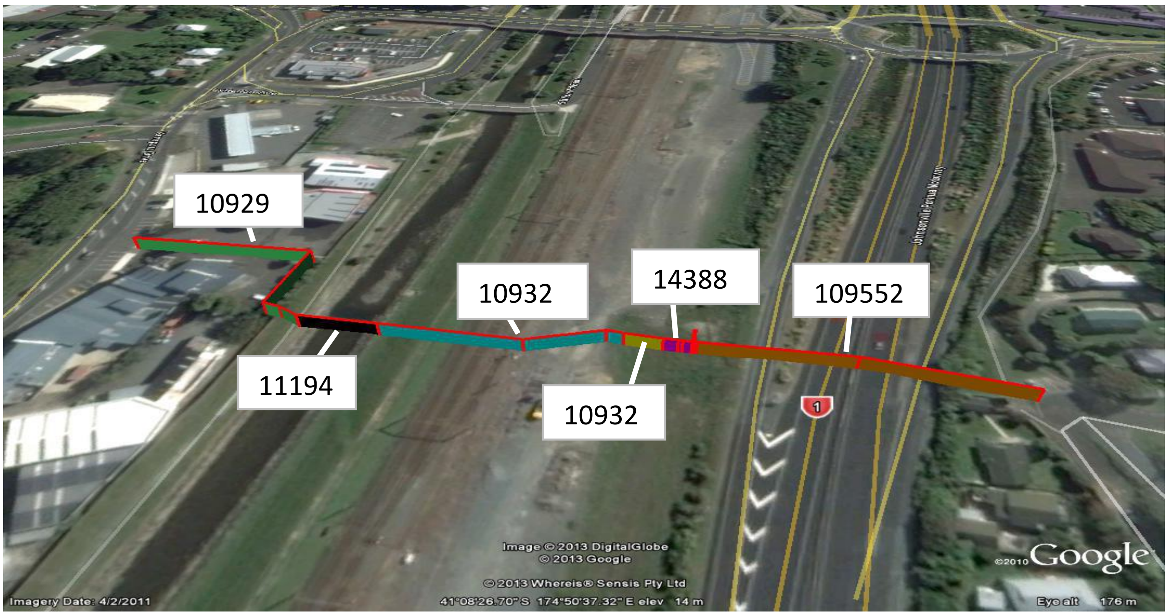
Background

The original watermain being relined was laid in the 1950's from Arawhata Street on the eastern side of the highway where the Photo was taken, to Kenepuru Drive on the Western side. This 250mm line is one of the main water lines to the CBD and Western side of the city. As time has marched on, it is a far different place now in terms of access availability than in the 50's.

Today the water main crosses underneath a much larger and busier State Highway 1, beneath Kiwi Rail Ontrack land and the railway lines, through the Regional Council stop banks, underneath the Porirua stream and back out on to Kenepuru Dr, and is now a vital water feed to the Western side of the city and Kenepuru Hospital.

The Southern main was a mixture of old 250mm asbestos cement pipe, cast iron bends, and 250mm concrete lined steel pipe.

A portion of the watermain within the stop banks ruptured in late December 2011, and this is where the journey began to find an alternative, cost effective structural repair method that did not involve dig and lay.



Stretch of pipeline to be relined: *The Photo shows the reline underneath the state Highway 1 before it continues on under the rail lines, the Regional Council stop banks and Porirua Stream*

New Technology Replacing Old Methods

The conventional methods of dig and lay are now fast becoming a redundant form of renewal due to the ever increasing costs and time associated with the following:

- Resource Consent approvals
- Design costs
- Unacceptable disruption with the digging up of roads and carriageways
- Reinstatement and maintenance period costs
- Difficulty finding alternative routes in already congested streets
- Locating and possibility of hitting other utilities
- Traffic and site management
- Overall disruption of services to residents and commercial businesses
- Overall conventional extended construction timeframes

Watermain relining has been used extensively in over 350 cities worldwide during the last 2 decades, is one of the most acceptable and economical forms of water main renewal developed. Capacity, with Porirua City adopted and introduced the structural Aquapipe liner as the only economic answer to its future renewals program.

The relining process results in a new high quality structural pipe inside the old pipe

Some of the benefits associated with internally relining old mains with a structural liner compared with the old dig and lay method are listed below:

- Lining pipes that are ever increasingly difficult to access
- Minimal requirements and costs associated with resource consents if required at all
- Minimal traffic management and disruption
- No future maintenance required with joints
- Little excavation when compared to traditional open cut
- Adjacent infrastructures or utilities not disturbed by work
- Utilising existing infrastructure rather than having abandoned mains everywhere
- Large sections of Roads not compromised
- Less disruptions and complaints from residents and commuters during work period. Little to no disruptions to retail businesses
- Work time frames dramatically reduced
- Cost can be as much as 70% cheaper than traditional methods
- Increased pressure and flow capacity
- Corrosion resistance
- Regained structural capacity
- Life span of 50+ years guaranteed, with an expected life of 80 +
- Little loss of Internal diameter, with the liner 4.5 and 6mm thick

In the photo below: *Desmond Scrimgeour who manages the Water and Stormwater networks for Porirua, with the Mayor Nick Legget, explaining, "some of the ever increasing challenges facing the city in terms of renewing its ageing infrastructure."*

The mayor, Nick Leggett stated that "the end result by introducing this technology means, we can do a lot more, for a lot less money, quicker and with less disruptions and end up with a high quality renewed water infrastructure"

Costings

An independent consultancy MWH, was engaged to evaluate the cost of a conventional method of dig and lay and find a new route where possible by thrusting, slip lining, pipe cracking and directional drilling, plus evaluate the resource consents and access permissions that would be needed from the 3 main parties, NZTA, Ontrack Kiwi Rail, and Regional Council compared with a relining option.

The conventional method was costed out at approximately $1.2million, with a 2 year planning time frame to gain all required resource consents and find a new alignment route, with an estimated 4 month construction period. This did not include any additional longer term costs that would be binding with any conditions of resource consent.

The structural relining was tendered out with 4 expressions of interest, and 3 parties tendering, with the winning tender and contract being awarded to ANZEL Ltd at $324,000, (less than a 1/3) with a construction time frame of 3 weeks for all preparation and being completely offsite.

Construction

Construction started in early April 2014 and was complete in May.

The Porirua Works Business Unit, which carriers out the day to day maintenance of the networks were also heavily involved in the project, first to learn and understand the process, secondly to access the valve sets and create the access pits for the liner and oversee the day to day servicing requirements to residents.

The main section of liner was pulled through in 2 sections. First was the Highway section from the Eastern side to the middle access pit and then under the railway line, stop banks and stream.

The liner was pulled, formed and cured in 1 day. The main was camered and disinfected, and brought back into service without any hitches. The lining and the process proved incredibly successful.

Relining Pit: *'Pig Catcher' in action, catching the forming swabs as they are propelled though the line during the forming and curing process*

Conclusions and Learnings

As with the application of any new technology or technique, there were steep learning curves all along the way. These learnings will provide further time and external cost savings for future projects.

Preparation was the key, ensuring everything and everyone was ready and knew their specific roles. The process of continuing to provide an uninterrupted service to customers through the works proved problematic at times, but was worked through and overcome by the Works unit.

The learning process involved, first finding a cost effective and long lasting new structural pipe alternative to conventional methods. Finding and fully evaluating the pros and cons of a number of available proposed structural Watermain liners available worldwide, and then the process of accessing it in NZ and working through the full preparation and construction process with all its twists and turns.

Working within the water industry at the time for Porirua City and now Capacity, as Wellington amalgamates its water services, there is always a keen interest from myself and the much wider industry, in getting more for less in tackling the really difficult jobs. Utilising innovative technologies that helps us renew a critical and ageing services whilst reducing costs of resource consents, disruption to services for residential & commercial customers, disruption to roads & carriageways, reducing the costs of traffic management makes good sense.

After being through this, I am of the belief that this technology is a proven method of structural watermain pipeline renewal and will become the mainstream renewal method very quickly in NZ.

Desmond Scrimgeour

Principle Engineer Water and Drainage Services

capacity
infrastructure
services

APPENDIX B – AQUAPIPE FREQUENTLY ASKED QUESTIONS

FREQUENTLY ASKED QUESTIONS

March 2015

1) What is AQUAPIPE®'s installation history?
Over 1000km of AQUAPIPE® with 60,000 service connections have been installed over the past two decades throughout 500 towns and cities in North America and Australasia.

2) In what size diameters is AQUAPIPE® available?
Any pipe internal diameter from 100mm to 630mm.

3) Can AQUAPIPE® be used for other applications?
AQUAPIPE® is specifically designed for water distribution systems but other pressure pipe systems such as force mains can also be rehabilitated using AQUAPIPE®.

4) Is AQUAPIPE® safe for potable water?
Yes, AQUAPIPE® is certified by Underwriters laboratory (UL) and by NSF to NSF/ANSI Standard 61 and also meets AS/NZS4020, WRAS BS6920 and NQ 3660-90/2003 requirements.

5) Are there problems with solvents in the water after the CIPP process?
No, the AQUAPIPE® epoxy is made of 100% solids. No VOCs or styrene is present.

6) How do you make sure the epoxy is not in contact with the water?
The watertight membrane fused to the inner jacket prevents the epoxy from being in contact with the water inside the pipe.

7) Is AQUAPIPE® an environmentally friendly technology?
AQUAPIPE® is a trenchless technology and therefore greatly reduces the carbon footprint of the project. AQUAPIPE®'s GHG emissions have been quantified according to international standards. It has been determined that for each mile of renewed pipe, AQUAPIPE® reduces GHG emissions by 378 tons or 84% compared to traditional open cut replacement. These quantities do not include GHG savings due to other impacts such as traffic detours and increased vehicle idling that are commonly observed using the traditional open-cut replacement.

8) How should fittings, line valves, hydrant branches, etc. be handled when setting up an AQUAPIPE® project?
In general, existing fittings, such as bends can be lined. Valves can also be replaced at their original location (requiring an access pit at that location) or relocated into another access pit to reduce costs. Hydrants and their branch lines can be replaced if requested by the owner or, if they are to be maintained, the tee is excavated and the location is used as an access pit.

9) Do valves have to be excavated?
Gate valves and Hydrants can be lined through, with the bonnets removed and throat sections cut back. Butterfly type valves have to be excavated.

10) Do you re-instate tees and hydrants from inside the pipe?

This can be done but it is not recommended. When reopening lined tees, the opening is not complete due to the curvature of the tee. Also, when tees remain in the section to be lined, it allows the epoxy to escape and accumulate in a puddle at the bottom of the pipe which may hinder the use of the shutoff valve on the branch line. Finally, at these locations some infiltration between the liner and the host pipe may sometimes occur.

11) Can service connections be damaged inside the pipe during the cleaning or lining process?
Yes, the service connection may be damaged during cleaning when using non-recommended equipment or procedures. The use of high pressure nozzles and reamers (rotating chains) is recommended to clean the pipe as opposed to rack bore or winch-pulled scrappers. The lining procedure will not cause any damage to the service connections.

12) Can the structural CIPP liner be used on asbestos cement pipe?
Yes, AQUAPIPE® has been successfully used to rehabilitate asbestos cement pipe.

13) Prior to installing AQUAPIPE® in a previously cement lined water main, is it necessary to remove the lining during the cleaning process?
During the cleaning process, it is necessary to remove the cement lining which may be loose. The cement remaining in place will not hinder the lining process. However, special care must be taken to scrape or chip away the cement layer at the extremities of each cut away section of pipe. This will assure that the liner will properly adhere to the host pipe and create a proper seal.

14) How does Sanexen assure the quality of work performed by its licensed installers?
An AQUAPIPE® installer is trained and certified by Sanexen and is provided with continuous technical support. The fact that Sanexen is also an installer reassures both Water Utilities and Installers of the high quality of training and support provided. Sanexen is present during the licensed installer's first installation project and provides ongoing support with regards to product and process standards. Having its own installation crews since 2000, has allowed Sanexen to develop and continually improve its products, tooling and procedures.

15) ***How long is the installation warranted?***
Installation is typically guaranteed 1 year from the date of installation.

16) Can AQUAPIPE® support diameter changes along the host pipe?
Yes, within reason. AQUAPIPE® is designed to be slightly larger than the interior of the host pipe to compensate for such variations. When the pipe diameter is smaller than that of the liner, a longitudinal fold or wrinkle will be visible. This is completely normal and assures and indicates contact with the host pipe. For large diameter changes, for example 150mm to 200mm, the reducer shall be excavated and the excavation shall be used as an access pit to line two diameters in each direction.

17) How much of a difference in diameter is acceptable between 2 sections of pipe for an AQUAPIPE® installation? E.g. a section of PVC pipe which was used to make a break repair on cast iron pipe
The AQUAPIPE® product was designed oversized so that the liner can compensate for changes in internal diameter. The allowed diameters are specified by the minimum and maximum allowable diameter for a specific pipe (ex. a 200mm liner will be suitable for pipes ranging from 197mm to 213mm internal diameter).

18) Up to what pressure can AQUAPIPE® be designed?
AQUAPIPE® can easily be designed for operating pressures up to 20 bar. Specialist designs can be done for greater pressures.

19) What is Aquapipe's burst pressure?
Aquapipe's maximum burst pressure is greater than 50 bar.

20) Does AQUAPIPE® resist vacuum?
Yes, AQUAPIPE® will resist a full vacuum. This has been verified by third party testing performed by the City of Toronto and the University of Waterloo.

21) Can CIPP be used in areas where the operating pressure is higher than 20 bar?
A standard AQUAPIPE® liner thickness will withstand operating pressures up to 20 bar depending on all site specific requirements. Some diameters may withstand greater pressures and are treated on a case by case basis. Specialist designs can be done for greater pressures.

22) Can AQUAPIPE® negotiate bends?
AQUAPIPE® can negotiate bends of up to 90° either vertically or horizontally. The number of bends that can be negotiated in one section will depend on the length and diameter of the section. This can only be answered on a case by case basis.

23) How many m/day can be lined using AQUAPIPE®?
Technically, up to 600m/day (2 liners). However, access pits may be strategically located at street intersections, valves, fire hydrants, or changes of direction and therefore will dictate the actual length of each liner to be installed on a given day. Statistically, 180m/day is typical.

24) What is the pot life of the epoxy resin?
Two AQUAPIPE® resins are available. One with a 2 hour at 20°C pot life and a second, when specific conditions are required, with a 4 hour at 20°C pot life. The curing process starts when the resin and hardener are mixed on site. The process is slowed by working in a refrigerated environment.

25) How does the fold affect the flow or hydraulic properties of AQUAPIPE®?
The longitudinal fold does not affect the flow properties of the rehabilitated pipe. It is well known that the flow in water mains is of the laminar type and is therefore not affected by the location of the fold.

26) What is the shear resistance of AQUAPIPE®?
The structural liner can resist and survive extreme ring fracture conditions to help it withstand soil movements, settlement and beam conditions. This is attested by ring fracture testing results carried out by the Trenchless Technology Center of Louisiana Tech University.

27) How does the liner react when the host pipe breaks after many years following rehabilitation?
If the host pipe of a rehabilitated section breaks for whatever reason, the AQUAPIPE® liner will resist and remain water tight, given that the failure does not occur at the extremities or at the service connections. The oldest AQUAPIPE® liner was installed in 2000 and has not experienced any breaks.

28) Is there a procedure to repair a damaged rehabilitated pipe?
Yes, the damaged section (host pipe and liner) must first be removed; once the new extremities are verified and repaired (if necessary), a new section of pipe is then installed using standard pipe and fittings.

29) Is it possible to carry out a hydrostatic pressure test after the service connections have been reinstated?
Yes, this type of test is performed, upon request, by certain clients. It is important that the client also considers carrying out a comparison test prior to the work before cleaning the pipe so as to demonstrate the overall performance of the rehabilitation of the host pipe. Note that rehabilitating the host pipe does not repair any leaks already present in the service connection lines and will, more often than not, show leaks in the system (service connections) that are very small and difficult to locate using conventional detection methods. It is therefore important when testing the system after the reinstatement of the service connections, to determine the proper test pressure for the pipe so as to not damage the service lines and curb stops.

30) What are AQUAPIPE®'s bonding characteristics with the host pipe?
The material characteristics of the epoxy allow the AQUAPIPE® liner to bond to the host pipe. This bonding is not necessary for the liner to be structural; however it assures a watertight seal at the extremities of the lined section and at the service connection locations after reinstatement using robotic equipment. Bonding also prevents the free flow of water in between the liner and the host pipe.

31) Does AQUAPIPE® require end seals?
No, end seals are not required.

32) Is it possible to pressure tap a new service on a rehabilitated pipe?
Yes, the new lining can be dry or pressure tapped. The only precaution would be to make sure that the utility workers use a saddle or tapping sleeve and a sharp shell cutter, and to make sure that they have cut through the walls of both the existing pipe and the liner. The use of the appropriate procedure and equipment is recommended.

Ref: Procedure No. APSOP-4.03 (2nd revision)

33) Are temporary mains required?
Yes, they are generally required to maintain fire protection and water to the residents.

34) How are service connections to residences handled with the CIPP system?
They are reinstated from within the pipe.

35) Is there any special treatment around the service connections before lining to ensure a good water tight seal?
Preparation of the pipe is the key factor in this case. The pipe and service connection must be properly cleaned in order to ensure a good seal. The service connection will be plugged before lining to avoid resin migration up the service line and ensure the presence of epoxy, which fills all voids, around the threads of the service connection. This presence of epoxy maintains water tightness.

36) Does the robot damage the service connection during reinstatement?
No, the robot is designed to minimize contact with the inside of the corporation stop.

37) What is the maximum diameter service connection that can be reinstated from within?
50mm maximum.

38) What is the service reinstatement success rate after rehabilitation?
Between 90 and 100%

39) How are (invisible) non – protruding service connections located after rehabilitation?
They are located using special void locating equipment which provides the technician with the precise location of the service connection. The service connection is then reinstated from within using the robotic equipment.

40) Does AQUAPIPE® need any specific end fittings and how do you reconnect the pipe?
No special fittings are required. Regular pipe and fittings are used to reconnect the 2 ends of lined pipe in the access pit.

41) How do you disinfect the pipe?
The pipe is disinfected as per city, state or AWWA standards. Identical to new installations.