IMPROVING SEWERAGE SYSTEM OPERATIONAL PERFORMANCE USING INNOVATIVE TRENCHLESS REHABILITATION TECHNOLOGY

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ABSTRACT

This paper will focus on Hunter Water Corporation's (HWC's) findings in regards to trenchless pipeline rehabilitation of sewer mains, completed for the purpose of reducing inflow / infiltration (I/I), with a focus on the coastal Swansea catchments.

Prior to sewer rehabilitation occurring, the Swansea catchments measured extremely high actual Average Dry Weather Flows (ADWFs), ranging between 444% - 735% of theoretical ADWFs. The flows were caused by the high groundwater table infiltrating into the system through joints and cracks in the pipework, which developed over time, since the original construction. The flows were resulting in various negative impact for the sewerage system, including high pump station run times, energy consumption, unnecessary treatment of groundwater, as well as the likely exfiltration of sewage from pipes, and increased sewer overflow levels.

Extensive sewer relining works were conducted in five Swansea catchments between 2010 - 2012, using next generation structural liners in order to reduce I/I, and structurally renew the mains in question for at least 50 years. Measurements taken prior to, and after rehabilitation, demonstrate the effectiveness of this method in reducing I/I. In addition, there are a number of operational and maintenance benefits associated with the works, such as improved system hydraulics, reduced sewer choke rates through the elimination of root entry, improved energy efficiencies, and environmental benefits.

1.0 INTRODUCTION

In 2007, Hunter Water Corporation (HWC) began a study to determine the extent of groundwater infiltration in the Swansea sewer catchments. The flow into each wastewater pumping station (WWPS) and pump rates were determined by undertaking a drawdown test at most wet wells. The catchments were assessed by comparing the measured ADWF to the theoretical ADWF, based on the population of the catchment.

Insituform Pacific's relining works, using proprietary cured-in-place-pipe (CIPP) technology at the five target catchments, were undertaken between 2010 - 2012. Between 60% - 85% of gravity mains in the five target catchments were initially included in the relining package. As of February 2012, the majority of relining works were completed, allowing the analysis on the effects to be undertaken.

Relining works were undertaken as follows:

- Swansea 12: 980m in Sep - Nov 2010, and 145m in 2011 - 2012
- Swansea 8: 870m in Sep - Nov 2010, and 370m in 2011 - 2012
- Swansea 10: 630m in Feb - Apr 2011, 560m in Jul - Oct 2011, and 280m in 2012
- Swansea 11: 1,240m in Feb - Apr 2011, 260m in Jul - Oct 2011, and 240m in 2012
- Swansea 6: 970m in Jul - Oct 2011, and 270m in 2012

Two additional catchments, Swansea 3A and Swansea 4, will be used as control catchments as no major relining works were undertaken in these catchments in the period during which Swansea 6, 8, 10, 11 and 12 WWPS were subject to relining projects.

Figure 1 shows the five catchments subject to relining works, and the two control catchments.

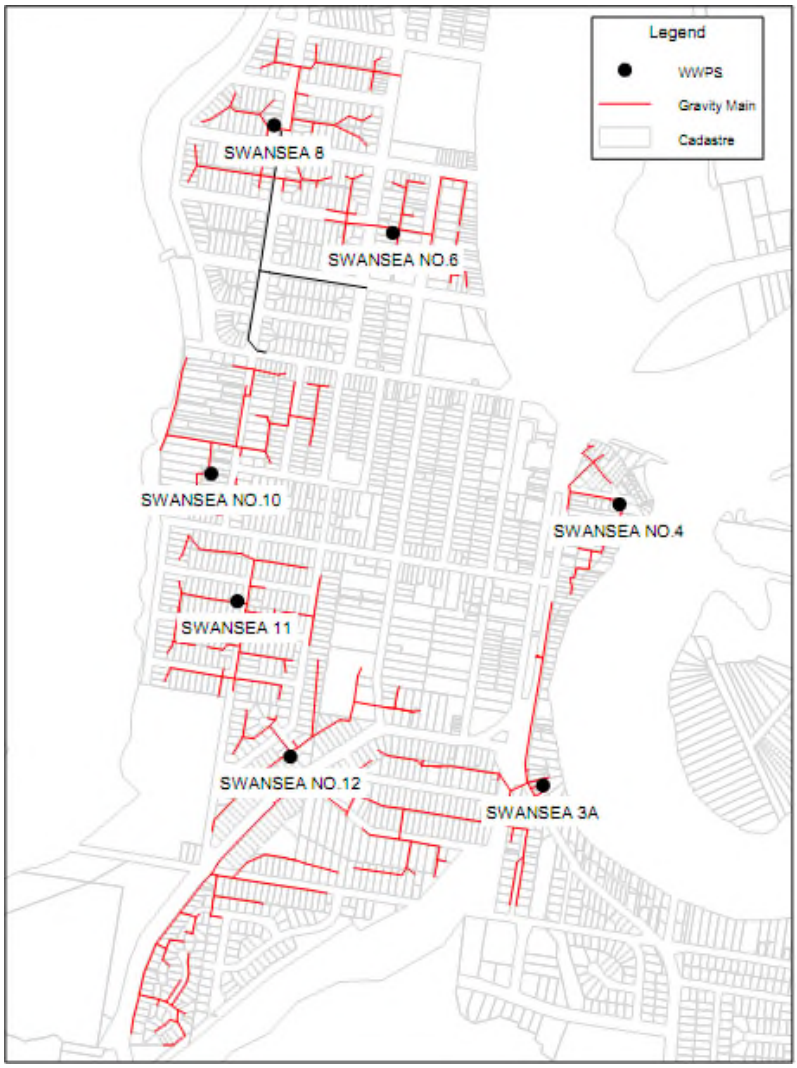


Figure 1: ***Swansea Catchments Gauged between 2010 - 2012***

2.0 DISCUSSION

Insituform Pacific has serviced HWC's previous (2009 - 2013) and current (2014 - 2018) term sewer rehabilitation program. iPlus Infusion CIPP is Insituform's preferred proprietary solution for small diameter pipelines. It is a continuous, jointless, tight-fitting 'pipe within a pipe', which is installed extremely quickly, to produce a new structural pipe with a life in excess of 50 years.

iPlus Infusion is unique, both in terms of its construction, and installation process. Insituform's iPlus Infusion liner is installed using a pull in process, followed by air inflation and steam curing, which drastically reduces energy consumption, time on site, and community impact. The iPlus Infusion liner construction and installation method also produces a very robust system for installation in high infiltration conditions.

The process is assisted by the use of the integrated sacrificial external polyethylene (PE) foil which protects the liner from infiltration during installation - this is often referred to as a "pre-liner". However, in the case of iPlus Infusion, the pre-liner is integrated with the main liner, and installed in a single process, rather than a two-stage process. The finished liner itself provides all the benefits of a structural CIPP liner, including a tough polypropylene (PP) inner wearing surface, designed to last for the life of the liner *(Refer Figure 2).*

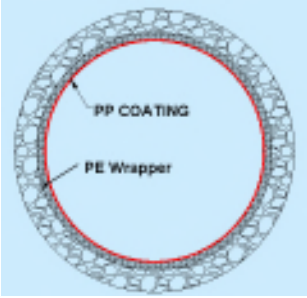


Figure 2: ***iPlus Infusion Construction inside Host Pipe with Polyethylene and Polypropylene Coatings***

The ability of Insituform's CIPP liners to control water migration into deteriorated pipes has been well tested and documented throughout the world.

The results shown in *Table 1* were published by the Trenchless Technology Centre (TTC) at Tulane University in the USA, as far back as 1997.

Table 1: ***TTC Test Results for Insituform's CIPP Liners***

Product	Reduction in Infiltration At Pressure Head of 5ft	Reduction in Infiltration At Pressure Head of 10ft
CIPP 1 (Insituform)	100%	95%

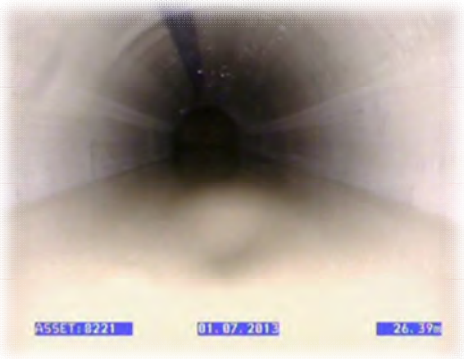
The TTC undertook an extensive study to determine the in-ground performance of different lining systems under different groundwater pressure conditions. Contractors were invited to voluntarily participate in the study, and the most widely used products were independently tested. All liners were installed by Contractors adopting standing installation procedures, without any additional works such as void grouting, or lateral and end sealing.

Insituform achieved the best results in the study, closely followed by another CIPP system. However, there was a significant difference in performance between the CIPP and non-CIPP systems.
It is understood that the CIPP process achieves these results through the following key factors;

- The tight-fit nature of the liner leaves almost no annulus between the liner and pipe for infiltration to travel;
- Excess resin is pushed into pipe cracks and other defects during the lining process to further reduce the potential for infiltration; and
- It is expected that these results will also have a direct correlation with the ability of the liner to stop the migration of both roots and backfill into the pipe after lining.

Figure 3: ***iPlus Infusion 'tight fit' Liner against the end of a Host Pipe***

The following photos are from a recent HWC works, and show the dramatic groundwater conditions encountered, and the infiltration control achieved through Insituform's CIPP lining works.



Figures 4 & 5: ***Photos Showing Heavy Infiltration before and after Relining***

2.1 Flow Gauging Results

Flow gauging was initially conducted between December 2010 – January 2011, prior to relining occurring in Swansea Catchments 6, 10 and 11. The initial gauging was conducted during a very dry period with negligible rainfall.

Post relining gauging was conducted between December 2011 - January 2012. During the post-relining works gauging period, 28mm of rain fell, with an additional 16mm in the 1 - 4 days prior to gauging.

Table 2: ***ADWF Rates from Gauging***

Catchment	Dec 10 – Jan 11 (L/s)	Dec 11 – Jan 12 (L/s)	Reduction (%)
Swansea 6	9.23	2.28	75
Swansea 8^	3.06	2.05	NA
Swansea 10	6.44	2.62	59
Swansea 11	5.53	1.67	70
Swansea 12^	1.76	2.00	NA
Swansea 3A*	6.44	5.05	22
Swansea 4*	1.59	1.34	16

- ^ Both sets of gauging were conducted after the majority of relining works were completed in these catchments. Assessment of relining effect will be conducted using pump run times

- *Control catchments - no relining was carried out in Swansea 3A or 4 between the gauging periods. Note that one control catchment, Swansea 3A, receives flows from Swansea 12.

Both control and relined catchments exhibit decreased flows between the gauging periods. The reduction is significantly greater in the relined catchments than in the controls, therefore, the improvement can be attributed to the relining works.

2.2 Pump Run Times

The flow rates at Swansea catchments 8 and 12 were calculated using pump rates and pump run times. Pump run times, in the form of hours of operation per day for each pump, were extracted from HWC's SCADA. The periods for January 2010 and January 2011 were chosen to represent pre and post-relining due to negligible rainfall, and the opportunity to compare the post-relining flow calculations with gauged data.

Pump rates were determined by undertaking a draw-down test at the wet well. The draw-down tests were conducted in January and April 2010 for Swansea catchments 8 and 12 respectively.

To compare with the gauging results, the average flow in L/s was derived from the pump run times, by multiplying the number of hours of operation by the pump rate, and then averaging. The results are shown in *Table 3*.

Table 3: ***ADWF from Pump Run Times***

Catchment	Pre-relining (L/s)	Post relining (L/s)	Reduction (%)
Swansea 8	6.86	3.14	54%
Swansea 12	4.01	1.39	65%

The results for both catchments show a significant reduction in flows, with the post relining flow rate comparable to the rate measured by gauging. The reduction in flows is similar to reductions measured at the other project catchments.

Note that although the average flow at Swansea 8 post-relining is similar to the ADWF gauged for the same period, the fluctuations over January 2011 do no match. The gauged data appears to be more consistent, ranging from 2.8L/s - 3.5 L/s, whereas the flows derived from pump run times fluctuate from 2.5L/s - 5.7 L/s. It is possible that the spikes in hours of pump operation could be caused by ragging or build up in the pump or pipe work.

In Swansea catchment 12, the flow rates derived from pump run times compared with the flows gauged in December 2010 to January 2011 vary by 23%. If the gauged post-relining flow rate and SCADA derived pre-relining flow rates are assumed to be most accurate, the reduction in flows is likely to be 57%, not 65%. It is probable that pump flow rates measured in the draw-down test are not representative of both the pre and post-relining periods as other work around the pump station, including repairs on the pumps and cleaning blockages from the riser pipework, may have affected the pumping rate. The above issues highlight the problems with using SCADA data to estimate catchment flow rates.

2.3 Comparison with Theoretical ADWF

HWC's aim for the relining works was to reduce flows in the five catchments to 1.5x (i.e. 150%) theoretical ADWF, based on the number and type of equivalent tenements within the catchment.

Table 4 compares the December 2011 - January 2012 gauging to the theoretical ADWF for all sites in 2007 prior to relining works.

Table 4: ***Comparison with ADWF***

Catchment	Measured/ Theoretical ADWF 2007	Post-relining/ Theoretical ADWF 2011-12
Swansea 6	735%	175%
Swansea 8	444%	121%
Swansea 10	541%	187%
Swansea 11	634%	88%
Swansea 12	630%	111%

3.0 CONCLUSION

Following relining works, flows at all sites are within 2x (200%) the ADWF, but two sites did not meet the 1.5x ADWF criteria. It should be noted that both sites, Swansea catchments 6 and 10, had flows in excess of 5x - 7x ADWF before relining works, and *Table 4* shows the significant reduction in flows at both sites.

Insituform's CIPP liners have been independently tested and proven to provide best performance in regards to the reduction of infiltration / exfiltration into deteriorated pipes, and therefore, the reduction of root intrusions, and related chokes. These results were achieved without ancillary or additional works being required.

The actual field results obtained in the Swansea study were also impressive, given the extent of infiltration encountered in the area. Once again, the liner was able to achieve these results with no additional or ancillary works being required in terms of void grouting or house service line rehabilitation. Therefore, the results were not only impressive, but also achieved in a highly cost effective manner.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

Bakeer, R. M., and L. K. Guice, 1997. *Tests for Evaluating Fluid Migration in Annular Space of Lined Piping Systems,* Tulane University, New Orleans, LA, and Louisiana Tech University, Ruston, LA.

Julie March. *Evaluation of the Effectiveness of Relining Works in Swansea using Flow Gauging* HW2009-1276 030