Pressure-management in mature networks using batch-processed pressure-dependent hydraulic modeling

S Tooms*, N Tansley, A Green+**

*Hyder Consulting, 50 Rocky Lane, Aston, Birmingham, B6 5RQ

**Severn Trent Water, 2297 Coventry Road, Birmingham, B26 3PU

+Advantica, Ashby Road, Loughborough, Leicestershire LE11 3GR

Keywords: Pressure, reduction, model,

Summary

Pressure management design is normally carried out for individual schemes working either directly from pressure measurements or using individual hydraulic models. This can lead to ad-hoc pressure management design rather than identifying the most cost-effective schemes at the outset.

However, many water companies now have hydraulic models of the whole of their network, and this provides a way to identify the potential for further pressure management within the network, even for a large water company including several million customers.

Severn Trent Water is a large water company, providing water and sewage services to a population of eight million people in central England. The network is fairly mature, with a growth rate of approximately 1% per annum, and more than 98% of the population connected to the network. Over the last twenty years the company has invested heavily in pressure management and now has over 3000 pressure reduction valves in the network, through which over 40% of this population is served. The company realised that there would be opportunities for further pressure management within the network, which may well deliver cost-effective savings. However identifying and prioritising those potential schemes by hand was seen as an expensive and staff-intensive process at a time when skilled staff are at a premium.

Therefore Severn Trent Water worked with leakage and network-model specialists from Hyder and Advantica to develop a batch processing system that would run the models, identify all the potential district-level schemes within the network, identify the optimum control mode for each scheme and carry out a cost-benefit analysis for each scheme. This would lead on to detailed design and construction of the cost-effective schemes. 130 individual models, covering 2000 existing metered districts were analysed in this way.

Pressure Management Strategy

Severn Trent Water has hydraulic network models covering almost all of their supply network, kept in an online library which can be accessed throughout the company. These were used in a four stage process to assess the need, identify areas for investigation and then design and construct new pressure management schemes.

Assessing the need

The first part of the project was to assess the current range of pressures throughout the network. All of the average-day models in the Severn Trent Water model database were extracted. The model nodes were matched to the DMAs used for leakage control and average pressures in each of the DMAs were calculated, for all 2000 DMAs, comprising 750,000 demand nodes. The results (in Figure 11 below) showed that there is a large range of average pressures across the DMAs in the network.

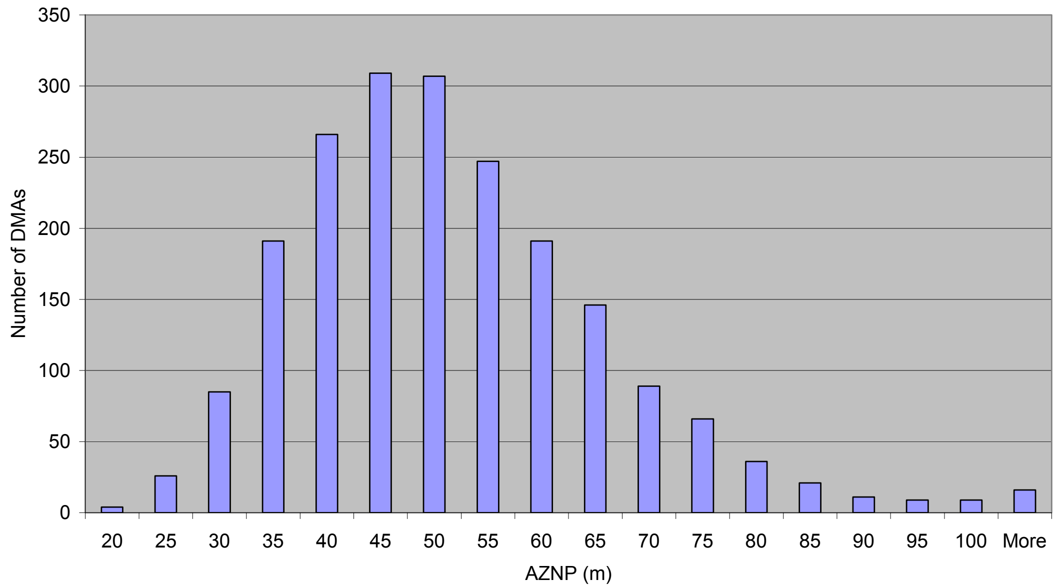


Figure 11: histogram of the distribution of average zone night pressures

According to this model analysis, more than 15% of DMAs (corresponding to 10% of properties) experienced average zone night pressures greater than 60 metres head.

Identify areas for investigation

The next stage in the project was to identify the parts of the network where maximum pressures are high enough to justify pressure management, and also the minimum pressures in that part of the network are high enough to provide the required pressure to customers after pressure management schemes had been put in place.

In each of the 2000 DMAs, the models were used again to identify:

- the critical node (the node with the lowest pressure at some time during the day)
- the inlet to the DMA (where it is a single feed) and
- the average pressure in the DMA at each one hour time step.

Actual night-flow losses were used to assess current leakage, and as a starting point for predicted leakage saving.

For each DMA where the minimum critical point pressure was greater than 25 metres, the critical point and average point pressures were recalculated to take into account the effect of a new PRV at the inlet. This recalculation included the headloss from the new PRV installation, the effect of alternative controllers and also the reduced head losses within the DMA resulting from reduced leakage. This is illustrated in Figure 12 below. In the figure, the second estimate of the total head takes into account the reduction in head loss caused by the reduction in demand. The new leakage (after pressure reduction) is related to the Average Zone Night Pressure (AZNP)

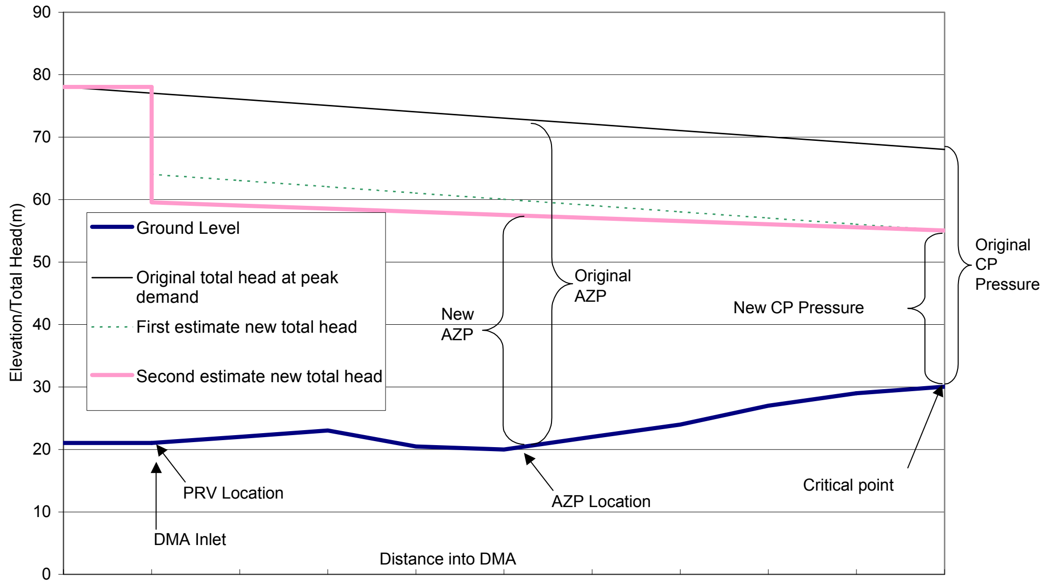


Figure 12: Assessment of the effects of pressure management

This process identified over 400 DMAs where further pressure management was feasible according to the models. Of these, 308 DMAs-level schemes were assessed to be cost effective even considering only flow reductions. Reductions in numbers of repairs make almost all of the schemes coist-effective. Figure 13 below shows the forecast costs and savings.

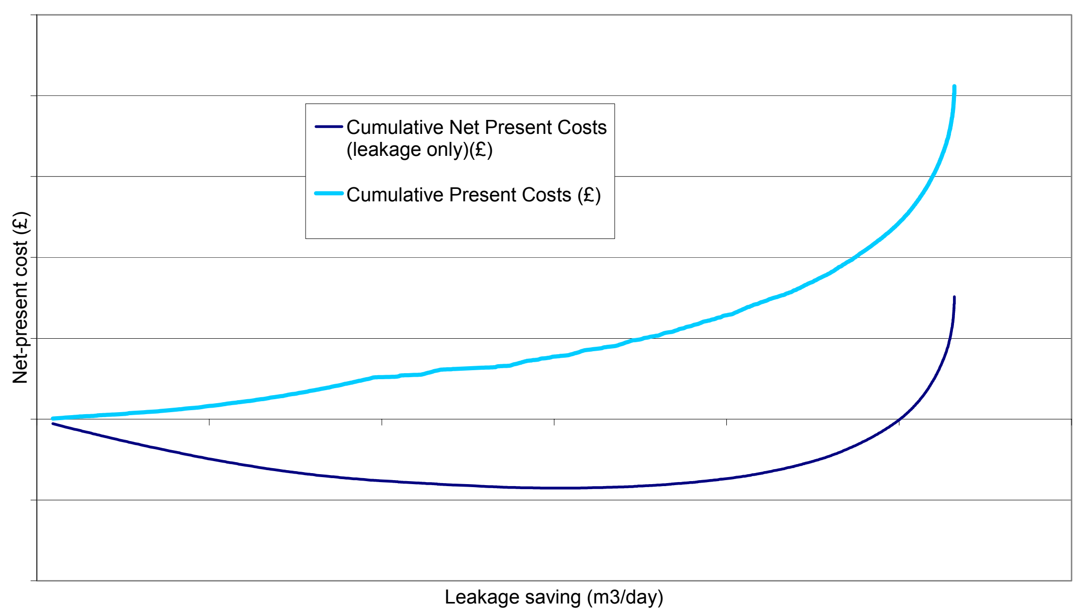
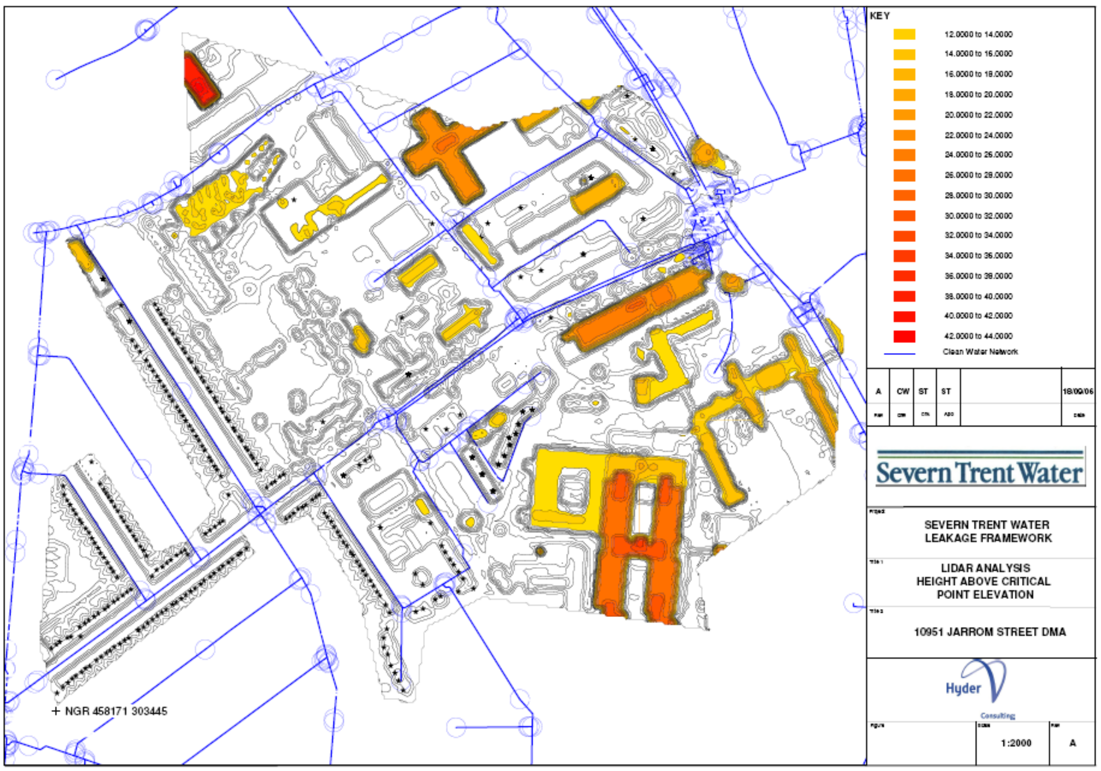


Figure 13: Net financial savings predicted

Design of New Schemes

From this set of 308 apparently cost-effective schemes, 81 of the most cost effective were selected for further investigation. The actual current inlet, critical-point and average pressures were measured. These measurements, over a one-week period, were used to produce a refined design, including sizing of PRVs and selecting the optimum controller.

In the urban areas of the Severn Trent Water Region, high rise buildings have historically limited pressure management. This is because some buildings relied on mains pressure to get water to the top floors, rather than using a pump. Two methods were used to identify these buildings in each scheme. For some DMAs the elevations of houses were mapped in detail from LiDAR survey data. LiDAR surveys gather surface elevation data at small intervals (typically 2 metre grid) with high vertical resolution (typically 20 cm). The results of one of these surveys is shown in Figure 14 below. This shows properties above the critical point elevation as shaded areas.



Note: colours indicate the height of buildings above the critical point in the mains.

Figure 14: Property elevations above critical points from LiDAR data

For other areas, aerial photos were used to estimate building heights, and these results were combined with a digital terrain model to identify buildings above the critical-point elevation.

Results

At the time of writing 45 new schemes have been designed in detail, and the first of these have already been implemented. Early results indicate that the savings originally estimated have been achieved.

Conclusions

This project is important in a number of ways:

- It identified further pressure management schemes in a region which had already been subjected to an intensive pressure management programme, indicating that further schemes can be available even in areas with established pressure management

- The project identified schemes that would not have otherwise been identified, including ones where critical point pressures were below the required level of service but could actually be raised by careful choice of pressure management and still deliver leakage savings
- It illustrated how batch processing of network models can efficiently deliver the results of a complex analysis for practical implementation in even the largest water companies

Next steps

Following this initial success, the approach is now being improved to incorporate automated outline design of sub-DMA level schemes. The cost-effective schemes will be investigated. The project is also being extended to take advantage of new pressure monitoring and telemetry within the network. All of this is helping to achieve rapid and cost-effective pressure management in a mature and well-managed network without overloading the skilled design staff. .