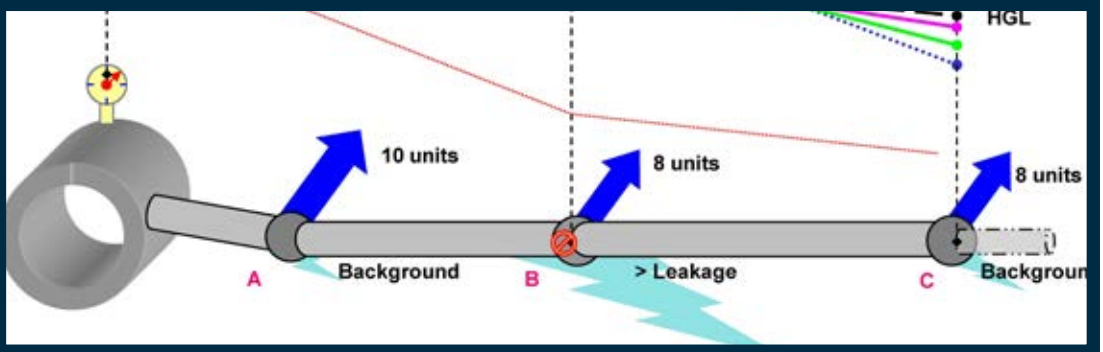

United Utilities Water Teams With Bentley® to Establish New Method for Locating Hard-to-Find Water Leakage Sources

Project Summary

Project
Optimization Method and Modeling Tool for Leakage Detection in Water Distribution Systems

Project Location
Warrington, United Kingdom

Organizations
United Utilities Water and Bentley

Be Inspired Awards Category
Innovation in Water Resources (finalist)

Project Objective
Use applied research to develop practical, model-based methods for detecting leak hotspot

Software Used
WaterGEMS®/WaterCAD® and the Darwin Calibrator module, Bentley® Map

Fast Facts

- With underground leaks being difficult, time-consuming, and costly to find, a need arose to develop a systematic method for achieving cost-effective leakage detection
- UUW collaborated with Bentley to develop a new leakage detection optimization method, based on genetic algorithm (GA) technology, for effective detection of the likely leakage hotspots
- The resulting method is used in the Darwin Calibrator module included in WaterGEMS and available for WaterCAD
- A thorough benchmark test and evaluation have been conducted using a number of UUW's water systems in conjunction with Atkins Water and Environmental Group

New Ways to Reduce Water Loss

The 2006 Water Management Report produced by the United Kingdom's House of Lords Science and Technology Committee estimated that about 15 percent of Britain's drinking water is lost to leakage, and other experts estimate the global figure is as high as 40 percent. In a world where water is increasingly scarce, loss of treated water is not just a revenue issue, it's very nearly a moral issue and water system managers everywhere are looking for new ways to reduce the amount of water lost to leakage.

United Utilities Water (UUW), the United Kingdom's largest operator of water and wastewater networks, has an added incentive – in the U.K., leakage is measured, targets are set, and failure to meet those targets results in severe financial penalties. To comply with these regulations, UUW teamed up with Bentley in an applied research project that investigated water system modeling in leak detection. The use of such models is routine for analysis of a system's hydraulic characteristics, but applying model-based methods to leak detection was new territory. The technology helped UUW locate hard-to-find leaks and determine the amount of water loss per hour in a given area, providing the water industry with an important new tool to help sustain world urban water infrastructure assets.

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There are three main methods of leak detection traditionally used in the industry: sounding surveys conducted by field crews with audio sensors, step testing of subsystems, and permanently installed acoustic loggers. All three are effective, but, in addition to being expensive and slow, they tend to work best on larger, "noisier" leaks. Since the hunt for leaks has been going on for several years, most of the 'low-hanging fruit' has been found, and two other trends work against traditional methods. The replacement of ferrous pipes with high density polyethylene (HDPE) reduces the acoustic signature of leaks, and increasingly sophisticated pressure management systems reduce both the acoustic signature and intensity of leaks. It's ironic that these two positive developments inhibit further leak detection.

Matched Simulated Flows and Pressures With Field Observed Values

Leakage can be modeled as a special instance of emitter flow, per the formula $Q_i = K_i * P_i\alpha$, where Q_i is the leakage aggregated at node i, P_i is the nodal pressure at node i, α is the exponent (usually 0.5 for leaks as a default) and K_i is the emitter coefficient. If the emitter coefficient, K_i, can be optimized usefully, then, in theory, it can be a good way to detect leaks in a system. But leakage tends to concentrate in relatively few 'hotspots,' and, in practice, optimizing hundreds or thousands of nodal emitter coefficients in order to detect the handful of spots with significant leakage has proven to be a significant computational challenge.

UUW and Bentley engineers got around this by matching simulated flows and pressures with field observed values and applying a genetic algorithm (GA) – a search and optimization method based on the principles of natural evolution and genetic reproduction – to the problem. Initial results were promising, so Bentley engineers developed the algorithm into a user-friendly software tool and included it in WaterGEMS. They also arranged for a real-world benchmark test and evaluation of the new method to be conducted on UUW's system by a third partner, the U.K.'s Atkins Water and Environmental Group.

Vindicated by Test Results

Atkins selected 13 district metered areas (DMAs) in UUW's systems for intensive leakage analysis by the new model-based method. An estimated total leakage of 10m3/hour was identified in 10 of the 13 DMAs, and this finding was confirmed by subsequent fieldwork. This translates to 15.4Ml/day, or about 3.4 percent of total leakage when applied across UUW's service region. Further trials, and refinement of the methodology, suggest that this figure can be improved to at least 5 percent of total leakage, which will save UUW about $10.6 million annually, in terms of reduced nonrevenue water.

"The leakage detection optimization model developed in collaboration with Bentley," says David Turtle, UUW's leakage and demand strategy manager, "is a valuable and important tool in helping to reduce leakage and to achieve

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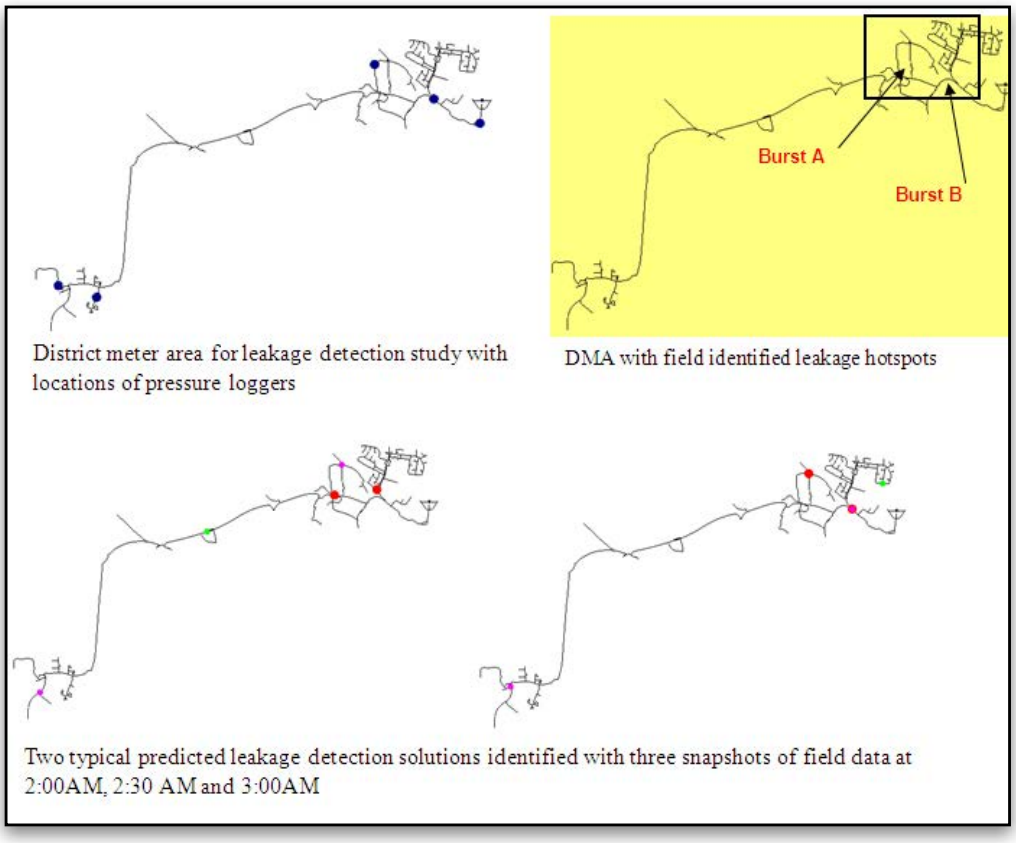

District meter area for leakage detection study with locations of pressure loggers

DMA with field identified leakage hotspots

Two typical predicted leakage detection solutions identified with three snapshots of field data at 2:00AM, 2:30 AM and 3:00AM

annual targets agreed on with Ofwat, the U.K. water industry regulator."

All parties in this collaboration are interested in spreading the news about a new, cost-effective way to locate leaks in mature systems. To that end, the complete model-based leakage hotspot detection method and practical applications have been submitted to the International Water Association (IWA) for peer review. In addition, they've appeared in several publications. The potential population affected is most of the developed and developing world, and the project has made significant contributions:

1. It solves a long-standing problem for the water industry, and enables utilities to focus their maintenance and repair efforts on the areas of their systems most likely to contain leaks.
2. It has already been developed into existing system modeling packages with familiar, user-friendly interfaces.
3. It has resulted in important practical and theoretical knowledge being shared with the international engineering community.
4. It provides a means of better sustaining world urban water infrastructure assets by detecting leaks that were previously unidentifiable.

New Methodology Fills Important Need

The new methodology developed by UUW and Bentley researchers fills an important need by helping managers in mature systems to further reduce water leakage after other methods have been exhausted. It also enables managers in any system to identify the water loss hotspots so that leak reduction programs can be effectively prioritized. By publicizing this new method and making it available for use worldwide, these organizations are having a significant positive effect on the world's water infrastructure.

Bentley
Sustaining Infrastructure