Chapter 11

Optimization tools for leak location – Hydraulic model

The water industry has accepted a hydraulic model as a routine computer simulation tool to analyze the hydraulic characteristics of the system elements (pipes, pumps, valves and storage facilities). Optimization technology has been developed to enable water companies to make use of the well established computer model for low cost localization of leaks. Although it is impossible to exactly locate the water losses or leakages in a distribution system by just using an optimization-simulation approach, case studies have shown that the method is effective in helping engineers to narrow down the possible water loss (including leakages, un-metered and illegal consumptions, etc) and thus enable more efficient leakage reduction programs.

11.1 OPTIMIZATION PRINCIPLE

The method requires a hydraulic model together with pressure and flow logging data from the network, which are used by an optimisation technique to identify the likely leakage hotspots that are emulated as emitters where leaks occur and depend on the local pressure. Genetic algorithm (GA) techniques have been used to search for the leakage hotspots such that the difference between the simulated and field observed pressures/flows is minimized. Engineers need to repetitively run the optimisation tool with the MNF-hour data for the same network model. Multiple runs provide an indication of most likely leakage hotspots in the network area. The essential steps for applying the optimization modelling method are as given below.

11.2 SYSTEM EVALUATION

Prior to embarking on leakage-detection optimization modelling, it is essential to evaluate the system behaviour by using the hydraulic model. Figure 11.1(a) illustrates system layout and connectivity. The DMA's supply boundary is simulated by using a reservoir with variable hydraulic

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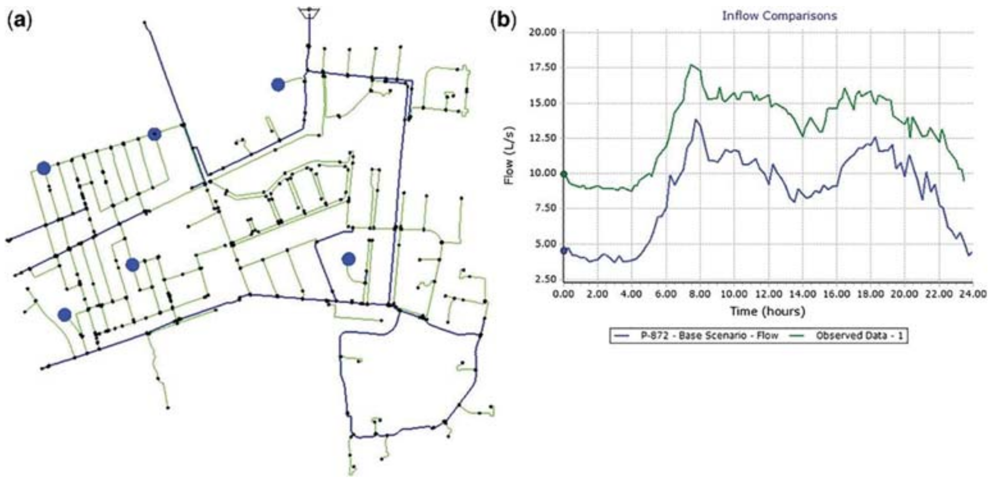

Figure 11.1 System evaluations prior to leakage detection optimization: (a) system layout and connectivity; (b) comparison between observed and simulated inflows. (Source: Bentley WaterGEMS, Darwin Calibrator Module, Bentley Systems Incorporated, Exton, PA, USA)

heads. The inflow into the DMA is recorded as time series over 24 hours and six pressure loggers are used for collecting pressures from the field. An extended hydraulic simulation is performed to evaluate the existing behaviour of the system. Figure 11.1(b) shows the comparison between the observed inflows and the simulated flows. The big flow difference at each time step represents the water loss within the DMA.

11.2.1 Field data process

A large set of data is collected from the field, including the pressures and the flows. The data is prepared and classified into different datasets. Each of them represents a snapshot of the system observation at the same time.

11.2.2 Optimization analysis

Leakage detection optimization study proceeds with setting up the optimization runs and then executing the runs. The software tools are flexible and powerful enough to permit engineers to use system-specific knowledge to make different target groups for effective leakage modelling.

11.2.3 Post-optimization analysis

It is important to process the identified leakage solutions, namely the identified emitter locations and the emitter coefficients. The post-optimization process includes creating a leakage node map as shown in Figure 11.2, in which each identified leakage node is represented by the colour-coded node for intuitive presentation of the most likely leak areas. The colour map can be used as a good guide for a field detection crew. The optimized leakage solution can be further evaluated by comparing the observed and simulated inflows over 24 hours. Figure 11.3 illustrates that the identified leakage nodes significantly improve the flow comparison.

There are a number of alternative techniques in use. All use one or more time steps in the network model. The differences in the techniques relate to the details of the optimization methods, pressure-demand

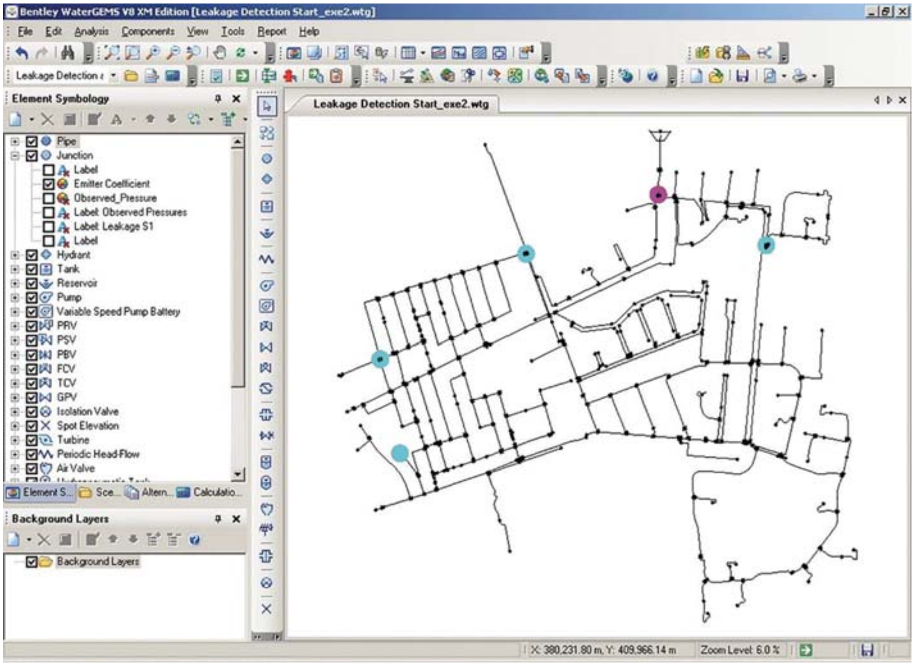

Figure 11.2 Created leakage map of identified leakage hotspots. (Source: Bentley WaterGEMS, Darwin Calibrator Module, Bentley Systems Incorporated, Exton, PA, USA)

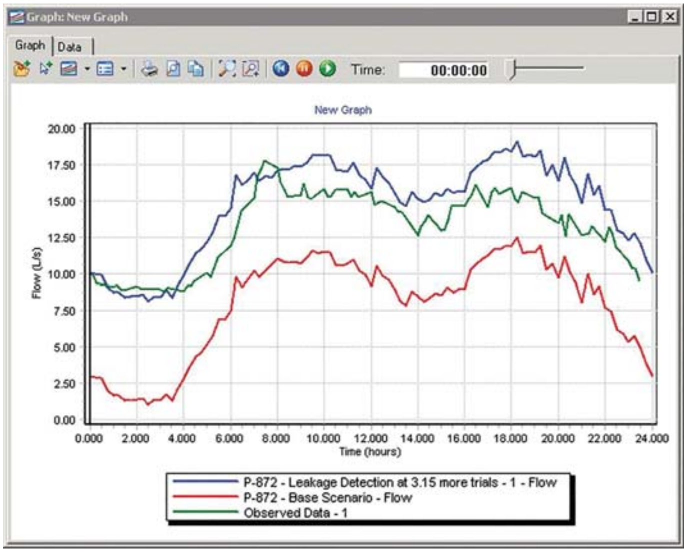

Figure 11.3 Comparison of the field-recorded flows with the extended period simulation. (Source: Bentley WaterGEMS, Darwin Calibrator Module, Bentley Systems Incorporated, Exton, PA, USA)

relationships, choice of time steps, the amount of demand re-allocated and the rules used for the demand re-allocation.

The location of the re-allocated demand gives an indication of leak locations or additional hidden demand. The approach will not pinpoint the leak location but will localise it, to make detection by other methods more cost-effective.