1. BACKGROUND

The data obtained from the monitoring system has shortfalls in terms of detection (i.e., weeks, months) with a significant volume of water being lost before the leak is located. To avoid these shortcomings, leakage detection based on mathematical models may be used by "comparing" and analyzing the network monitoring data with the network model simulated outputs [1].

Currently, the calibration of hydraulic models is based on trial-and-error techniques for given parameters and initial data, due to the lack of major advances from the practitioner's perspective. This is to simulate pressures within an accuracy of ±5%, more relevant to observations (2), which is too coarse a criterion for supporting operational work at the calibration macro-level.

Example Calibration

<table>
<thead>
<tr>
<th>Measured</th>
<th>Simulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (m)</td>
<td>-</td>
</tr>
</tbody>
</table>

This is a result of systematic uncertainties associated with accidentally left (open) valves, which are untreated in the Geographica Information System, incorrect pipe state information and unidentified leaks, which cause a considerable effect on flow accuracy and can model simulate Water Distribution Network (WDN) hydraulic results [5].

2. METHODOLOGY

A two-stage optimization calibration approach is applied to a WDN for the ultimate purpose of detecting leakage hotspots, supported by improved reconciliation of observing pressure and flow data collected during night-time flow tests. The selected approach is thought to be a two-stage calibration method. Both approaches consider candidate unknown status valves, pipes with unknown roughness, and candidate leakage hotspots. Different leakage scenarios are tested for each approach to determine the number of objectives that best represent losses within the WDN.

Previous topological analysis and geospatial methods are used to simplify the calibration problem. Then, optimization algorithms are carried out using a Genetic Algorithm to minimize the sum of squared differences, between observed and simulated pressures and flows.

3. THE TRUE STATE SYSTEM

The WDN contains 464 junction nodes, 859 pipes, 104 valves and one main reservoir. Flow from the main reservoir is between 12.13 to 17.23 L/s at mid-flood stage. Water demand in the network was introduced as entries leading to a total leakage of 9.89 L/s during minimum domestic demand. Demand and pipe material roughness were considered for the calibration problem. The next were assumed to have a known leakage coefficient.

4. RESULTS

Table 3. Roughness calibration result

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Material</th>
<th>True Ks</th>
<th>Calibrated Ks</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>3.0</td>
<td>2.0</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>CICL</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>DI</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Pipe roughness calibration was also generally unsatisfactory (Table 3). CICL pipe material roughness was randomly calibrated and suggested that values for CI pipes were rebated relative. As the initial unsaturated models with values very close to the true KS of the pipe groups. On the other hand, KS CI was increased relative to the starting unsaturated model. The adjusted sensitivity lead to a reasonable simulation of the global leakage in the WDN during minimum demand conditions of 9.89 L/s, compared to true water losses of 9.89 L/s, however, give a false sense of being correct.

5. CONCLUSION

The results obtained suggested that relative to a one-stage approach, a two-stage approach where the status of candidate valves is firstly detected to provide insight in WDN topology can lead to an improved leakage detection. The model has been successfully used to test for the detection of unknown valve statuses.

6. REFERENCES


Project sponsored by EPSRC, Severn Trent Water Ltd and WITSConsult Ltd, as part of STREAM-IDC (www.stream-idc.net).

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