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ORIGINAL ARTICLE

Pressure control for minimizing leakage in water distribution systems

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Abstract In the last decades water resources availability has been a major issue on the international agenda. In a situation of worsening scarcity of water resources and the rapidly increasing of water demands, the state of water losses management is part of man's survival on earth. Leakage in water supply networks makes up a significant amount, sometimes more than 70% of the total water losses. The best practices suggest that pressure management is one of the most effective way to reduce the amount of leakage in a water distribution system. The approach presented in this study is aimed at modeling leakage as a function of pressure and pipe length, calibrating leakage coefficient, using fixed pressure reducing valves (PRVs) to develop pressure fluctuation and developing WaterCAD scenarios to minimize leakage through the most effective settings of PRVs. This approach was applied on a district metered area (DMA) in Alexandria, Egypt. The application of this approach produced some encouraging results, where the leakage through DMA was dropped by 37% for the best scenario. Thus, this approach is recommended as a decision support tool for determining a desirable solution for leakage reduction.

1. Introduction

Globally, water losses from water distribution systems are reaching alarming levels. They are made up of various components including physical losses (leakage), unauthorized consumption and apparent losses [1]. Leakage makes up a large part, sometimes more than 70% of the total water losses [1].

Leakages are the annual volumes lost through all types of leaks, bursts and overflows up to the point of customer metering [2]. They are caused by lack of active leakage control (ALC), excess pressure, poor operations and maintenance, poor quality of underground assets, vibration and traffic loading and Corrosion [3].

Bursts and background estimates (BABE) philosophy provides a pragmatic and simple approach to the very complex problem of leakage from water distribution system [4].

BABE concept recognizes that the annual volume of physical losses consists of numerous leakage events. Each

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individual loss volume is influenced by flow rate and duration of leak run time before it is repaired [5].

In BABE analyses, components of leakage can be categorized into three categories [5–7]:

- Reported breaks and leaks: They typically have high flow rates and short run time before they are reported to the utility either by the general public or the water utility's own staff. They are visibly evident and disruptive.
- Unreported breaks and leaks: They have moderate flow rates and a long run time. They are located by leak detection team as part of their active leakage control (ALC) program.
- Background losses: They are individual events (from joints, fittings, and small cracks) with flow rates too low to be detected by traditional acoustic leak detection techniques. They will continue to flow either detected by chance or until they gradually worsen to a point where they can be detected.

The total leakage from small hidden leaks and undetected breaks is significantly greater than from reported breaks. Main breaks that surfacing and causing supply disruptions are reported quickly and repaired within a short time. Conversely, small hidden leaks and undetected breaks may run for much longer periods until they are detected [7].

The BABE concepts are most effective when applied in conjunction with the following [4]:

- Fixed area variable area discharges principles.
- The infrastructure leakage index.
- Unavoidable annual real losses principles.

Infrastructure leakage index (ILI) can be defined as the current annual real losses (CARL) divided by the unavoidable annual real losses (UARL) [8]. The volume of unavoidable annual real losses (UARL) represents the lowest technically achievable annual real losses for a well-maintained and well-managed water distribution system [9].

There are four fundamental leakage management practices that will constrain physical losses including pressure management, speed and quality of repair, active leakage control (ALC), and asset management [2].

Pressure management is one of the most influential and cost-effective activities of reducing leakage. It can be defined as the practice of managing water distribution system pressures to the optimum levels of service ensuring sufficient and efficient supply to consumers [10].

The general objectives of pressure management for leakage minimization are three-fold [5,6]:

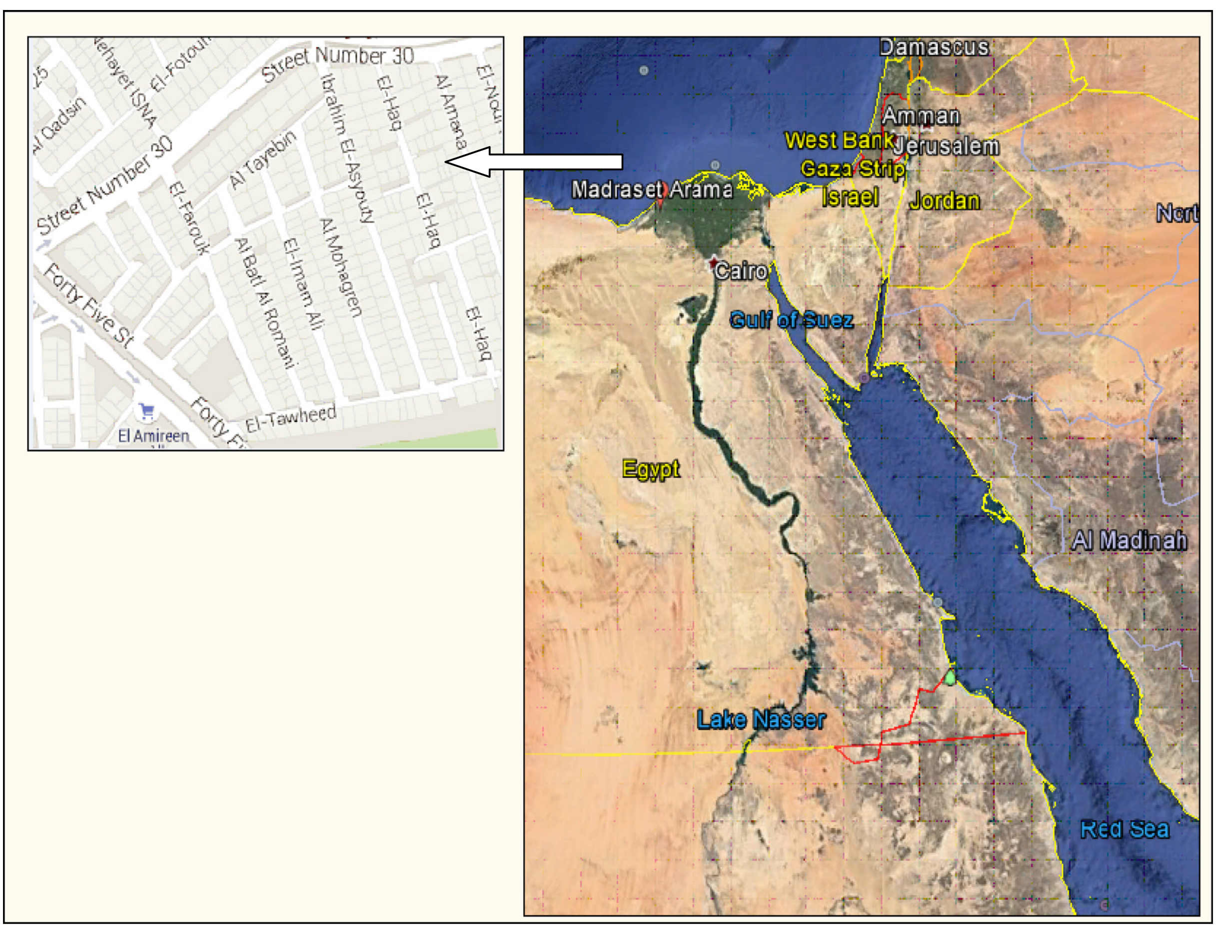

Fig. 1a Arama (DMA), Alexandria, Egypt.