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Q-WARP

Researchers have developed a decision support tool to predict the effects of aging water mains on water quality in distribution networks

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A typical modern water supply system is complex and comprises the water source(s), treatment plant(s), transmission mains and distribution network. The distribution network includes pipes, pumps and tanks. While water quality can be compromised at any point in the system, failure at the distribution level can be critical because it is closest to the point of delivery and, with the exception of rare filter devices used at the consumer level, there are virtually no safety barriers before consumption.

Water quality failures that compromise either the safety or the aesthetics of water within distribution networks are caused by (see figure):

1. the intrusion of contaminants through deteriorated (corroded) system components, misuse or cross-connection, or deliberate introduction of harmful substances;
2. internal corrosion of system components due to an oxidation-reduction reaction that releases byproducts;
3. leaching of chemicals from pipe or lining due to the dissolution of the exposed material surface;
4. biofilm formation and regrowth of microorganisms;
5. formation of disinfection byproducts (such as Trihalomethanes), and loss of disinfectant, and
6. permeation of hydrocarbon compounds from surrounding soil/groundwater through the walls of plastic pipes and appurtenances.

Numerous factors can, directly and indirectly, affect water quality in the distribution networks. These factors include pipe properties, treated water chemistry, design and operational conditions and surrounding soil characteristics. Interactions amongst these factors are very complex and often not well understood. Historically, water quality failures in distribution networks are rare,

which make statistically significant generalizations difficult. However, the rarity of water quality failures belies their seriousness, since each failure indicates the potential for harmful public health effects and increased public mistrust and complaints.

At NRC-IRC we have developed a model that can incorporate uncertain, subjective/linguistic and incomplete/missing data to predict water quality failures in distribution networks. Fuzzy logic is a soft computing method, which lends itself well to deal with problems that are imprecise and vague in nature. The proposed model uses a technique called "fuzzy cognitive map" to describe ill-defined and qualitative cause-and-effect relationships that govern water quality in the distribution networks.

Based on this model, we developed a prototype computer program called Q-WARP (water Quality – WAter main Renewal Planner), as a decision-support tool. Q-WARP is currently a proof-of-concept software with the following capabilities:

- can handle qualitative/quantitative and incomplete/missing data in the analyses;
- can predict potential for various water quality deterioration mechanisms (see figure), and risk of water quality failures (aesthetic, physico-chemical, and microbiological) in a pipe for a given set of conditions;
- can perform sensitivity analysis under a given set of conditions to identify critical input factors, and
- can generate multiple scenarios of risk reduction representing different decision actions to facilitate decision-making.

The research project will be completed in September 2007. The final report and the Q-WARP prototype will be available through the American Water Works Association Research Foundation in early 2008. Technical details have been published (or submitted for publication) in refereed journals as well as international conferences. Background information and related publications can be found on the NRC-IRC web site http://irc.nrc-cnrc.gc.ca/ui/bu/agingwater_e.html.

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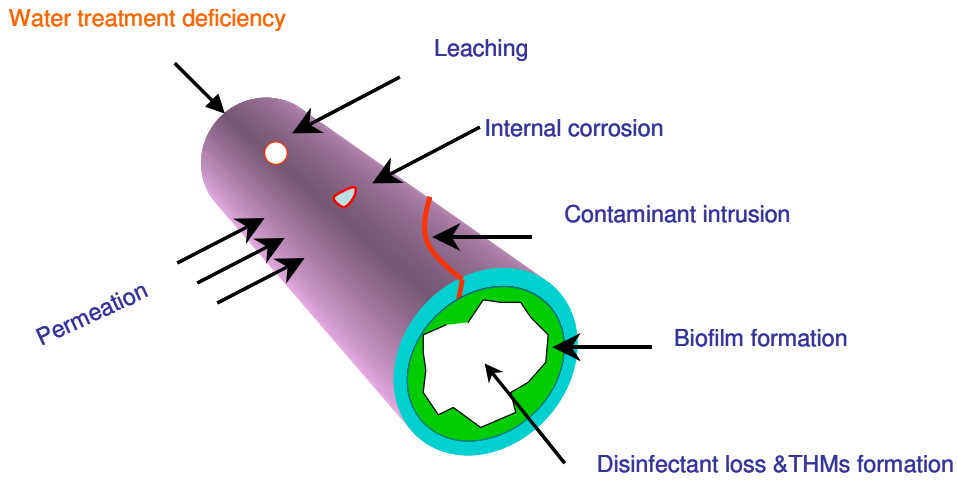

Deterioriation mechanisms in distribution networks causing risk of water quality failures.