SUPPLEMENTAL MATERIALS

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Economically Optimal Leak Management: Balancing Pressure Reduction, Energy Recovery, and Leak Detection and Repair

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1 Rate of Rise

Estimating the rate of rise is difficult, as most utilities do not collect the necessary data. For more details on estimating the rate of rise, see the supplemental information provided by Rupiper et al.[1] and the American Water Works Association's (AWWA) Manual of Practice (M36).[2] The rate of rise assumed to apply to Marin Municipal Water District's (Marin's) system (10.5 L service conn.$^{-1}$ d^{-1} year^{-1}) is based on an assumption made for Eastern Municipal Water District in Western Riverside county in California that is outlined in a report by the Water Research Foundation and the EPA.[3] The assumption is that the rate of rise may be conservatively estimated to be equivalent to the unavoidable annual real losses (UARL) for the system. First, we distribute the UARL to each of the pressure zones weighted by the average pressure in that zone. Zones with higher pressure will tend to leak more. Second, the rate of rise is estimated by taking each zone's UARL estimation and dividing it by the number of days in the year to give units of $Volume \times Time^{-2}$. However, it may not be realistic to assume the rate of rise increases linearly until the end of the study period, depending on the distribution network conditions. The definition of water saved is somewhat arbitrary and arguments can be made for considering all water saved after the initial survey, or only the water avoided after the first interval has passed (see Figure 2).

2 Hydraulic Model Calibration

Calibration is a somewhat subjective task, with no clear standards set by industry. However, rather than focusing on altering pipe roughness values as is traditional, our calibration efforts focus primarily on adjusting pump settings, tank dimensions, leak losses and other likely culprits of discrepancies between observed and modeled flows and tank levels. For further guidance, please see the AWWA's Manual of Practice (M32).[4]

3 Skeletonization

Skeletonization is the process of reducing the number of links in a hydraulic model. This reduces complexity and improves the solvability of the model. Here we remove dead-ends and where applicable reduce multiple connected pipes with no demand to a single pipe with equivalent average diameter and

roughness (except where more than two pipes connect). For further guidance, please see the AWWA's Manual of Practice (M32).[4]

4 District Metered Area Identification

Pressure zones, or district metered areas (DMAs) are identified by iterating over each link and node in the hydraulic model and determining which links are hydraulically connected and which are separate. This automated generation of DMAs was performed over the entirety of Marin's distribution network as represented by the hydraulic model.

References

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