United States Environmental Protection Agency

Distribution System Water Quality

Use of Modeling to Protect Water Quality

Water quality modeling can help public water systems (PWSs) determine how a system's water quality would be impacted by system operations or design changes. Models can be developed to predict water age or the concentrations of disinfectants and other constituents and can help systems understand operational changes such as blending. There are a variety of software applications used to conduct water quality modeling including EPANET, a public domain software that can be downloaded from EPA's website (https://www.epa.gov/water-research/epanet), freely copied, and distributed. EPANET can be used to design and size new water infrastructure, retrofit existing infrastructure, optimize operations of tanks and pumps, and investigate water quality issues. This fact sheet is part of EPA's Distribution System Toolbox developed to summarize best management practices that PWSs, particularly small systems, can use to maintain distribution system water quality and protect public health.

Examples of Utility Actions

A PWS in the midwestern U.S. serving approximately 100,000 people wanted to better understand the impact of their storage tank operational practices on water quality. A water age study in EPANET was conducted simulating different tank operational decisions. Based on model results, one tank was removed from operation and the utility improved their ability to maintain disinfectant residuals without other capital improvements.

A PWS serving approximately 500,000 people in the western U.S. converted from a conventional static model to a real-time water quality model to allow the system to import SCADA data to compare actual disinfectant residual results with modeled data. The utility considered using post-chlorination stations to meet a new state disinfectant residual requirement, however, modelling indicated changes in tank turnover and pressure reducing valve settings could be used to meet the requirements. Using the information from the model, the system was able to meet its regulatory requirements, while saving money and reducing DBP risks by not installing post-chlorination stations.

Why use Water Quality Models?

- Water quality modeling can help utility managers and engineers make design and operational decisions at a lower cost than some other managerial approaches.
- Water quality models can analyze current conditions, predict the effects of changes in the water distribution system, and locate potential sources and causes of water quality problems.
- Water quality models allow systems to improve their water quality efficiently by targeted operational adjustments.

Objectives of Water Quality Modeling

- Identify the anticipated concentrations over time of specific constituents throughout water distribution systems.
- Assess potential strategies for water quality planning and management.
- Predict potential impacts from externalities (e.g., population growth, climate change, source water) on water quality conditions.

Parameters Predicted in Water Quality Modeling

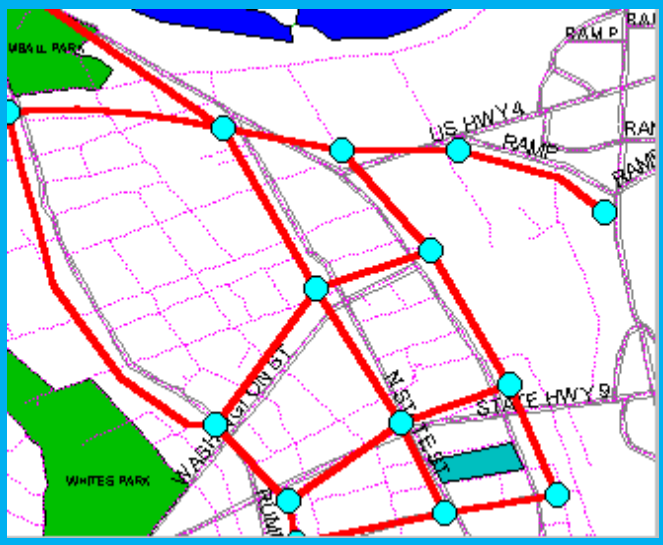
- The portion of water that flows from a specific source (referred to as flow tracing or source tracing).
- Water age (the time water spends in the distribution system prior to use).
- The concentration of a non-reacting tracer component added to or removed from the system.
- The concentration of residual disinfectant (e.g., chlorine or chloramines) which can be modeled with additional inputs of its decay rate.
- Disinfection by-products (DBPs) concentrations (e.g., trihalomethanes or haloacetic acids).

Data Requirement for Water Quality Modeling

- Hydraulic model output (e.g., flow, pressure, tank level). Hydraulic modeling is a prerequisite for water quality modeling. Hydraulic simulation results help predict the transport and behavior of water quality constituents.
- Water quality input data (e.g., chlorine concentration leaving a source), disinfectant residual reaction rate data. For more complicated water quality modeling and simulation problems, trihalomethane (THM) formation coefficients or other reaction rate data may be needed.

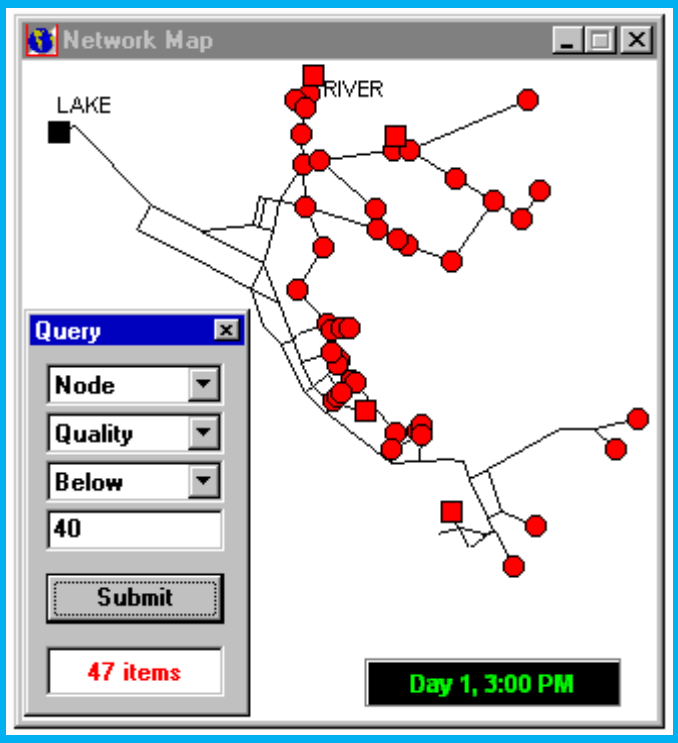
Table 1. Resources and Guidelines for Water Quality Modeling

Resource Title and URL	Relevance to Water Quality Modeling
American Water Works Association. 2017. Computer modeling of water distribution systems (M32). *American Water Works Association*. www.awwa.org. Note: There may be a fee associated with obtaining this resource.	Presents the basics of computerized programs and processes for control and maintenance of a water distribution system. Information about water quality models is included in this manual.
Clark, R.M. 1999. Water quality modeling--case studies. Water distribution systems handbook. New York: McGraw Hill. Note: There may be a fee associated with obtaining this resource.	Includes several case studies that use hydraulic and water quality models to evaluate the causes of water quality degradation.
Clark, R.M. 2012. What Are the Basics of Water Quality Modeling and Monitoring? Opflow. www.awwa.org Note: There may be a fee associated with obtaining this resource.	Describes different distribution system models including hydraulic models and water quality models.
Smith, R. 2015. Real-Time Modeling Improves Operations. *Opflow*. www.awwa.org Note: There may be a fee associated with obtaining this resource.	Presents the benefits of the application of the real-time water model to a specific utility.
USEPA. EPANET-Application for Modeling Drinking Water Distribution Systems. https://www.epa.gov/water-research/epanet	Describes EPANET, its capabilities, and typical applications.



Map of the pipe network being modeled

Image source: EPANET User Manual



Results of a Map Query identifies nodes or links on the network map that meet a specific criterion

Image source: EPANET User Manual