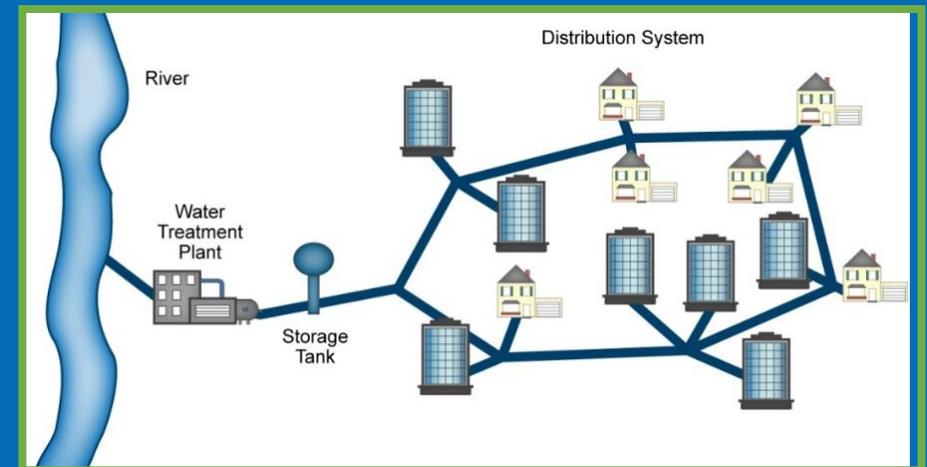


EPA Tools & Resources Webinar: Drinking Water Models and Tools

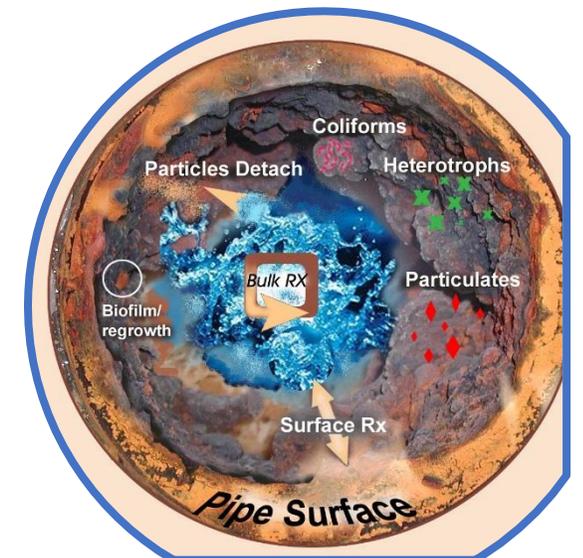
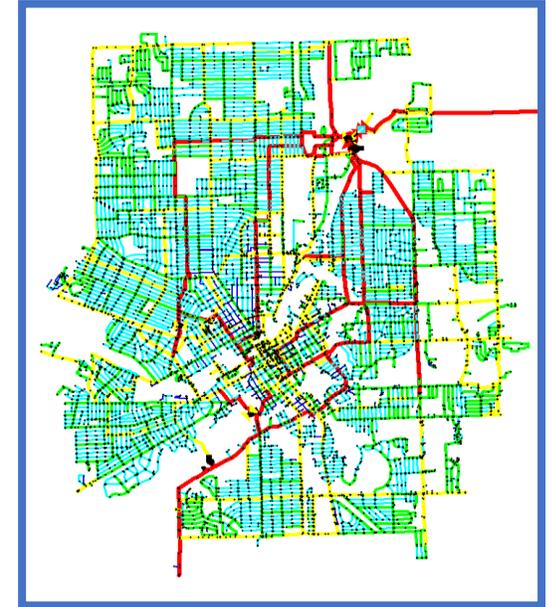
Regan Murray, PhD
US EPA Office of Research and Development

November 18, 2020

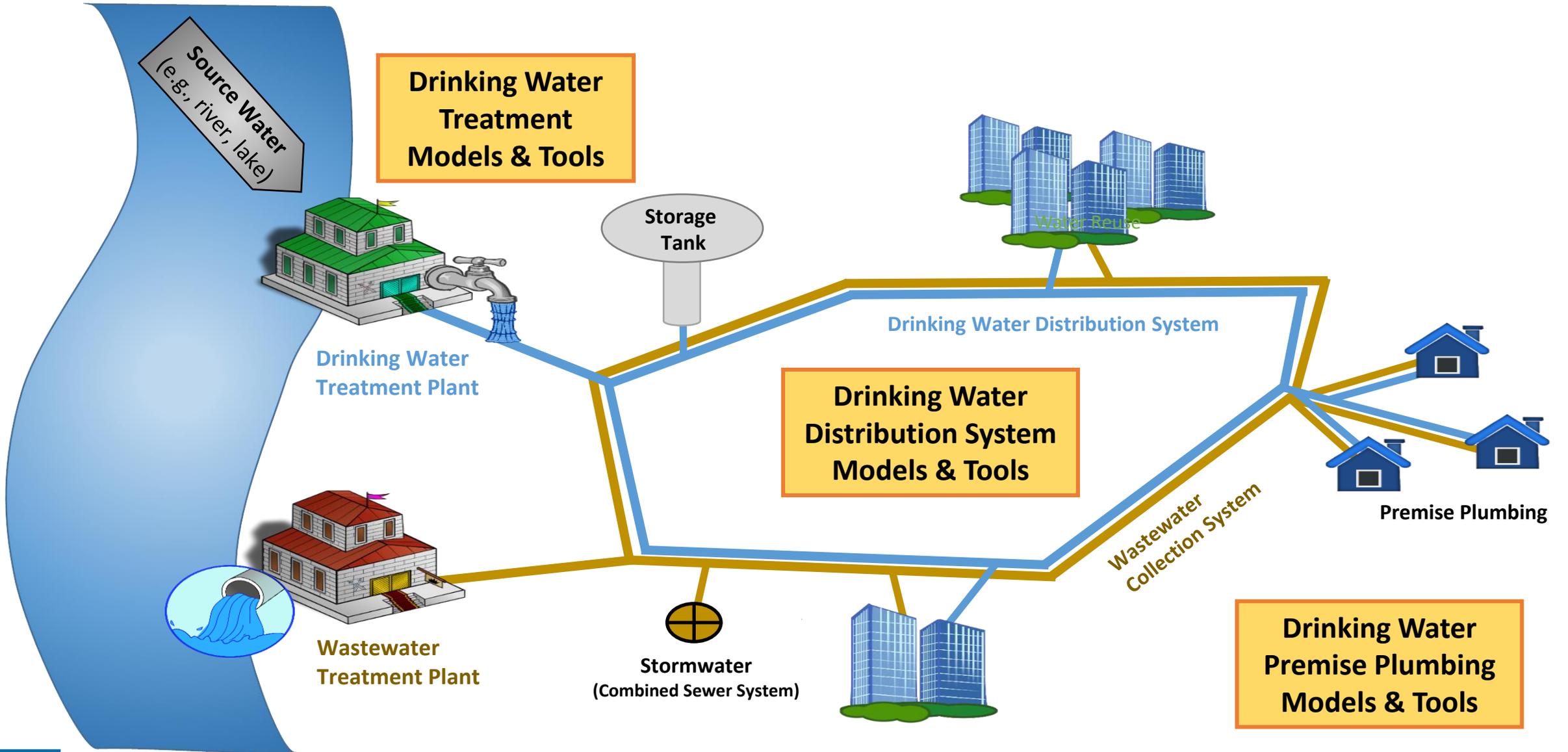


Background and Motivation

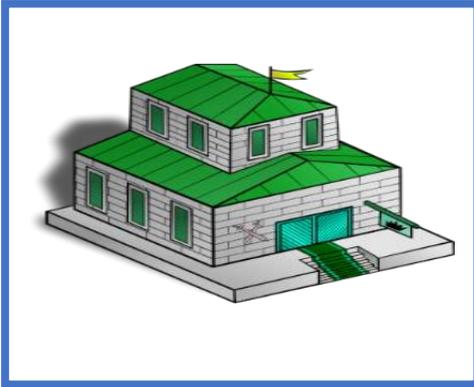
- Drinking water systems are large and complex.
- Changes to treatment processes or distribution systems can affect water quality downstream in unforeseen ways.
- Modeling is a powerful, cost-effective tool to predict and evaluate the effects of such changes prior to implementing them in the real system.



Water Infrastructure

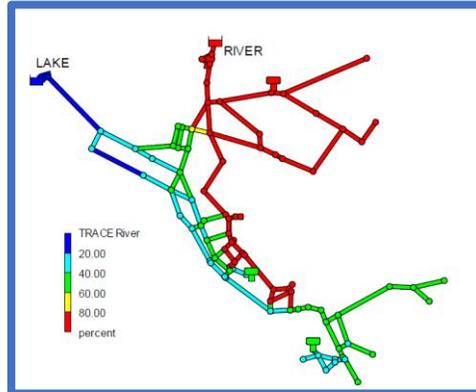


Drinking Water Models and Tools



Drinking Water Treatment Models & Tools

- CFD
- CBCS
- FCCAS
- FCEDTS
- WTM
- ETDOT
- Treatability DB



Drinking Water Distribution System Models & Tools

- EPANET
- EPANET-MSX
- EPANET-RTX
- RTX:LINK
- TEVA-SPOT
- CANARY
- WNTR



Drinking Water Premise Plumbing Models & Tools

- PPM Tools

Access these models and tools through EPA's [Science Models and Research Tools \(SMaRT\) Search](#)

Distribution System Model: EPANET

- Simulates hydraulics within a water distribution network.
- Models decay/growth of a single substance.
- More than 50,000 downloads per year.
- Components utilized for multiple commercial software packages.
- Latest official release: version 2.2 in July 2020.

epa.gov/water-research/epanet

EPANET

Application for Modeling Drinking Water Distribution Systems

EPANET is a software application used throughout the world to model water distribution systems. It was developed as a tool for understanding the movement and fate of drinking water constituents within distribution systems, and can be used for many different types of applications in distribution systems analysis. Today, engineers and consultants use EPANET to design and size new water infrastructure, retrofit existing aging infrastructure, optimize operations of tanks and pumps, reduce energy usage, investigate water quality problems, and prepare for emergencies. It can also be used to model contamination threats and evaluate resilience to security threats or natural disasters.

Software, Compatibility, and Manuals

EPANET is public domain software that can be freely copied and distributed. It is a Windows®-based program that will work with all versions of Windows. Continued development and bug fixes are of interest to interested parties.

- EPA's G

Software

Date

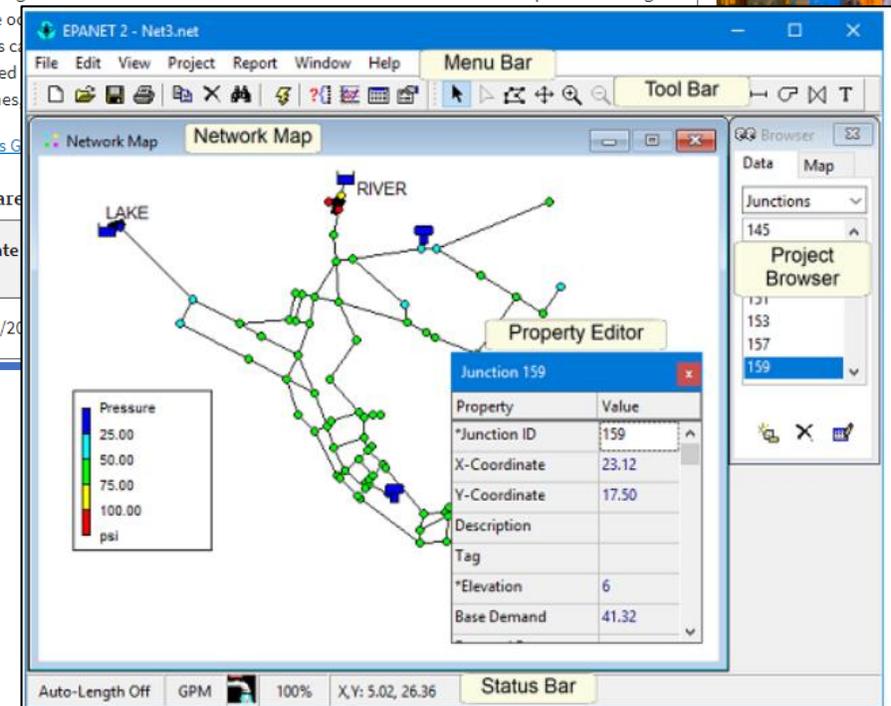
07/23/20

On this Page

- [Software, Compatibility, and Manuals](#)
- [Capabilities](#)
- [Applications](#)
- [Related Resources](#)
- [Technical Support](#)



trade names,
does not
EPA. EPA and its
commercial
prises.



EPANET 2 - Net3.net

File Edit View Project Report Window Help Menu Bar

Tool Bar

Network Map Network Map

LAKE RIVER

Property Editor

Property	Value
*Junction ID	159
X-Coordinate	23.12
Y-Coordinate	17.50
Description	
Tag	
*Elevation	6
Base Demand	41.32

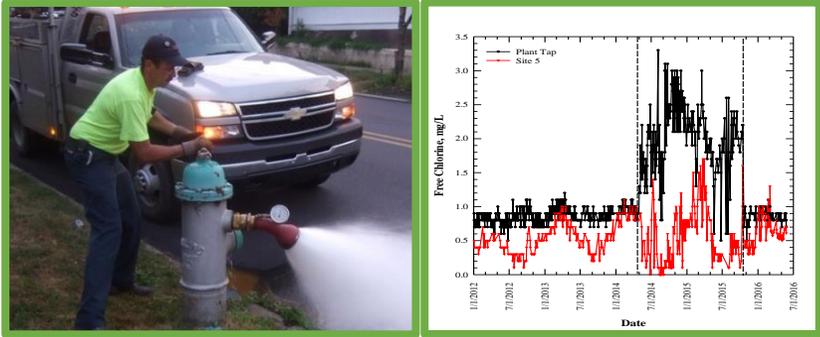
Pressure

25.00
50.00
75.00
100.00
psi

Auto-Length Off GPM 100% X,Y: 5.02, 26.36 Status Bar

EPANET Typical Uses and Applications

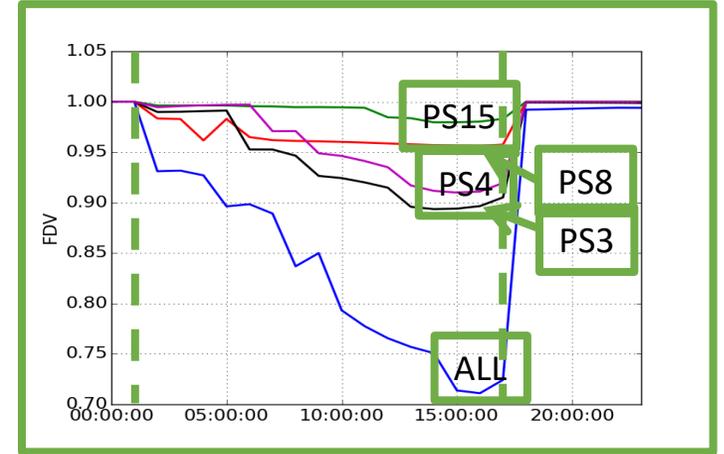
Solving Regulatory Problems



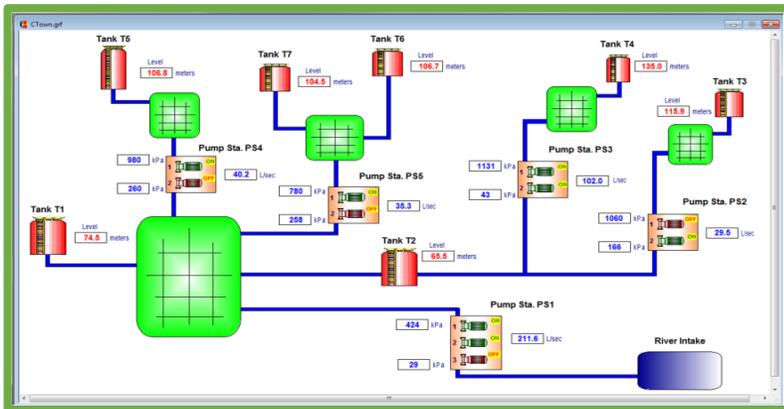
Designing and Replacing Aging Infrastructure



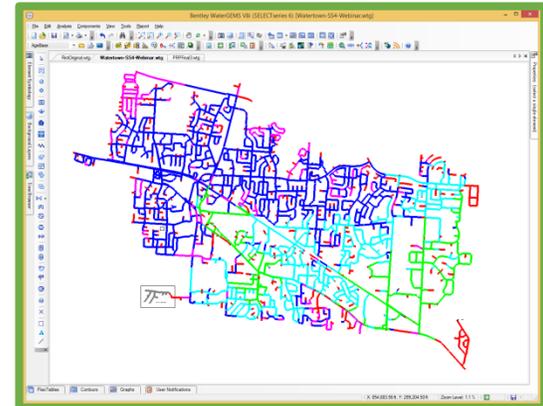
Preparing for Emergencies



Optimizing Operations to Improve Water Quality

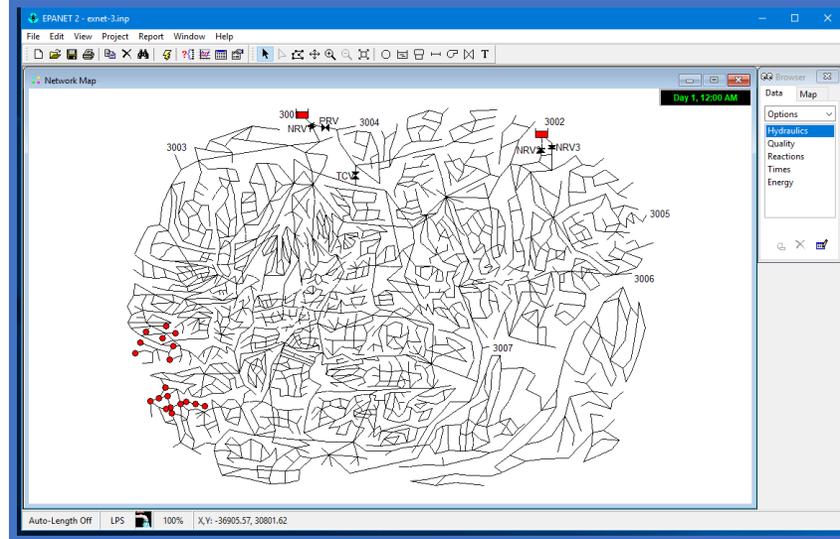


Real-time Operations and Decision Making



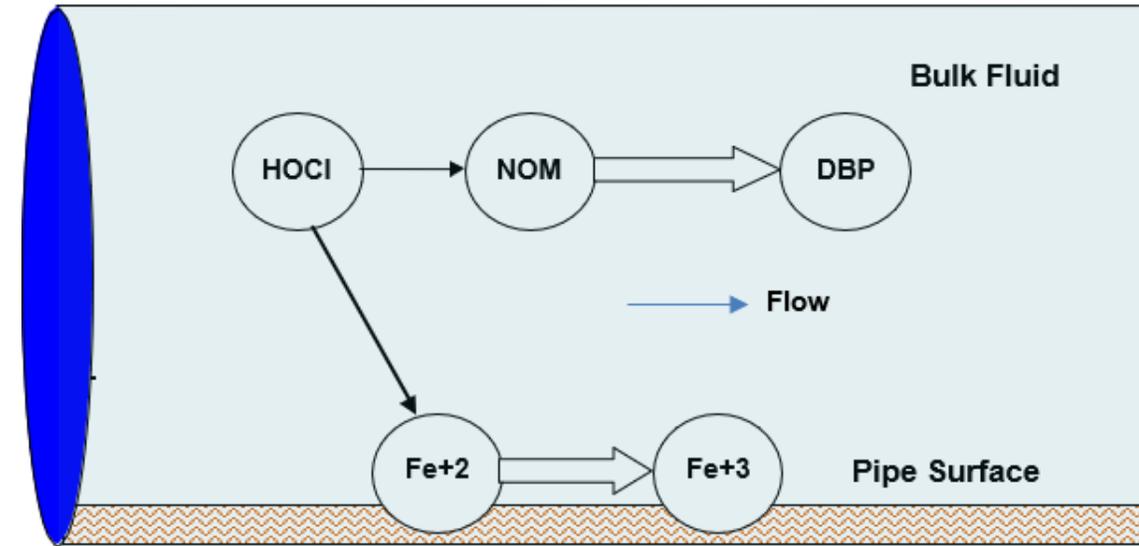
EPANET Recent Updates (*version 2.2*)

- 💧 Online User Manual
- 💧 Testing and QA
- 💧 User interface
- 💧 Improved solution performance and accuracy
 - Pressure dependent demand analysis
 - Water quality mass balance
 - Handling of low flows
 - Convergence criteria
- 💧 External contributors



Distribution System Model: EPANET-MSX

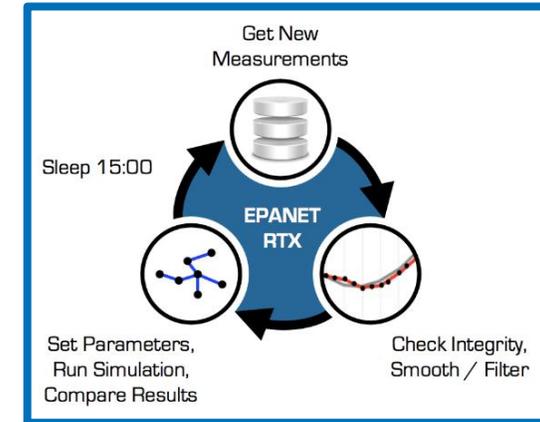
- EPANET-MSX can model the following:
 - Adsorption/desorption on pipe walls
 - Attachment to biofilms
 - Chemical reactions
 - Biological growth and decay
- Planned features:
 - Graphical user interface
 - Dispersion modeling
 - Parcel tracking
 - Built in contaminant fate and transport models



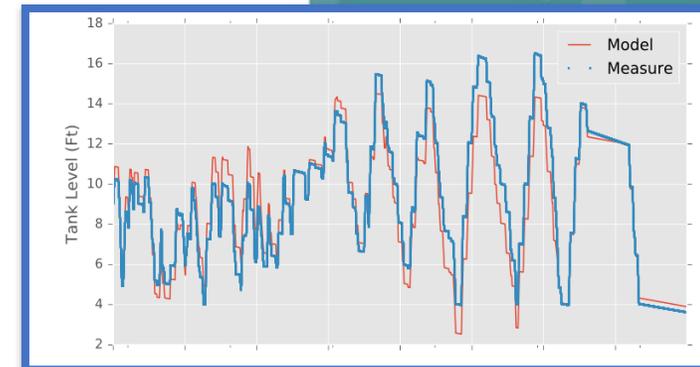
epa.gov/water-research/epanet

Distribution System Model: EPANET-RTX

- EPANET in real-time.
- Suite of software libraries to integrate EPANET model with SCADA operational data.
- Real-time analytics for automated:
 - Forward and hind cast
 - Model calibration
 - Simulate and compare operational decisions
- Continuous comparison and analysis between model and SCADA outputs allowing for more accurate predictions.



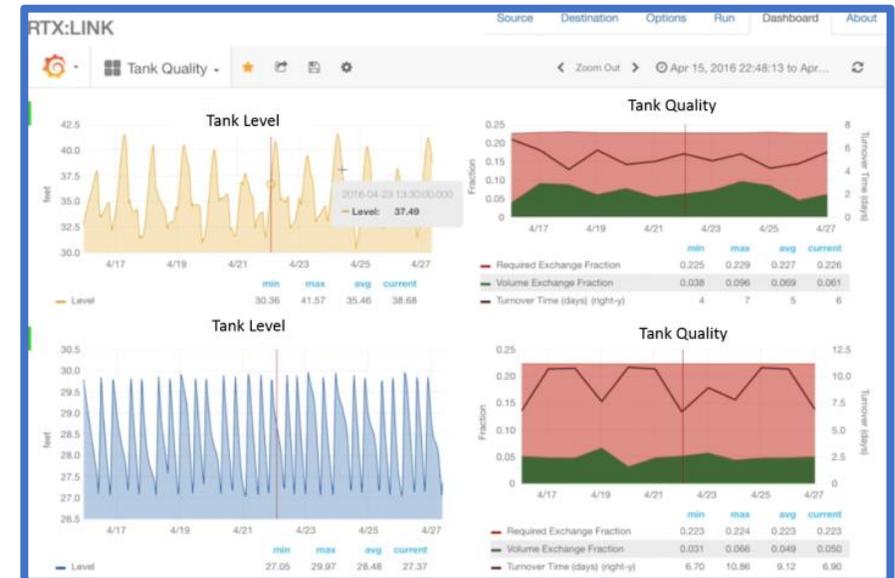
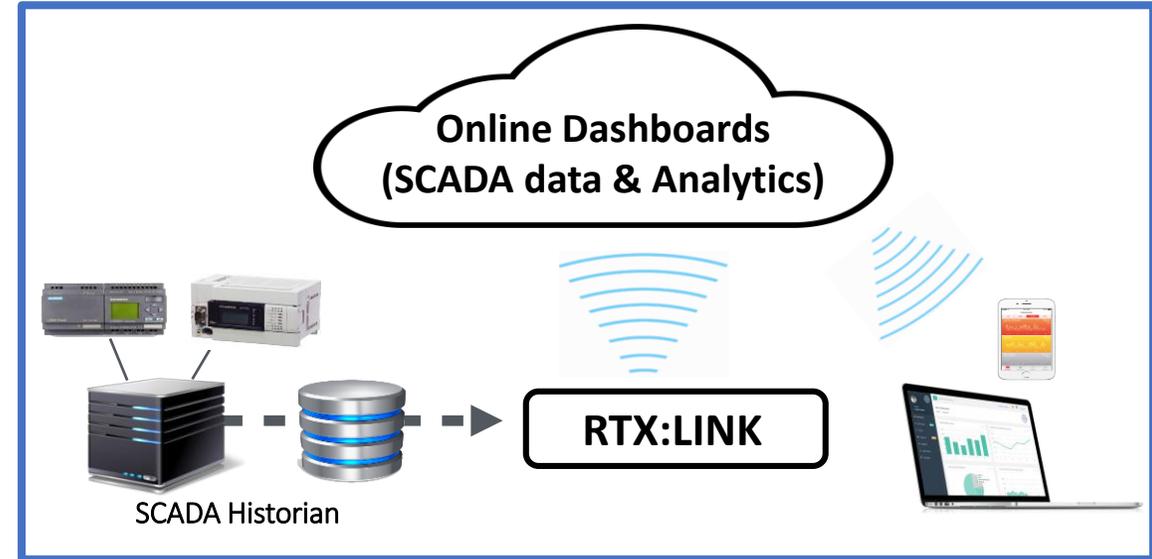
Water Utility Case Study of Real-Time Network Hydraulic and Water Quality Modeling Using EPANET-RTX Libraries



Distribution System Tool: RTX:LINK

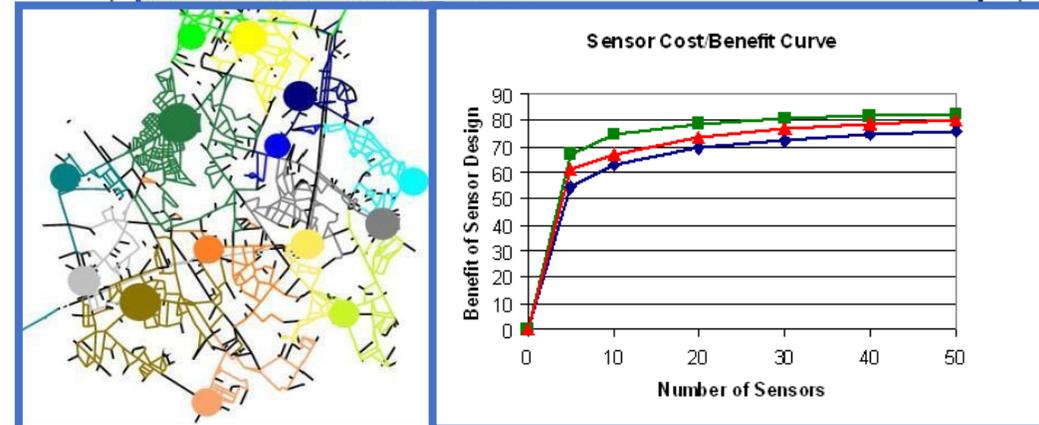
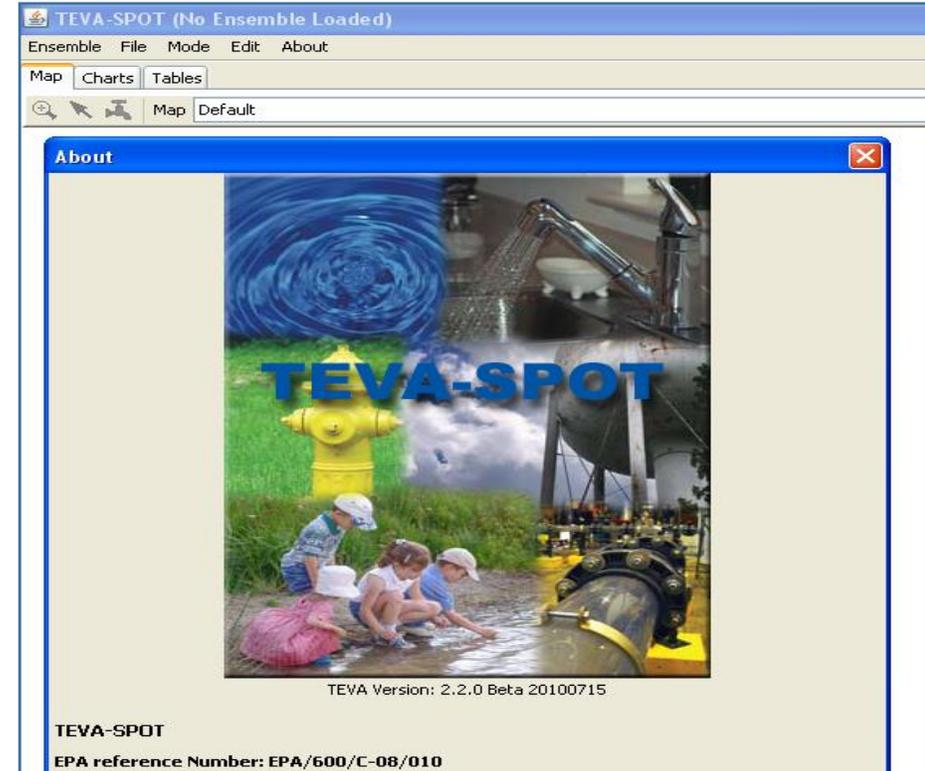
RTX:LINK provides the technology to view water system data and simple analytics on smart phones and mobile devices.

- Available for free on EPA's website.
- Shows real-time statistics and trends, water age, tank turnover time, tank degree of mixing, energy usage and system demand.
- Can alert based on min/max (set point) levels or other methods.
- Helps support rapid and accurate decision making at water utilities.



Distribution System Model: Sensor Placement

- TEVA-SPOT:
 - Threat Ensemble Vulnerability Assessment
 - Sensor Placement Optimization Tool
- Assess impacts of contamination incidents.
- Optimize sensor network designs.
- Evaluate/compare the performance of different sensor layouts.
- Command line (research) and Graphical User Interface (end user) versions available.



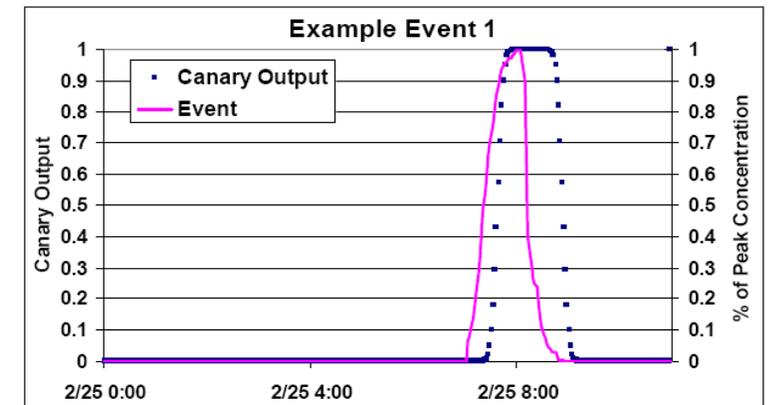
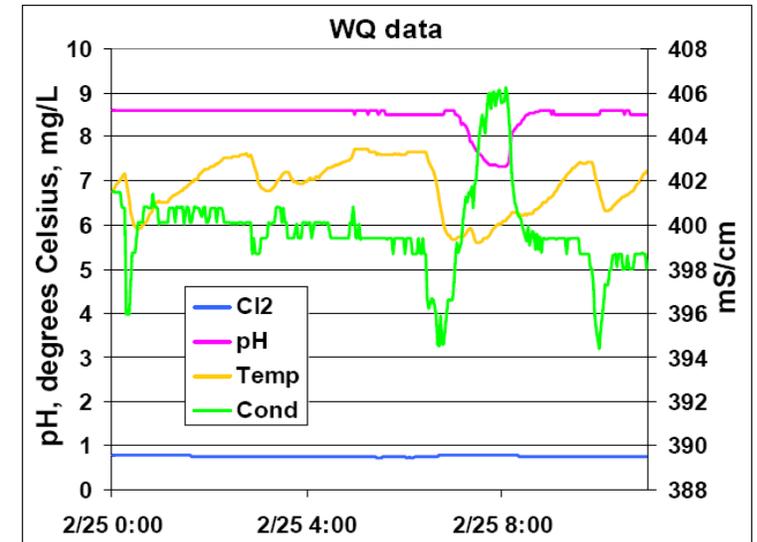
Distribution System Tool: CANARY



CANARY is a water quality event detection software.

- **Monitors** water quality data at multiple sensor locations continuously.
- **Recognizes** recurring water quality patterns.
- **Ignores** data during periods of sensor malfunction or hardware alarms.
- **Analyzes** data using multiple statistical algorithms.
- **Alerts** during periods of anomalous water quality.
- **Produces** graphics for analysis.

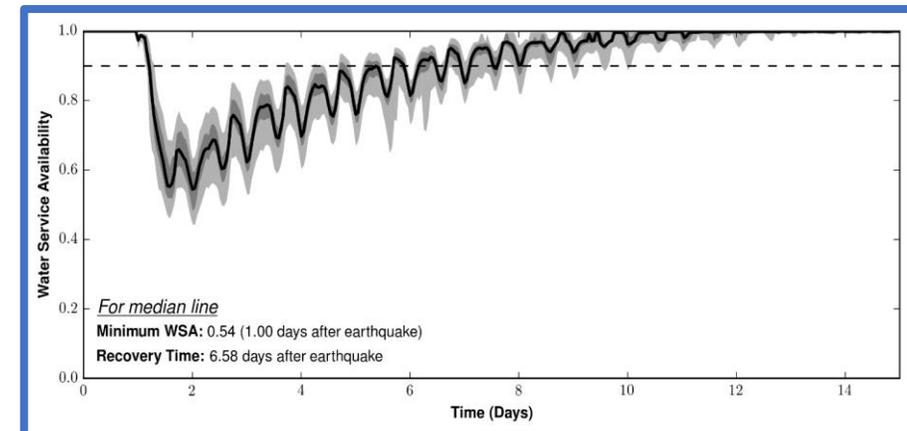
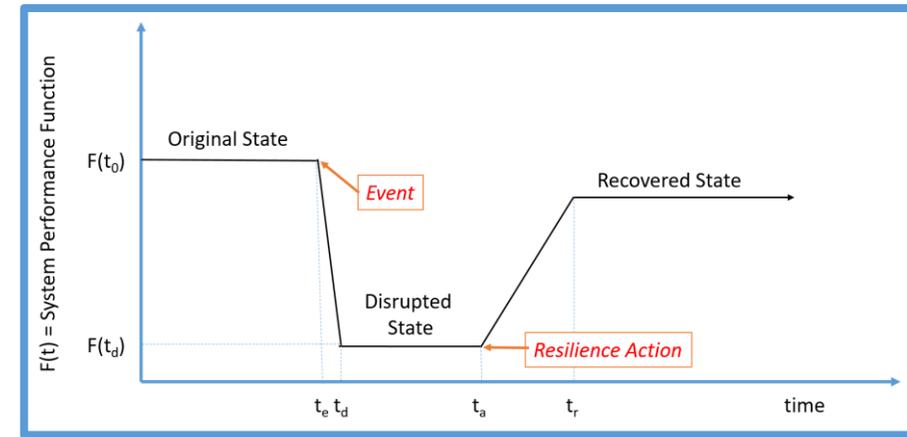
<https://github.com/USEPA/CANARY/releases/tag/v4.3.3>



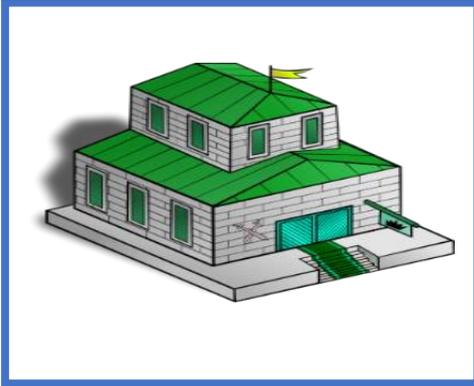
Distribution System Tool: WNTR

- Simulates disaster scenarios such as earthquakes, power outages, floods, and contamination incidents.
- Predicts damage to infrastructure.
- Calculates resilience metrics.
- Evaluates response and mitigation strategies to improve resilience.

<https://github.com/USEPA/WNTR>

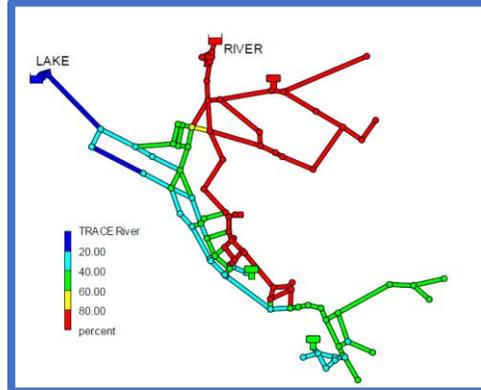


Drinking Water Models and Tools



Drinking Water Treatment Models & Tools

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Drinking Water Distribution System Models & Tools

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- EPANET-MSX
- EPANET-RTX
- RTX:LINK
- TEVA-SPOT
- CANARY
- WNTR



Drinking Water Premise Plumbing Models & Tools

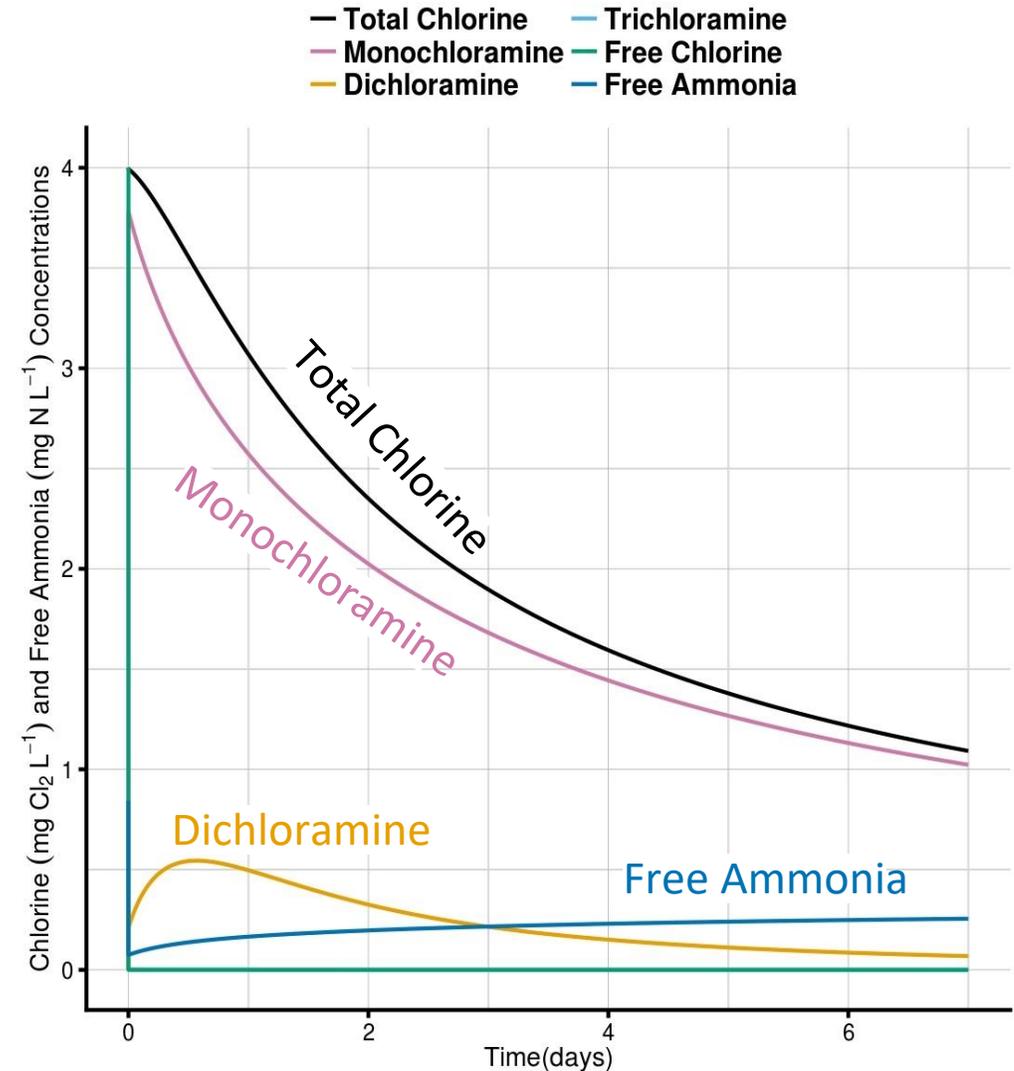
- PPM Tools

Access these models and tools through EPA's [Science Models and Research Tools \(SMaRT\) Search](#)

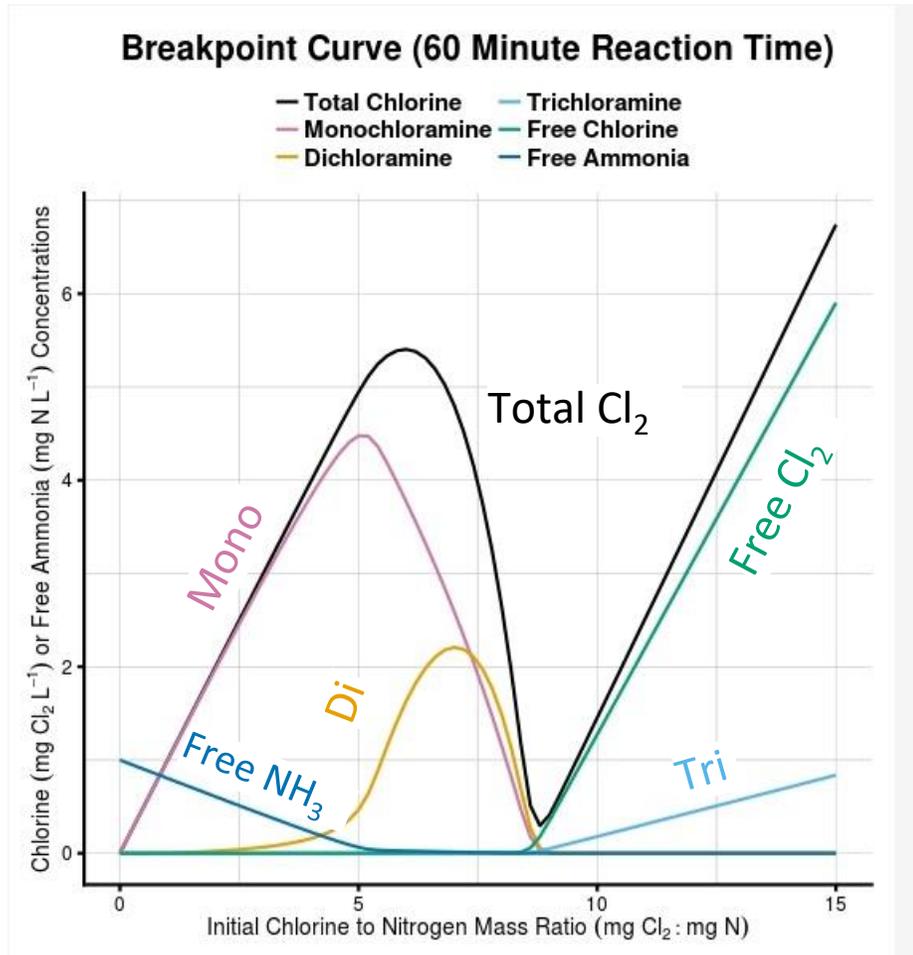
Treatment Models: Chloramine Formation/Decay

- 💧 Chloramine formation and decay
- 💧 Batch (plug flow) reactor
- 💧 Allows comparison of input choices:
 - Free chlorine, free ammonia
 - pH, alkalinity, temperature, Total Organic Carbon (TOC)
 - Simultaneous addition, booster chlorination, or preformed chloramines

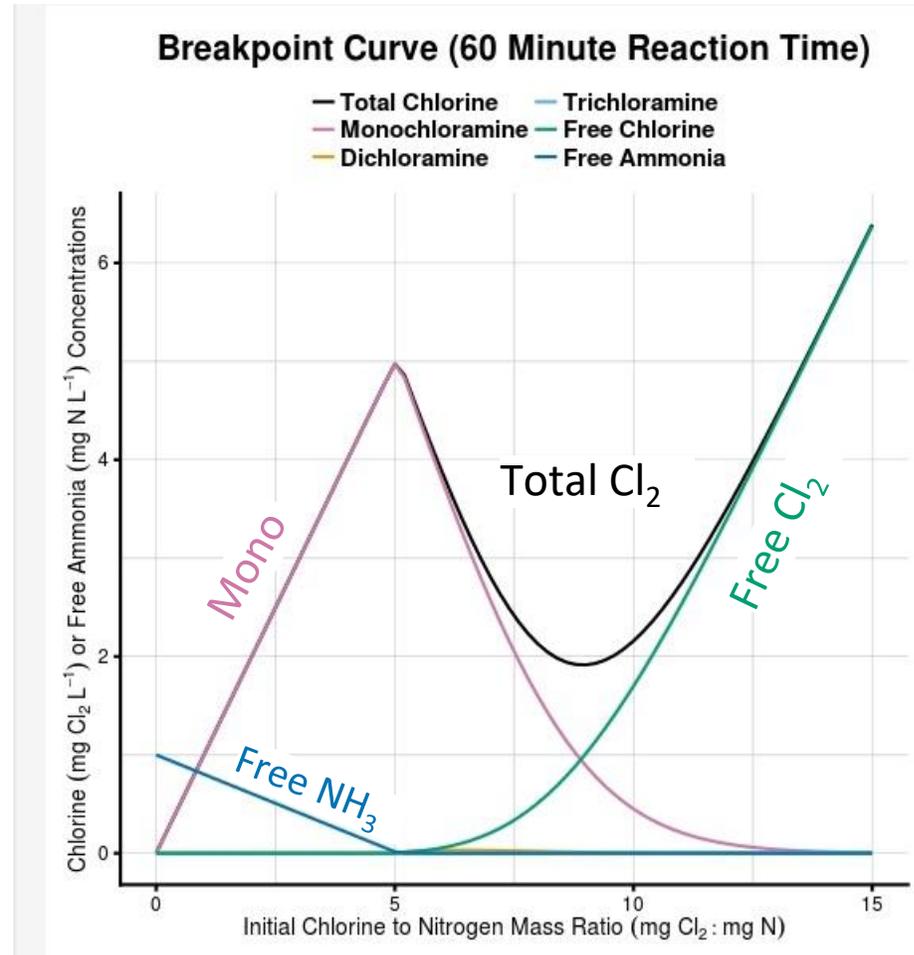
<https://shiny.epa.gov/cfd/>



Treatment Models: Chlorine Breakpoint Curve



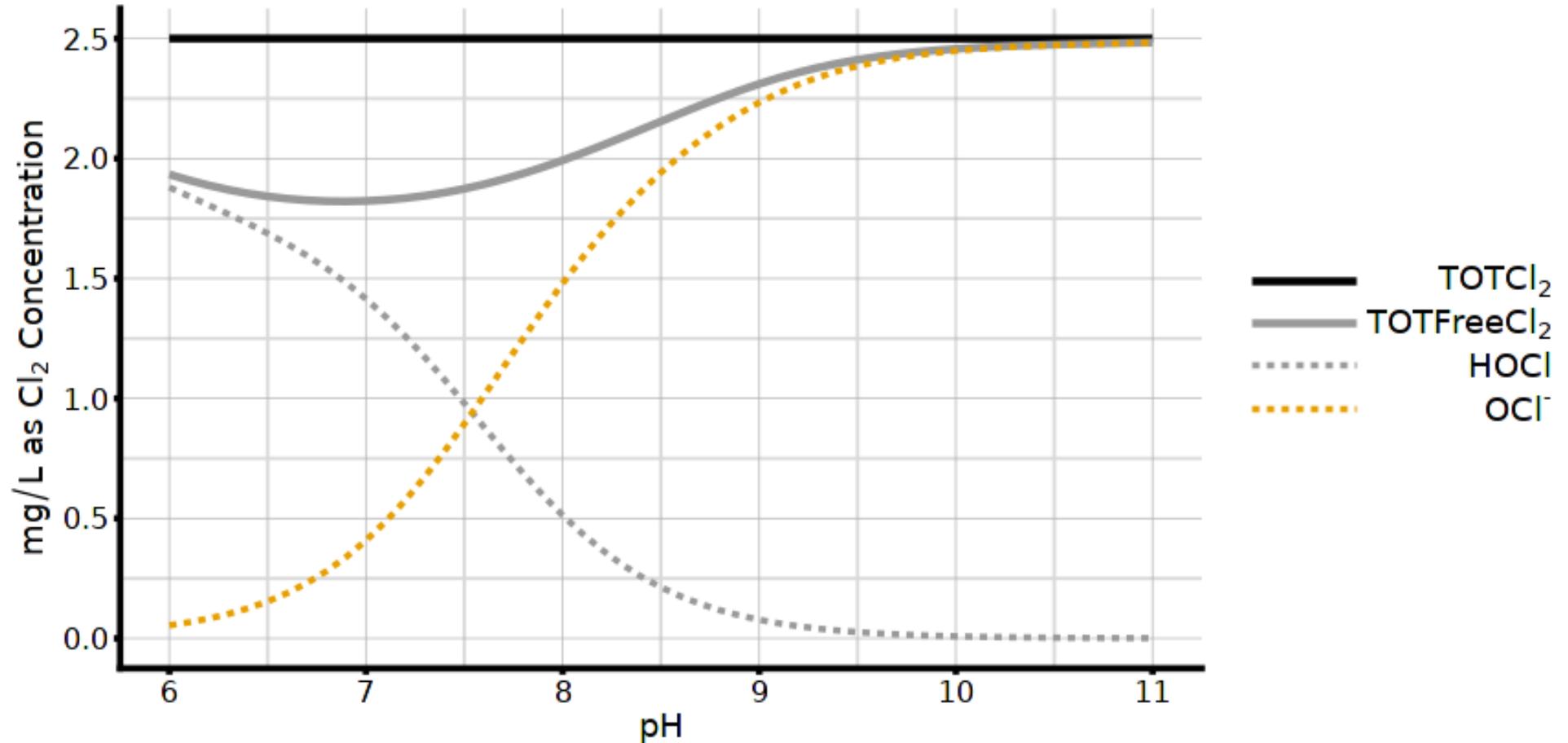
pH 7



pH 9

Treatment Models: Free Chlorine and Cyanuric Acid

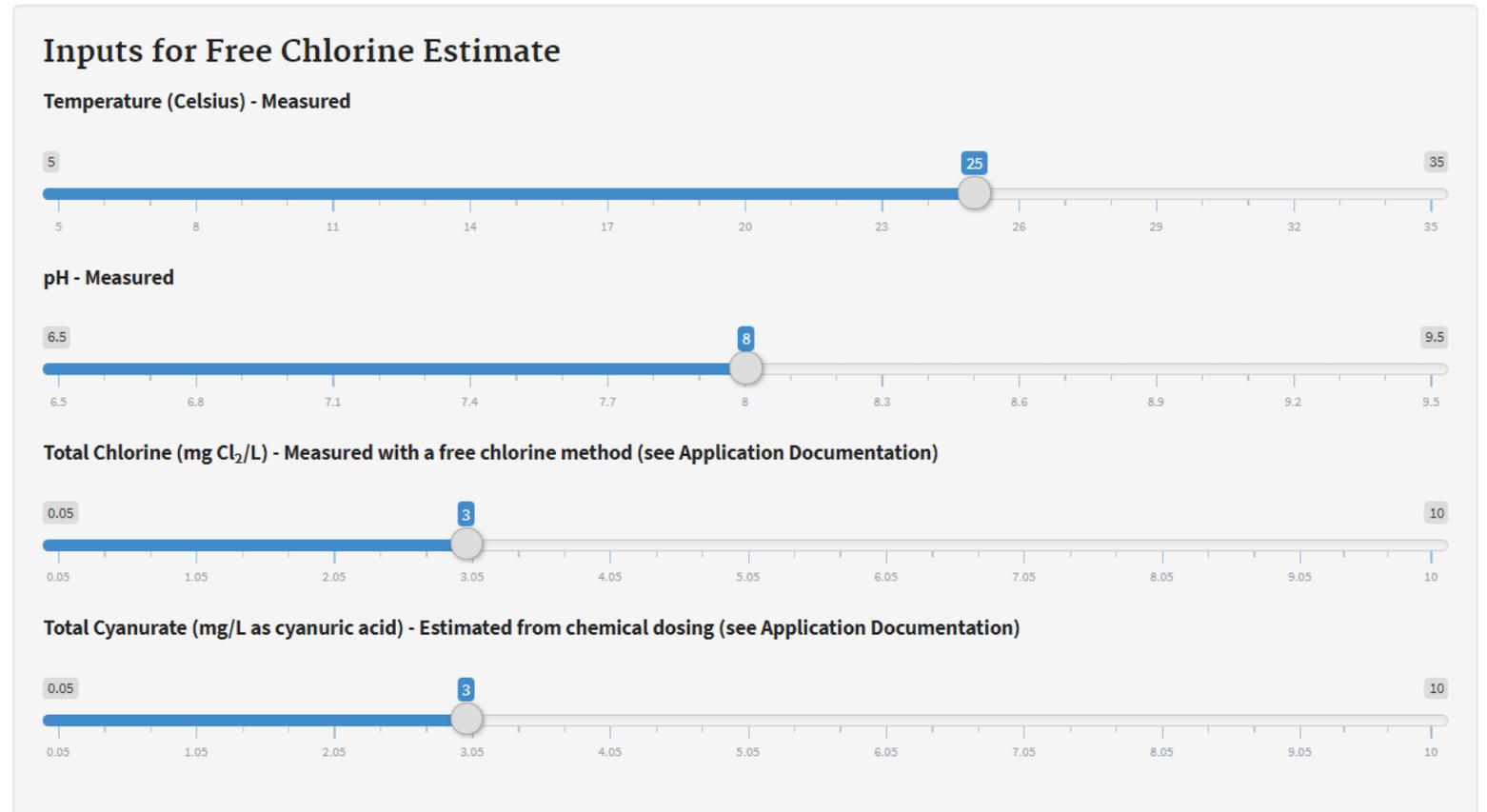
Predicts chlorine chemistry for various initial conditions when using Dichlor or Trichlor as the free chlorine source.



Treatment Models: Free Chlorine Estimator for Dichlor and Trichlor Systems

- 💧 Calculates free chlorine concentration.
- 💧 Dichlor or trichlor are used as disinfectant.
- 💧 Uses measured free chlorine as an input.

<https://shiny.epa.gov/fcedts>



Estimated free chlorine concentration = 1.44 mg/L as chlorine

Treatment Models: WTM

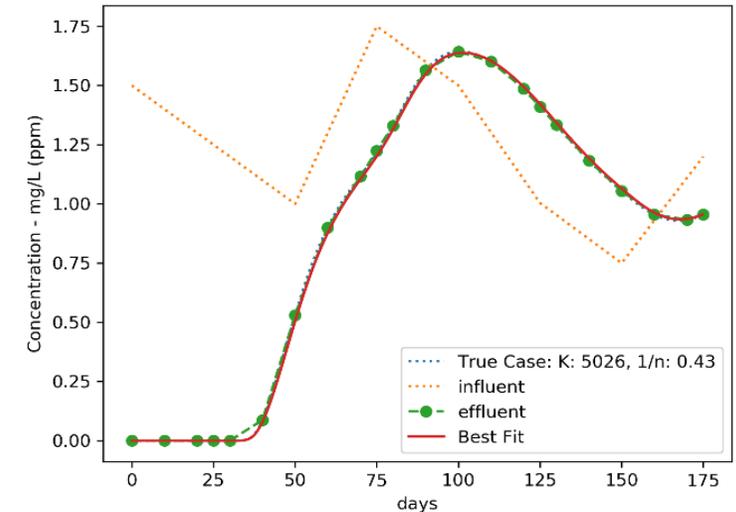
💧 Granular Activated Carbon Model

- Pore and Surface Diffusion Model (PSDM)
- Fouling related to natural organic matter
- Estimates model parameters
- Supports multiple component adsorption
- Estimates real-world operational bed replacement

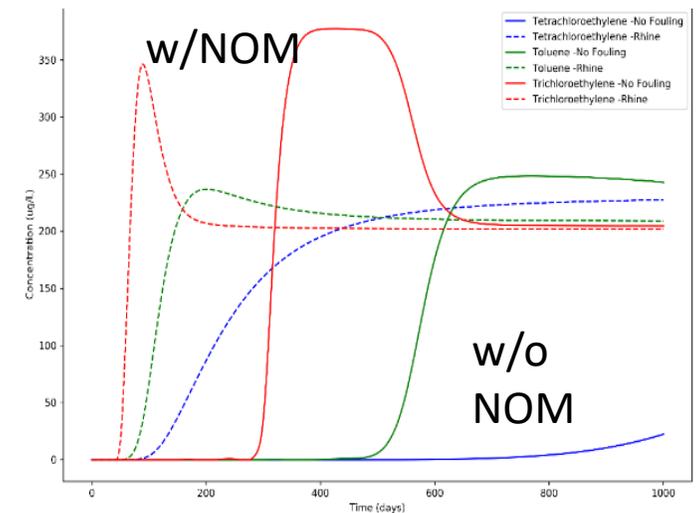
💧 Ion Exchange Media

- Supports gel-type ion exchange resins
- Planned support for macroporous resins (early 2021)
- Applicable to low natural organic matter waters
- Model competition from divalent ions, such as sulfate

Parameter Estimation



Competitive Adsorption

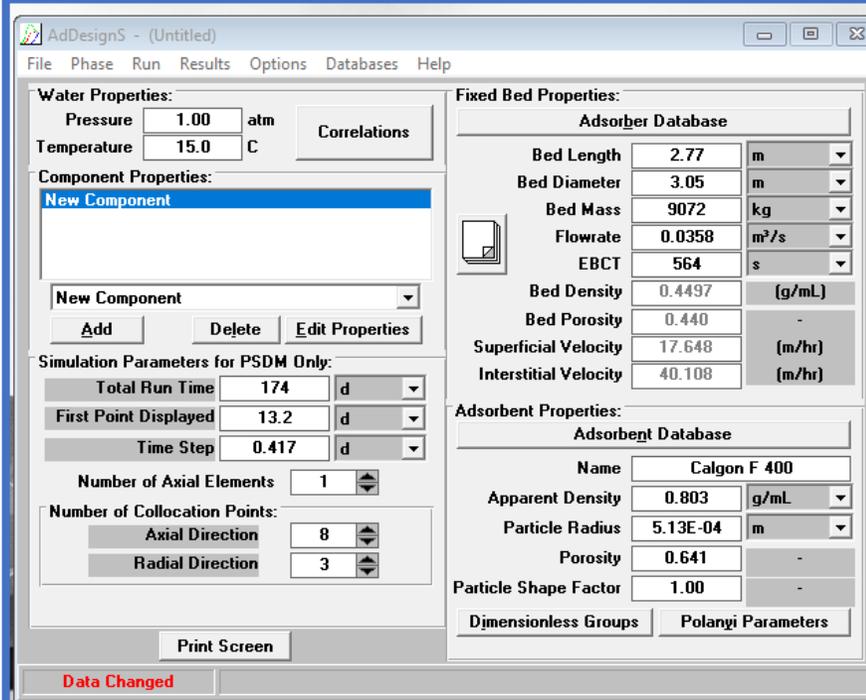


Treatment Models: ETDOT

Environmental Technologies Design Option Tool (ETDOT)

- 💧 Suite of software for modeling a variety of treatment technologies.
- 💧 Originally developed by Michigan Technological University (MTU).
- 💧 Now available on EPA's website.
- 💧 Includes models for adsorption, advanced oxidation, aeration, biofilters, PAC adsorption, ion exchange.

Example: AdDesignS



The screenshot displays the AdDesignS software interface with the following sections:

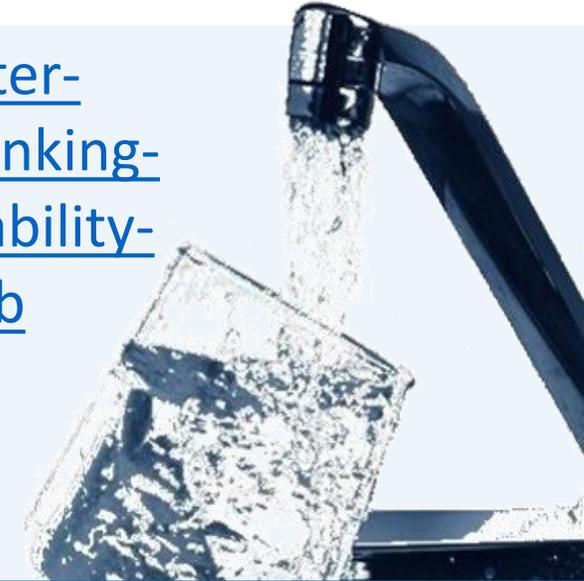
- Water Properties:** Pressure (1.00 atm), Temperature (15.0 C), Correlations button.
- Component Properties:** New Component list, Add, Delete, Edit Properties buttons.
- Simulation Parameters for PSDM Only:** Total Run Time (174 d), First Point Displayed (13.2 d), Time Step (0.417 d), Number of Axial Elements (1), Number of Collocation Points (Axial Direction: 8, Radial Direction: 3).
- Fixed Bed Properties:** Adsorbent Database table with parameters: Bed Length (2.77 m), Bed Diameter (3.05 m), Bed Mass (9072 kg), Flowrate (0.0358 m³/s), EBCT (564 s), Bed Density (0.4497 g/mL), Bed Porosity (0.440), Superficial Velocity (17.648 m/hr), Interstitial Velocity (40.108 m/hr).
- Adsorbent Properties:** Adsorbent Database table with parameters: Name (Calgon F 400), Apparent Density (0.803 g/mL), Particle Radius (5.13E-04 m), Porosity (0.641), Particle Shape Factor (1.00), Dimensionless Groups, Polanyi Parameters.

Buttons: Print Screen, Data Changed (red text).

Treatment Tools: Treatability Database

- Interactive searchable database.
- 123 regulated and unregulated contaminants.
- 35 treatment processes commonly employed or known to be effective.
- Referenced information gathered from thousands of literature sources.

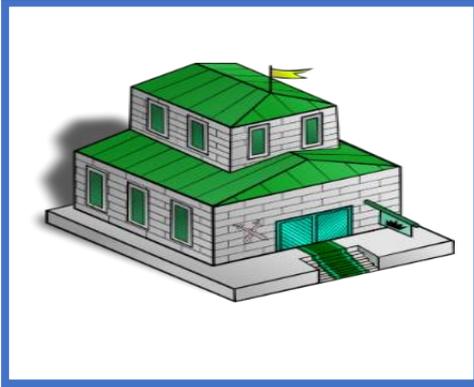
epa.gov/water-research/drinking-water-treatability-database-tdb



[Home](#) [About the TDB](#) [Contact Us](#) [Find Contaminant](#) [Find Treatment Process](#) [Help](#) [Quick Links](#)

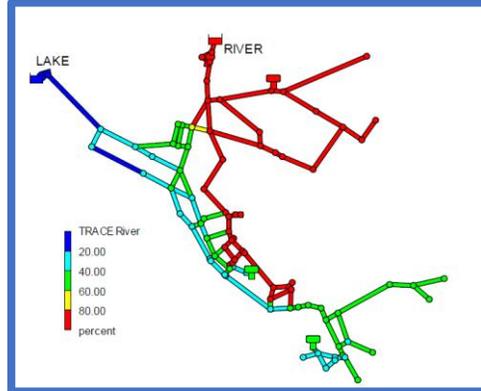
Welcome to the Drinking Water Treatability Database

Drinking Water Models and Tools



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Drinking Water Distribution System Models & Tools

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- RTX:LINK
- TEVA-SPOT
- CANARY
- WNTR

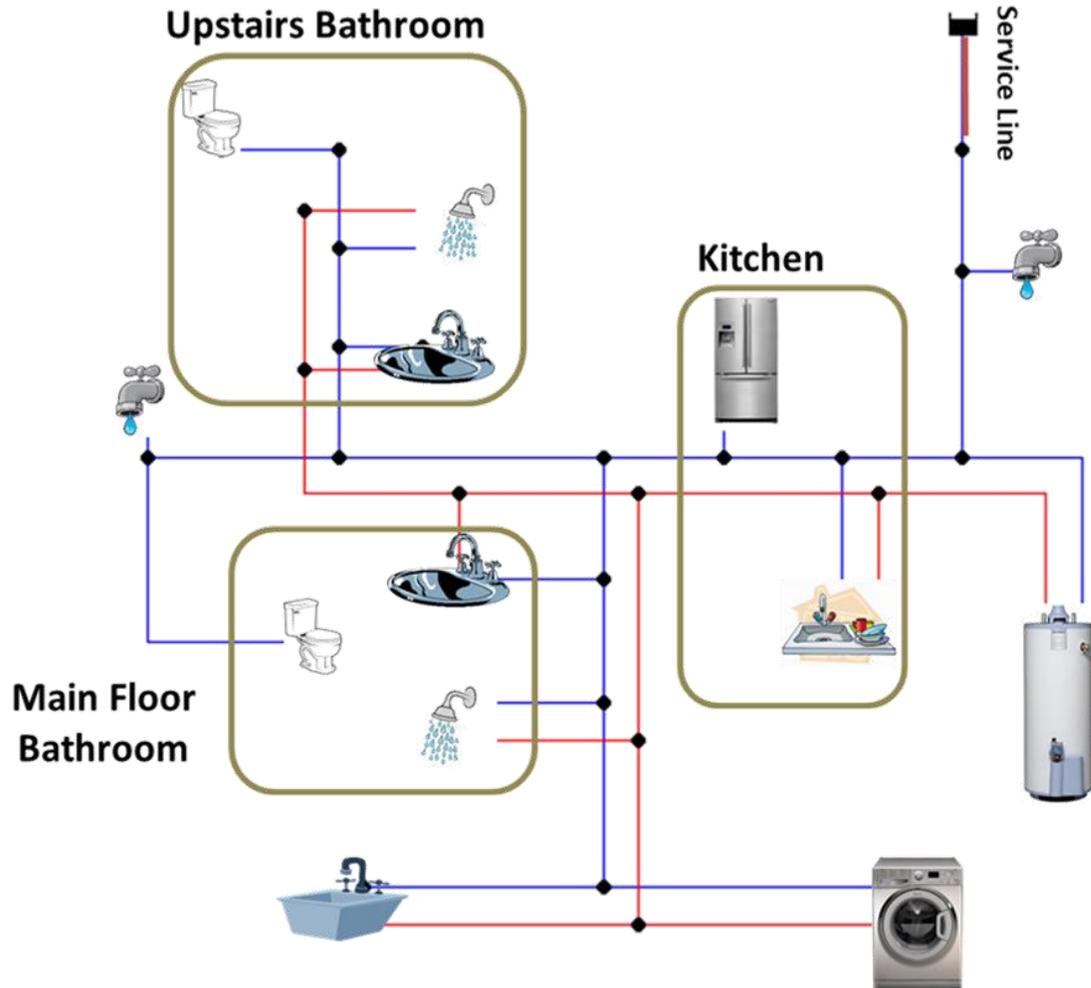


Drinking Water Premise Plumbing Models & Tools

- PPM Tools

Access these models and tools through EPA's [Science Models and Research Tools \(SMaRT\) Search](#)

Premise Plumbing Tool: PPM Tools



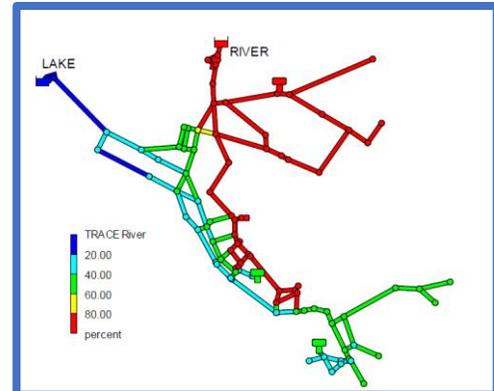
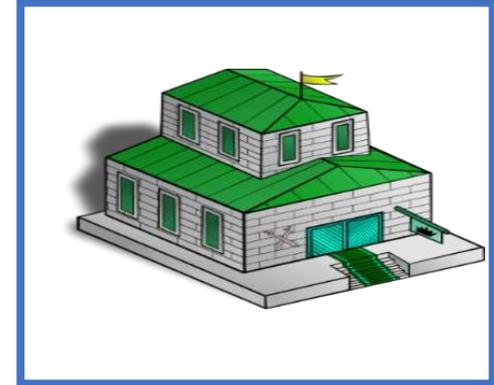
Premise Plumbing Modeling Tools (PPM Tools)

- Leverages EPANET and WNTR.
- Models real-world fixtures.
- Estimates realistic usage patterns.
- Generates and runs many scenarios.
- Predicts water quality information over time (e.g., water age, contaminant concentration).
- Simulates flushing to remove contaminants.
- Estimates exposure to contaminants.

<https://github.com/USEPA/PPMtools>

Summary

- Models and other tools can be used to help solve drinking water problems:
 - Water distribution systems design, vulnerability and resilience assessment, operational improvements.
 - Water treatment design, evaluation, assessment.
 - Premise plumbing design, contaminant exposure assessment, flushing.
- Tools and supporting documentation are available for free on the web and easily searchable from EPA's [Science Models and Research Tools \(SMaRT\) Search](#).



Contacts

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Center for Environmental Solutions and Emergency Response

US EPA Office of Research and Development

murray.regan@epa.gov

513-569-7031



Specific Models and Tools:

- ◆ **EPANET and EPANET-MSX:** Feng Shang (shang.feng@epa.gov)
- ◆ **EPANET-RTX, RTX:LINK and TEVA-SPOT:** Robert Janke (janke.robert@epa.gov)
- ◆ **WNTR:** Terra Haxton (haxton.terra@epa.gov)
- ◆ **CANARY, ETDOT, WTM and PPM Tools:** Jonathan Burkhardt (burkhardt.jonathan@epa.gov)
- ◆ **CFD, CBCS, FCCAS, FCEDTS:** David Wahman (wahman.david@epa.gov)
- ◆ **TDB:** Page Jordan (jordan.page@epa.gov)