Water Network Tool for Resilience Model Components

The **Water Network Tool for Resilience (WNTR)** uses a hydraulic model of a drinking water distribution system. That model can be obtained from the water utility (in EPANET input (INP) or related file format) or be generated from different data sources. The basic features of the model are shown in Figure 1 and described in Table 1. Some model attributes can be approximated from publicly available data sources, as outlined in Table 2. Models should be calibrated to replicate system operations.

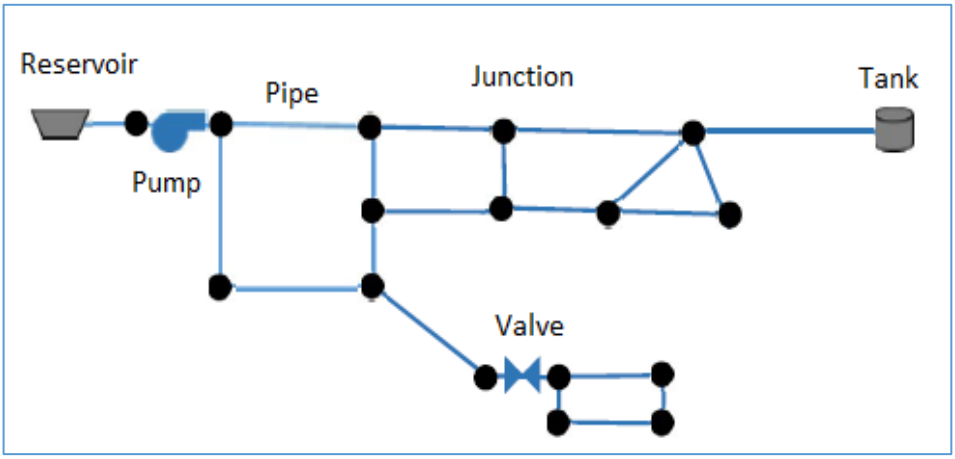

Figure 1: WNTR model representation of a drinking water distribution system

WNTR models a drinking water distribution system as a *network* with nodes and links.

Nodes represent water sources, water demands, and where links meet:

- **Reservoirs**
- **Tanks**
- **Junctions**

Links represent elements that convey water, connect nodes, or regulate the system:

- **Pipes**
- **Pumps**
- **Valves**

Table 1: Drinking water distribution system model components

Component	Definition	Attributes
Nodes		
Junctions	Junctions connect pipes, pumps, and valves. Junctions can also have *demands* which represent withdrawals from the drinking water distribution system. When a junction has demands associated with it, it is a **demand point**.	- Location - Elevation Demand points have additional attributes: - Base demand rate - Demand pattern
Reservoir	Reservoirs define the water source of the drinking water distribution system, such as a water treatment plant.	- Location - Elevation - Hydraulic head (elevation plus water pressure)
Tanks	Tanks are storage units whose water level can change over time.	- Location - Minimum and maximum water level - Diameter or volume pattern
Links		
Pipes	Pipes connect junctions, reservoirs, and tanks, and represent how water flows through the drinking water distribution system.	- Start and end location - Length - Diameter - Material or roughness coefficient
Pumps	Pumps raise hydraulic head.	- Location and direction of flow - Operational settings (pump curve or constant power)
Valves	Valves limit pressure or flow.	- Location and direction of flow - Type (e.g., pressure reducing, flow control) - Operational setting (pressure or flow) - Status (open or closed)

For more information on drinking water distribution system models, see the EPANET 2.2 online user manual, EPA's website on Small System Challenges and Solutions, and WNTR documentation on water network models.

Water Network Tool for Resilience Data Requirements

The **Water Network Tool for Resilience (WNTR)** requires certain data and component attributes to run hydraulic simulations and perform analyses. These data can be obtained directly from the drinking water utility or approximated from publicly available data sources. Table 2 outlines data requirements, attribute details, and possible data sources that only approximate WNTR model components. Models should be calibrated to replicate system operations.

Table 2: WNTR model data requirements, sources, and approximations

Component	Requirement	Attribute Details	Data Sources and Approximations
Nodes	Required	- All node locations are expressed as X, Y coordinates and can be in any coordinate system - Elevation can be from Z coordinate or set explicitly - Elevation is expressed as meters (m)	Elevation can be determined using digital elevation maps United States Geological Survey Digital Elevation Model: https://apps.nationalmap.gov/downloader/#/
Junctions	Required to connect components		The location of junctions can be inferred from link start and end location. If using street maps to approximate pipes, street intersections can be used to approximate junctions.
Demand points	Required for hydraulic simulation	- Base demand rate is expressed as a volume over time (m^3/s) - Demand patterns define how water use changes over time - Different patterns can be used to define changes in daily, weekly and seasonal demands or to demonstrate different water demands by sector or industry such as residential, commercial, and industrial	Demand location and base value can be approximated in several ways; for example, from open-source data on building footprints or census data of population density. General demand patterns can be used (e.g., peak mid-day for commercial use or peak morning and evening for residential use, and reduced demand during winter).
Reservoir	At least one reservoir or tank is required	- Hydraulic head is equal to elevation plus water pressure - Hydraulic head and water pressure are both in meters (m)	Location can be estimated using online maps of the region. Reservoirs are often open to the atmosphere and therefore have a water pressure of 0, and hydraulic head can be estimated as equal to the elevation (m).
Tanks	At least one reservoir or tank is required	- Minimum and maximum water level expressed as height of water in meters (m) - Diameter of cylindrical tank in meters (m) - If a tank is not cylindrical, a volume pattern can be used instead of diameter. A volume pattern shows how volume varies with water level.	Tank location and size can sometimes be approximated from satellite images. Volume patterns are difficult to approximate without guidance from the utility.
Links	Required	- All links have a start and end location - All links have a status that indicates if that link is in operation (OPEN) or not (CLOSED) - Link status and operational settings can be controlled with a schedule or other operating rules	
Pipes	Required to connect components	- Length in meters (m) - Diameter in meters (m) - Roughness coefficient in millimeters (mm) is used to calculate head loss as a function of flow rate	Because pipes generally follow streets, the location of pipes can be approximated using open-source street data. Attributes like diameter and roughness can be estimated if needed. Roughness can be estimated by pipe material, if known.
Pumps	Not required if the system is gravity fed	- Direction of flow - Operational settings such as pump curve or constant power setting - A pump curve defines how much hydraulic head is added to the system at different flow rates	Pump attributes are difficult to approximate without guidance from the utility.
Valves	While most systems include valves, they are not required	- Direction of flow - Types of valves include pressure reducing valve, flow control valve, pressure sustaining valve, throttle control valve, pressure breaker valve, and general pressure valve - Operational setting determines the pressure or flow rate the valve regulates for	Valve attributes are difficult to approximate without guidance from the utility.