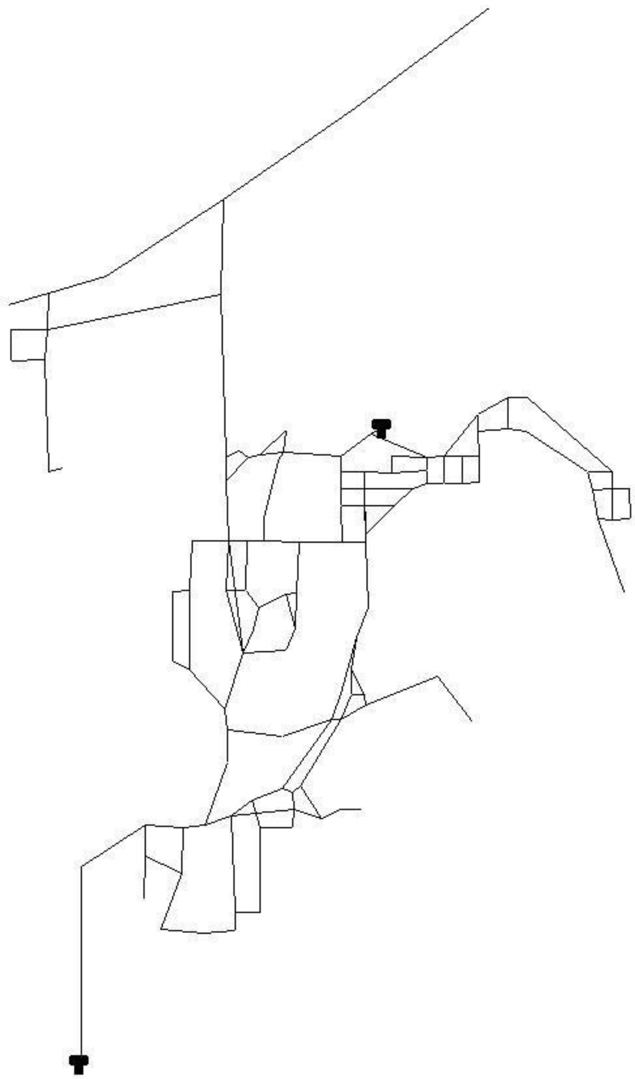
SYSTEM ID: WA1

NARRATIVE DESCRIPTION

The WA1 system is based on the Bellingham, WA water distribution system. The system has an average demand of 5.9 MGD provided to 57,000 people. The network was developed as part of study by Vasconcelos et al. (1997). It is divided into 11 pressure zones where 8 have gravity storage. The region used in the study is relatively isolated and is supplied almost entirely by the high service pumps from the clear well of the treatment plant. A general schematic of the system is shown below. The system has two tanks and 30.5 miles of pipe.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The WA1 system was originally developed by Vasconcelos et al. (1997) as part of an article “Kinetics of Chlorine Decay” which was published in 1997 in *AWWA Journal*. Free chlorine was measured at hourly intervals at 31 locations over a 35-hour period.

ORIGINAL REFERENCE:

Vasconcelos, J.J., Rossman, L.A., Grayman, W.M., Boulos, P.F. and Clark, R.M., 1997. Kinetics of chlorine decay. *Journal-American Water Works Association*, *89*(7), pp.54-65. https://doi.org/10.1002/j.1551-8833.1997.tb08259.x

ABSTRACT: Models of chlorine kinetics in distribution systems characterize chlorine decay as a combination of first-order decay in the bulk liquid and first-order or

zero-order decay reactions at the pipe wall. Proper understanding, characterization, and prediction of water quality behavior in drinking water distribution systems are critical to ensure meeting regulatory requirements and customer-oriented expectations. This article investigates the factors leading to loss of chlorine residual in water distribution systems. Kinetic rate equations describing the decay of chlorine were developed, tested, and evaluated using data collected in field-sampling studies conducted at several water utility sites. Results indicated that chlorine decay in distribution systems can be characterized as a combination of first-order reactions in the bulk liquid and first-order or zero-order mass transfer–limited reactions at the pipe wall. Wall reaction kinetic constants were inversely proportional to pipe roughness coefficients. Wide variations in both bulk reaction constants and wall reaction constants were observed among the sites.

ADDITIONAL CITATIONS:

The original publication of Vasconcelos et al. (1997) and by inference the WA1 system have been cited by 305 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 305 Citations.

AVAILABLE INFORMATION

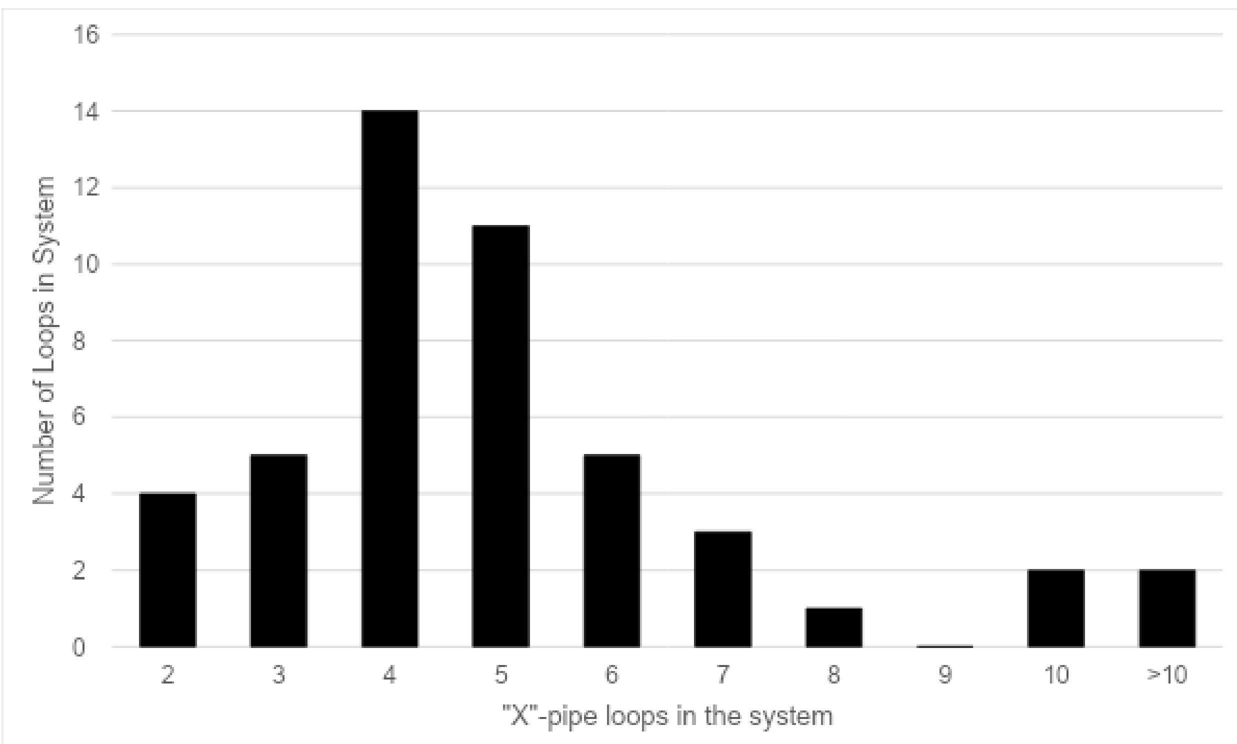
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	NA
Useful horsepower	
Pump operating curves	
Tank data	Yes
Elevation data	Yes
Stage storage curves	No
Water quality information	Yes
Valve data	Yes
PRV/FCV data	No
Isolation valve data	Yes
Hydrant data	No
Demand data	Yes
Total system demand	No
Nodal demand data	Yes
Temporal data demands	Yes
System leakage	No
Hydraulic data	No
Hydraulically calibrated model	
Field hydraulic calibration data	
Water quality data	Yes
Disinfection method	Yes
Chlorine residual data	No
Booster station data	No
Fluoride/Chloride field data	No
Water quality calibrated model	No
Operational data	No
SCADA datasets	
Operational rules	

SYSTEM CLASSIFICATION:

PIPE/LOOP HISTOGRAM:

Hoagland et al. (2015) designed a network classification algorithm for use in classifying water distribution systems as either “branched,” “looped,” or “gridded” based on the observed frequency of network loops with different numbers of distinct pipe segments. The frequency distribution for the WA1 system is provided below. Using this information, Hoagland et al., classified this system as being a LOOPED system.

# Total Pipes:	170
# Branch Pipes:	17
Ratio (Branch Pipes / Total Pipes):	0.10



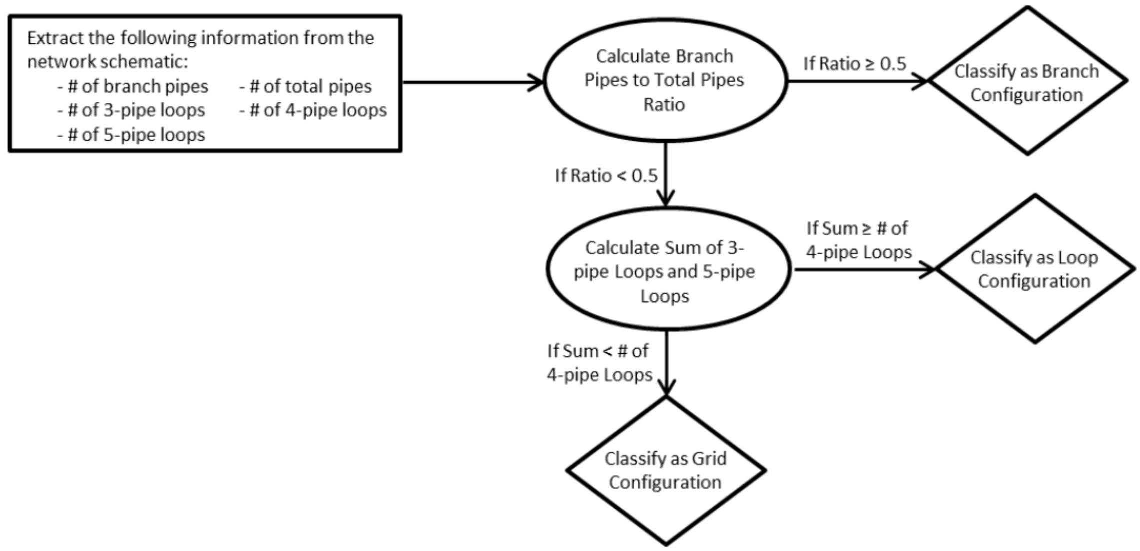


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

Hoagland, Steven & Schal, Stacey & Ormsbee, Lindell & Bryson, Lindsey. (2015). Classification of Water Distribution Systems for Research Applications. 696-702. 10.1061/9780784479162.064.

NETWORK STRUCTURE METRICS:

Building on the work of Hoagland et al., (2015), Hwang & Lansey (2017) created an expanded classification system that allows for further classification of a system as being either a transmission or distribution branched, looped, gridded, or hybrid system. Their algorithm streamlines the classification system by removing unnecessary nodes that do not contribute to the structure of the system while still retaining their use as intermediate points for demand data entry. A full description of the algorithm can be found in the cited reference.

Application of the Hwang and Lansey classification algorithm to the system yields the following statics and associated classification:

Parameter	Value
Edges	169
Pipes	168
Nodes	123
Average Diameter	8.5
Reduced Nodes	81
Reduced Edges	127
Branched Edges	16
Branched Index	0.1
Meshed Connectedness	0.2
Reduced Meshed Connectedness	0.3
Link Density	0
Average Node Degree	2.8
Hwang & Lansey Classification	Distribution Dense-Grid

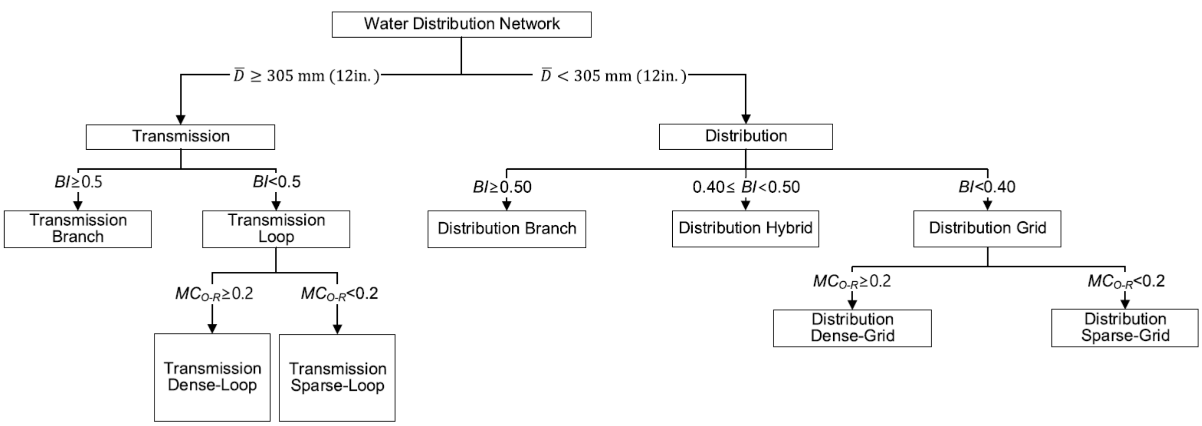


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

Hwang H. & Lansey, K. (2015) "Water distribution system classification using system characteristics and graph theory metrics." *Journal of water resource planning and management* 143(12) https://doi.org/10.1061/(ASCE)WR.1943-5452.0000850

DETAILED DATA SUMMARIES

PHYSICAL ASSETS:

Asset Type:	# of Assets
Master Meters	0
Tanks	2
Pumps	0
Water Sources	0

NETWORK CHARACTERISTICS:

# Total Pipes:	170
# Junctions	121
# Reservoirs	0
# Tanks	2
# Regulating Valves	0
# Isolation Values	1
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
4	12,053
6	45,130
8	48,763
10	18,890
12	29,310
16	3,200
18	3,802

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	NO

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Feet & inches
Pipe Age		
Node Elevation	X	Feet
Node Demand	X	GPM
Valves		
Hydrants		
Tank Levels	X	Feet
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		