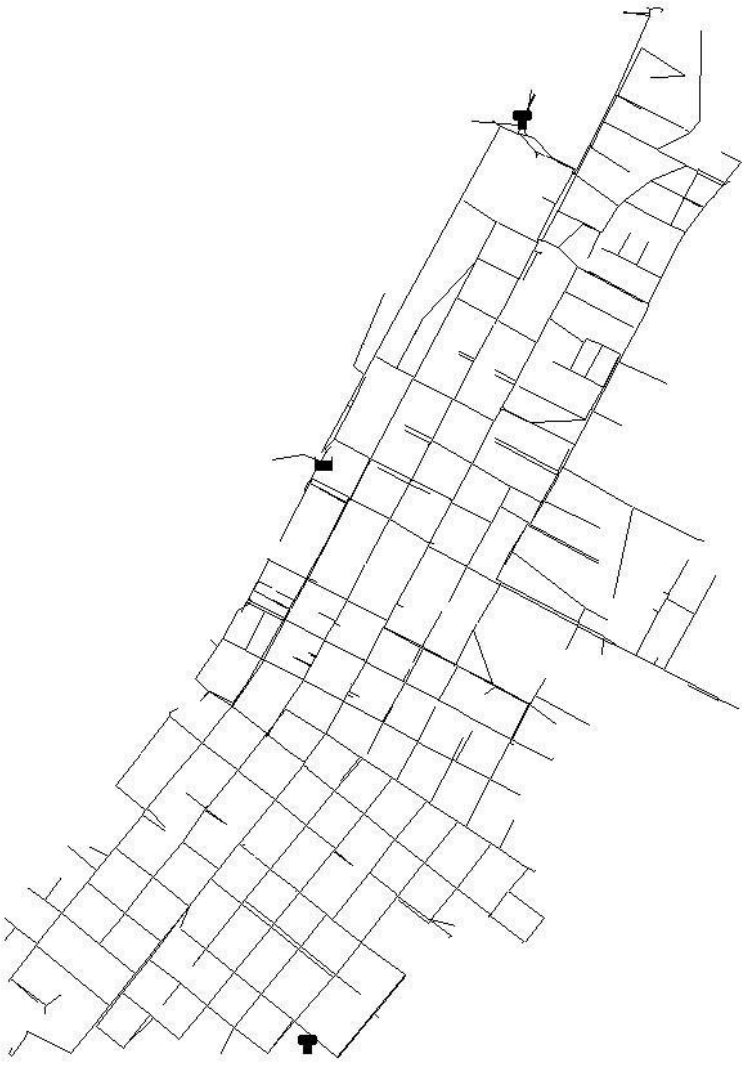
SYSTEM ID: KY 1

NARRATIVE DESCRIPTION

The KY 1 system is based on a real-world water distribution system in Kentucky. It serves about 6,422 customers and sells water at a rate of $8.00 per 1,000 gallons. The system has an average demand of 2.00 MGD. The network was used by Hoagland et al. (2015) as part of a classification study. A general schematic of the system is shown below. The system has one reservoir, two elevated storage tanks, and one pump. Water loss within the system is estimated to be 21%.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The KY 1 system was originally created by Steven Hoagland in 2015 as part of an article “Classification of Water Distribution Systems for Research Applications” which was presented in 2015 in the *World Environmental and Water Resources Congress*.

ORIGINAL REFERENCE:

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

ABSTRACT: Water distribution system models can aid utilities in achieving more reliable and optimal operations of their system. They are also useful in research efforts aimed at improving the planning, design, and operation of systems. This paper outlines the development, classification process, and analysis of 15 water distribution systems for the purpose of creating a database of system models which can be used among the research community to test newly developed algorithms. Differences in basic system characteristics based on configuration are also examined to determine if certain characteristics (e.g. number of tanks, average pipe diameter, etc.) vary systematically by configuration. The study aims to help quantify differences in the three main system configurations beyond the general layout differences. Such a classification may be useful in generalizing the economic performance, reliability, resiliency, or required characteristics (e.g. number of pumps, tanks, etc. per total system demand) of such systems. Such statistics may also be useful in helping to forecast system expansion needs (pipe, tanks, etc.), and security needs (i.e. number of water quality sensors, etc.) as the system continues to grow and expand.

ADDITIONAL CITATIONS:

The original publication of Hoagland et. al. (2015) and by inference the KY 1 system have been cited by 7 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 7 Citations

AVAILABLE INFORMATION

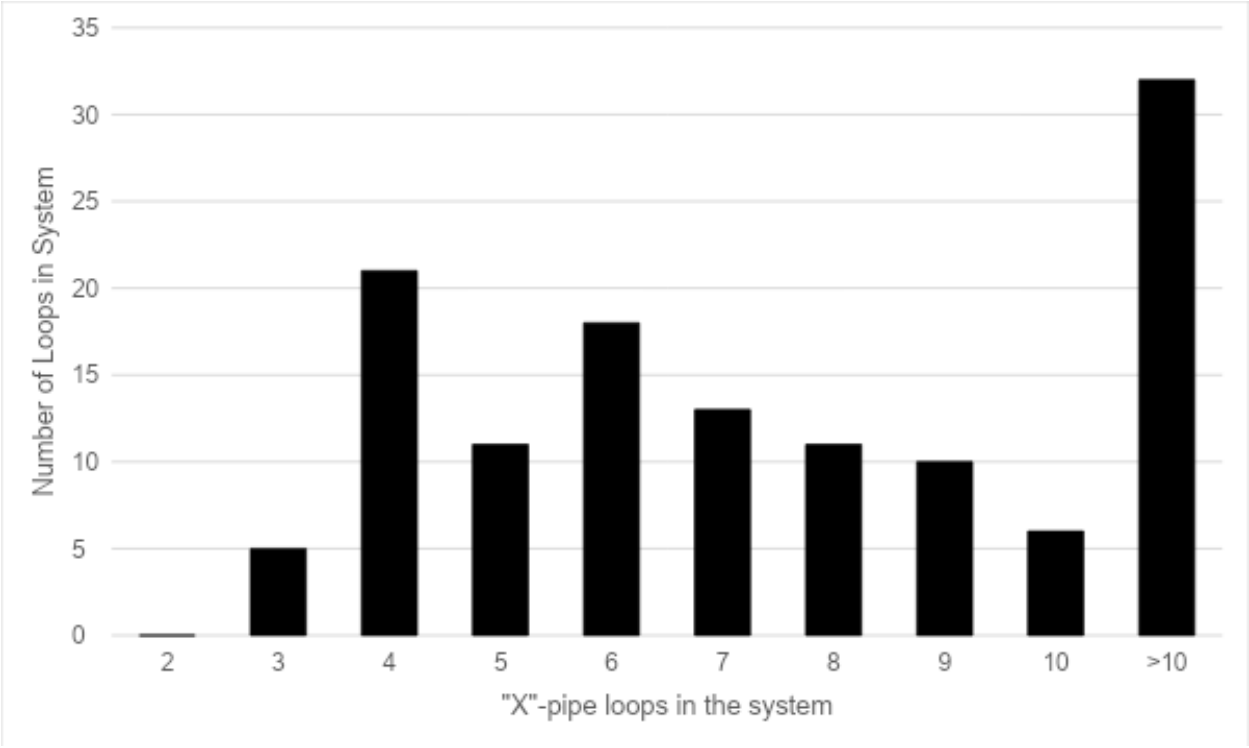
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	Yes
Background map	Yes
Elevation data	Yes
Pipe data	Yes
Pipe material	Yes
Pipe age	Yes
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	Yes
Useful horsepower	Yes
Pump operating curves	No
Tank data	Yes
Elevation data	Yes
Stage storage curves	No
Water quality information	No
Valve data	No
PRV/FCV data	
Isolation valve data	
Hydrant data	
Demand data	Yes
Total system demand	Yes
Nodal demand data	Yes
Temporal data demands	No
System leakage	No
Hydraulic data	Yes
Hydraulically calibrated model	
Field hydraulic calibration data	
Water quality data	No
Disinfection method	
Chlorine residual data	
Booster station data	
Fluoride/Chloride field data	
Water quality calibrated model	
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 KY 1 system is provided below. Using this information, Hoagland et al., classified this system as being a GRIDDED system.

# Total Pipes:	984
# Branch Pipes:	322
Ratio (Branch Pipes / Total Pipes):	0.327



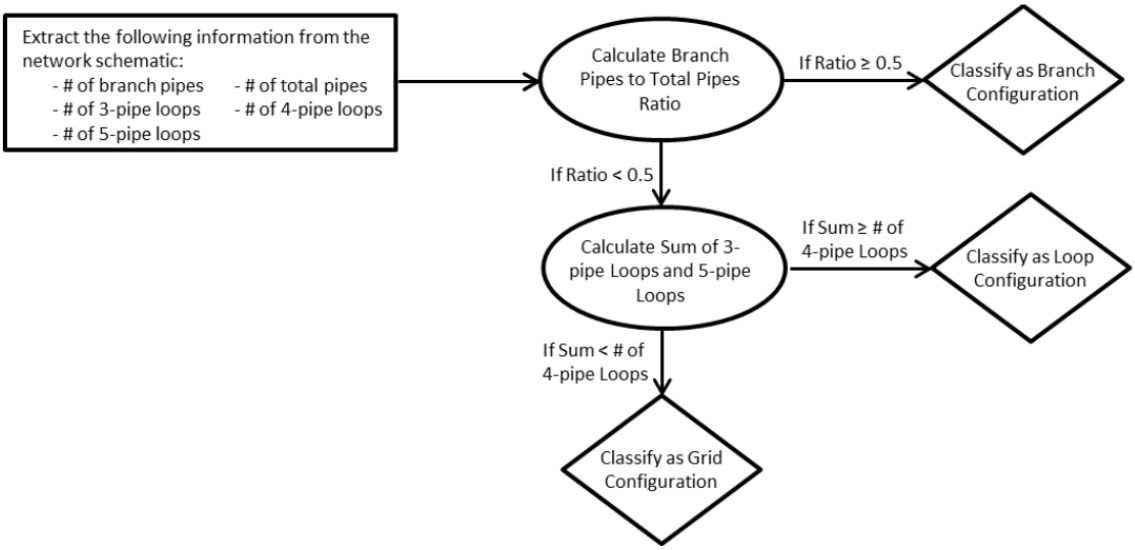


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	985
Pipes	984
Nodes	859
Average Diameter	8
Reduced Nodes	347
Reduced Edges	473
Branched Edges	308
Branched Index	0.4
Meshed Connectedness	0.1
Reduced Meshed Connectedness	0.18
Link Density	0
Average Node Degree	2.3
Hwang & Lansey Classification	Distribution Sparse-Grid

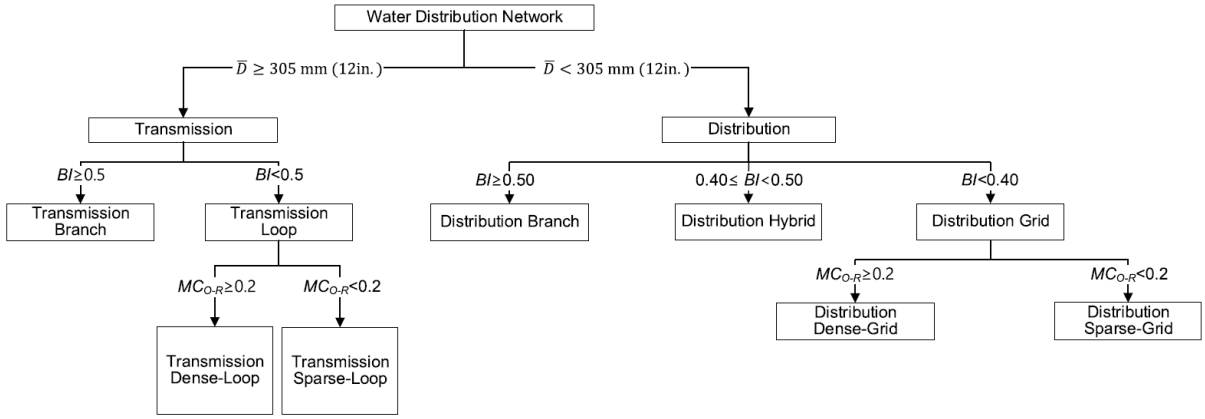


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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	1
Water Sources	1

NETWORK CHARACTERISTICS:

# Total Pipes:	984
# Junctions	854
# Reservoirs	1
# Tanks	2
# Regulating Valves	0
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
0.75	92
1	5240
1.25	4069
1.5	5935
2	16732
2.5	670
3	4818
4	25699
5	3812
6	58301
8	34379
10	1454
12	28688
14	515
18	4454
20	13962
24	2569
36	3197

PUMP DATA:

Pump Horsepower	YES
Pump Curves:	NO

DEMAND STATISTICS:

Demographic Type	Population	Households
Directly Serviceable:	16,025	6,468
Indirectly Serviceable:		
Total Serviceable:	16,025	16,025

Production Statistics	
Total Annual Volume Produced (MG):	
Total Annual Volume Purchased (MG):	490.702
Total Annual Volume Provided (MG):	490.702
Estimated Annual Water Loss:	21%

Water Costs	
Customer Type	Cost per 1000 gallons
Customers within the municipality	$8.18
Customers outside the municipality	

CUSTOMERS AND USAGE:

Customer Type	Customer Count	Average Demand (MG)
Wholesale:		
Residential:	6,148	313.230
Commercial:	273	36.253
Institutional:		
Industrial:	1	12.476
Other:		
Total Customers:	6,422	
Flushing, Maintenance & Fire Protection:		27.879
Total Water Usage:		389.838

DATA FILE ATTRIBUTES:

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