SYSTEM ID: KY 13

NARRATIVE DESCRIPTION

The KY 13 system is based on a real-world water distribution system in Kentucky. It serves 6,650 customers and sells water for $5.60 to $6.24 per 1,000 gallons. The system has an average demand of 2.7 MGD. The network was used by Schal et al. (2014) as part of a study on sensor placement in small utilities. A general schematic of the system is shown below. The system has two reservoirs, four pumps, five elevated storage tanks, and 95 miles of pipe. Water loss within the system is estimated to be 5%.

NETWORK SCHEMATIC:

HISTORY OF THE NETWORK FILE

The KY 13 system was originally created by Stacey Schal in 2014 as part of an article "A Graphical Procedure for Sensor Network Placement Guidance for Small Utilities" which was published in 2016 in the *American Water Works Association Journal*.

ORIGINAL REFERENCE:

Schal, S., Bryson, L.S. and Ormsbee, L., 2014. A graphical procedure for sensor-placement guidance for small utilities. *Journal-American Water Works Association*, *106*(10), pp.E459-E469. https://doi.org/10.5942/JAWWA.2014.106.0093

ABSTRACT: Efforts to improve water security have led to the development of contamination warning systems aimed at providing early indication of accidental or intentional contamination in drinking water distribution systems. Sensors that detect changes in water quality are a critical component of a contamination warning system. Because the extent of any monitoring system is constrained by a limited budget, focus is placed on optimizing the placement of sensors to maximize contamination detection and protect human health. Robust models and algorithms have been developed to recommend sensor deployment, but many require hydraulic or water quality models. Small utilities typically do not possess the resources to develop these models; therefore, researchers for this study developed the Water Quality Sensor Placement Tool to recommend placement of one water quality sensor without a model or complicated algorithm. This simple graphical procedure allows utility managers to use basic information about the geometry of their network to determine near-optimal sensor placement in limited time without complicated software.

ADDITIONAL CITATIONS:

The original publication of Schal et. al. (2014) and by inference the KY 13 system have been cited by 3 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 3 Citations

AVAILABLE INFORMATION

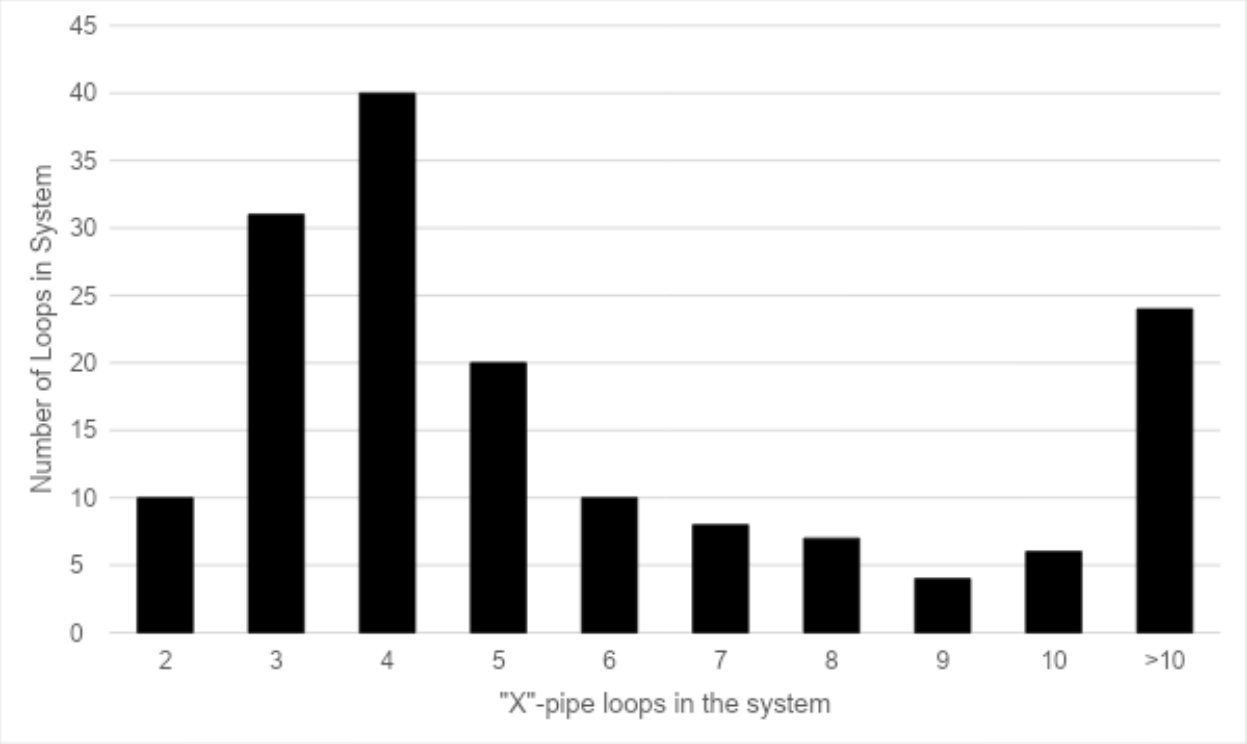
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	Yes
Background map	Yes
Elevation data	Yes
Pipe data	Yes
Pipe material	Yes
Pipe age	Yes
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	Yes
Useful horsepower	Yes
Pump operating curves	No
Tank data	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	Yes
System leakage	No
Hydraulic data	No
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	Yes
SCADA datasets	No
Operational rules	Yes

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 13 system is provided below. Using this information, Hoagland et al., classified this system as being a LOOPED system.

# Total Pipes:	940
# Branch Pipes:	377
Ratio (Branch Pipes / Total Pipes):	0.401



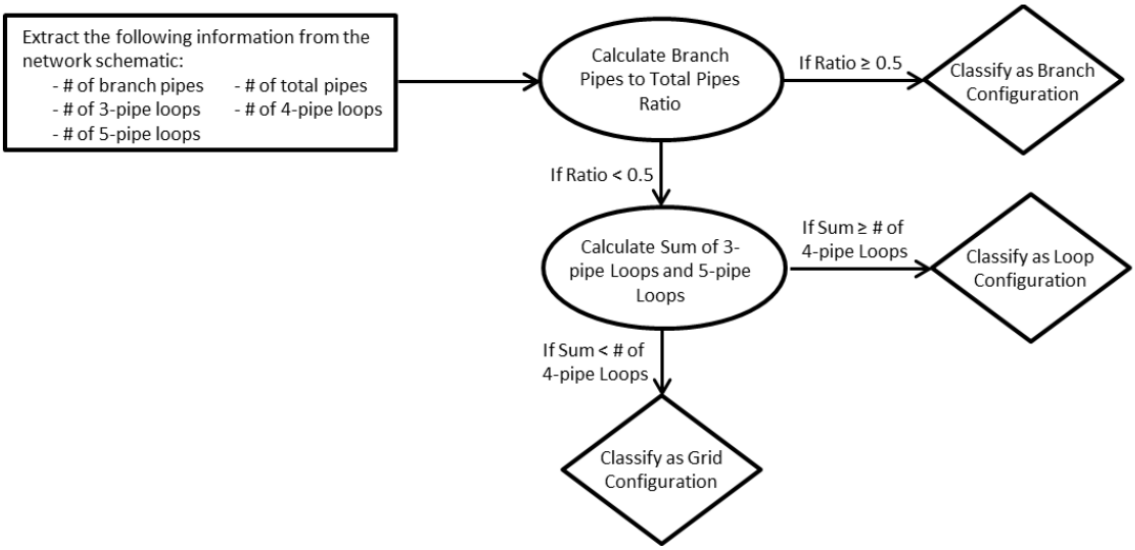


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	944
Pipes	940
Nodes	785
Average Diameter	8.5
Reduced Nodes	406
Reduced Edges	565
Branched Edges	366
Branched Index	0.4
Meshed Connectedness	0.1
Reduced Meshed Connectedness	0.2
Link Density	0
Average Node Degree	2.4
Hwang & Lansey Classification	Distribution Sparse-Grid

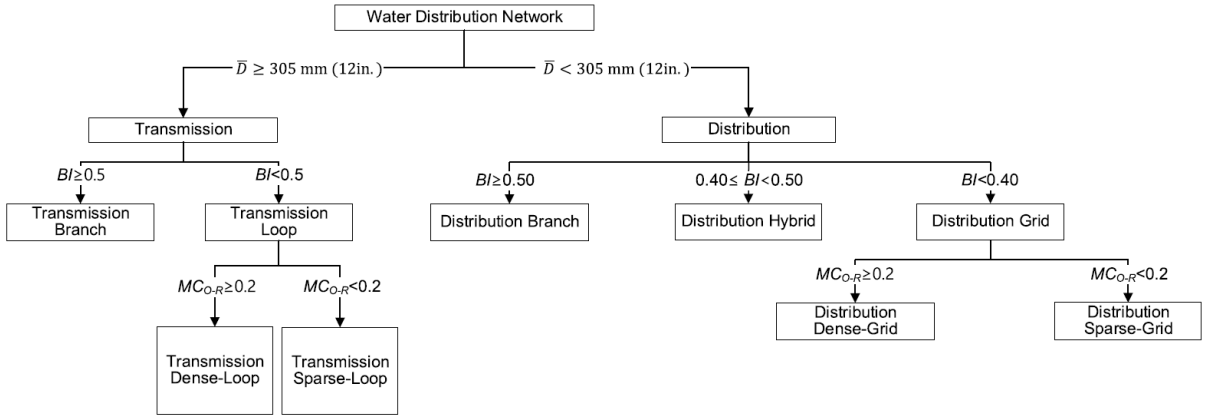


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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	5
Pumps	4
Water Sources	2

NETWORK CHARACTERISTICS:

# Total Pipes:	940
# Junctions	770
# Reservoirs	2
# Tanks	5
# Regulating Valves	0
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
1	3200
1.5	296
2	12,983
3	4,270
4	38,861
6	154,289
8	124,594
12	61,461
16	22,478

PUMP DATA:

Pump Horsepower	YES
Pump Curves:	NO

DEMAND STATISTICS:

Demographic Type	Population	Households
Directly Serviceable:	12,011	5,525
Indirectly Serviceable:	24,685	10,731
Total Serviceable:	36,696	16,256

Production Statistics	
Total Annual Volume Produced (MG):	1,032.325
Total Annual Volume Purchased (MG):	
Total Annual Volume Provided (MG):	1,032.325
Estimated Annual Water Loss:	5%

Water Costs	
Customer Type	Cost per 1000 gallons
Customers within the municipality	$5.60
Customers outside the municipality	$6.24

CUSTOMERS AND USAGE:

Customer Type	Customer Count	Average Demand (MG)
Wholesale:	6	310.435
Residential:	5,898	202.473
Commercial:	699	74.653
Institutional:	12	4.557
Industrial:	34	148.990
Other:	1	0.104
Total Customers:	6,650	
Flushing, Maintenance & Fire Protection:		128.192
Total Water Usage:		869.404

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		
Pump Data	X	HP