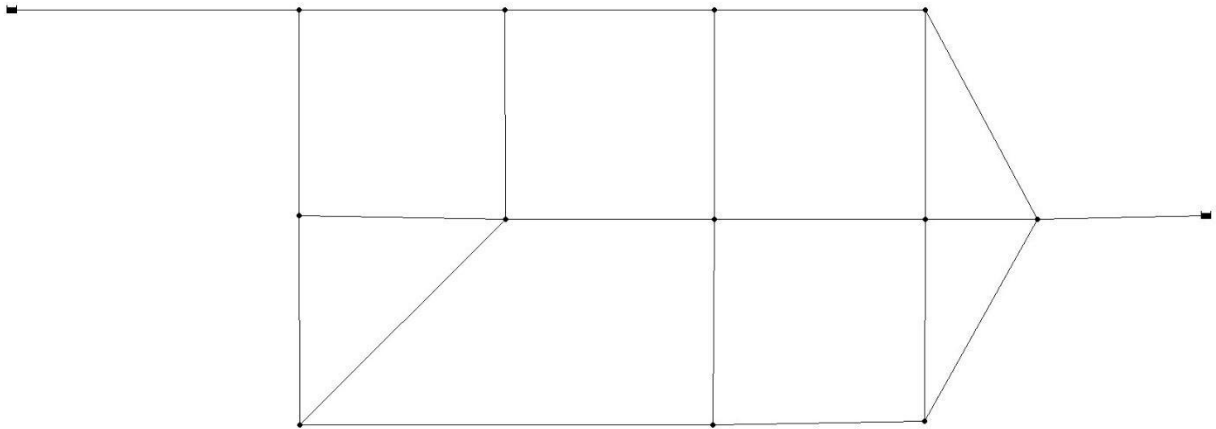


SYSTEM ID: Nineteen Pipe System

NARRATIVE DESCRIPTION

The Nineteen Pipe system is an artificial network used by Wood et al. (1972). A general schematic of the system is shown below. The system had two sources (represented by the square reservoirs in the schematic). There is elevation and demand data for junctions and length, diameter, and roughness data for pipelines.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Wood et al. (1972) and has since been republished in a modified form by Ormsbee & Wood (1972). Elevation data comes from this updated modified model. The original citation and abstract are listed below.

ORIGINAL REFERENCE:

Wood, Don J., Charles, Carl O. A. "Hydraulic network analysis using linear theory."
Journal of the hydraulics division, Proceedings of the American Society of Civil Engineers (July 1972): 1157-1170.

ABSTRACT: A method of analyzing flow distribution in hydraulic networks is presented. Basically, this method uses a linearized head loss term which allows a network of n pipes to be described by a set of n linear equations which can be solved simultaneously for the flow distribution. Because of the linear approximations used, several trials will be required to get an accurate solution. This method of analyzing hydraulic networks is characterized by an assured convergence which is very rapid when compared to other available methods. One reason for this is that it is possible to compute a fairly accurate initial flow distribution and no initial estimates are required. In addition, the method applies directly to both closed loop systems and open-closed loop systems. The method is also easy to program for a solution on a digital computer.

ADDITIONAL REFERENCES:

Ormsbee, Lindell E., Wood, Don L. "Hydraulic design algorithms for pipe networks."
Journal of Hydraulic Engineering, 1986 112(12): 1195-1206.

ADDITIONAL CITATIONS:

The original publication of Wood (1972) and by inference the Nineteen Pipe system have been cited by 354 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: [354 Citations](#). The additional reference has been cited 41 times and those citations can be found here: [41 Citations](#)

AVAILABLE INFORMATION

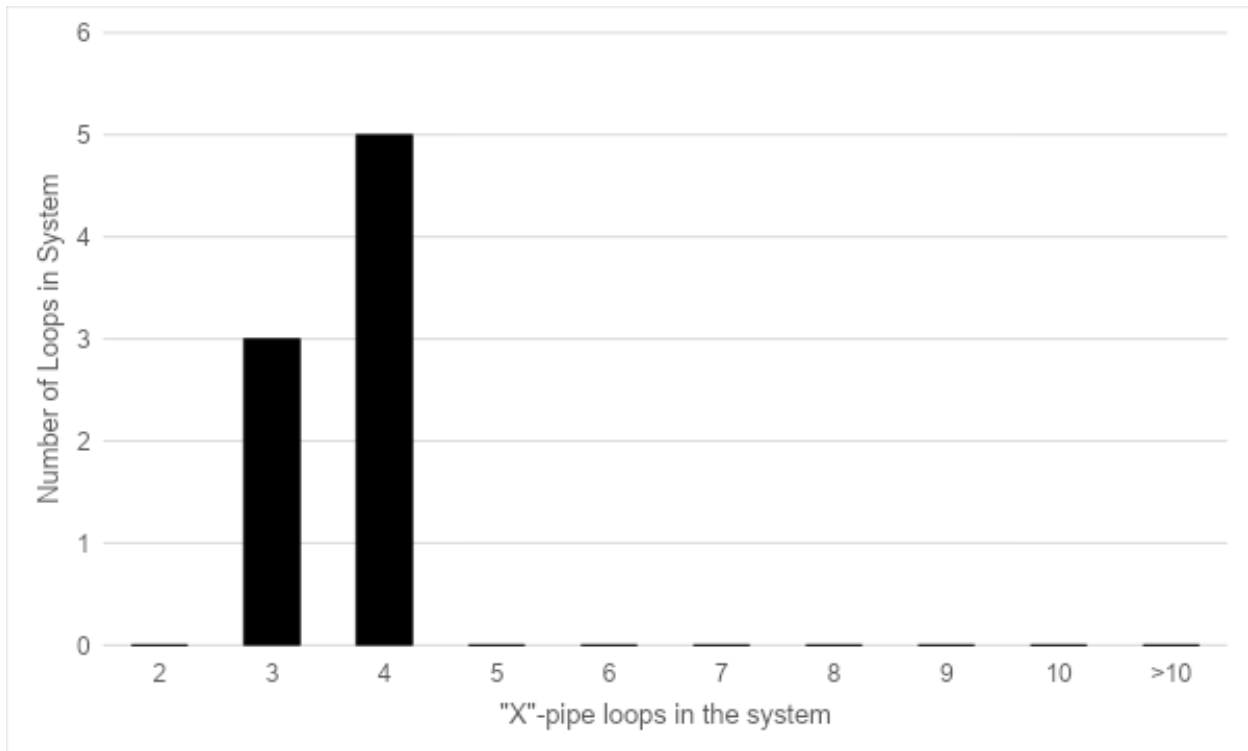
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
<i>Pipe material</i>	Yes
<i>Pipe age</i>	Yes
<i>Pipe pressure class</i>	No
<i>Nominal or actual diameters</i>	Nominal
Pump data	NA
<i>Useful horsepower</i>	
<i>Pump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

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 Nineteen Pipe system is provided below. Using this information, Hoagland et al., classified this system as being a GRIDDED system.

# Total Pipes:	21
# Branch Pipes:	2
Ratio (Branch Pipes / Total Pipes):	0.1



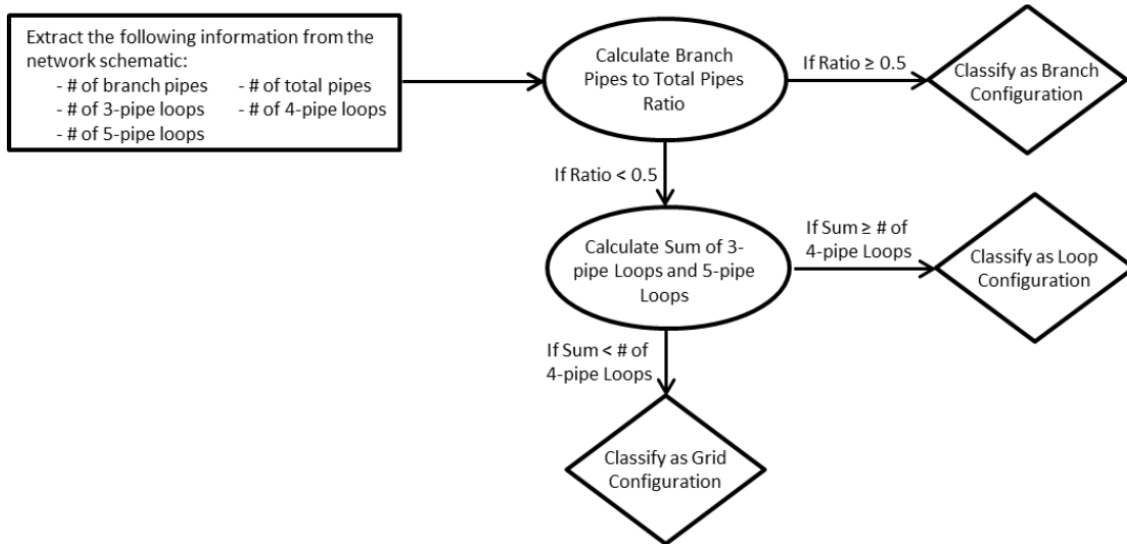


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	21
Pipes	21
Nodes	14
Average Diameter	7.75
Reduced Nodes	12
Reduced Edges	19
Branched Edges	2
Branched Index	0.1
Meshed Connectedness	0.4
Reduced Meshed Connectedness	0.24
Link Density	0.2
Average Node Degree	3
Hwang & Lansey Classification	Distribution Dense-Grid

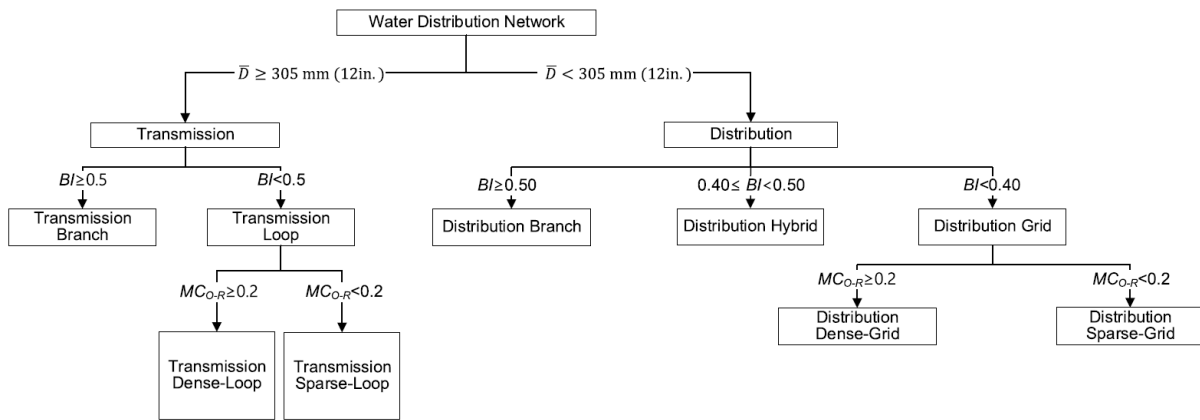


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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](https://doi.org/10.1061/(ASCE)WR.1943-5452.0000850)

DETAILED DATA SUMMARIES

PHYSICAL ASSETS:

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

NETWORK CHARACTERISTICS:

# Total Pipes:	21
# Junctions	12
# Reservoirs	2
# Tanks	0
# Regulating Valves	Unknown
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
6	10100
8	12400
10	3300
12	1631

PUMP DATA:

Pump Horsepower	NA
Pump Curves:	NA

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		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		