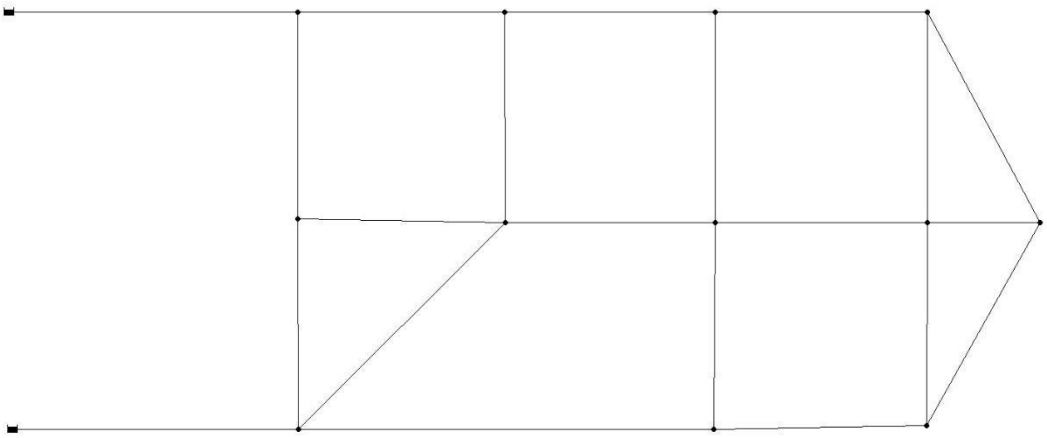
SYSTEM ID: Modified Nineteen Pipe System

NARRATIVE DESCRIPTION

The Modified Nineteen pipe system is an artificial system created to test computer modeling. The network was used by Ormsbee & Contractor (1981). It has a total demand of 3.1 MGD. 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. A pump is modeled by a negative demand at the right most node on the schematic.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Ormsbee and Contractor (1981) with a focus on the optimization of hydraulic network design. The original citation and abstract are listed below.

ORIGINAL REFERENCE:

Ormsbee, L.E. and Contractor, D.N., 1981, July. Optimization of hydraulic networks. In *International Symposium on Urban Hydrology, Hydraulics, and Sediment Control, Kentucky, Lexington, KY* (pp. 255-261).

ABSTRACT: Since the distribution system is often the major investment of a municipal waterworks, it is important that any design satisfies system requirements at a minimum cost. In current practice, the designer will usually employ a trial and error procedure to obtain a hydraulically feasible solution (i.e. one that satisfies flow and pressure constraints) and then compare the costs of the two solutions to obtain a least cost design. This process may be repeated a number of times until the designer is satisfied with the final design. Such a procedure can be very tedious and time consuming and requires a great deal of engineering judgement. It also suffers from the disadvantage that the designer can never really be sure that he has obtained the true or globally optimal solution.

The author has developed a general computer program to be used in the optimal design of hydraulic networks. The computer program can be used to optimize three basic variables; tank elevation, pump head, and discrete pipe diameter sizes. A modified Box-Complex optimization technique is used to minimize a nonlinear objective function while the linear method of hydraulic analysis is used in the evaluation of the network system constraints.

The optimization program was applied to two example networks. The general results of this study show that the new method is very efficient and has a strong tendency toward finding the global or absolute optimal solution.

ADDITIONAL CITATIONS:

The original publication of Ormsbee & Contractor (1981) and by inference the Modified Nineteen Pipe system have been cited by 16 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 16 Citations.

AVAILABLE INFORMATION

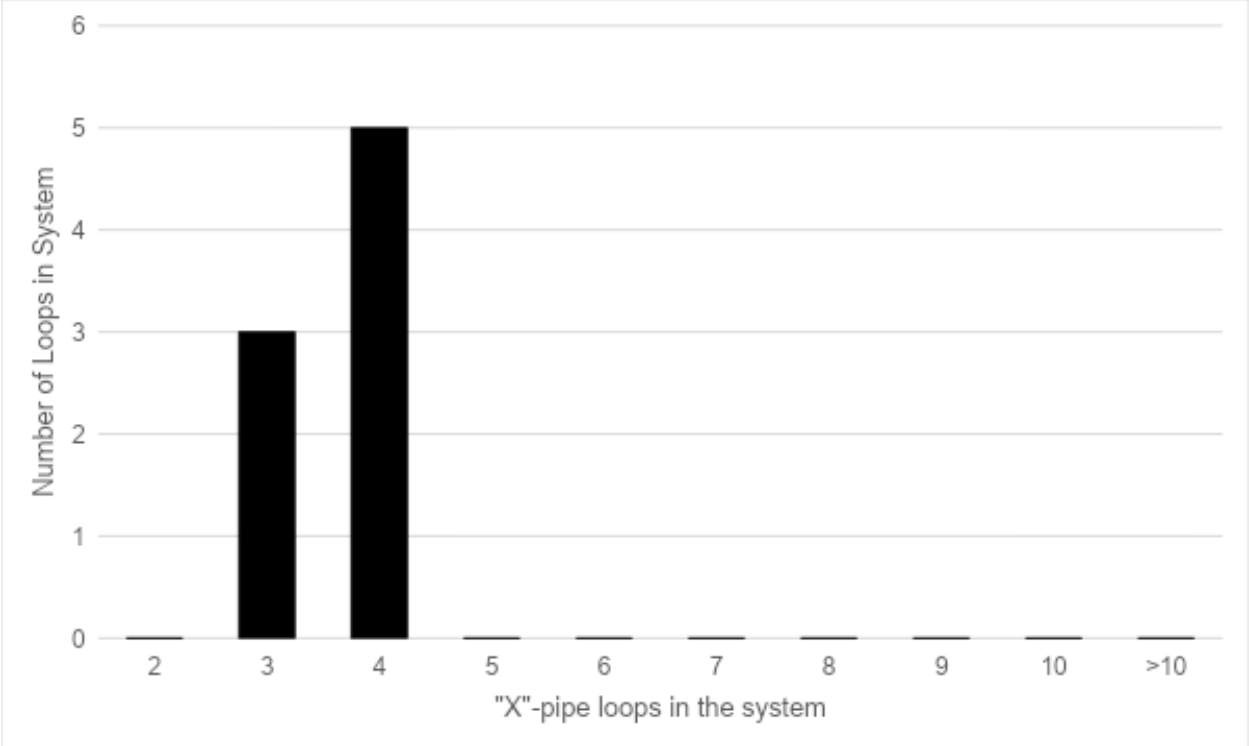
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	NA
Useful horsepower	
Pump operating curves	
Tank data	NA
Elevation data	
Stage storage curves	
Water quality information	
Valve data	NA
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	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	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 Modified 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



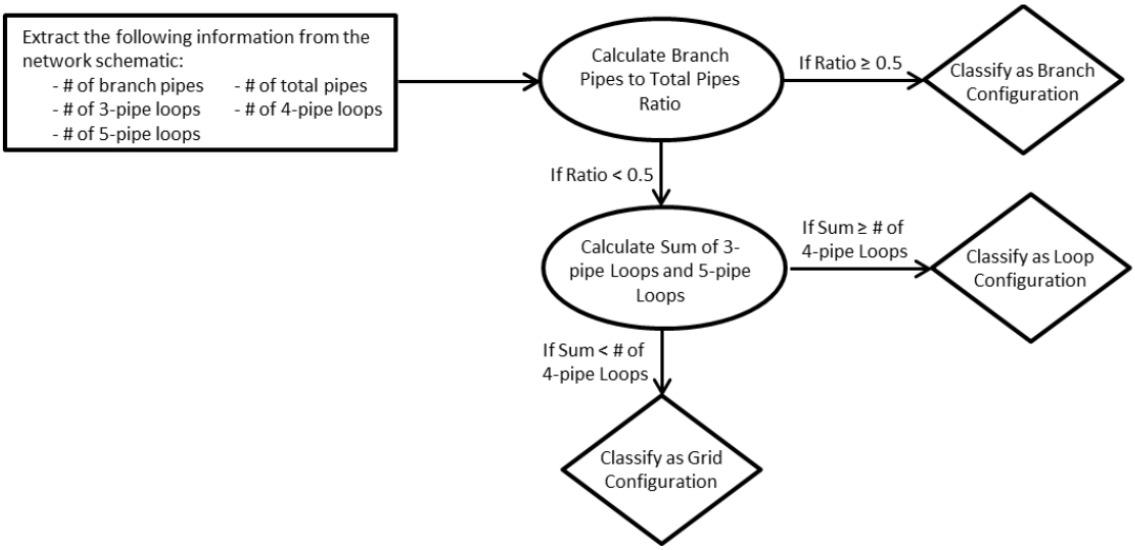


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	10
Reduced Nodes	12
Reduced Edges	19
Branched Edges	2
Branched Index	0.1
Meshed Connectedness	0.3
Reduced Meshed Connectedness	0.42
Link Density	0.2
Average Node Degree	3
Hwang & Lansey Classification	Distribution Dense-Grid

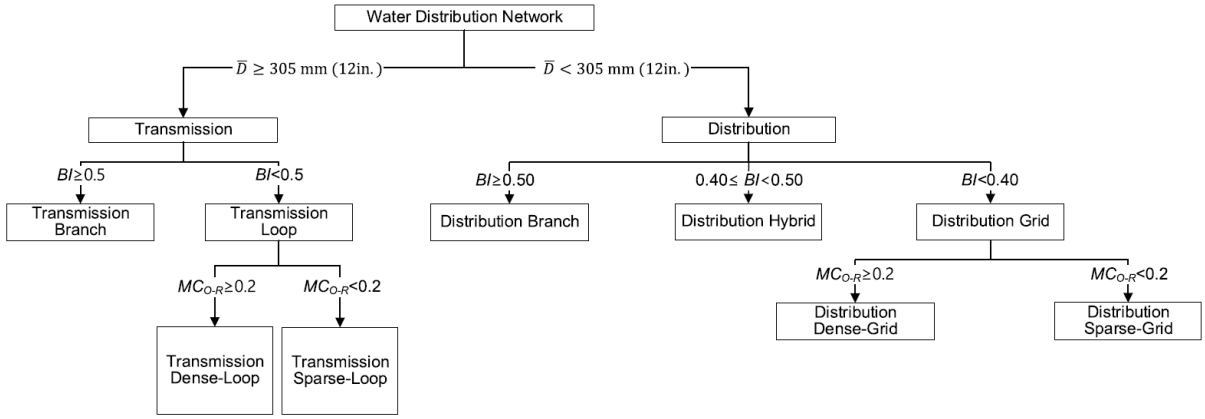


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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

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)
8	12600
10	13300
12	1100
14	6000

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		