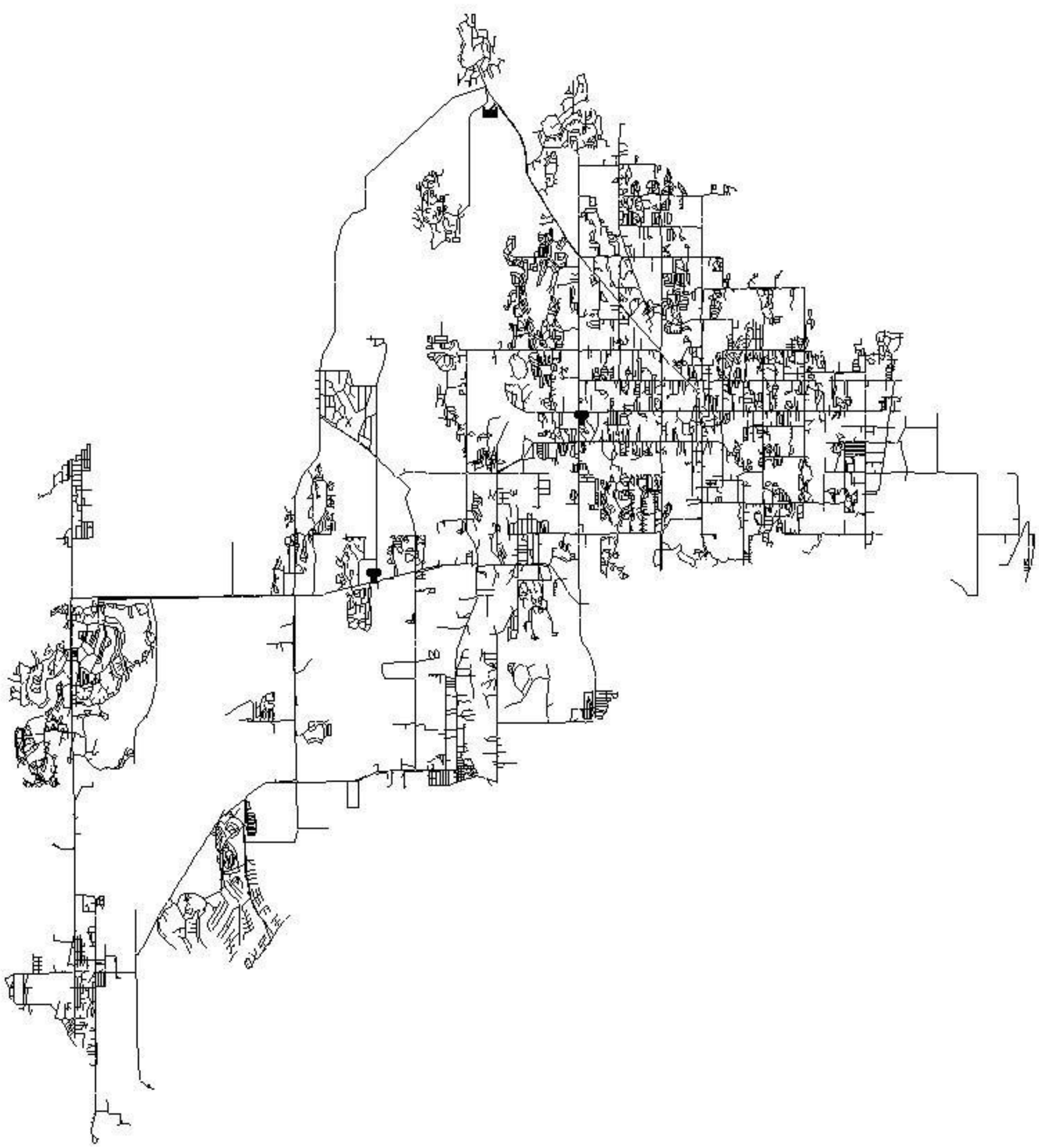
SYSTEM ID: Water Sensor Network 2

NARRATIVE DESCRIPTION

The Water Sensor Network 2 system is a larger example network provided as part of a design challenge aimed to improve water system design by Ostfield et al. (2008). It is a real system but the network has been distorted to conserve anonymity. The system has an average demand of 24 MGD. A general schematic of the system is shown below. The system has two sources, four pump stations, and two elevated storage tanks.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Ostfield et al. (2008) as part of the Battle of the Water Sensor Networks (BWSN): A Design Challenge for Engineers and Algorithms for Water Distribution System Analysis 2006 conference. For the Challenge, the teams were asked to develop designs according to a precise set of rules to facilitate design comparisons. These rules specified design performance metrics, the characteristics of contamination events, and the detection technology used to raise an alarm.

ORIGINAL REFERENCE:

Ostfeld, A., (2008). “The battle of the water sensor networks (BWSN): A design challenge for engineers and algorithms.” J. Water Resour. Plann. Manage., 134(6), 556–568.10.1061/(ASCE)0733-9496(2008)134:6(556)

ABSTRACT: Following the events of September 11, 2001, in the United States, world public awareness for possible terrorist attacks on water supply systems has increased dramatically. Among the different threats for a water distribution system, the most difficult to address is a deliberate chemical or biological contaminant injection, due to both the uncertainty of the type of injected contaminant and its consequences, and the uncertainty of the time and location of the injection. An online contaminant monitoring system is considered as a major opportunity to protect against the impacts of a deliberate contaminant intrusion. However, although optimization models and solution algorithms have been developed for locating sensors, little is known about how these design algorithms compare to the efforts of human designers, and thus, the advantages they propose for practical design of sensor networks. To explore these issues, the Battle of the Water Sensor Networks (BWSN) was undertaken as part of the 8th Annual Water Distribution Systems Analysis Symposium, Cincinnati, Ohio, August 27–29, 2006. This paper summarizes the outcome of the BWSN effort and suggests future directions for water sensor networks research and implementation.

ADDITIONAL CITATIONS:

The original publication of Ostfield et. al. (2008) and by inference the Water Sensor Network 2 system have been cited by 503 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 503 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	
Useful horsepower	
Pump operating curves	
Tank data	
Elevation data	Yes
Stage storage curves	
Water quality information	
Valve data	N.A.
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	No
Chlorine residual data	No
Booster station data	No
Fluoride/Chloride field data	No
Water quality calibrated model	No
Operational data	No
SCADA datasets	No
Operational rules	No

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

# Total Pipes:	14838
# Branch Pipes:	3831
Ratio (Branch Pipes / Total Pipes):	0.26

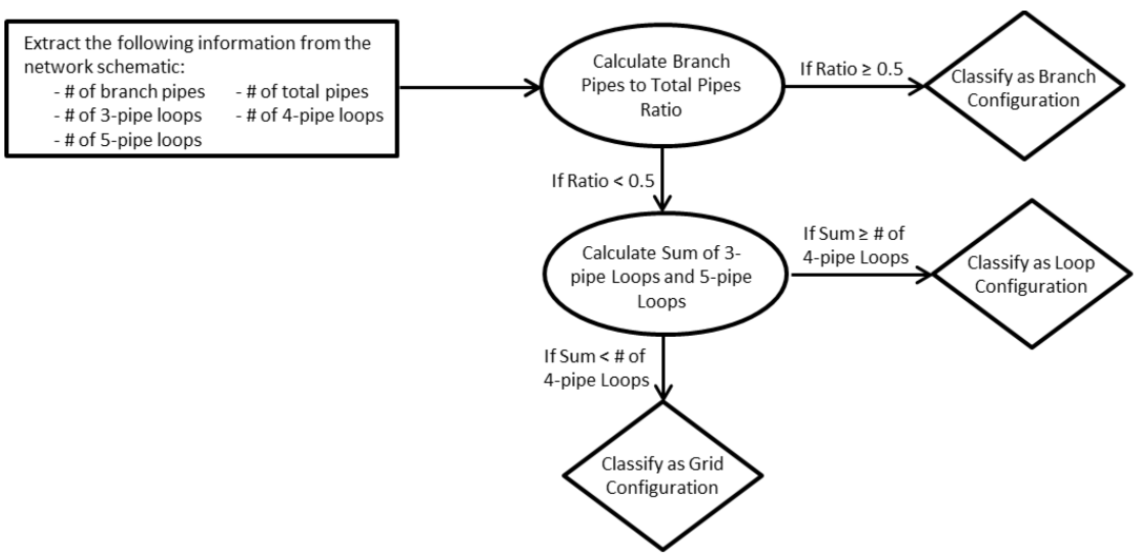


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	14831
Pipes	14820
Nodes	12527
Average Diameter	8.3
Reduced Nodes	9593
Reduced Edges	11897
Branched Edges	2934
Branched Index	0.2
Meshed Connectedness	0
Reduced Meshed Connectedness	0.12
Loop Density	0
Average Node Degree	2
Hwang & Lansey Classification	Distribution Sparse-Grid

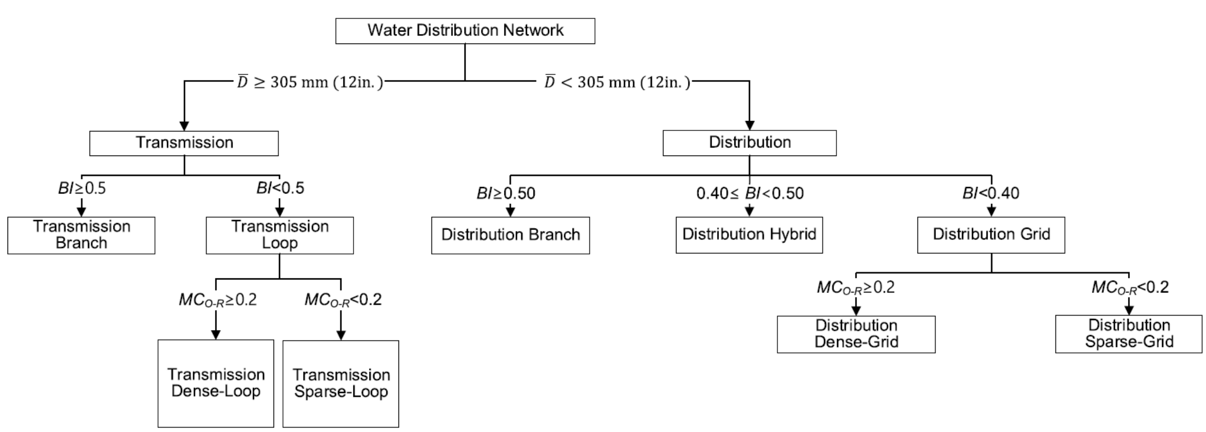


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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	4
Water Sources	2

NETWORK CHARACTERISTICS:

# Total Pipes:	14822
# Junctions	12523
# Reservoirs	2
# Tanks	2
# Regulating Valves	5
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
1	6935.4
1.5	2335.5
2	332217.64
2.5	11560.6
3	58387
4	759510.5
5	896.9
6	2203668.3
8	1312683.4
10	134821.92
12	659391.7
14	6888.2
16	202696.17
18	46443.99
20	92088.02
24	57003.6
30	20085.71
36	77204.07
42	63593.1

48	173

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		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		