Concise User Guide WDC Version 2.2

Dan Cole

Estimating Peak Demand for the Water Supply System Using the Water Demand Calculator

Learning Objectives

- Understand the development of Hunter's curve and reasons for its shortcomings
- Understand the features of the Water Demand Calculator for estimating peak water demand
- Have a basic knowledge of how to use and apply the Water Demand Calculator

History of Hunter's Curve and the Need for Revision

What are the chances? Cautious risk-takers and gamers want to know the odds of winning or losing before investing or laying a bet. Of course, you have the extremes of those who throw all caution to the wind and gamble away their money, and those who take no risks at all, wanting that 100 percent certainty of success before making a move. Solving problems regarding games of chance for the cautious risk-takers have occupied mathematicians since the 17th century. Christian Huygens, Pierre Remond de Montmort, and Jakob Bernoulli are famous for publishing mathematical solutions relating to doctrines of chance that launched a new mathematical trajectory of probability and statistics. Before laying their money down, gamers and risk-takers wanted to know their chances for winning and the odds of losing and they would send their inquiries to the mathematicians. Card theory, slot machines, roulette, craps, poker, and 21 all became subject to the burgeoning principles of probability.

Gaming was not the only application for mathematical probability. Today, probability and statistics have spread throughout the world of business, industry, manufacturing, sports, SATs, medicine, insurance, and wherever there is the need to predict outcomes. Even plumbing benefited from principles of probability. When designing a plumbing system, is there a need to predict an outcome? Is there a chance of failure if the system is not designed properly? Are there risks associated with improperly sizing a plumbing system? Is there a way to know the odds on whether the system design will be a success or failure? Is guesstimating throwing caution to the wind, or should systems be designed with a 100 percent certainty basing the expected outcome on every fixture and appliance operating simultaneously every time?

Prior to the 1920s there was no uniformity on how to estimate the water supply demand needed for a building or how to determine the minimum supply pipe size. Generally, it was a guess, and the pipe was generously sized to meet any demand. Pipe sizes and costs of material could be reduced if a peak demand could be calculated and applied to the supply pipe. A peak demand would only include fixtures that would be on simultaneously. What calculation would determine that? If the problem was framed as a question asking, what are the chances of more than one fixture being on at the same time, the solution involves mathematical probability.

Applying principles of probability to the design of the plumbing system was first introduced by Roy B. Hunter in a 1923 National Bureau of Standards publication.[1] Originally applied for the drainage system, he later refined the principles of probability when applied to the water distribution system in a 1940 publication.[2] Since that time, all plumbing codes in the U.S.A. and even abroad adopted the method of probabilities developed by Hunter for estimating the demand loads for water distribution systems.

What was Hunter doing and how was he applying principles of probability to the plumbing system? Which outcome was he trying to predict? Were there odds of failure?

Hunter was trying to eliminate the tendency for oversizing the water distribution system in cases where there were many fixtures in larger buildings, which was more of a rule-of-thumb procedure often resulting in too large an estimate. The principles of probability would more accurately predict the estimated outcome of how many fixtures out of a total number of fixtures would be operating at the same time. Designing a water distribution system based on a predicted outcome is an estimation of peak demand. Peak demand is the predicted number of fixtures (let's call this number *x*) out of a total number of fixtures (let's call this number *n*) that are expected to be drawing from the water supply at the same time. The water supply would be designed for the peak demand of the number of *x* fixtures and not the total number of *n* fixtures.

To predict this *x* value, Hunter applied the Bernoulli trial, the law of combinations, and the binomial distribution. A *Bernoulli trial* is one that has only two possible outcomes. In the case of plumbing fixtures and appliances, the only two possible outcomes are that the fixture is either on or off. The probability (p) that a fixture is on is determined by t/T, where t is the duration of time that water is flowing through the fixture when it is on, and T is the average time in between successive uses of the fixture. Suppose a tank-type toilet takes sixty seconds to fill after a flush, and that it is used on average every 300 seconds (five minutes) during a busy time. The probability that the toilet fixture is on is 0.20 (60/300), or 20%.

The *law of combinations* was applied to the number of ways in which two or more independent events can occur together at the same instant of observation. This accounts for random selection. Suppose there is a battery of six toilets. How many ways can two independent toilets flush together at the same time? The mathematical expression is $C\binom{6}{2}$ = 15. There are 15 different ways to combine two independent toilets out of a total number of 6 toilets.

The *binomial distribution* models the probability distribution of the number of successes x in a sequence of independent outcomes for a given number of trials, n. The mathematical formula gets a little more complicated and is expressed as:

$$\Pr\left[x\ busy\ \ fixtures \middle| n,p\right]=\binom{n}{x}(p)^{x}(1-p)^{n-x} \qquad x=0,1,\ldots,n \qquad [1]$$

Equation [1] gives the probability that a number of fixtures *x* that would be on at the same time out of a total of *n* fixtures. Suppose there were a total number of n = 100 toilets each having a probability of p=0.20 of being on. A cumulative binomial distribution is seen in Figure 1 showing three cases. In case 1, what is the probability of at most fifteen toilets flushing at the same time? The cumulative binomial distribution predicts 0.13 or a 13% chance. What does this mean? It means that there is a 13% chance that no more than 15 toilets will be flushing at the same time. Or to describe it another way, there is an 87% chance that more than 15 toilets will flush simultaneously. In case 2, what is the probability of at most twenty toilets flushing at the same time? The cumulative binomial distribution predicts 0.56 or 56%. That means that there is a 44% chance that more than 20 toilets will flush simultaneously. In case 3, the probability of no more than thirty toilets flushing simultaneously is 0.99 or 99%. That means that there is only a 1% chance that more than 30 toilets will flush simultaneously. Which outcome do you select for design purposes? The 13%, 56% or the 99% confidence level? Hunter chose the scenario at the 99th percentile. This means that you would design the water supply for the demand for only thirty toilets rather than the total number of 100 toilets, a substantial savings at a very low risk of under sizing the water supply distribution.

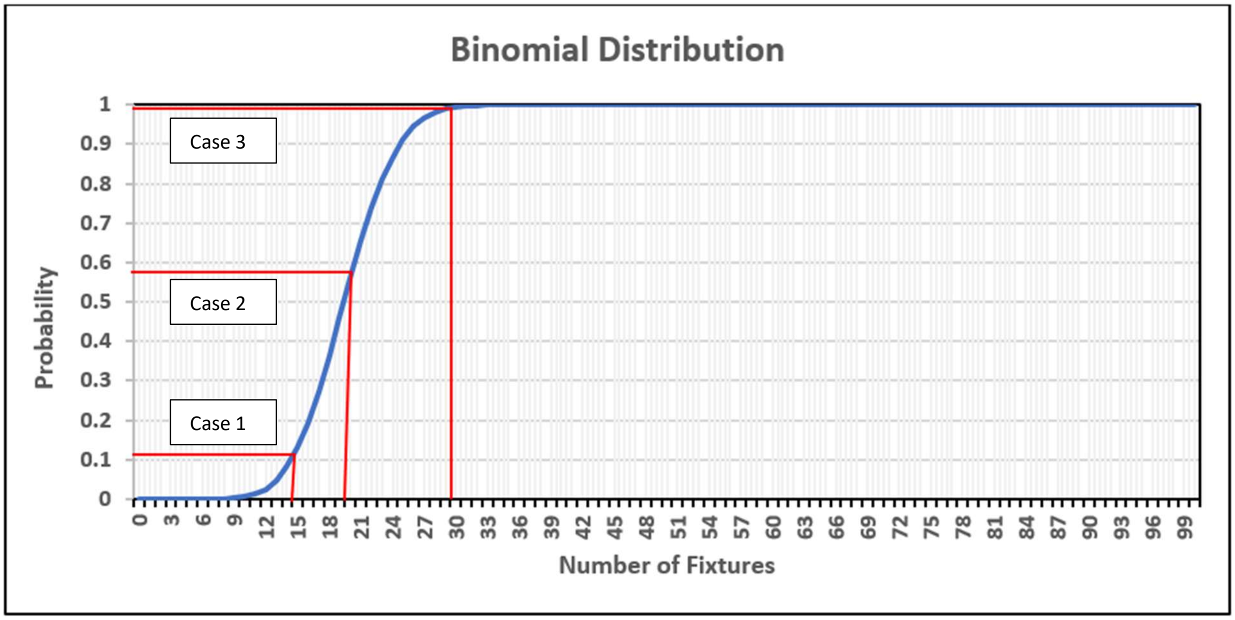


Figure 1: Cumulative Binomial Distribution

Using the 99th percentile as his threshold, Hunter developed a binomial distribution curve for design purposes (see Figure 2). This was a boon for the plumbing industry and was universally adopted in plumbing codes throughout the U.S.A. for water supply estimating and pipe sizing.

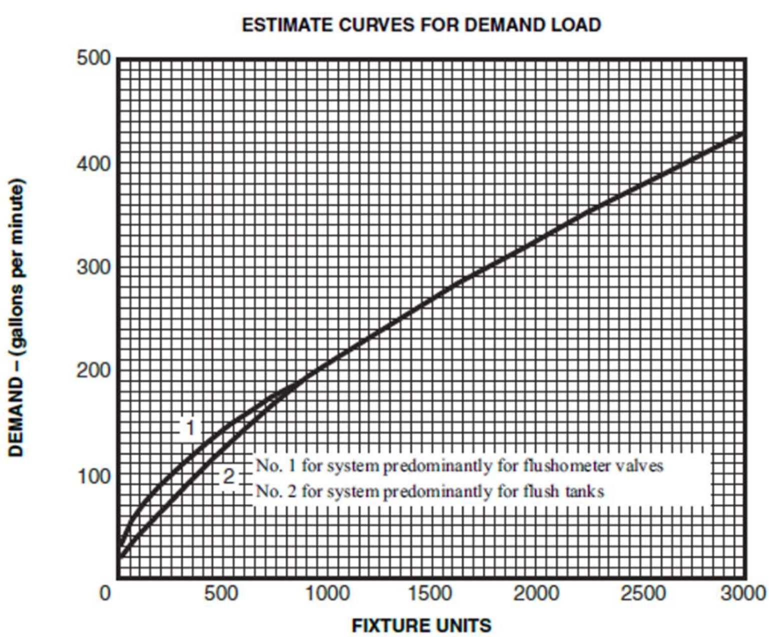


Figure 2: Hunter's Curve

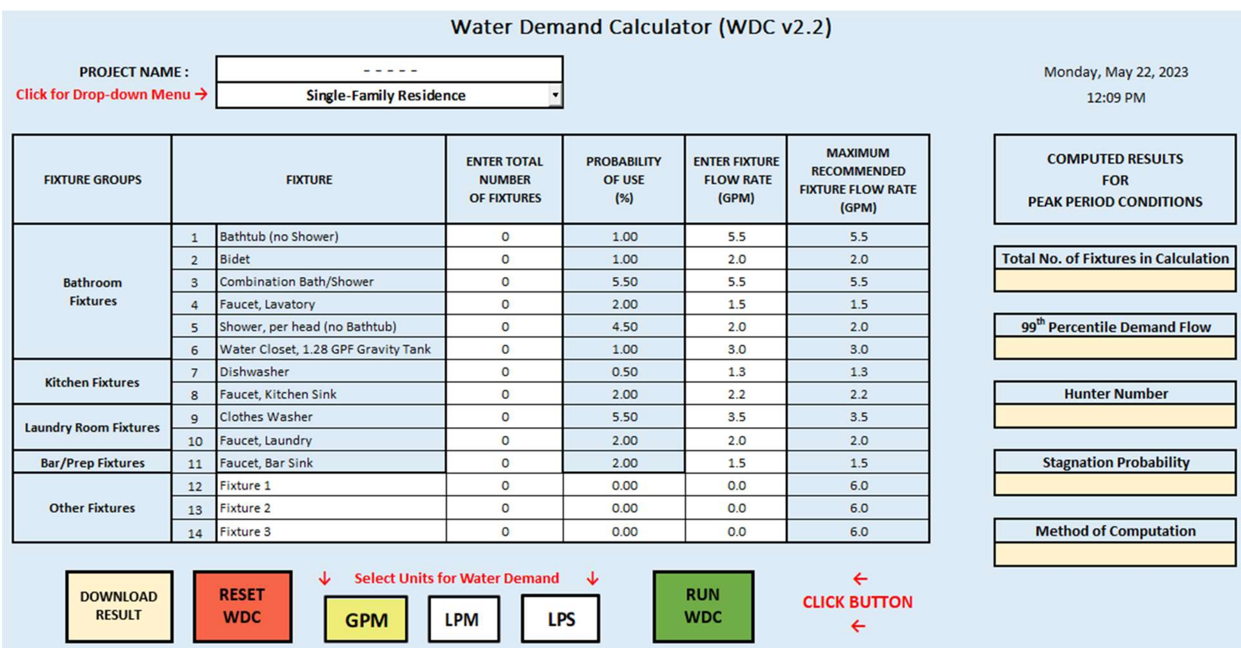
Hunter's method worked well for 30 years until criticism arose among practicing engineers that the curve estimates of peak demand were excessive, causing the system to be oversized.[3] Even though the values of fixture units were reduced in plumbing codes, peak demands were still overestimated. Sparsity of field data prevented any improvement to modify the parameters of the probability model.

What were the reasons for the curve estimates to become excessive 30 years later? There were two things occurring over the years since the 1940s. Plumbing fixtures and appliances were becoming more efficient with lower water consumption. Secondly, the frequency of use for the same kind of fixture varied significantly in different building types as modern building design and occupancy became more diversified. In other words, the Bernoulli trial mentioned above (t/T), which determined the probability of when a fixture is on, was no longer constant in every building classification. It was only applicable when the frequency of use was experiencing congested conditions where people in queue were waiting to use a fixture, one following the other user.

Furthermore, government policies such as the Energy Policy Act (EPAct) of 1992, which mandated water conservation for plumbing fixtures, and the EPA WaterSense program, which recommends water reductions by 20% lower than EPAct, exacerbated over estimating peak demand when using Hunter's design curve. States experiencing problems of drought and water scarcity are still resolving to further reduce water consumption for plumbing fixtures.

Building a Better Computational Model

IAPMO now offers a solution to the problem of overestimating peak water demand. Having partnered with the American Society of Plumbing Engineers and the University of Cincinnati, IAPMO developed a new Water Demand Calculator™ (WDC) for estimating water supply demand for residential single and multifamily dwellings (see Figure 3). This new method is published in the IAPMO American National Standard Codes.[4]


Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

Monday, May 22, 2023
12:09 PM

FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	0	5.50	5.5	5.5
	4	Faucet, Lavatory	0	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	0	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation

99th Percentile Demand Flow

Hunter Number

Stagnation Probability

Method of Computation

DOWNLOAD RESULT | RESET WDC | Select Units for Water Demand: GPM | LPM | LPS | RUN WDC | ← CLICK BUTTON ←

Figure 3: Input Template for Water Demand Calculator

New probability computations for peak water demand are brought into the 21st century through a programmed MS Excel spreadsheet with a table of plumbing fixtures and appliances most commonly found in residential dwellings. The blue cells are locked, but the white cells allow for input values. The white cells for Other Fixtures allow the input of other indoor fixtures not listed in the WDC. No outdoor fixtures such as hose bibbs and lawn irrigation may be considered as other fixtures. Notice the fixture flow rates are for water-conserving plumbing fixtures and appliances, and the values in the flow rate column (white cells) may be lowered as actual fixture flow rates are being reduced, but they cannot exceed the recommended maximum flow rates shown in the right-most blue column. The probability of fixture use was derived from a large U.S. database for residential end use of water survey.[5] To use this spreadsheet for estimating peak water supply demand loads, enter the number of fixtures and appliances in the Total Number of Fixtures column and then click on the box that says Run WDC. The estimated demand flow will automatically be calculated and then displayed in the computed results on the right-hand side.

The WDC saves time, reduces the margin of error, promotes broader applicability, and is user-friendly. This is what the Water Demand Calculator provides for plumbing system designers in an MS Excel spreadsheet. There are three formulas programmed in the Excel spreadsheet. The calculator will select only one formula based on the numbers placed in the spreadsheet and will display the method used in the yellow box under Method of Computation when the calculator is run. It will then evaluate the number for each kind of fixture with its corresponding frequency of use (the p-value), sum up the values, and place that value within a range determined for one of the formulas. Once the formula is chosen, the WDC computes the peak demand and places the answer in the 99th Percentile Demand Flow box within seconds.

Application – Single and Multi-family Dwellings

The WDC can be downloaded free using the link provided at the end of this chapter. It is recommended that you use the WDC in the following examples. The isometric drawing (Figure 4) shows a residential home with one bathroom, kitchen, and clothes washer. First, estimate the demand for the whole house at Pipe Section 4. Notice there are six indoor fixtures – one lavatory, combination bath/shower, water closet, kitchen faucet, dishwasher, and clothes washer. Since there is only one of each, place the number 1 in the Number of Fixtures column after each of the six fixtures in the WDC. After doing so, click on the box that says Run WDC. The estimated demand for the whole house will appear in the 99th Percentile Demand Flow box. In this example, the estimated demand for the whole house is 9.0 gpm (see Figure 5).

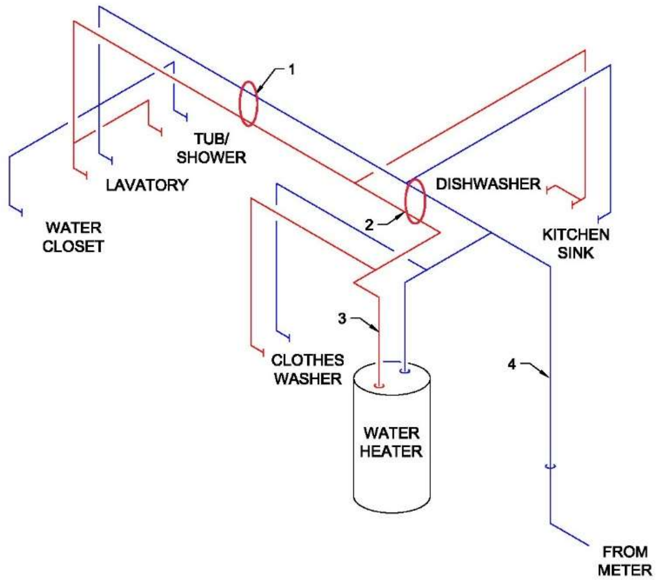
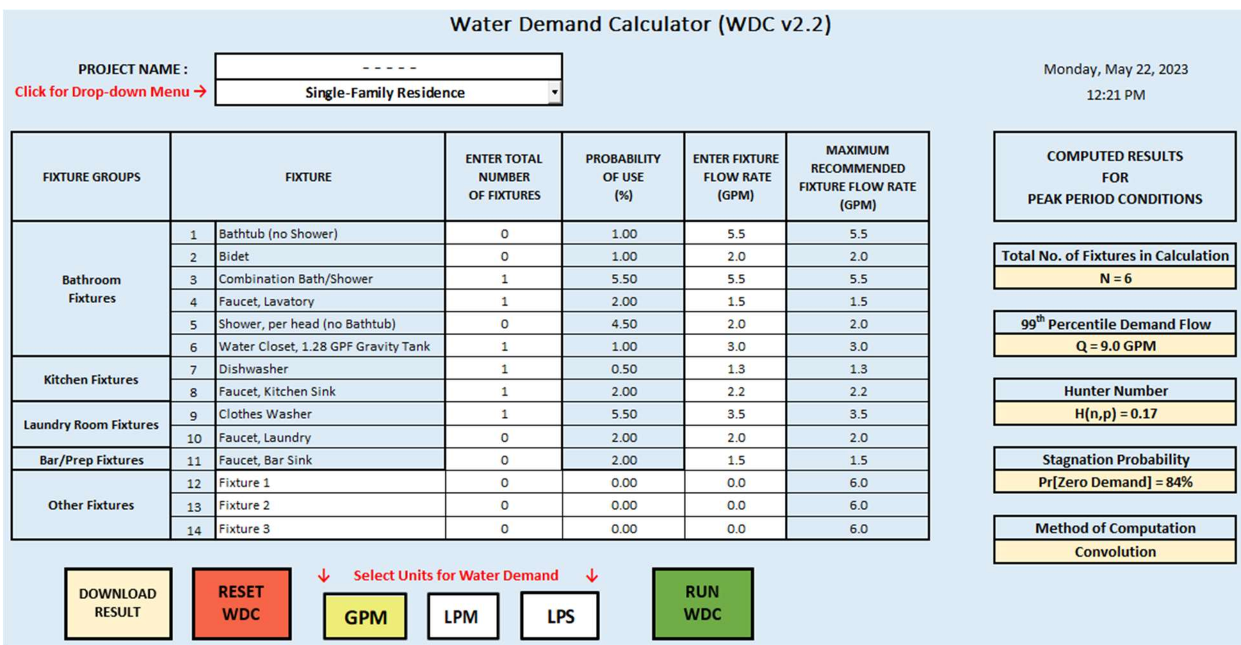


Figure 4: Sample Isometric Plan for Water Supply to Single Family Home



Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

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FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	1	5.50	5.5	5.5
	4	Faucet, Lavatory	1	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	1	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	1	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	1	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	1	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

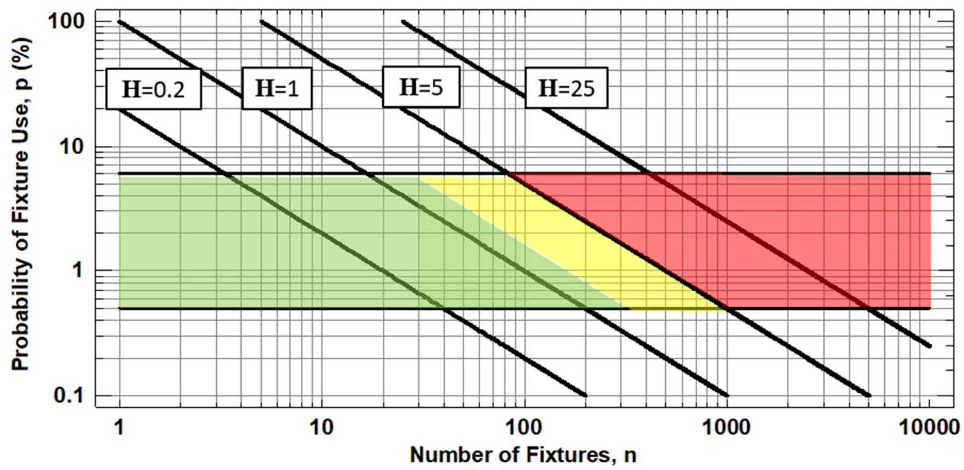
COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation	N = 6
99th Percentile Demand Flow	Q = 9.0 GPM
Hunter Number	H(n,p) = 0.17
Stagnation Probability	Pr[Zero Demand] = 84%
Method of Computation	Convolution

DOWNLOAD RESULT | RESET WDC | ↓ Select Units for Water Demand ↓ | GPM | LPM | LPS | RUN WDC

Figure 5: Total Demand Load

Notice also on the right-hand side that the computed results show a stagnation probability. This shows the chances that there is no demand and, hence, no flow occurring at the instant of observation during the peak period. In Figure 5, there is an 84% chance that there will be no flow occurring during the peak period in this building. The Hunter number showing 0.17 is an indicator of a few things. See Figure 6. The Hunter number (H) of 0.17 with 6 fixtures falls below the diagonal line identified as H = 0.2 in the green zone which indicates a small building with a very high probability of stagnation. The green zone uses a specific algorithm as shown in Figure 7. The WDC download link at the end of this chapter provides a peak water demand study explaining more on the algorithms.[6] As the number of fixtures increase the Hunter number will increase and move into different regions with different algorithms for estimating peak demands in different sizes of dwellings.



(Image Modified from Original provided by Dr. Steven Buchberger, University of Cincinnati)

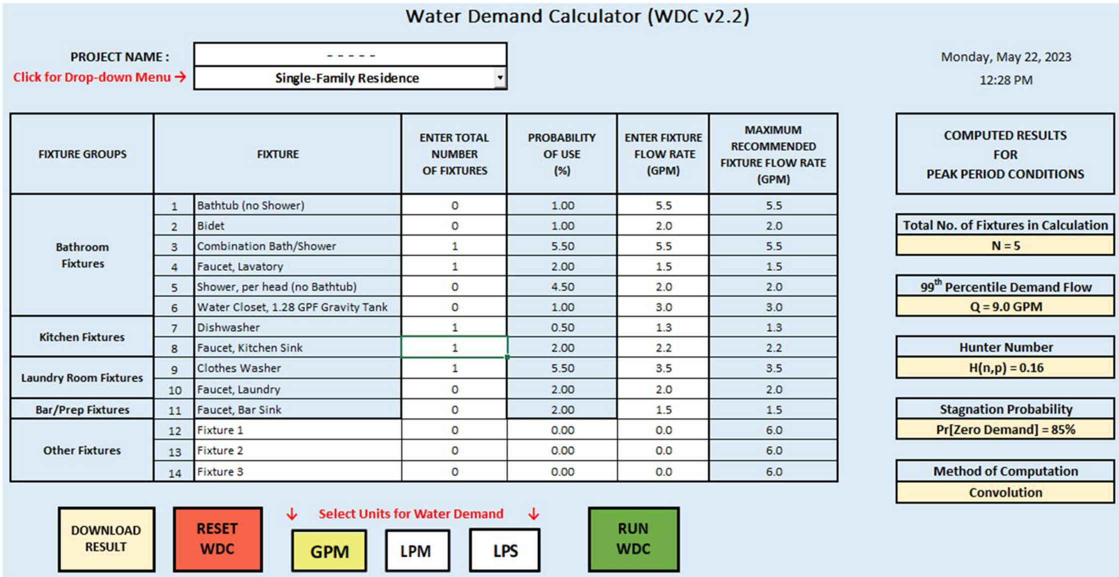
Figure 6: Hunter Number in Regions Representing Building Size

Region in Figure 6	Building Size	Algorithm in Water Demand Calculator	Boundary Criteria	Probability of Peak Period Stagnation, P_0
Green	Small/Medium	Convolution	$H \leq 2$	Very High
Yellow	Medium	Modified Wistort Method (MWM)	$2 < H < 5$	Moderate
Red	Large	Wistort Method (WM)	$H \geq 5$	Very Low

(Image Modified from Original provided by Dr. Steven Buchberger, University of Cincinnati)

Figure 7: Table of Algorithms to Estimate Peak Demand

The next example will show branch sizing. First, click the Reset button in the Calculator and it will clear all the previous numbers you entered. Estimate the demand for the hot water branch at the water heater, Pipe Section 3 in Figure 4 isometric example. The water closet is the only fixture that does not use hot water, so it would be excluded in the calculator. Enter the number 1 after the other five fixtures and then click Run WDC. The estimated demand for the hot water branch at the water heater is 9.0 gpm (see Figure 8). Eliminating one water closet did not change the estimated demand for the total hot water because the frequency of use for a water closet is so low in single family dwellings.



Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

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FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	1	5.50	5.5	5.5
	4	Faucet, Lavatory	1	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	1	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	1	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	1	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation: N = 5

99th Percentile Demand Flow: Q = 9.0 GPM

Hunter Number: H(n,p) = 0.16

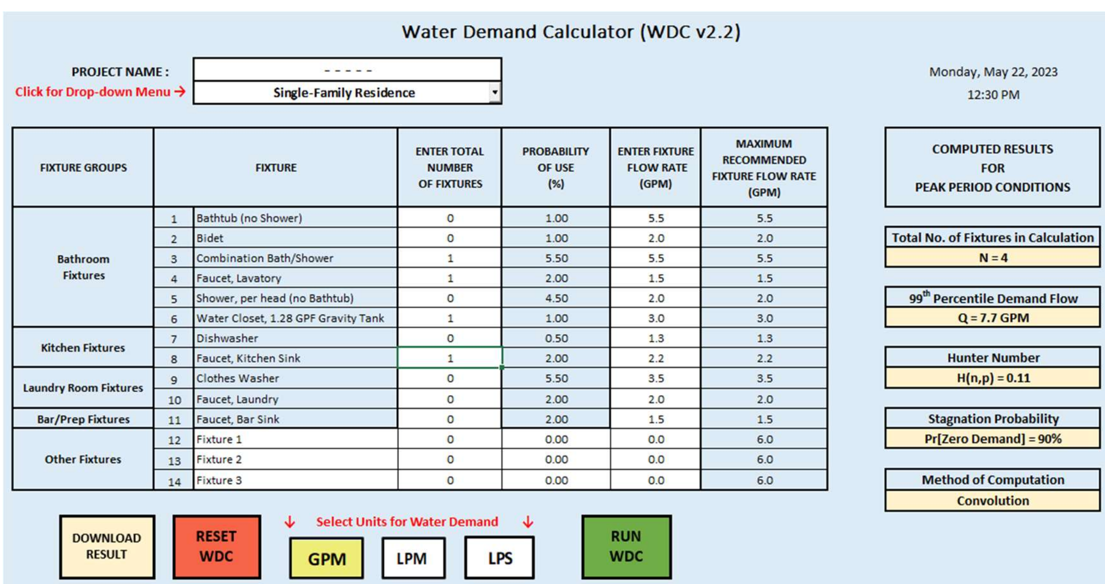
Stagnation Probability: Pr[Zero Demand] = 85%

Method of Computation: Convolution

DOWNLOAD RESULT | RESET WDC | Select Units for Water Demand: GPM, LPM, LPS | RUN WDC

Figure 8: Total Hot Water Demand

Pipe Section 2 in Figure 4 shows a cold and hot water branch. To estimate the cold branch demand, enter the number 1 in the Total Number of Fixtures column after the kitchen faucet, the combination bath/shower, lavatory, and water closet. These are the fixtures that use cold water. The dishwasher is excluded. Click Run WDC. The cold-water branch at Pipe Section 2 has an estimated demand of 7.7 gpm (see Figure 9). To estimate the hot water demand at Pipe Section 2, exclude the water closet and include the dishwasher. The hot water branch also has an estimated demand of 7.7 gpm.



Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

Monday, May 22, 2023

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FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	1	5.50	5.5	5.5
	4	Faucet, Lavatory	1	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	1	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	1	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation: N = 4

99th Percentile Demand Flow: Q = 7.7 GPM

Hunter Number: H(n,p) = 0.11

Stagnation Probability: Pr[Zero Demand] = 90%

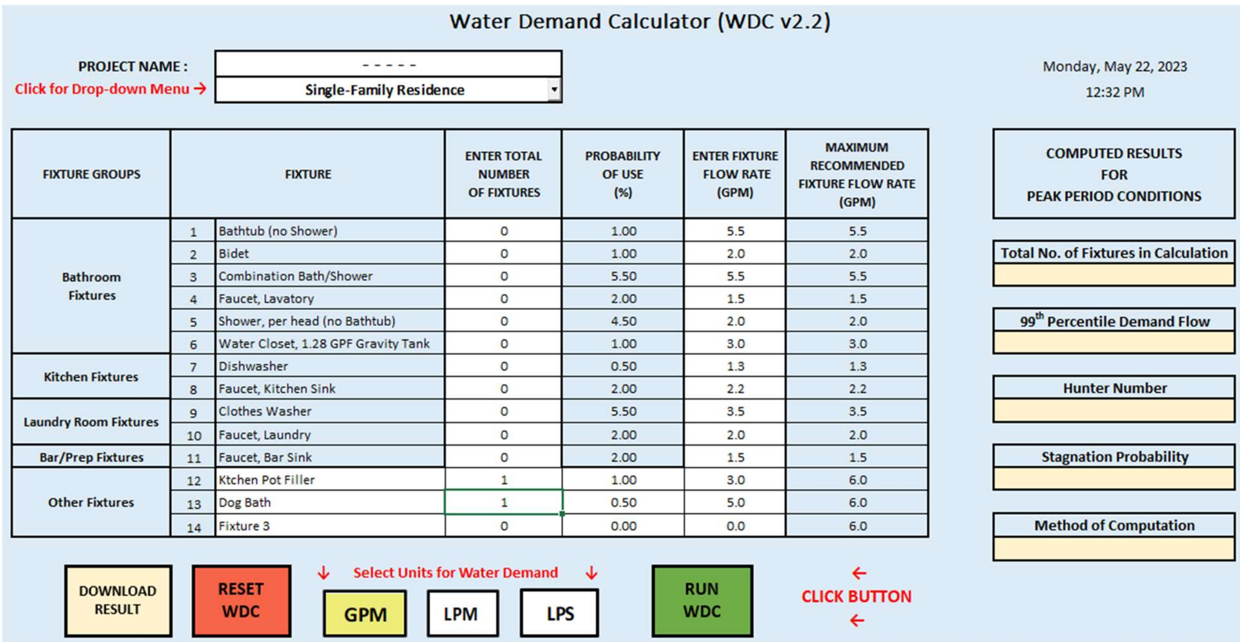
Method of Computation: Convolution

DOWNLOAD RESULT | RESET WDC | Select Units for Water Demand: GPM, LPM, LPS | RUN WDC

Figure 9: Cold Water Branch

As the number of fixtures on a branch is reduced to one fixture, the remaining fixture supply has a flow rate dictated by that fixture. For example, a fixture supply to a lavatory faucet has a flow rate of 1.5 gpm. There is no need to put a single fixture in the calculator, but if you do, the result will just be the flow rate for that single fixture.

Additional rows are provided for Other Fixtures not included in the WDC as mentioned above. For example, you can add a pot filler and a dog bath to the list of fixtures. When doing this, find an indoor fixture that has a similar probability of use and add that to the column. Then enter the actual flow rate of the fixture you entered (see Figure 10). Then click Run WDC.



Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

Monday, May 22, 2023
12:32 PM

FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	0	5.50	5.5	5.5
	4	Faucet, Lavatory	0	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	0	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Ktchen Pot Filler	1	1.00	3.0	6.0
	13	Dog Bath	1	0.50	5.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS
Total No. of Fixtures in Calculation
99th Percentile Demand Flow
Hunter Number
Stagnation Probability
Method of Computation

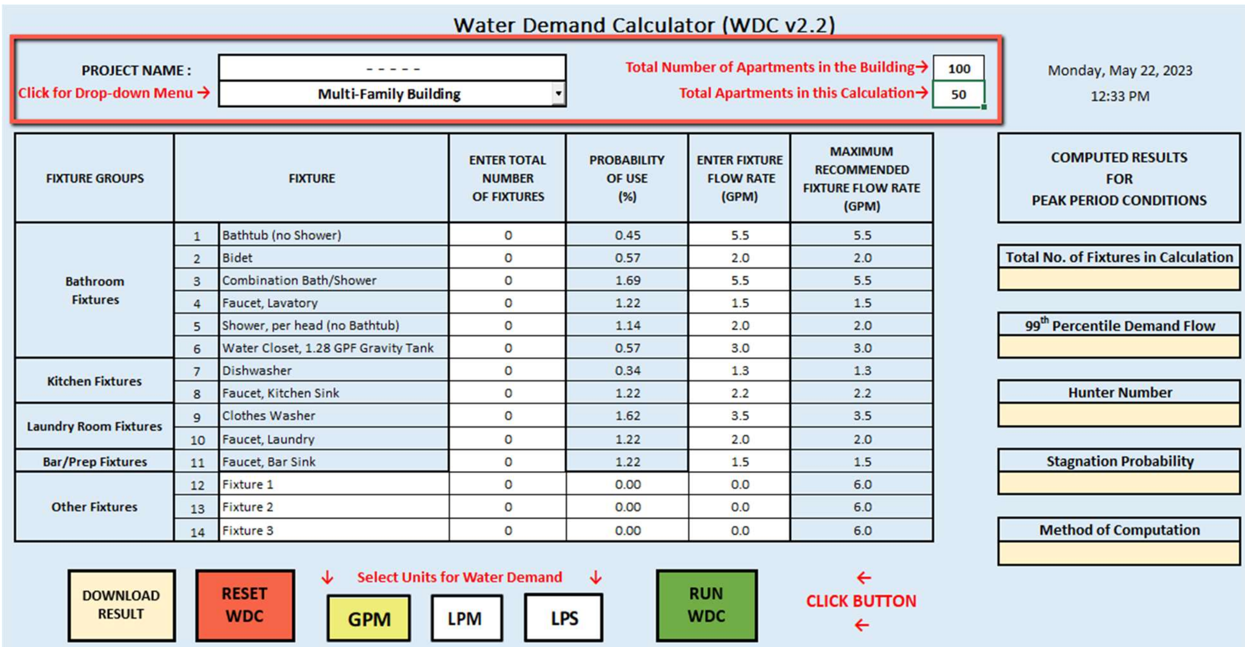
DOWNLOAD RESULT | RESET WDC | Select Units for Water Demand: GPM | LPM | LPS | RUN WDC | CLICK BUTTON

Figure 10: Other Fixtures

There is one caveat that must be observed. The WDC is limited to indoor fixtures and appliances where intermittent water use tends to be brief. Outdoor water uses such as hose bibbs and landscape irrigation tend to be seasonal and have very long durations of use. Such continuous flow fixtures are not to be entered into the Water Demand Calculator as Other Fixtures. The flow rates of outdoor water use are added to the Demand Flow estimate. For example, Figure 5 shows the whole house demand flow of 9.0 gpm. If there is a hose bibb with a flow rate of 2.0 gpm, then 2.0 gpm would be added to 9.0 gpm for a total whole house estimated demand of 11.0 gpm.

The Water Demand Calculator was purposely developed for water-conserving fixtures and appliances. Hence, high-flow Roman tub fillers (exceeding the maximum bathtub flow rates in the WDC) and luxury shower spas fall outside the calculator's scope. Such luxury fixtures can be entered as Other Fixtures, but the maximum flow rate allowed in the WDC is 6.0 gpm.

An additional feature to point out is the drop-down menu on the top left corner that allows you to select either single-family residence or a multi-family building. Choosing the multi-family option opens two more boxes to fill in information (see Figure 11). When estimating for a multi-family building, enter the total number of apartments in the building in the first box. The example shows a total of 100 apartments in the building. The second box is for the number of apartments you will be calculating. If you are calculating for the whole building, enter the same number of 100 in the second box. If you are calculating for half the apartments, enter 50. If you are estimating for only one apartment, then enter the number one. The total number of apartments in the first box with not change in any of your calculations. Then use the WDC as was explained earlier for sizing branches and risers.



Water Demand Calculator (WDC v2.2)

PROJECT NAME : - - - - -
Click for Drop-down Menu → Multi-Family Building
Total Number of Apartments in the Building→ 100
Total Apartments in this Calculation→ 50
Monday, May 22, 2023
12:33 PM

FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	0.45	5.5	5.5
	2	Bidet	0	0.57	2.0	2.0
	3	Combination Bath/Shower	0	1.69	5.5	5.5
	4	Faucet, Lavatory	0	1.22	1.5	1.5
	5	Shower, per head (no Bathtub)	0	1.14	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	0.57	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.34	1.3	1.3
	8	Faucet, Kitchen Sink	0	1.22	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	1.62	3.5	3.5
	10	Faucet, Laundry	0	1.22	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	1.22	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS
Total No. of Fixtures in Calculation
99th Percentile Demand Flow
Hunter Number
Stagnation Probability
Method of Computation

DOWNLOAD RESULT
RESET WDC
Select Units for Water Demand
GPM
LPM
LPS
RUN WDC
CLICK BUTTON

Figure 11: Multi-family Building

Sizing the Pipe

Now that you know how to use the Water Demand Calculator to find the estimated demand for each pipe segment of a water distribution system, how do you go from the flow rate to finding the pipe size? At this point you must consult your plumbing code and look for an appendix for sizing the water supply system (all the model codes have one). If your adopted plumbing code does not have this appendix, then refer to the Uniform Plumbing Code, Appendix A for a good reference guide.

Generally, the sizing rules begin with estimating the demand in fixture units, and then converting fixture units into flow rates (gpm). This step can be eliminated since the Water Demand Calculator predicts the demand in gallons per minute without using fixture units. The sizing rules will then lay out steps for calculating friction loss and direct you to nomograph charts that include friction loss per 100 feet of pipe, velocity, and flow rate to determine the appropriate pipe size.

The Water Demand Calculator may be downloaded free of charge by following the link below.

https://www.iapmo.org/water-demand-calculator/

References

[1] Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings, BH2, National Bureau of Standards, 1924

[2] Hunter, Roy B., Methods of Estimating Loads in Plumbing Systems, BMS65, National Bureau of Standards, 1940

[3] Water Distribution and Supply within Buildings: National Research Needs, National Academy of Sciences-National Academy of Engineering National Research Council, 1974

[4] 2018/2021/2024 Uniform Plumbing Code and 2020 WEStand, IAPMO

[5] Buchberger, Steven, Omaghomi, Toritseju, Wolfe, Timothy, Hewitt, Jason, Cole, Daniel, Peak Water Demand Study, IAPMO, 2017

[6] Ibid