Appendix D

Residential Service Line Pressure

- Policy Statement 129
- Residential Service Line Pressure Loss Study Technical Memorandum

Policy Statement 129

POLICY STATEMENT 129
MINIMUM WATER SUPPLY PRESSURE

Prepared by:	Stephen J. Brown, P.E., Engineering Services Manager
Adopted by Council:	11/9/00
Effective:	11/9/00

PURPOSE:

1. To establish a minimum water supply pressure to be provided throughout the Town of Cary's water distribution system;
2. To ensure that water distribution system improvements are designed to provide adequate flow and pressure for both supply and fire protection.

COVERAGE:

This policy shall apply to the water distribution system within the Town of Cary's utility service area, owned and operated by the Town of Cary, for customers billed by the Town of Cary.

POLICY:

The Town shall design and maintain its water distribution facilities such that the following residual water pressures will normally be available throughout the water distribution system:

1. 40 pounds per square inch (psi) at average day and maximum day demand conditions;
2. 30 psi at maximum hour demand conditions;
3. 20 psi at max day demand with maximum applicable fire flow demand conditions applied at worst-case location. Minimum fire flow rates shall be as required by the Town of Cary Standard Specifications and Details;

to be consistent with North Carolina Department of Environment and Natural Resources (NCDENR) requirements stated in NCAC T15A and other applicable regulations.

This policy is intended to establish minimum conditions. Higher pressures may in fact be available depending upon the geographical and topographical location in the system. If pressures higher than the stated minimums are required at a given service location, it shall be the responsibility of the customer to provide the necessary engineering analysis and pressure boosting facilities.

The Town shall develop and maintain a hydraulic model of its water distribution system. This model will serve as the basis for planning hydraulic performance of the system. Model results will be used to predict water pressure availability under the various demand conditions described above. Designs for new water distribution lines and system appurtenances (storage tanks, valves, etc.) shall provide the above mentioned minimum pressures. Designers shall provide a design report, including hydraulic analysis results, to show that these conditions are met at all times.

This policy is not to be viewed as a guarantee of minimum water pressure availability. Rather it is intended to provide a basis for design of facilities connected to and utilizing the water distribution system by water customers. The requirements of this policy are not intended to exempt other policies.

All construction shall meet the current Town Standard Specifications.

Residential Service Line Pressure Loss Study Technical Memorandum

Town of Cary Water System Master Plan
Residential Service Line Pressure Loss Study

PREPARED FOR: Glen Harrell, Town of Cary

PREPARED BY: Brian Skeens, CH2M HILL

DATE: July 9, 2008

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Introduction

The Town of Cary has requested an analysis of appropriate procedures and policies for the selection of residential water service line and meter sizes. Typically, the size of a service line for residential service is ¾-inch. However, the Town of Cary's current standard detail for new residential service connection is 1-inch meter and service line. There are predictable pressure losses that occur in a residential water service line related to the water meter, check valve, and length of the line. Depending on the flow rate in the line, these losses can be substantial. The flow rate in the service line is related to the number of fixtures in use concurrently. For most homes, these losses are not substantial enough in a standard ¾-inch service line and meter to cause noticeable low pressures inside a residence. However, extensive irrigation system use, and a larger home with many bathrooms, or stories can exacerbate this problem. In this case, a larger service line and water meter may be used to alleviate these pressure losses, and maintain adequate pressures for indoor fixtures.

This Technical Memorandum (TM) will review several issues related to the pressure losses in residential service lines for the purpose of recommending a policy for new homes.

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Baseline and Assumptions

The factors that may lead to low pressure in single family detached homes due to service line pressure losses are described in this TM. The home must have been constructed since the Town requirement for irrigation meters. The characteristics of the home are as follows:

- 2 or more stories
- 3 or more bathrooms
- 4,000 square feet or greater
- Separately metered irrigation

The fixtures in this house will all meet the maximum flow rates listed in the current 2002 North Carolina Plumbing Code, Section 604.4, shown in Appendix A. However, the code does not specify maximum flow rates for water-using appliances. For those water-using appliances such as dishwashers and clothes washers the flow rates are assumed to be similar to a kitchen faucet for the purpose of the analysis.

The length of the service line is also a factor in the pressure losses that occur in the service line. If the service line is longer than average, the pressure loss will be greater, and should be considered when sizing the service line.

Prior Investigations

The Town of Cary performed an "Individual Plumbing and Irrigation Study" in 2006, which investigated ten homes for low pressures related to indoor and irrigation water use. Of those ten existing homes, seven were investigated for indoor plumbing pressures. The study includes fairly new, existing homes only, and no assumptions could be made about deterioration of plumbing components. The results are documented in a summary dated November 2006. The results related to indoor pressures include the following:

- Only one home had a problem between the water main and meter.
- Pressure losses following the meter could usually be reduced by removing or adjusting the pressure reducing valve.
- Beyond the removal of the pressure reducing valve, more expensive options were to replace the service line with a larger size or to install an individual tank and pump system, but none of the customers were interested in either of these options.

The study also documents the issues with irrigation systems, and the common theme is lack of maintenance. Problems identified in the study include the following:

- Zone valve stuck in the open position, thus running more than one zone at the same time, resulting in lower overall pressure and poor performance of the sprinkler heads.
- Pipe or valve leaking resulting in lower overall pressure and poor performance of the sprinkler heads.

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Billing Data Review

The Town's billing data was queried to find some customers that meet the criteria described above, and their data is presented below. One concern about these data is that they are recorded on a monthly basis, so the flow is a monthly average, and does not represent the peak instantaneous flow rate that may occur when multiple fixtures and water-using appliances are in use. Also, when converted to gallons per minute from gallons per month, the result is much lower than the instantaneous flow rate. However, it does show the relative increase in indoor water demands for larger residences, versus smaller residences. Table 1 below shows an example of these data:

TABLE 1
Residential Monthly Indoor Water Demands

House Type	Maximum Monthly Indoor Demand in 2005 (gpm)	Average Monthly Indoor Demand in 2005 (gpm)
2 story 3.5 or more bathrooms 4,400 square feet	2.85	0.54
2.5 story 3.5 or more bathrooms 3,823 square feet	1.93	0.46
2 story 3.5 or more bathrooms 3,332 square feet	1.92	0.59
2 story 3 bathrooms 3,174 square feet	0.45	0.15
2 story 3 bathrooms 3,212 square feet	0.29	0.11

Notes: These houses were all built in 2004.
The parcel database contains a maximum of 2.5 stories and 3.5 or more bathrooms.
gpm = gallons per minute

This limited dataset indicates that the number of bathrooms impacts the amount of water used. The houses with 3.5 or more bathrooms generally used more water than the houses with 3 bathrooms. It can also be noted that those homes with the highest indoor use in the dataset also had the highest irrigation use.

The usage data from the billing data are of little value for this TM because of the lack of instantaneous flow readings. Therefore, it is recommended that a meter flow logger be used on some homes that meet the criteria above. These meter flow loggers are already owned by the Town of Cary, and currently used by technicians to help identify leaks in customers' homes. These meters could help increase the Town's understanding of its current customers' water use habits, and peak instantaneous water demands in larger residences. An example output screen of this information from the Town is shown in Appendix B. If the Town of Cary wishes, to conduct this monitoring and provide the data to CH2M HILL

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for some residences that meet the criteria above, further evaluation will be made and this TM will be revised.

AWWA Manual M22 Review

The AWWA M22 Manual entitled "Sizing Water Service Lines and Meters" (2004) provides a methodology and protocol for calculating service line sizes that is accepted by the water industry. However, there are several disclaimers in the text of the document that the fact that much of the research behind the formulas and empirical calculations date back as far as 1940. Much has changed in the field of indoor water-using fixtures and appliances, especially since the early 1990's with the National Energy Policy Act that lowered the maximum flow rates for toilets, faucets, and showerheads. The success of the EPA Energy Star™ program in the late 1990's and 2000's has lowered the water use for clothes washers and dishwashers substantially. Many of these Energy Star™ appliances are high-end and typically are installed in residences that meet the criteria above, such as horizontal-axis, front-loading clothes washers.

The methodology in M22 for sizing service lines is dependent on estimates of water use in a home, with the use rates provided by the Manual. Therefore, the flow rate calculations that are given for many of these fixtures and appliances are overestimated and do not apply to the new homes that are being built in the Town of Cary. See Appendix C for an excerpt of the disclaimer by AWWA.

The overestimation of residential flows in M22 results in an overestimation of the pressure losses through the service line, as well as the meter and check valve. The length of the service line further exaggerates this overestimation, which could result in oversized meters and service lines. An example calculation is shown below based on the M22 methodology that would result in a larger service line due to the overestimation of flow.

M22 flows:	NC Plumbing Code flows:
Bath = 8 gpm	Bath = 4 gpm
Toilet = 4 gpm	Toilet = 3 gpm
Clothes Washer = 6 gm	Clothes Washer = 4 gpm

3 toilets, 1 clothes washer, 1 bath flow rate:

M22:	NC Plumbing Code:
(3x4)+6+8=26 gpm	(3x3)+4+4=17 gpm

Headloss in a 50 foot service line, ¾-inch K-type Copper:

M22:	NC Plumbing Code:
pressure loss	pressure loss
0.7 psi/ft at 26 gpm	0.35 psi/ft at 17 gpm
0.7x50=35 psi loss	0.35x50=17.5 psi loss

This calculation shows a doubling of the pressure loss experienced due to overestimation of indoor flows.

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The Town of Cary also performed some sample calculations to demonstrate that an increase in service line size from ¾-inch to 1-inch provides the greatest opportunity to reduce pressure losses. While this conclusion is correct, it is based on flows that may be overestimated by the M22 Manual. Using a larger service line size decreases the pressure loss, but also costs more in capital costs of the service line, meter, check valve, and other appurtenances.

Other Utilities' Practices

The issue of water service line and meter sizing is not exclusive to the Town of Cary. Other water utilities face the same issue and have developed methodologies for addressing the issue. Two water utilities with growth trends similar to Cary were interviewed to understand their practices with regard to service line and meter sizing. These two water utilities were the Town of Purcellville, Virginia and Forsyth County, Georgia. They are both ranked in the top 5 richest counties in the country, and are experiencing affluent, residential growth.

According to the Capital Projects and Engineering Manager for the Town of Purcellville, they require a Utility Form be filled out prior to approval of water service. This form was developed originally for businesses, but is now being used for residences, also. The form uses a methodology based on water supply fixture units that appears to originate from the 2006 International Residential Code. This calculation is then used to determine the meter size the business or residence must use. This Utility Form is included in Appendix D.

According to the Deputy Director of the Forsyth County Water and Sewer Department, they typically let the builder/homeowner decide what size meter to select. However, the Forsyth County Plumbing Inspector recommends the use of the calculations in Section 29 of the 2006 International Residential Code for sizing water service lines and meters. The plumbing inspector also confirmed that the number of bathrooms provides a good indicator of the size needed. He stated that a home with 6 or more bathrooms is required to have a 1-inch meter and 1-inch service line instead of a standard residential ¾-inch service line and meter. However, any residential customer is allowed to purchase a 1-inch meter if they are willing to pay the higher up front costs. Also, if the length of the service line is longer than an average of fifty to seventy feet, he recommends a 1-inch service line and meter.

Conclusions and Recommendations

Based on the findings of this evaluation, the number of bathrooms is an important factor in determining the service line and meter size for a residential water customer. The breakpoint cannot be determined with the information collected as part of this study, without additional data. Also critical to the pressure loss equation is the length of the service line. This must be considered in calculations by the Town. We recommend that the Town of Cary collect additional indoor water demand data for new, large residences which would help determine the peak flow rates in those homes. Upon collection of this data, CH2M HILL will provide additional recommendations. In the meantime, CH2M HILL recommends that the Town of Cary consider incorporating the 2006 International

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Residential Code calculations (Appendix E) as part of local policies and meter sizing practices.

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References

AWWA M22 Manual, Sizing Water Service Lines and Meters, Second Edition, 2004

2006 International Residential Code, International Code Council

2002 North Carolina Plumbing Code

Forsyth County Department of Water and Sewer, Deputy Director, Barry Lucas

Town of Purcellville Public Works, Engineering Manager, Alex Vanegas

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Appendix A

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HELP

Plumbing Code - 2002 Edition

604.3 Water distribution system design criteria.

The water distribution system shall be designed, and pipe sizes shall be selected such that under conditions of peak demand, the capacities at the fixture supply pipe outlets shall not be less than shown in Table 604.3. The minimum flow rate and flow pressure provided to fixtures and appliances not listed in Table 604.3 shall be in accordance with manufacturer's installation instructions.

TABLE 604.3
WATER DISTRIBUTION SYSTEM DESIGN
CRITERIA REQUIRED CAPACITIES AT
FIXTURE SUPPLY PIPE OUTLETS

FIXTURE SUPPLY OUTLET SERVING	FLOW RATE[a] (gpm)	FLOW PRESSURE (psi)
Bathtub	4	8
Bidet	2	4
Combination fixture	4	8
Dishwasher, residential	2.75	8
Drinking fountain	0.75	8
Laundry tray	4	8
Lavatory	2	8
Shower	3	8
Shower, temperature controlled	3	20
Sillcock, hose bibb	5	8
Sink, residential	2.5	8
Sink, service	3	8
Urinal, valve	15	15
Water closet, blow out, flushometer valve	35	25
Water closet, flushometer tank	1.6	15
Water closet, siphonic, flushometer valve	25	15
Water closet, tank, close coupled	3	8
Water closet, tank, one piece	6	20

For **SI:** 1 psi = 6.895 kPa, 1 gallon per minute (gpm) = 3.785 L/m.

a. For additional requirements for flow rates and quantities, see Section 604.4.

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HELP

Plumbing Code - 2002 Edition

604.4 Maximum flow and water consumption.

The maximum water consumption flow rates and quantities for all plumbing fixtures and fixture fittings shall be in accordance with Table 604.4.

Exceptions:

1. Blowout design water closets [3.5 gallons (13 L) per flushing cycle].
2. Vegetable sprays.
3. Clinical sinks [4.5 gallons (17 L) per flushing cycle].
4. Service sinks.
5. Emergency showers.

TABLE 604.4
MAXIMUM FLOW RATES AND CONSUMPTION
FOR PLUMBING FIXTURES
AND FIXTURE FITTINGS

PLUMBING FIXTURE OR FIXTURE FITTING	MAXIMUM FLOW RATE OR QUANTITY[b]
Water closet	1.6 gallons per flushing cycle
Urinal	1.0 gallon per flushing cycle
Shower head[a]	2.5 gpm at 60 psi
Lavatory, private	2.2 gpm at 60 psi
Lavatory (other than metering), public	0.5 gpm at 60 psi
Lavatory, public (metering)	0.25 gallon per metering cycle
Sink faucet	2.2 gpm at 60 psi

For **SI**: 1 gallon = 3.785 L, 1 gallon per minute = 3.785 L/m, 1 psi = 6.895 kPa.

a. A hand–held shower spray is a shower head.

b. Consumption tolerances shall be determined from referenced standards.

Appendix B

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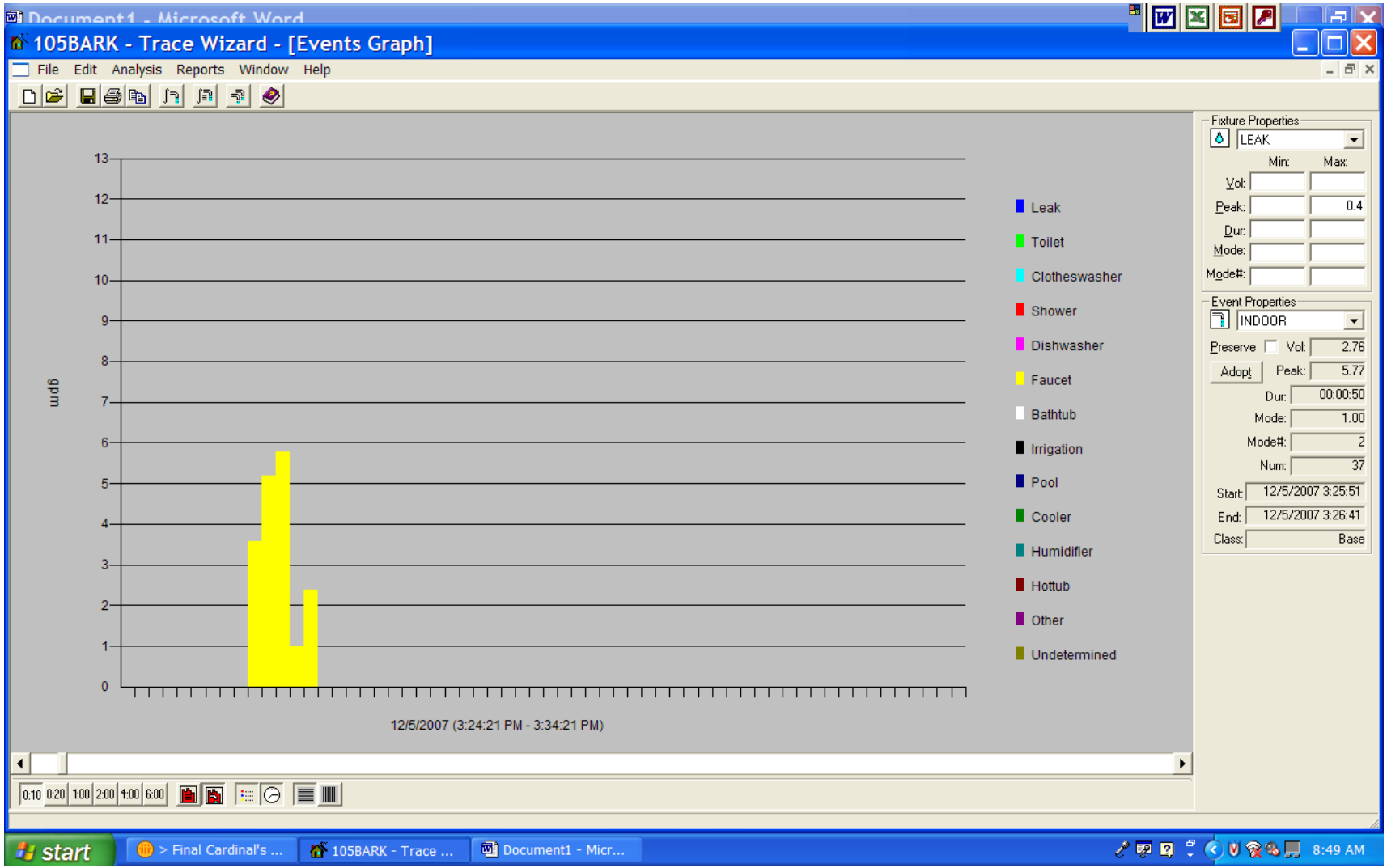
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Leak
Toilet
Clotheswasher
Shower
Dishwasher
Faucet
Bathtub
Irrigation
Pool
Cooler
Humidifier
Hottub
Other
Undetermined
Fixture Properties
LEAK
Min: Max:
Vol:
Peak: 0.4
Dur:
Mode:
Mode#:
Event Properties
INDOOR
Preserve Vol: 2.76
Adopt Peak: 5.77
Dur: 00:00:50
Mode: 1.00
Mode#: 2
Num: 37
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End: 12/5/2007 3:26:41
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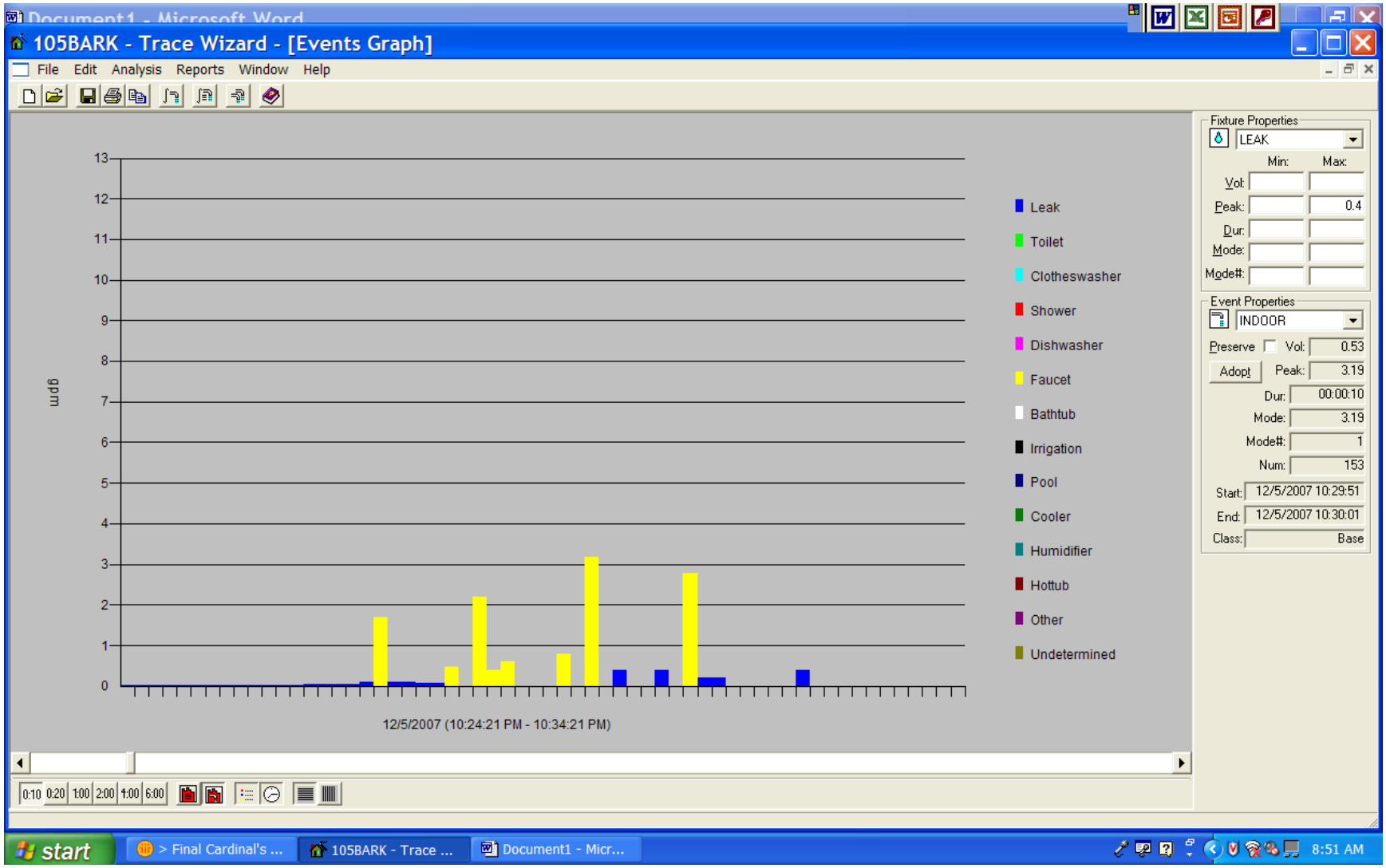
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gpm
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12/5/2007 (10:24:21 PM - 10:34:21 PM)
Leak
Toilet
Clotheswasher
Shower
Dishwasher
Faucet
Bathtub
Irrigation
Pool
Cooler
Humidifier
Hottub
Other
Undetermined
Fixture Properties
LEAK
Min: Max:
Vol:
Peak: 0.4
Dur:
Mode:
Mode#:
Event Properties
INDOOR
Preserve Vol: 0.53
Adopt Peak: 3.19
Dur: 00:00:10
Mode: 3.19
Mode#: 1
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Appendix C

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Chapter 4

Estimating Demands Using Fixture Values

INTRODUCTION

To properly size water taps, meters, and service lines, it is essential to know the peak demands that any specific tap will be called on to serve. This problem has been difficult to solve because there is no clear-cut way to calculate peak demands. Although it is certainly possible to calculate the maximum potential demand for a specific customer based on the simultaneous use of all the fixtures and appliances in the building, this calculation has little bearing on the actual peak flows because these are a function of the *probability* that multiple fixtures and appliances will be operated simultaneously. These probability patterns cannot be calculated theoretically but must be determined through empirical methods, i.e., through observations.

In 1940, Roy Hunter developed a method for estimating peak water demands in which peak flows were related to the number and type of fixtures being served by the tap, referred to as "fixture units" (Hunter 1940). The report contained tables of the load-producing characteristics of commonly used fixtures and—the Hunter curve—of peak flow versus fixture units that has found its way into many plumbing codes, where it has been institutionalized into the orthodoxy of plumbing and mechanical systems design. However, in many cases, these codes have failed to take Hunter's own words into consideration in their efforts to create a uniform procedure for engineers to follow in sizing systems. Hunter pointed out that "the details of application of any method in practice must be guided to a large extent by engineering judgment in order that it may lead to satisfactory results," and that the "choice of values employed in evaluating the probability function and in converting estimates in numbers of fixtures flowing to estimates in gallons per minute represents the author's [Hunter's] judgment."

Experience has shown that in many cases the Hunter curve approach overestimates demands in the building to which it is applied. These overestimates occur because Hunter developed the basic probability function with highly congested uses

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in mind, i.e., with the toilets, bathtubs, showers, and faucets in nearly continuous use. He recognized this tendency toward oversizing supply lines and ascribed it to difficulty in estimating the probability of overlapping demands among various types of fixtures and appliances in the buildings. In some cases, the Hunter's curve may be the method of choice for plumbing engineers in designs of interior plumbing systems. The selection of the most appropriate method for estimating water demand must involve careful consideration of many variables with site-specific weighting.

The 1975 edition of AWWA's Manual M22 employed a system of empirical measurements to replace the demand curves generated by Hunter's fixture unit approach. The 1975 manual presented a family of curves that were derived from a series of actual field measurements in the United States and Canada. The authors of the 1975 manual described this approach as "a matter of necessity in order to provide detailed and accurate design criteria" (AWWA, 1975, p. 24). Many practitioners have shied away from using the 1975 M22 demand curves because the M22 curves gave substantially lower demands than did the Hunter curves, and it was not clear how they were developed.

In the last few years there has been a great deal of discussion about how to improve the methodology for estimating peak demands in new buildings. Some have advocated a return to a modified version of the Hunter curve, and others have advocated continuing research on an empirical approach. This matter is still open for discussion, and the current revision of M22 seeks to add what new information is available and provide more flexibility for engineers to use current technology to estimate demands. It is anticipated that future M22 revisions will include new research to enhance the empirical demand projections because advances in technology have greatly simplified the acquisition of flow trace data from water meters.

In 1975, mechanical data loggers were used to collect peak flow data for a range of customers. This information was used to create a family of demand curves for several customer categories, including residential, apartments, hotels, commercial, and public (see Figures 4-1 through 4-3, which originally appeared in the 1975 edition of M22). These demand curves are not the same as the original Hunter curves, which have been incorporated into the Uniform Plumbing Code (UPC), and represent refinements of estimation technique. The major shortcoming of the 1975 curves is that they are based on a fairly limited sample of customers. It is hoped that future research will be conducted systematically to obtain flow trace data that can be used to refine the 1975 curves using representative samples of customers of all major categories. As to whether the Hunter or 1975 M22 approach is best, data collected in recent studies using the type of portable data loggers described in chapter 3 have shown that the 1975 M22 curves appear to match observed demands fairly well, with a reasonable margin of safety.

An example of the comparison between peak flow predicted by the Hunter curves, the 1975 M22 curves, and peak flows measured using data loggers between 1995 and 1999 is given in Figure 4-4. This figure is based on 36 multifamily buildings in the greater Denver area. In each case, the predicted peak flows were calculated from the fixture units using the Hunter curve and from fixture values using the curves from the 1975 M22 (see Figure 4-2), without any pressure adjustments. The Hunter curve predictions of peak flow are shown in the top line of Figure 4-4, the M22 predicted peak flows are shown in the middle line, and observed peak flows from the flow profile analysis are shown in the bottom line. Figure 4-4 shows clearly that in this specific situation the 1975 curves fit the observed data quite well while providing a reasonable margin of safety, while the Hunter curves from the UPC greatly overestimated peak demands. As noted earlier, the 1975 M22 demands presented in this example did not include any adjustment for pressure in the distribution system.

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Appendix D

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Town of Purcellville

130 East Main Street, Purcellville, VA 20132
For more information, please contact the Director of Utilities at (540) 338-5024 ext. 13.

Business Utility Form

1. Name of Business:	
2. Location of Business:	
3. Mailing Address:	

4. Major products manufactured or services supplied:

5. Number of Employees:	6. Hours of Operation:
Check Appropriate Box	7. Has the plumbing been modified? ☐ Yes ☐ No

☐ 8. Change in use, describe new use of utilities:	☐ 9. Expansion of existing use, describe expansion of utilities:	10a. Please provide the fixture unit count for new or upgraded facility and calculations demonstrating appropriate meter size (se the guide on the reverse of this form for you calculations.) 10b. Calculate your average expected water use in gallons per minute:

11. Expected water consumption rate in gallons per day:	12. Backflow prevention device required: ☐ Yes ☐ No

13. List types and concentrations of pollutants discharged to the sewer system:

14. List hazardous materials stored on site (SARA Title III)

15. Describe on-site and/or off-site pretreatment facilities or recycling practices:

16. Briefly describe the Spill Prevention Control (SPCC) Plan and attach SPCC plan.

17. Name of Owner:	Phone:	Fax:
18. Name of Manager:	Phone:	Fax:
19. 24-Hour Contact:	Phone:	Fax:

20. Signature:	Date:
21. Town Approval:	Date:

Instructions for Completing the Town of Purcellville's Business Utility Form

The Business Utility Form should be completed by all new businesses applying for a water account, or any business that is modifying or expanding their existing water usage. Please use the information provided below to complete the form. The numbered instructions match the numbered form on the reverse. Attach additional sheets if needed.

It is imperative that this information be accurate. It will be confirmed at the time of occupancy. If you have questions please contact the Director of Utilities at 540-338-5024 ext. 13.

1-6 Self Explanatory

7. If the answer to 7 is "no., skip 8-10 and complete only 11-20. If the answer to 7 is ”yes” please complete the remainder of the form.

8.& 9. Describe new uses or changes or expansions of the existing utility use.

10a. List fixtures, complete Table 1 below to obtain equivalent fixture unity, multiply the numbers times the value and enter the total WSFU in this space. Not every possible use can be listed. Use your judgment to determine an equivalent use. For example, a salon sink would be used more like a shower head than a lavatory.

10b. Use Table 2 to determine the equivalent GMS's and show that number. Note there is a difference between flush valves and flush tanks, please make sure which you have before completing the form. Use Table 3 to convert GPM to Meter size.

11. This number will need to be provided for all uses to be master metered, in particular businesses that expect to use lots water such as gymnasiums, fitness facilities, etc. It is best provided by a professional versed in these usages.

12. This is to be determined by the Utility Department depending on the answers to questions 13 & 14.

13.& 14. If your facility maintains MSDS sheets on site list those chemicals in these blanks. Be aware that some chemicals not considered to be hazardous in their final form may be hazardous before being diluted. Block 13 is where fats and cooking oils or fluids from car repair or processing businesses are listed.

15.& 16. If items are listed in 13 & 14 please complete these blocks.

17-20 Self Explanatory

Table 1

Fixture or Group	Number of Fixtures or groups in Building or Unit	Supply Fixture Unity Values	Water Supply Fixture Units WSFUs
Bathroom Group		6	
Bath Tub		2	
1/2 Bath Group		2.6	
Shower Head		4.5	
Lavatory		1	
Urinal		3	
Water Closet		2	
Clothes Washer		3	
Kitchen Sink		2	
Dishwashing Machine		2	
Service Sink		2	
Laundry Tray		3	
Restaurant Sink		4	
Combination Fixture		3	
Drinking Fountain		0.25	
Ice Machine		0.75	
Hose Bib		2.5	

Table 2

	GPM Supply Demand	
WFSU's	Flush Valves Predominate	Flush Tanks Predominate
5	22	4
10	27	8
20	35	14
30	42	20
40	46	24
50	51	28
60	54	32
88	64	40
124	74	48
160	81	56
236	98	72
300	108	85
400	127	106
470	135	118
500	143	124
600	157	143
660	162	152
700	170	161
800	183	178
850	189	186
900	197	195
1000	208	208
1100	216	216
1280	243	243
1510	270	270
1990	324	324
2480	378	378
2990	432	432

Table 3

Meter Size	Gallons per Minute	Gallons per Day
5/8"	<20	1000
3/4"	>20 <=30	>1000 <=1500
1"	>30 <=100	>1500 <=2500
1 1/2"	>50 <=100	>2500 <=5000
2"	>100 <=160	>5000 <=8000
3"	>160 <=300	>8000 <=15000
4"	>300 <=500	>15000 <=25000
6"	>500 <=1000	>25000 <=50000

Appendix E

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CHAPTER 29

WATER SUPPLY AND DISTRIBUTION

SECTION P2901
GENERAL

P2901.1 Potable water required. Dwelling units shall be supplied with potable water in the amounts and pressures specified in this chapter. In a building where both a potable and nonpotable water-distribution system are installed, each system shall be identified by color marking, metal tag or other appropriate method. Any nonpotable outlet that could inadvertently be used for drinking or domestic purposes shall be posted.

SECTION P2902
PROTECTION OF POTABLE WATER SUPPLY

P2902.1 General. A potable water supply system shall be designed and installed as to prevent contamination from nonpotable liquids, solids or gases being introduced into the potable water supply. Connections shall not be made to a potable water supply in a manner that could contaminate the water supply or provide a cross-connection between the supply and a source of contamination unless an approved backflow-prevention device is provided. Cross-connections between an individual water supply and a potable public water supply shall be prohibited.

P2902.2 Plumbing fixtures. The supply lines and fittings for every plumbing fixture shall be installed to prevent backflow. Plumbing fixture fittings shall provide backflow protection in accordance with ASME A112.18.1.

P2902.3 Backflow protection. A means of protection against backflow shall be provided in accordance with Sections P2902.3.1 through P2902.3.6. Backflow prevention applications shall conform to Table P2902.3, except as specifically stated in Sections P2902.4 through P2902.5.5.

P2902.3.1 Air gaps. Air gaps shall comply with ASME A112.1.2 and air gap fittings shall comply with ASME A112.1.3. The minimum air gap shall be measured vertically from the lowest end of a water supply outlet to the flood level rim of the fixture or receptor into which such potable water outlets discharge. The minimum required air gap shall be twice the diameter of the effective opening of the outlet, but in no case less than the values specified in Table P2902.3.1. An air gap is required at the discharge point of a relief valve or piping. Air gap devices shall be incorporated in dishwashing and clothes washing appliances.

P2902.3.2 Atmospheric-type vacuum breakers. Pipe-applied atmospheric-type vacuum breakers shall conform to ASSE 1001 or CSA B64.1.1. Hose-connection vacuum breakers shall conform to ASSE 1011, ASSE 1019, ASSE 1035, ASSE 1052, CSA B64.2, CSA B64.2.1, CSA B64.2.1.1, CSA B64.2.2 or CSA B64.7. These devices shall operate under normal atmospheric pressure when the critical level is installed at the required height.

P2902.3.3 Backflow preventer with intermediate atmospheric vent. Backflow preventers with intermediate atmospheric vents shall conform to ASSE 1012 or CSA CAN/CSA B64.3. These devices shall be permitted to be installed where subject to continuous pressure conditions. The relief opening shall discharge by air gap and shall be prevented from being submerged.

P2902.3.4 Pressure-type vacuum breakers. Pressure-type vacuum breakers shall conform to ASSE 1020 or CSA B64.1.2 and spillproof vacuum breakers shall comply with ASSE 1056. These devices are designed for installation under continuous pressure conditions when the critical level is installed at the required height. Pressure-type vacuum breakers shall not be installed in locations where spillage could cause damage to the structure.

P2902.3.5 Reduced pressure principle backflow preventers. Reduced pressure principle backflow preventers shall conform to ASSE 1013, AWWA C511, CSA B64.4 or CSA B64.4.1. Reduced pressure detector assembly backflow preventers shall conform to ASSE 1047. These devices shall be permitted to be installed where subject to continuous pressure conditions. The relief opening shall discharge by air gap and shall be prevented from being submerged.

P2902.3.6 Double check-valve assemblies. Double check-valve assemblies shall conform to ASSE 1015, CSA B64.5, CSA B64.5.1 or AWWA C510. Double-detector check-valve assemblies shall conform to ASSE 1048. These devices shall be capable of operating under continuous pressure conditions.

P2902.4 Protection of potable water outlets. Potable water openings and outlets shall be protected by an air gap, reduced pressure principle backflow preventer with atmospheric vent, atmospheric-type vacuum breaker, pressure-type vacuum breaker or hose connection backflow preventer.

P2902.4.1 Fill valves. Flush tanks shall be equipped with an antisiphon fill valve conforming to ASSE 1002 or CSA B125. The fill valve backflow preventer shall be located at least 1 inch (25 mm) above the full opening of the overflow pipe.

P2902.4.2 Deck-mounted and integral vacuum breakers. Approved deck-mounted vacuum breakers and faucets with integral atmospheric or spill-proof vacuum breakers shall be installed in accordance with the manufacturer's installation instructions and the requirements for labeling with the critical level not less than 1 inch (25 mm) above the flood level rim.

P2902.4.3 Hose connection. Sillcocks, hose bibbs, wall hydrants and other openings with a hose connection shall be protected by an atmospheric-type or pressure-type vacuum breaker or a permanently attached hose connection vacuum breaker.

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TABLE P2902.3
APPLICATION FOR BACKFLOW PREVENTERS

DEVICE	DEGREE OF HAZARD[a]	APPLICATION[b]	APPLICABLE STANDARDS
Air gap	High or low hazard	Backsiphonage or backpressure	ASME A112.1.2
Air gap fittings for use with plumbing fixtures, appliances and appurtenances	High or low hazard	Backsiphonage or backpressure	ASME A112.1.3
Antisiphon-type fill valves for gravity water closet flush tanks	High hazard	Backsiphonage only	ASSE 1002 CSA CAN/CSA B125
Backflow preventer with intermediate atmospheric vents	Low hazard	Backpressure or backsiphonage Sizes $^1/_4$″ – $^3/_4$″	ASSE 1012 CSA B64.3
Double check backflow prevention assembly and double check fire protection backflow prevention assembly	Low hazard	Backpressure or backsiphonage Sizes $^3/_8$″ – 16″	ASSE 1015, AWWA C510 CSA B64.5, CSA B64.5.1
Double check detector fire protection backflow prevention assemblies	Low hazard	Backpressure or backsiphonage (Fire sprinkler systems) Sizes 2″ – 16″	ASSE 1048
Dual-check-valve-type backflow preventer	Low hazard	Backpressure or backsiphonage Sizes $^1/_4$″ – 1″	ASSE 1024, CSA B64.6
Hose connection backflow preventer	High or low hazard	Low head backpressure, rated working pressure backpressure or backsiphonage, Sizes $^1/_2$″ – 1″	ASSE 1052, CSA B64.2.1.1
Hose-connection vacuum breaker	High or low hazard	Low head backpressure or backsiphonage Sizes $^1/_2$″, $^3/_4$″, 1″	ASSE 1011, CSA B64.2, CSA B64.2.1
Laboratory faucet backflow preventer	High or low hazard	Low head backpressure and backsiphonage	ASSE 1035, CSA B64.7
Pipe-applied atmospheric-type vacuum breaker	High or low hazard	Backsiphonage only Sizes $^1/_4$″ – 4″	ASSE 1001 CSA B64.1.1
Pressure vacuum breaker assembly	High or low hazard	Backsiphonage only Sizes $^1/_2$″ – 2″	ASSE 1020, CSA B64.1.2
Reduced pressure detector fire protection backflow prevention assemblies	High or low hazard	Backsiphonage or backpressure (Fire sprinkler systems)	ASSE 1047
Reduced pressure principle backflow preventer and reduced pressure principle fire protection backflow preventer	High or low hazard	Backpressure or backsiphonage Sizes $^3/_8$″ – 16″	ASSE` 1013, AWWA C511 CSA B64.4, CSA B64.4.1
Spillproof vacuum breaker	High or low hazard	Backsiphonage only Sizes $^1/_4$″ – 2″	ASSE 1056
Vacuum breaker wall hydrants, frost-resistant, automatic draining type	High or low hazard	Low head backpressure or backsiphonage Sizes $^3/_4$″ – 1″	ASSE 1019, CSA B64.2.2

For SI: 1 inch = 25.4 mm.

a. Low hazard—See Pollution (Section 202). High hazard—See Contamination (Section 202).

b. See Backpressure (Section 202). See Backpressure, Low Head (Section 202). See Backsiphonage (Section 202).

Exceptions:

1. This section shall not apply to water heater and boiler drain valves that are provided with hose connection threads and that are intended only for tank or vessel draining.
2. This section shall not apply to water supply valves intended for connection of clothes washing machines where backflow prevention is otherwise provided or is integral with the machine.

P2902.5 Protection of potable water connections. Connections to the potable water shall conform to Sections P2902.5.1 through P2902.5.5.

P2902.5.1 Connections to boilers. The potable supply to the boiler shall be equipped with a backflow preventer with an intermediate atmospheric vent complying with ASSE 1012 or CSA B64.3. Where conditioning chemicals are introduced into the system, the potable water connection shall be protected by an air gap or a reduced pressure principle backflow preventer complying with ASSE 1013, CSA B64.3 or AWWA C511.

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TABLE P2902.3.1
MINIMUM AIR GAPS

FIXTURE	MINIMUM AIR GAP	
	Away from a wall[a] (inches)	Close to a wall (inches)
Effective openings greater than 1 inch	Two times the diameter of the effective opening	Three times the diameter of the effective opening
Lavatories and other fixtures with effective opening not greater than $^1/_2$ inch in diameter	1	1.5
Over-rim bath fillers and other fixtures with effective openings not greater than 1 inch in diameter	2	3
Sink, laundry trays, gooseneck back faucets and other fixtures with effective openings not greater than $^3/_4$ inch in diameter	1.5	2.5

For SI: 1 inch = 25.4 mm.

a. Applicable where walls or obstructions are spaced from the nearest inside edge of the spout opening a distance greater than three times the diameter of the effective opening for a single wall, or a distance greater than four times the diameter of the effective opening for two intersecting walls.

P2902.5.2 Heat exchangers. Heat exchangers using an essentially toxic transfer fluid shall be separated from the potable water by double-wall construction. An air gap open to the atmosphere shall be provided between the two walls. Heat exchangers utilizing an essentially nontoxic transfer fluid shall be permitted to be of single-wall construction.

P2902.5.3 Lawn irrigation systems. The potable water supply to lawn irrigation systems shall be protected against backflow by an atmospheric-type vacuum breaker, a pressure-type vacuum breaker or a reduced pressure principle backflow preventer. A valve shall not be installed downstream from an atmospheric vacuum breaker. Where chemicals are introduced into the system, the potable water supply shall be protected against backflow by a reduced pressure principle backflow preventer.

P2902.5.4 Connections to automatic fire sprinkler systems. The potable water supply to automatic fire sprinkler systems shall be protected against backflow by a double check-valve assembly or a reduced pressure principle backflow preventer.

Exception: Where systems are installed as a portion of the water distribution system in accordance with the requirements of this code and are not provided with a fire department connection, isolation of the water supply system shall not be required.

P2902.5.4.1 Additives or nonpotable source. Where systems contain chemical additives or antifreeze, or where systems are connected to a nonpotable secondary water supply, the potable water supply shall be protected against backflow by a reduced pressure principle backflow preventer. Where chemical additives or antifreeze is added to only a portion of an automatic fire sprinkler or standpipe system, the reduced pressure principle backflow preventer shall be permitted to be located so as to isolate that portion of the system.

P2902.5.5 Solar systems. The potable water supply to a solar system shall be equipped with a backflow preventer with intermediate atmospheric vent complying with ASSE 1012 or a reduced pressure principle backflow preventer complying with ASSE 1013. Where chemicals are used, the potable water supply shall be protected by a reduced pressure principle backflow preventer.

Exception: Where all solar system piping is a part of the potable water distribution system, in accordance with the requirements of the *International Plumbing Code*, and all components of the piping system are listed for potable water use, cross-connection protection measure shall not be required.

P2902.6 Access. Backflow prevention devices shall be accessible for inspection and servicing.

SECTION P2903
WATER-SUPPLY SYSTEM

P2903.1 Water supply system design criteria. The water service and water distribution systems shall be designed and pipe sizes shall be selected such that under conditions of peak demand, the capacities at the point of outlet discharge shall not be less than shown in Table P2903.1.

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TABLE P2903.1
REQUIRED CAPACITIES AT POINT OF OUTLET DISCHARGE

FIXTURE AT POINT OF OUTLET	FLOW RATE (gpm)	FLOW PRESSURE (psi)
Bathtub	4	8
Bidet	2	4
Dishwasher	2.75	8
Laundry tub	4	8
Lavatory	2	8
Shower	3	8
Shower, temperature controlled	3	20
Sillcock, hose bibb	5	8
Sink	2.5	8
Water closet, flushometer tank	1.6	15
Water closet, tank, close coupled	3	8
Water closet, tank, one-piece	6	20

For SI: 1 gallon per minute = 3.785 L/m,
1 pound per square inch = 6.895 kPa.

P2903.2 Maximum flow and water consumption. The maximum water consumption flow rates and quantities for all plumbing fixtures and fixture fittings shall be in accordance with Table P2903.2.

TABLE P2903.2
MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS[b]

PLUMBING FIXTURE OR FIXTURE FITTING	PLUMBING FIXTURE OR FIXTURE FITTING
Lavatory faucet	2.2 gpm at 60 psi
Shower head[a]	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Water closet	1.6 gallons per flushing cycle

For SI: 1 gallon per minute = 3.785 L/m,
1 pound per square inch = 6.895 kPa.

a. A handheld shower spray is also a shower head.

b. Consumption tolerances shall be determined from referenced standards.

P2903.3 Minimum pressure. Minimum static pressure (as determined by the local water authority) at the building entrance for either public or private water service shall be 40 psi (276 kPa).

P2903.3.1 Maximum pressure. Maximum static pressure shall be 80 psi (551 kPa). When main pressure exceeds 80 psi (551 kPa), an approved pressure-reducing valve conforming to ASSE 1003 shall be installed on the domestic water branch main or riser at the connection to the water-service pipe.

P2903.4 Thermal expansion control. A means for controlling increased pressure caused by thermal expansion shall be installed where required in accordance with Sections P2903.4.1 and P2903.4.2.

P2903.4.1 Pressure-reducing valve. For water service system sizes up to and including 2 inches (51 mm), a device for controlling pressure shall be installed where, because of thermal expansion, the pressure on the downstream side of a pressure-reducing valve exceeds the pressure-reducing valve setting.

P2903.4.2 Backflow prevention device or check valve. Where a backflow prevention device, check valve or other device is installed on a water supply system using storage water heating equipment such that thermal expansion causes an increase in pressure, a device for controlling pressure shall be installed.

P2903.5 Water hammer. The flow velocity of the water distribution system shall be controlled to reduce the possibility of water hammer. A water-hammer arrestor shall be installed where quick-closing valves are used. Water-hammer arrestors shall be installed in accordance with manufacturers' specifications. Water-hammer arrestors shall conform to ASSE 1010.

P2903.6 Determining water-supply fixture units. Supply loads in the building water-distribution system shall be determined by total load on the pipe being sized, in terms of water-supply fixture units (w.s.f.u.), as shown in Table P2903.6, and gallon per minute (gpm) flow rates [see Table P2903.6(1)]. For fixtures not listed, choose a w.s.f.u. value of a fixture with similar flow characteristics.

P2903.7 Size of water-service mains, branch mains and risers. The minimum size water service pipe shall be $^3/_4$ inch (19 mm). The size of water service mains, branch mains and risers shall be determined according to water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and developed length of pipe [feet (m)], including equivalent length of fittings. The size of each water distribution system shall be determined according to the procedure outlined in this section or by other design methods conforming to acceptable engineering practice and approved by the administrative authority:

1. Obtain the minimum daily static service pressure [psi (kPa)] available (as determined by the local water authority) at the water meter or other source of supply at the installation location. Adjust this minimum daily static pressure [psi (kPa)] for the following conditions:

   1.1. Determine the difference in elevation between the source of supply and the highest water supply outlet. Where the highest water supply outlet is located above the source of supply, deduct 0.5 psi (3.4 kPa) for each foot (305 mm) of difference in elevation. Where the highest water supply outlet is located below the source of supply, add 0.5 psi (3.4 kPa) for each foot (305 mm) of difference in elevation.

   1.2. Where a water pressure reducing valve is installed in the water distribution system, the minimum daily static water pressure available is 80 percent of the minimum daily static water pressure at the source of supply or the set pressure downstream of the pressure reducing valve, whichever is smaller.

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1.3. Deduct all pressure losses caused by special equipment such as a backflow preventer, water filter or water softener. Pressure loss data for each piece of equipment shall be obtained from the manufacturer of such devices.

1.4. Deduct the pressure in excess of 8 psi (55 kPa) caused by installation of special plumbing fixtures, such as temperature controlled showers and flushometer tank water closets.

Using the resulting minimum available pressure, find the corresponding pressure range in Table P2903.7.

2. The maximum developed length for water piping is the actual length of pipe between the source of supply and the most remote fixture, including either hot (through the water heater) or cold water branches multiplied by a factor of 1.2 to compensate for pressure loss through fittings.

Select the appropriate column in Table P2903.7 equal to or greater than the calculated maximum developed length.

3. To determine the size of water service pipe, meter and main distribution pipe to the building using the appropriate table, follow down the selected "maximum developed length" column to a fixture unit equal to, or greater than the total installation demand calculated by using the "combined" water supply fixture unit column of Table P2903.6. Read the water service pipe and meter sizes in the first left-hand column and the main distribution pipe to the building in the second left-hand column on the same row.

4. To determine the size of each water distribution pipe, start at the most remote outlet on each branch (either hot or cold branch) and, working back toward the main distribution pipe to the building, add up the water supply fixture unit demand passing through each segment of the distribution system using the related hot or cold column of Table P2903.6. Knowing demand, the size of each segment shall be read from the second left-hand column of the same table and a maximum developed length column selected in Steps 1 and 2, under the same or next smaller size meter row. In no case does the size of any branch or main need to be larger that the size of the main distribution pipe to the building established in Step 3.

P2903.8 Gridded and parallel water distribution system manifolds. Hot water and cold water manifolds installed with gridded or parallel-connected individual distribution lines to each fixture or fixture fittings shall be designed in accordance with Sections P2903.8.1 through P2903.8.6.

TABLE P2903.6
WATER-SUPPLY FIXTURE-UNIT VALUES FOR VARIOUS PLUMBING FIXTURES AND FIXTURE GROUPS

TYPE OF FIXTURES OR GROUP OF FIXTURES	WATER-SUPPLY FIXTURE-UNIT VALUE (w.s.f.u.)		
	Hot	Cold	Combined
Bathtub (with/without overhead shower head)	1.0	1.0	1.4
Clothes washer	1.0	1.0	1.4
Dishwasher	1.4	—	1.4
Full-bath group with bathtub (with/without shower head) or shower stall	1.5	2.7	3.6
Half-bath group (water closet and lavatory)	0.5	2.5	2.6
Hose bibb (sillcock)[a]	—	2.5	2.5
Kitchen group (dishwasher and sink with/without garbage grinder)	1.9	1.0	2.5
Kitchen sink	1.0	1.0	1.4
Laundry group (clothes washer standpipe and laundry tub)	1.8	1.8	2.5
Laundry tub	1.0	1.0	1.4
Lavatory	0.5	0.5	0.7
Shower stall	1.0	1.0	1.4
Water closet (tank type)	—	2.2	2.2

For SI: 1 gallon per minute = 3.785 L/m.

a. The fixture unit value 2.5 assumes a flow demand of 2.5 gpm, such as for an individual lawn sprinkler device. If a hose bibb/sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

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P2903.8.1 Sizing of manifolds. Manifolds shall be sized in accordance with Table P2903.8.1. Total gallons per minute is the demand for all outlets.

P2903.8.2 Minimum size. Where the developed length of the distribution line is 60 feet (18 288 mm) or less, and the available pressure at the meter is a minimum of 40 pounds per square inch (276 kPa), the minimum size of individual distribution lines shall be $^3/_8$ inch (10 mm). Certain fixtures such as one-piece water closets and whirlpool bathtubs shall require a larger size where specified by the manufacturer. If a water heater is fed from the end of a cold water manifold, the manifold shall be one size larger than the water heater feed.

P2903.8.3 Orientation. Manifolds shall be permitted to be installed in a horizontal or vertical position.

P2903.8.4 Support and protection. Plastic piping bundles shall be secured in accordance with the manufacturer's installation instructions and supported in accordance with Section P2605. Bundles that have a change in direction equal to or greater than 45 degrees (0.79 rad) shall be protected from chafing at the point of contact with framing members by sleeving or wrapping.

TABLE P2903.6(1)
CONVERSIONS FROM WATER SUPPLY FIXTURE UNIT TO GALLON PER MINUTE FLOW RATES

SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS			SUPPLY SYSTEM PREDOMINANTLY FOR FLUSH VALVES		
Load	Demand		Load	Demand	
(Water supply fixture units)	(Gallons per minute)	(Cubic feet per minute)	(Water supply fixture units)	(Gallons per minute)	(Cubic feet per minute)
1	3.0	0.04104	—	—	—
2	5.0	0.0684	—	—	—
3	6.5	0.86892	—	—	—
4	8.0	1.06944	—	—	—
5	9.4	1.256592	5	15.0	2.0052
6	10.7	1.430376	6	17.4	2.326032
7	11.8	1.577424	7	19.8	2.646364
8	12.8	1.711104	8	22.2	2.967696
9	13.7	1.831416	9	24.6	3.288528
10	14.6	1.951728	10	27.0	3.60936
11	15.4	2.058672	11	27.8	3.716304
12	16.0	2.13888	12	28.6	3.823248
13	16.5	2.20572	13	29.4	3.930192
14	17.0	2.27256	14	30.2	4.037136
15	17.5	2.3394	15	31.0	4.14408
16	18.0	2.90624	16	31.8	4.241024
17	18.4	2.459712	17	32.6	4.357968
18	18.8	2.513184	18	33.4	4.464912
19	19.2	2.566656	19	34.2	4.571856
20	19.6	2.620128	20	35.0	4.6788
25	21.5	2.87412	25	38.0	5.07984
30	23.3	3.114744	30	42.0	5.61356
35	24.9	3.328632	35	44.0	5.88192
40	26.3	3.515784	40	46.0	6.14928
45	27.7	3.702936	45	48.0	6.41664
50	29.1	3.890088	50	50.0	6.684

For SI: 1 gallon per minute = 3.785 L/m, 1 cubic foot per minute = 0.4719 L/s.

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TABLE P2903.7
MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES

Pressure Range—30 to 39 psi

METER AND SERVICE PIPE (inches)	DISTRIBUTION PIPE (inches)	MAXIMUM DEVELOPMENT LENGTH (feet)									
		40	60	80	100	150	200	250	300	400	500
3/4	1/2[a]	2.5	2	1.5	1.5	1	1	.5	.5	0	0
3/4	3/4	9.5	7.5	6	5.5	4	3.5	3	2.5	2	1.5
3/4	1	32	25	20	16.5	11	9	7.5	6.5	5.5	4.5
1	1	32	32	27	21	13.5	10	8	7	5.5	5
3/4	1 1/4	32	32	32	32	30	24	20	17	13	10.5
1	1 1/4	80	80	70	61	45	34	27	22	16	12
1 1/2	1 1/4	80	80	80	75	54	40	31	25	17.5	13
1	1 1/2	87	87	87	87	84	73	74	56	45	36
1 1/2	1 1/2	151	151	151	151	117	92	79	69	54	43

Pressure Range—40 to 49 psi

METER AND SERVICE PIPE (inches)	DISTRIBUTION PIPE (inches)	MAXIMUM DEVELOPMENT LENGTH (feet)									
		40	60	80	100	150	200	250	300	400	500
3/4	1/2[a]	3	2.5	2	1.5	1.5	1	1	.5	.5	.5
3/4	3/4	9.5	9.5	8.5	7	5.5	4.5	3.5	3	2.5	2
3/4	1	32	32	32	26	18	13.5	10.5	9	7.5	6
1	1	32	32	32	32	21	15	11.5	9.5	7.5	6.5
3/4	1 1/4	32	32	32	32	32	32	32	27	21	16.5
1	1 1/4	80	80	80	80	65	52	42	35	26	20
1 1/2	1 1/4	80	80	80	80	75	59	48	39	28	21
1	1 1/2	87	87	87	87	87	87	87	78	65	55
1 1/2	1 1/2	151	151	151	151	151	130	109	93	75	63

Pressure Range—50 to 60 psi

METER AND SERVICE PIPE (inches)	DISTRIBUTION PIPE (inches)	MAXIMUM DEVELOPMENT LENGTH (feet)									
		40	60	80	100	150	200	250	300	400	500
3/4	1/2[a]	3	3	2.5	2	1.5	1	1	1	.5	.5
3/4	3/4	9.5	9.5	9.5	8.5	6.5	5	4.5	4	3	2.5
3/4	1	32	32	32	32	25	18.5	14.5	12	9.5	8
1	1	32	32	32	32	30	22	16.5	13	10	8
3/4	1 1/4	32	32	32	32	32	32	32	32	29	24
1	1 1/4	80	80	80	80	80	68	57	48	35	28
1 1/2	1 1/4	80	80	80	80	80	75	63	53	39	29
1	1 1/2	87	87	87	87	87	87	87	87	82	70
1 1/2	1 1/2	151	151	151	151	151	151	139	120	94	79

(continued)

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TABLE P2903.7—continued
MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES

Pressure Range—greater than 60 psi

METER AND SERVICE PIPE (inches)	DISTRIBUTION PIPE (inches)	MAXIMUM DEVELOPMENT LENGTH (feet)									
		40	60	80	100	150	200	250	300	400	500
$^3/_4$	$^1/_2$[a]	3	3	3	2.5	2	1.5	1.5	1	1	.5
$^3/_4$	$^3/_4$	9.5	9.5	9.5	9.5	7.5	6	5	4.5	3.5	3
$^3/_4$	1	32	32	32	32	32	24	19.5	15.5	11.5	9.5
1	1	32	32	32	32	32	28	22	17	12	9.5
$^3/_4$	$1^1/_4$	32	32	32	32	32	32	32	32	32	30
1	$1^1/_4$	80	80	80	80	80	80	69	60	46	36
$1^1/_2$	$1^1/_4$	80	80	80	80	80	80	76	65	50	38
1	$1^1/_2$	87	87	87	87	87	87	87	87	87	84
$1^1/_2$	$1^1/_2$	151	151	151	151	151	151	151	144	114	94

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.
a. Minimum size for building supply is $^3/_4$-inch pipe.

TABLE P2903.8.1
MANIFOLD SIZING

PLASTIC	METALLIC		
Nominal Size ID (inches)	Maximum[a] gpm	Nominal Size ID (inches)	Maximum[a] gpm
$^3/_4$	17	$^3/_4$	11
1	29	1	20
$1^1/_4$	46	$1^1/_4$	31
$1^1/_2$	66	$1^1/_2$	44

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m, 1 foot per second = 0.3048 m/s.
NOTE: See Table P2903.6 for w.s.f.u and Table 2903.6(1) for gallon-per-minute (gpm) flow rates.
a. Based on velocity limitation: plastic—12 fps; metal—8 fps.

P2903.8.5 Valving. Fixture valves, when installed, shall be located either at the fixture or at the manifold. If valves are installed at the manifold, they shall be labeled indicating the fixture served.

P2903.8.6 Hose bibb bleed. A readily accessible air bleed shall be installed in hose bibb supplies at the manifold or at the hose bibb exit point.

P2903.9 Valves. Valves shall be installed in accordance with Sections P2903.9.1 through P2903.9.3.

P2903.9.1 Service valve. Each dwelling unit shall be provided with an accessible main shutoff valve near the entrance of the water service. The valve shall be of a full-open type having nominal restriction to flow, with provision for drainage such as a bleed orifice or installation of a separate drain valve. Additionally, the water service shall be valved at the curb or property line in accordance with local requirements.

P2903.9.2 Water heater valve. A readily accessible full-open valve shall be installed in the cold-water supply pipe to each water heater at or near the water heater.

P2903.9.3 Fixture valves and access. Valves serving individual fixtures, appliances, risers and branches shall be provided with access. An individual shutoff valve shall be required on the fixture supply pipe to each plumbing fixture other than bathtubs and showers.

P2903.9.4 Valve requirements. Valves shall be of an approved type and compatible with the type of piping material installed in the system. Ball valves, gate valves, globe valves and plug valves intended to supply drinking water shall meet the requirements of NSF 61.

P2903.10 Hose bibb. Hose bibbs subject to freezing, including the "frost-proof" type, shall be equipped with an accessible stop-and-waste-type valve inside the building so that they can be controlled and/or drained during cold periods.

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