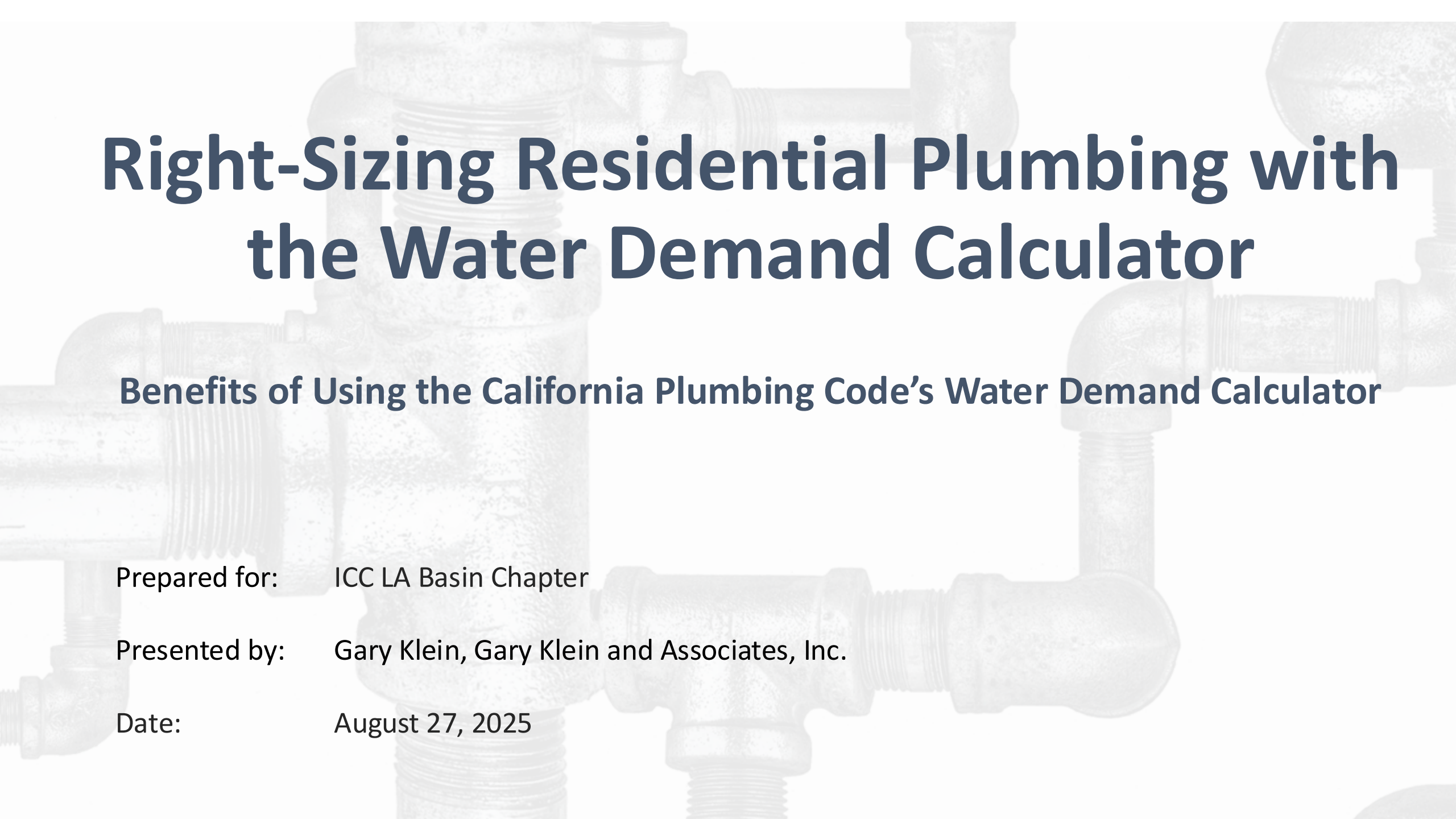




Right-Sizing Residential Plumbing with the Water Demand Calculator

Benefits of Using the California Plumbing Code's Water Demand Calculator

Prepared for: ICC LA Basin Chapter

Presented by: Gary Klein, Gary Klein and Associates, Inc.

Date: August 27, 2025

Learning Objectives

- Identify the differences between the “default” water supply demand sizing method and the Water Demand Calculator (WDC) regarding peak water demand calculation criteria.
- Explain potential reductions in cost, water usage, energy consumption, and carbon emissions when utilizing the WDC in multifamily plumbing design.
- Summarize changes in public health and safety risk, as well as improvements in water quality, associated with using the WDC for plumbing systems.
- Find instructional resources to support the application of the WDC in future plumbing project design

Topics

- **Nueva Esperanza Development: an Exemplary Project**
- Overview and Problems with the Hunter's Curve
- Data Dive on the Water Demand Calculator (WDC)
- Benefits of Right-Sizing Premise Plumbing
- The WDC in the Codes and Standards
- Collaboration Opportunities on Data Collection Efforts

Affordable Housing Project in Oregon

Location: Hillsboro, OR

Year: Nueva Esperanza project completed in 2023

Number of Units: Total of 150 units (studios to 4-bedroom units) in 12 multifamily buildings on a single 6-acre parcel*

Architect: Scott Edwards Architecture

Plumbing Engineer: Interface Engineering Inc.



*Nueva Esperanza project includes total of 13 buildings (12 multifamily buildings plus 1 community building) that are connected to a single domestic water meter.

Nueva Esperanza development project **achieved significant cost savings by applying the WDC** when sizing the water meter and water pipes.

Affordable Housing Project in Oregon, *cont.*

Water SDC Quote Worksheet

CITY OF HILLSBORO UTILITIES COMMISSION
FOR RETAIL CUSTOMERS
SDC WORKSHEET FOR METERS GREATER THAN 2"

Date 03/12/2021
Project Name Nueva Esperanza
Project Address Ne Corner of NE 53rd Ave & Hidden Creek Dr.
Size of Water Meter 4"
Quote given by Brian Jansen

Since the customer was unable to provide a usage estimate, this quote is based on 150 apartment units at the Utilities Commission approved average daily use of 225 gallons per day/per apartment and a peaking factor of 1.5x.

PEAK DAY SDC COST IS:

Peaking Factor = 1.5x Average
(or client-provided amount, whichever is greater)

Estimated Peak Day Usage is 1123 = 45.08 (peak day flow of Gallons/Day/ME) X 50,625 gpd divided by \$9,095
= (peak day SDC cost for a 5/8" x 3/4" meter) = \$ 410,003.90

AVERAGE DAILY WATER USAGE SDC COST IS:

Number of Multi-Fam Units= 150
AAD is 225 gpd per unit (UC Res #198)

Estimated Average Day Usage is 741 = 45.55 (average day flow of Gallons/Day/ME) X 33,750 gpd divided by \$1,655
= (average day SDC cost for a 5/8" x 3/4" meter) = \$ 75,379.55

TOTAL SDC

	SDC	Usage
Peak Day SDC	\$410,003.90	50,625
Average Day SDC	\$75,379.55	33,750
Administrative Charge	\$37.00	

Total SDC Charge \$ 485,420.45

Plus Connection Charge \$7,600.00

Total Estimated Meter Cost \$493,020.45

SET FEES FOR LARGE METERS:

Meter Size	Connection Fees
3-Inch	\$3,800
4-Inch	\$7,600
6-Inch	\$12,000
8-Inch	\$20,000

An initial quote from the water utility for the Nueva Esperanza development project for **System Development Charge (SDC)** based on default water use inputs* **was ~\$485K for a 4-inch water meter.**

*Default water use inputs assume average daily use of 225 gallons per day per apartment and a peaking factor of 1.5x.

Affordable Housing Project in Oregon, *cont.*

City of Hillsboro In-Town Retail Customers

2021 Water System Development Charge (SDC) Schedule

Water Meter Size	SDCs 8/1/21 – 6/30/22
5/8 inch by 3/4 inch	\$11,035
3/4 inch (residential customers only)	\$16,553
1 inch	\$27,588
1 1/2 inch	\$55,175
2 inch	\$88,280
3 inch and larger	Water SDCs are based on estimated average day and maximum day demands expressed in 5/8 inch by 3/4 inch water meter equivalents

*Notes:

- The calculated design flow for the project's water meter and water service was ~72 gpm.
- The WDC was used to calculate the design flows for residential fixtures and the current practice "Water Supply Fixture Units" method was used to calculate the design flows for commercial fixtures. These design flows were added to size the water service.

The **use of the WDC** for the entire Nueva Esperanza development allowed the project to install a **2-inch water meter** serving the entire development* and **reduced the SDC charge** by ~\$400K from the initial quote, resulting in **cost savings of ~\$2,650 per dwelling unit.**

Affordable Housing Project in Oregon, *cont.*

Base case – sizing plumbing pipes using a standard practice
(Water Supply Fixture Unit method)

Metric	Savings due to the use of the WDC
In-Unit Water Savings*	1,106 gal/dwelling unit per year
In-Unit Electricity Savings*	2,435 kWh/dwelling unit per year
Greenhouse Gas Emissions Avoided	0.78 MTCO2/dwelling unit per year
Electricity Cost Savings	\$278 per dwelling unit per year
Piping Cost Savings	\$67 per dwelling unit
Pipe Fitting Cost Savings	\$65 per dwelling unit

*Conservative estimate, only accounting for clearing cooled water in hot water piping at the beginning of hot water events (not accounting for additional wasted water to re-heat the cooled hot water piping)

The **use of the WDC** for the entire Nueva Esperanza development **reduced costs by \$43,840**, solely for the pipe materials and fittings.

Topics

- Nueva Esperanza Development: an Exemplary Project
- **Overview and Problems with the Hunter's Curve**
- Data Dive on the Water Demand Calculator (WDC)
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- Collaboration Opportunities on Data Collection Efforts

Overview

- **Sizing plumbing** in residential new construction and **sizing water meters and mains** are now undergoing a **major transformation**.
- This is a topic that you likely have not heard about before.
- But it is an important topic now. How many other areas of modern life are still governed by thinking back from the 1940s?
- Did you know that the **formula from the 1940s for design flow rates** assumes that every **home operates like a sports stadium at halftime** with queue lines to use fixtures?

Overview, *cont.*

- Reducing the volume of water in the building's piping has many **benefits including water savings, energy savings, carbon savings, cost savings.**
- Volume is a combination of distance and diameter.
- Architects are responsible for the distance between the mechanical room and the wet rooms.
- The plumbing professionals have no choice but to connect the fixtures and appliances so that they do not leak.
- Today, we will explore the benefits of right-sizing the **diameter** of the **piping** using **the Water Demand Calculator.**

Reductions in Water Consumption by Residential Plumbing Products and Appliances

Residential Plumbing Product or Appliance	1980s Water Use (Typical)	Energy Policy and Conservation Act of 1992 and Model Plumbing Code (UPC)	California Title 20 Appliance Efficiency Standards	% Reduction in Typical Water Use since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm (eff. 1994) 2.2 gpm (eff. 1998)	1.2 gpm (manufactured since 2016)	66%
Kitchen Faucet	3.5+ gpm	2.5 gpm (eff. 1994) 2.2 gpm (eff. 1998)	1.8 gpm (2.2 gpm temporary override is allowed; sold since 2016)	49%
Showerhead	3.5+ gpm	2.5 gpm (eff. 1994)	2.0 gpm (manufactured July 2016-July 2018) 1.8 gpm (manufactured since July 2018)	49%
Residential Toilet	5.0+ gpf	1.6 gpf (eff. 1994)	1.28 gpf (sold since 2016)	74%
Residential Clothes Washers	51 gallons per load	No Requirement	13-23 gallons per load (manufactured March 2015-January 2018) 13-19 gallons per load (manufactured since January 2018)	55-75%
Residential Dishwasher	14 gallons per cycle	No Requirement	3.5 gallons per cycle for compact 5.0 gallons per cycle for standard (manufactured since 2013)	64-75%

gpm = gallons per minute, gpf = gallons per flush

Over the past ~40 years, residential plumbing products and appliances have experienced about **~50-75% reductions in water use.**

Sources:

2023 Title 20 CASE Report on Water Closets <https://efiling.energy.ca.gov/GetDocument.aspx?tn=252134&DocumentContentId=87140> (electronic page 44)

Energy Policy and Conservation Act of 1992 <https://www.govinfo.gov/content/pkg/STATUTE-106/pdf/STATUTE-106-Pg2776.pdf>

California Title 20 Appliance Efficiency Standards

[https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=ID0318F505CCE11EC9220000D3A7C4BC3&originationContext=documenttoc&transitionType=Default&contextData=\(sc.Default\)](https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=ID0318F505CCE11EC9220000D3A7C4BC3&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default))

Treating Homes Like Sports Stadiums?



The probability of simultaneous use of fixtures and fittings in a residential building is lower than previously assumed.

Water Meters and Minimum Flow Rate Rating



SPECIFICATIONS

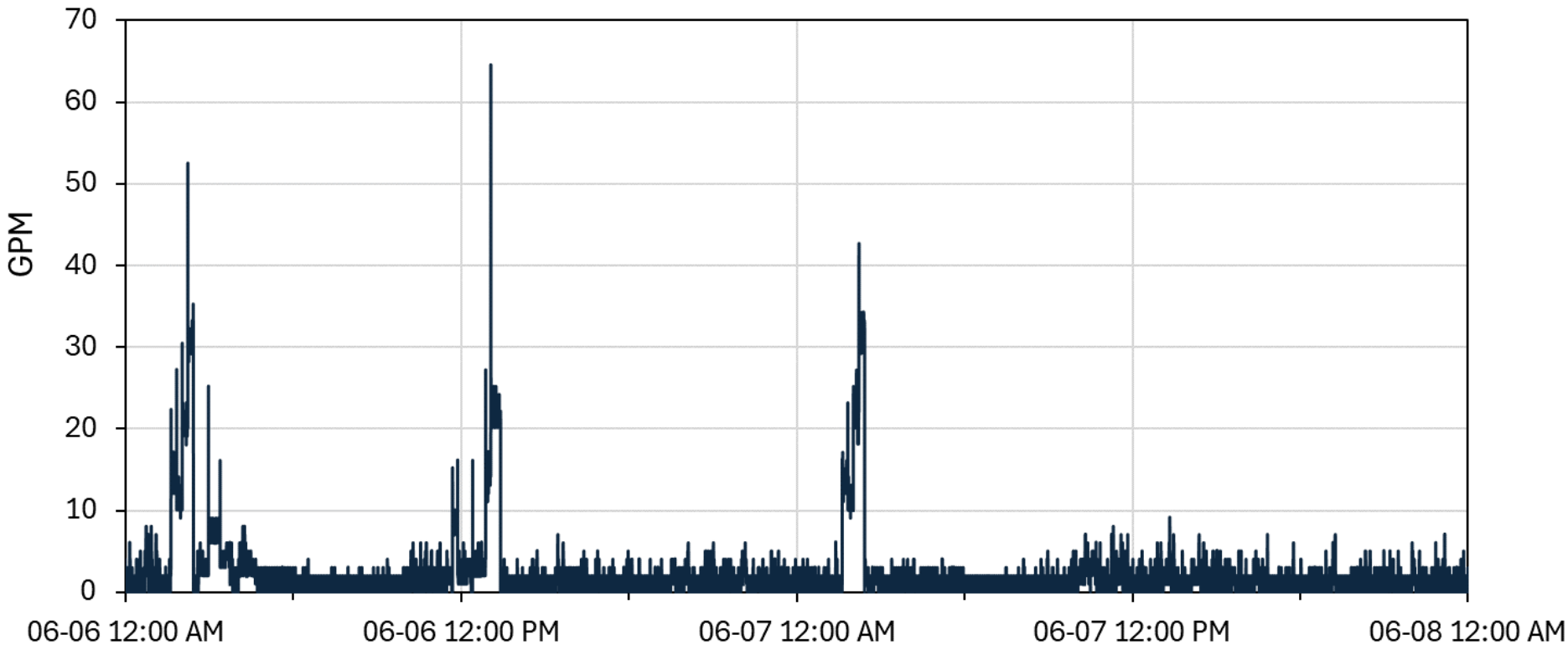
Ultrasonic flow meters

Meter Model	M120	M170
Typical Operating Range (100% ± 1.5%)	2.5...120 gpm (0.57...27 m³/hr)	2.5...170 gpm (0.57...39 m³/hr)
Low Flow (Min. 95%)	1.25 gpm (0.28 m³/hr)	1.5 gpm (0.34 m³/hr)
Maximum Continuous Operation	80 gpm (18 m³/hr)	100 gpm (23 m³/hr)
Pressure Loss at Maximum Continuous Operation	4.8 psi at 80 gpm (0.33 bar at 18 m³/hr)	3.3 psi at 100 gpm (0.23 bar at 23 m³/hr)
Maximum Operating Temperature	80° F (26° C)	80° F (26° C)
Maximum Operating Pressure	150 psi (10 bar)	150 psi (10 bar)

Very small flow rates or even leaks often escape monitoring of many water meters. Most of the time **the peak flow rate is below minimum flow rate rating for commonly used water meters.**

Example: 18-unit Condo in Phoenix, Arizona

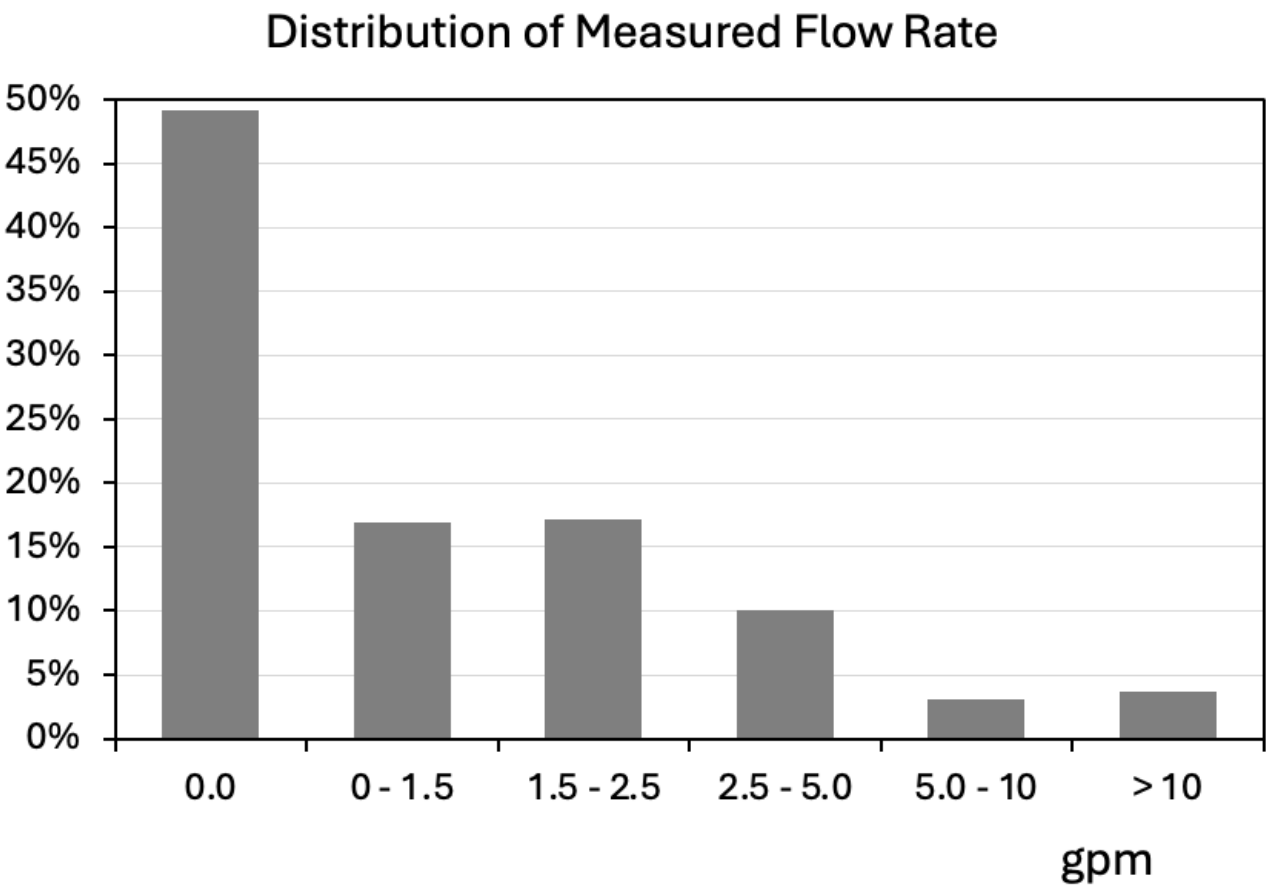
Building Demand Flow



- 30 study days
- Maximum recorded peak = 67.5 gpm
- Irrigation + pool flow = 50 gpm
- Hunter's Curve meter size: 2" Turbine (153 gpm)
- Hunter's Curve main size: 3" (153 gpm)
- WDC meter size: 1" Disc
- WDC main size: 2" (68.7 gpm)

Example: 18-unit Condo in Phoenix, Arizona, cont.

Distribution of 495,649 data points collected every 5 seconds over 30 days in 2024



Flow rate (gpm)	Percentage including zero flows	Percentage excluding zero flows
0	49%	-
0 - 1.5	17%	33%
1.5 - 2.5	17%	33%
2.5 – 5.0	10%	20%
5.0 - 10	3%	6%
> 10	4%	6%

Topics

- Nueva Esperanza Development: an Exemplary Project
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Water Demand Calculator® (WDC v2.2 - macOS)

PROJECT NAME :
Click for Drop-down Menu →

TOTAL INDOOR Design Flow for 3-Story, 48-Unit Building

Multi-Family Building

Single-Family Residence

Multi-Family Building

FIXTURE

Total Number of Apartments in the Building →

48

Total Apartments in this Calculation →

48

Tuesday, November 19, 2024

9:49 PM

FIXTURE GROUPS		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	0.46	5.5
	2	Bidet	0	0.57	2.0
	3	Combination Bath/Shower	36	1.71	5.5
	4	Faucet, Lavatory	84	1.23	1.5
	5	Shower, per head (no Bathtub)	48	1.16	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	84	0.57	3.0
Kitchen Fixtures	7	Dishwasher	48	0.34	1.3
	8	Faucet, Kitchen Sink	48	1.23	2.2
Laundry Room Fixtures	9	Clothes Washer	48	1.64	3.5
	10	Faucet, Laundry	0	1.23	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	1.23	1.5
Other Fixtures	12	Fixture 1	0	0.00	6.0
	13	Fixture 2	0	0.00	6.0
	14	Fixture 3	0	0.00	6.0

DOWNLOAD
RESULT

RESET
WDC

↓ Select Units for Water Demand ↓

GPM

LPM

LPS

RUN
WDC

COMPUTED RESULTS
FOR
PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation

N = 396

99th Percentile Demand Flow

Q = 26.5 GPM

Hunter Number

H(n,p) = 4.23

Stagnation Probability

Pr[Zero Demand] = 1%

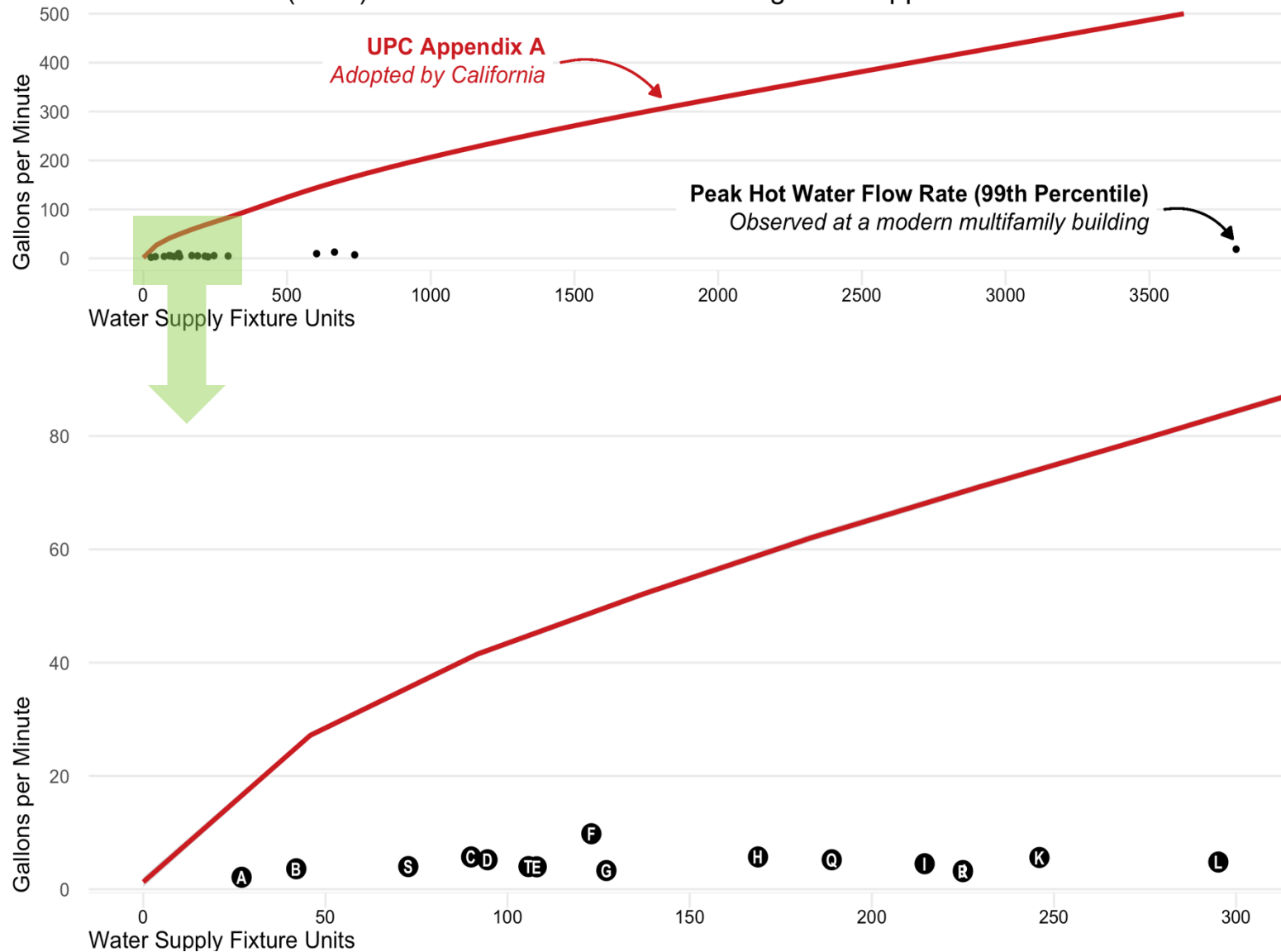
Method of Computation

Modified Wistort's Method

The Water Demand Calculator (WDC) can be used to **estimate the demand load** (design flow rates in gallons per minute) **for the building water supply, branches, and risers** for single family and multifamily dwellings.

Comparing Hunter's Curve to Actual Peak Flow Rates

Hunter's Curve (1940) is the basis of Uniform Plumbing Code Appendix A



Water Supply Fixture Units = WSFU

California Plumbing Code (CPC)/Uniform Plumbing Code (UPC) Appendix A codifies the standard practice WSFU method.

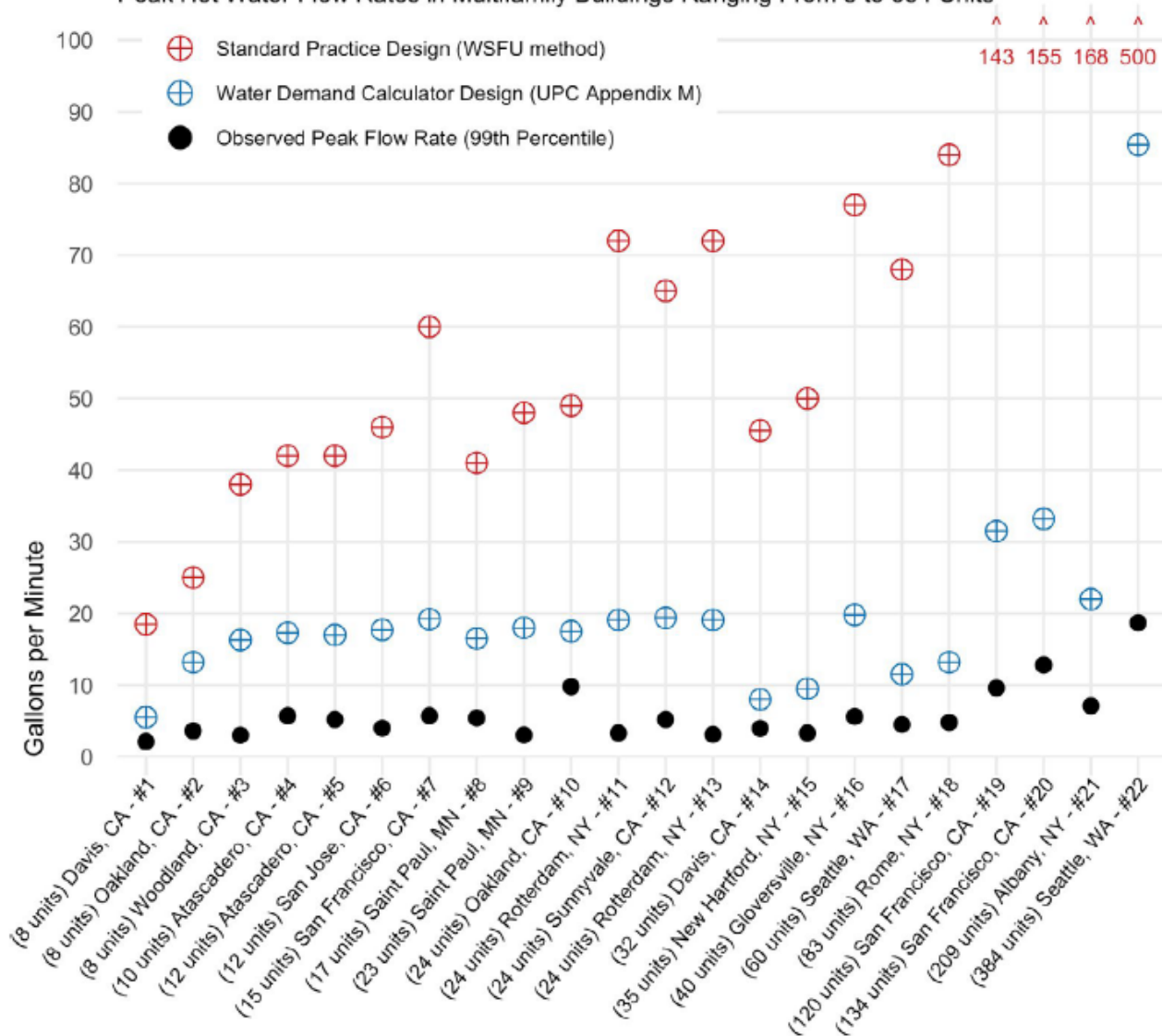
Credits: Observed peak flow rate data was collected and provided by the Association for Energy Affordability, Ecotope, Frontier Energy, E2G Solar, and the University of California Davis Western Cooling Efficiency Center.

Based on the analyzed actual hot flow rates from **multifamily buildings** ranging from 8 to 384 apartments,

Standard Practice WSFU design flow rates are 5 to 27 times larger than the observed peak hot water flow rates.

Standard Practice Design Greatly Exceeds Actual Peak Flow Rates

Peak Hot Water Flow Rates in Multifamily Buildings Ranging From 8 to 384 Units



The **WDC design flow rates** are **between 2 and 6 times** the observed peak hot water flow rates in **22 multifamily buildings**.

CPC/UPC Appendix M codifies the Water Demand Calculator.

Data was collected during the period of 2019 to 2022; monitoring period ranged from 9 days to over 2 years, and logging interval ranged from 1 to 60 seconds. Observed peak flow rate is the 99th percentile of non-zero flow rates observed over each study's duration.

Credits: Observed peak flow rate data was collected and provided by the Association for Energy Affordability, Center for Energy and Environment, E2G Solar, Ecotope, Frontier Energy, and the University of California Davis Western Cooling Efficiency Center.

Table 3. Summary of Detailed Data for the Analyzed Multifamily Buildings

	City	Monitored Apartments	Monitoring Data				CPC Appendix M		CPC Appendix A		
			Monitoring Period (day)	Logging Interval (sec)	Time at Zero Flow	Study Peak (gpm)	Design (gpm)	Design Relative to Study Peak	WSFU	Design (gpm)	Design Relative to Study Peak
A	Davis, CA	8	304	15	87%	2.1	6	3x	27	19	9x
B	Oakland, CA	8	10	1	-	3.6	13	4x	42	25	7x
C	Atascadero, CA	10	257	60	-	5.7	17	3x	94	42	7x
D	Atascadero, CA	12	257	60	-	5.2	17	3x	97	42	8x
E	Davis, CA	32	304	15	56%	4.0	8	2x	108	46	11x
F	Oakland, CA	24	14	1	48%	9.8	18	2x	123	49	5x
G	New Hartford, NY	35	26	60	69%	3.3	10	3x	127	50	15x
H	San Francisco, CA	15	9	1	-	5.7	19	3x	174	60	11x
I	Seattle, WA	60	823	60	-	4.5	12	3x	215	68	15x
J	Rotterdam, NY	24	18	60	38%	3.3	19	6x	234	72	22x
K	Gloversville, NY	40	12	60	-	5.6	20	4x	261	77	14x
L	Rome, NY	83	15	60	37%	4.8	13	3x	295	84	18x
M	San Francisco, CA	120	12	1	-	9.6	32	3x	603	143	15x
N	San Francisco, CA	134	12	1	38%	13	33	3x	665	155	12x
O	Albany, NY	209	21	60	-	7.1	22	3x	735	168	24x
P	Seattle, WA	384	609	60	8%	19	85	5x	3,946	500	27x
Q	Sunnyvale, CA	24	272	60	-	5.4	19	4x	198	65	12x
R	Rotterdam, NY	24	19	1	-	3.1	19	6x	234	72	23x
S	Woodland, CA	9	128	60	84%	4	16	4x	76	38	10x
T	San Jose, CA	12	59	60	72%	4	18	4x	110	46	12x
Median							3x				12x

Notes: Study Peak is the 99th percentile of non-zero hot water flow rates observed during the monitoring period. WSFU stands for Water Supply Fixture Units. Percent Time with Zero Flow is not displayed where monitoring issues may have impacted the accuracy of the metric. For building P, the WSFU exceeds the CPC Appendix A design curve, therefore the last value on the design curve was used. Detailed information on building occupancy during the study periods for each building is not available. The requirement for a dataset to be included in this analysis was a minimum occupancy being greater than 80% during the study period.

Table 4. Summary of Fixture Counts for the Analyzed Multifamily Buildings

	City	Monitored Apartments	Occupancy Type	Combo Bath /Shower	Lavatory Faucet	Shower	Water Closets	Dish-washer	Kitchen Faucet	Clothes Washer	Total Fixtures
A	Davis, CA	8	MF Low Income	0	8	8	8	0	8	0	32
B	Oakland, CA	8	MF Market Rate (Rent Controlled)	8	8	0	8	0	8	1	33
C	Atascadero, CA	10	MF Low Income	18	18	0	18	10	10	0	74
D	Atascadero, CA	12	MF Low Income	18	18	0	18	12	12	0	78
E	Davis, CA	32	MF Low Income	0	32	32	32	0	32	0	128
F	Oakland, CA	24	MF Market Rate	24	24	0	24	0	24	2	98
G	New Hartford, NY	35	MF Senior	0	35	35	35	0	35	3	143
H	San Francisco, CA	15	MF Low Income	24	24	0	24	15	15	15	117
I	Seattle, WA	60	MF Senior Low Income	0	60	60	60	0	60	4	244
J	Rotterdam, NY	24	MF Net Zero (Mixed Occupancy)	24	28	4	28	24	24	24	156
K	Gloversville, NY	40	MF Low-and-Moderate Income	40	40	0	40	40	40	2	202
L	Rome, NY	83	MF Senior	0	83	83	83	0	83	5	337
M	San Francisco, CA	120	MF Low Income	120	120	0	120	0	120	6	486
N	San Francisco, CA	134	MF Low Income	134	134	0	134	0	134	4	540
O	Albany, NY	209	MF Senior	0	209	209	209	0	209	10	846
P	Seattle, WA	384	MF Market Rate	454	565	0	565	384	384	384	2,736
Q	Sunnyvale, CA	24	MF Low Income	36	36	0	36	24	24	0	189
R	Rotterdam, NY	24	MF Net Zero (Mixed Occupancy)	24	28	4	28	24	24	24	156
S	Woodland, CA	9	MF Low Income	14	14	0	14	9	9	0	60
T	San Jose, CA	12	MF Low Income	21	21	0	21	12	12	0	87

Notes: The CPC Appendix M design flow rate is determined based on fixture counts, probabilities of use, and fixture flow rates. The shower type in apartments in a multifamily building significantly impacts CPC Appendix M design flow rate. A building with combo bath/showers will have higher design flow rate compared to the same building with showers only. For hot water, design demand calculations exclude water closets since water closets use cold water only.

CPC APPENDIX M:
**Alternative Methodology
for Calculating Peak
Water Demand**

Opportunity for Early Adoption

Prepared by:

Steffi Becking and Elise Wall, 2050 Partners, Inc.

Gary Klein, Gary Klein and Associates, Inc.

Jack Aitchison and Amy Dryden, The Association for Energy Affordability

Prepared for:

Kelly Cunningham, Codes and Standards Program Pacific Gas and Electric Company (PG&E)



Pacific Gas and
Electric Company



SOUTHERN CALIFORNIA
EDISON
Energy for What's Ahead



SDGE



For more information,
access the **report**
summarizing the
analysis that compared
design flow rates to
actual data for hot water
flow rates in 20
multifamily buildings.

Source:

<https://localenergycodes.com/content/reach-codes/energy-plus-water-1>

(to access the report, click "VIEW AND DOWNLOAD RESOURCES" for the "require alternative method for sizing water pipes in residential buildings" measure)

https://localenergycodes.com/download/1461/file_path/fieldList/2024%20CPC%20Appx%20M-Alternative%20Calc%20Water%20Demand.pdf (direct download link)

Topics

- Nueva Esperanza Development: an Exemplary Project
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Benefits of Right-Sizing Premise Plumbing

- **Construction cost savings** due to smaller diameter pipes and fittings, less pipe insulation material, smaller water heaters, and reduced water service entrance size
- **Ongoing cost savings** to occupants and homeowners from water and energy savings
- **Faster delivery of hot water** to occupants
- **Water and embedded energy savings** due to faster hot water delivery times
- **Additional energy savings** due to decreased heat loss in the hot water distribution system (particularly in multifamily buildings with a recirculation system) and due to decreased energy use by booster pumps (in multifamily buildings)
- **Reduced carbon emissions** due to material savings (embodied carbon) and energy reductions (operational carbon)
- **Reduced public health and safety risk** and improved water quality due to shorter water dwell times in premise plumbing systems

Benefits Specific to Water Utilities

- **Revenue from small flows** for water utilities since smaller meters capture small flows
- **Improve water quality** as smaller pipes reduce water age and the potential for pathogen growth; increased disinfectant residual due to lowered retention time
- Smaller meters are better at **detecting leaks**, potentially saving water for both utilities and customers
- Utilities have potential to **reallocate water** that customers save

Sizing Water Service Lines and Meters

Fourth Edition

PROJECT NO.
4689

Assessing Water Demand
Patterns to Improve Sizing of
Water Meters and Service Lines



Badger Meter

DENVER WATER

American Water Works
Association

“Oversized meters can result in lost revenue because of inaccurate registration at low flow. From the standpoint of registration accuracy and revenue, water meters should not be sized conservatively, i.e., larger than needed.”

2024 AWWA 4th Edition
Manual M22 “Sizing
Water Service Lines and
Water Meters”
**recommends using the
WDC** for estimating peak
water demand in
residential buildings.

The 15-County Metropolitan North Georgia Water Planning District and Local Amendments to the Georgia Plumbing Code

2024 Georgia State Minimum Standard Plumbing Code is based on the 2018 International Plumbing Code (IPC).

Local Amendment to 2018 IPC Appendix E Sizing of Water Piping System:

FINAL – December 2022
Redline of Changes to Current Code

Metro Water District – Water Efficiency Code Requirements **Local Amendment to Plumbing Code**

[NOTE: The redlines in this local amendment show the changes included in the Metro Water District – Water Efficiency Code Requirements compared to the current Georgia State Minimum Standard Plumbing Code. To adopt this local ordinance, the tracked changes should all be accepted.]

Appendix E, Section E101.1.2. Revise Section E.101.1.2 to read as follows:

Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for sizing of the water piping system. Accordingly, other sizing or design methods conforming to good engineering practice standards are acceptable alternatives to those presented herein. Without limiting the foregoing, such acceptable design methods may include for multi-family buildings the Peak Water Demand Calculator from the IAPMO/ANSI 2020 Water Efficiency and Sanitation Standard for the Built Environment, which accounts for the demands of water-conserving plumbing fixtures, fixture fittings, and appliances. If future versions of the Peak Water Demand Calculator including other building types, such as commercial, such updated version shall be an acceptable design method.

The Metropolitan North Georgia Water Planning District directed local governments within their region to adopt an amendment (by January 1, 2024) to the 2024 Georgia Plumbing Code **to explicitly state that the WDC is an acceptable design method for sizing water piping system.**

Sources:

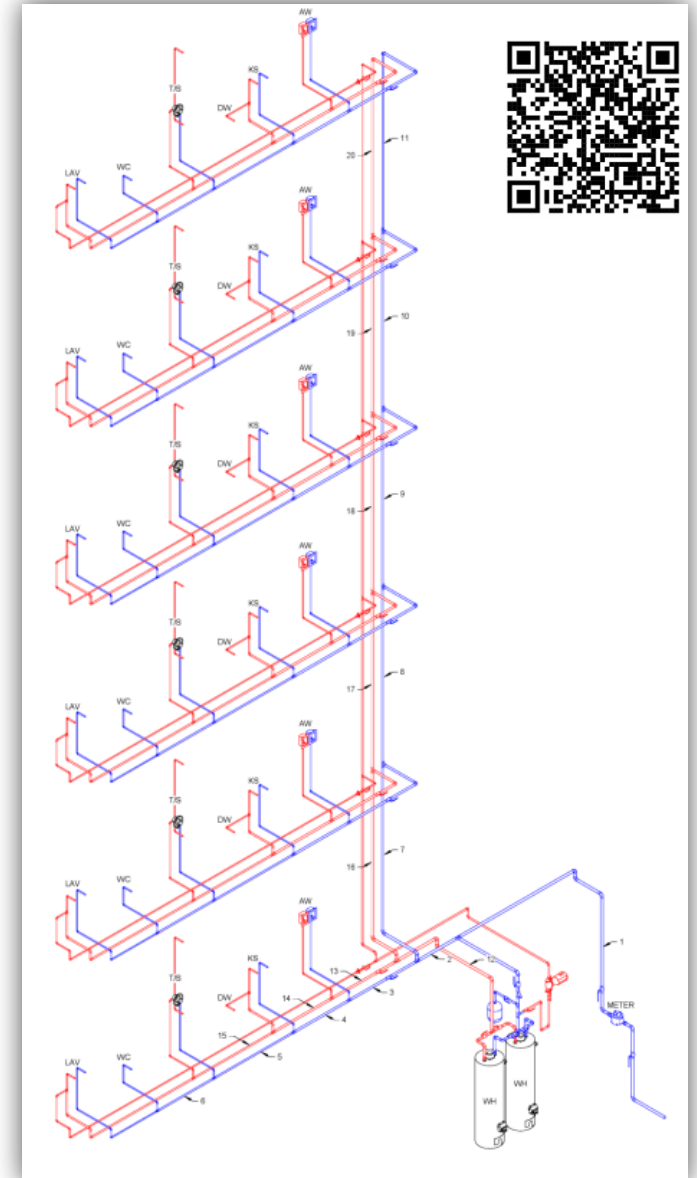
Local amendments to the Georgia State Plumbing Code <https://northgeorgiawater.org/resource/metro-water-district-water-efficiency-code-requirements> (direct download link)

The 2022 Water Resources Management Plan by the Metropolitan North Georgia Water Planning District <https://northgeorgiawater.org/wp-content/uploads/2015/05/2022.12.14-%E2%80%932022-Water-Resources-Management-Plan.pdf> (e-page 137)

Visualizing the Source of Benefits

Multifamily Hot and Cold Water Supply: 6-Unit Apartment Complex

Table 610.4 Sizing			Appendix A Sizing				Appendix A / WDC			
			Psi/100		5		Psi/100		12	
Pipe	Wsfu	Size	Pipe	Wsfu	Gpm	Size	Pipe	Gpm	Size	
1	78.0	1 1/2	1	78.0	38.0	1 1/2	1	13.2	1	
2	62.4	1 1/2	2	62.4	21.2	1 1/2	2	13.2	1	
3	10.4	3/4	3	10.4	4.8	3/4	3	9.0	3/4	
4	7.4	3/4	4	7.4	4.3	3/4	4	7.7	3/4	
5	6.3	3/4	5	6.3	3.5	3/4	5	7.0	3/4	
6	3.3	3/4	6	3.3	2.5	3/4	6	3.0	1/2	
7	51.9	1 1/2	7	51.9	18.5	1 1/4	7	12.5	1	
8	41.5	1 1/4	8	41.5	15.2	1 1/4	8	11.2	1	
9	31.1	1 1/4	9	31.1	11.9	1	9	11.0	1	
10	20.8	1	10	20.8	8.6	1	10	10.5	1	
11	10.4	3/4	11	10.4	4.8	3/4	11	9.0	3/4	
12	47.3	1 1/4	12	47.3	21.2	1 1/4	12	12.7	1	
13	7.9	3/4	13	7.9	4.5	3/4	13	9.0	3/4	
14	6.4	3/4	14	6.4	4.0	3/4	14	7.7	3/4	
15	3.8	3/4	15	3.8	2.0	1/2	15	7.0	3/4	
16	39.4	1 1/4	16	39.4	17.0	1 1/4	16	12.5	1	
17	31.5	1 1/4	17	31.5	14.0	1	17	11.2	1	
18	23.6	1	18	23.6	11.0	1	18	11.0	1	
19	15.8	1	19	15.8	8.0	1	19	10.5	1	
20	7.9	3/4	20	7.9	4.5	3/4	20	9.0	3/4	



First Construction Cost Savings

Cost Savings* for a four-story, 92-unit multifamily building:

- \$6,000 in savings on piping
- \$6,000 in savings on fittings, valves, hangers, pipe insulation, pumps
- \$30,000 in savings on water heaters
- \$16,000 - \$68,000 in savings for water service connection fee for smaller water meter size

For a four-story, 92-unit multifamily building, estimated **cost savings** in the range of \$58,000 to \$110,000 for the building, or **~\$600 to \$1,200 per dwelling unit.**

*Prices pulled in September 2022.

Water and Energy Savings

- **Water savings range from ~200 to 1,600 gallons per dwelling unit per year** (for nine considered buildings).
- **Natural gas savings range from ~3 to 8 therms per dwelling unit per year** (for six considered buildings).
- Water and energy savings are highly dependent on the plumbing configuration and fixture use patterns (which fixtures are used in what order).

	Single Family Dwellings		Multifamily Buildings						
	House A ¹	House B ²	Low-rise Loaded Corridor ¹	6-Unit ²	45-Unit ²	Low-rise Garden Style ^{1,3}	Mid-rise Loaded Corridor ^{1,3}	Mid-rise Mixed Use ^{1,3}	High-rise Mixed Use ^{1,3}
Number of Stories	1	1	3	3	5	2	3	5	10
Building Total Size (ft²)	1,290	2,380	n/a	14,280	45,090	7,680	n/a	n/a	n/a
Dwelling Unit Average Size (ft²)	1,290	2,380	n/a	2,380	1,002	960	n/a	n/a	n/a
Number of Dwelling Units	1	1	24	6	45	8	36	96	108
Furthest Fixture Type from Hot Water Source	n/a	Shower	n/a	Shower	Kitchen Sink	n/a	n/a	n/a	n/a
Number of Uses per Day for Furthest Fixture	n/a	1	n/a	1	4	n/a	n/a	n/a	n/a
Building Total Water Savings (gal per year)	1,096	451	9,696	2,980	71,258	2,056	11,520	22,464	25,704
Total Water Savings (gal/dwelling unit per year)	1,096	451	404	497	1,584	257	320	234	248
Natural Gas Savings (therms/dwelling unit per year)	7.7	n/a	7.1	n/a	n/a	2.8 - 3.0	3.7 - 4.0	4.0 - 4.5	4.4 - 4.9

n/a = Not available

¹ 2024 Report by 2050 Partners, Gary Klein and Associates, and the Association for Energy Affordability

² 2023 Report on Energy and Carbon Savings Opportunities by Arup

³ 2020 Final CASE Report on Multifamily Domestic Hot Water for 2022 California Energy Code by TRC , ZYD Energy, Beyond Efficiency https://title24stakeholders.com/wp-content/uploads/2020/09/2022_T24_Final-CASE-Report-MF-DHW-Dist.pdf (Appendix H, electronic page 193-215 for details on building characteristics and plumbing designs; Section 4.3.3, electronic pages 79-88 for natural gas savings on the recirculation loop)

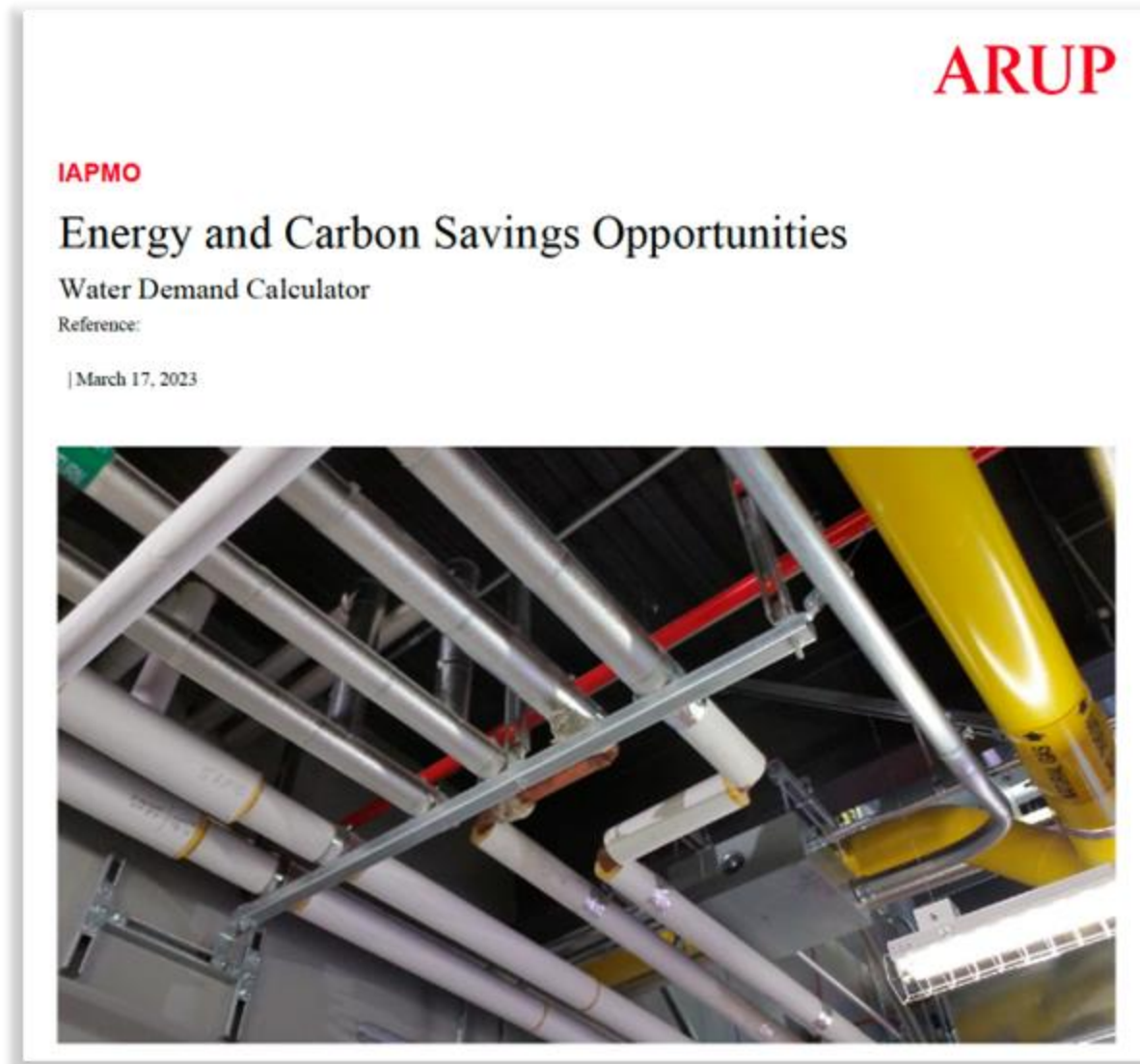
Additional Energy Savings from Booster Pumps

Sizing Method for Supply Water Pipes	Annual Energy Use from Booster Pumps (kWh per year)
UPC Appendix A	19,343
The WDC	3,137

Booster Pump Energy Savings: 16,206 kWh per year or 84%

The sizing with the WDC for a 48-unit, 8-story high-rise building is estimated to result in an **84% energy savings** for **booster pump energy use** compared to the UPC Appendix A sizing..

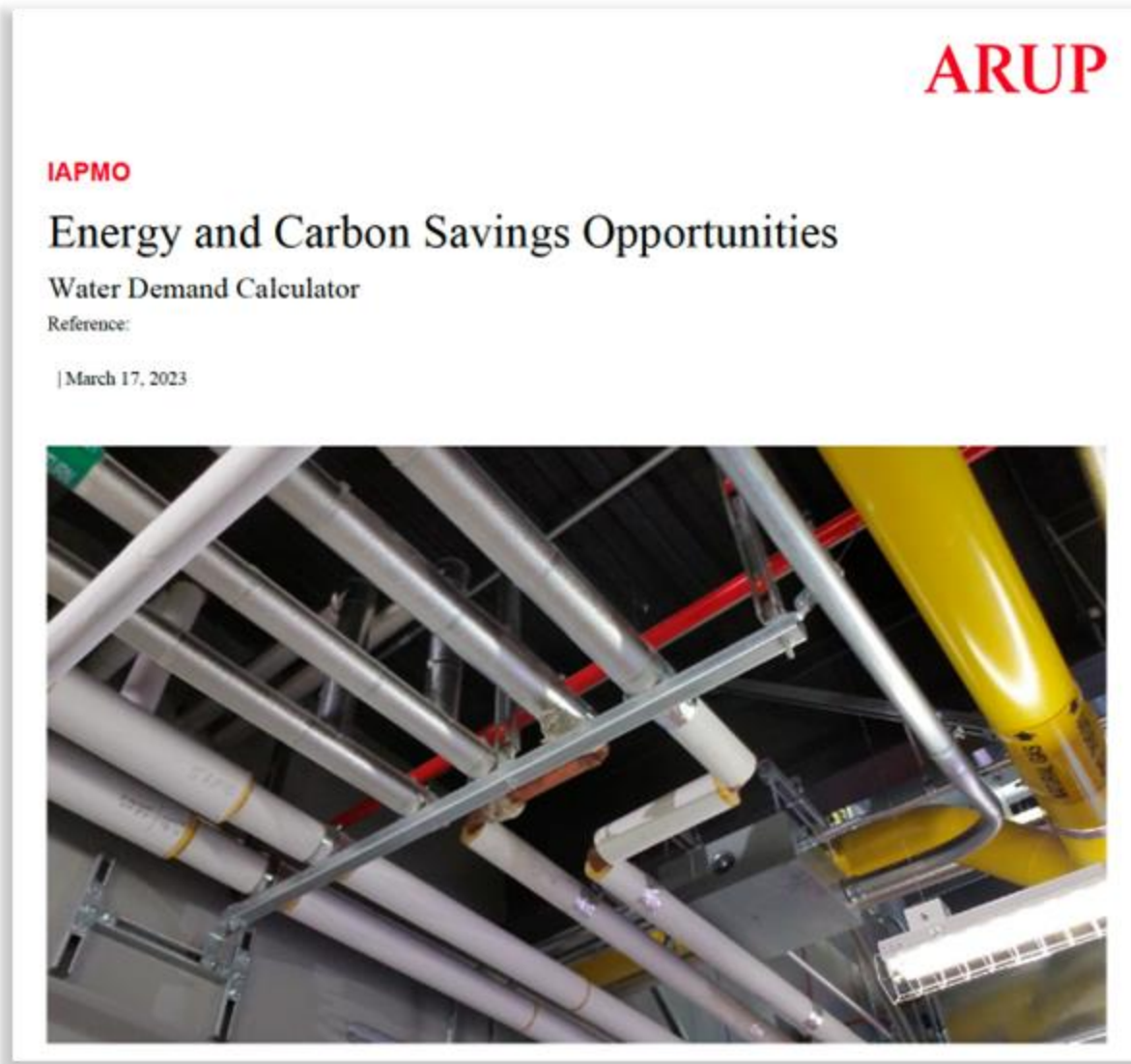
Embodied Carbon Savings



The Report's Conclusions:

- Using the WDC instead of the UPC Appendix A for sizing copper piping, backflow preventers, water meters, and shut-off valves in a high-rise building results in a **41% reduction in embodied carbon**.
- When scaled to a typical single-family home water service entry, the WDC achieves a **33% embodied carbon savings** compared to the UPC Appendix A

Operational Carbon Savings



The Report's Conclusion:

In a 48-unit high-rise apartment, booster pump sizing with the WDC instead of UPC Appendix A achieved **73% to 84% operational carbon savings.**

Resources on Benefits

- 2024 Report by **2050 Partners, Gary Klein and Associates, and the Association for Energy Affordability** (assessing water, energy, and cost savings)¹
- 2023 Report on Energy and Carbon Savings Opportunities by **Arup** (assessing water, energy, and carbon savings)²
- 2023 Final CASE Report on Multifamily Domestic Hot Water for 2025 California Energy Code by **TRC and Frontier Energy** (assessing energy and cost savings)³
- 2021 Report on Connection Fees and Service Charges by Meter Size by the **Alliance for Water Efficiency** (assessing cost savings from downsizing meters)⁴
- 2020 Study on Water Demand Calculator by **Stantec** (assessing cost savings)⁵
- 2020 Final CASE Report on Multifamily Domestic Hot Water for 2022 California Energy Code by **TRC , ZYD Energy, Beyond Efficiency** (assessing energy savings)⁶

¹ https://localenergycodes.com/download/1461/file_path/fieldList/2024%20CPC%20Appx%20M-Alternative%20Calc%20Water%20Demand.pdf

² https://www.iapmo.org/media/lvooslf/iapmo_energy_savings_arup_report.pdf

³ https://title24stakeholders.com/wp-content/uploads/2023/08/2025_T24_CASE-Report-_MF-DHW-Final-1.pdf

⁴ <https://www.iapmo.org/media/valfp1bw/awe-meter-size-connection-fee-research.pdf>

⁵ https://www.iapmo.org/media/ra3frnnn/water_demand_calculator_study-final.pdf

⁶ https://title24stakeholders.com/wp-content/uploads/2020/09/2022_T24_Final-CASE-Report-MF-DHW-Dist.pdf

RESOURCES

Home / Water Demand Calculator® / Resources

Third Party Studies and Reports Regarding Right Sizing and the Water Demand Calculator

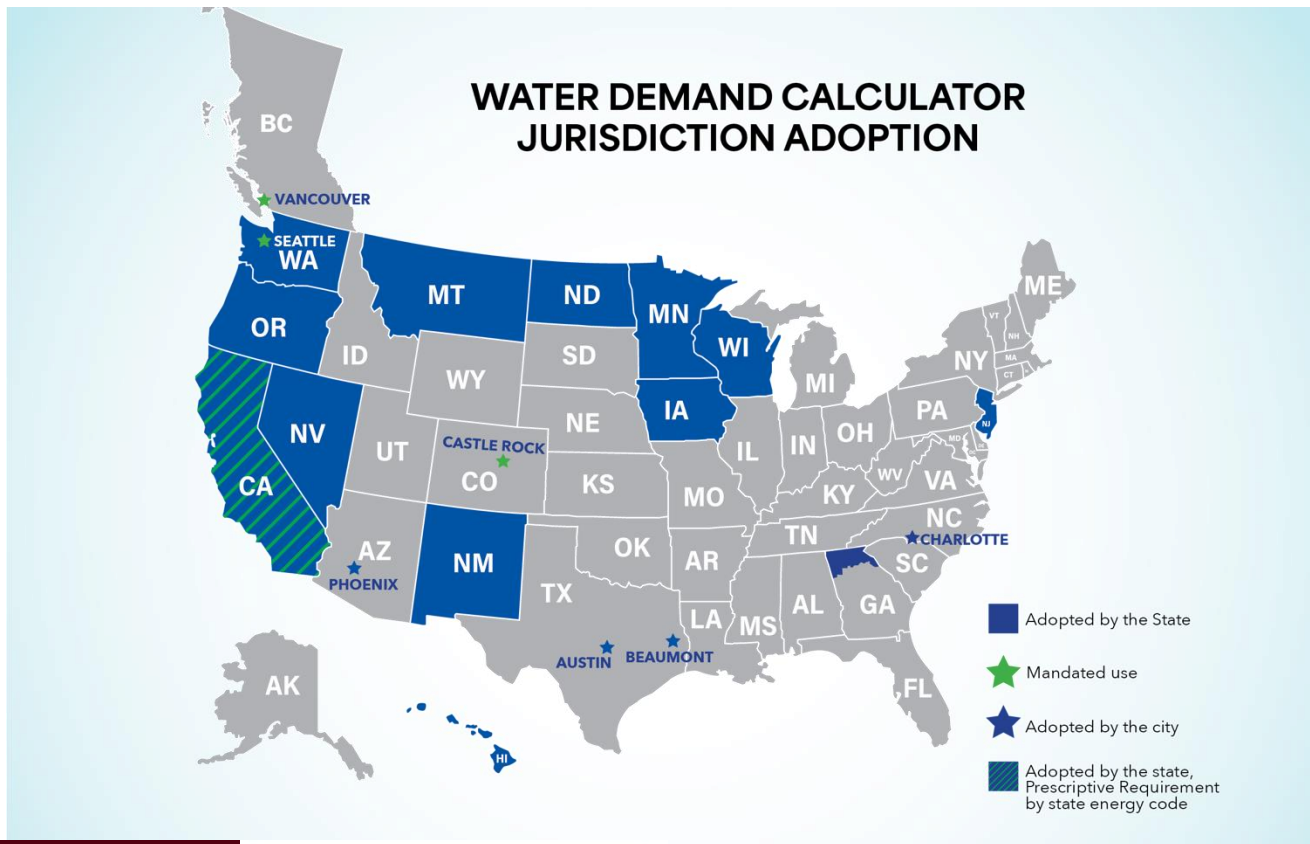
- Links to Water Demand Calculator Studies ▾
- Peer Review Literature Regarding Benefits of Right Sizing ▾



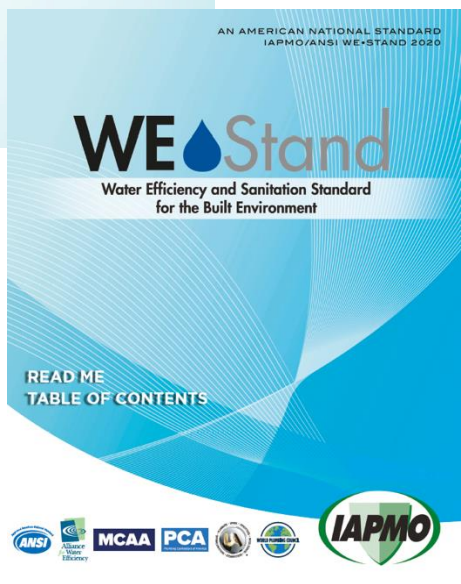
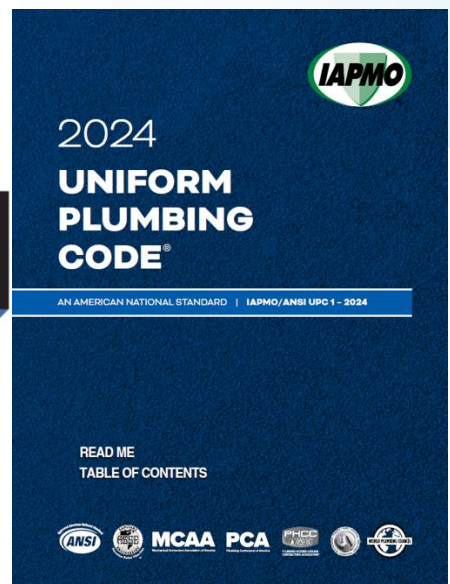
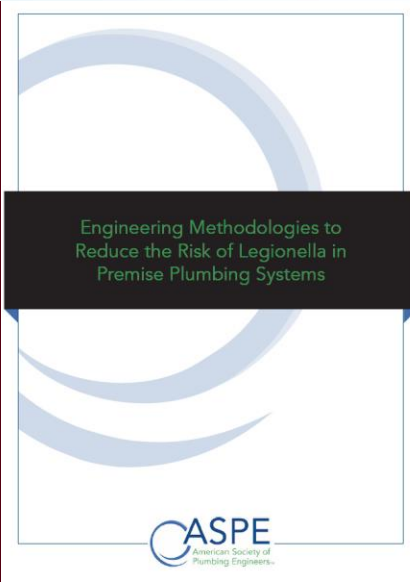
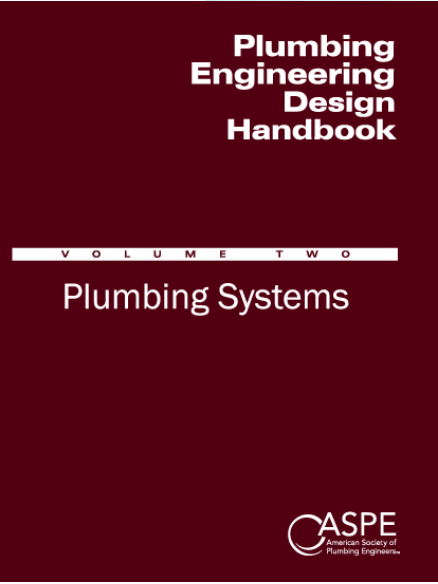
For additional resources including resources on the water quality benefit from right-sizing premise plumbing, **access the IAPMO’s webpage on the WDC Resources.**

Topics

- Nueva Esperanza Development: an Exemplary Project
- Overview and Problems with the Hunter's Curve
- Data Dive on the Water Demand Calculator (WDC)
- Benefits of Right-Sizing Premise Plumbing
- **The WDC in the Codes and Standards**
- Collaboration Opportunities on Data Collection Efforts



The **WDC** has become an **accepted engineering practice** in over a dozen construction industry standards and codes and **adopted in over 10 states.**



2022 California Plumbing Code, Chapter 6
Water Supply and Distribution, Section 610.5

610.5 Sizing per Appendices A, C, and M. Except as provided in Section 610.4, the size of each water piping system shall be determined in accordance with the procedure set forth in Appendix A. For *alternative* methods of sizing water supply systems, see Appendix C or Appendix M.

2022 California Plumbing Code, Appendix A

A 103.1 Supply Demand. Estimate the supply demand for the building main, the principal branches and risers of the system by totaling the fixture units on each, Table A 103.1, and then by reading the corresponding ordinate from Chart A 103.1(1) or Chart A 103.1(2), whichever is applicable.

Exception: For the applicable fixtures, the supply demand flow rate values calculated using Appendix M may be substituted for the flow rates calculated using the fixture units in Table A 103.1 and Chart A 103.1(1) or Chart A 103.1(2), whichever is applicable.

A 103.2 Continuous Supply Demand. Estimate continuous supply demands in gallons per minute (gpm) (L/s) for lawn sprinklers, air conditioners, etc., and add the sum to the total demand for fixtures. The result is the estimated supply demand of the building supply.

2022 California Plumbing Code, Appendix
M Peak Water Demand Calculator

M 101.0 General.

M 101.1 Applicability. This appendix provides an *alternative* method for estimating the demand load for the building water supply and principal branches for single- and multi-family dwellings with water-conserving plumbing fixtures, fixture fittings, and appliances.

M 102.0 Demand Load.

M 102.1 Water-Conserving Fixtures. Plumbing fixtures, fixture fittings, and appliances shall not exceed the design flow rate in Table M 102.1.

TABLE M 102.1
DESIGN FLOW RATE FOR WATER-CONSERVING PLUMBING
FIXTURES AND APPLIANCES IN RESIDENTIAL OCCUPANCIES

FIXTURE AND APPLIANCE	MAXIMUM DESIGN FLOW RATE (gallons per minute)
Bar Sink	1.5
Bathtub	5.5
Bidet	2.0
Clothes Washer	3.5
Combination Bath/Shower	5.5
Dishwasher	1.3
Kitchen Faucet	1.8
Laundry Faucet (with aerator)	2.0
Lavatory Faucet	1.2
Shower, per head	1.8
Water Closet, 1.28 GPF Gravity Tank	3.0

For SI units: 1 gallon per minute = 0.06 L/s

The WDC has been
adopted into California
Plumbing Code,
effective July 1, 2024.

It applies to residential
new construction and
can justify the use of
existing premise
plumbing for renovation
or adaptive reuse
projects.

2025 California Energy Code, Final Express Terms

Multifamily Buildings

Section 170.2 Prescriptive Approach

(d) ~~**Domestic Hot Water Systems**~~~~Water-heating systems.~~ Water-heating systems shall meet the applicable requirements of either 1 or, 2, ~~3 or 4~~ below:

2. **Central Systems.** For systems serving multiple dwelling units, the water-heating system shall meet the applicable requirement of A through F, or shall meet the performance compliance requirements of Section 170.1:

~~4C.~~ All hot water distribution piping shall be sized in accordance with the California Plumbing Code Appendix M.

The California Energy Commission adopted the new **prescriptive requirement** in the **2025 California Energy Code** to use the **WDC** in new construction multifamily buildings, **effective January 1, 2026.**

2021 Seattle Commercial Energy Code

C404.3.3 Demand load for Group R-2 occupancies. Demand load for water supply of dwelling units within Group R-2 occupancies shall be determined using Appendix M of the Seattle Plumbing Code. Piping shall be no more than one pipe size larger than the minimum size permitted when sized for maximum allowable velocity based upon the specified piping material in conjunction with the Appendix M demand load flow rate at any specific node within the water distribution system.

EXCEPTION: Existing buildings are not required to comply with this section if the existing plumbing fixtures have higher flow rates than those listed in Table M102.1 of the Seattle Plumbing Code.

2021 Seattle Building Code

Chapter 3 Occupancy Classification and Use

SECTION 310 RESIDENTIAL GROUP R

310.1 Residential Group R. Residential Group R includes, among others, the use of a building or structure, or a portion thereof, for sleeping purposes when not classified as an Institutional Group I or when not regulated by the *International Residential Code*. Group R occupancies not constructed in accordance with the *International Residential Code* as permitted by Sections 310.4.1 and 310.4.2 shall comply with Section 420.

[S] 310.3 Residential Group R-2. Residential Group R-2 occupancies containing *sleeping units* or more than two *dwelling units* where the occupants are primarily permanent in nature, including:

- Apartment houses
- Congregate living facilities (nontransient) with more than 16 occupants
- Boarding houses (nontransient)
- Convents
- Dormitories
- Fraternities and sororities
- Monasteries
- Hotels (nontransient)
- ~~((Live/work))~~ Buildings that contain three or more live/work units
- Motels (nontransient)
- Vacation timeshare properties

The City of **Seattle** adopted the **mandatory use** of the **WDC** in new construction multifamily buildings, **effective November 15, 2024.**

Topics

- Nueva Esperanza Development: an Exemplary Project
- Overview and Problems with the Hunter's Curve
- Data Dive on the Water Demand Calculator (WDC)
- Benefits of Right-Sizing Premise Plumbing
- The WDC in the Codes and Standards
- **Collaboration Opportunities on Data Collection Efforts**



The IAPMO is working on expanding the scope of the WDC to commercial, long term care, hospitality, dormitory, and other applications.

Specification for Needed Data

- Building type
- Water flow data from the appropriate and accessible point(s)
- Monitoring duration of 3 to 4 weeks
- Logging interval of less than 60 seconds
- The number and types of fixtures serviced from the point of measurement
- The occupancy rate of the building when the data was collected

Need about 140 buildings per building type to ensure the data is statistically representative.

IAPMO is **looking for partners** to support the ongoing efforts to **collect peak water use data in nonresidential applications!**



Data Collection Project: **VALUE PROPOSITION AND ASK**

GENERAL DESCRIPTION

The International Association of Plumbing and Mechanical Officials (IAPMO) is working with building owners and organizations, including multiple Fortune 500 companies, to gather data on water flow rates in commercial buildings. By gathering this data IAPMO is attempting to update an 80-year-old pipe sizing methodology. The benefits and ask to the owner are detailed below.

VALUE PROPOSITION

- **Immediate Benefit to Owner:** a 3 to 4 week long water usage report that can potentially identify water leaks or inefficient water use.
- **Future Benefits to Owner:** With anonymized data, IAPMO can update the way hotel water systems are sized. This allows future project benefits that include renovation, addition, or ground up construction. Initial small data batch for hotels show a strong correlation to residential occupancies. Thus similar benefits to hospitality could look like:

Cost Savings:

Hotels may be able to save up to hundreds of thousands of dollars in piping material costs, and water service impact fees. (For residential 200-unit apartment estimated up to ~\$250,000 in construction costs).¹



Water Savings:

Smaller piping means that water is delivered more efficiently from hot water source to tap, meaning less water is used. (For residential buildings, estimated water savings typically range from about 200-500 gallons per apartment unit).²



Energy Savings:

Smaller estimated peak flow rates; the resulting smaller piping also means lower energy use. This occurs due to needing smaller booster pumps and less heat loss from smaller piping. (For residential buildings, estimated energy savings typically range from about 1.43 kWh per year per apartment unit).³

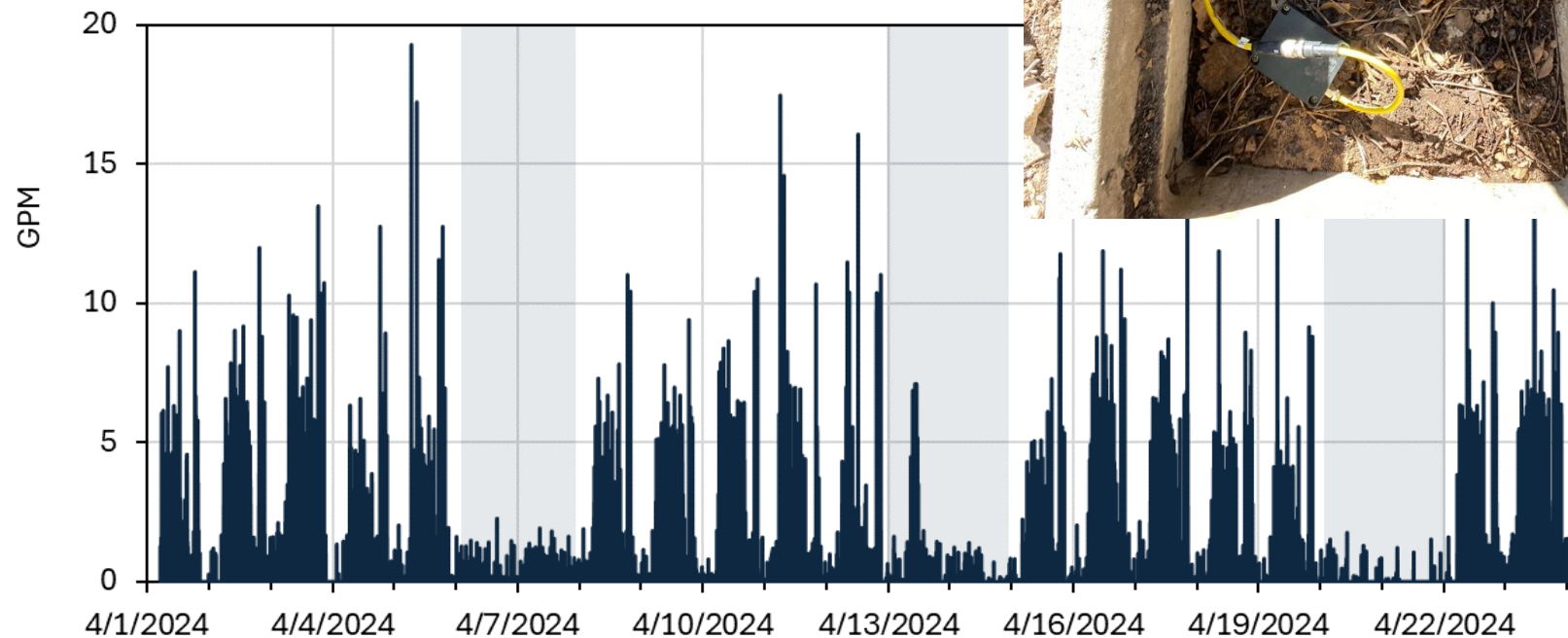


Carbon Reduction:

Smaller piping means lowered embodied carbon. Lowered energy use also results in carbon savings. (For a 48-unit residential apartment building, estimated embodied carbon savings were 20% for copper piping and 2,000 to 12,700 lbs. of CO₂ for booster pump annual carbon emissions savings).⁴

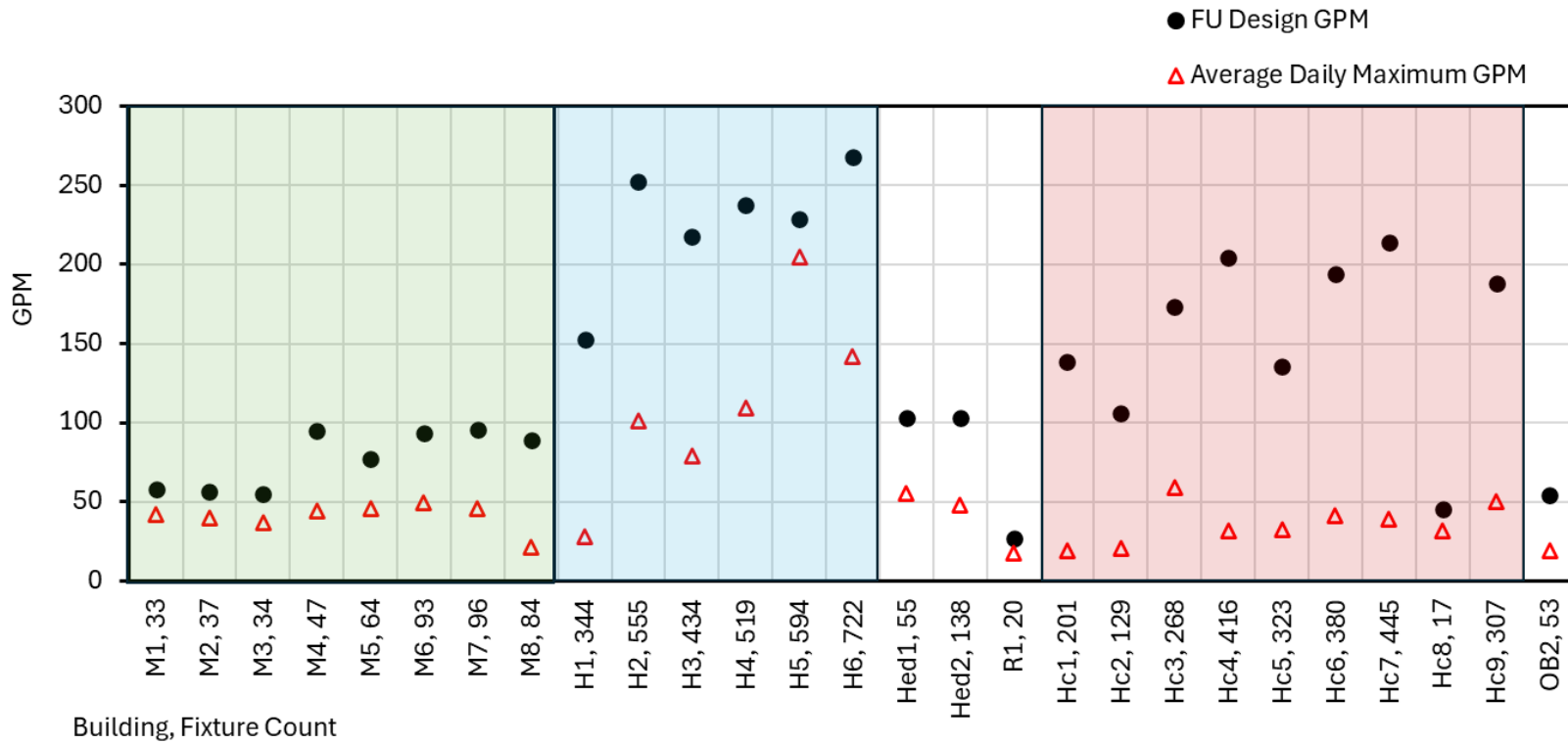


**Data Collection Project
#2401: Data Collection
via Mini-Water Audits**



Looking Forward:
Commercial Buildings
Water Demand
Calculator Data
Collection Research

Figure 1-Building Demand Flow Measured at the Meter of OB1



M – Mercantile; **H** – Hotel; **Hed** – Higher Education; **Hc** – Healthcare; **R** – Restaurant; **OB** – Office Building

Data was collected between 14 – 77 days at the various sites

Summary of Building Demand



IAPMO INNOVATION AND RESEARCH FUND

Get Involved and Support Today

Welcome to the **IAPMO Innovation and Research Fund**—a dedicated resource fueling cutting-edge research, innovative solutions, and impactful initiatives in water, plumbing, and mechanical technologies. Our mission is to improve public health, enhance climate resiliency, and promote housing affordability through advanced methodologies, smarter infrastructure, and collaborative partnerships.



<https://iapmo.org/research/support-innovation>

Innovation and Research Fund (IRF)

What Can You Do Next?

- Share what you have learned today with your team.
- Ask your plumbing designers and engineers how the WDC can be used on upcoming projects. Projects need to opt in.
- Ask your team to attend future trainings on the WDC by signing up on the IAPMO webpage.¹
- Ask IAPMO for assistance on applying the WDC to specific projects.
- Help us identify opportunities to collaborate on data collection to support the expansion of the WDC to nonresidential occupancies.

¹ Upcoming educational events on the WDC: <https://iapmo.org/we-stand/water-demand-calculator/educational-events>

Discussion

- Thoughts on using the WDC on upcoming projects?
- Thoughts on using the WDC to size water meters?
- Collaboration opportunities on data collection to support expansion of the WDC to nonresidential occupancies?
- Anything else?

Thank you

Gary Klein

President of Gary Klein and Associates, Inc.

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