Memorandum to Support Statewide Adoption of Uniform Plumbing Code Appendix M into the California Plumbing Code

Date:	November 1, 2021
From:	Gary Klein, Gary Klein and Associates, Inc.
To:	California Buildings Standards Commission (CBSC) staff
Copied:	Staff members from the California Department of Housing and Community Development (HCD), the California General Services Administration Division of State Architect (DSA), the California Office of Statewide Health Planning and Development (OSHPD), and California Department of Water Resources (DWR)
Subject:	Title 24 Petition to adopt Uniform Plumbing Code, Appendix M "Peak Water Demand Calculator" (UPC Appendix M) into the California Plumbing Code (Title 24, Part 5 or CPC) during 2022 Intervening Code Cycle

Introduction

This memorandum provides supporting analysis for the Title 24 Petition to adopt Uniform Plumbing Code, Appendix M "Peak Water Demand Calculator" (UPC Appendix M) into the California Plumbing Code (Title 24, Part 5 or CPC) as an alternative methodology for sizing water pipes in new single family and multifamily residential buildings.

This memorandum includes the following attachments:

- Attachment 1 – Nine-Point Criteria Analysis (for compliance with HSC Section 18930),
- Attachment 2 – Factsheet on UPC Appendix M (includes a list of Documents Relied Upon),
- Attachment 3 – Details for 16 Existing Multifamily Buildings (used in the analysis), and
- Attachment 4 – Additional Information on Cost Savings.

Code Change Proposal

During 2022 Intervening Code Cycle, this code change proposal is to:

- Adopt UPC Appendix M into the CPC and
- Amend CPC, Chapter 6, Section 610.5 "Sizing per Appendices A and C" by adding a reference to Appendix M as an alternative method of sizing water supply systems. Proposed language:

  Section 610.5 Sizing Per Appendices A, ~~and~~ 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 alternate methods of sizing water supply systems, see Appendix C and Appendix M.

The changes above to the code language are marked with red underlining (new language) and ~~strikethroughs~~ (deletions). Attachment 1 includes our analysis of how adopting UPC Appendix M meets the nine-point criteria outlined in Health and Safety Code (HSC) Section 18930(a).

Background and Statewide Significance

Three clauses from UPC Appendix M provide context for this memorandum:

> **M101.1 Applicability**. This appendix provides a 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 102.2 Water Demand Calculator.** The estimated design flow rate for the building supply and principal branches and risers shall be determined by the IAPMO Water Demand Calculator available for download at https://www.iapmo.org/water-demand-calculator/
>
> **M 102.7 Size of Water Piping per Appendix A.** Except as provided in Section M 102.0 for estimating the demand load for single- and multi-family dwellings, the size of each water piping system shall be determined in accordance with the procedure set forth in Appendix A. After determining the permissible friction loss per 100 feet (30 480 mm) of pipe in accordance with Section A 104.0 and the demand flow in accordance with the Water Demand Calculator, the diameter of the building supply pipe, branches and risers shall be obtained from Chart A 105.1(1) through Chart A 105.1(7), whichever is applicable, in accordance with Section A 105.0 and Section A 106.0. Velocities shall be in accordance with Section A 107.0. Appendix I (IS 31), Figure 3 and Figure 4 shall be permitted when sizing PEX systems.

Following the procedures in UPC Appendix M, the estimated design flow rates for single family and multifamily dwellings are determined using the IAPMO Water Demand Calculator. These flow rates (instead of those estimated using the Water Supply Fixture Unit (WSFU) method) are then incorporated into the pipe size selection method contained in CPC/UPC Appendix A.

The addition of UPC Appendix M would be consistent with the existing requirements in California's Appliance Efficiency Regulations (Title 20) that specify that plumbing fixtures, fixture fittings, and appliances sold in California be water efficient.[1] It also compliments the requirements on compact hot water distribution design in the California Energy Code (Title 24, Part 6),[2] and the California Green Building Standards Code (Title 24, Part 11 or CALGreen).[3] Designs based on UPC Appendix M result in smaller pipe *diameters* for the water supply and principal branches compared to current practice; compact hot water distribution designs result in shorter pipe *lengths* to deliver hot water at a fixture. These two measures are complimentary.

The adoption of UPC Appendix M into the CPC would enable the voluntary use of Appendix M for all residential occupancies that fall within the jurisdictions of HCD, CBSC, DSA, and OSHPD. Statewide adoption would make it equally convenient to use CPC Appendix A and UPC Appendix M.

Other states and local jurisdictions have taken the lead in adopting UPC Appendix M, including Nevada (2018), North Dakota (2020), Oregon (2021), and City of Seattle and King County, Washington (2021). In 2019, Foster City, California, adopted the voluntary use of UPC Appendix M as a mitigation measure in conjunction with the Bay Area Water Supply and Conservation Agency drought contingency plan. The California Energy Commission is also considering adopting a new compliance credit in the 2022 CBECC-Res software for projects using UPC Appendix M for pipe sizing in multifamily dwellings.

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[1] Sections 1605.1(o) and (p), 1605.3(h) of California Code of Regulations, Appliance Efficiency Regulations https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I8F8F3BC0D44E11DEA95CA4428EC25FA0&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)

[2] Per Section 150.1(C)8 of 2019 Title 24, Part 6, compact hot water distribution system is an option for prescriptive compliance for low rise residential buildings. https://www.energy.ca.gov/sites/default/files/2021-06/CEC-400-2018-020-CMF_0.pdf

[3] Per Section A4.203.1.2 of 2019 Title 24, Part 11, compact hot water distribution system is one of the prerequisite compliance options for residential voluntary measures in new construction. https://codes.iccsafe.org/content/CGBC2019P3/appendix-a4-residential-voluntary-measures#CGBC2019P3_AppxA4_SecA4.2

The Factsheet in Attachment 2 provides additional background information, links to the adopted codes, and the list of Documents Relied Upon to prepare this memorandum.

Problem Definition and Measure Benefits

In California, the standard practice is to use CPC Appendix A (sometimes with the addition of C – bathroom groups) to estimate peak water demand and ultimately to determine pipe sizing. Figure 1 compares standard practice (UPC or CPC Appendix A, also known as the Hunter's curve) to observed 99th percentile flow rates for the main hot supply pipe in 16 multifamily buildings ranging in size from 8 to 384 apartments. The figure underscores that the standard practice – based on the Hunter's curve – overestimates the peak flow rates when compared to use with plumbing fixtures and appliances that have been in buildings since the Energy Policy Act of 1992 went into effect the mid-1990s. The *observed* peak hot water flow rates are 80-96 percent less than the peak *predicted* using UPC Appendix A methodology. Overestimating peak water flow rates results in pipe diameters that are much larger than needed for modern buildings.

Please refer to Attachment 3 for the details on the multifamily buildings used in the analysis. Note that alphabetical labels for the buildings in Figure 1 denote the same buildings in Attachment 3 and Figure 2.

Using UPC Appendix M to calculate peak water demand for the building supply and principal branches then subsequently using these peak demand values in CPC/UPC Appendix A when sizing water pipes provides the following benefits:

- Construction cost savings due to
  - Smaller diameter pipes and fittings, valves, pumps, and other equipment,
  - Smaller inside diameter pipe insulation, and
  - Smaller water service entrance size, resulting in smaller water meter size with lower connection fees.
- Ongoing cost savings due to
  - Water savings from faster hot water delivery times, resulting in smaller monthly water service charges and lower associated volumetric sewer charges,
  - Energy savings due to decreased heat loss in hot water distribution system, particularly in multifamily buildings with a recirculation system, and
  - Embedded energy savings for the water and wastewater utilities due to customer indoor water savings.
- Reduced public health and safety risk and improved water quality due to shorter water dwell times within plumbing systems. Each floor plan determines the distance between the mechanical room and the fixtures. UPC Appendix M does not change the length of the pipe, only the diameter. With the pipe diameter on each segment reduced, the pipe volume will be reduced.

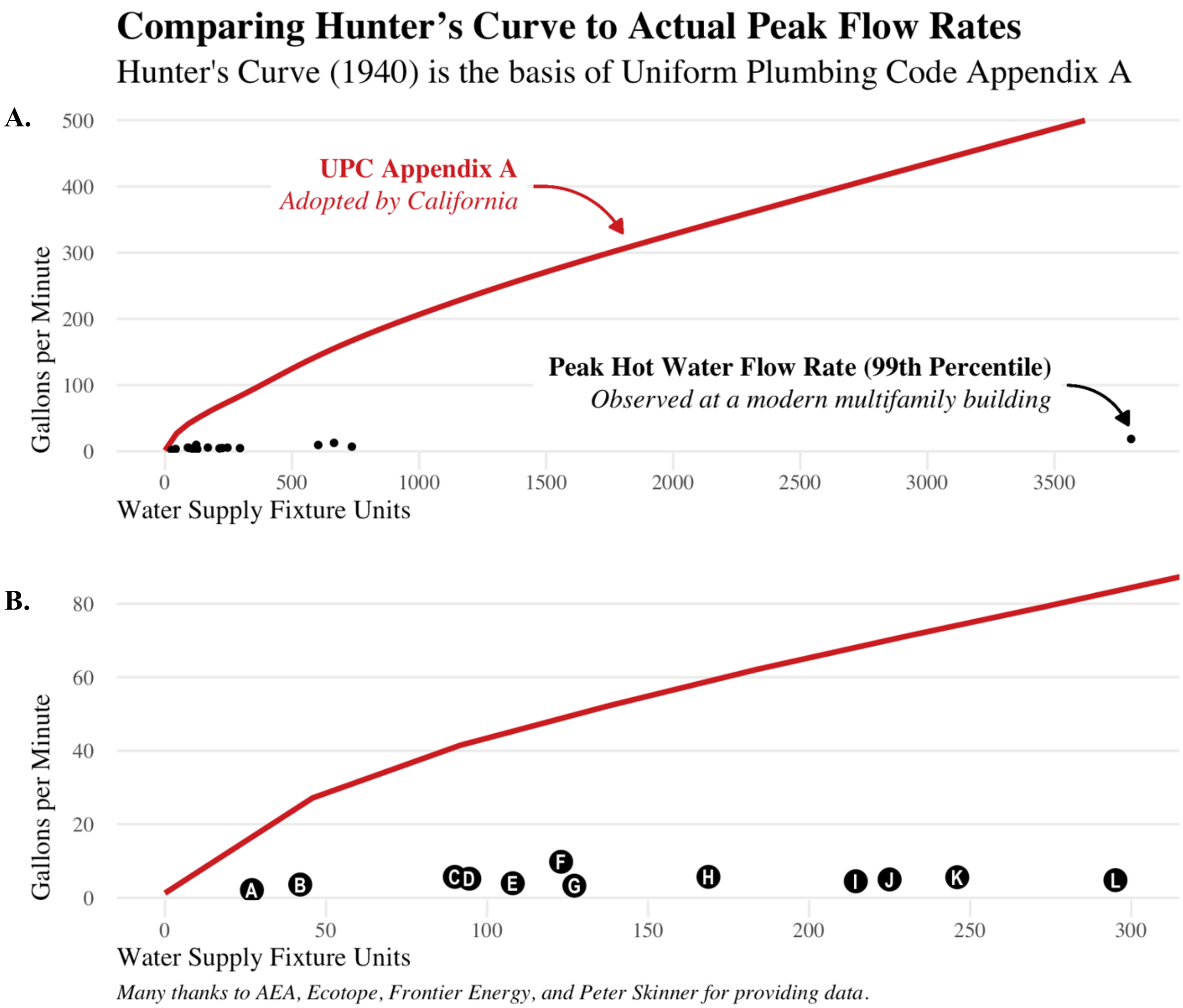

Figure 1: Comparing UPC Appendix A (Hunter's Curve) to Actual Peak Flow Rates (99th Percentile) in Multifamily Buildings (ranging in size from 8 to 384 apartments). Figure 1A shows data for all buildings analyzed to date. Figure 1B zooms in on the cluster of buildings with fewer than 300 Water Supply Fixture Units (WSFU).

UPC Appendix M Methodology is a Conservative Approach

Figure 2 compares the monitored data from the 16 multifamily buildings to the peak water demand estimates based on UPC Appendix M. The comparison shows that UPC Appendix M is still a conservative approach to estimate peak water flow rates, providing a margin of safety at least 1.8 times the measured data in multifamily buildings.

The multifamily buildings are of special interest because the probabilities of peak water use in Peak Water Demand Calculator were based on analyzing data for over 1,000 single family dwellings. The derived probabilities were assumed to apply to multifamily buildings.

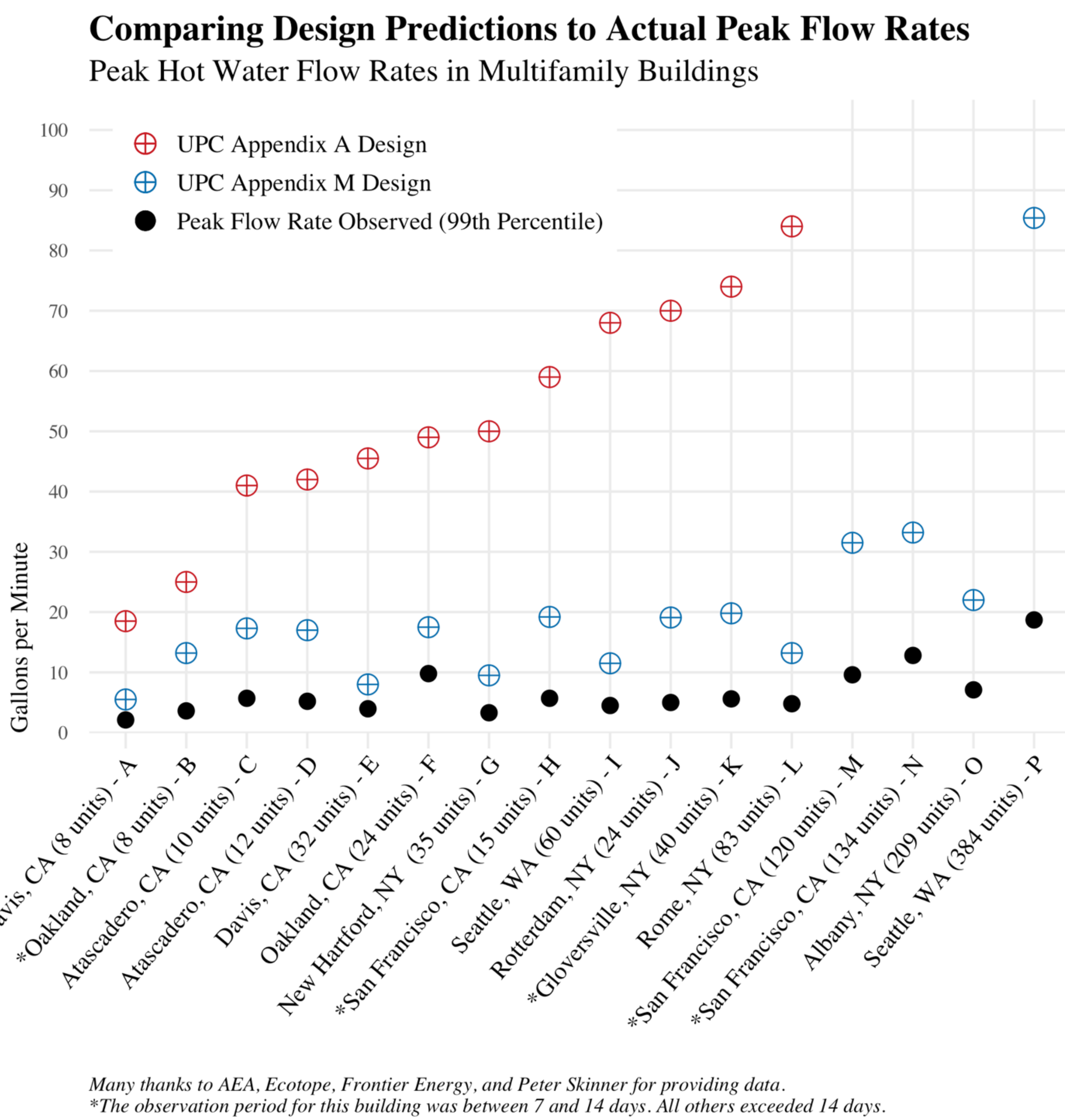

Figure 2: Comparing Design Estimates to Actual Peak Hot Water Flow Rates (99th Percentile) in Multifamily Buildings. UPC Appendix A values for buildings M, N, O, and P are out of scale and are shown in Attachment 3.

Water and Energy Impacts

Reducing the volume of water in the piping will result in structural savings of water and energy. If the pipe volume is cut in half, there is half as much water to clear out of the hot water piping at the beginning of a hot water event and there is half as much water that will cool down when the event is over. Water will be saved from needing to wait less time for hot water to arrive. Energy savings will be achieved in three ways:

- Less energy needed for keeping a smaller diameter recirculation loop from a central water heating system hot,

- Less water (with associated embedded electricity) running down the drain while waiting for the hot water to arrive, and
- Less hot water in the branch pipes that cool down between uses (less heat loss).

The table below summarizes preliminary conservative estimates for annual per dwelling water and energy savings (from reducing structural and not behavioral waste). The values marked as TBD will be added prior to submitting the petition.

Table 1: Estimated Annual Water and Energy Impacts Per Dwelling Unit

Building Type	Water Savings (gal/Dwelling Unit per Year)	Embedded Electricity Savings (kWh/Dwelling Unit per Year)	Natural Gas Savings (therms/Dwelling Unit per Year)	
Low-Rise Loaded Corridor, 3-story, 24-unit building in Sunnyvale, CA	404	2.0	3.4 (recirc loop only)	
Prototype Low-Rise Garden Style, two-story, eight-unit building	TBD	TBD	1.0 – 1.2 (recirc loop only)	(1)
Prototype Mid-Rise Loaded Corridor, three-story, 36-unit building	TBD	TBD	1.4 – 1.7 (recirc loop only)	(1)
Prototype Mid-Rise Mixed-Use, five-story, 96-unit building	TBD	TBD	2.3 – 2.8 (recirc loop only)	(1)
Prototype High-Rise Mixed-Use, 10-story, 108-unit building	TBD	TBD	2.6 – 3.1 (recirc loop only)	(1)
Single family dwelling	128	0.62	TBD	(2)

Notes: Water savings are from reduced structural water waste due to faster hot water delivery times. For embedded electricity savings, assumed 4,848 kWh/million gallons. A recirculation loop is abbreviated as recirc loop.
(1) Prototype buildings are based on Ecotope designs documented in 2022 CASE Report on Multifamily Domestic Hot Water Distribution[4]; natural gas savings vary based on climate zone.
(2) Based on the analysis of LBNL data, the structural waste is reported to be 0.7 gal per shower event. Assumed a home with water pipes sized using UPC Appendix M will save 0.35 gal per shower event. Assumed one shower event per dwelling per day. Estimates do not account for water savings due to faster hot water delivery time at faucets.

Cost Savings

In 2020, I had the opportunity to evaluate the design of the plumbing for a 92-unit multifamily building in Seattle, Washington. Each apartment had one bathroom (shower, lavatory faucet, and toilet) and a kitchen (kitchen faucet only). I calculated the peak water flow rates using the methods in both UPC Appendix A and Appendix M and then used UPC Appendix A with each of those values to size the piping. The configuration of the plumbing was the same in both calculations, the differences in diameters were due to the different estimates of peak water demand. Water velocities and pressure drops were considered when selecting the pipe diameters from the building entrance to the branches to each apartment.

Table 2 shows the comparisons of peak flow rates and resulting pipe sizes for the building water supply and the hot water branch. The UPC Appendix M method predicts a significantly smaller peak water demand: both the building water supply and the hot water branch will experience more than nine times less demand than predicted by UPC Appendix A. The UPC Appendix A predictions for pipe diameter result in 3-inch pipe for both the building water supply and the hot water branch. Using UPC Appendix M

[4] https://title24stakeholders.com/wp-content/uploads/2020/09/2022_T24_Final-CASE-Report-MF-DHW-Dist.pdf (electronic page 79, 187)

peak flow rates would result in these pipe diameters being right-sized down to 1-inch pipe. The corresponding reduction in internal pipe volume is somewhat more than 50 percent.

Table 2. Comparison of Peak Water Demand and Pipe Size for a 92-unit Multifamily Building

Sizing Method	Building Water Supply Peak Flow Rate (gpm)	Building Water Supply Pipe Size (inches)	Hot Water Branch Peak Flow Rate (gpm)	Hot Water Branch Pipe Size (inches)
UPC Appendix A	127	3	105	3
UPC Appendix M	14	1	11	1

Summing up all of the initial cost savings together indicates that the reductions in first costs can be on the order of $500-$1,000 per apartment. For operational cost savings, savings from less water and energy use will continue for the life of the building. Since water will be saved while waiting for hot water to arrive, water and associated sewer charges could be reduced. Attachment 4 provides more details on cost savings.

Please see 2020 Stantec Report and 2021 Alliance for Water Efficiency Report in the Documents Relied Upon section of Attachment 2 for their analysis of the cost savings.

Conclusion

In conclusion, the Statewide CASE Team and I encourage the CBSC, HCD, DSA, and OSHPD to adopt UPC Appendix M into the CPC during the 2022 Intervening Code Adoption Cycle.

Attachment 1: Nine-Point Criteria Analysis

As outlined in the table below, adopting UPC Appendix M meets the nine-point criteria outlined in Health and Safety Code (HSC) Section 18930(a).[5]

Table 3: HSC 18930(a) Building Standards Nine-Point Criteria and Adoption of 2021 UPC Appendix M into CPC

HSC 18930(a) Building Standards Nine-Point Criteria	Proposal to Adopt 2021 UPC Appendix M into CPC
(1) The proposed building standards do not conflict with, overlap, or duplicate other building standards.	The proposal meets this criterion.
(2) The proposed building standard is within the parameters established by enabling legislation and is not expressly within the exclusive jurisdiction of another agency.	The proposal meets this criterion.
(3) The public interest requires the adoption of the building standards. The public interest includes, but is not limited to, health and safety, resource efficiency, fire safety, seismic safety, building and building system performance, and consistency with environmental, public health, and accessibility statutes and regulations.	Using 2021 UPC Appendix M "Peak Water Demand Calculator" to size water pipes results in: • Reduced public health and safety risk and improved water quality due to shorter water dwell times in plumbing systems. • Water and embedded energy savings due to faster hot water delivery times. • Additional energy savings due to decreased heat loss in distribution system, particularly in multifamily buildings with a recirculation system.
(4) The proposed building standard is not unreasonable, arbitrary, unfair, or capricious, in whole or in part.	The proposal meets this criterion.
(5) The cost to the public is reasonable, based on the overall benefit to be derived from the building standards.	Using 2021 UPC Appendix M "Peak Water Demand Calculator" to size water pipes results in construction cost savings due to smaller diameter pipes and fittings, less pipe insulation material, and reduced water service entrance size.
(6) The proposed building standard is not unnecessarily ambiguous or vague, in whole or in part.	The proposal meets this criterion.
(7) The applicable national specifications, published standards, and model codes have been incorporated therein as provided in this part, where appropriate.	The proposal meets this criterion. Appendix M is part of 2021 IAPMO UPC model code.
(8) The format of the proposed building standards is consistent with that adopted by the commission.	The proposal meets this criterion.
(9) The proposed building standard, if it promotes fire and panic safety, as determined by the State Fire Marshal, has the written approval of the State Fire Marshal.	This criterion is not applicable.

[5] HSC 18930(a), Division 13 Housing, Part 2.5 State Building Standards, Chapter 3 Powers of the Commission https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=HSC&division=13.&title=&part=2.5.&chapter=3.&article=

Attachment 2: Factsheet on UPC Appendix M "Peak Water Demand Calculator"

The purpose of this factsheet is to provide information about an opportunity to adopt into California Plumbing Code (CPC) an alternative methodology for sizing water pipes in new residential buildings as prescribed in 2021 Uniform Plumbing Code (UPC) Appendix M "Peak Water Demand Calculator."

Scope of 2021 UPC Appendix M	2021 UPC Appendix M provides a method for estimating the demand load for the building water supply and principal branches for single family and multifamily dwellings with water-conserving plumbing fixtures, fixture fittings, and appliances.
Background	Key points about UPC Appendix M "Peak Water Demand Calculator": • Peer-reviewed alternative pipe sizing methodology that was developed in response to the increased prevalence of low-flow fixtures in California and other states. • Culmination of a multi-year project, 2011- 2017, sponsored by the International Association of Plumbing and Mechanical Officials (IAPMO). • First major update of water pipe sizing in buildings in over 80 years. • Added as Appendix M "Peak Water Demand Calculator" to 2018 IAPMO UPC for the first time; Appendix M was approved to remain in 2021 UPC.
Benefits	Using 2021 UPC Appendix M "Peak Water Demand Calculator" to size water pipes results in: • Reduced public health and safety risk and improved water quality due to shorter water dwell times in plumbing systems. • Water and embedded energy savings due to faster hot water delivery times. • Additional energy savings due to decreased heat loss in distribution system, particularly in multifamily buildings with a recirculation system. • Construction cost savings due to smaller diameter pipes and fittings, less pipe insulation material, and reduced water service entrance size.
Adoption in CA	• In 2019 CPC code cycle, 2018 UPC was adopted but not its Appendix M. • Effective with the 2019 CPC, Foster City, California, adopted the voluntary use of Appendix M in its jurisdiction as part of the mitigation measures in conjunction with the Bay Area Water Supply and Conservation Agency (BAWSCA) drought contingency plan. • The California Energy Commission is considering adopting a new credit in 2022 Compliance Software (CBECC-Res) for projects using UPC Appendix M for pipe sizing in multifamily dwellings. • While local jurisdictions in California can adopt 2021 UPC Appendix M within their jurisdiction, statewide adoption will remove the need for this additional step. • AB 1434, Friedman 2021, proposes to amend Section 10609.4 of the Water Code to lower the standard for indoor residential water use from 55 to 40 gallons per capita per day in three steps starting in January 2023, January 2025, and January 2030. Calculating peak water demands in accordance with UPC Appendix M and using these lower values to size residential piping systems will support achieving these targets.
Adoption Status Outside of CA	• In 2018, State of Nevada adopted UPC Appendix M into 2018 Nevada Plumbing Code. • In 2020, State of North Dakota adopted UPC Appendix M into 2018 North Dakota Plumbing Code (effective April 1, 2020). • In 2021, State of Oregon adopted UPC Appendix M into 2021 Oregon Plumbing Specialty Code (effective April 1, 2021). • In 2021, City of Seattle and King County, Washington, adopted UPC Appendix M into 2018 Seattle Plumbing Code.

Documents Relied Upon	• **2021 UPC, Appendix** M "Peak Water Demand Calculator" http://epubs.iapmo.org/2021/UPC/#p=453 https://www.uniformcodes.org/water-demand-calculator • **2017 Study** on Peak Water Demand by S. Buchberger et al. (basis for Water Demand Calculator) https://www.iapmo.org/media/3857/peak-water-demand-study-executive-summary.pdf • **2020 Study** on Water Demand Calculator by Stantec (assessment of cost savings from using Water Demand Calculator) https://www.iapmo.org/group/update/stantec-wdc-savings-study https://www.iapmo.org/media/25276/water_demand_calculator_report_summary.pdf • **2021 Report** on Connection Fees and Service Charges by Meter Size by Alliance for Water Efficiency (assessment of cost savings from downsizing meters) https://www.iapmo.org/media/25939/awe-meter-size-connection-fee-research.pdf • **Case Study on** Applying Water Demand Calculator on a Project in the State of New York https://www.phcppros.com/articles/11971-practically-perfect-plumbing-in-multifamily • Adoption of UPC Appendix M into **Foster City** Municipal Code https://www.codepublishing.com/CA/FosterCity/?FosterCity15/FosterCity1516.html&?f • Adoption of UPC Appendix M into 2018 **Seattle** Plumbing Code https://www.seattle.gov/Documents/Departments/SDCI/Codes/PlumbingCode/2018SeattlePlumbingCode.pdf • Adoption of UPC Appendix M into 2018 **Nevada** Plumbing Code https://up.codes/viewer/nevada/upc-2018/chapter/M/peak-water-demand-calculator#M • Adoption of UPC Appendix M into 2018 **North Dakota** Plumbing Code https://casetext.com/regulation/north-dakota-administrative-code/title-62-state-board-of-plumbing/article-62-031-plumbing-installation-standards/chapter-62-031-01-administration/section-62-031-01-01-effective-412020conformance-with-the-north-dakota-plumbing-code • Adoption of UPC Appendix M into 2021 **Oregon** Plumbing Specialty Code https://www.oregon.gov/bcd/codes-stand/code-adoption/Pages/2020-opsc-adoption.aspx • 2022 California Energy Code (2022 Title 22, Part 6), Proposed Measure C "CPC Appendix M Sizing" https://title24stakeholders.com/measures/cycle-2022/multifamily-domestic-hot-water/ • AB 1434, Friedman, 2021, Bill to amend Section 10609.4 of the Water Code https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1434

Attachment 3: Details for 16 Existing Multifamily Buildings

The effort to collect more peak water flow data, particularly on cold branch, is ongoing.

Table 4: Summary of detailed data for the multifamily buildings from Figure 1 and Figure 2

		Monitoring Data			*UPC Appendix M*		*UPC Appendix A*			
	City	**Monitored Apartments**	**Monitoring Period (days)**	**99th Percentile Flow Rate (gpm)**	**Design Estimate (gpm)**	**Percent Difference**	**Water Supply Fixture Units (WSFUs)**	**Design Estimate (gpm)**	**Percent Difference**	
A	Davis, CA	8	304	2	6	62%	27	19	89%	
B	Oakland, CA	8	10	4	13	73%	42	25	86%	(1)
C	Atascadero, CA	10	257	6	17	67%	90	41	86%	
D	Atascadero, CA	12	257	5	17	69%	95	42	88%	
E	Davis, CA	32	304	4	8	51%	108	46	91%	
F	Oakland, CA	24	14	10	18	44%	123	49	80%	
G	New Hartford, NY	35	26	3	10	65%	127	50	93%	(3)
H	San Francisco, CA	15	9	6	19	70%	169	59	90%	
I	Seattle, WA	60	823	5	12	61%	215	68	93%	(1)
J	Rotterdam, NY	24	18	5	19	74%	225	70	93%	(1), (3)
K	Gloversville, NY	40	12	6	20	72%	246	74	92%	(1), (3)
L	Rome, NY	83	15	5	13	64%	295	84	94%	
M	San Francisco, CA	120	12	10	32	70%	603	143	93%	
N	San Francisco, CA	134	12	13	33	61%	665	155	92%	(1)
O	Albany, NY	209	21	7	22	68%	735	168	96%	(3)
P	Seattle, WA	384	609	19	85	78%	3802	500	96%	(2), (3)
					Average	**66%**			**91%**	
					Median	**68%**			**92%**	

(1) Data for this site only considers flows above 0.1 gpm to be non-zero due to possible underestimation of zero flow events (e.g., calibration errors or leaks). This fix has the effect of slightly overestimating the observed 99th percentile flow rate. (2) The UPC Appendix A WSFU landed off the Appendix A design estimate gpm curve. The given value for UPC Appendix A gpm is the last value on the curve. (3) Monitoring data includes hot water use in common and/or utility areas; UPC Appendix M design value does not include this additional water use (conservative approach for comparing observed vs. predicted flow rates).

Table 5: Summary of fixture counts for the multifamily (MF) buildings used in the analysis

	Occupancy Type	Combo Bath/Shower	Lavatory Faucet	Shower	Dishwasher	Kitchen Faucet	Clothes Washer
A	MF Low Income	0	8	8	0	8	0
B	MF Market Rate (Rent Controlled)	8	8	0	0	8	1
C	MF Low Income	18	18	0	10	10	0
D	MF Low Income	18	18	0	12	12	0
E	MF Low Income	0	32	32	0	32	0
F	MF Market Rate	24	24	0	0	24	2
G	MF Senior	0	35	35	0	35	3
H	MF Low Income	24	24	0	15	15	15
I	MF Senior Low Income	0	60	60	0	60	4
J	MF Net Zero (Mixed Occupancy)	24	28	4	24	24	24
K	MF Low-and-Moderate Income	40	40	0	40	40	2
L	MF Senior	0	83	83	0	83	5
M	MF Low Income	120	120	0	0	120	6
N	MF Low Income	134	134	0	0	134	4
O	MF Senior	0	209	209	0	209	10
P	MF Market Rate	454	565	0	384	384	384

For standard practice (UPC/CPC Appendix A methodology), fixture counts are converted into Water Supply Fixture Units (WSFUs), which in turn are used to determine design flow rate based on lookup table/graph codified in UPC/CPC; for this analysis, WSFUs were calculated based on the conversion factors in UPC/CPC Appendix A and are included in the table below for convenience.

For UPC Appendix M methodology, the concept of WSFUs is not used; the design flow rate is determined based on fixture counts, probabilities of use, and fixture flow rates. For this analysis, default fixture flow rates from Water Demand Calculator were used (except for two new construction buildings in Davis, CA) and are included in the table below for convenience. The two buildings in Davis have kitchen faucets rated at 1.8 gpm, so 1.8 value was used for kitchen faucet fixture flow when determining UPC Appendix M design estimate (conservative approach for comparing observed vs. predicted flow rates).

Table 6: Conversion factors for Water Supply Fixture Units (WSFU) and default flow rates from Peak Water Demand Calculator

	Total Building Supply	*Hot Water Branch*	*Cold Water Branch*	*UPC Appendix M Water Demand Calculator*
	Conversion Factor to WSFU	**Conversion Factor to WSFU**	**Conversion Factor to WSFU**	**Default Fixture Flow Rate (gpm)**
Bathtub	4	3	3	5.5
Combination Bath/Shower	4	3	3	5.5
Lavatory Faucet	1	0.75	0.75	1.5
Shower	2	1.5	1.5	2.0
Water Closet (cold branch ONLY)	2.5	0	1.875	3.0
Dishwasher (hot branch ONLY)	1.5	1.125	0	1.3
Kitchen Faucet	1.5	1.125	1.125	2.2
Clothes Washer	4	3	3	3.5

Notes: dishwasher is connected to hot water line only; water closet is connected to cold water line only.

Attachment 4: Additional Information on Cost Savings

Table 7 compares the first costs of the piping for the 92-unit multifamily building in Seattle using both methods for pipe sizing: one based on WSFUs and another based on the Water Demand Calculator. The total pipe length is 2,314 feet in both cases; the difference is the lengths of each pipe diameter. When using UPC Appendix M, the building no longer needs pipe larger than 1-inch nominal diameter. The cost savings for the *pipe only* are estimated to be about $5,000 for the whole building. There are additional estimated first cost savings of about $5,000 for the fittings and valves throughout the building, and the pumps, and other major equipment in the mechanical room.

Table 7. Comparison of Piping Costs for a 92-unit Multifamily Building

4-Story Apartment Building in Seattle, 92 units, 1 bath and 12 Washing Machines						
Nominal Dia. (in)	Water Supply Fixture Unit Method			Water Demand Caculator V2.1		
	Total (feet)	Cost per Foot ($)	Cost per Dimension ($)	Total (feet)	Cost per Foot ($)	Cost per Dimension ($)
3	20	$ 18.75	$ 375	0	$ 18.75	$ -
2.5	90	$ 13.81	$ 1,243	0	$ 13.81	$ -
2	114	$ 10.55	$ 1,203	0	$ 10.55	$ -
1.5	136	$ 5.26	$ 715	0	$ 5.26	$ -
1.25	346	$ 4.50	$ 1,557	0	$ 4.50	$ -
1	808	$ 1.70	$ 1,374	176	$ 1.70	$ 299
0.75	730	$ 0.94	$ 686	1908	$ 0.94	$ 1,794
0.5	70	$ 0.57	$ 40	230	$ 0.57	$ 131
Totals	2314		$ 7,193	2314		$ 2,224
Prices are for PEX piping taken from www.ferguson.com on September 18, 2020. Table shows only the differences in the cost of the pipe for both hot and cold.						

In addition to the cost savings in the piping and related equipment, since the Water Demand Calculator method predicts that the peak hot water demand will be more than nine times smaller compared to the WSFU method, the water heater can be sized much smaller as well. For a 35-unit multifamily building in New York State built in 2020 using UPC Appendix M method to size the pipes, where there was only a factor of four decrease in peak hot water demand, the builder was able to save about $20,000 on the water heaters.

A smaller building water supply (based on the smaller peak water demand) should result in a smaller water meter. Connection fees and development charges vary widely, but the savings ranged from $16,000-$68,000 for the 92-unit building in Seattle. Assuming that the water meter can be reduced in size to better match the diameter of the building water supply, the monthly service charge based on meter size could also be reduced.