

PENNBOC

Gettysburg, PA

2023

Fundamentals of Plumbing Theory

Water sizing

WSFU

What is Hunters Curve?

Roy B Hunter issued “Methods of Estimating Loads in Plumbing Systems” developed for the National Bureau of Standards on December 16, 1940.

The question Mr. Hunter sought to answer was given n (identical) fixtures in a system, each opened once in (T) seconds on average, and opened for an average duration of (t) seconds, what is the probability that (k) fixtures will be open simultaneously at any given time? Mr. Hunter used a Binomial distribution model which considered pulse intensity (q) , duration (t) and frequency (T) . He solved for a 99% chance the fixtures would be in use.

As a result he developed the idea of a Fixture Unit (FU). A fixture unit is an arbitrary comparative dimensionless value assigned to a plumbing fixture which represents the probable flow which will occur. Each fixture is assigned a value which can be tallied and converted to demand in GPM.

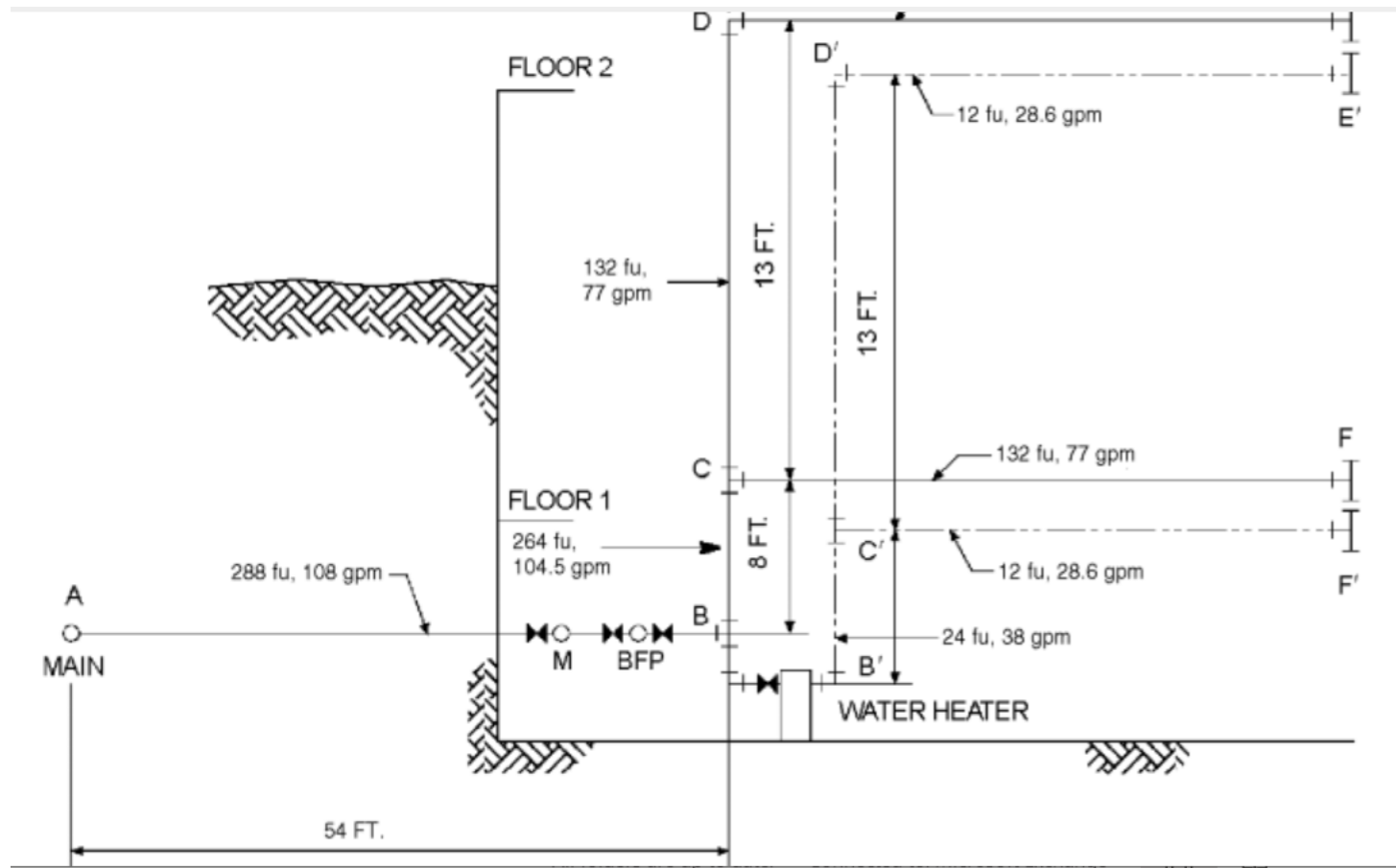


TABLE E103.3(6) PRESSURE LOSS IN FITTINGS AND VALVES EXPRESSED AS EQUIVALENT LENGTH OF TUBE^a(feet)

NOMINAL OR STANDARD SIZE (inches)	FITTINGS				Coupling	VALVES			
	Standard Ell		90-Degree Tee			Ball	Gate	Butterfly	Check
	90 Degree	45 Degree	Side Branch	Straight Run					
3/8	0.5	—	1.5	—	—	—	—	—	1.5
1/2	1	0.5	2	—	—	—	—	—	2
5/8	1.5	0.5	2	—	—	—	—	—	2.5
3/4	2	0.5	3	—	—	—	—	—	3
1	2.5	1	4.5	—	—	0.5	—	—	4.5
1 1/4	3	1	5.5	0.5	0.5	0.5	—	—	5.5
1 1/2	4	1.5	7	0.5	0.5	0.5	—	—	6.5
2	5.5	2	9	0.5	0.5	0.5	0.5	7.5	9
2 1/2	7	2.5	12	0.5	0.5	—	1	10	11.5
3	9	3.5	15	1	1	—	1.5	15.5	14.5
3 1/2	9	3.5	14	1	1	—	2	—	12.5
4	12.5	5	21	1	1	—	2	16	18.5
5	16	6	27	1.5	1.5	—	3	11.5	23.5
6	19	7	34	2	2	—	3.5	13.5	26.5
8	29	11	50	3	3	—	5	12.5	39

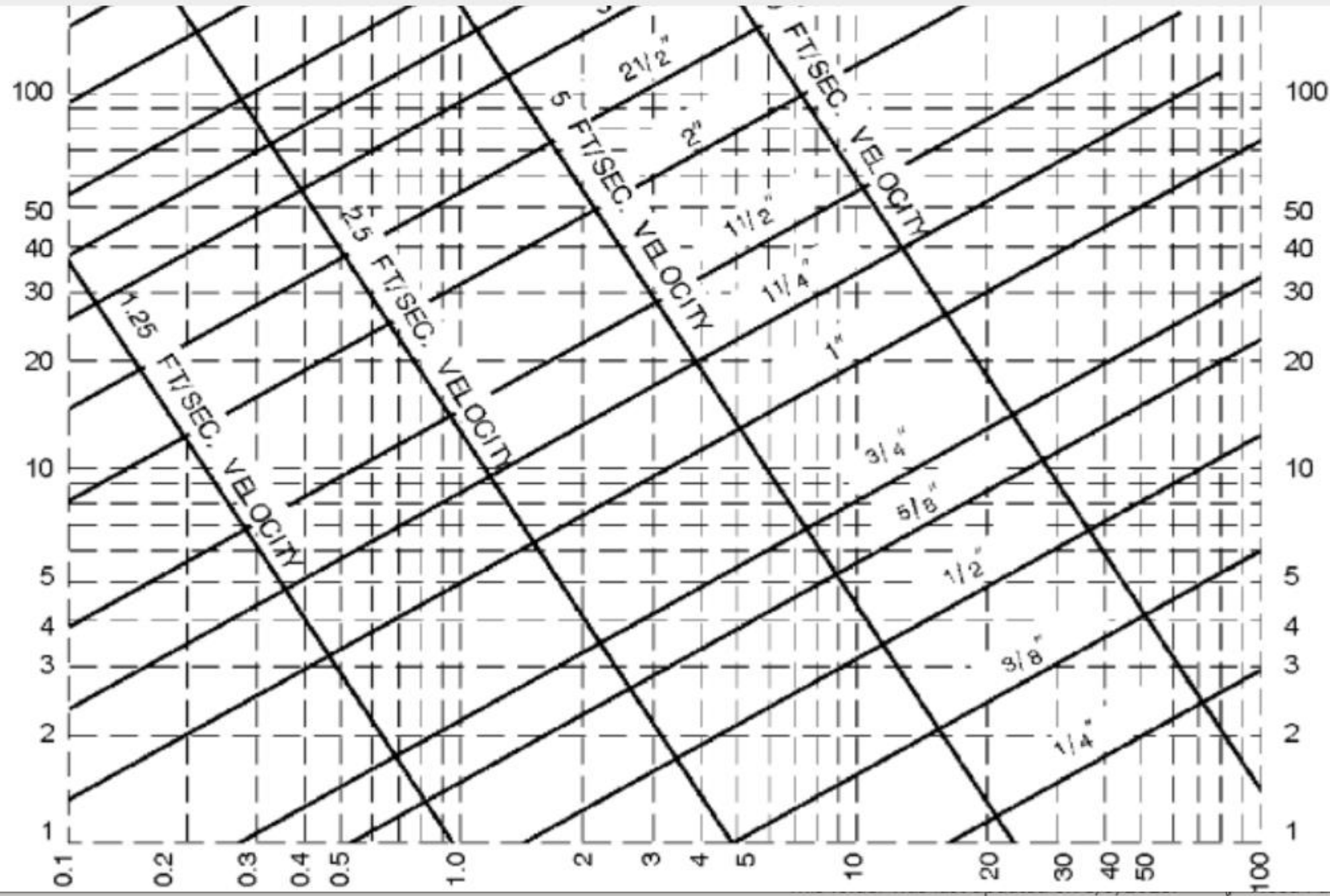
SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS			SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETER VALVES		
Load	Demand		Load	Demand	
(Water supply fixture units)	(Gallons per minute)	(Cubic feet per minute)	(Water supply fixture units)	(Gallons per minute)	(Cubic feet per minute)
200	65.0	8.6892	200	90.0	12.0312
225	70.0	9.3576	225	95.5	12.76644
250	75.0	10.026	250	101.0	13.50168
275	80.0	10.6944	275	104.5	13.96956
300	85.0	11.3628	300	108.0	14.43744
400	105.0	14.0364	400	127.0	16.97736
500	124.0	16.57632	500	143.0	19.11624
750	170.0	22.7256	750	177.0	23.66136
1,000	208.0	27.80544	1,000	208.0	27.80544
1,250	239.0	31.94952	1,250	239.0	31.94952
1,500	269.0	35.95992	1,500	269.0	35.95992
1,750	297.0	39.70296	1,750	297.0	39.70296

MATERIAL	PIPE OR TUBE SIZE (inches)	MAXIMUM VELOCITY (feet per second)
All pipe and tube material	1/2 and smaller	5
Copper or copper-alloy pipe and tubing (hot water systems)	5/8 and larger	5
Copper or copper-alloy pipe and tubing (cold water systems)	5/8 and larger	8
Chlorinated polyvinyl (CPVC) plastic pipe	5/8 - 1 1 1/4 and larger	8 10
Cross-linked polyethylene (PEX) plastic tubing	5/8 and larger	8
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe	5/8 and larger	8
Galvanized steel pipe	5/8 - 1	8
	2 - 4	10
	4 and larger	12
PE-AL-PE	5/8 and larger	8

For SI: 1 inch = 25.4 mm, 1 foot per second = 0.3048 m/s.

Commentary Figure 604.1(1)
MAXIMUM FLOW VELOCITY
FOR VARIOUS PIPE MATERIALS

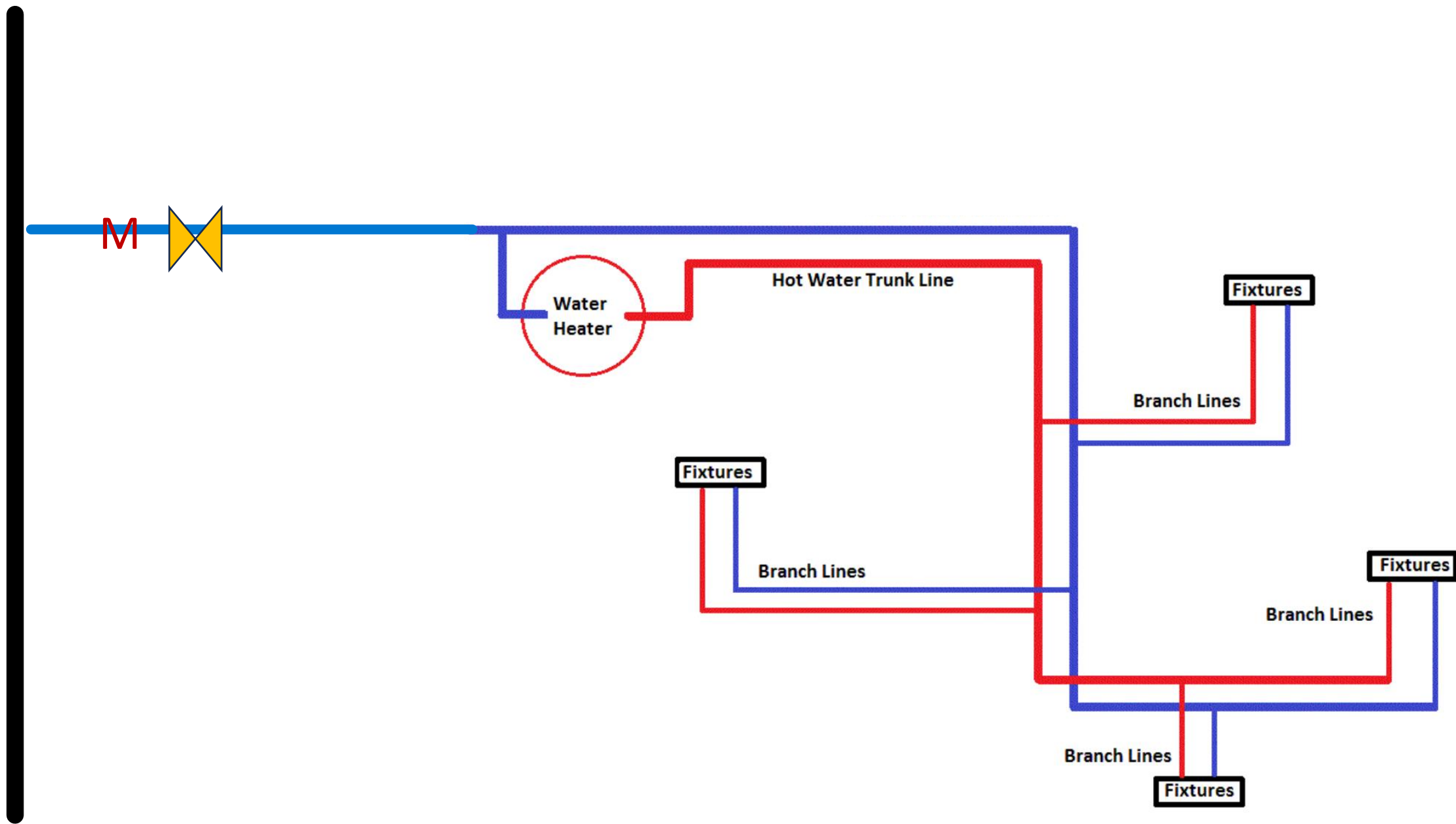
WATER FLOW RATE, GALLONS PER



Page 146
Figure
E103.3(2)

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3/8	0.5	—	1.5	—	—	—	—	—	1.5
1/2	1	0.5	2	—	—	—	—	—	2
5/8	1.5	0.5	2	—	—	—	—	—	2.5
3/4	2	0.5	3	—	—	—	—	—	3
1	2.5	1	4.5	—	—	0.5	—	—	4.5
1 1/4	3	1	5.5	0.5	0.5	0.5	—	—	5.5
1 1/2	4	1.5	7	0.5	0.5	0.5	—	—	6.5
2	5.5	2	9	0.5	0.5	0.5	0.5	7.5	9
2 1/2	7	2.5	12	0.5	0.5	—	1	10	11.5
3	9	3.5	15	1	1	—	1.5	15.5	14.5
3 1/2	9	3.5	14	1	1	—	2	—	12.5
4	12.5	5	21	1	1	—	2	16	18.5
5	16	6	27	1.5	1.5	—	3	11.5	23.5
6	19	7	34	2	2	—	3.5	13.5	26.5
8	29	11	50	3	3	—	5	12.5	39



Drainage ,Waste and Vent sizing

DFU

1/8" per foot slope- Table 710.1(1)

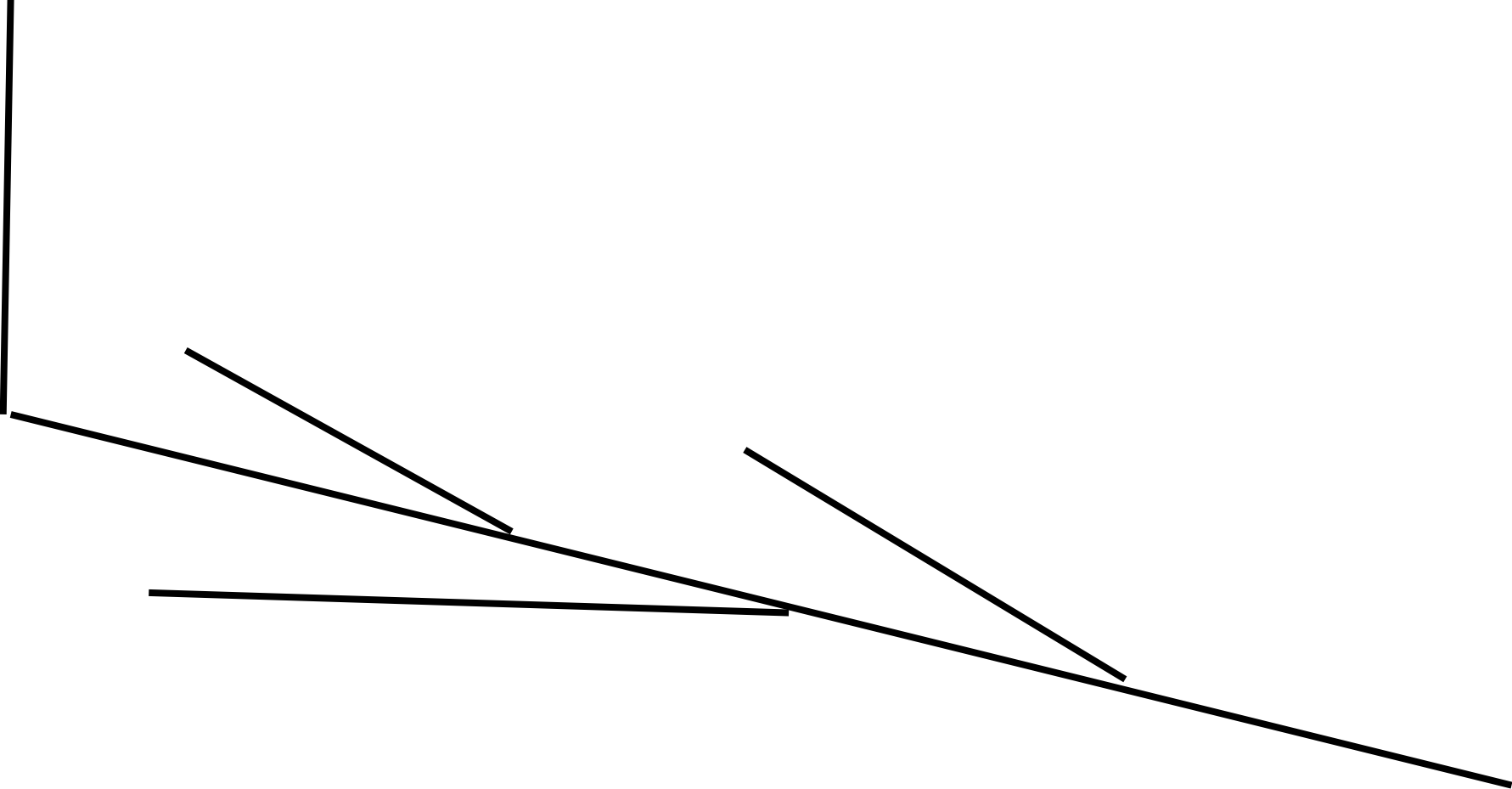


TABLE 710.1(2)

HORIZONTAL FIXTURE BRANCHES AND STACKS^a

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks^b		
		Total discharge into one branch interval	Total for stack of three branch Intervals or less	Total for stack greater than three branch intervals
1 ¹ / ₂	3	2	4	8
2	6	6	10	24
2 ¹ / ₂	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

TABLE 710.1(2)

HORIZONTAL FIXTURE BRANCHES AND STACKS^a

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks ^b		
		Total discharge into one branch interval	Total for stack of three intervals or less	Total for stack greater than three branch intervals
1½	3	2	4	8
2	6	6	10	24
2½	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

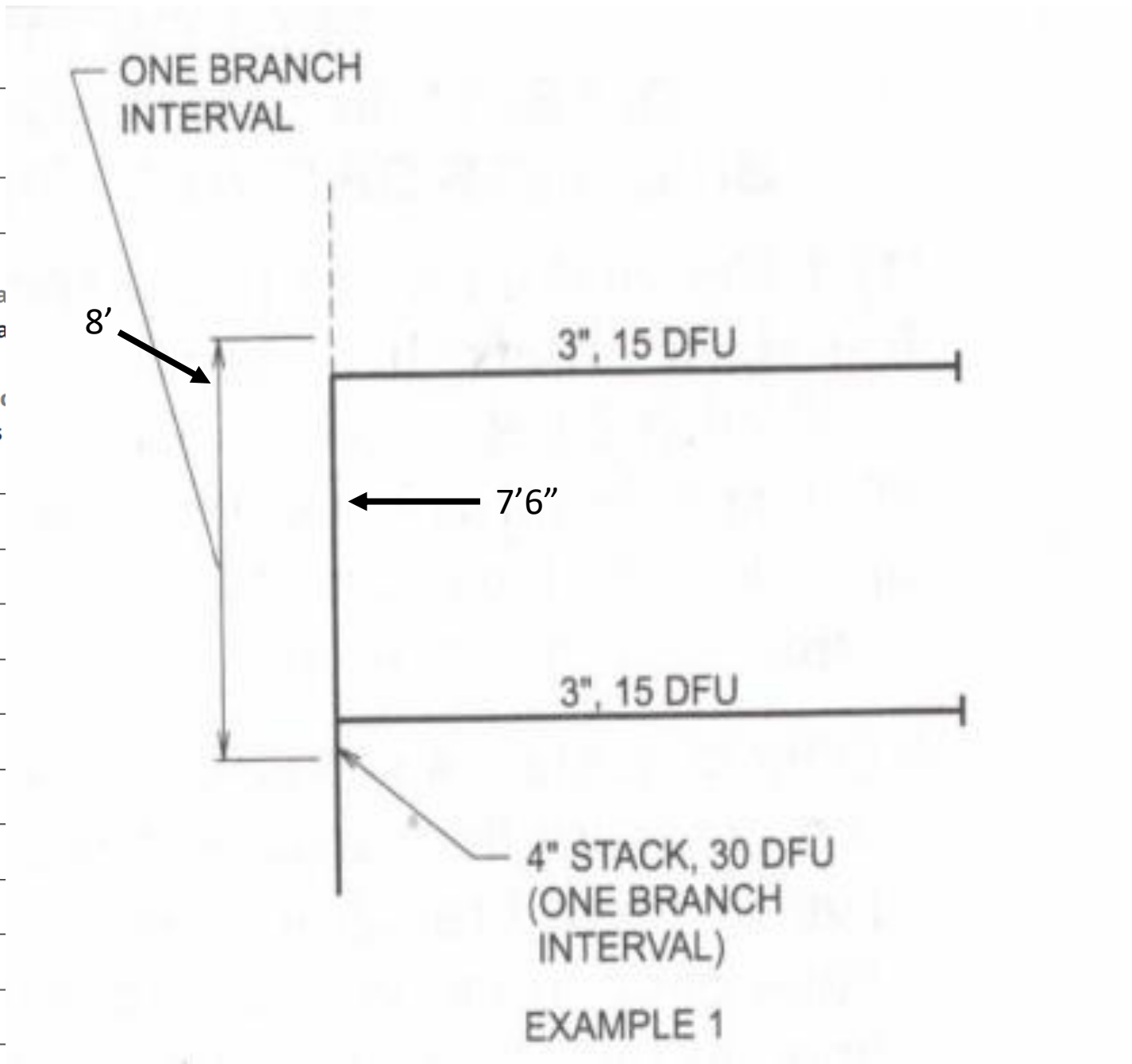


TABLE 710.1(2)

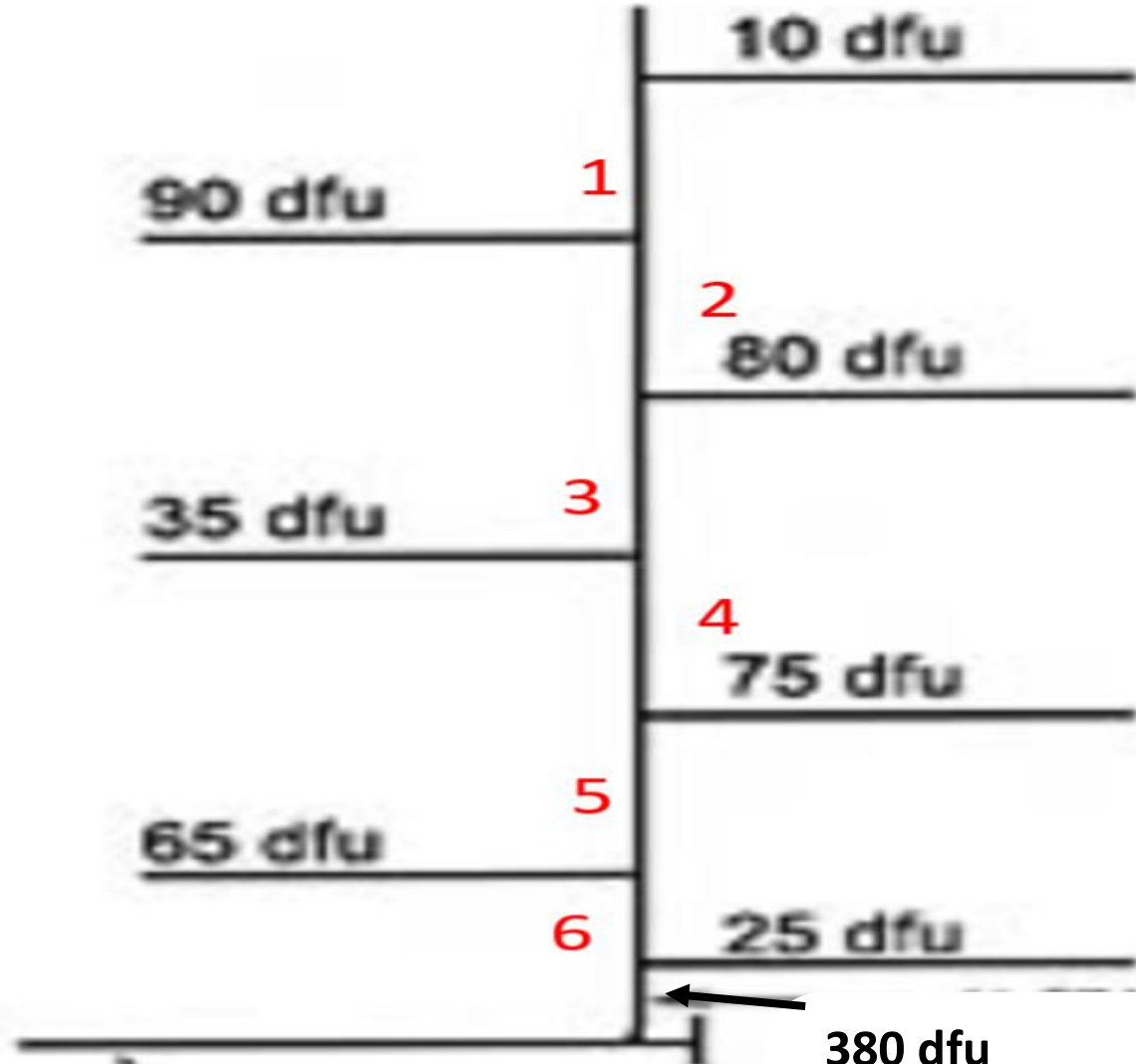
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3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

TABLE 710.1(2)

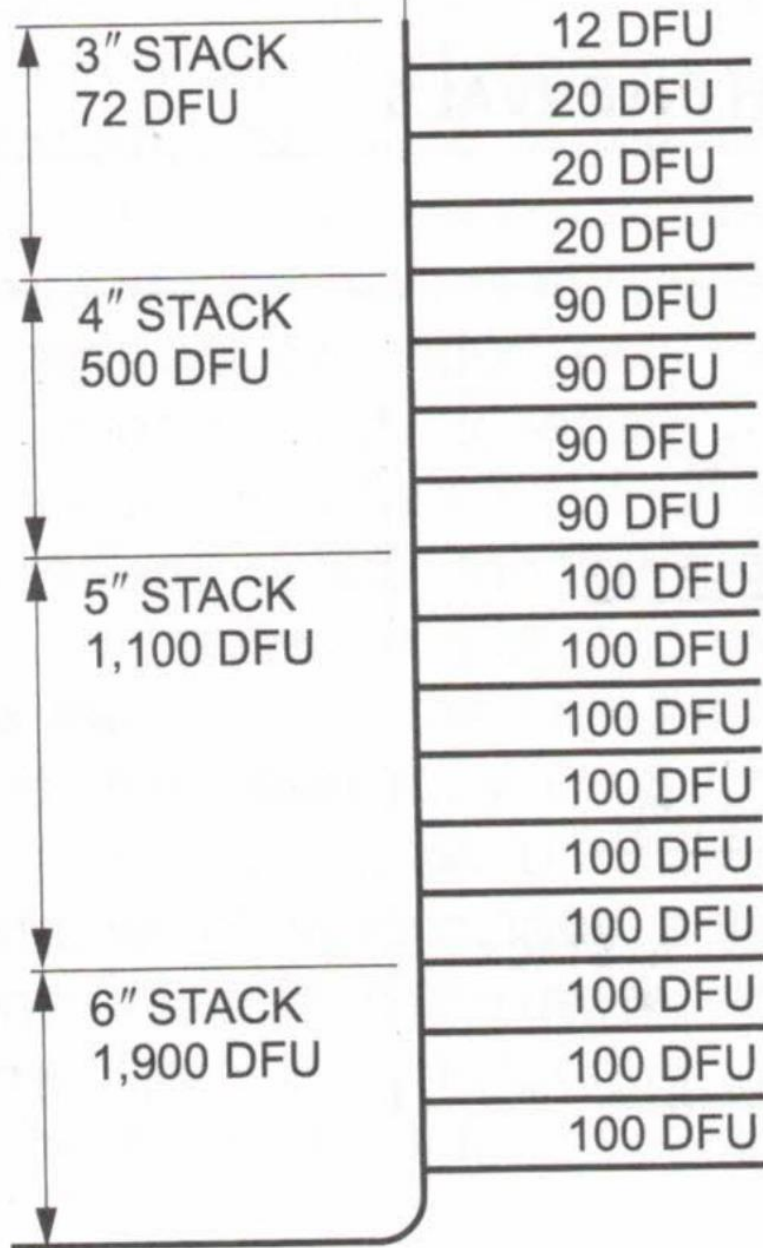
HORIZONTAL FIXTURE BRANCHES AND STACKS^a

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks ^b		
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1½	3	2	4	8
2	6	6	10	24
2½	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

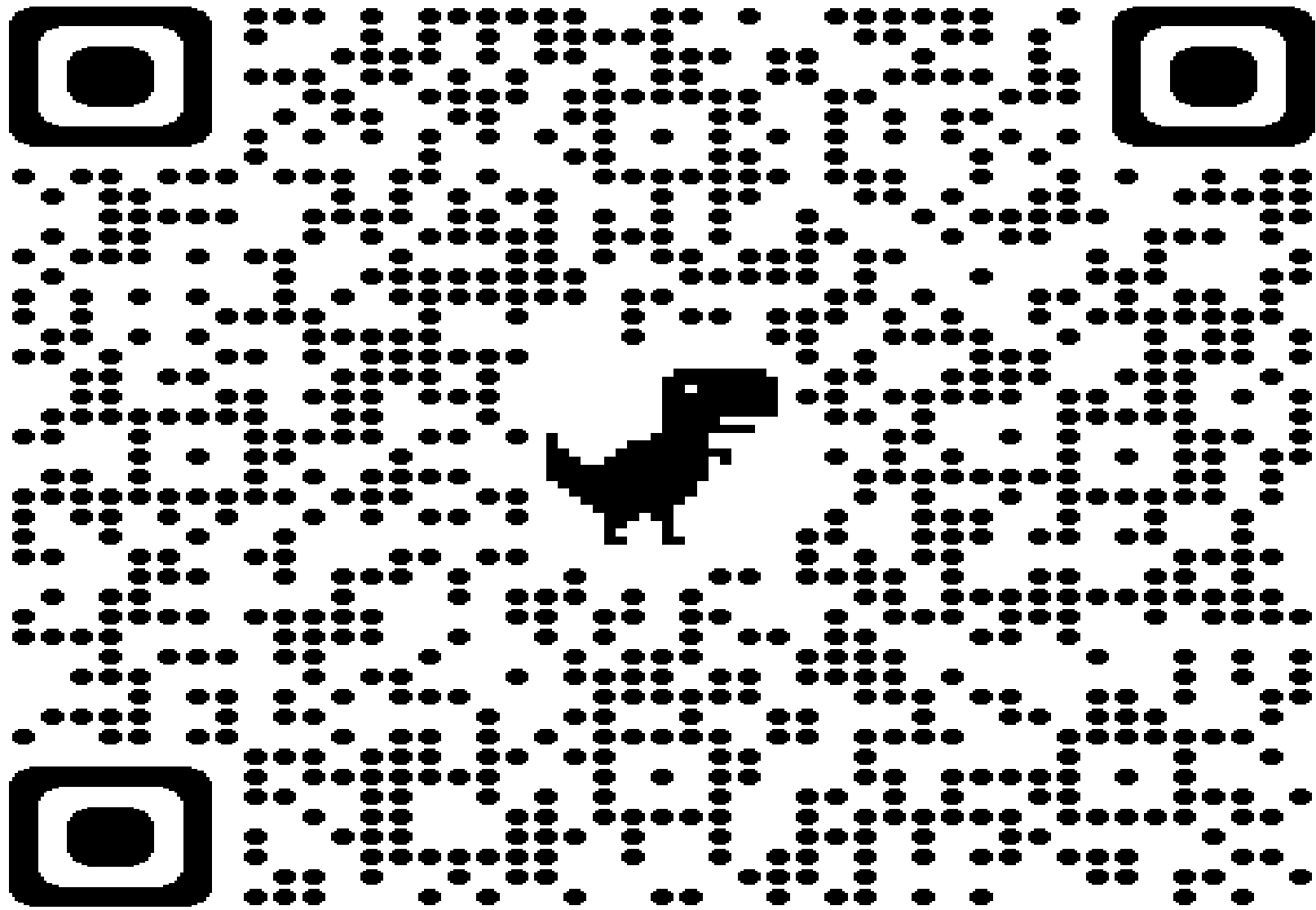


**Building drain
380 dfu-1/8" per foot slope**

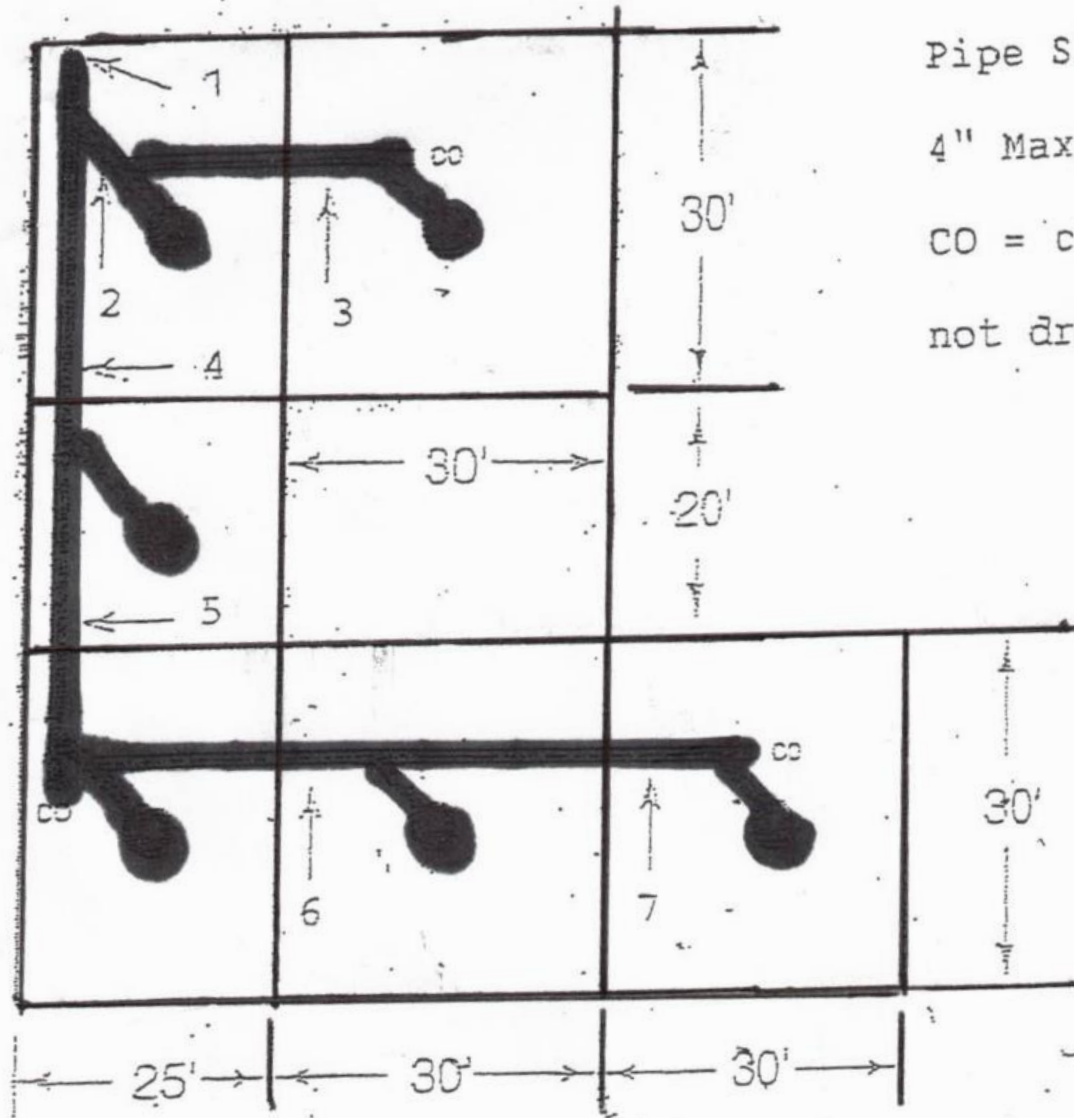
**380 dfu
4" stack**



DIAMETER OF SOIL OR WASTE STACK (inches)	TOTAL FIXTURE UNITS BEING VENTED (dfu)	MAXIMUM DEVELOPED LENGTH OF VENT (feet) ^a										
		DIAMETER OF VENT (inches)										
		1¼	1½	2	2½	3	4	5	6	8	10	12
6	500					33	130	400	1,000			
6	1,100	—	—	—	—	26	100	310	780	—	—	—
6	2,000					22	84	260	660			
6	2,900					20	77	240	600	—		
8	1,800	—	—	—	—	—	31	95	240	940	—	—
8	3,400					—	24	73	190	729		
8	5,600						20	62	160	610	—	
8	7,600	—	—	—	—	—	18	56	140	560	—	—
10	4,000						—	31	78	310	960	
10	7,200							24	60	240	740	
10	11,000	—	—	—	—	—	—	20	51	200	630	—
10	15,000							18	46	180	571	
12	7,300								31	120	380	940
12	13,000	—	—	—	—	—	—	—	24	94	300	720
12	20,000								20	79	250	610



Roof Drain System



Pipe Slope is 1/4" per foot

4" Max/hr. Rainfall

CO = cleanout

not drawn to scale

2021 IPC

$$\text{GPM} = R \times A \times 0.0104$$

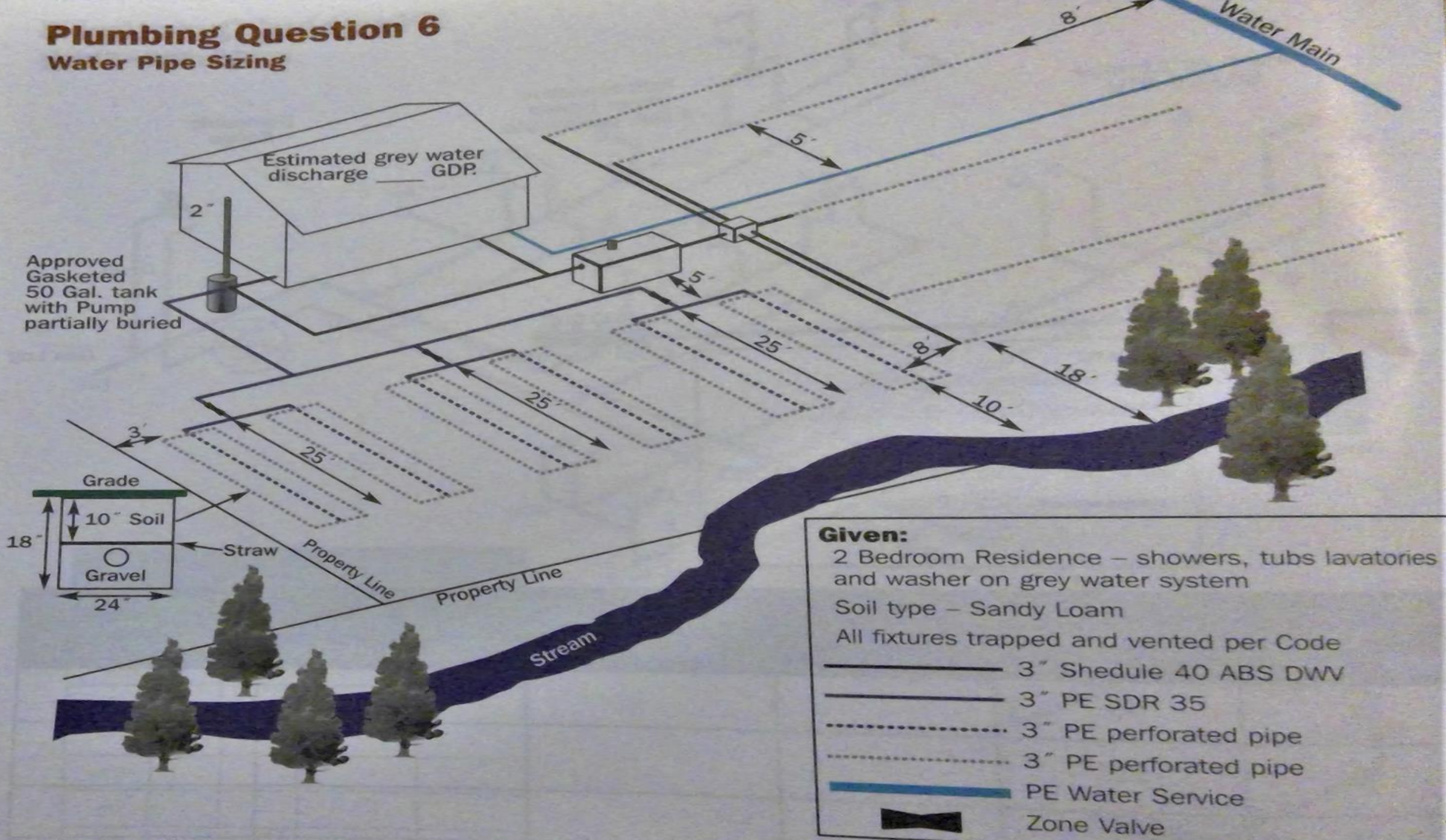
SEC. -1106.2.1

R = Rainfall intensity in inches (mm) per hour.

A = Roof area in square feet (m^2).

Plumbing Question 6

Water Pipe Sizing



Section 1402- system design and sizing

$$C = A \times B$$

C = Estimated graywater discharge per occupant

A = number of occupants

A = Number of occupants:

Residential—Number of occupants shall be determined by the actual number of occupants, but not less than two occupants for one bedroom and one occupant for each additional bedroom.

Commercial—Number of occupants shall be determined by the *International Building Code*.

B = Estimated flow demands for each occupant:

Residential—25 gallons per day (94.6 lpd) per occupant for showers, bathtubs and lavatories and 15 gallons per day (56.7 lpd) per occupant for clothes washers or laundry trays.

Commercial—Based on type of fixture or water use records minus the discharge of fixtures other than those discharging gray water.

C = Estimated gray water discharge based on the total number of occupants.