The High Velocity Hurricane Zone Roof Drainage Requirements

PRESENTED BY THE OFFICE OF BUILDING CODE COMPLIANCE

Why is roof drainage so important?

- Roofs are typically designed for a 30 psf. live load.*
- One square foot of water, one inch deep, weighs 5.2 lbs.
- The maximum depth of water allowed by Code is 5”, weighing 26 lbs./ft.^{2}.
- It would take only one hour at the design rainfall rate for 5” to accumulate.
- There are 3000 roof collapses a year in the USA, many because of inadequate drainage.

Roof Slopes

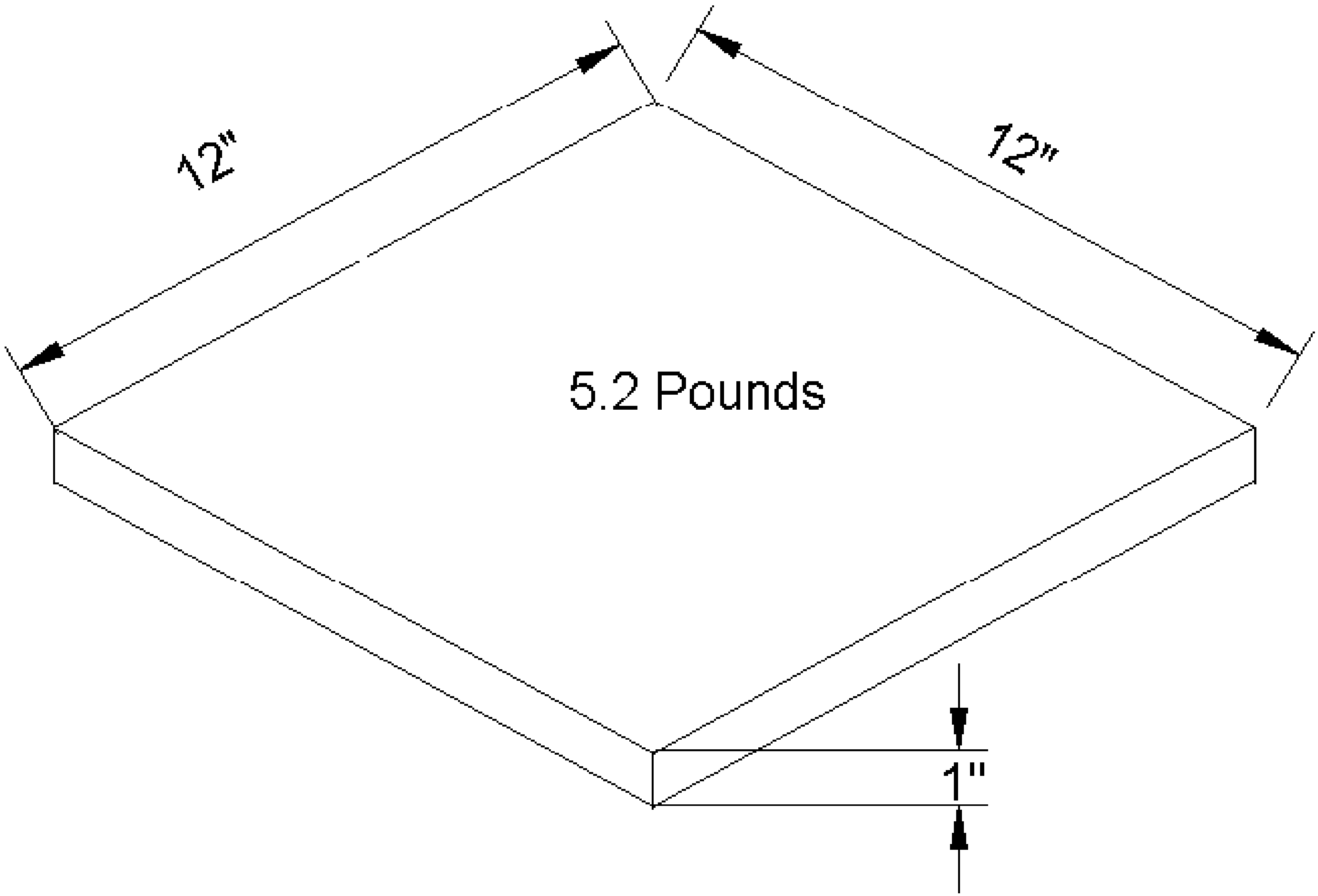
- A roof with a slope of 1:240 is considered the same as a dead-level roof for a roof to be considered to have a positive slope it must have a slope of more than 1:240.
- The Florida Building Code Requires a slope of 1:48 or a ¼" per foot.*
- This is done to preclude ponding instability.

SECTION 1515 HIGH VELOCITY HURRICANE ZONES - PERFORMANCE REQUIREMENTS

- §1515.2.2.1 All roofing systems must be installed to assure drainage.
- In new construction the minimum deck slope shall be not less than
- 1/4:12.

Ponding Instability

- Ponding instability is a phenomenon that occurs anytime that water accumulates on a roof. When water accumulates on a roof the roof deflects under the weight of the water consequently, more water ponds and the more water that ponds the more it deflects and continues to compound itself until failure occurs or the situation is remedied.


12"
12"
5.2 Pounds
1"


Primary scupper could be easily blocked.
Overflow provisions are not provided.

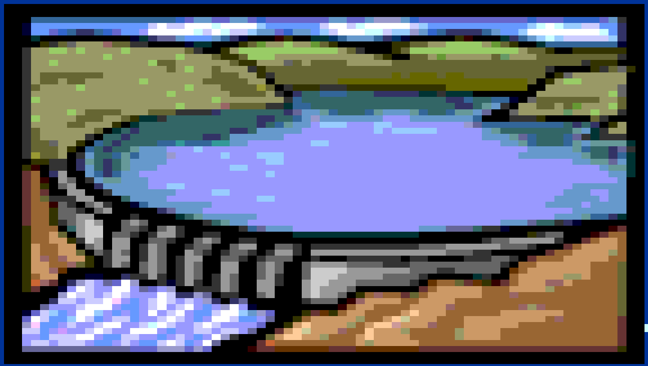
All three roof drains on this section are blocked. No overflow provisions were provided.


Debris blocked scupper.
No overflow provisions.

Strainer is blocked with debris, but flow through the top of the strainer is still possible.

Properties of water

- Water weighs 8.33 lbs./gal.
- There are 231 in.^{3} in one gallon.
- There are 7.48 gallons in a cubic foot.
- A cubic foot of water weighs 62.4 lbs.
- A rainfall of 1 gpm = 8.02 ft.^{3}/hr



Where do we find drainage information in the FBC?

- Chapter 15, Building Volume HVHZ 1514.4*
- Chapter 16, Building Volume HVHZ 1614.1
- Chapter 11, Plumbing Volume P1102.3
- ASCE 7-98
- Chapter 8 Code of Miami-Dade County
- Drainage design requires the coordination of the Architect, Structural Engineer and Plumbing Engineer.

Building **(Changed)**

- HIGH VELOCITY HURRICANE ZONES - GENERAL

~~§1611.1.7 In any conflict between ASCE 7 with commentary and this code, the more stringent requirement shall apply.~~

1612.1.3 No building structure or part thereof shall be designed for live loads less than those specified in this chapter or ASCE-7 with commentary, except as otherwise noted in this code.

HVHZ

- §1514.4.2 Overflow drains and scuppers. Where roof drains are required, overflow drains having the same size as the roof drains shall be installed with the inlet flow line located 2 inches (51 mm) above the low point of the roof, overflow scuppers shall be a minimum of 4 inches (102mm) in height and shall be placed in walls or parapets with the inlet flow line not less than 2 inches (51mm) above the roof surface, excluding sumps, or more than 4 inches (102 mm) above the roof surface and shall be located as close as practical to required vertical leaders or downspouts or wall and parapet scuppers. Overflow drains and scuppers shall also comply with the **Florida Building Code, Plumbing,** and §1616 of this code.*

Florida Building Code Plumbing

- P1107.3 Sizing of secondary drains. Secondary (emergency) roof drain systems shall be sized in accordance with §P1106 based on the rainfall rate for which the primary system is sized **but with the sizing adjusted by dividing the values for horizontally projected roof area in Table P1106.2, Table P1106.3 and Table P1106.6 by two.** The minimum cross-sectional area of an overflow scupper shall be three times the cross-sectional area of the primary roof drain and the scupper shall have a minimum opening dimension of 4 inches (102 mm). The flow through the primary system shall not be considered when sizing the secondary roof drain system.

Florida Building Code Plumbing (new)

- **1107.3 Sizing of secondary drains.** Secondary (emergency) roof drain systems shall be sized in accordance with Section 1106 based on the rainfall rate for which the primary system is sized in Tables 1106.2, 1106.3 and 1106.6. Scuppers shall be sized to prevent the depth of ponding water from exceeding that for which the roof was designed as determined by Section 1101.7. Scuppers shall not have an opening dimension of less than 4 inches (102 mm). The flow through the primary system shall not be considered when sizing the secondary roof drain system.

When are roof drains required?

- Unless roofs are sloped to drain over roof edges, roof drains shall be installed at each low point of the roof. (HVHZ 1514.4)
- "Drains or scuppers installed to provide overflow drainage shall be not less in aggregate area than as shown in Figure 1616.3, but not less than 4 inches (102 mm) dimension in any direction and shall be placed in parapets not less than 2 inches (51 mm) nor more than 4 inches (102 mm) above the roof deck" (HVHZ 1616.3)*
- All roof systems must be installed to assure drainage. (HVHZ 1515.2.2.1)
- In new construction the minimum deck slope shall be ¼ : 12. (HVHZ 1515.2.2.1)
- Primary drains are to be sized per Table P1106.2.

Could a Scupper be Used as a Primary Roof Drain?

- Where required for roof drainage, scuppers shall be placed level with the roof surface in a wall or parapet. (HVHZ 1514.4)*
- The scupper shall be located as determined by the roof slope and contributing roof area. (HVHZ 1514.4)
- Parapet wall roof drainage scupper location shall comply with the FBC Building Volume. Plumbing (1106.5)

Using a Scupper as a Primary Drain

- When using a scupper as a primary means of roof drainage care must be exercised to direct the water away from the building.
- The Code does not allow water to be drained less than a foot from the wall of the building.

When is secondary or overflow drainage required?

- When roof drains are required. (HVHZ 1514.4.2)
- When roof perimeter construction extends above the roof, where water would be trapped if the primary drains allow build-up **for any reason.** (P1107.1)
- When parapets or curbs are constructed, water build-up in excess of that considered in the design shall be prevented. (HVHZ 1616.1)

Structural Concerns

- No accumulation in excess of that considered in the design. (HVHZ 1616.1)
- No more than **5”** of water accumulation when not designed per 1616.1. (HVHZ 1616.2)
- Depth caused by hydraulic head needed to cause flow through the secondary drain shall be included in determining the load. (HVHZ 1616.2)
- All roofs shall be designed with sufficient slope or camber. (HVHZ 1614.4)

What is Hydraulic Head?

- **Is the amount of head needed to cause water to flow out of a drain or a scupper at a set rate.**

  Example for a 4” roof drain to be able to drain 170 Gals. Per minute it must have 2” of head over the drain. With 1” of head it will only drain 80 G.P.M

How do you size a primary drain

- First establish the projected horizontal area of the roof (square footage) including any vertical wall that drains unto the roof (do not include parapets)
- Next establish the rate of rainfall. 4.7” for Miami-Dade.
- Size as per Table 1106.2 of the Plumbing Code.

TABLE 1106.2

TABLE 1106.2
SIZE OF VERTICAL CONDUCTORS AND LEADERS

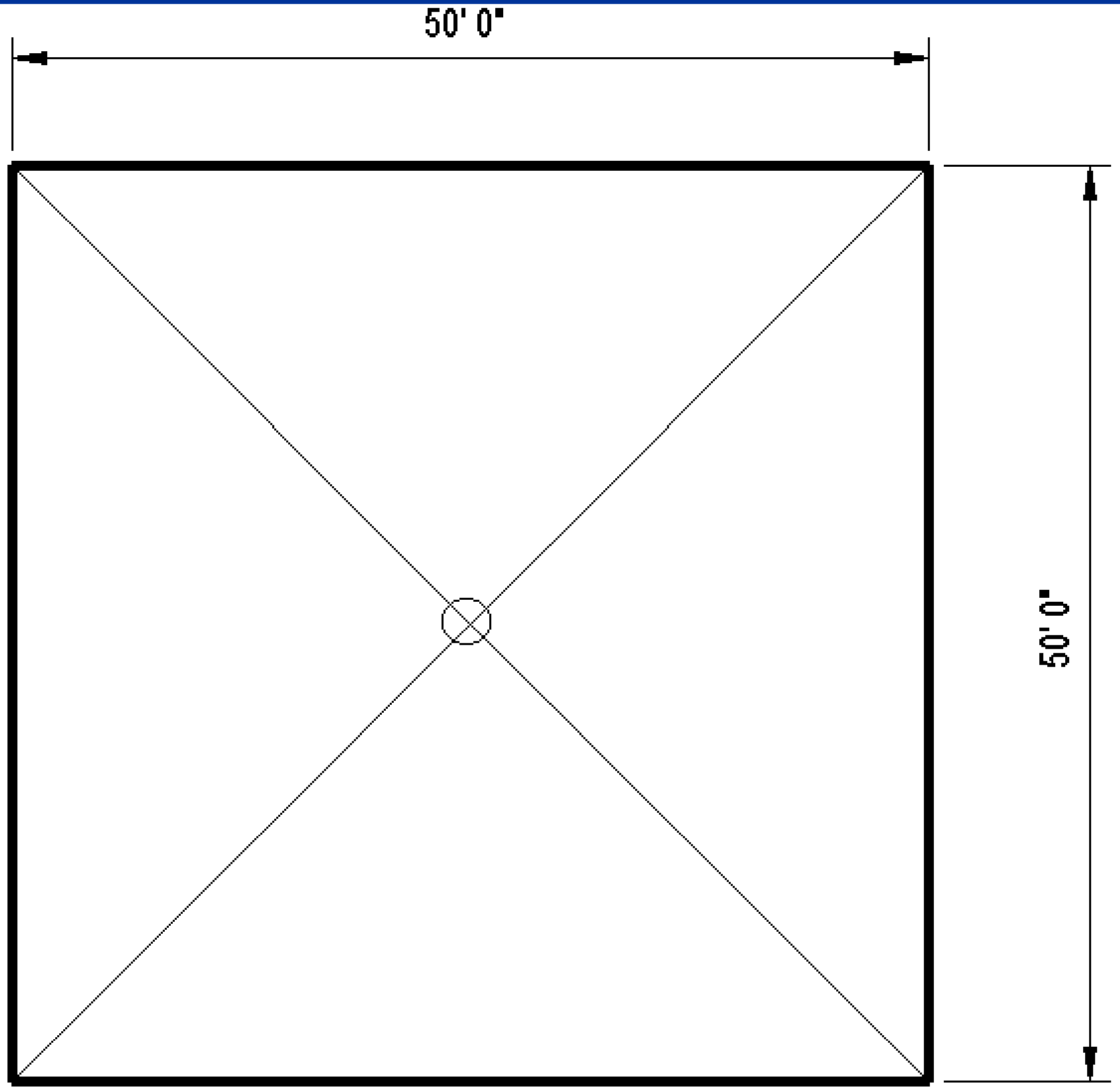
DIAMETER OF LEADER (inches)[a]	HORIZONTALLY PROJECTED ROOF AREA (square feet) Rainfall rate (inches per hour)											
	1	2	3	4	5	6	7	8	9	10	11	12
2					575							
3					1,760							
4					3,680							
5					6,920							
6					10,800							
8					23,200							

For **SI:** 1 inch = 25.4 mm, 1 square foot = 0.0929 m^2.

a Sizes indicated are the diameter of circular piping. This table i[illegible]plicable to piping of other shapes provided the cross-sectional shape fully encloses a circle of the diameter indicated in this table.

Only section of table that may be used for Miami-Dade County

Example #1



2500 sq. ft. of roof area.

Minimum roof pitch is ¼” per foot.

Job is located in Miami-Dade County

Example #1

- With this information go to Figure 1106.1 Chapter 11 of the Plumbing Code. Or go to Appendix “B” Rates of rainfall for various cities . Here you will determine that the rate for Miami –Dade is 4.7”. The commentary tells us that we should go to the next higher number in the table, in this case 5”

Figure 1106.1
Plumbing Code

FIGURE 1106.1
100-YEAR, 1-HOUR RAINFALL (inches)
EASTERN UNITED STATES

For SI: 1 inch = 25.4 mm.
Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.

APPENDIX PB RATES OF RAINFALL FOR VARIOUS CITIES

Florida:

Jacksonville	4.3”
Key West	4.3”
Miami-Dade	4.7”
Tampa	4.5”

Next you go to table table 1106.2

Zoom version of figure 1106.1

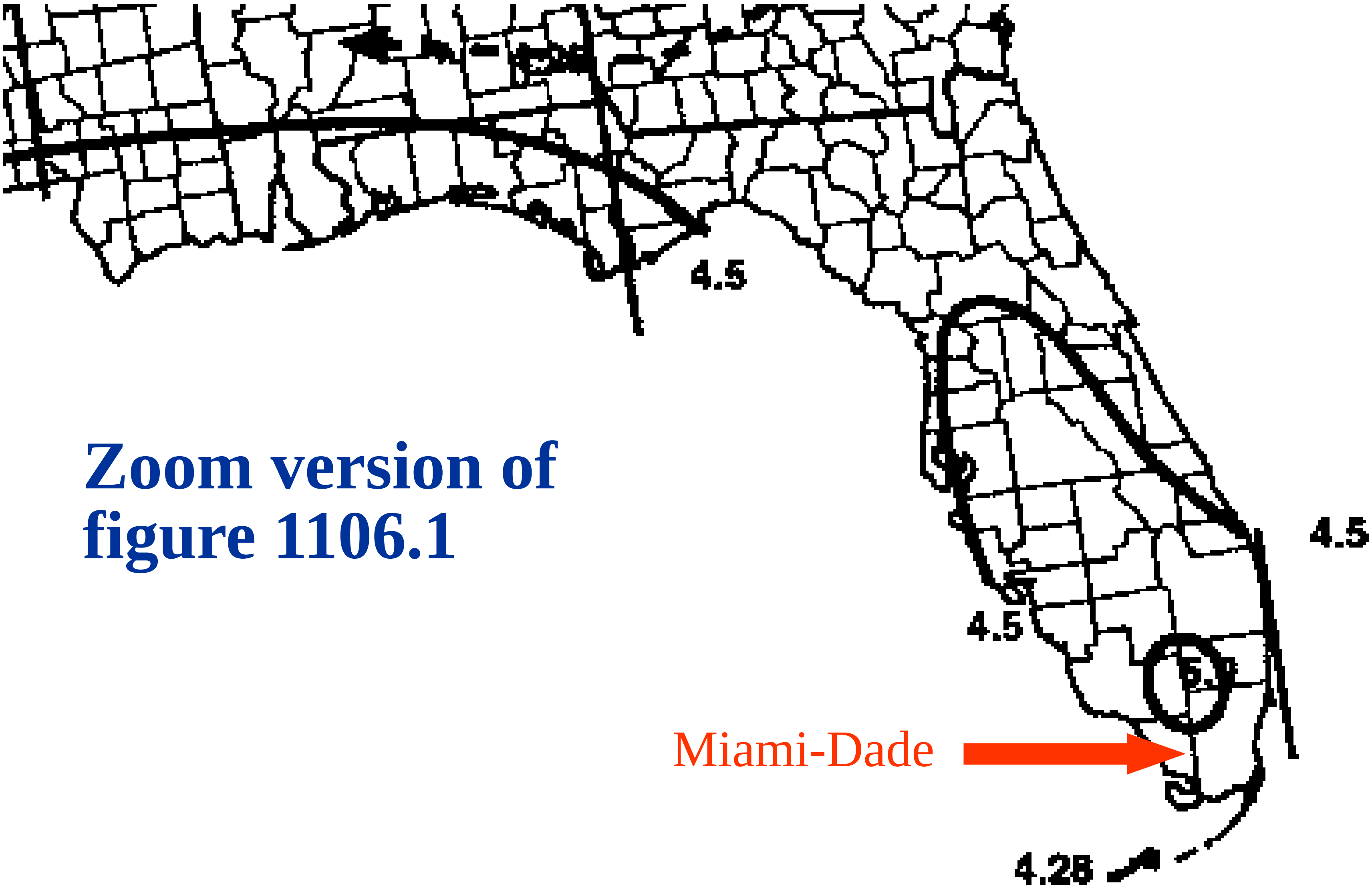


FIGURE 1106.1
100-YEAR, 1-HOUR RAINFALL (inches)
EASTERN UNITED STATES

Diameter of Leader Inches	HORIZONTALLY PROJECTED ROOF AREA (square feet) Rainfall rate (inches per hour)						
	1	2	3	4	5	6	7
2”	2880	1440	960	720	**575**	480	360
3”	8800	4400	2930	2200	**1760**	1470	
4”	18400				**3680**		
5”	34600				**6920**		
6”	54000				**10800**		
8”	**116000**				**23200**		

TABLE 1106.2
SIZE OF VERTICAL CONDUCTORS AND LEADERS

DIAMETER OF LEADER (inches)[a]	HORIZONTALLY PROJECTED ROOF AREA (square feet) Rainfall rate (inches per hour)											
	1	2	3	4	5	6	7	8	9	10	11	12
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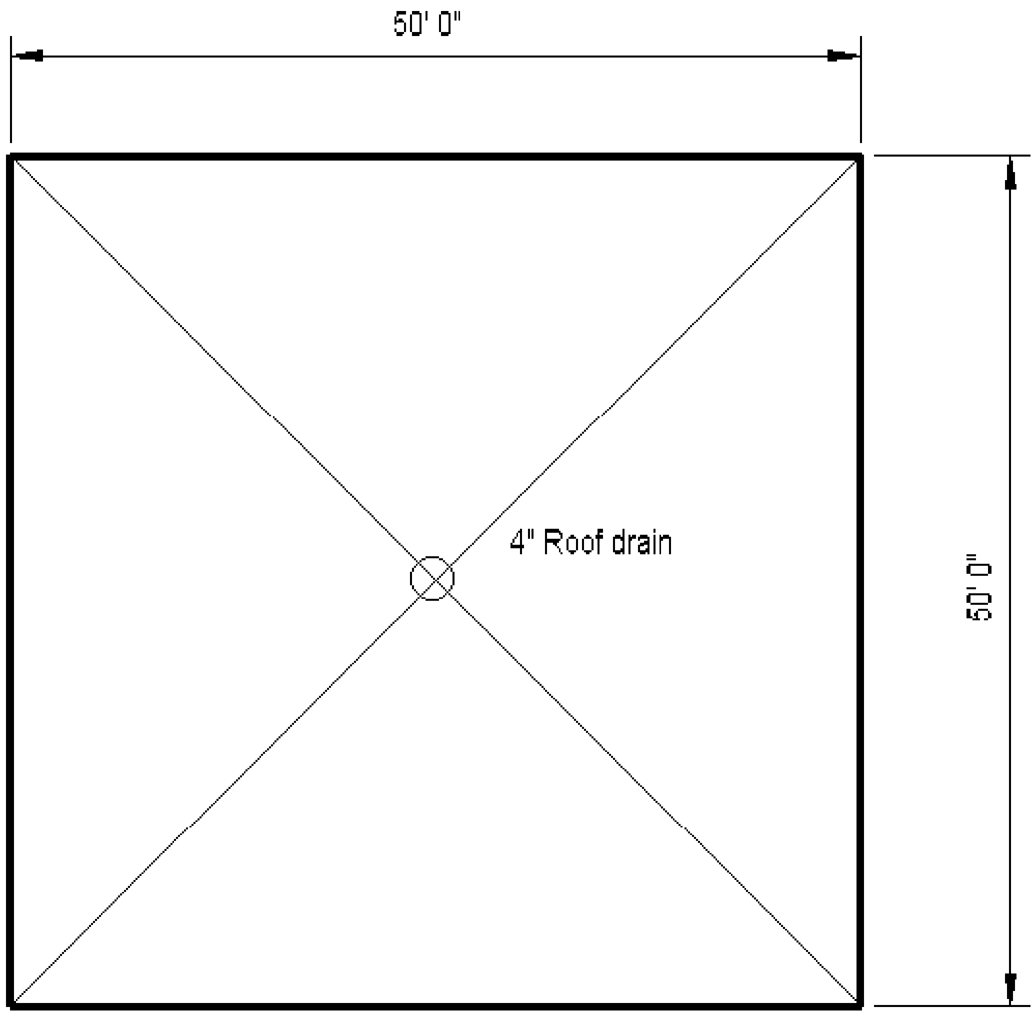
For **SI:** 1 inch = 25.4 mm, 1 square foot = 0.0929 m^2.

a Sizes indicated are the diameter of circular piping. This table i[…]plicable to piping of other shapes provided the cross-sectional shape fully encloses a circle of the diameter indicated in this table.

If you work your way down the 5” column until you get to a number that is higher than 2500 in this case 3680 and follow that across to the left it establishes a 4” leader.



It has been established that a 4” roof drain is required.

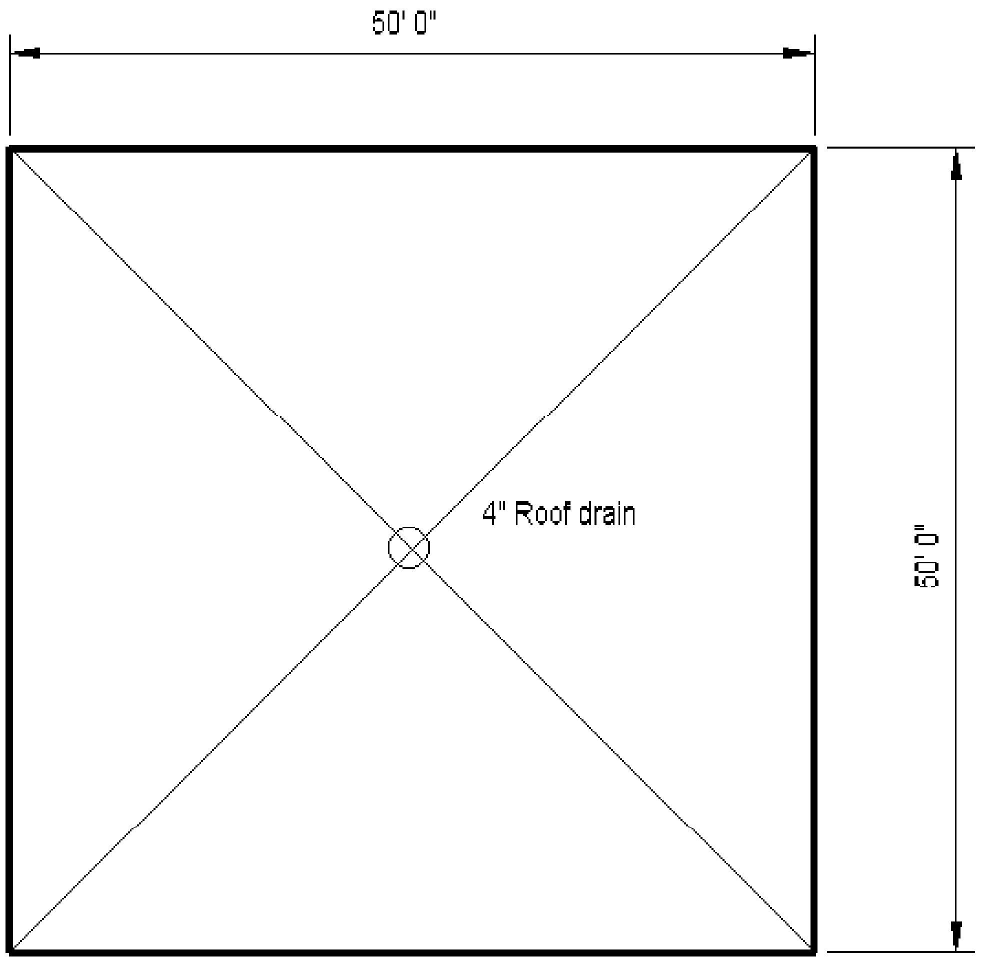
There is 144 cubic inches of water in a 12” x 12” x 1” deep section and there are 231cu. in. of water in a gallon of water .

144 ÷ 231 ÷ 60 = .0104 gals per minute per square foot.

.0104 is the gallons per minute that fall on one square foot of roof at a design rainfall rate of 1”.

Since the rate of rainfall for Miami-Dade is 5” per hour the square footage of the roof is multiplied by 5 then by .0104.

In this case 2500 x 5 x .0104 = 130 gals. per minute is the amount of rain falling on that roof.



This is a 2500 sq.ft. roof that according to table P1106.2 requires a 4” roof drain

After establishing the 130 gals per min. go to table C8-1 in ASCE 7-98 and find the hydraulic head

This table comes from ASCE 7-98. ASCE 7- 98 is a Standard adopted by the Florida Building Code

TABLE C8-1. Flow Rate, *Q*, in Gallons per Minute of Various Drainage Systems at Various Hydraulic Heads, d_h in Inches [2]

	Hydraulic Head, d_h, inches									
Drainage	1	2	2.5	3	3.5	4	4.5	5	7	8
4 in. diameter drain	80	170	180							
6 in. diameter drain	100	190	270	380	540					
8 in. diameter drain	125	230	340	560	850	1,100	1,170			
6 in. wide, channel scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	194	321	393
24 in. wide, channel scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,284	1,572
6 in. wide, 4 in. high, closed scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	177	231	253
24 in. wide, 4 in. high, closed scupper	72	200	—[1]	360	—[1]	560	—[1]	708	924	1,012
6 in. wide, 6 in. high, closed scupper	18	50	—[1]	90	—[1]	140	—[1]	194	303	343
24 in. wide, 6 in. high, closed scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,212	1,372

[1] Interpolation is appropriate, including between widths of each scupper.
[2] Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided.

This is the table that is used to establish the hydraulic head of drains and scuppers.

DRAINAGE SYSTEM	FLOW RATE (gpm)									
	Depth of water above drain inlet (hydraulic head) (inches)									
	1	2	2.5	3	3.5	4	4.5	5	7	8
4-inch-diameter drain	80	170	180							
6-inch-diameter drain	100	190	270	380	540					
8-inch-diameter drain	125	230	340	560	850	1,100	1,170			
6-inch wide, open top scupper	18	50	*	90	*	140	*	194	321	393
24-inch wide, open top scupper	72	200	*	360	*	560	*	776	1,284	1,572
6-inch wide, 4-inch high, closed top scupper	18	50	*	90	*	140	*	177	231	253
24-inch wide, 4-inch high, closed top scupper	72	200	*	360	*	560	*	708	924	1,012
6-inch wide, 6-inch high, closed top scupper	18	50	*	90	*	140	*	194	303	343
24-inch wide, 6-inch high, closed top scupper	72	200	*	360	*	560	*	776	1,212	1,372

For **SI:** 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

Source: Factory Mutual Engineering Corp. Loss Prevention Data 1-

Figure 1101.7(1)

FLOW RATE, IN GALLONS PER MINUTE OF VARIOUS ROOF DRAINS AT VARIOUS WATER DEPTHS AT DRAIN INLETS (INCHES)

This table is found in the commentary to the IPC and it is almost identical to the one in ASCE 7-98

Roof Drainage

- 130 gals per minute on a 4” drain you may interpolate and obtain about 1 ¾” hydraulic head.
- This means that at its design capacity there is going to be 1 ¾” of water over the drain, this is fine since the code requires the roof to be designed in a way that the maximum amount of water that can accumulate is less than 5”.
- This means that the secondary drain has to be placed a minimum of 1 ¾” above the roof. *

Why the concern with hydraulic head?

- §1616.2 Where roofs are not designed in accordance with §1616.1, overflow drains or scuppers shall be placed to prevent an accumulation of more than 5 inches (927 mm) of water on any portion of the roof. In determining the load that could result should the primary drainage system be blocked, the loads caused by the depth of water (i.e., head) needed to cause the water to flow out the scuppers or secondary drainage system shall be included.*

When is secondary or overflow drainage required?

- When roof drains are required. (1514.4.2)
- When roof perimeter construction extends above the roof, where water would be trapped if the primary drains allow build-up **for any reason.** (1107.1)
- When parapets or curbs are constructed, water build-up in excess of that considered in the design shall be prevented. (1616.1)

Roof Drainage

- The code requires that the secondary drainage has to be sized using table 1106.2 and dividing the values by two.*

- **1107.3 Sizing of secondary drains.** Secondary (emergency) roof drain systems shall be sized in accordance with Section 1106 based on the rainfall rate for which the primary system is sized but with the sizing adjusted by dividing the values for horizontally projected roof area in Tables 1106.2, 1106.3 and 1106.6 by two. The minimum cross-sectional area of an over-flow scupper shall be three times the cross-sectional area of the primary roof drain and the scupper shall have a minimum opening dimension of 4 inches (102 mm). The flow through the primary system shall not be considered when sizing the secondary roof drain system.

As per the requirements of 1107.3 we have created a table to accomplish this.

Diameter of Leader	4”	5”
2”	360	**288**
3”	1100	**880**
4”	2300	**1840**
5”	4325	**3460**
6”	6750	**5400**
8”	14500	**11600**

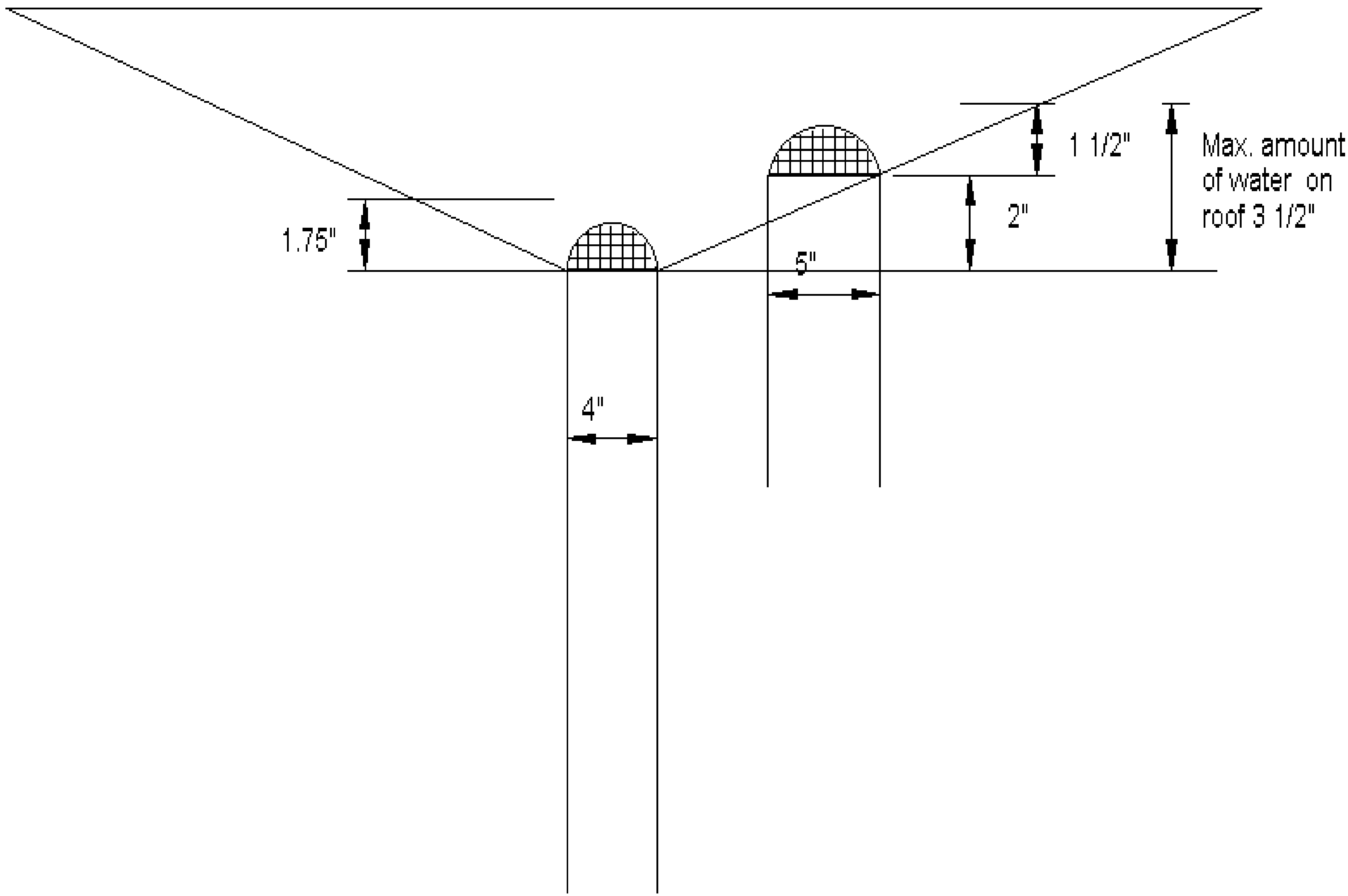
If you compare this table with 1106.2 you will notice that we have taken those values and divided them by two.

Consequently we are required a 5” secondary drain.

Roof Drainage

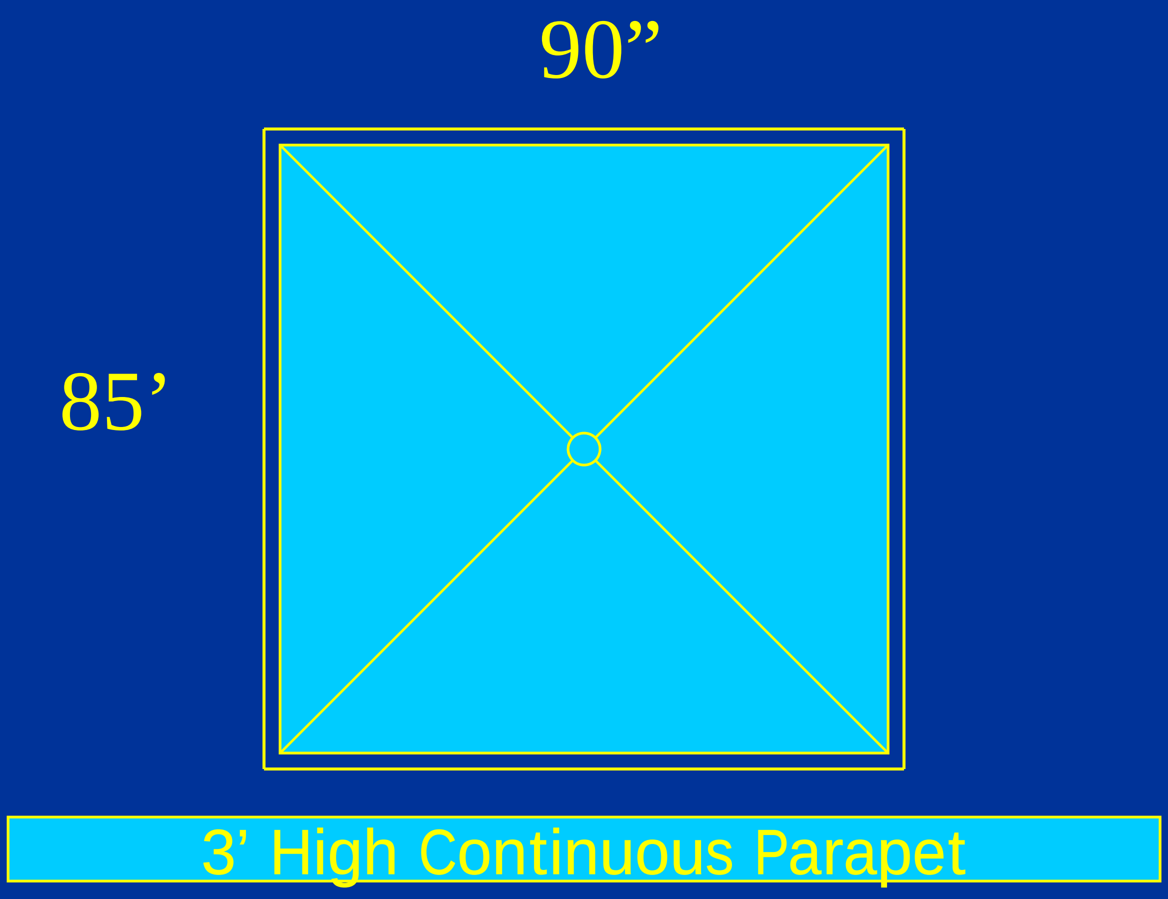
The head over the primary has been established at 1 ¾", 130 gals per min on a 5" drain would give us 1 ½" of hydraulic head. Place the secondary at 2" above the deck with 1 ½" of hydraulic head this would give us a maximum of 3 ½" of water on the roof even if the primary were to become clogged.

There are drains that have a dam built in, or the drain can placed at a location were the 2" above the low point in the deck happens to be on deck.



1 1/2"
Max. amount
of water on
roof 3 1/2"
2"
1.75"
5"
4"

Example #2, roof slopes at ¼ in./ft. to a single interior drain.



Size the primary drain for example roof #2.

- Roof area 90' x 85' = 7650 $ft.^2$
- Rainfall rate for Miami =5"
- Read down the 5" rainfall column of Table 1106.2 until a projected roof area figure that is equal to or greater than the sample roof area is found. Then read across the Table to find the required drain size.
- A 6" drain is found to be required.

TABLE 1106.2
SIZE OF VERTICAL CONDUCTORS AND LEADERS

DIAMETER OF LEADER (inches)[a]	HORIZONTALLY PROJECTED ROOF AREA (square feet) Rainfall rate (inches per hour)											
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2					575							
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4					3,680							
5					6,920							
6					10,800							
8					23,200							

For **SI:** 1 inch = 25.4 mm, 1 square foot = 0.0929 m^2.

a Sizes indicated are the diameter of circular piping. This table is applicable to piping of other shapes provided the cross-sectional shape fully encloses a circle of the diameter indicated in this table.

Establish the hydraulic head at the primary drain for example roof #2

- To establish rainfall in gallons per minute. Multiply square footage, times the Miami rainfall rate, then multiply times the conversion factor.
- 7650 x 5 x 0.0104 = 398 gal/min.
- Refer to ASCE 7-98 Table C8-1.
- Hydraulic head for a 6” drain, that must drain 398 gal/min., falls between 3” and 3.5”.
- Interpolation is necessary to establish an exact hydraulic head.

TABLE C8-1. Flow Rate, Q, in Gallons per Minute of Various Drainage Systems at Various Hydraulic Heads, d_h, in Inches [2]

Drainage	Hydraulic Head, d_h, inches									
	1	2	2.5	3	3.5	4	4.5	5	7	8
4 in. diameter drain	80	170	180							
6 in. diameter drain	100	190	270	380	540					
8 in. diameter drain	125	230	340	560	850	1,100	1,170			
6 in. wide, channel scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	194	321	393
24 in. wide, channel scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,284	1,572
6 in. wide, 4 in. high, closed scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	177	231	253
24 in. wide, 4 in. high, closed scupper	72	200	—[1]	360	—[1]	560	—[1]	708	924	1,012
6 in. wide, 6 in. high, closed scupper	18	50	—[1]	90	—[1]	140	—[1]	194	303	343
24 in. wide, 6 in. high, closed scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,212	1,372

[1] Interpolation is appropriate, including between widths of each scupper.
[2] Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided.

540 – 380 = 160 -- 3.5 – 3 = .5 -- .5 ÷ 160 = .003125

398 – 380 = 18 18 x .003125 = .05625

3 + .05625 = 3.056”

In this case is it worth the trouble to do interpolation?

.0625 = 1/16” Round it off to $3^{1/16}$”?

Could overflow scuppers be used to provide secondary drainage?

The easy way to figure this is to just divide the distance from the primary to the parapet by 4 to obtain the height of water at the primary.

In this case divide 42.5' ÷ 4 = 10.6" consequently you could not use a scupper as a means of secondary drainage.

You would have 10.6" of water on the roof before it reached the scupper.

Secondary Drain

- Piping must be separate. Why? (1107.2)*
- Secondary must discharge above grade. Why? (1107.2)
- Discharge must be in a location where it would be normally observed. Why? (1107.2)
- Height placement of the invert of the secondary drain must be above the depth of water of the primary drain at its design flow. This requirement seems to be implied by the Code, though not explicit.

A secondary drain will be required, how is it sized?

- The projected roof areas shown in Table 1106.2 must be divided by two.
- Then read down the 5” rainfall column until a figure equal to or greater than the projected roof area is found.
- Projected roof area 7650 $ft.^2$

Table 1106.2 with sizing adjusted by dividing values by two

- **Projected roof area 7650 ft.^{2}**

Diameter of Leader	4”	5”
2”	360	**288**
3”	1100	**880**
4”	2300	**1840**
5”	4325	**3460**
6”	6750	**5400**
8”	14500	**11600**

5”
575
1760
3680
6920
10800
23200

Overflow drain size – 8” diameter

Establish the hydraulic head above the secondary drain

- For an 8" secondary drain the head falls between 2.5"-3".
- 2.5" +[(398-340 ÷ 560-340) x .5] = h_d
- 2.5" + [(58 ÷ 220) x .5] = h_d
- 2.5" + 0.1318 = 2.63"
- If the primary drain could not handle the peak flow for any reason, the secondary would accommodate the design flow.
- At the design rainfall rate, there would be a depth of water 2.6" above the secondary drain.

This table comes from ASCE 7-98. ASCE 7- 98 is a Standard adopted by the Florida Building Code

TABLE C8-1. Flow Rate, Q, in Gallons per Minute of Various Drainage Systems at Various Hydraulic Heads, d_h in Inches [2]

	Hydraulic Head, d_h, inches									
Drainage	1	2	2.5	3	3.5	4	4.5	5	7	8
4 in. diameter drain	80	170	180							
6 in. diameter drain	100	190	270	380	540					
8 in. diameter drain	125	230	340	560	850	1,100	1,170			
6 in. wide, channel scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	194	321	393
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[1] Interpolation is appropriate, including between widths of each scupper.
[2] Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided.

This is the table that is used to establish the hydraulic head of drains and scuppers.

In this case the Hydraulic head will be 2.6” Roughly 2 ½”?

Alternate method

TABLE C8-1. Flow Rate, Q, in Gallons per Minute of Various Drainage Systems at Various Hydraulic Heads, d_h in Inches [2]

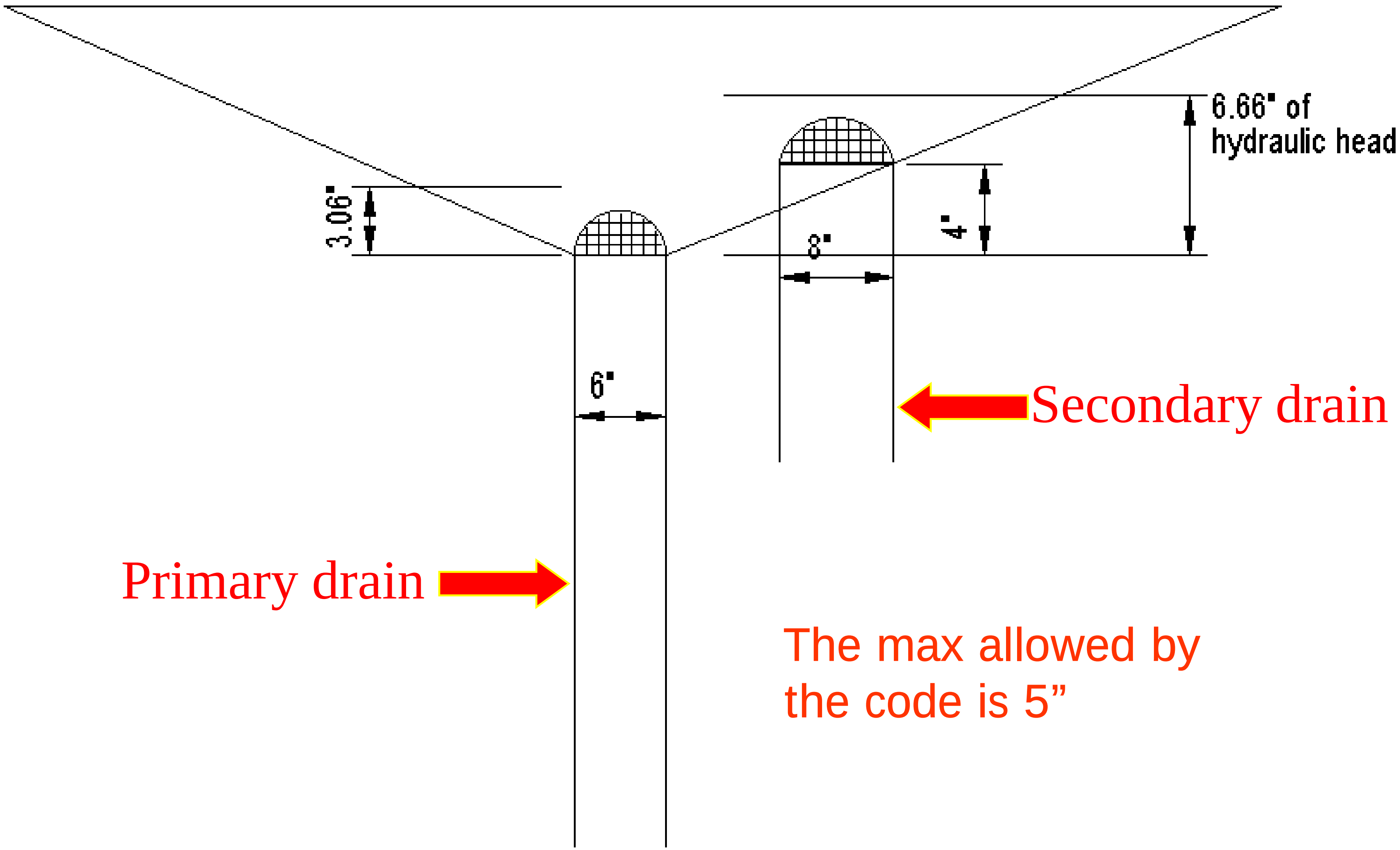
Drainage	Hydraulic Head, d_h, inches									
	1	2	2.5	3	3.5	4	4.5	5	7	8
4 in. diameter drain	80	170	180							
6 in. diameter drain	100	190	270	380	540					
8 in. diameter drain	125	230	340	560	850	1,100	1,170			
6 in. wide, channel scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	194	321	393
24 in. wide, channel scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,284	1,572
6 in. wide, 4 in. high, closed scupper[2]	18	50	—[1]	90	—[1]	140	—[1]	177	231	253
24 in. wide, 4 in. high, closed scupper	7[illegible]	[illegible]	—[1]	360	—[1]	560	—[1]	708	924	1,012
6 in. wide, 6 in. high, closed scupper	18	50	—[1]	90	—[1]	140	—[1]	194	303	343
24 in. wide, 6 in. high, closed scupper	72	200	—[1]	360	—[1]	560	—[1]	776	1,212	1,372

[1] Interpolation is appropriate, including between widths of each scupper.
[2] Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided.

The GPM remains at 398. Subtract 340 from 398 = 58. Subtract 340 on the table from the 560 on the table = 220. Subtract 2.5” from the 3” of hydraulic head on the table = .5. Divide .5 into 220 = .002272. Multiply 58 x .002272 = .1318. Add .1318 to 2.5 = 2.6318 round off to 2.6”.

Are the structural rain load requirements of the Code met?

- Depth above the primary = 3.06”
- Placement of the invert of the secondary = 4” above the low point.
- Depth above the secondary = 2.6”
- 3.06” + .94” + 2.6” = 6.6”
- This depth of water exceeds maximum 5” load allowed by the Code.
- Even if the secondary was placed with the invert at the point of the hydraulic head of the primary you still have 5.66” of water on the roof.
- Even though the plumbing requirements are met, the structural requirements are not.



6.66" of
hydraulic head
3.06"
4"
8"
6"
Secondary drain
Primary drain
The max allowed by
the code is 5”

Options

- Go to a bigger primary.
- Go to a bigger secondary.
- Or both.
- Or design the structure to withstand this rain load.

TABLE 1106.7
SIZING SCUPPERS FOR A 5” PER HOUR RATE OF RAINFALL

	HORIZONTALLY PROJECTED ROOF AREA (SQUARE FEET)						
HEAD IN INCHES	**LENGTH OF WEIR IN INCHES**						
	4	**6**	**8**	**12**	**16**	**20**	**24**
1	230	346	461	692	923	1153	1384
2	641	961	1282	1923	2564	3205	3846
3	1153	1730	2307	3461	4615	5769	6923
4	1794	2692	3589	5384	7179	8974	10769

Note: to adjust this table for other than a 5” design rain fall rate multiply the square footage on the table by 5 then divide by the local design rain fall rate. Example: For 4” of design rainfall rate a 4” long scupper with a 1” head would accommodate 287 square feet. 230 x 5 /4 = 287

Drainage system	Flow in gallons per minute Depth of water over drain inlet or hydraulic head							
	1	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
4 inch roof drain	80	170	180					
6 inch roof drain	100	190	270	380	540			
8 inch roof drain	125	230	340	560	850	1,100	1,170	
6 inch wide open scupper	18	50		90		140		194
24 inch wide open scupper	72	200		360		560		776
6 inch wide 4 inch high closed scupper	18	50		90		140		177
24 inch wide 4 inch high closed scupper	72	200		360		560		708
6 inch wide 6-inch high closed scupper	18	50		90		140		164
24 inch wide 6-inch high closed scupper	72	200		360		560		776

This table is similar to the ones found in ASCE 7 98 and in the Plumbing Commentary.

EXAMPLE: for a 24” long scupper with a 1” head take the $72 \div .0104 \div 5 = 1385$

Formulas

- **To obtain the gallons per minute that fall on a given roof at the rate for Miami-Dade County (5" per hour)**.
- There is 144 cubic inches in a section of roof 12" x 12" x 1".
- There is 231 cubic inches in a gallon.
- If you divide 144 by 231 you obtain accumulation of rainfall in gals. per hour per sq. ft.
- To obtain gals. Per minute divide the result by 60
- 144 ÷ 231 ÷ 60 =.0104
- Square feet of roof x 5" x .0104 = gpm falling on the roof.

Formulas

- Formula to calculate amount ponding water on the roof:

$$V = \frac{4p}{3} \times \frac{W}{2} \times \frac{L}{2} \times \frac{D}{2}$$

- **V= Cubic Feet**
- **W= Width**
- **L= Length**
- **D= Depth**

- Depth must be expressed in feet or decimal of feet

Formulas

- Francis Formula:
- $Q = 3.33\,(b-0.2H)H^{1.5}$
- b = scupper with in feet
- Q = Flow in Cu. Ft. per Sec.
- H = Hydraulic head in feet (or height of scupper)

Formulas

- Factory Mutual Formula for Flow:
- $Q = 2.9\ b(H)^{1.5}$
- Q = Flow in gallons per minute
- b = Base or in this case width of scupper
- H = Hydraulic head or height of scupper

Estimating Weight of Ponded Roof Water

- $$V = \frac{4p}{3} \; x \; \frac{W}{2} \; x \; \frac{L}{2} \; x \; \frac{D}{2}$$

Example; A pond 70’ long by 40’ wide and 7/8”deep at the center:

$$V = 4 \; x \; 3.14 \; ¸ \; 3 \; x \; 40 \; ¸ \; 2 \; x \; 70 \; ¸ \; 2 \; x \; \left(\frac{7/8” \; ¸ \; 12}{2}\right) =$$

4.18 x 20 x 35 x .0364 = 106.67 Cu. Ft. = V

V= 106.67 Cu. Ft. x 62.4 = 6656.65 lbs ¸ 2000 = 3.3 Tons

Drainage system	Flow in gallons per minute							
	Depth of water over drain inlet or hydraulic head							
	1	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
4 inch roof drain	80	170	180					
6 inch roof drain	100	190	270	380	540			
8 inch roof drain	125	230	340	560	850	1,100	1,170	
6 inch wide open scupper	18	50		90		140		194
24 inch wide open scupper	72	200		360		560		776
6 inch wide 4 inch high closed scupper	18	50		90		140		177
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6 inch wide 6-inch high closed scupper	18	50		90		140		164
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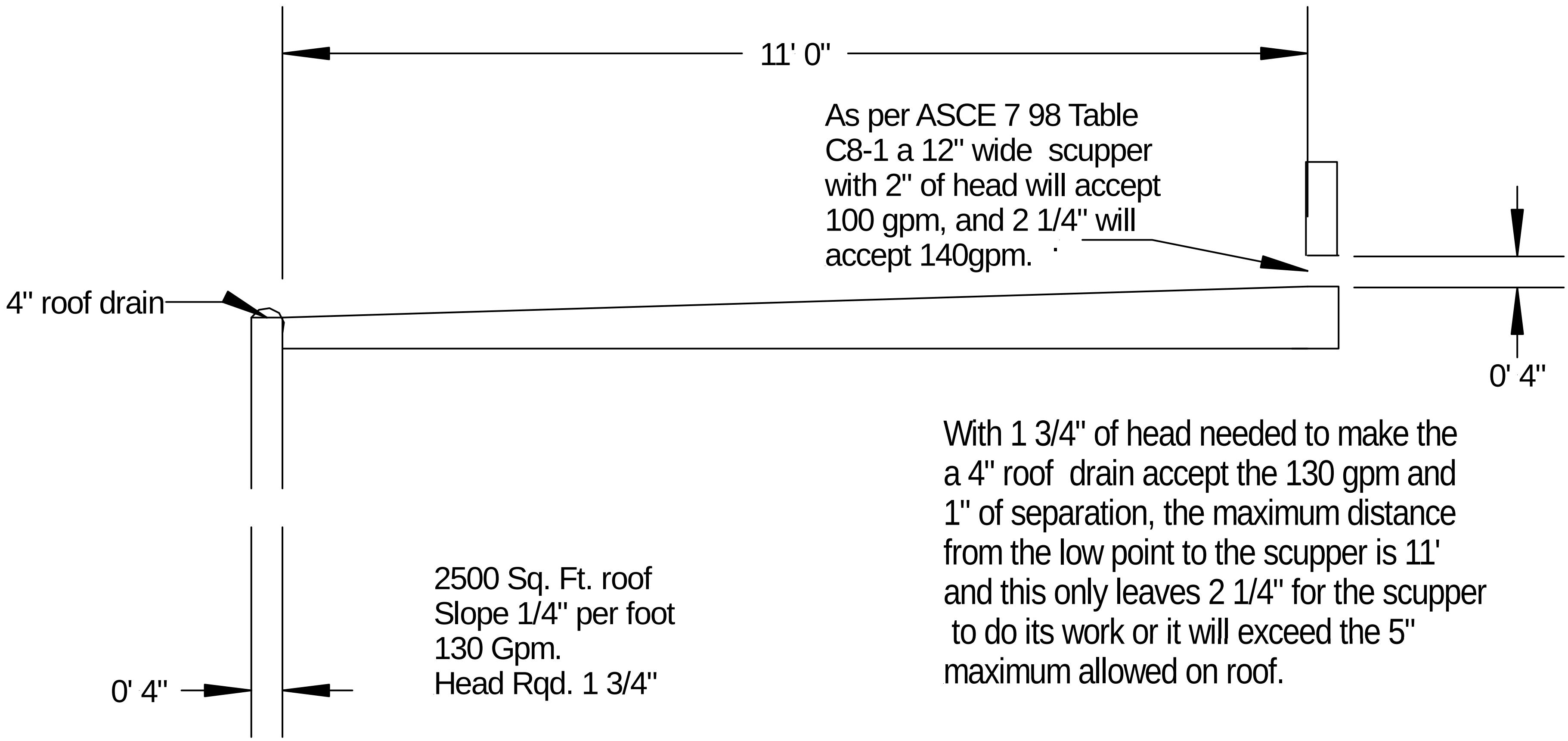
This table is similar to the ones found in ASCE 7 98 and in the Plumbing Commentary.


11' 0"
As per ASCE 7 98 Table C8-1 a 12" wide scupper with 2" of head will accept 100 gpm, and 2 1/4" will accept 140gpm.
4" roof drain
0' 4"
With 1 3/4" of head needed to make the a 4" roof drain accept the 130 gpm and 1" of separation, the maximum distance from the low point to the scupper is 11' and this only leaves 2 1/4" for the scupper to do its work or it will exceed the 5" maximum allowed on roof.
2500 Sq. Ft. roof
Slope 1/4" per foot
130 Gpm.
Head Rqd. 1 3/4"
0' 4"

THE END