2013 ASPE TECHNICAL SYMPOSIUM

September 19-22, 2013
Orlando, Florida
Buena Vista Palace Hotel

Siphonic Roof Drainage

Saturday, September 21, 2013

2:15 – 5:15 p.m.

Peter A. Kraut, P.E.

- B.S. Architectural Engineering Technology
  - Wentworth Institute of Technology, Boston
- Professional Engineer, Mechanical
  - Arizona, California, Colorado, Connecticut, Georgia, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Texas, Virginia, Washington, Wisconsin
- 20 years experience designing plumbing systems
- South Coast Engineering Group, Inc., 2001

Outline

- Codes and Approvals
- Roof Slopes and Catchment Areas
- Structural Coordination
- Building Coordination
- Configuration
- Preliminary Pipe Sizing

Codes and Approvals

Codes and Approvals

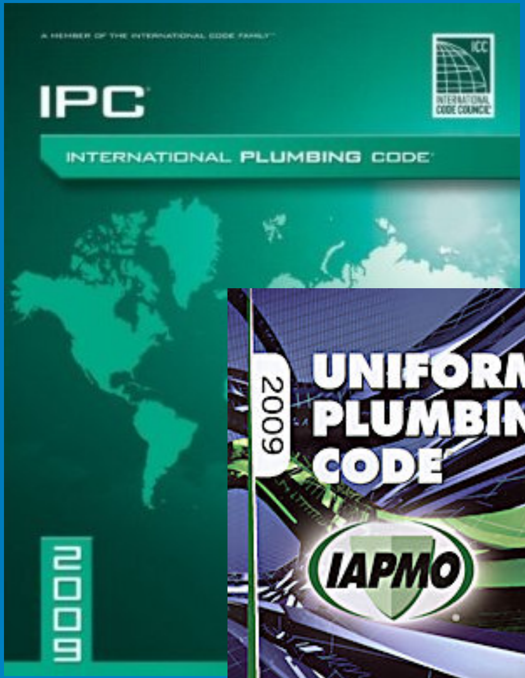
- Proposal
- Coordination
  - five (5) feet outside of the building footprint
    - Manhole, Civil POC
  - *Rerouting requires re-engineering*
  - *Simultaneous modeling*
  - *Construction related changes*

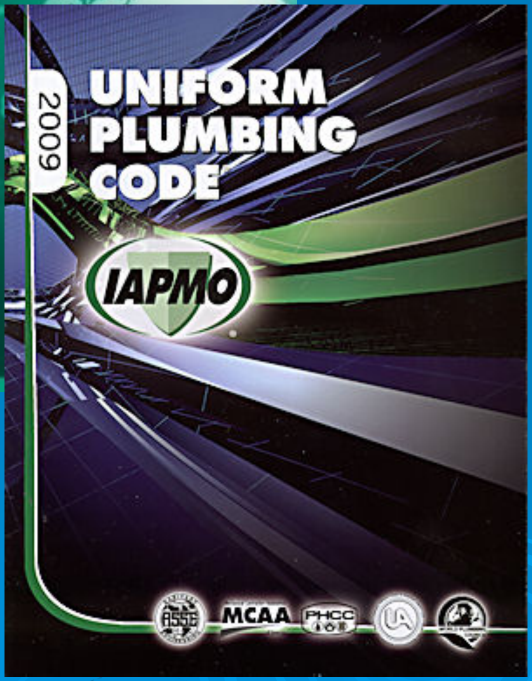
Codes and Approvals

- National standards
  - ANSI / ASME A112.6.9 Siphonic Roof Drains
  - ASPE Technical Standard 45 Siphonic Roof Drainage Systems
- Model Codes
  - Alternate Engineered System
  - Certification

Codes and Approvals

- Not specifically listed in any model plumbing code
- Alternate engineered system.
  - Acceptance by the authorities having jurisdiction is not guaranteed
  - and if it is rejected …





Codes and Approvals

- Draft a Letter to the Code Official
  - Basic Concepts
  - History
    - Finland 1970
    - Boston Massachusetts 2001
  - Experience
  - Nearby Installations

Codes and Approvals

- The flow of rainwater under pressure is governed by the Darcy-Weisbach equation:

$$h_f = f\left(\frac{L}{D}\right)\frac{V^2}{2g}$$

- Where:
  - h_f = pressure loss due to friction in feet
  - f = friction factor
  - L = length of pipe in feet
  - D = diameter of pipe in feet
  - V = velocity in feet per second
  - g = gravitational constant; 32 feet/second2

Codes and Approvals

- Overflow Drains are Required
- If a roof drain system is designed to the 100 year storm, what is the likelihood that it will experience a greater rainfall intensity in the 100 year lifetime of the building?

Probability of Exceeding Intensity					
Storm Period	Lifetime of Building (years)				
(years)	25	50	100	200	400
10	92	99	100	100	100
25	63	87	98	100	100
50	40	64	87	98	100
100	22	39	63	87	99
500	5	10	18	33	55
1000	2	5	10	18	33

Codes and Approvals

- Request approval of the *concept*
- Indicate what will be provided
  - Calculations
  - Plans
  - Dimensions
  - Construction administration
- Final approval after plans are submitted

Roof Slopes and Catchment Areas

Roof Slopes

- 2010 Uniform Plumbing Code

  1101.11.1 Primary Roof Drainage. Roof areas of a building shall be drained by roof drains or gutters. The location and sizing of drains and gutters shall be coordinated with the structural design and pitch of the roof. Unless otherwise required by the Authority Having Jurisdiction, roof drains, gutters, vertical conductors or leaders, and horizontal storm drains for primary drainage shall be sized based on a storm of 60 minutes duration and 100 year return period. Refer to Table D 1.0 (in Appendix D) for 100 year, 60 minute storms at various locations.

Roof Slopes

- 2009 International Building Code
  1507.13.1 Slope. Thermoplastic single-ply membrane roofs shall have a design slope of a minimum of one-fourth unit vertical in 12 units horizontal (2-percent slope).

- Surface Slope
  - Surfaces sloped less than ¼" per foot (2%) may not have adequate surface flow
  - Slope is dependent on material roughness

Roof Slopes

- 2010 Uniform Plumbing Code

  1105.3 Strainers for Flat Decks. Roof drain strainers for use on sun decks, parking decks, and similar areas that are normally serviced and maintained, shall be permitted to be of the flat surface type. Such roof drain strainers shall be level with the deck and shall have an available inlet area of not less than two (2) times the area of the conductor or leader to which the drain is connected..

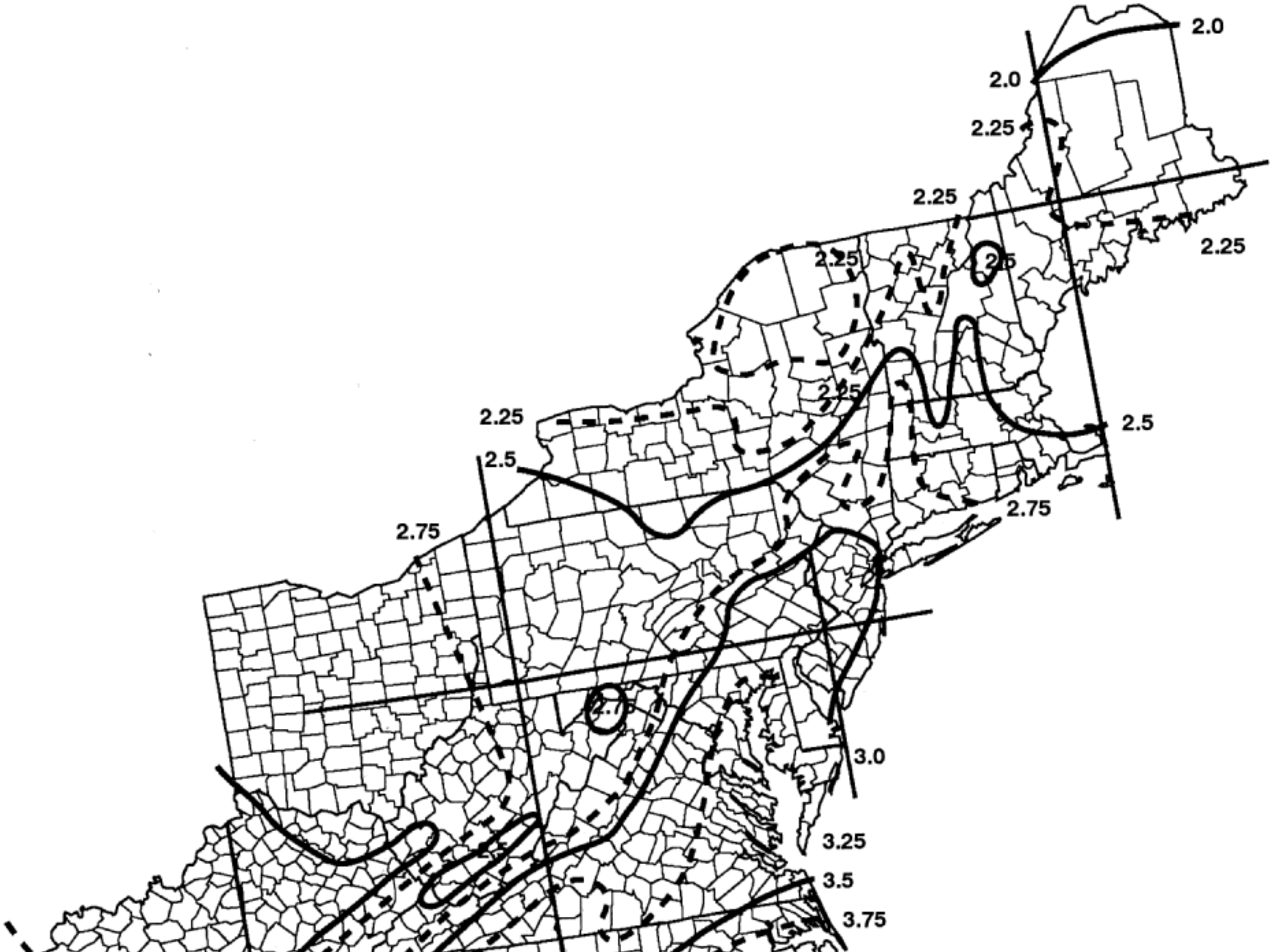
- Rule of Thumb: Use eight (8) or more times the area when placing over a siphonic drain

Roof Slopes

- Load Rating ASME Standard A112.6.3M
- **6.1 Loading Classifications:** Grates and top rims shall be designed to meet the following loading classifications.
  - **6.1.1 – Light Duty** All grates having safe live under 2000 lb.
  - **6.1.2 – Medium Duty** All grates having safe live load between 2000 lb. and 4999 lb.
  - **6.1.3 – Heavy Duty** All grates having safe live load between 5000 lb. and 7499 lb.
  - **6.1.4 – Extra Heavy Duty** All grates having safe live load between 7500 lb. and 10,000 lb.
  - **6.1.5 – Special Duty** Grates having safe live load over 10,000 lb. shall be considered special and treated accordingly.

Rainfall Rates

- Rainfall Rates
- City of Los Angeles = 2” per hour
- Los Angeles County = 3” per hour
- City of Santa Ana = 4” per hour
- The following charts are for conceptual information only!
- Check Local Codes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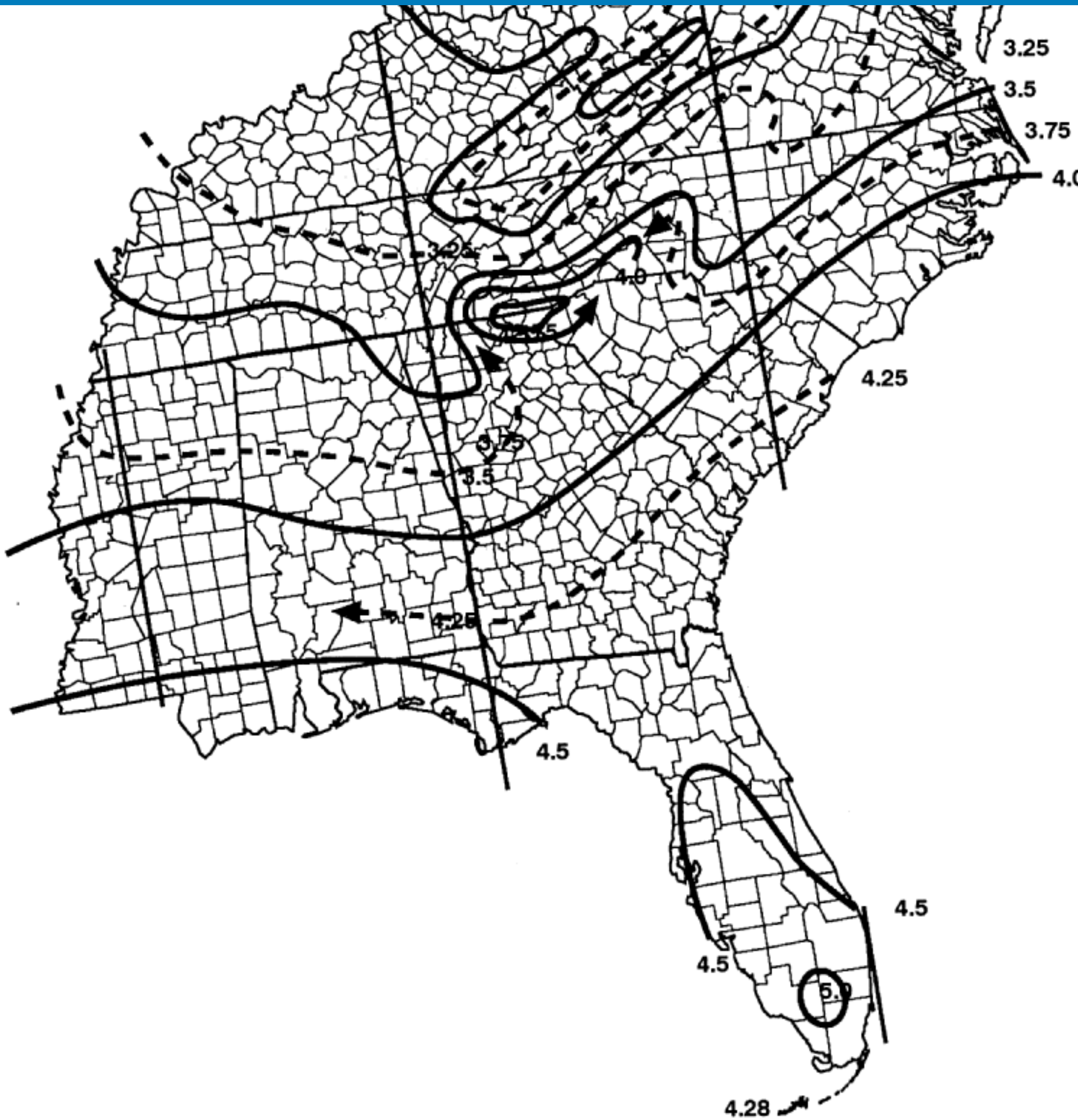

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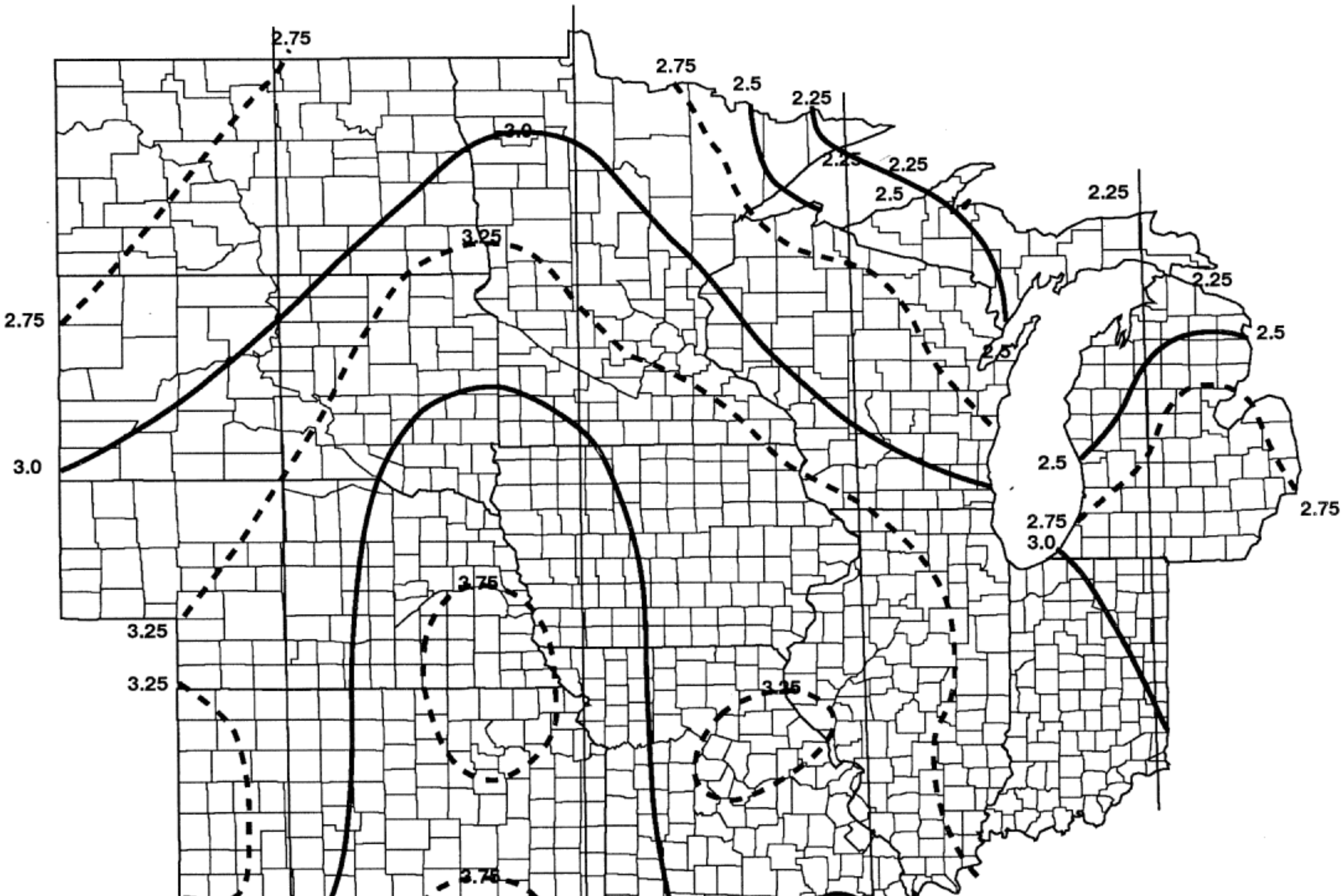

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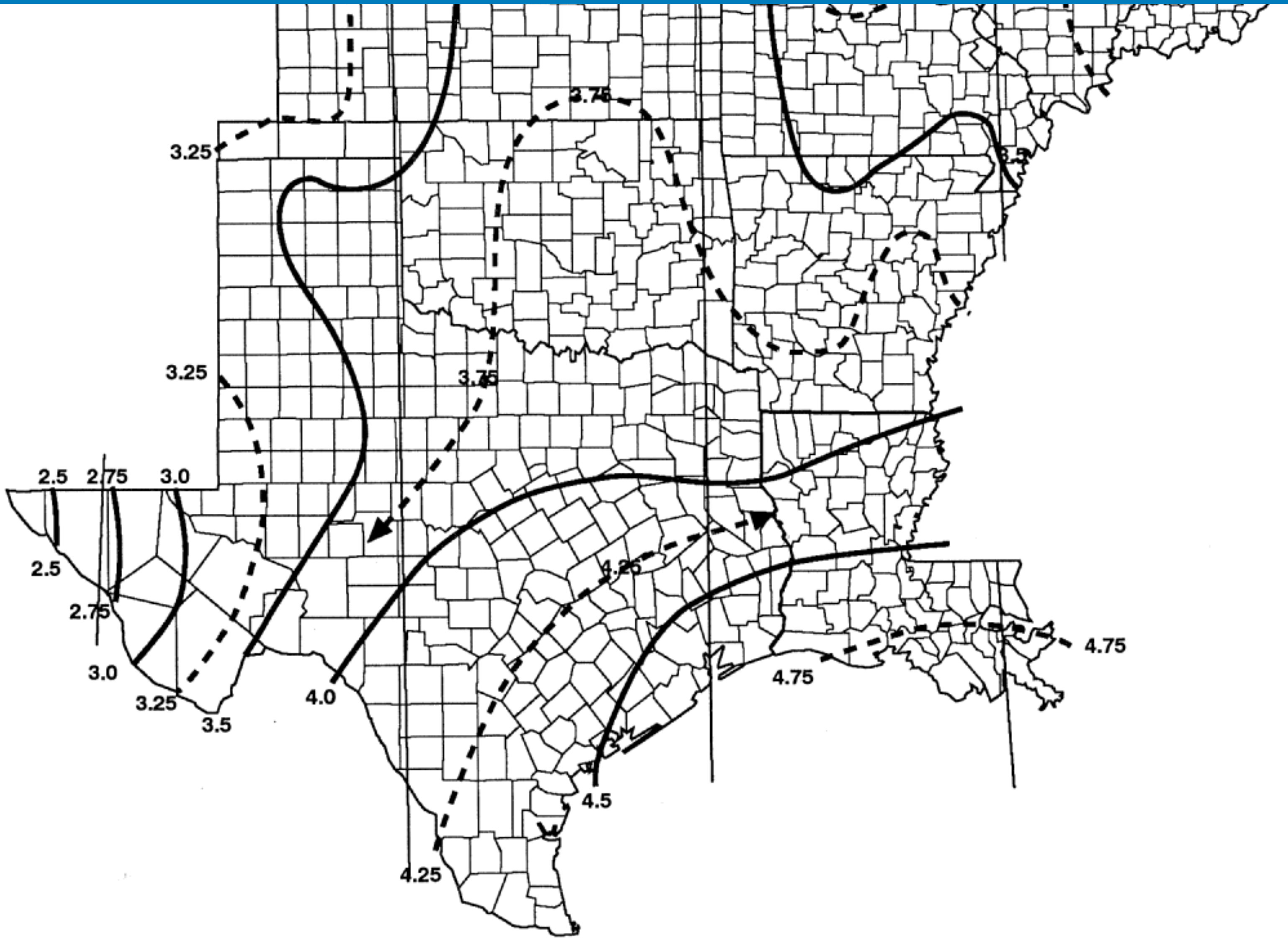

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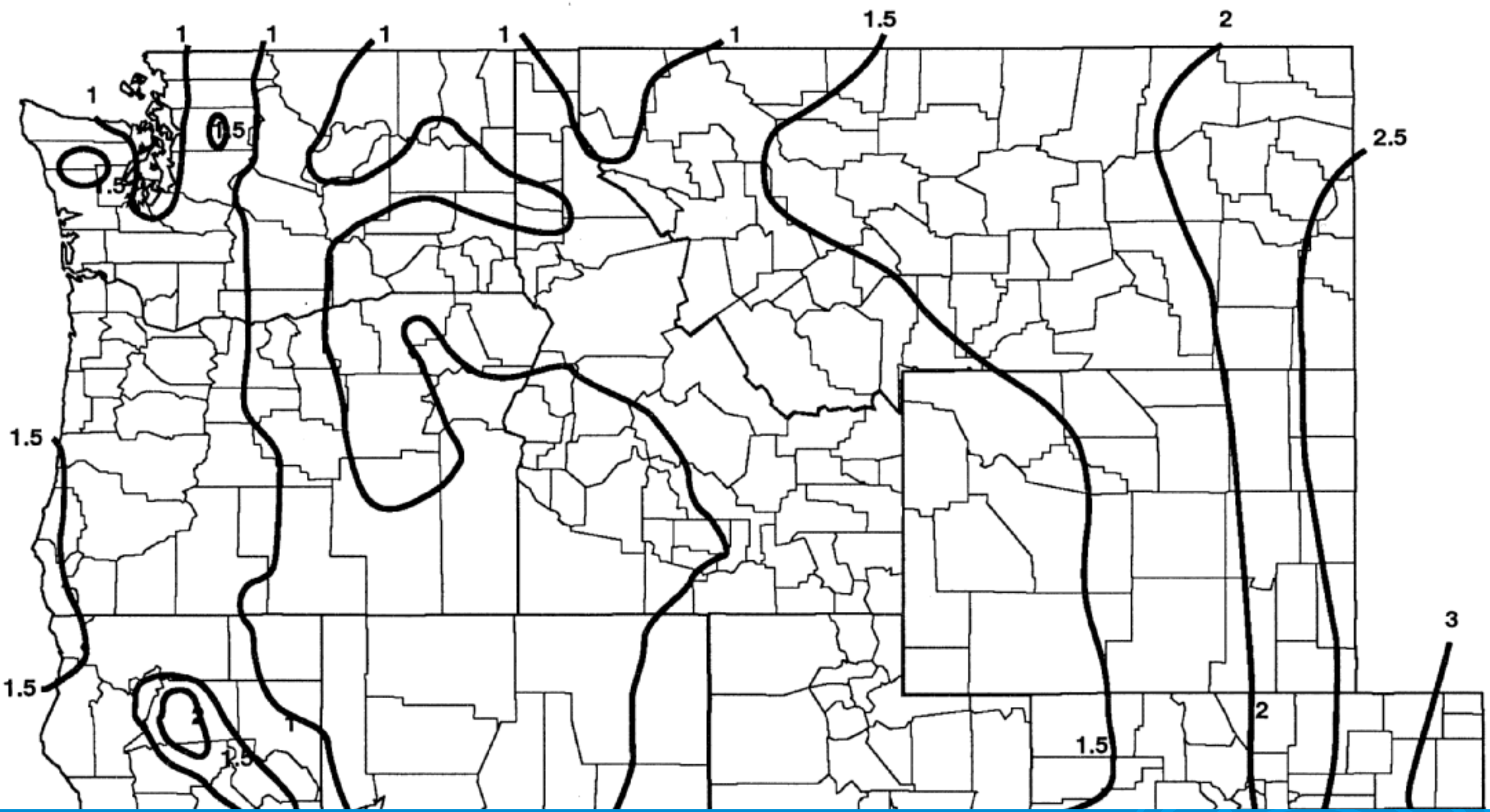
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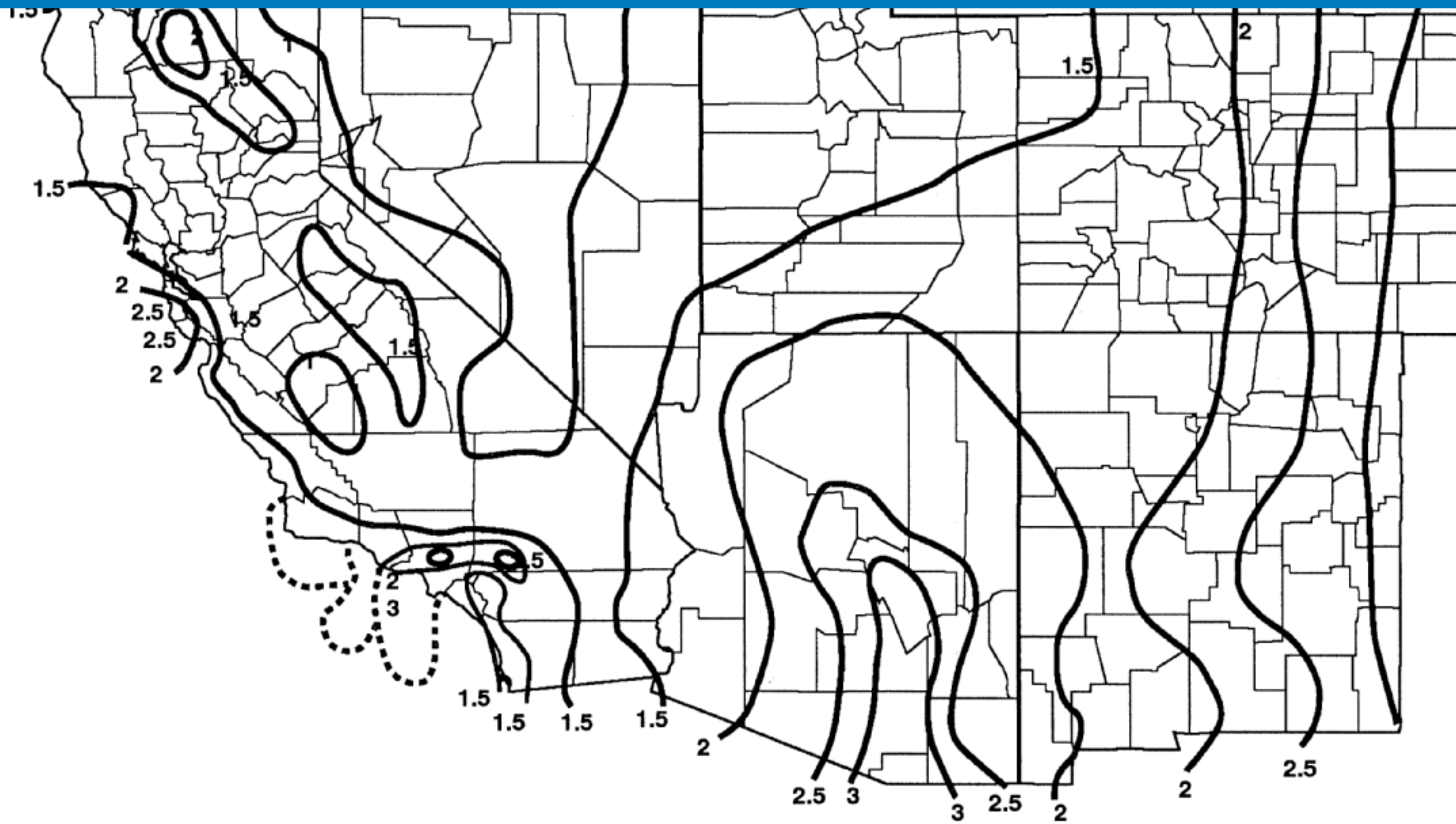

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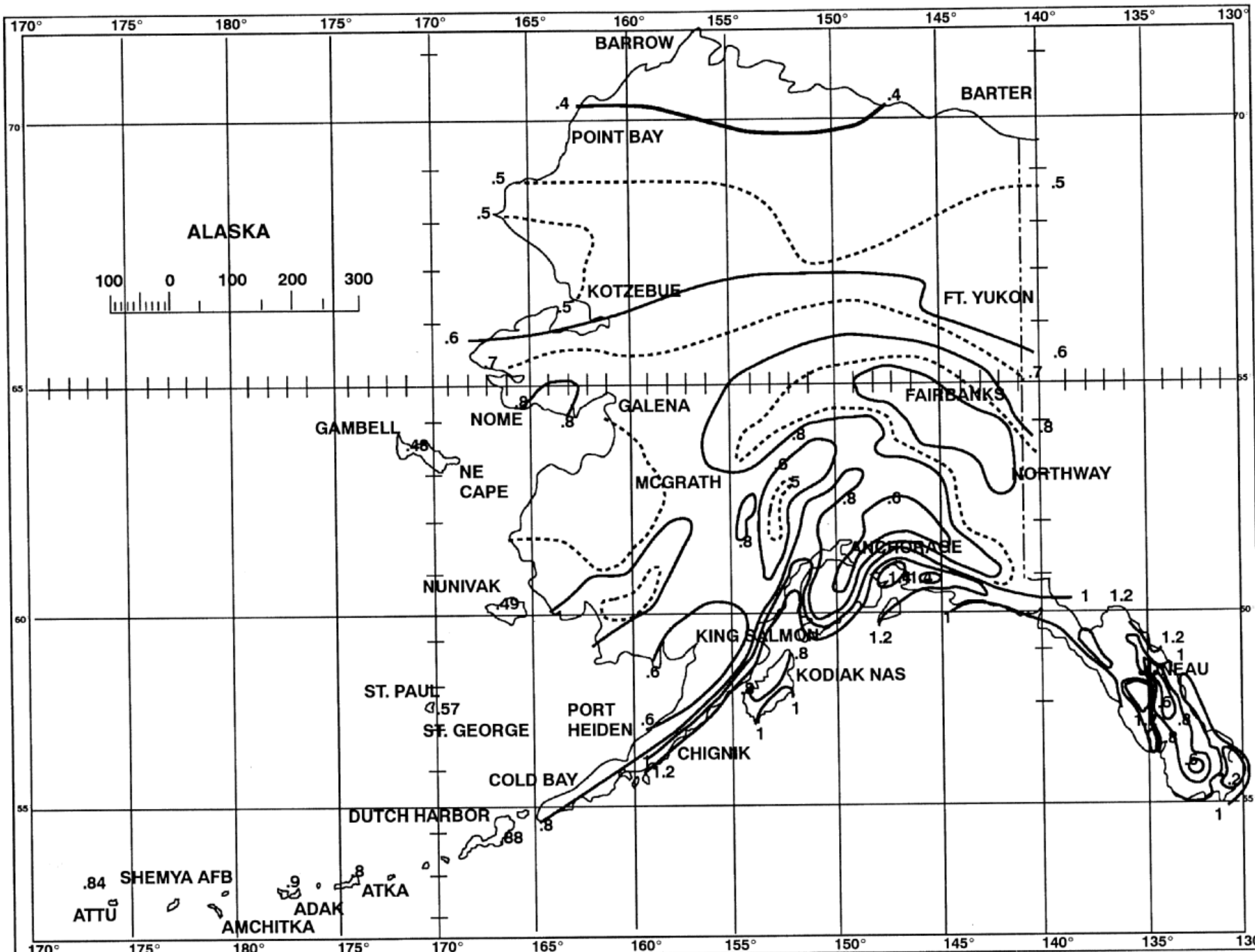

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MCGRATH
NORTHWAY
ANCHORAGE
NUNIVAK
KING SALMON
KODIAK NAS
ST. PAUL
ST. GEORGE
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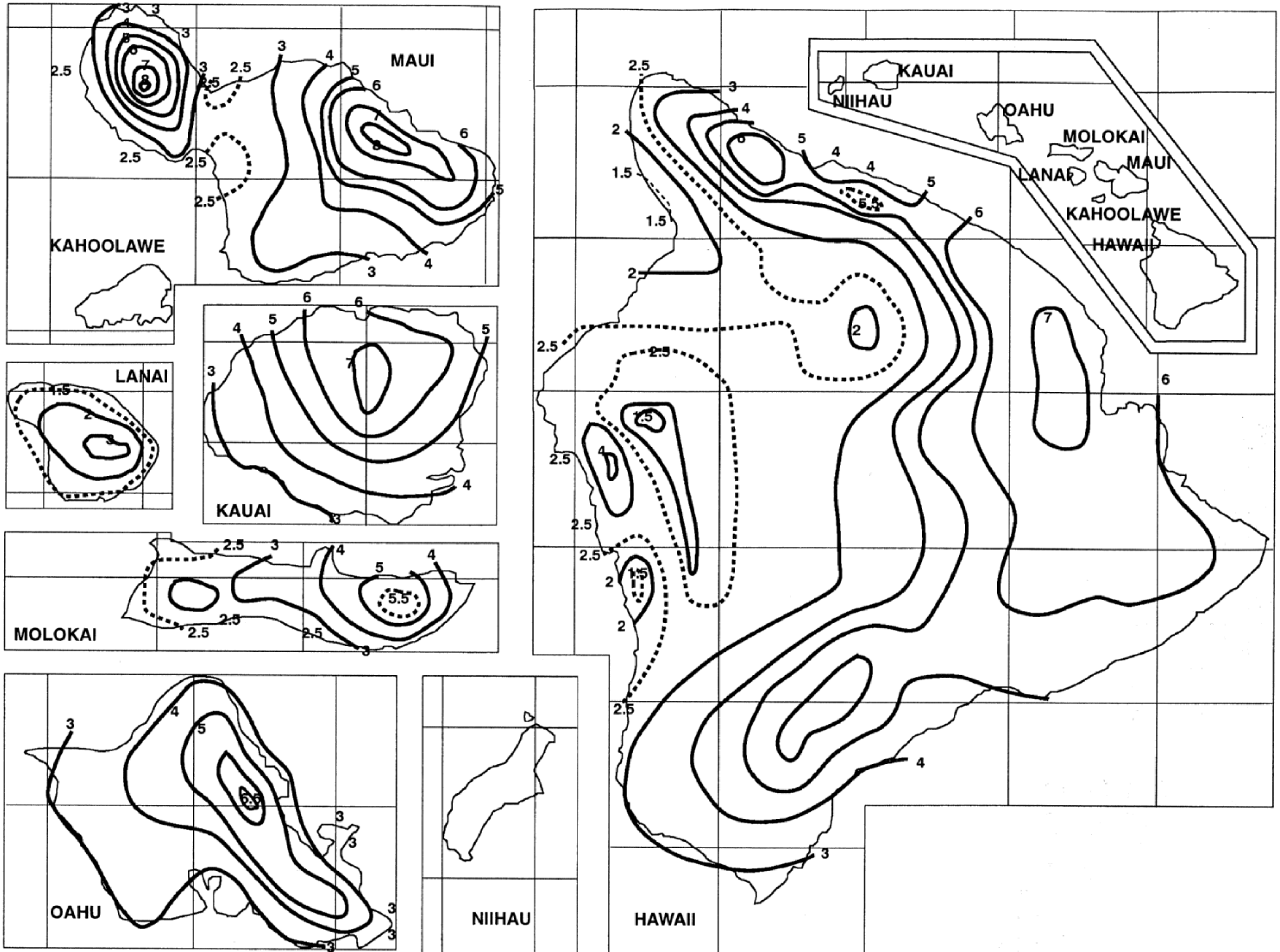


FIGURE 1106.1—continued
100-YEAR, 1-HOUR RAINFALL (INCHES)
HAWAII

Side Walls

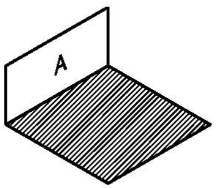
- 2010 Uniform Plumbing Code

  1106.4 Side Walls Draining onto a Roof. Where vertical walls project above a roof so as to permit storm water to drain to the roof area below, the adjacent roof area shall be permitted to be computed … as follows:

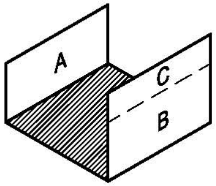
Side Walls

- For one (1) wall – add fifty (50) percent of the wall area to the roof area figures.
- For two (2) adjacent walls – add thirty-five (35) percent of the total wall areas.
- Two (2) walls opposite of same height – add no additional area.
- Two (2) walls opposite of differing heights – add fifty (50) percent of wall area above top of lower wall.
- Walls on three (3) sides – add fifty (50) percent of area of the inner wall below the top of the lowest wall, plus allowance the for area of wall above top of lowest wall, per (2) and (4) above.
- Walls on four (4) sides – no allowance for wall areas below top of lowest wall – add for areas above the top of the lowest wall per (1), (2), (4) and (5) above.

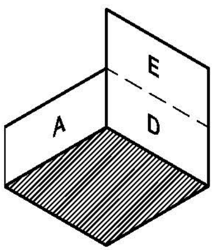
Side Walls



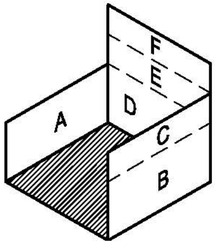
AREA = ROOF AREA + 0.50 A



AREA = ROOF AREA + ~~0.50 A~~ + ~~0.50B~~ + 0.50 C
AREA = ROOF AREA + 0.50 C



AREA = ROOF AREA + 0.35 A + 0.35 D + 0.50 C



AREA = ROOF AREA + ~~0.50 A~~ + ~~0.50B~~ + 0.50 D + (0.35 C + 0.35E) + 0.50F
AREA = ROOF AREA + 0.50 D + (0.35 C + 0.35E) + 0.50F

Structural Coordination

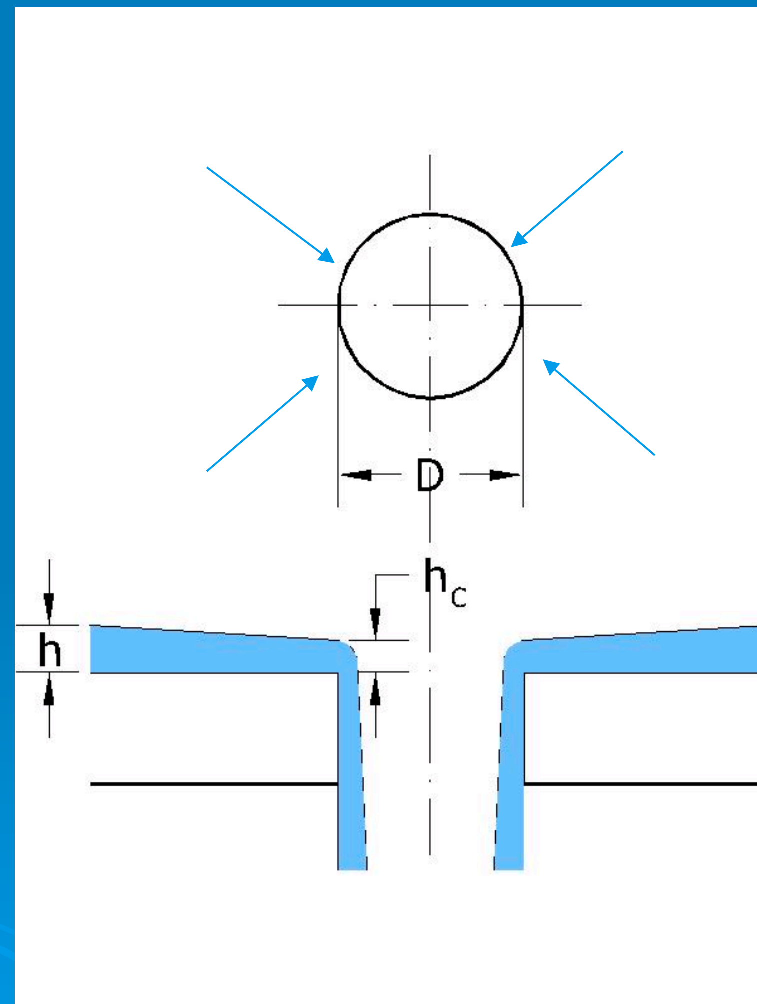
Depth of Water

- Remember conventional flow:

$$Q = \pi D e \sqrt{g h_c^3}$$

- where

$$h_c = {}^{2}/_{3}\, h$$



Depth of Water

- Using conventional drains and the maximum flow rate allowed by code:

Size	Maximum flow rate	Depth of water
2”	23 gpm	1.1”
3”	67 gpm	1.7”
4”	144 gpm	2.4”
5”	261 gpm	3.1”
6”	424 gpm	3.7”
8”	913 gpm	5.2”

Depth of Water

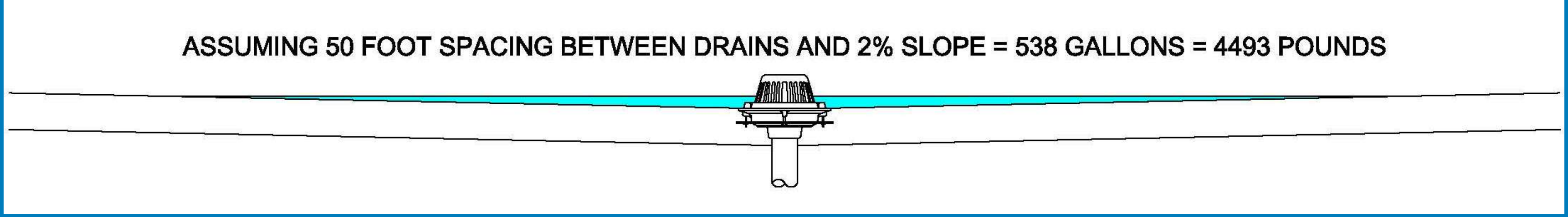
- Using one manufacturer's siphonic roof drain and the same flow rates (except 4"):

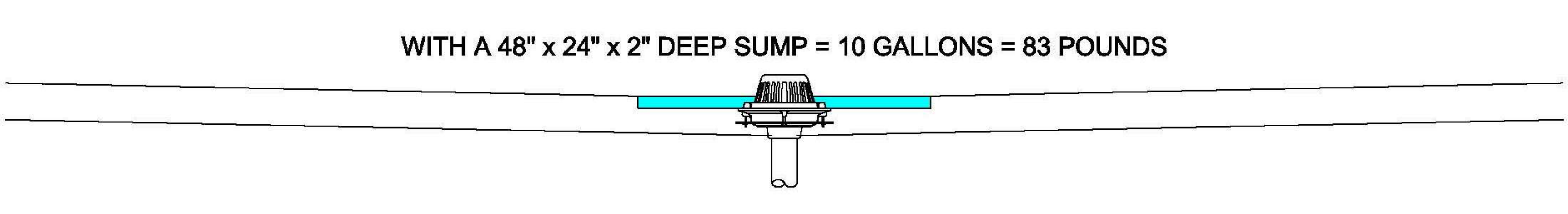
Size	Maximum flow rate	Depth of water
n/a	23 gpm = 0.05 cfs	n/a
2"	67 gpm = 0.15cfs	0.8"
2"	144 gpm = 0.32 cfs	1.4"
2 ½"	261 gpm = 0.58 cfs	2.0"
3"	424 gpm = 0.94 cfs	2.6"
4"	765 gpm = 1.7 cfs	3.5"

Depth of Water

- Placing drains in a sump allows the water level to rise without ponding
- With 50 foot drain spacing and ¼" per foot slope, a 2" deep rise will cover up to 867 square feet and weigh up to 4493 pounds
- A 2' x 4' x 2" deep sump, when full, weighs 83 pounds
- Sumps eliminate weight on the structure

Depth of Water





Building Coordination

Discharge

- 2010 Uniform Plumbing Code

  1101.1 Where Required. Roofs, paved areas, yards, courts, and courtyards, vent shafts, light wells, or similar areas having rainwater, shall be drained into a separate storm sewer system, or into a combined sewer system where a separate storm sewer system is not available, or to some other place of disposal satisfactory to the Authority Having Jurisdiction. In the case of one- and two-family dwellings, storm water shall be permitted to be discharged on flat areas, such as streets or lawns, so long as the storm water shall flow away from the building and away from adjoining property, and shall not create a nuisance.

Discharge

- Increase to a conventional size for 10 pipe diameters (1% slope) to break the siphon
- Discharging into a vented manhole is best
- Daylighting pipes may be acceptable
  - Check velocities
- Alternatively, increase to conventional size in the vertical
  - Vent if necessary

Discharge

- If the city storm drain becomes blocked, your system could back-up
- If the city storm drain surcharges, your 30’ siphon could turn into a 130’ siphon creating negative pressures far greater than your system can handle

Expansion

- Given the length of many siphonic systems, expansion must be considered
- PVC Pipe has significant expansion and contraction

PVC – Thermal Expansion and Contraction							
Change in Length (inches) versus change in Temperature							
Coefficient of Linear Expansion, e = 2.9×10^{-5} in/in·ºF							
Length (feet)	40ºF	50ºF	60ºF	70ºF	80ºF	90ºF	100ºF
20	0.278	0.348	0.418	0.487	0.557	0.626	0.696
40	0.557	0.696	0.835	0.974	1.114	1.235	1.392
60	0.835	1.044	1.253	1.462	1.670	1.879	2.088
80	1.134	1.392	1.670	1.949	2.227	2.506	2.784
100	1.392	1.740	2.088	2.436	2.784	3.132	3.480

Configuration

Tailpiece

Tailpiece

- To ensure priming, tailpieces should be at least 24” long
- Tailpieces must turn horizontal before connecting to a collector pipe
- Connections to the collector should be made on the side

Tailpiece

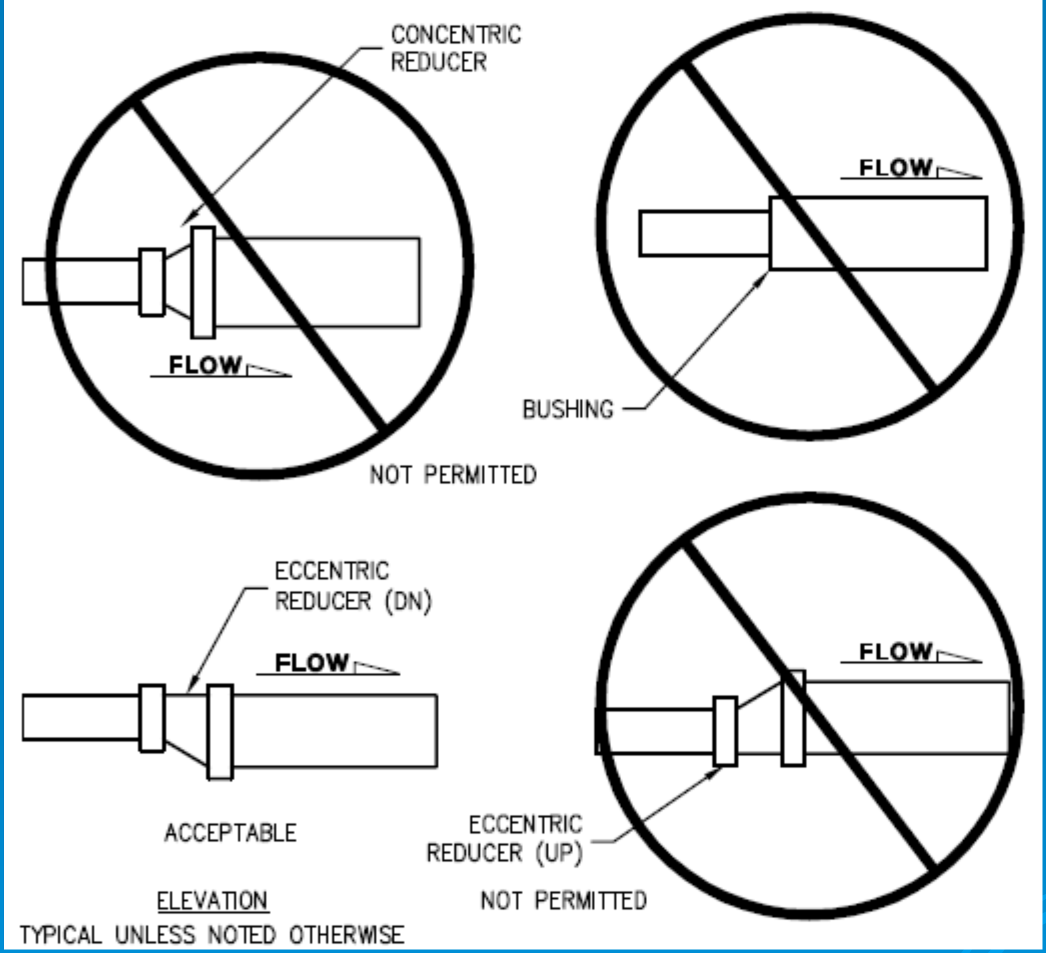
Wyes

- Fitting used in the calculations must match fittings used in the drawings and in the installed condition.
- DWV fittings are required
- Wyes are required

Reducer Placement

- When available, use eccentric reducers
  - In horizontal piping
    - placed with the flat side UP
  - No air pocket to delay priming
- Concentric reducers may be used

Reducer Placement

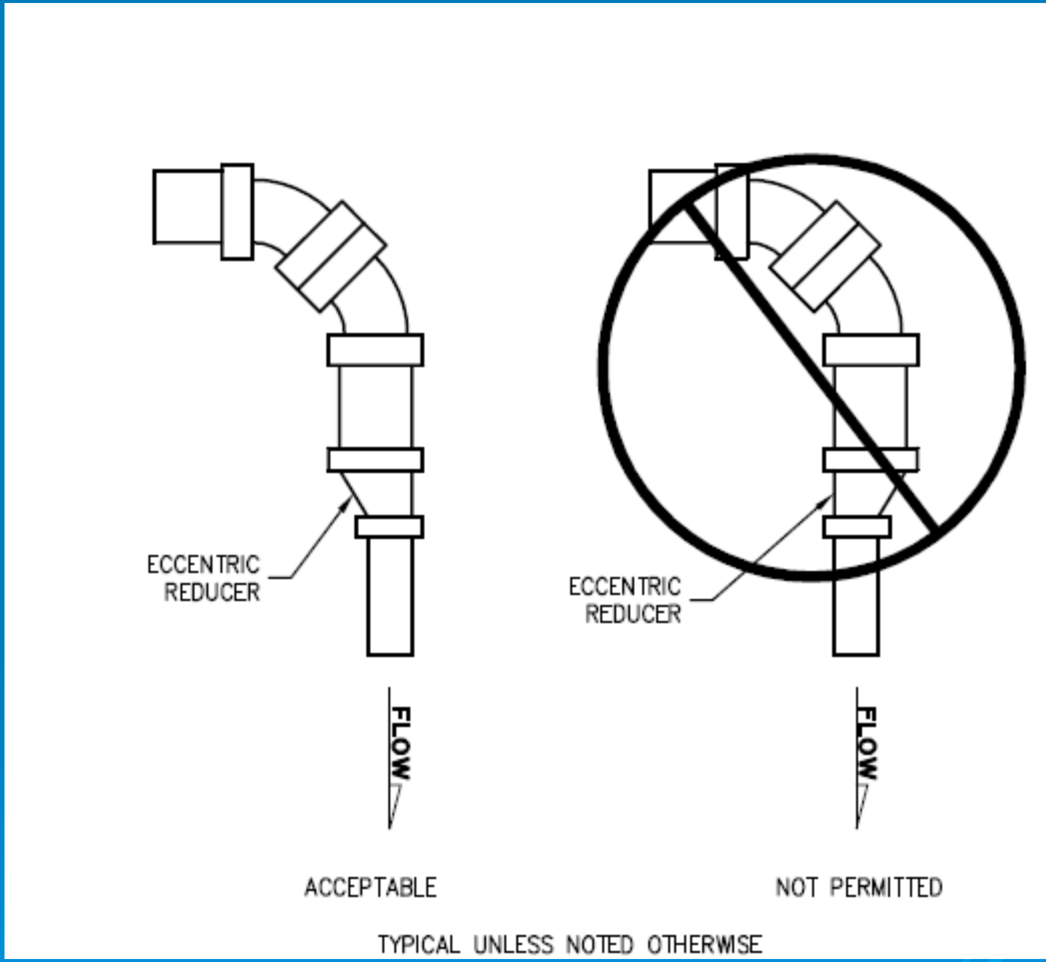


Horizontal Pipes

Reducer Placement

- Decrease pipe size at the top of risers
  - placed with the flat side on the inside
  - Alternatively, offset the pipe
- Increasing the pipe size in the vertical will almost always break the siphon
- Use this technique in tall buildings where the available head is much more than you need.

Reducer Placement

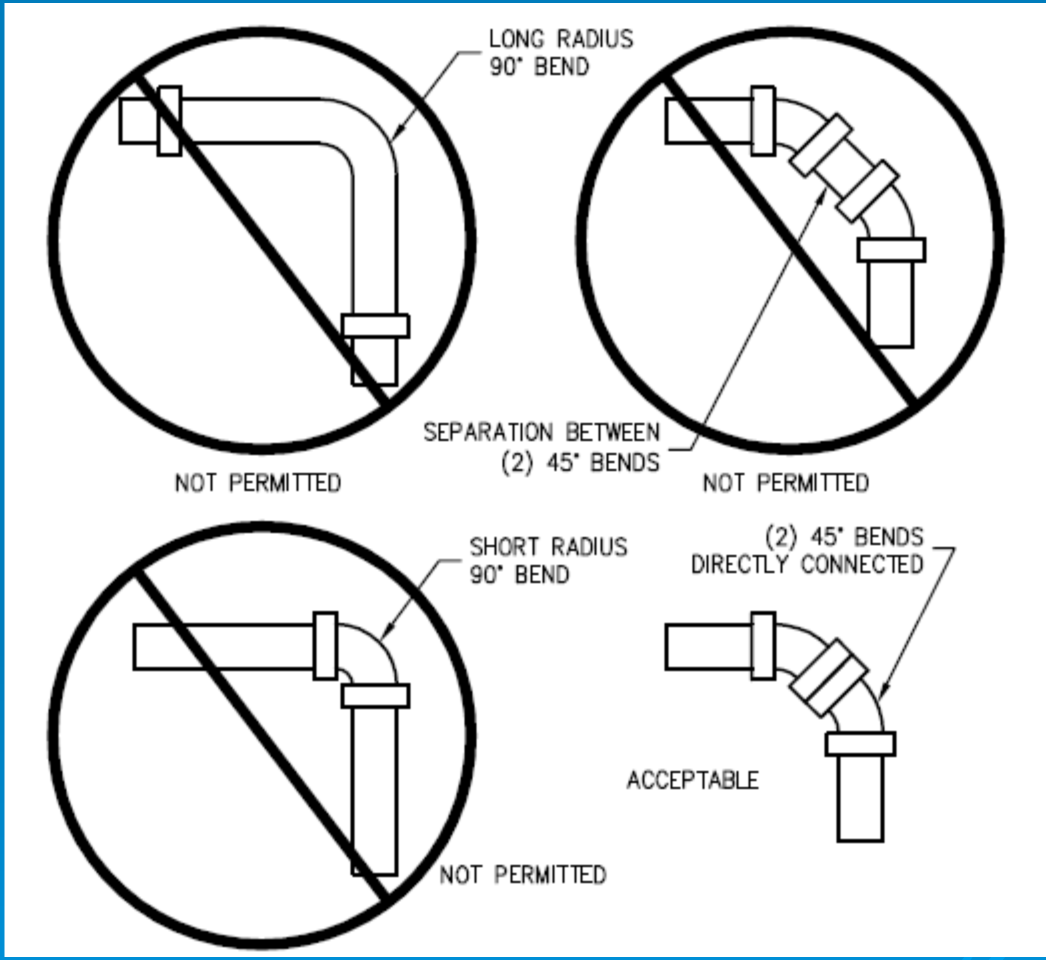


Top of Downpipe

Elbows

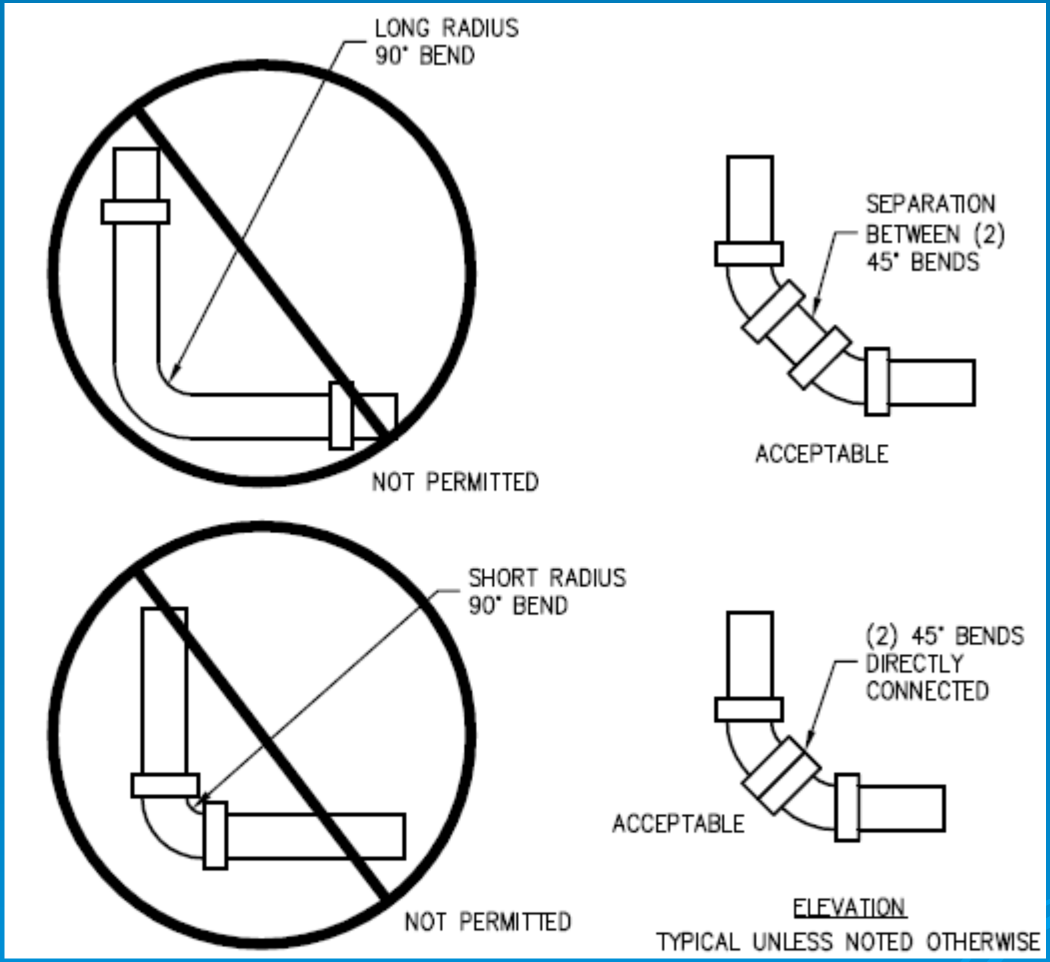
- Fitting used in the calculations must match fittings used in the drawings and in the installed condition.
- Do not use short radius fittings
- Use DWV fittings
- Long radius bends permitted
- Use two (2) eighth bends (45º)

Elbows



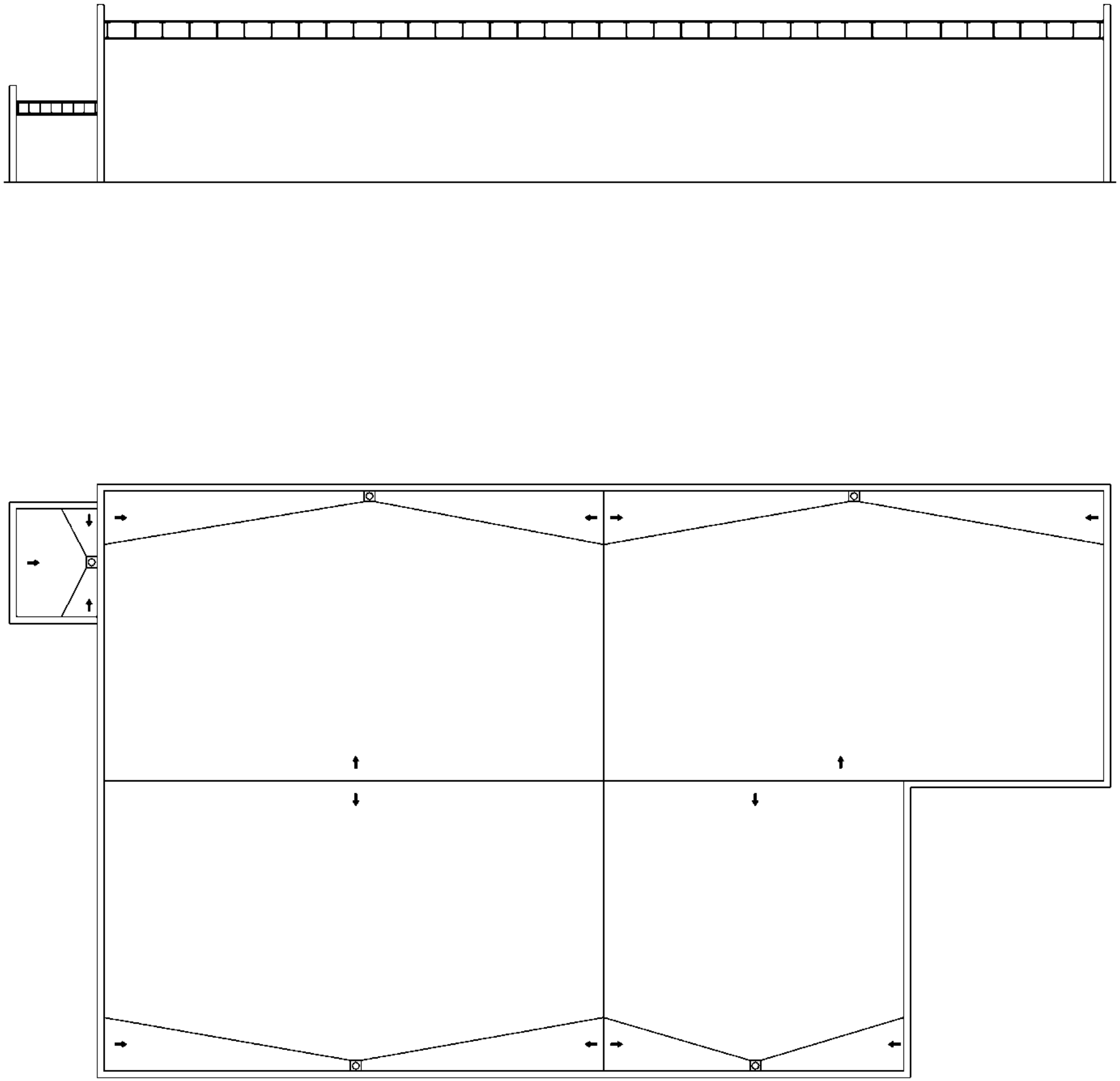
Top of Downpipe

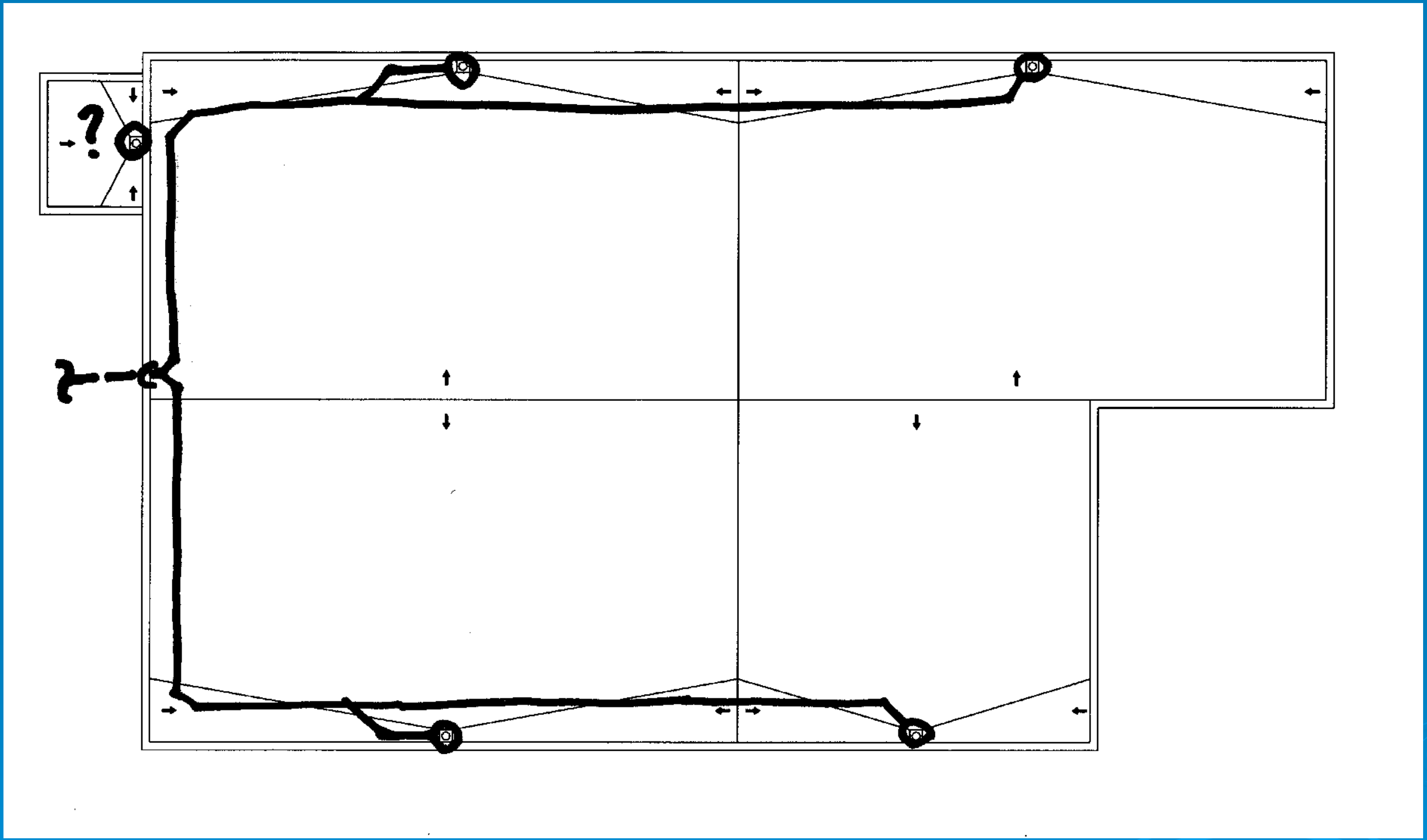
Elbows



Bottom of tailpieces and Downpipe

Preliminary Pipe Sizing





Preliminary Pipe Sizing

- Early suggestions include size at 1/8” per foot slope and cut the pipe size in half
  - 8” pipe becomes 4” pipe
  - Good for ballpark estimates
  - Difficult to balance
- Instead, try the constant friction method

Preliminary Pipe Sizing

- Step 1. Determine the tributary area of each drain
- Example
  - RD1 = 5000 sf
  - RD2 = 5000 sf
  - RD3 = 3000 sf
  - RD4 = 5000 sf
  - RD5 = 300 sf

Preliminary Pipe Sizing

- Step 2. Apply rainfall intensity and convert to gallons per minute
- Q = 0.0104 x R x A

  where:
  - Q = Flow Rate (gallons per minute)
  - R = Rainfall intensity (inches/hour)
  - A = Area (square feet)
  - 0.0104 = Conversion factor gpm/sq. ft./inch/hr.

Preliminary Pipe Sizing

- Example
  - Rainfall Intensity = 4 inches per hour
  - RD1 = 0.0104 x 4”/hr x 5000 sf = 208 gpm
  - RD2 = 0.0104 x 4”/hr x 5000 sf = 208 gpm
  - RD3 = 0.0104 x 4”/hr x 3000 sf = 125 gpm
  - RD4 = 0.0104 x 4”/hr x 5000 sf = 208 gpm
  - RD5 = 0.0104 x 4”/hr x 300 sf = 12.5 gpm

Preliminary Pipe Sizing

- Step 3. Convert to cubic feet per second

- $V = Q / 448.8$

  where:
  - V = Volumetric Flow Rate (cubic feet per second)
  - Q = Flow Rate (gallons per minute)
  - 448.8 = Conversion factor cfs/gpm

Preliminary Pipe Sizing

- Example
  - RD1 = 208 gpm / 448.8 = 0.46 cfs
  - RD2 = 208 gpm / 448.8 = 0.46 cfs
  - RD3 = 125 gpm / 448.8 = 0.28 cfs
  - RD4 = 208 gpm / 448.8 = 0.46 cfs
  - RD5 = 12.5gpm / 448.8 = 0.028 cfs

Preliminary Pipe Sizing

- Step 4. Select a drain using manufacturer's data
- Generally the smallest drain without exceeding the maximum flow
- USE SPECIFIC MANUFACTURER"S INFORMATION

Drain	Resistanc e coefficient	Maximum flow
size	k	cfs
2" gutter	0.65	0.40
2"	0.13	0.50
2½"	0.13	0.60
3"	0.16	1.40
4"	0.23	1.70

Preliminary Pipe Sizing

- Step 5. Calculate disposable head
  - Subtract – vent elevation from drain elevation
- Example:
  - Roof elevation = 452’
  - Discharge elevation = 420’
    - Vented manhole cover elevation = 422’
  - Disposable head = 452’ – 422’ = 30’

Preliminary Pipe Sizing

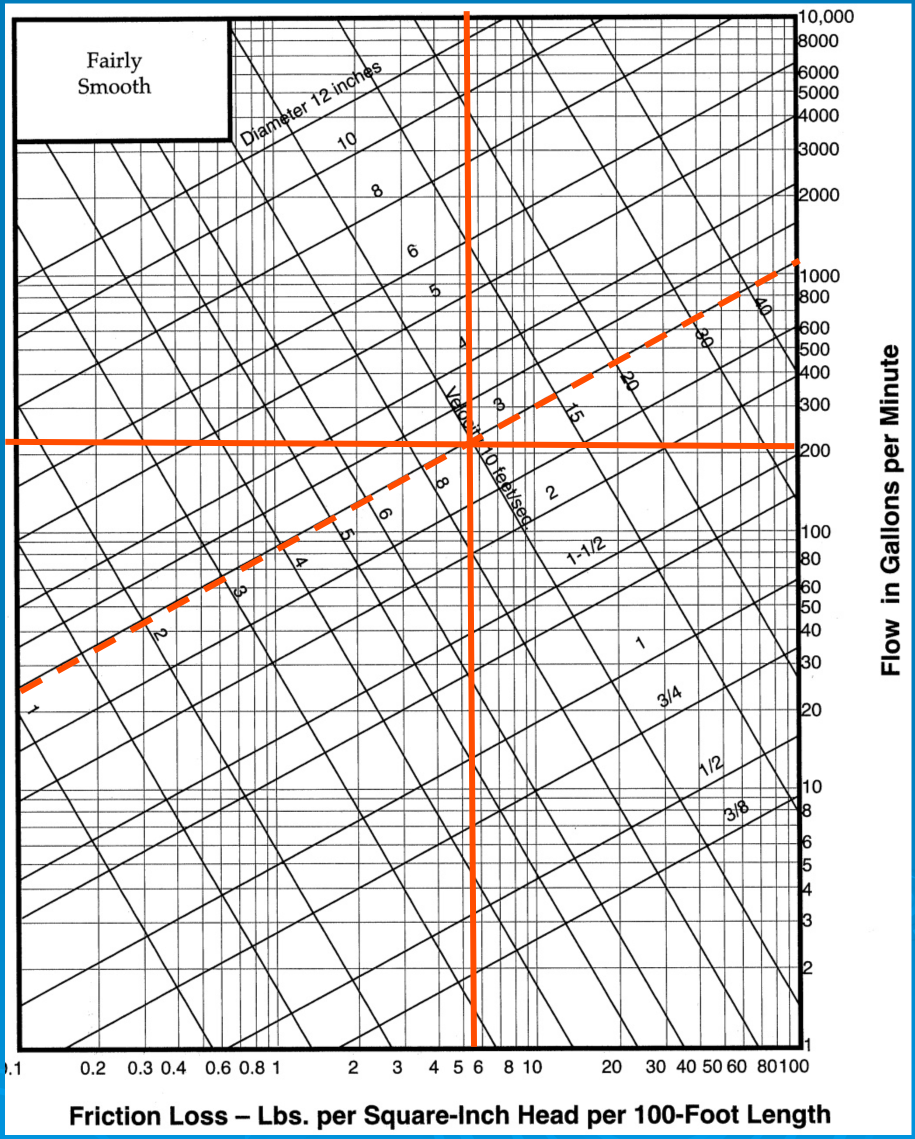
- Step 6. Calculate system length
  - Add horizontal and vertical pipe lengths
  - Add 10% for fittings
- Example:
  - System length (Assumes 10% for fittings)
    - RD1 = 220’ + 22’ = 242’
    - RD2 = 120’ + 12’ = 132’
    - RD3 = 210’ + 21’ = 231’
    - RD4 = 140’ + 14’ = 154’
    - RD5 = 40’ + 4’ = 44’

Preliminary Pipe Sizing

- Step 7. Divide disposable head by system, length and multiply by 100
- Example:
  - RD1 = 30’ / 242’ x 100 = 12.4 ft/100ft
  - RD2 = 30’ / 132’ x 100 = 22.7 ft/100ft
  - RD3 = 30’ / 231’ x 100 = 13.0 ft/100ft
  - RD4 = 30’ / 154’ x 100 = 19.5 ft/100ft
  - RD5 = 30’ / 44’ x 100 = 34.1 ft/100

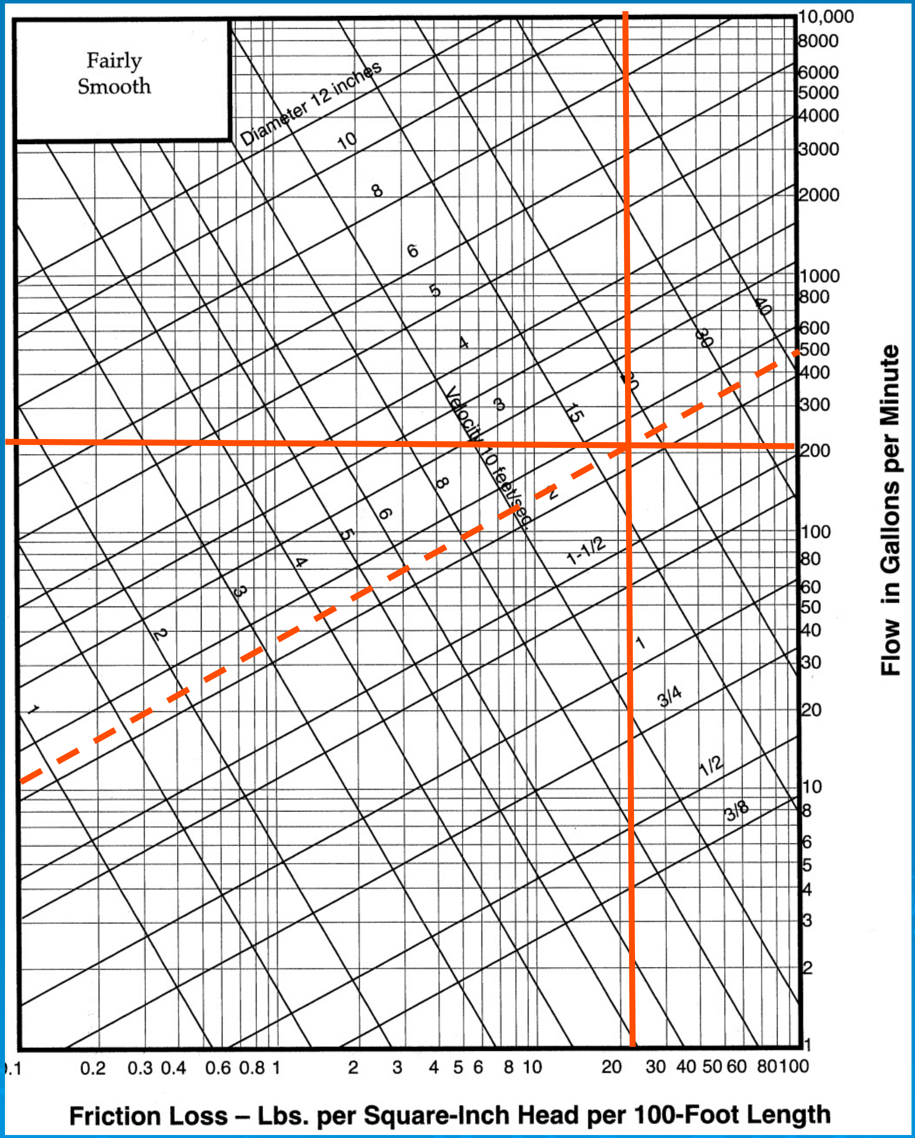
RD1

- Draw a line at 12.4 feet per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is just under 3"
- Use 3"pipe



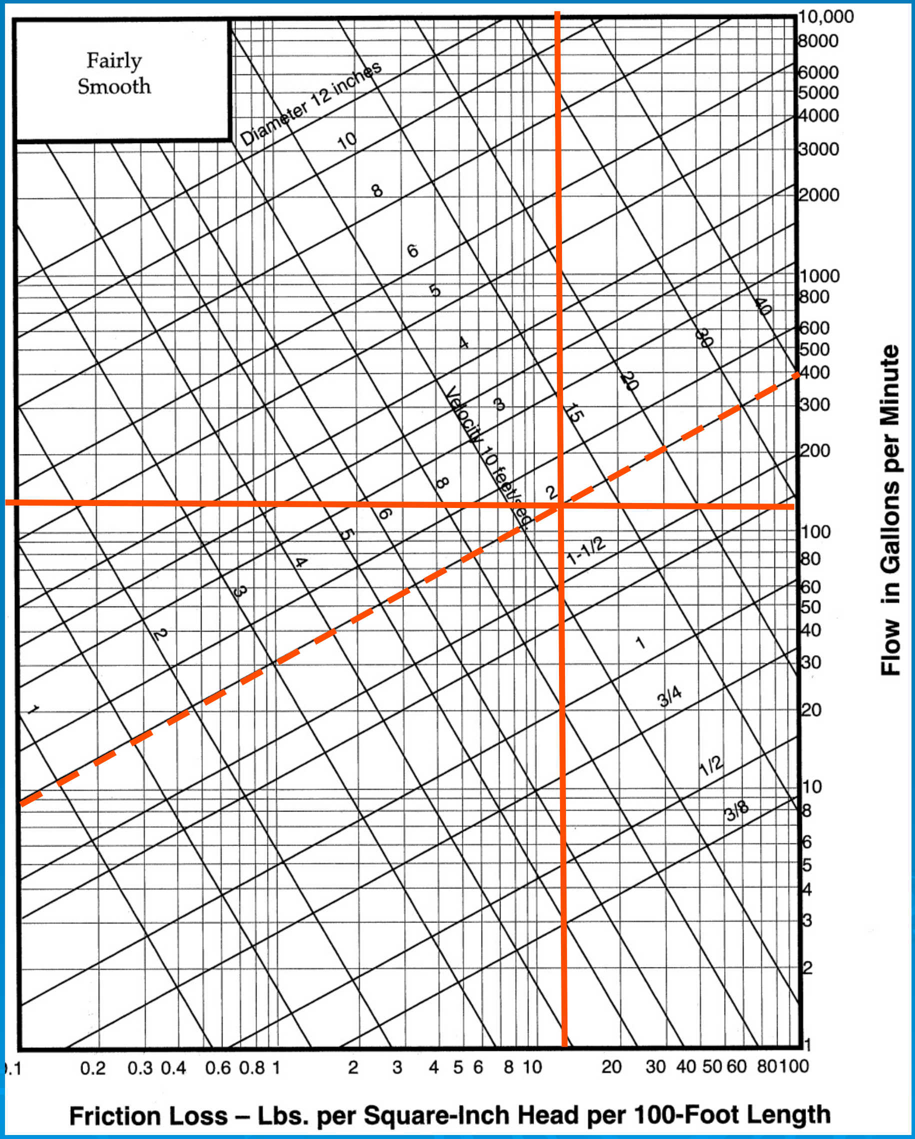
RD2

- Draw a line at 22.7 feet per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is between 2" and 2½"
- Use 2" pipe, but increase to 2½" after the tailpiece



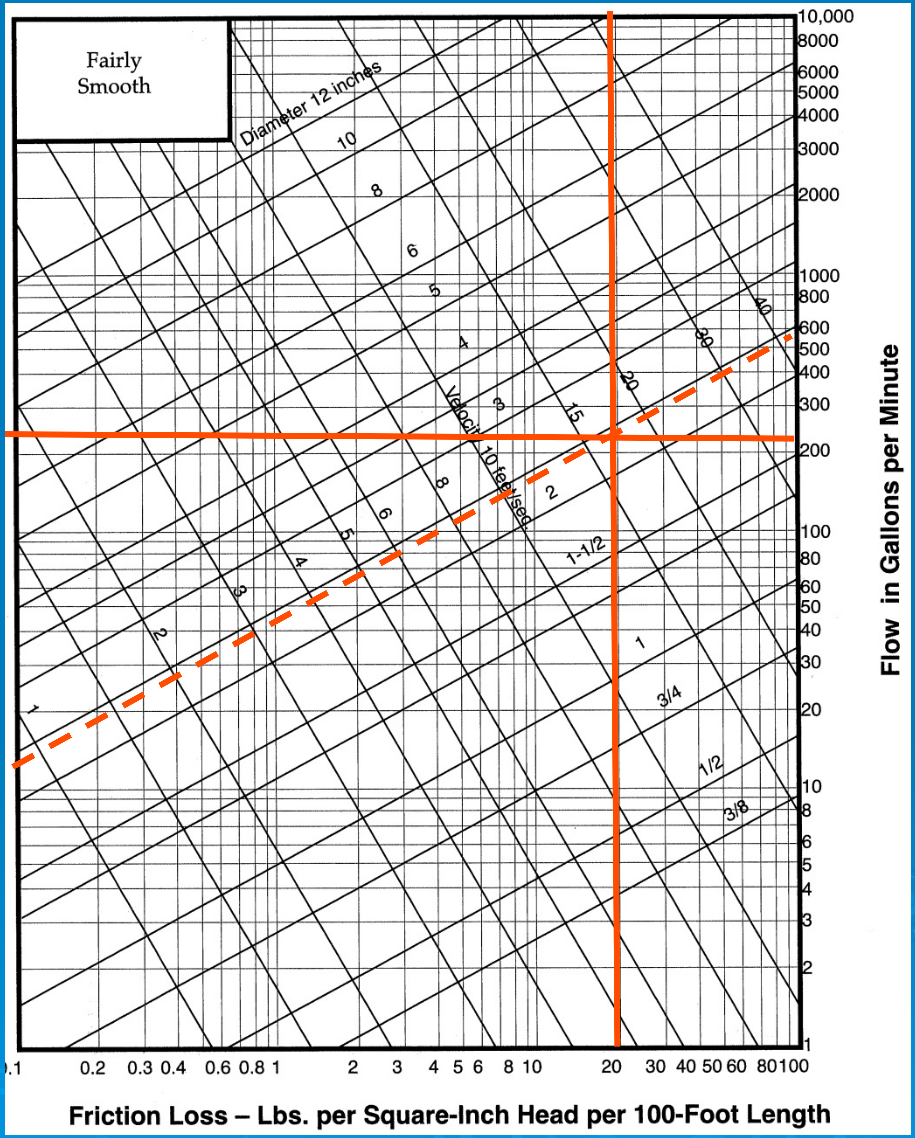
RD3

- Draw a line at 13.0 feet per 100 feet
- Draw a line at 125 gallons per minute
- The intersection is just under 2”
- Use 2” pipe



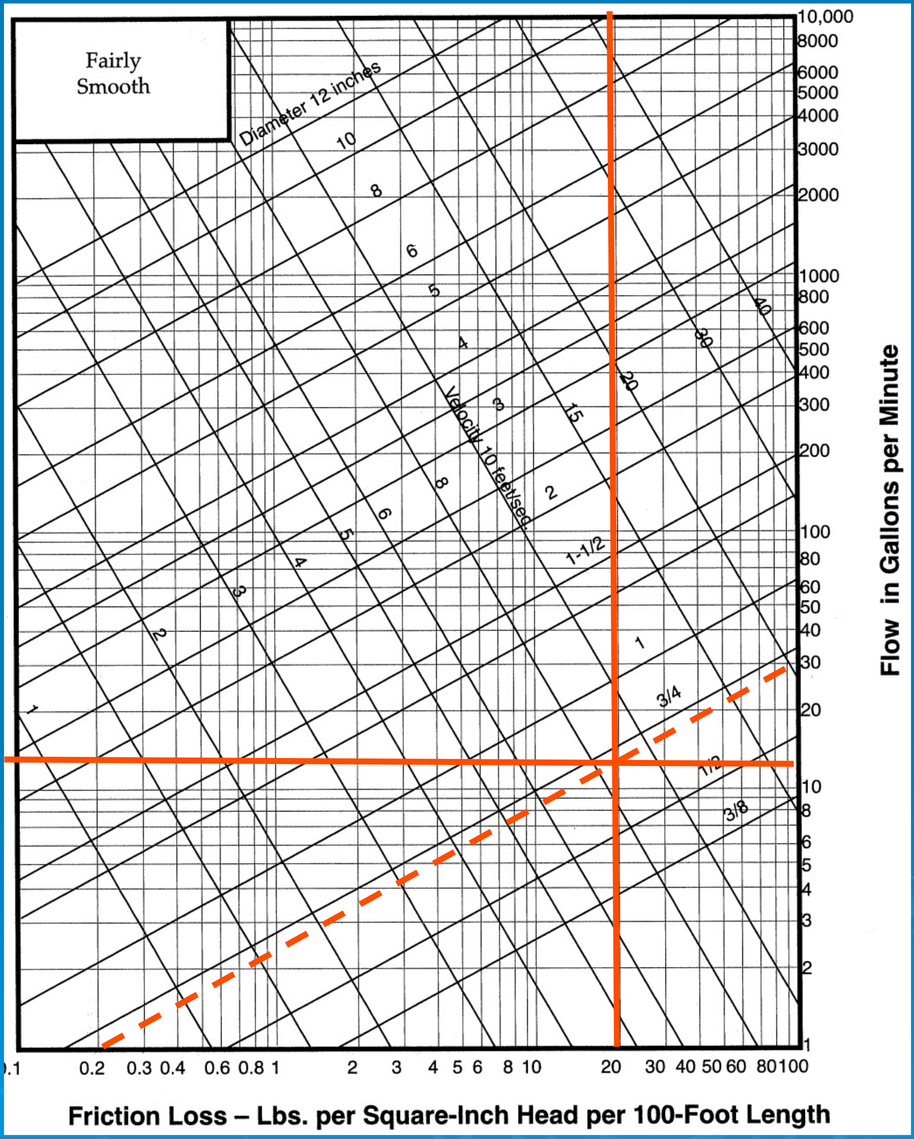
RD4

- Draw a line at 19.5 feet per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is between 2” and 2½”
- Use 2” pipe, but increase to 2½” after the tailpiece



RD5

- Draw a line at 19.5 feet per 100 feet
- Draw a line at 12.5 gallons per minute
- The intersection is between ½” and ¾”
- Using 1½” pipe, the velocity is only 2 feet per minute …
- NO SIPHON

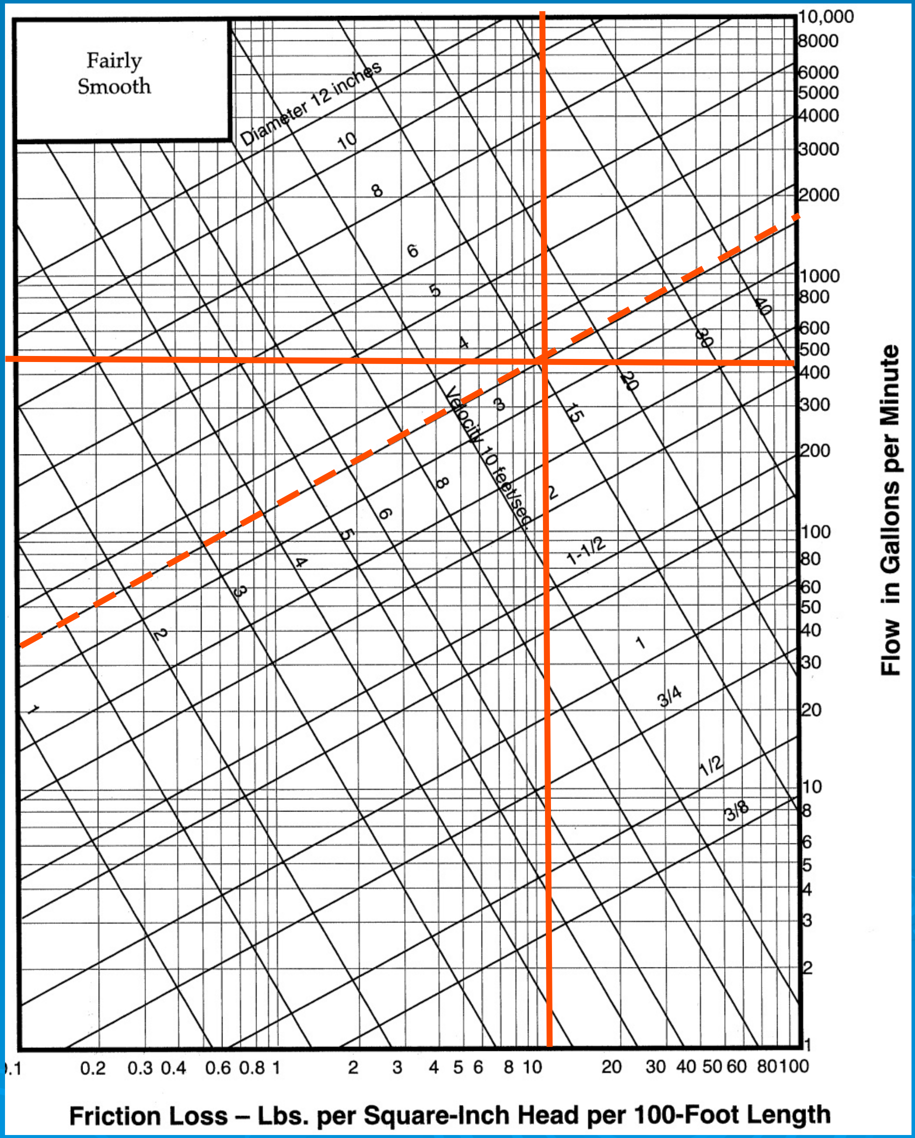


Preliminary Pipe Sizing

- For combined pipe segments, use the lowest friction and the combined flow rate

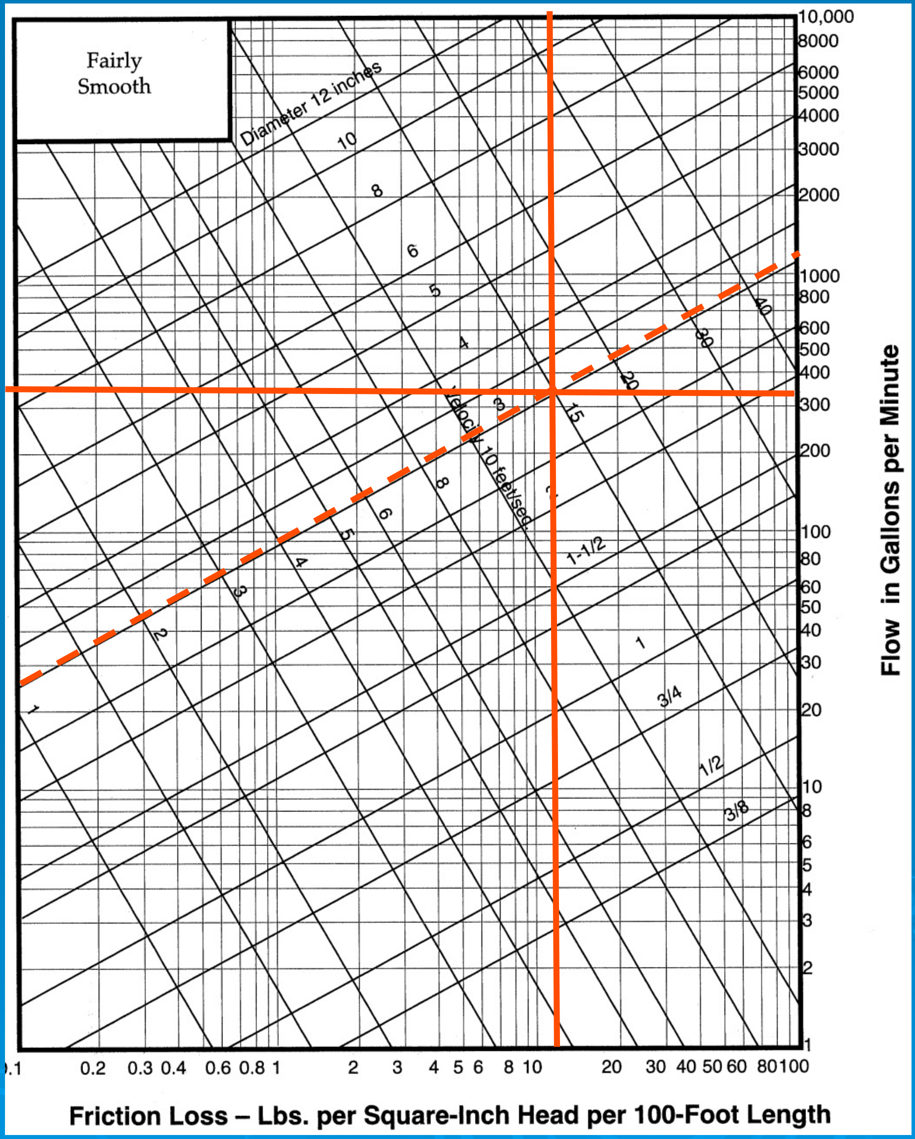
RD1+RD2

- Draw a line at 12.4 feet per 100 feet
- Draw a line at 416 gallons per minute
- The intersection is between 3” and 4”
- Use 3” pipe, but increase to 4” *before* the next bend



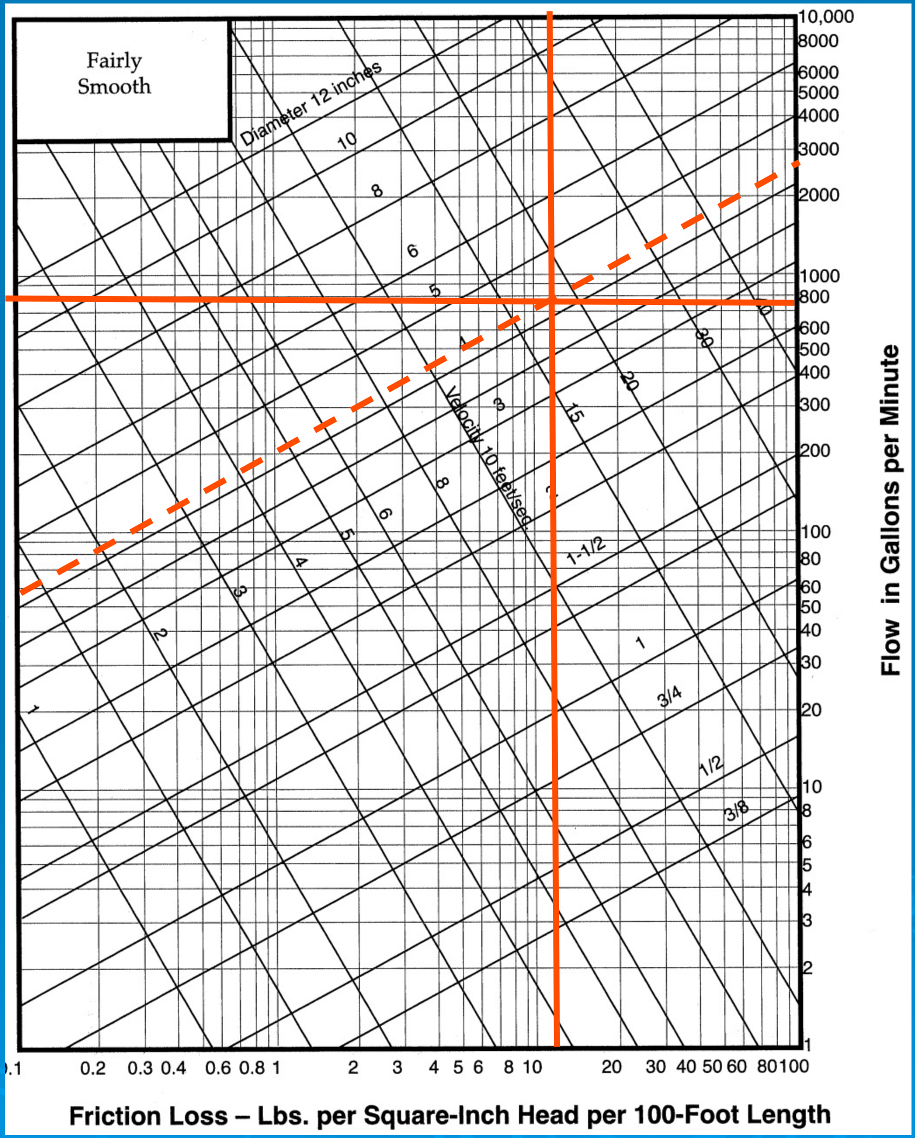
RD3+RD4

- Draw a line at 13.0 feet per 100 feet
- Draw a line at 333 gallons per minute
- The intersection is between 3” and 4”
- Use 3” pipe, but increase to 4” *after* the next bend



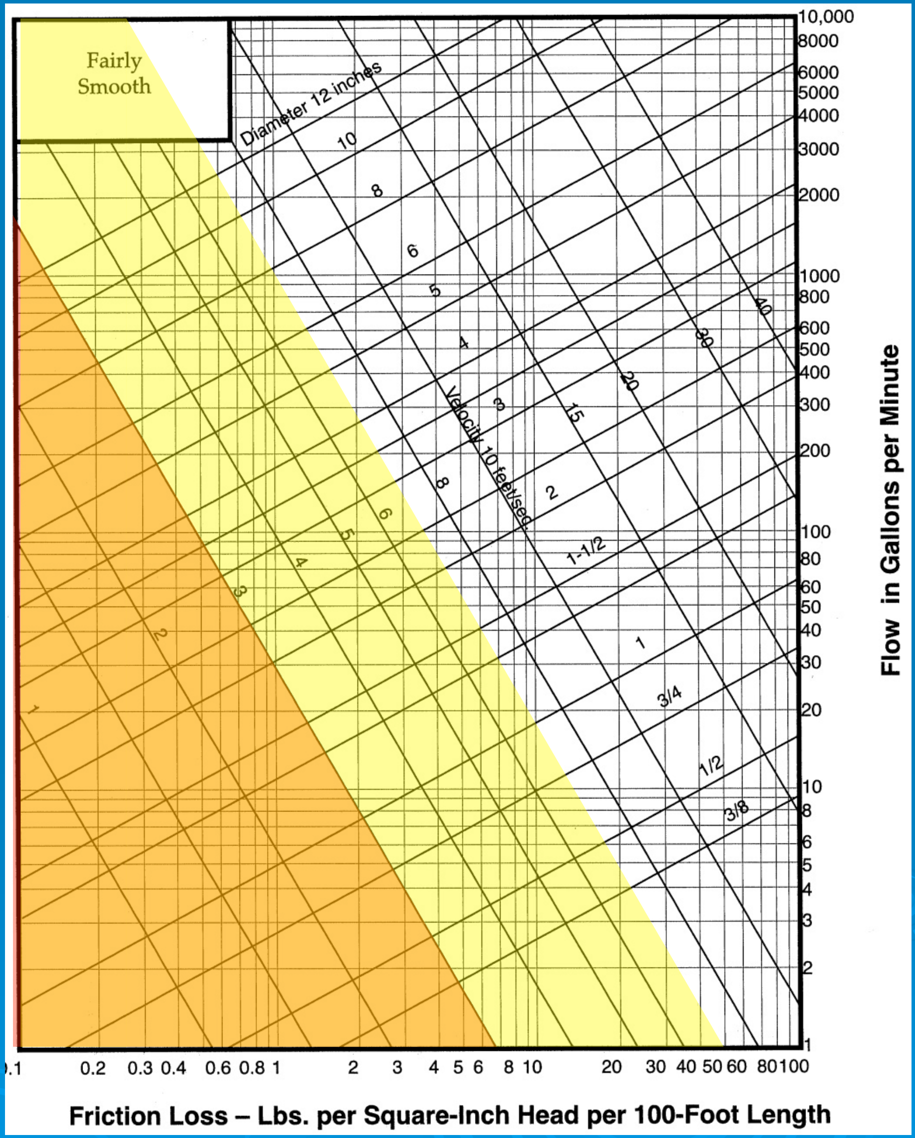
Downpipe

- Draw a line at 12.4 feet per 100 feet
- Draw a line at 749 gallons per minute
- The intersection is between 4” and 5”
- Use 6” pipe at the junction, but decrease to 4” *after* the drop



Downpipe

- Check to make sure that velocities in horizontal pipe are 3 feet per second or greater
- Check to make sure that velocities in horizontal pipe are 7.2 feet per second or greater



Questions

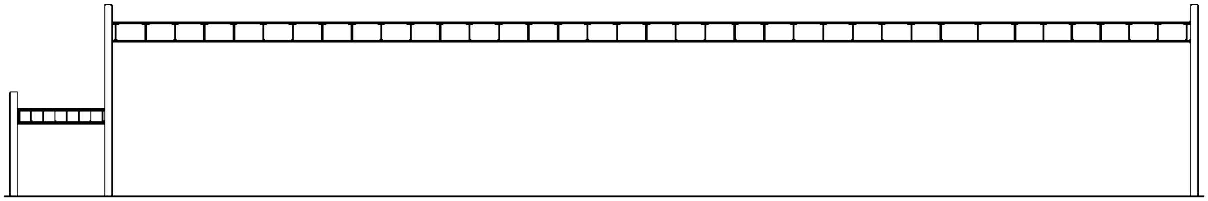
BREAK

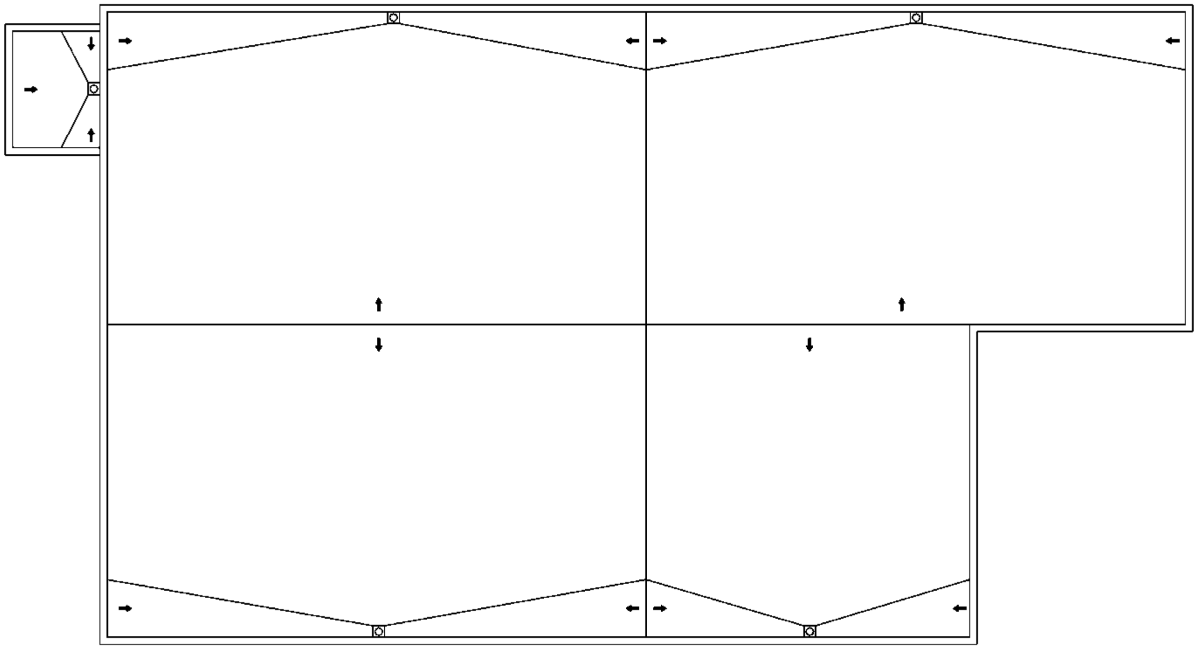
Be back in 15 minutes!

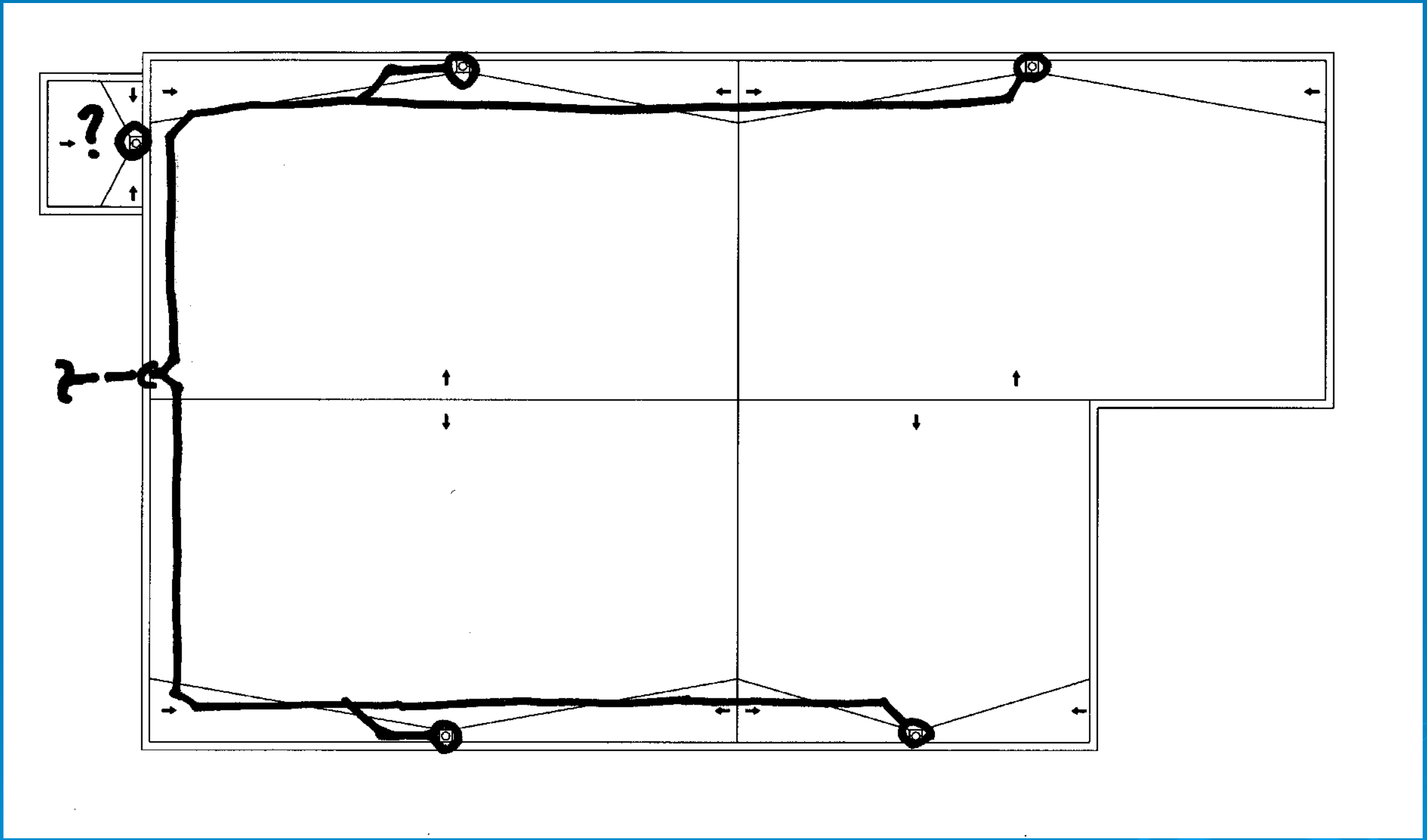
Outline

- Review
- Parameters
- Balancing
- Drawing Standards
- Construction Administration

Review







Review

Preliminary Pipe Size				
Segment	Flow Rate (CFS)	Drain Size	Beginning pipe size	Ending pipe size
RD-1	0.46	2”	3”	3”
RD-2	0.46	2”	2”	2 ½”
RD-1 to RD-2	0.92	n/a	3”	4”
RD-3	0.28	2”	2”	2”
RD-4	0.46	2”	2”	2 ½”
RD3 to RD-4	0.74	n/a	3”	4”
Downpipe	1.66	n/a	6”	4”
RD-5	0.028	2” conv.	2”	3”

Parameters

Parameters

- Velocities in horizontal pipe must be 3 feet per second or greater
  - If not, the pipe sizes must be made smaller
- Velocities of 3 to 25 feet per second or greater are normal
- Do not exceed maximum velocity for pipe material
  - Copper = 8 feet per second
- Slower speeds will break the siphon

Parameters

- Velocities in Vertical pipe must be 7.2 feet per second or greater
  - Varies with pipe size
  - Smaller pipes need less
  - Larger pipes need more
- Slower speeds will break the siphon

Parameters

- Negative pressures should be greater than (negative) -25’ to avoid cavitation
  - Check the top of the riser first
- Cavitation will reduce the energy in the siphon

Parameters

- 0’ to 3.0’ of residual head is required
  - Additional capacity
  - Installation flexibility
- Less than 0’ of residual head indicates that the system will not carry the 100 year storm
- More than 3.0’ of residual head yields larger than necessary pipe sizes and can lead to imbalance at lower flow rates

Parameters

- A balanced system requires:
  - Imbalance ≤ 1.5 feet of head
  - Imbalance ≤ 10% of the building height
- An unbalanced system will result in one drain running dry before the others
  - This will break the siphon and greatly reduce the carrying capacity
  - Like drinking out of a straw with a hole in it

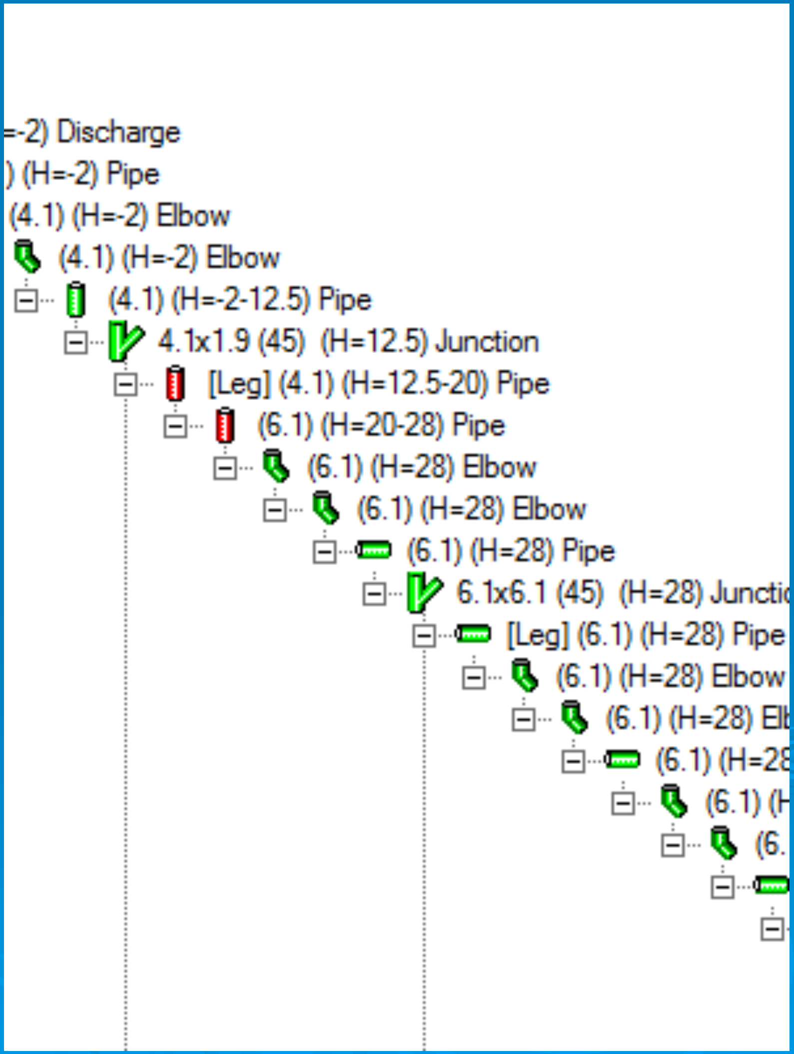
Balancing

Balancing

- With a good first guess, dimension your sketch
- Starting with the discharge, enter your system into the calculation software
- Check for a valid configuration

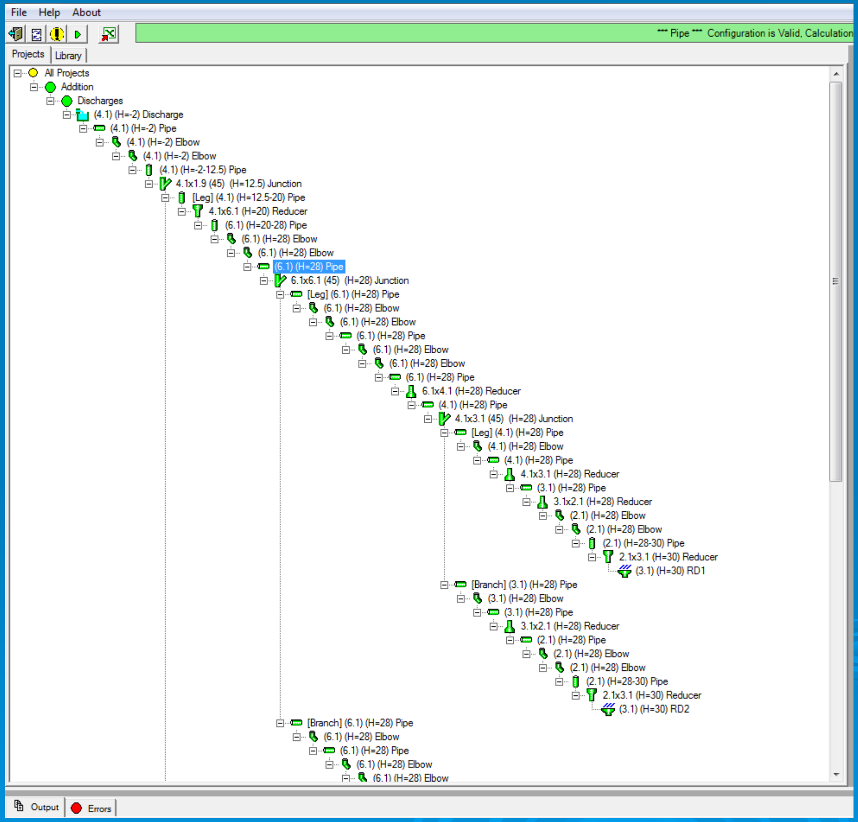
Balancing

- Enter pipe and fittings one at a time until the entire system is accurately reflected in the software.
- 6x4 reducer is not entered



Balancing

- Most software will give an indication of a valid configuration
- In this case, a green bar appears at the top



Balancing

Configuration | Calculation | Imbalance

Friction (ft)	0.019
Pressure In (ft)	-8.208
Pressure Out (ft)	-8.581
Velocity In (ft/s)	5.411
Friction Energy Lost (ft)	0.373
Flow Rate (cfs)	0.278
Total Energy In (ft)	12.93 = -8.208(P) + 0.455(V) +-7.314(Fr) +28(H)
Total Energy Out (ft)	12.93 = -8.581(P) + 0.455(V) +-6.941(Fr) + 28(H)
Total Friction Lost (ft)	-7.314(Friction) = 15.05(Total Friction lost) - 22.37(Friction Lost From Discharge)
Velocity Head Out (ft)	0.455
Velocity Head In (ft)	0.455
Energy Lost At Roof (ft)	15.052
Reynolds Number	98,852.638

Balancing

- 0.1’ to 3.0’ of residual head
- Imbalance ≤ 1.5 feet of head
- Imbalance ≤ 10% of the building height
- Negative pressures greater than -25’
- Velocities in horizontal pipe ≥ 3 fps
- Velocities in vertical pipe ≥ 7.2 fps

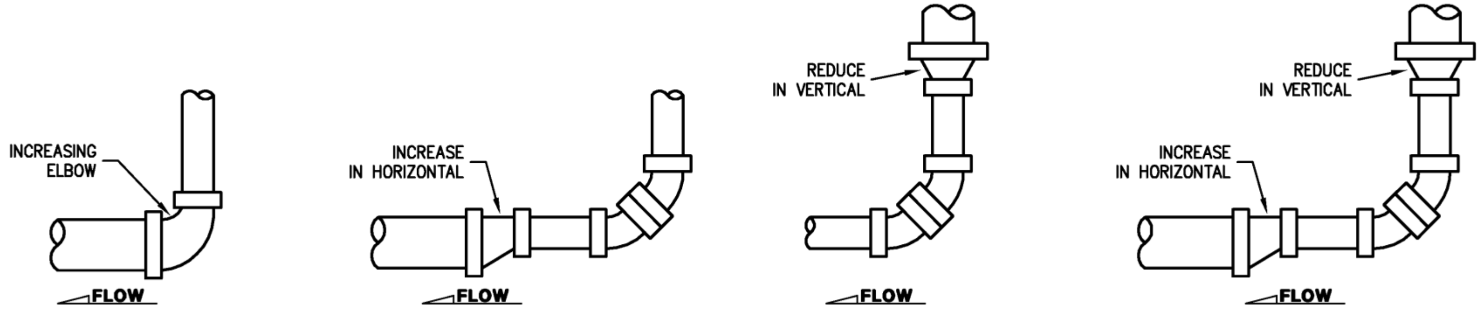
Balancing

- To increase friction, make the segments with the smaller pipe longer and the segments with the larger pipe shorter.
- To decrease friction, make the segments with the smaller pipe shorter and the segments with the larger pipe longer.

Balancing

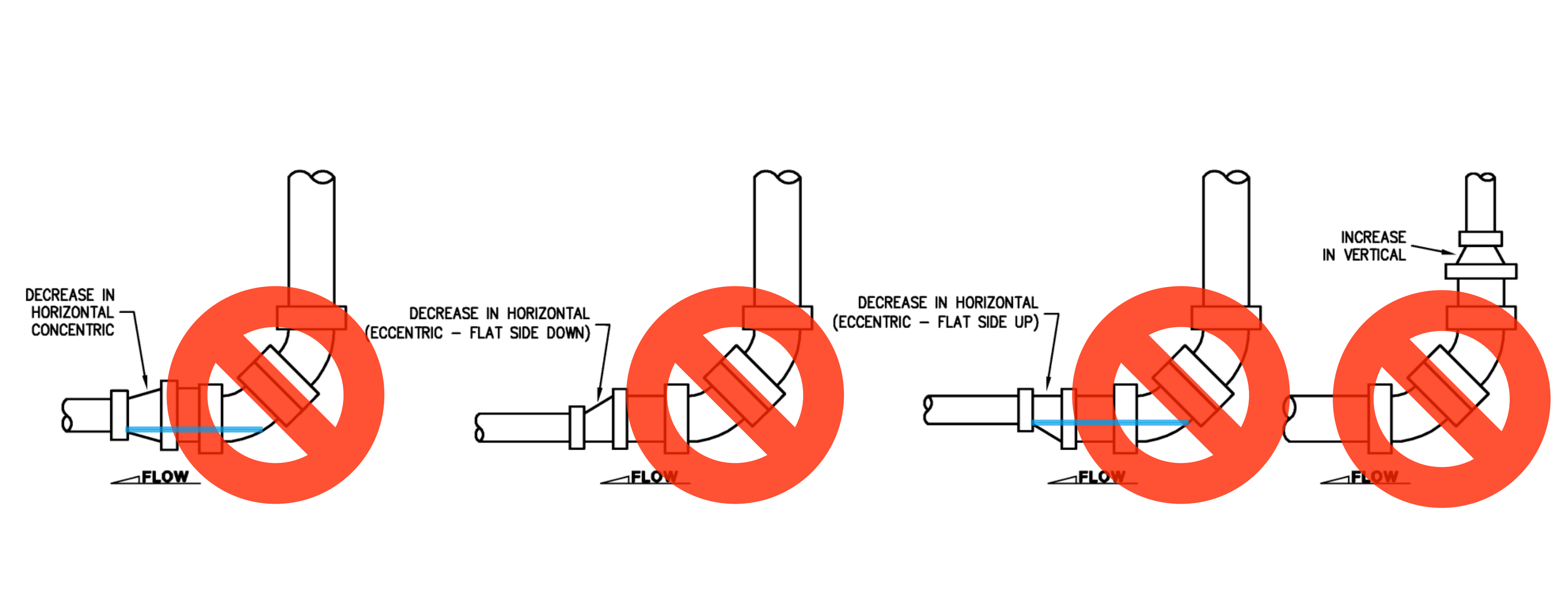
- With the parameters in mind, adjust the system so that each drain has a similar residual head
- Balance the system by repositioning reducers.
  - Vertical pipe sizes may be reduced
  - Vertical pipe sizes may NOT be increased
  - Horizontal pipe sizes may NOT be reduced
  - Horizontal pipe sizes may be increased

Balancing



INCREASING
ELBOW
FLOW
INCREASE
IN HORIZONTAL
FLOW
REDUCE
IN VERTICAL
FLOW
REDUCE
IN VERTICAL
INCREASE
IN HORIZONTAL
FLOW

Balancing



DECREASE IN
HORIZONTAL
CONCENTRIC
FLOW
DECREASE IN HORIZONTAL
(ECCENTRIC – FLAT SIDE DOWN)
FLOW
DECREASE IN HORIZONTAL
(ECCENTRIC – FLAT SIDE UP)
FLOW
INCREASE
IN VERTICAL
FLOW

Balancing

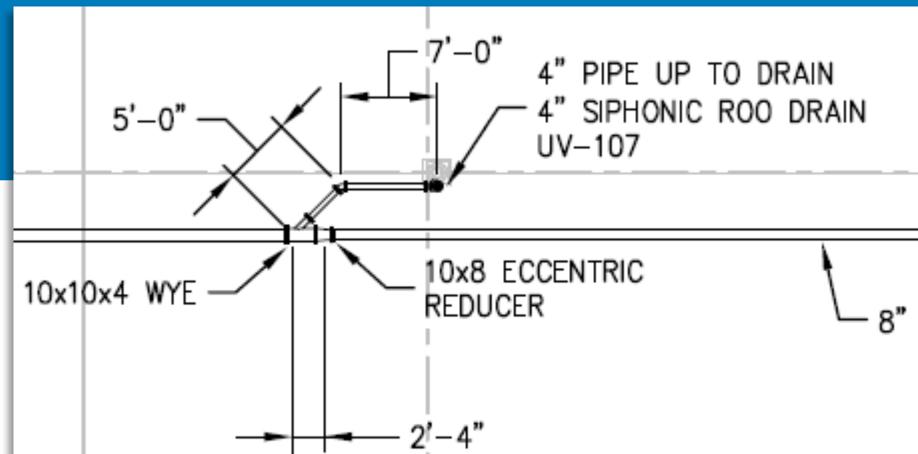
Configuration | Calculation | Imbalance

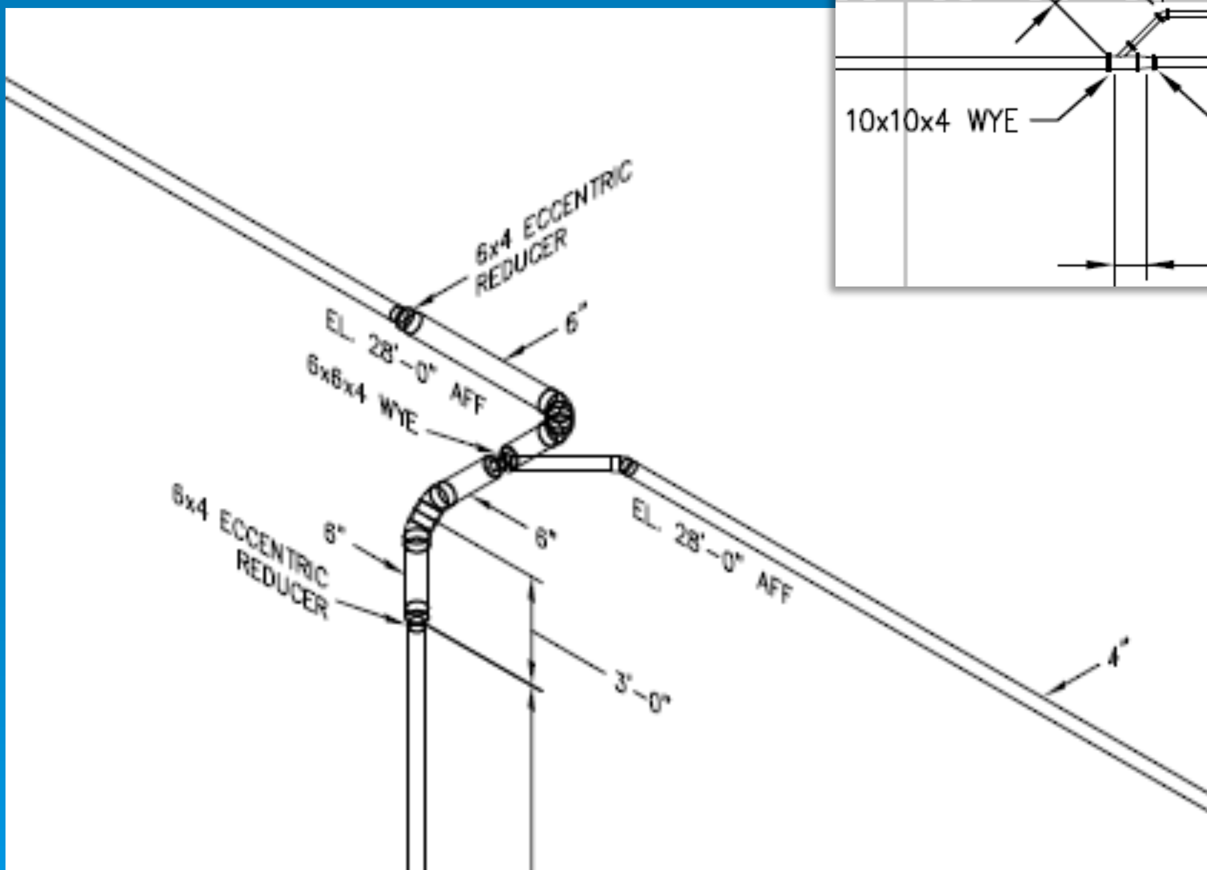
Imbalance: 1.177, Max height: 30, Imbalance as a percent of max height: 3.92%, Max height percent: 10%

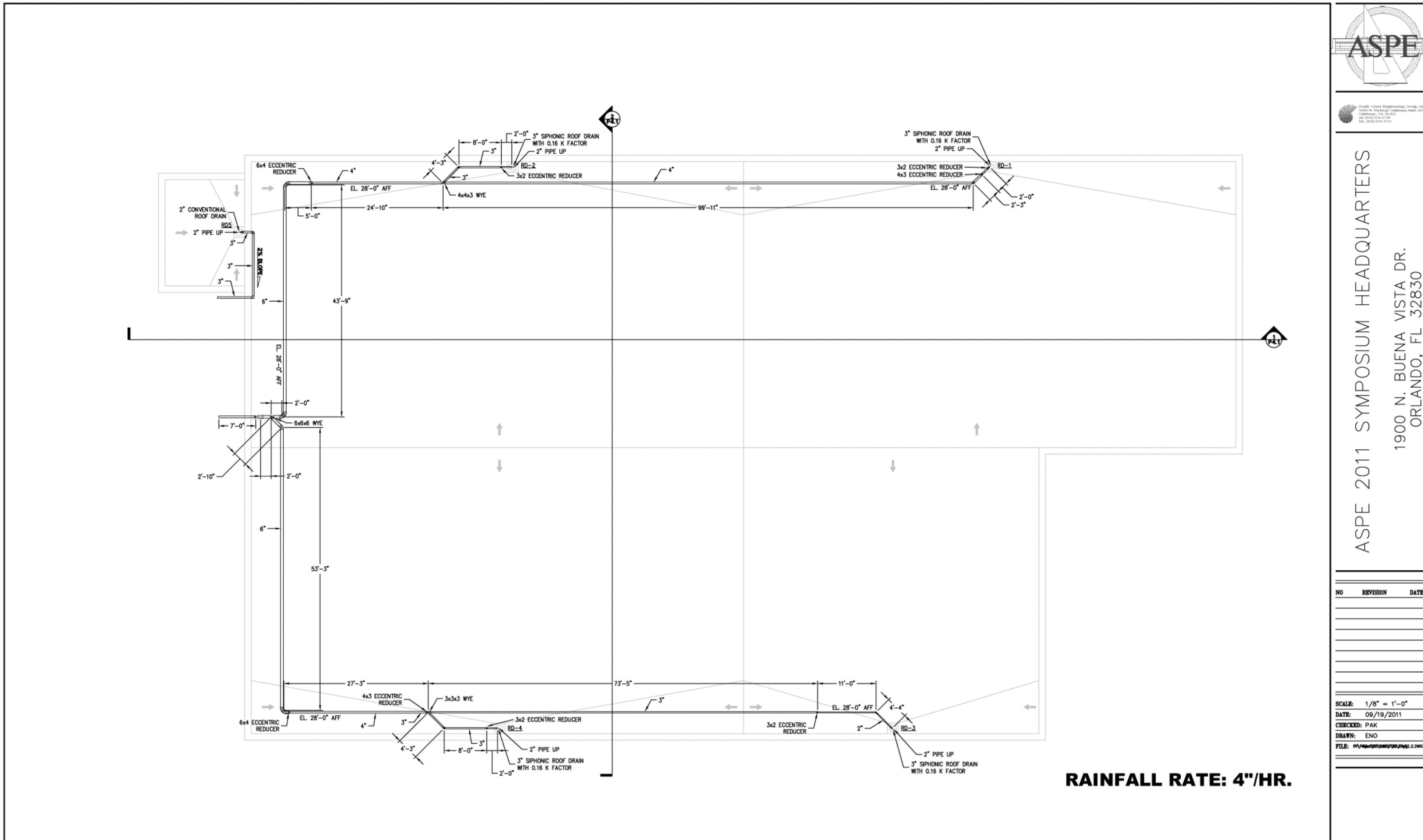
#	Name	Library Element	Area (sq.f)	Height (ft)	Total Energy Lost (ft)	Residual Head (ft)
1	RD1	3.1 JRS 1005T	5,000	30	31.230	0.770
2	RD2	3.1 JRS 1005T	5,000	30	31.183	0.817
3	RD3	3.1 JRS 1005T	3,000	30	31.149	0.851
4	RD4	3.1 JRS 1005T	5,000	30	31.212	0.788
5	RD5	2.1 JRS 1005T	300	15	15.052	1.948

- A balanced system requires:
  - Residual Head ≥ 0 feet of head
  - Residual Head < 3 feet of head
  - Imbalance ≤ 1.5 feet of head
  - Imbalance ≤ 10% of the building height

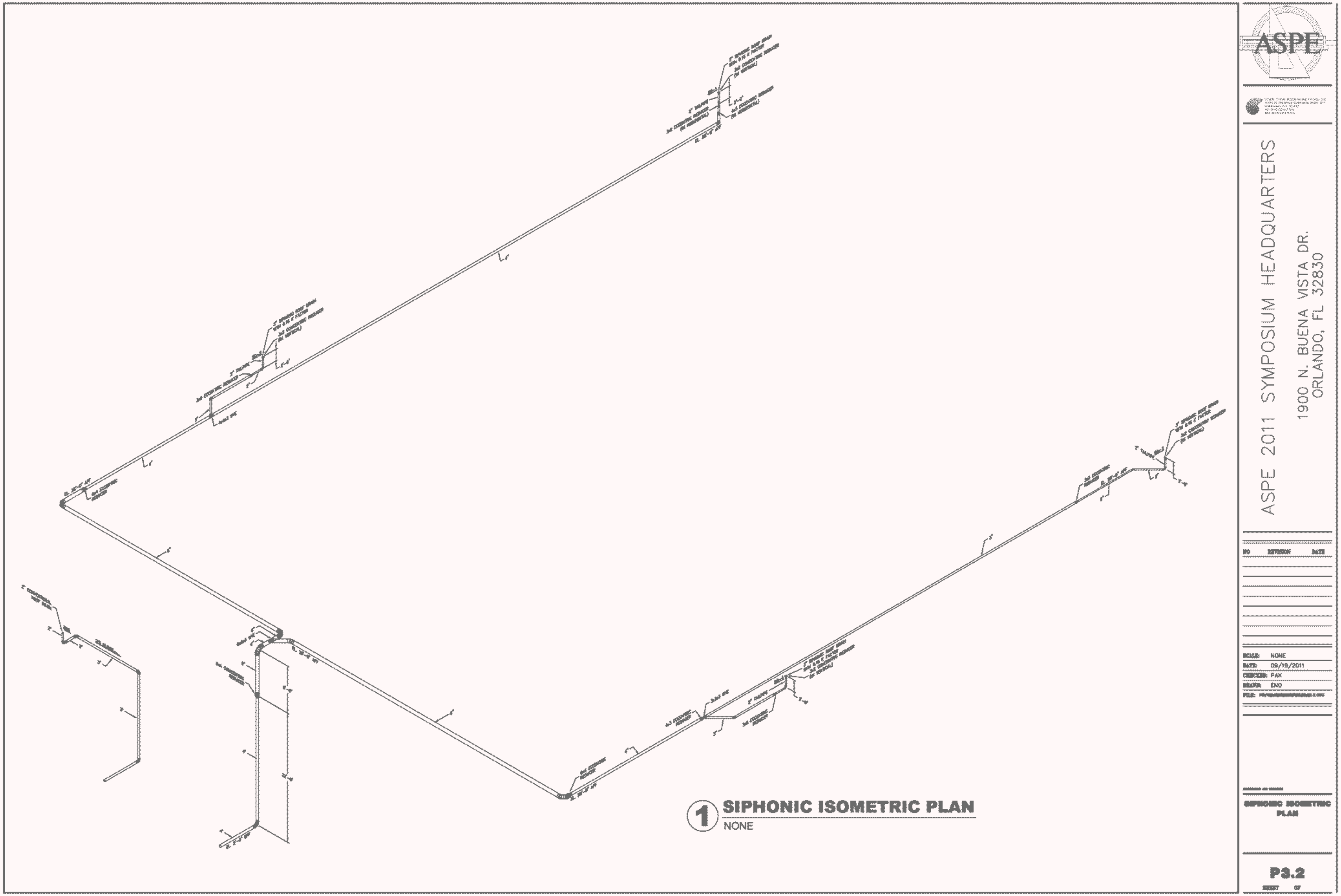
Drawing Standards



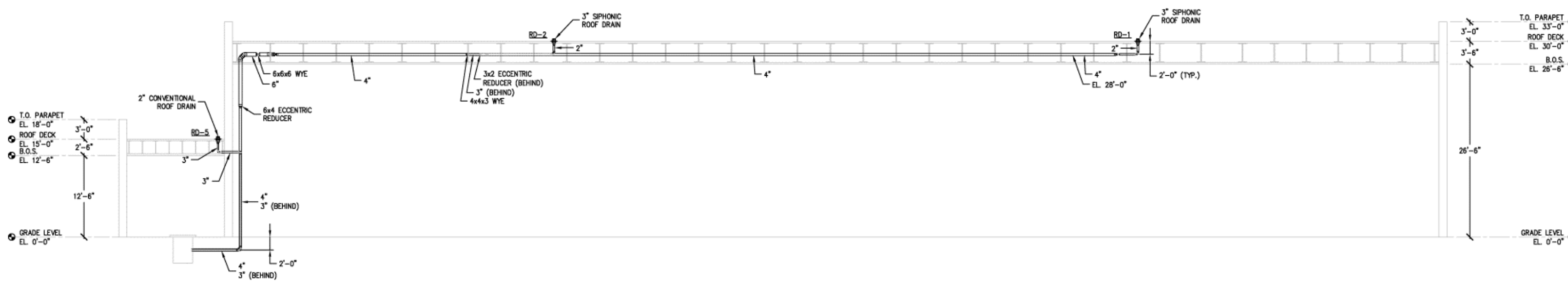




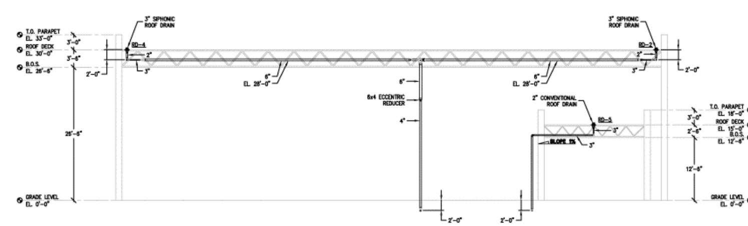
1 SIPHONIC ROOF PLAN
1/8" = 1'-0"



ASPE
ASPE 2011 SYMPOSIUM HEADQUARTERS
1900 N. BUENA VISTA DR.
ORLANDO, FL 32830
NO REVISION DATE
SCALE: NONE
DATE: 09/19/2011
CHECKED: PAK
DRAWN: ENO
SIPHONIC ISOMETRIC PLAN
P3.2
1 SIPHONIC ISOMETRIC PLAN
NONE



1 BUILDING SECTION
1/8" = 1'-0"



2 BUILDING SECTION
3/32" = 1'-0"

ASPE

ASPE 2011 SYMPOSIUM HEADQUARTERS

1900 N. BUENA VISTA DR.
ORLANDO, FL 32830

NO	REVISION	DATE

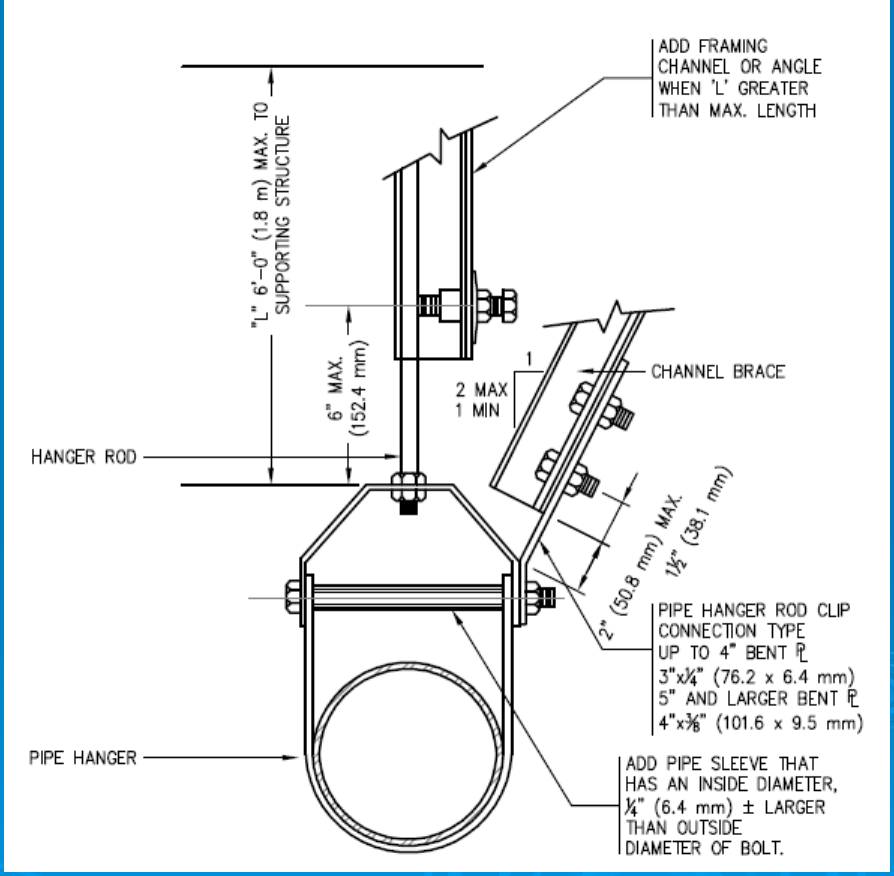
SCALE: AS NOTED
DATE: 09/19/2011
CHECKED: PAK
DRAWN: ENO

BUILDING SECTIONS

P4.1
SHEET OF

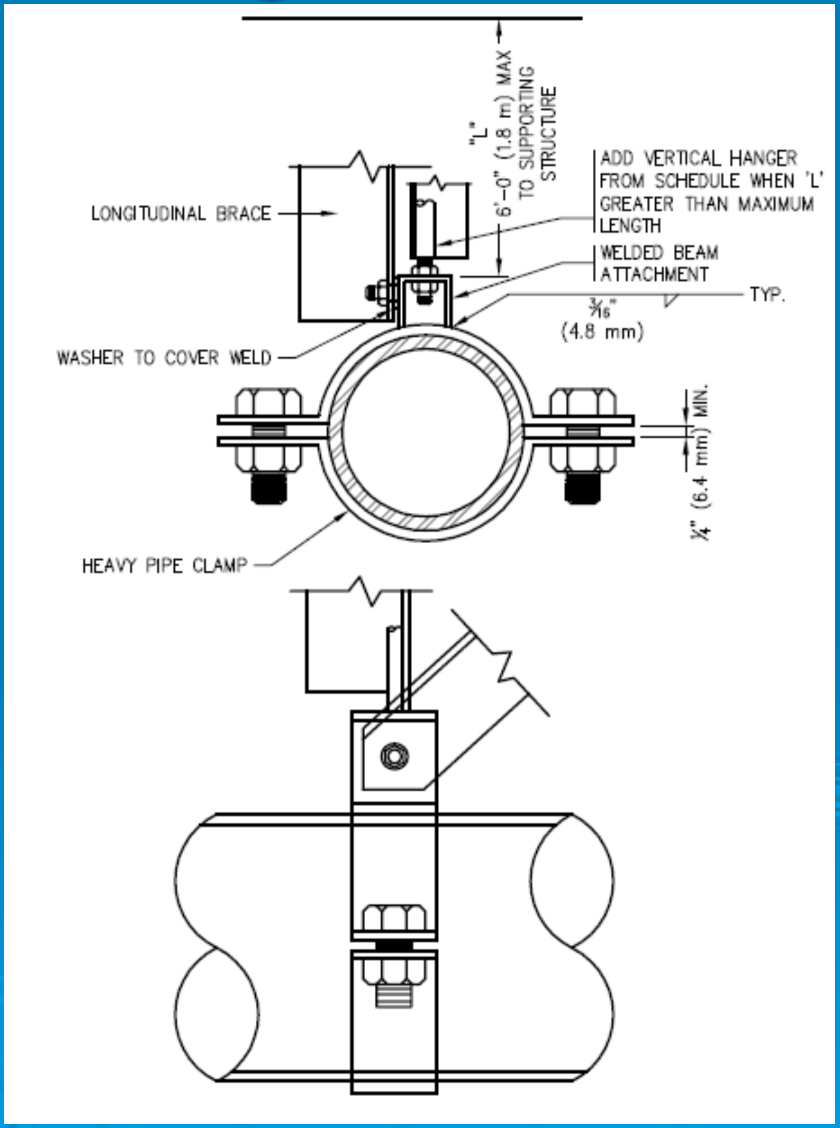
Pipe Bracing

- Lateral Bracing Required:
  - At each tailpiece
  - At branch take-offs
  - At each change in direction
  - At 30 foot intervals



Pipe Bracing

- Longitudinal Bracing Required



Construction Administration

- Any changes must be submitted, reviewed and recalculated
- Revised drawings must be issued if balance or residual head do not meet parameters indicated earlier
- Engineering Fees …

Construction Administration

- The branch that runs straight through the wye has the greater pressure drop
- Check that installed conditions match the plans

Construction Administration

- Field Observation is essential
- Check that no drains have been moved or added
- Check that downpipes have not been moved or reconfigured
  - Offsets to avoid miscellaneous steel

Construction Administration

- Check pipe material
- Check tailpiece connection

Construction Administration

- Check pipe sizes
- Check lengths between reducers
  - Pipes up to 4”Ø shall be ± 4”
  - Pipes 5”Ø and larger shall be ± 8”
- Use building columns for reference

Construction Administration

- Check drain attachment to structure
- Check for unobstructed waterway
- Check for a secure baffle

Construction Administration

- Check leaf strainer
- Check for debris
- Even a small amount of debris can change the performance of a system

Construction Administration

- Check lateral and longitudinal bracing
  - Spacing
  - Attachment to structure

Questions