Conventional Landscape Irrigation

ASM/SWES 404/504

Irrigation - Introduction

What determines how often and how much irrigation water should be applied?

Irrigation Systems

- Conventional
  - sprinkler
  - surface
- Low-Volume
  - microirrigation
  - drip
  - Xerigation

Irrigation System Components

Conventional vs. Low-Volume Irrigation

	Conventional	Low-volume
Design	Design goal is to broadcast water as evenly as possible across entire area. Water is delivered to the surface of the plant area.	Design goal is to apply water to a uniform depth, either directly to the plant root zone or in a limited area. Water is delivered at or below surface.
Installation	Most of the system installed in underground trenches.	Most of the system installed at or near grade and covered with several inches of mulch. Installation requires less time with lower labor costs.
Maintenance	Problems with system are easy to spot. Many problems require trenching to repair.	Problems with system may be less noticeable. Scheduled maintenance requires greater attention.

Choosing Conventional Irrigation Systems

- Sprinkler commonly used for turf applications, also used in landscapes, gardens
  - susceptible to wind and evaporation losses
- Surface/flood can be used for turf, landscapes, gardens
  - generally applies deeper irrigation and requires higher flow rates for shorter periods of time
  - requires careful design for efficient irrigation

Conventional Landscape Irrigation Design Process-*Rain Bird*

1. Understand basic hydraulics
2. Obtain site information
3. Determine irrigation requirements
4. Determine water and power supply
5. Select sprinklers and spacing ranges
6. Lateral layout, circuit sprinklers into valve groups
7. Size pipes and valves and calculate system pressure requirements
8. Locate controller and size valve and power wires
9. Prepare final irrigation plan

Understanding Basic Hydraulics

- Water weighs __________
- Water is compressible or incompressible?
- Water exerts pressure or doesn't exert pressure?
- If you double the height of the water, the pressure is doubled or tripled or doesn't change?

Static Water Pressure

- **Static water pressure** = pressure of water with no flow
  - – relates to changes in elevation or pressure caused by a pump
  - – an indication of the potential pressure available to operate a system
- To convert pressure in feet to pressure in psi, multiply the feet value by 0.433.

What is the static water pressure at point:

A?

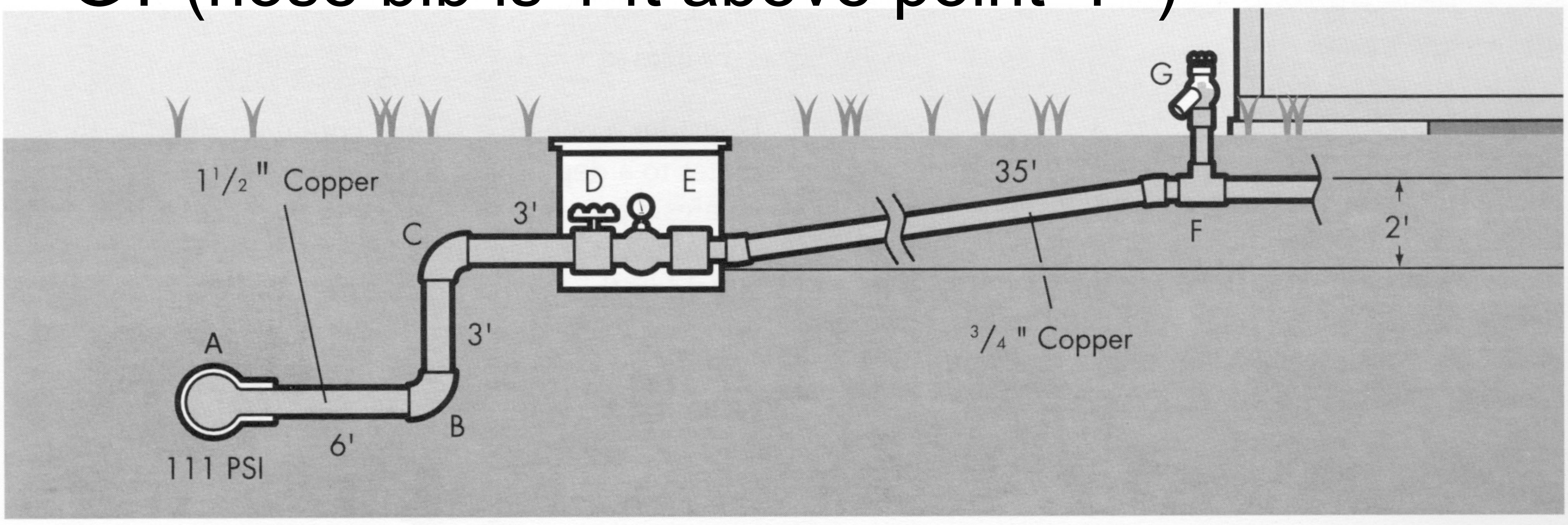
B?

C?

E?

F?

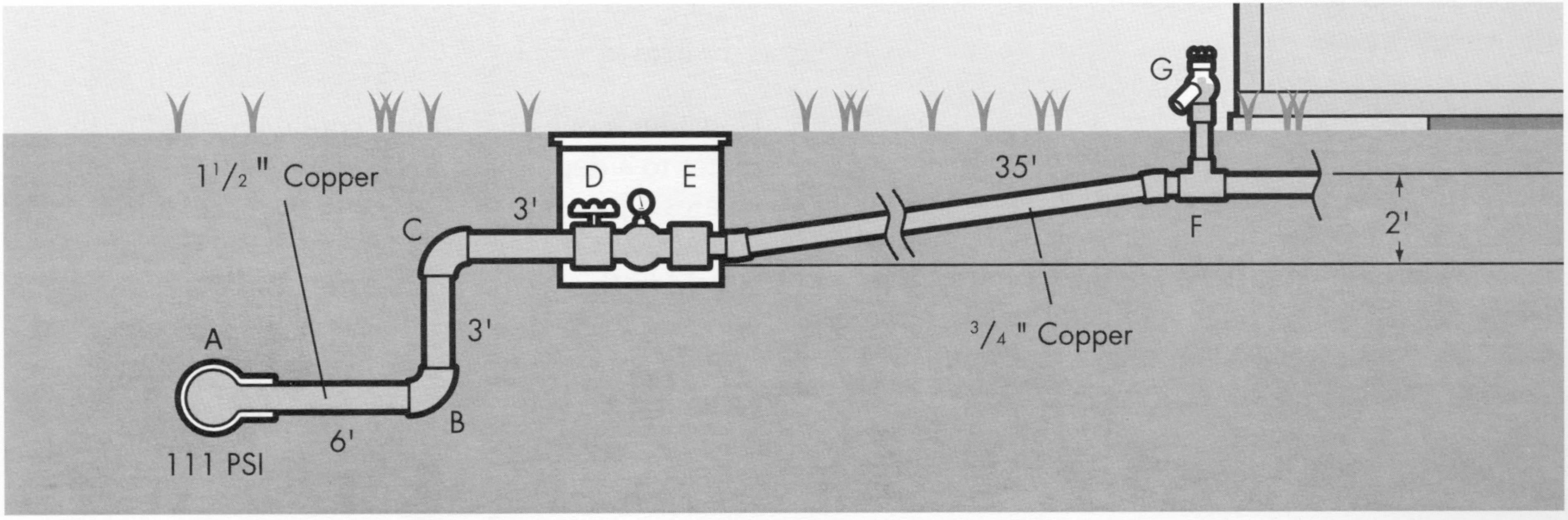
G? (hose bib is 1 ft above point "F")



Dynamic Water Pressure

- = water pressure or *working pressure*
- pressure of water with water flow
  - differs from static water pressure due to friction losses through pipes, fittings, and components of the system
  - it is the *design pressure*
- **amount of water flowing** through the components of the system affects the friction loss
  - more water being forced through the system, the higher the flow velocity, and higher the water pressure loss.
- **speed that water moves** through components affects friction loss
  - the faster water moves through a pipe, the higher the friction loss

Dynamic Water Pressure



If water flow is 20 gpm, what is the dynamic water pressure, in psi, at points:

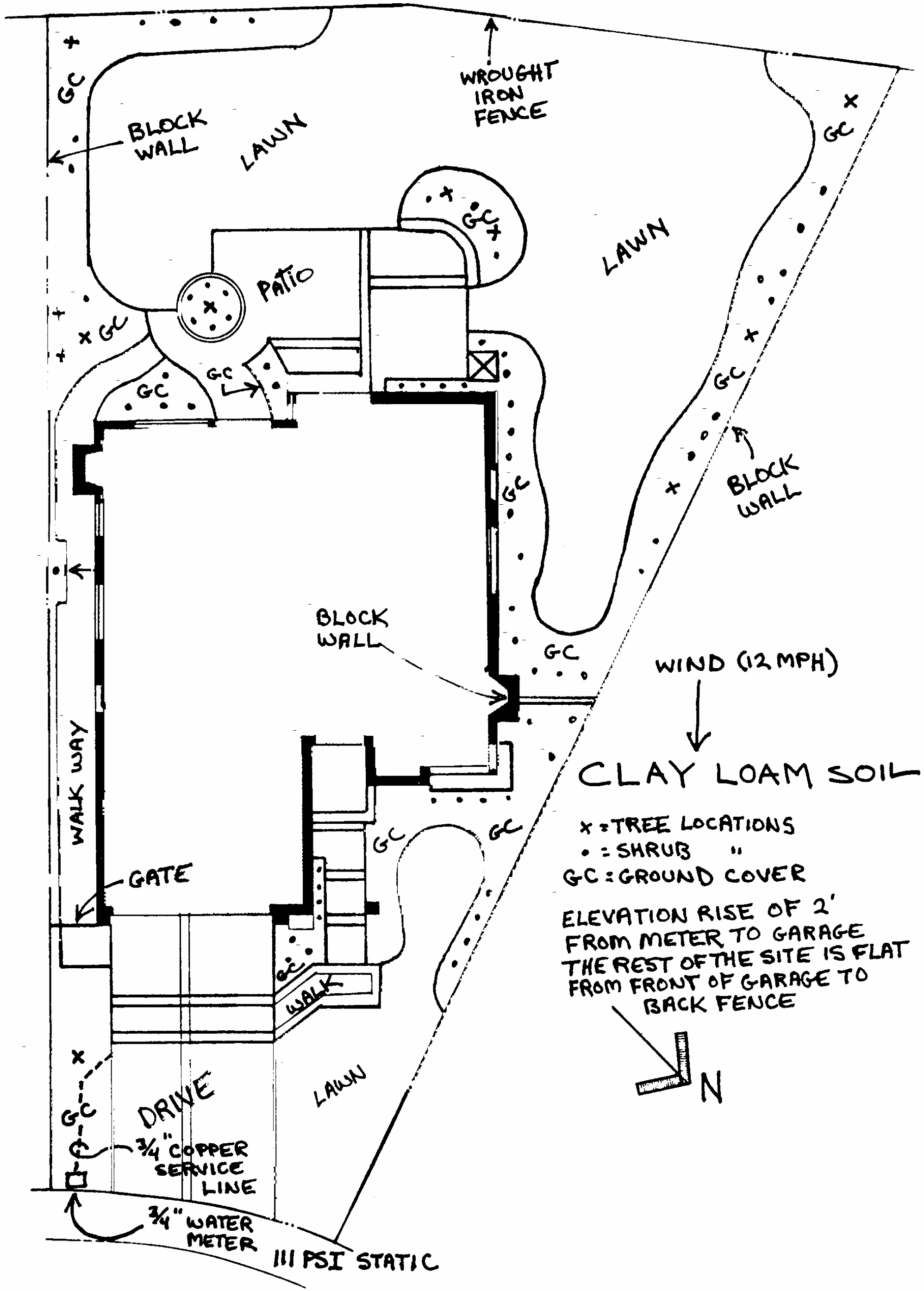
B?

E?

G?

Step 1: Obtaining Site Information

- locate all buildings, walkways, driveways, parking areas, light or utility poles, retaining walls, stairways
- indicate slopes, soil type, wind direction
- indicate no water drift areas
- locate all trees, shrubs and pinpoint plant materials
- indicate hydraulic data (location of water source, size of water meter & service line, ascertain static water pressure)



WROUGHT IRON FENCE
BLOCK WALL
LAWN
GC
PATIO
LAWN
GC
GC
GC
GC
BLOCK WALL
BLOCK WALL
GC
GC
WIND (12 MPH)
CLAY LOAM SOIL
x = TREE LOCATIONS
• = SHRUB "
GC = GROUND COVER
ELEVATION RISE OF 2' FROM METER TO GARAGE THE REST OF THE SITE IS FLAT FROM FRONT OF GARAGE TO BACK FENCE
WALK WAY
GATE
GC
GC
WALK
N
LAWN
GC
DRIVE
3/4" COPPER SERVICE LINE
3/4" WATER METER
111 PSI STATIC

Step 2: Determining Irrigation Requirements

- Irrigation requirement is measured in:
  - inches per week
  - inches per day
- Is the amount of water each plant needs less than, equal to, or greater than the amount of water the irrigation system supplies?
- What two primary factors affect the amount of water needed to satisfy the plant?

Evapotranspiration (ET)

- measured in inches per day
- ET is different for different plants
- system designed for worst ET
- ET estimated from
  - mathematical equations
  - Arizona meteorological data = AZMET

    http://ag.arizona.edu/azmet
  - OR...

Estimating ET - *Rain Bird*

Climate	Inches Daily
Cool Humid	0.10 –0.15
Cool Dry	0.15 – 0.20
Warm Humid	0.15 – 0.20
Warm Dry	0.20 – 0.25
Hot Humid	0.20 – 0.30
Hot Dry	0.30 – 0.45

What Affects a Plant's ET?

<u>Increases ET</u>

-
-
-
-
-
-

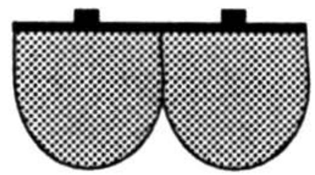
<u>Decreases ET</u>

-
-
-
-
-
-

Soils

- Determine how fast and how often water can be applied to the plant material
  - soil type and texture
    - affects irrigation operational schedule
  - soil's intake rate
    - dictates how fast water can be applied by the irrigation system
    - sprinkler type
  - need to consider rolling terrain, steep slopes

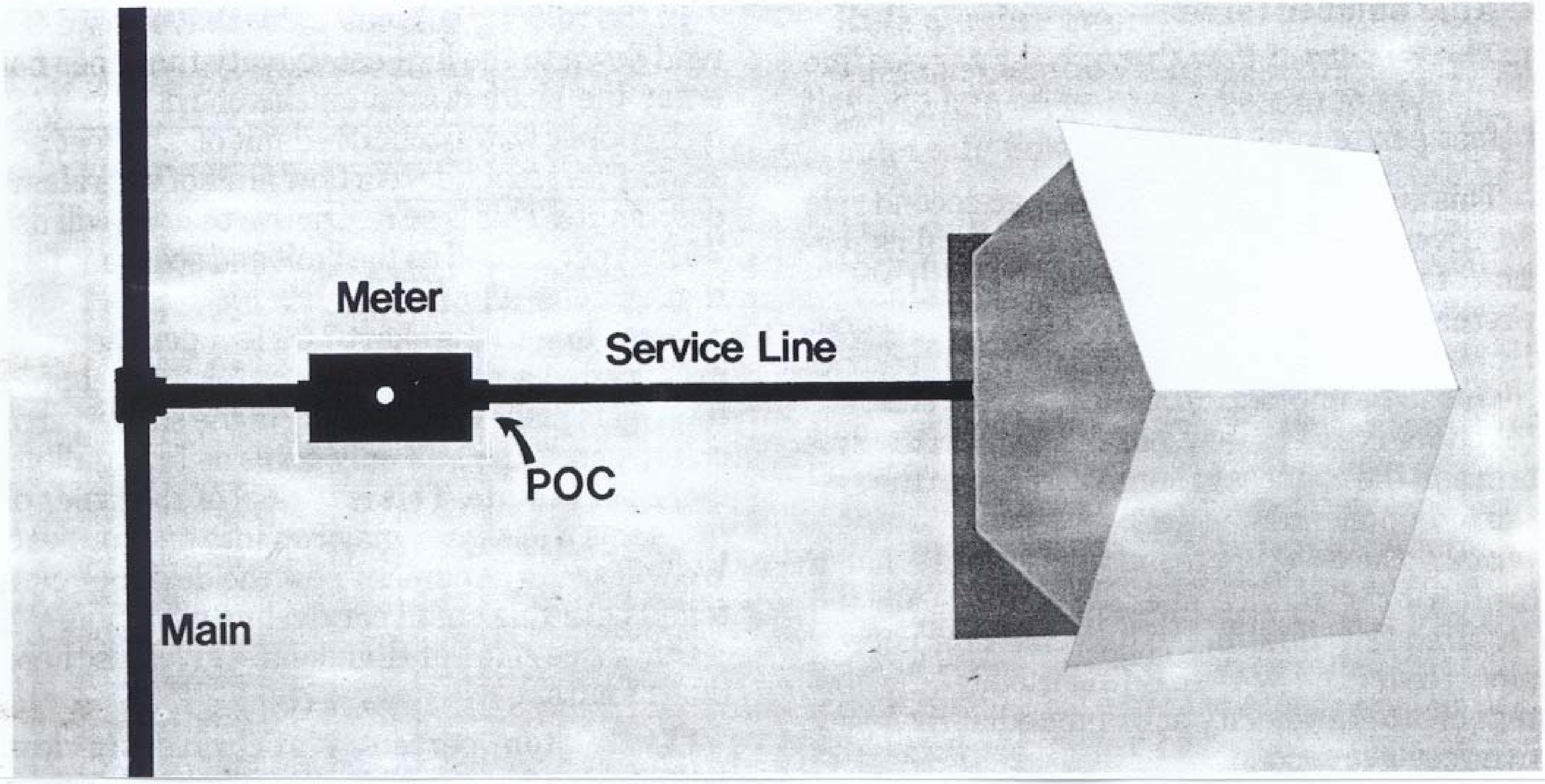
TABLE 3-2: DETERMINING THE SOIL TYPE	
SOIL TYPE	CHARACTERISTICS
Coarse	Soil particles are loose. Squeezed in the hand when dry, it falls apart when pressure is released. Squeezed when moist, it will form a cast, but will crumble easily when touched.
Medium	Has a moderate amount of fine grains of sand and very little clay. When dry, it can be readily broken. Squeezed when wet, it will form a cast that can be easily handled.
Fine	When dry, may form hard lumps or clods. When wet, the soil is quite plastic and flexible. When squeezed between the thumb and forefinger the soil will form a ribbon that will not crack.

TABLE 3-3: SOIL INFILTRATION AND WETTING PATTERN				
Soil Type	**Maximum Infiltration Rate**	**Wetting Pattern**	**Maximum Wetted Diameter**	**Available Water (AW)**
Coarse (sandy loam)	.72 - 1.25 inches per hour		1.0 - 3.0 feet	1.4 inches per foot
Medium (loam)	.25 - .75 inches per hour		2.0 - 4.0 feet	2.0 inches per foot
Fine (clay loam)	.13 - .25 inches per hour		3.0 - 6.0 feet	2.5 inches per foot

SOIL TEXTURE	MAXIMUM PRECIPITATION RATES: INCHES PER HOUR							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12%+ slope	
	Cover	Bare	Cover	Bare	Cover	Bare	Cover	Bare
Course sandy soils	2.00	2.00	2.00	1.50	1.50	1.00	1.00	0.50
Course sandy soils over compact subsoils	1.75	1.50	1.25	1.00	1.00	0.75	0.75	0.40
Light sandy loams uniform	1.75	1.00	1.25	0.80	1.00	0.60	0.75	0.40
Light sandy loams over compact subsoils	1.25	0.75	1.00	0.50	0.75	0.40	0.50	0.30
Uniform silt loams	1.00	0.50	0.80	0.40	0.60	0.30	0.40	0.20
Silt loams over compact subsoil	0.60	0.30	0.50	0.25	0.40	0.15	0.30	0.10
Heavy clay or clay loam	0.20	0.15	0.15	0.10	0.12	0.08	0.10	0.06

Step 3: Determining Water and Power Supply

- Water supply data needed:
  - flow, gpm, available for irrigation system
  - working pressure, psi, at the flow above at the P-O-C
  - to obtain these, additional data needed:
    - static water pressure
    - water meter size
    - service line size, length, type


Meter
Service Line
POC
Main

Static water pressure

- Determine by either:
  - direct pressure gauge reading
  - obtain from water company
- Use “worst case” condition (summer, daylight pressure)

Water meter size

- usually stamped or cast somewhere on the upper half of meter itself
- sometimes printed inside reading lid
- otherwise, contact your water supplier

Calculating water meter capacity

To calculate the flow, gpm, for irrigation, you will follow 3 rules. Using 3 rules, determine the gpm for each, chose the most restrictive

Rule #1

- The pressure loss through the water meter should not exceed 10% of the minimum static water pressure available in the city main.
  - Prevents heavy pressure loss from occurring early in the system
  - example: 3/4” water meter, city water pressure is 111 psi, what is maximum flow that will produce acceptable loss?

Rule #2

- The maximum flow through the meter for irrigation should not exceed 75% of the maximum safe flow of the meter.
  - Designed to protect water meter from excess demand
  - example: 3/4" water meter, what is maximum safe flow of the meter?

Rule #3

- The velocity of flow through the service line should not exceed 5 - 7.5 fps.
  - Velocities in excess are **more** likely to cause damaging surge pressures
  - metallic pipes commonly used in water supply systems can withstand higher velocities than thermoplastic pipes in irrigation systems
  - example: 3/4” water meter, what are flows associated with 5 and 7.5 fps velocity?

Example:

- Calculated flow is:
  - – rule #1: 24 gpm limit
  - – rule #2: 22.5 gpm limit
  - – rule #3: 10 gpm limit
- What is flow capacity for the system?

Calculating working pressure

- Determine the dynamic water pressure at the P-O-C
  – from the source to the P-O-C, calculate the friction losses through all components, take into account any elevation losses or gains, and calculate remaining working pressure.

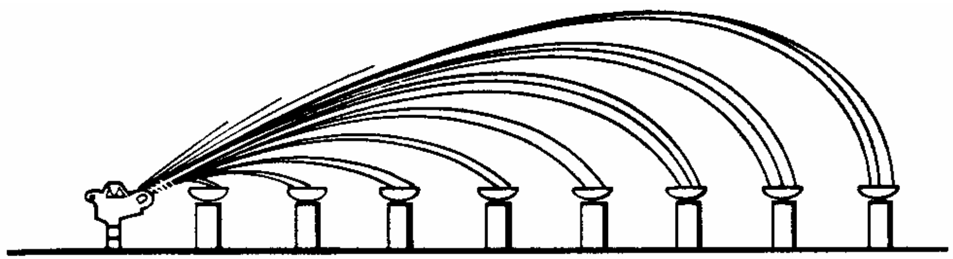
Step 4: Selecting Sprinklers and Spacing Ranges

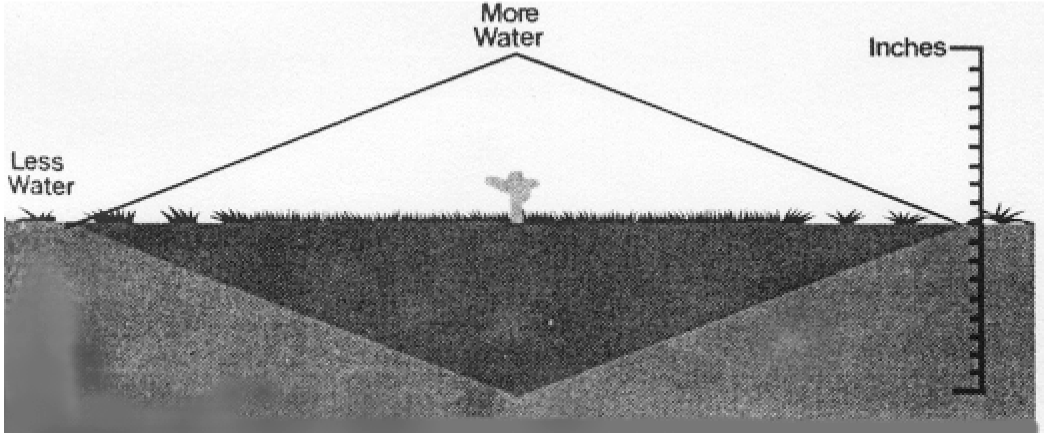
- Types
  - spray sprinklers (fixed-head sprinklers)
    - shrub sprayheads
    - pop-up sprayheads
  - rotating sprinklers
    - impulse or impact sprinklers
    - pop-up gear drive sprinklers
  - bubblers and drip irrigation devices
    - zero-radius or short radius types
    - ultra-low volume types

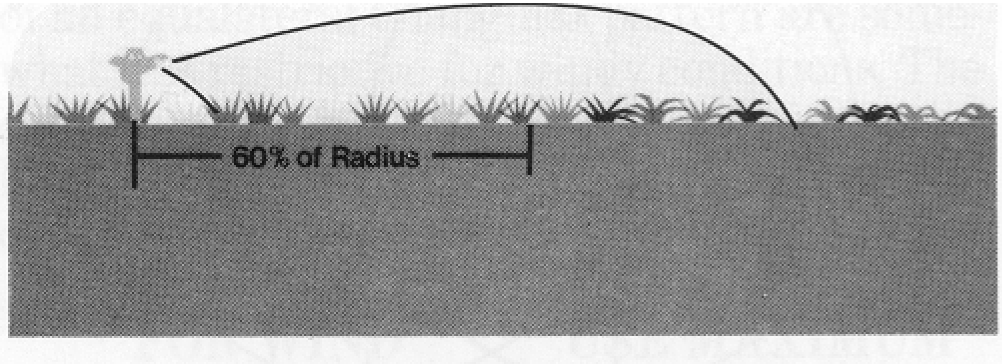
Sprinkler Selection

- Factors to consider
  - size and shape of areas to be irrigated
  - types of plant materials to be irrigated
  - water pressure and flow available
  - local environmental conditions
    - wind, temperature, precipitation
  - soil type and rate at which it can accept water
  - compatibility of sprinklers to be grouped

Sprinkler - Water Distribution

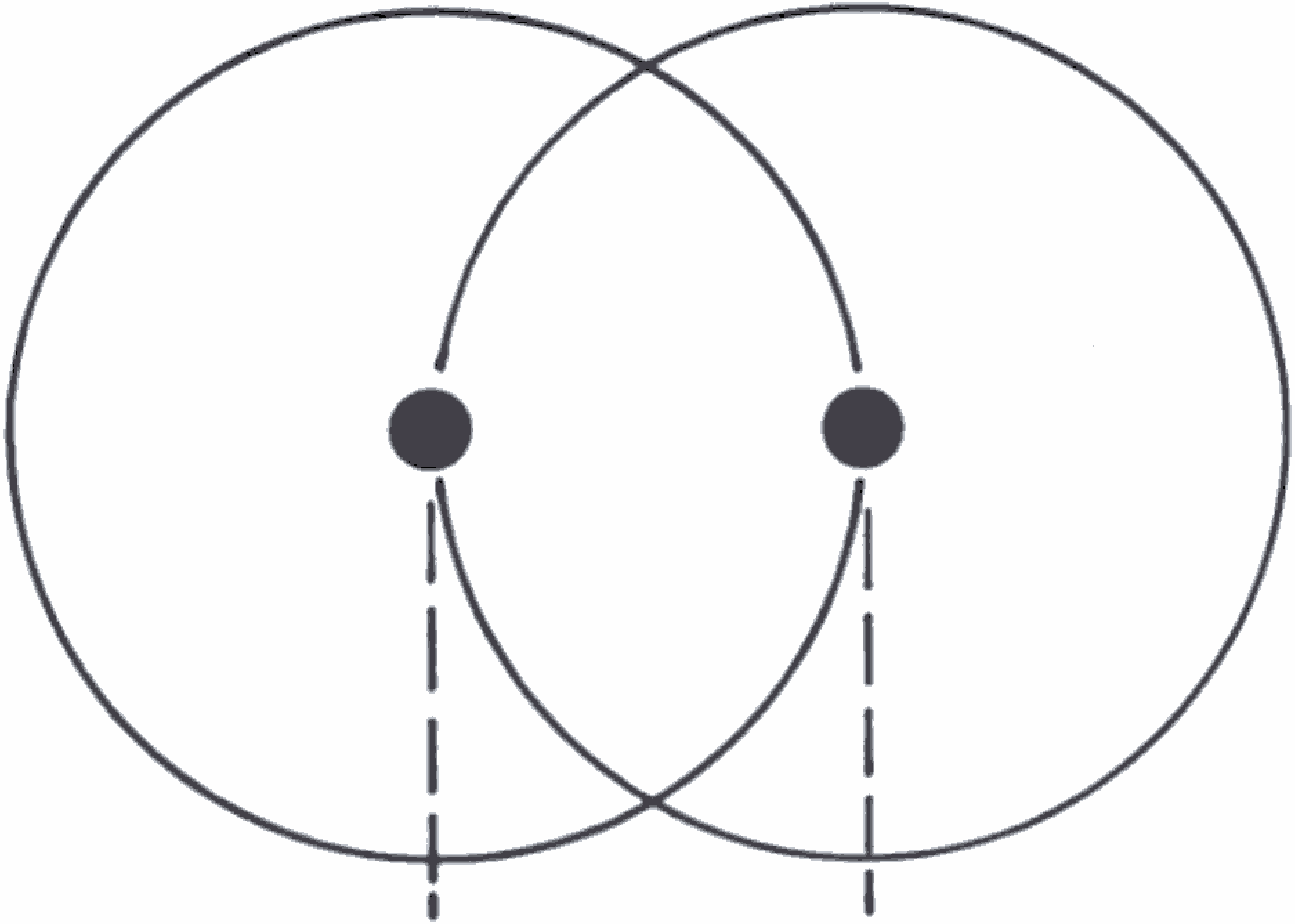






Sprinkler Spacing

- Maximum spacing recommended is 60% of the diameter.
- In cases where very coarse soil, high winds, low humidity, or high heat inhibit effective irrigation, use head-to-head spacing (50% diameter).

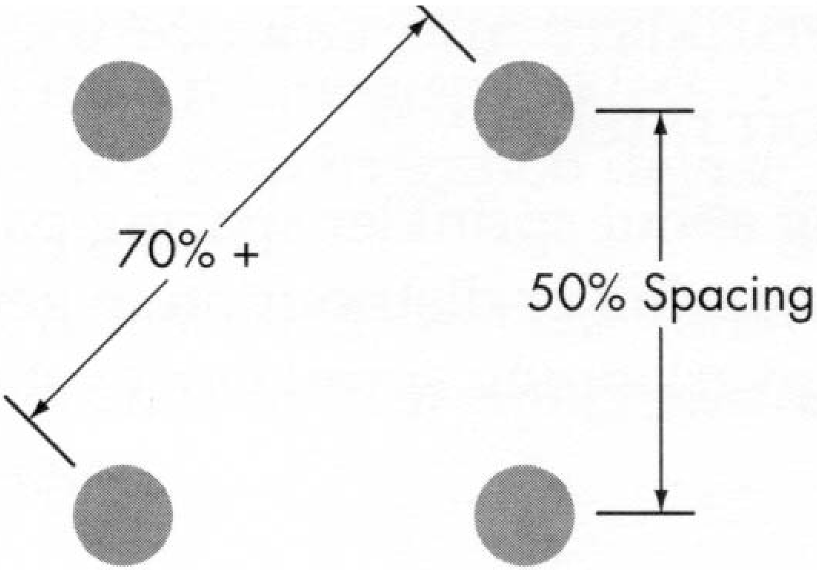


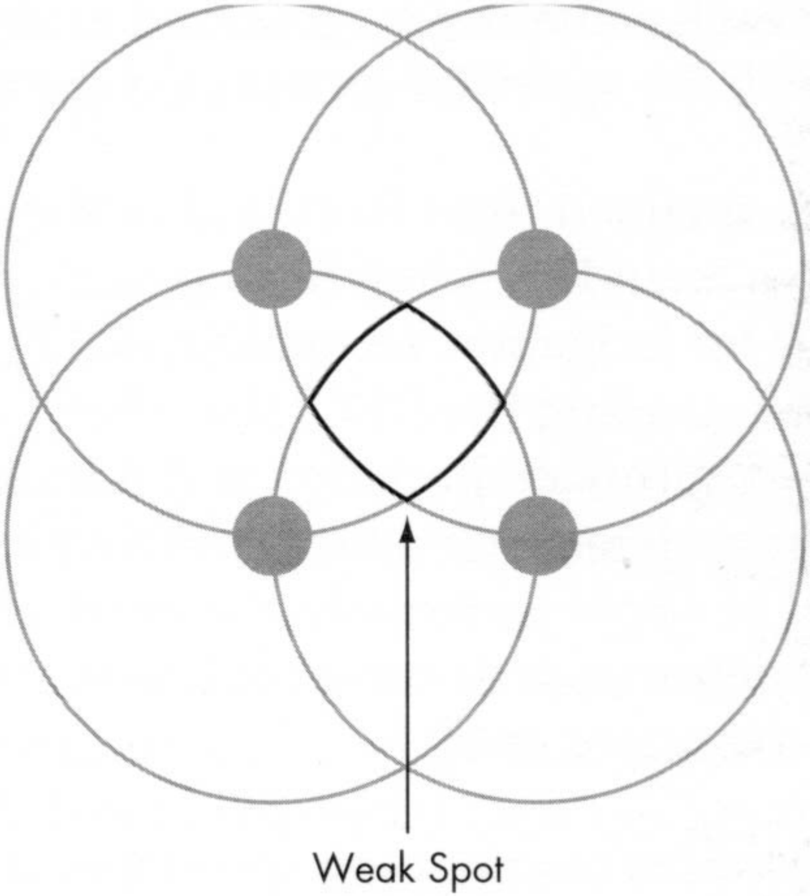
50% SPACING (HEAD-TO-HEAD)

Sprinkler Spacing Patterns

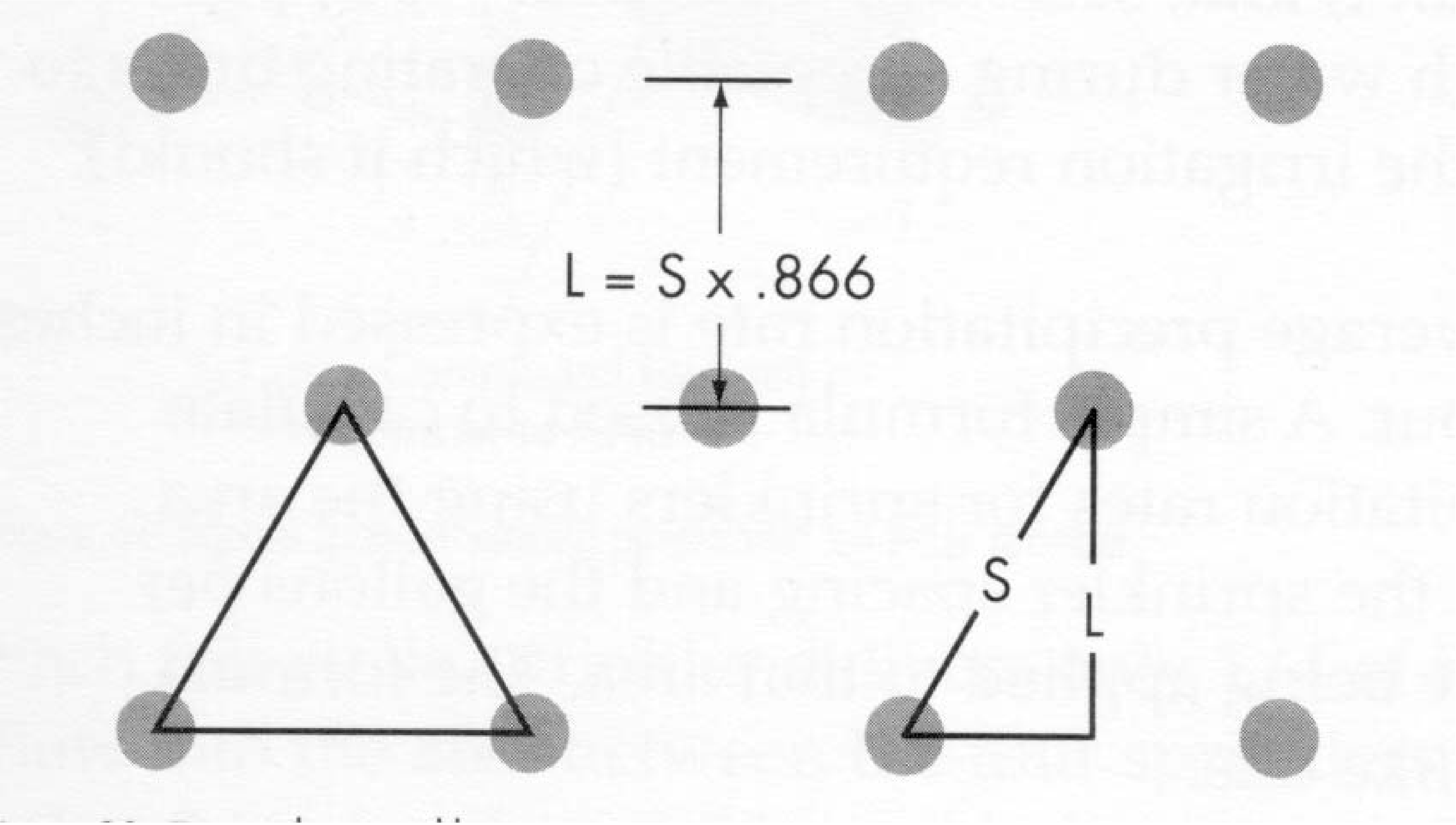
- Square
- Triangular
- Rectangular
- Sliding

Square pattern

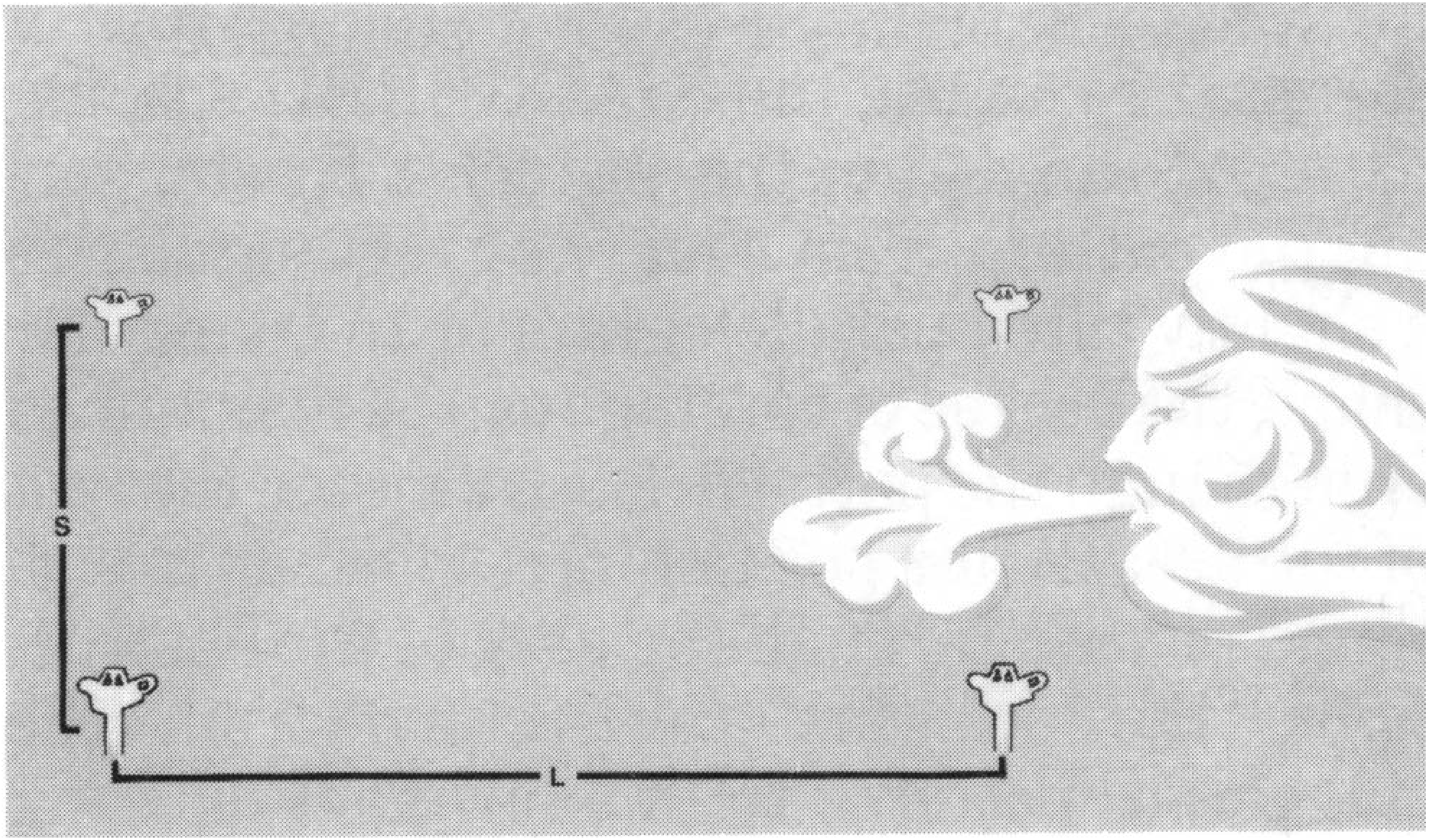




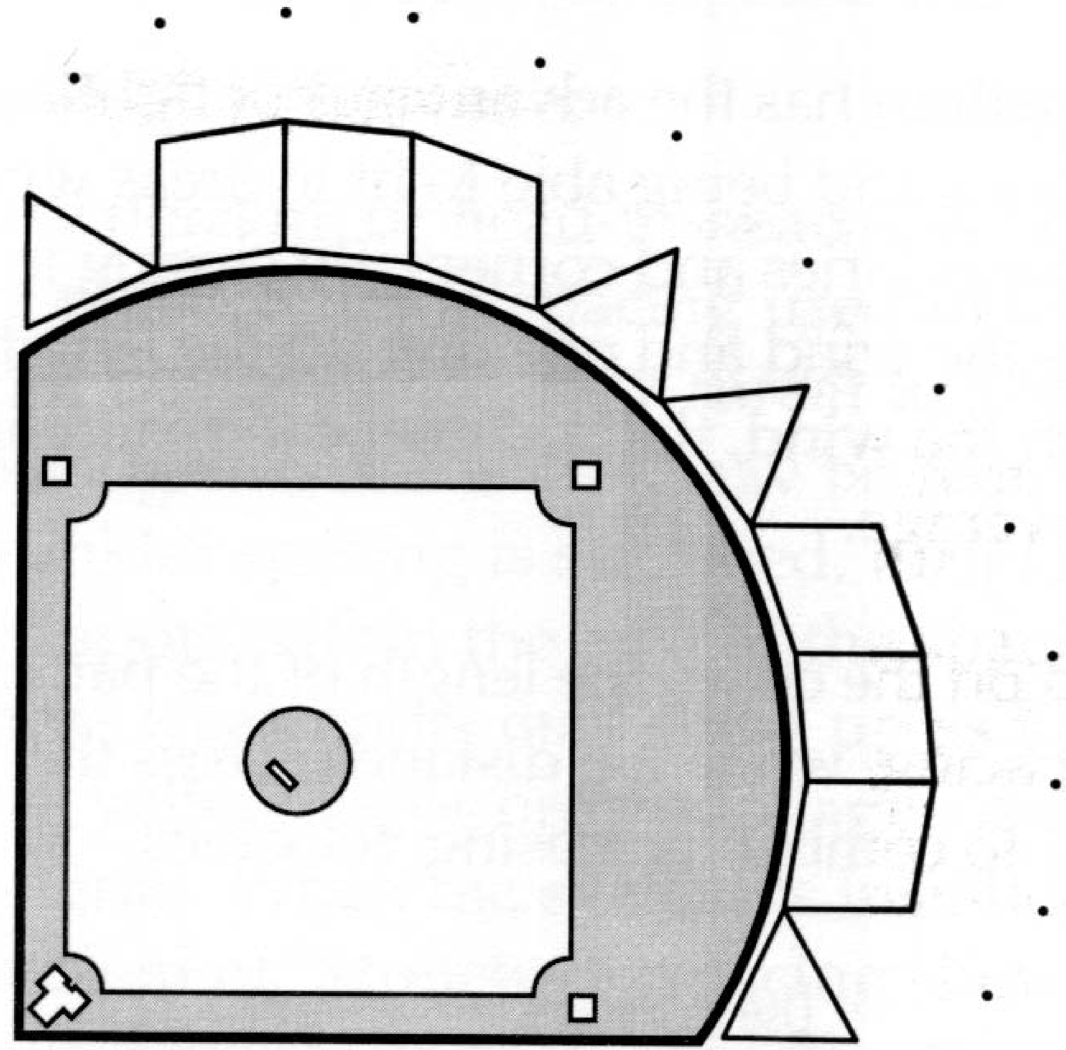
Triangular pattern



Rectangular pattern



Sliding pattern



Sprinkler Spacing in Windy Conditions

Wind Velocity	Max Spacing Square	Max Spacing Triangle
0 to 3 mph	55% of diam.	60% of diam.
4 to 7 mph	50% of diam.	55% of diam.
8 to 12 mph	45% of diam.	50% of diam.

Precipitation Rate

(or how fast you apply the water)

- Expressed in inches per hour
- Determines if the rate exceeds the soil's absorption rate.
- Determines if the rate will apply enough water during water times to meet irrigation requirement.
- Need to know
  - total gallons per minute applied by sprinklers
  - spacing between sprinklers
  - spacing between rows of sprinklers

Precipitation Rate

$$PR = \frac{96.3 * GPM \text{ (applied to area)}}{S * L}$$

Where:

PR = average precipitation rate, in/hr

GPM = total gallons per minute applied to area by sprinklers

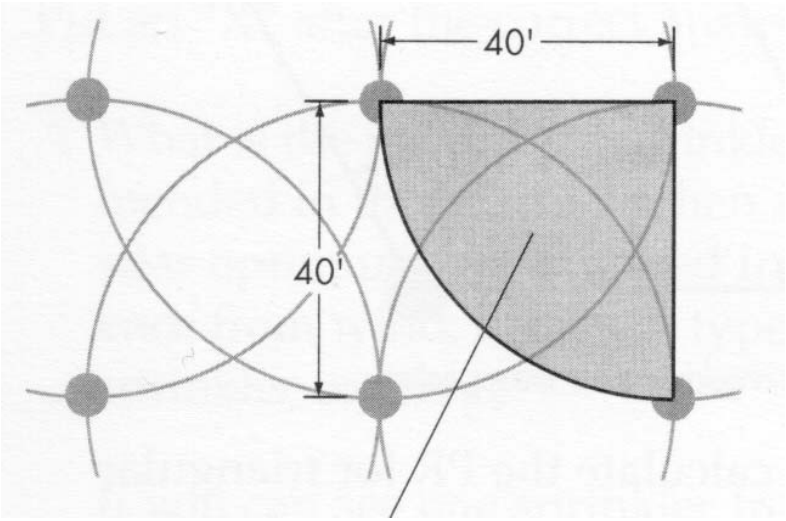
S = spacing between sprinklers

L = spacing between rows of sprinklers

Precipitation Rate

Example 1:

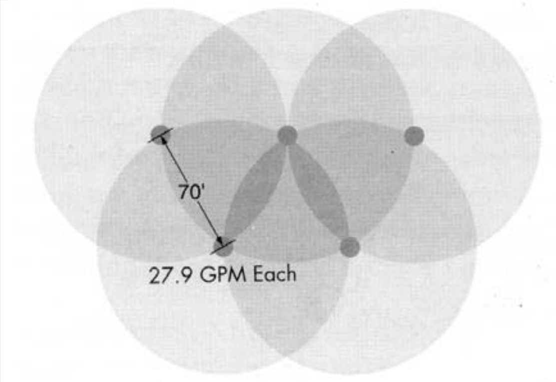
Four full-circle impact sprinklers each with a radius of throw of 40 feet at 40 psi, a discharge of 4.4 gpm, and a square spacing of 40-foot.



Precipitation Rate

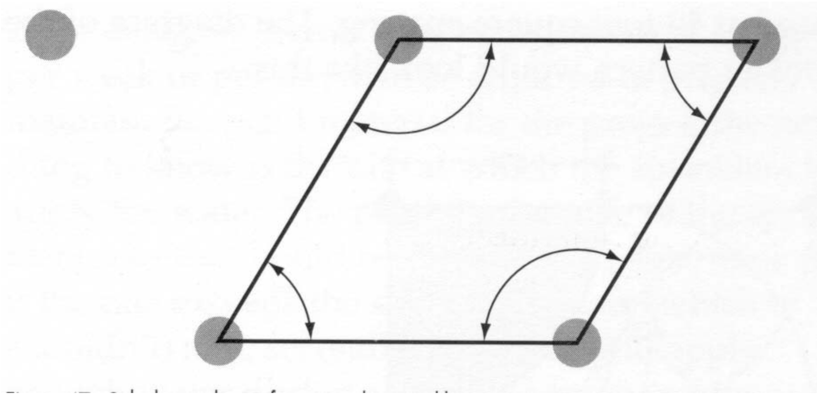
Example 2:

Large-size rotor pop-up sprinklers spaced head-to-head at 70’ in a triangular pattern. The flow from each full-circle sprinkler is 27.9 gpm. What is the PR?



Precipitation Rate

Example 2: Solution



Locating Sprinklers on the Plan

Why is this step important?

-
-
-

The goal of sprinkler positioning is to make sure all irrigated areas have adequate sprinkler coverage!!!

Locating Sprinklers on the Plan

Remember:

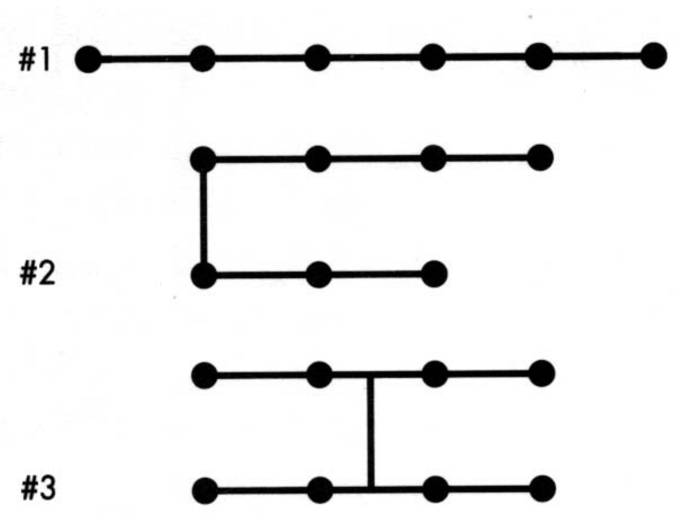
- Begin laying out sprinklers in troubled areas first.
- Wherever possible, use the same type of sprinklers over a given area.
- After locating all the sprinklers on the plan, visually check entire system for proper spacing and good coverage.

Step 5: Lateral Layout, Circuiting Sprinklers into Valve Groups

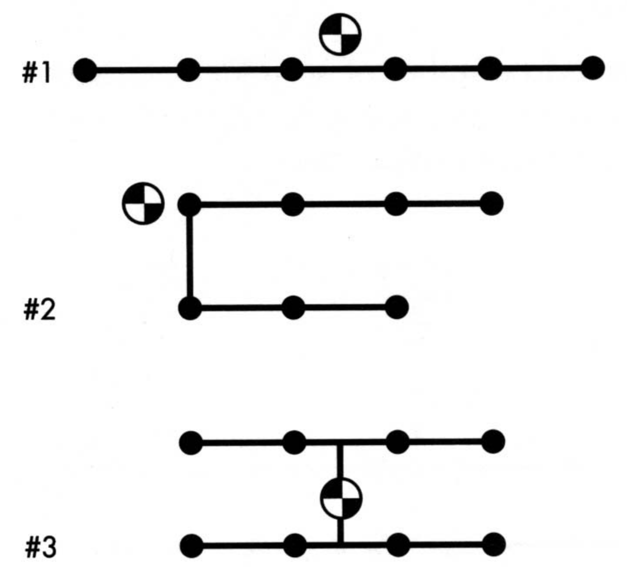
- Add up the flows of similar sprinklers in each area -- this would be the "valve group"
  - keep the total flow in each group equal to or less than the available flow for irrigation calculated in step 3
  - consider micro-climate conditions, vegetation heights

Circuit configurations

- Straight line lateral circuit



- Split-length lateral circuit



Calculating lateral operating time

- Why do we *need* to do this?

- How
  - determine the daily water time (minutes) each circuit will need to run to satisfy the weekly irrigation needs of the plants

Calculating lateral operating time

$$OT = \frac{I \times 60}{PR \times DA}$$

Where:

OT = circuit operating time, min/d

I = system irrigation requirement, in/wk

PR = circuit precipitation rate, in/hr

DA = days available for irrigation per week

Example 1

The system irrigation requirement is 1.5 inches per week, you can water 3 days per week, sprinklers put out 3.5 gpm in a full-circle radius of 14 ft, and the sprinkler spacing is 13 x 15 ft rectangular.

Example 2

The system irrigation requirement is 1.5 inches per week, you can water 3 days in the week, sprinklers put out 4.5 gpm in a full-circle radius of 40 ft, and the sprinkler spacing is 40 x 45 ft rectangular.

Step 6: Sizing Pipe and Valves & Calculating System Pressure Requirements

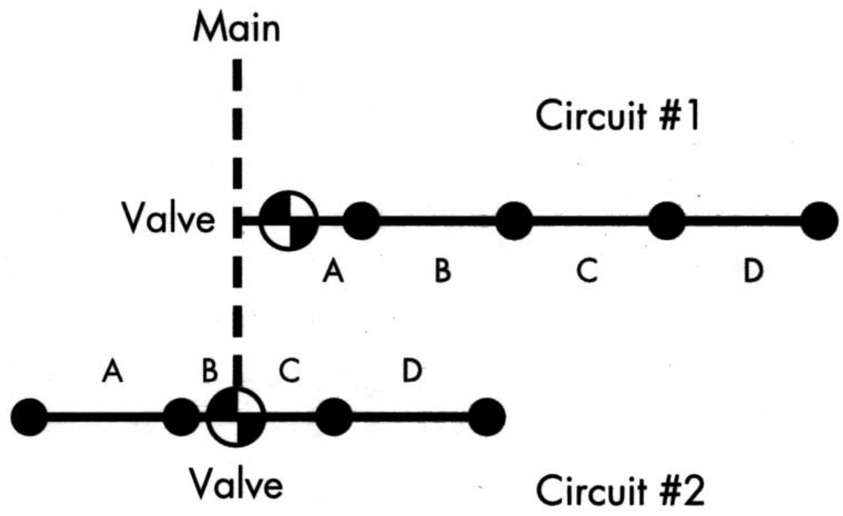
- Need to ensure adequate flow and pressure within system to properly operate all sprinklers on the project
- Use the 5 fps rule to determine pipe sizing

What was the 5 fps rule, and why was it important?

Sizing Pipe Process

- pipe sizing for a sprinkler lateral is done in reverse
- first pipe to be sized is the pipe reach supplying the last or furthest sprinkler from the valve
- critical circuit length

Example



Each circuit has:

4 medium-sized rotor pop-up sprinklers, that throw 47 ft radius at 55 psi and require 9.8 gpm each.

Example, continued

- How big should the main line be?

Sizing Lateral Valves

Guidelines

- flow through valve should not produce loss greater than 10% of static water pressure available in main line
- valve should either be same size as largest pipe in lateral it serves, or no more than 1 nominal size smaller than pipe.
- Valve should not be larger than pipes in lateral unless a high flow results from split lateral

Sizing Valves Process

- Use guidelines
- Data needed
  - static pressure at meter
  - elevation changes through main
  - pipe sizes in circuit that each valve serves

Determining the System's Total Pressure Requirement

WHY? -- Simply to determine if the system will work!!

$$Pr = Ps - (Po + Pls)$$

Pr = pressure remaining after satisfying total system requirement

Ps = static water pressure

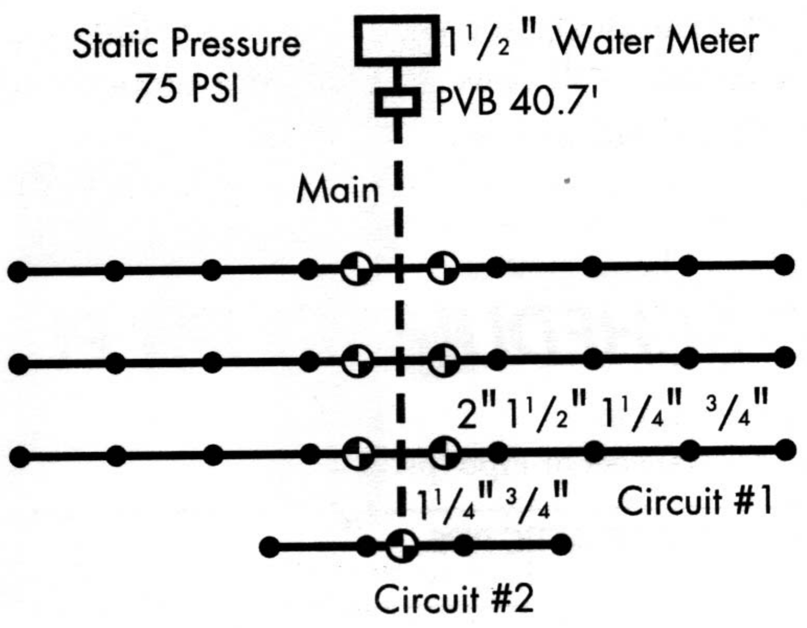
Po = operating pressure for "worst case" sprinkler

Pls = pressure loss through system main line and "worst case" lateral circuit

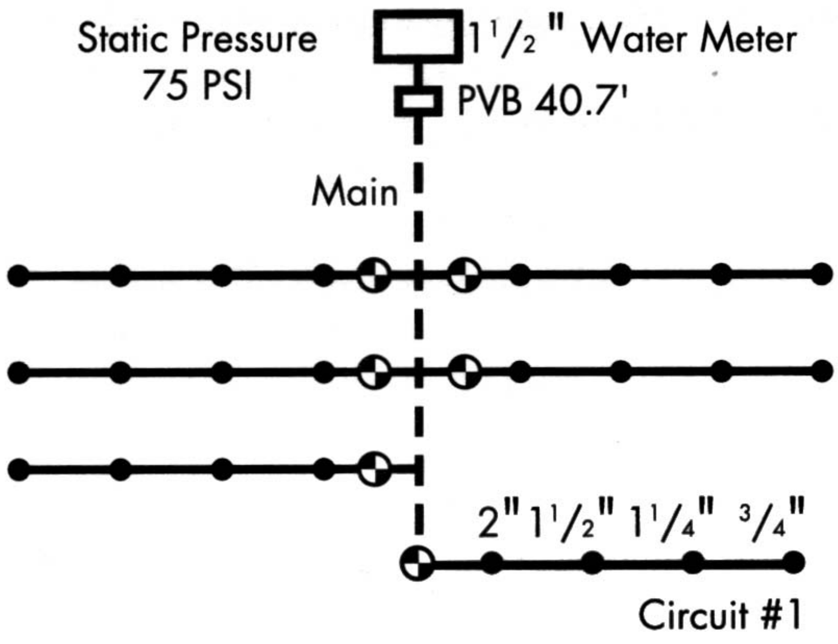
Determining System Total Pressure Requirement Process

- Find “worst case” lateral
- Find “worst case” sprinkler

Example



Static Pressure
75 PSI
1 1/2" Water Meter
PVB 40.7'
Main
2" 1 1/2" 1 1/4" 3/4"
1 1/4" 3/4"
Circuit #1
Circuit #2



Static Pressure
75 PSI
1 1/2" Water Meter
PVB 40.7'
Main
2" 1 1/2" 1 1/4" 3/4"
Circuit #1

Step 7: Locating the Controller and Sizing Valve and Power Wires

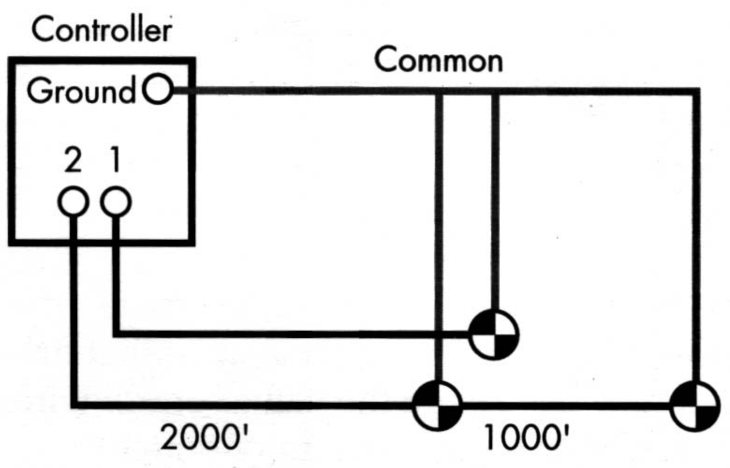
- Locating the controller
  - locate controller centrally to valve group to minimize lengths of field wires to valve
  - locate in pairs or groups to minimize the length of power supply lines
  - locate away from direct water spray

Sizing Valve Wires

- Always check local electrical codes
- Valve wires usually carry only 24 VAC, are buried (and if buried require UF labeled wire)
- Higher pressure at valve, more power it takes to raise plunger
  - therefore, static water pressure important when sizing valve control wires

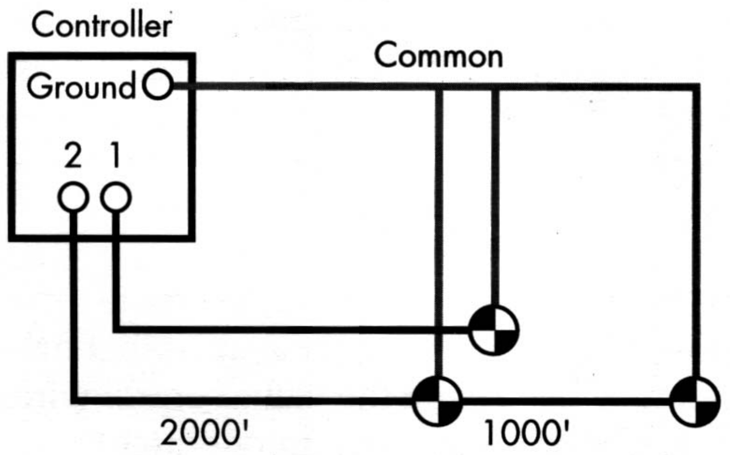
Sizing Valve Wire Process

1. Determine actual wire run distance (feet) from the controller to the first valve on a circuit and between each of the other valves on a multiple valve circuit.



Sizing Valve Wire Process

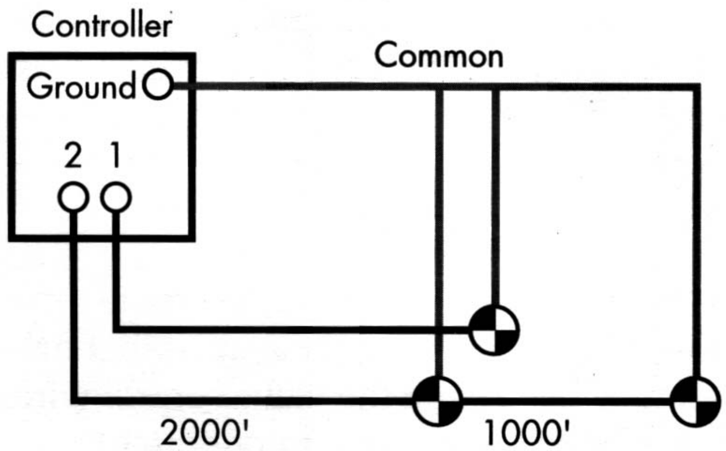
2. Calculate the "equivalent circuit length" for each valve circuit.



Sizing Valve Wire Process

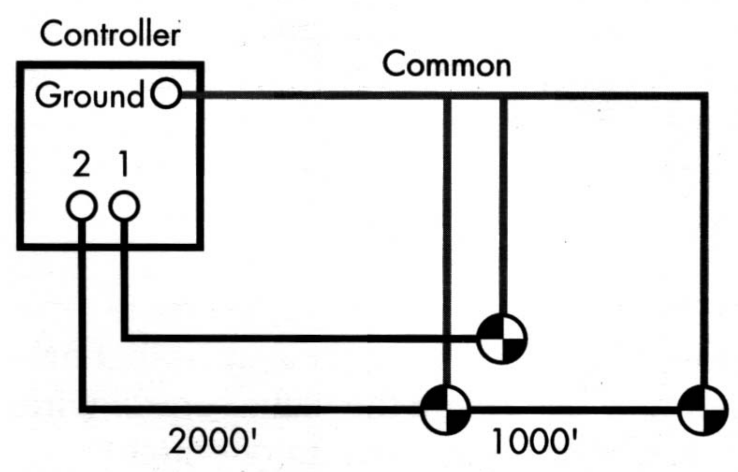
3. From the Rain Bird wire sizing chart, select the common and control wire sizes for the circuit with the highest equivalent circuit length (the “worst case” circuit).

Note: wires should be same size or no more than one size apart; larger one is to be used as the common wire



Sizing Valve Wire Process

4. Having the common wire established, use the wire sizing chart to determine the control wire size for each of the remaining valve circuits on the controller.

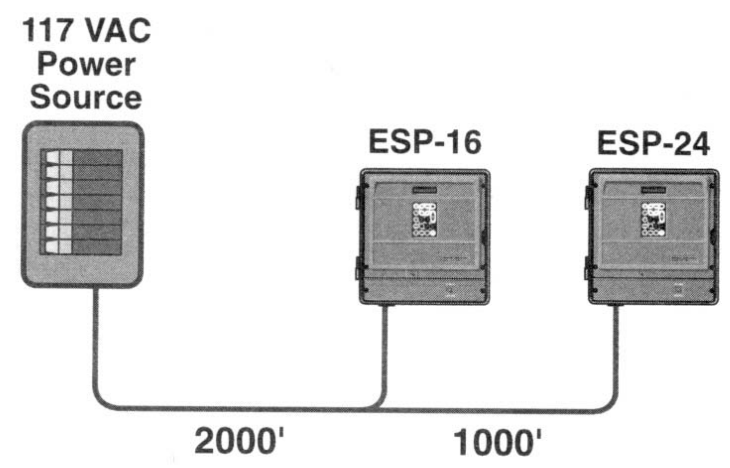


Sizing Controller Supply Wires

- Factors affecting size of wire
  - available voltage at power source
  - distance from the power source to the controllers
  - minimum voltage required to operate the controller
  - power required by type of valve used
  - number of valves used on any one station
  - number of controllers operating at one time

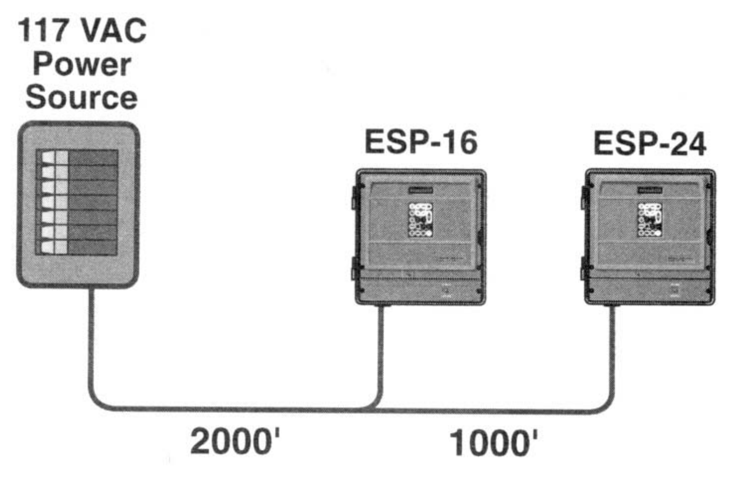
Sizing Controller Supply Wire Process

1. Using Rain Bird chart for power wire sizing, determine the power requirements for the controller selected along with the requirements for the number of solenoid valves that will be operating at one time.



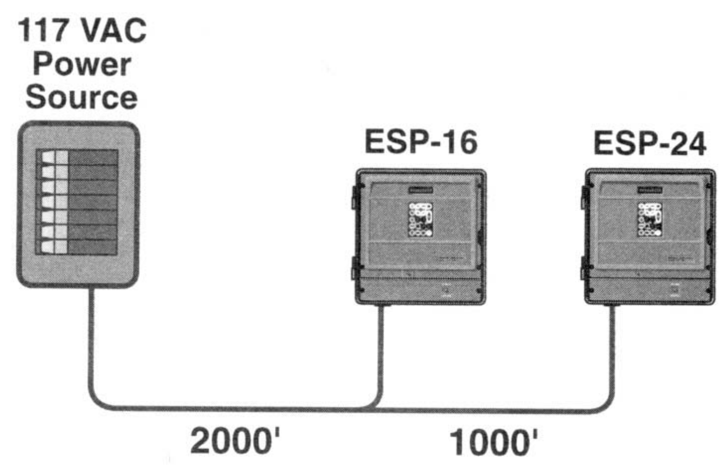
Sizing Controller Supply Wire Process

2. Determine the maximum allowable voltage drop along the wires from the power source to the controllers.



Sizing Controller Supply Wire Process

3. Calculate the equivalent circuit length for the power wire and controller(s).

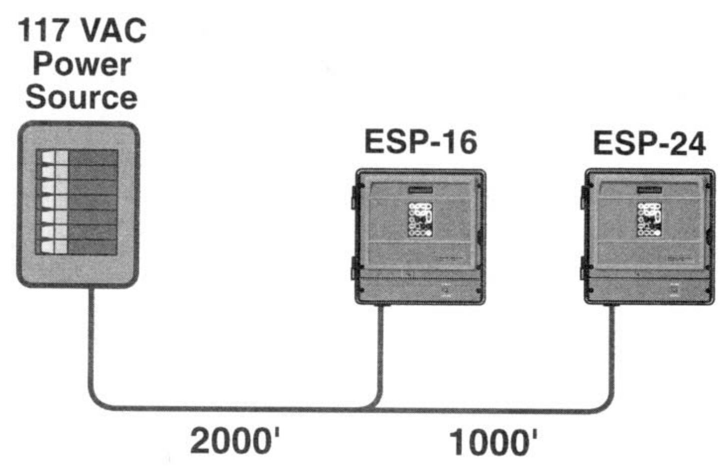


Sizing Controller Supply Wire Process

4. Using the formula below, calculate the F factor for the circuit.

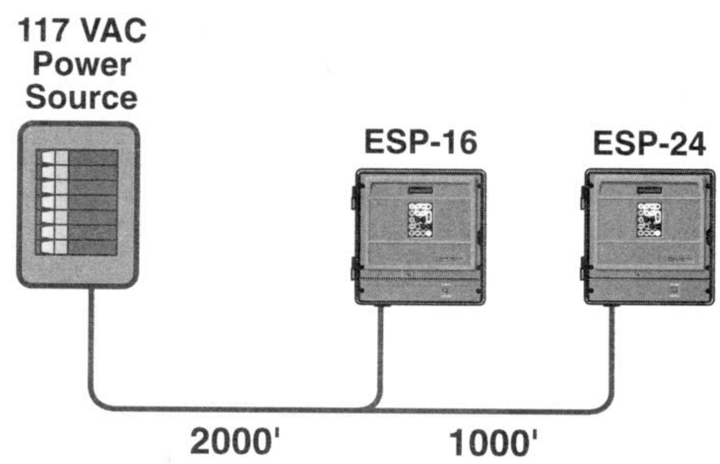
$$F = \frac{\text{allowable voltage drop}}{\text{amps/control unit} \times \text{equivalent length}}$$

Note: equivalent length is in 1000s of feet



Sizing Controller Supply Wire Process

5. Select a power wire size from Rain Bird chart that has an F factor *equal to or less than* the calculated F factor.



Step 8: Preparing Final Irrigation Plan

- Diagram representing what the sprinkler system should look like *after* installation
  - be readable, usable, drawn to convenient scale
  - contain *detailed* legend explaining all symbols used in drawing
  - show any major elevation changes
  - show ALL water and power utility locations

Proper design and operation of irrigation systems require ...

- experience
- science
- art!!!