TEXAS A&M AGRILIFE EXTENSION

Efficient Irrigation System Design

1

Agenda

- TCEQ Rules for Design
- Zoning Principles
- Basic Pressure Concepts
- Pressure Regulation
- Comparison of Spray Vs. Rotors
- Drip Irrigation
- Piping System & Components
- Tools and Software

2

WHAT IS DESIGN??

3

TCEQ Definition: Design

- The act of determining the various elements of a landscape irrigation system that will include, but not limited to, elements such as:
  - Collecting site specific information
  - Defining the scope of the project
  - Defining plant watering needs
  - Selecting and layout out emission devices
  - Locating system components
  - Conducing hydraulics calculations
  - Identifying any local regulatory requirements
  - Scheduling irrigation work at a site

4

Overview

Irrigation Designs

- Physical Design
  - TCEQ/Municipal Rules Tell Us What is Needed
- Implementation and Thought Process Behind The Design
  - Producing the Best Design Possible

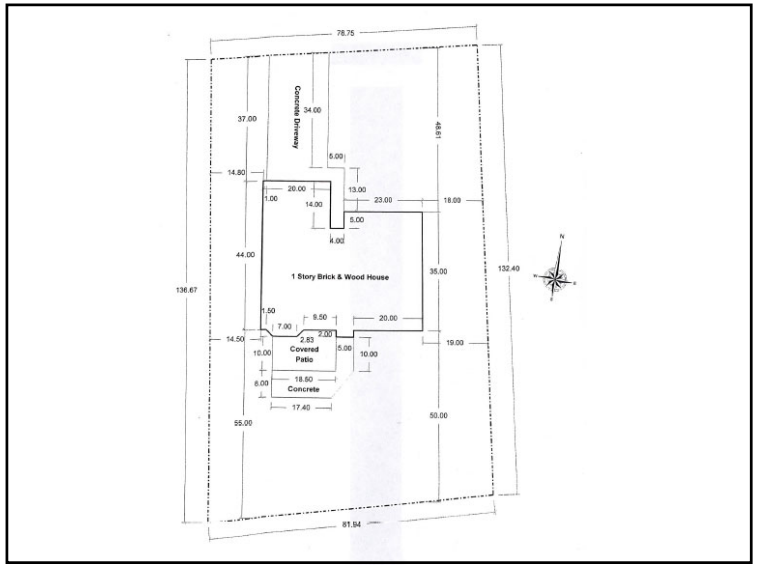
"*Only as Efficient as the person behind the design, installation and management*"

5

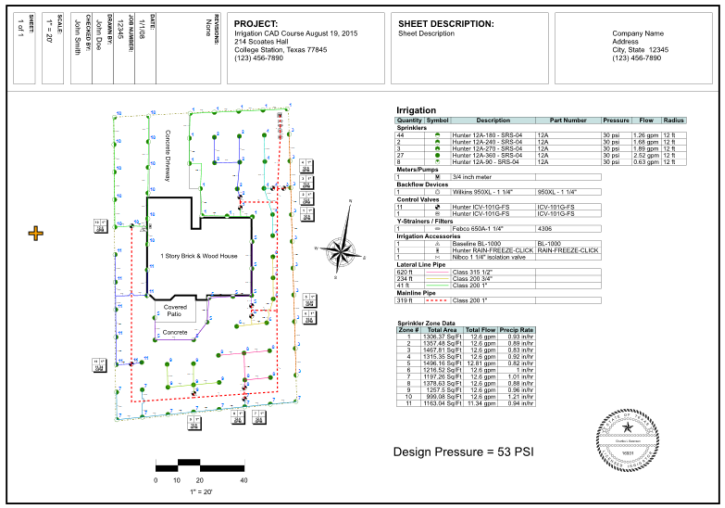
Review of Irrigation System Plan (Design) Requirements

- Irrigators Seal, Signature and Date of signing
- All physical feature and boundaries to watered
- North Arrow
- Legend
- Zone Flow Measurement
- Controller & Sensor
- Water Source & Backflow
- Emission Devices (Sprinklers, Drip, Bubblers, Etc.)
- Valves: Isolation, Zone & Master Valve
- Mainline & Lateral Piping
- Scale
- Design Pressure

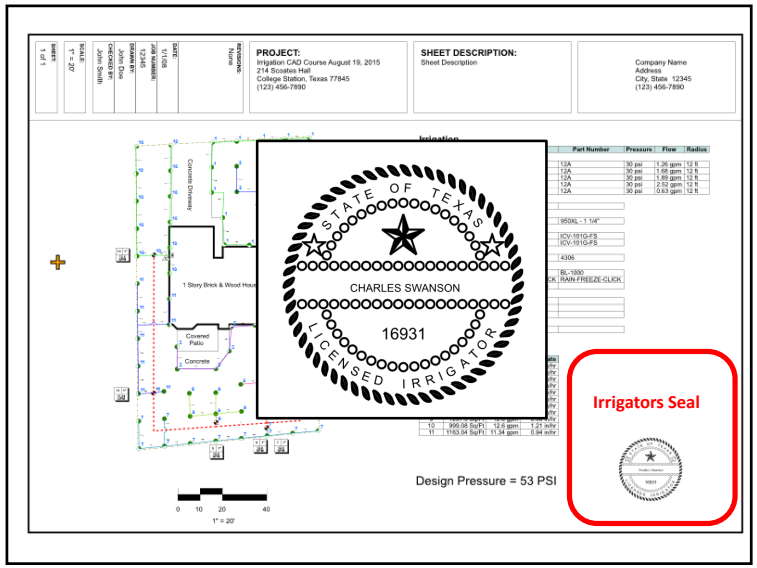
6



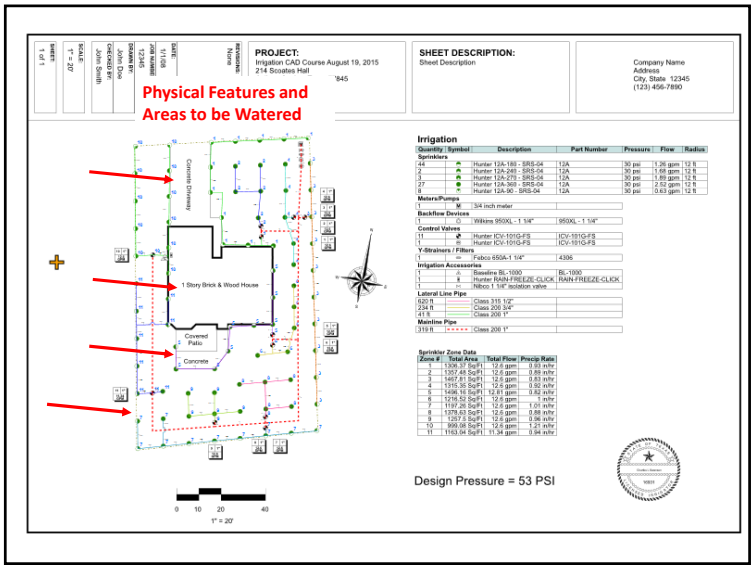
7



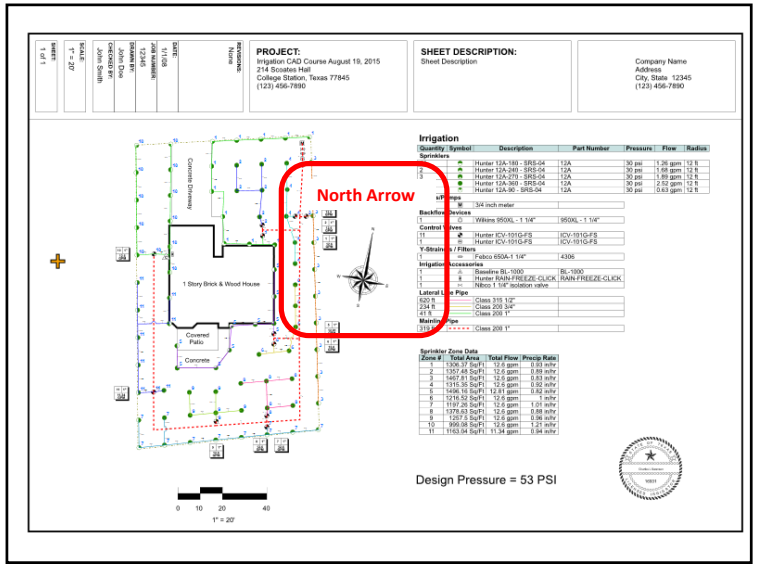
8


PROJECT:
Irrigation CAD Course August 19, 2015
214 Scoates Hall
College Station, Texas 77845
(123) 456-7890
SHEET DESCRIPTION:
Sheet Description
Company Name
Address
City, State 12345
(123) 456-7890
STATE OF TEXAS
CHARLES SWANSON
16931
LICENSED IRRIGATOR
Irrigators Seal
Design Pressure = 53 PSI

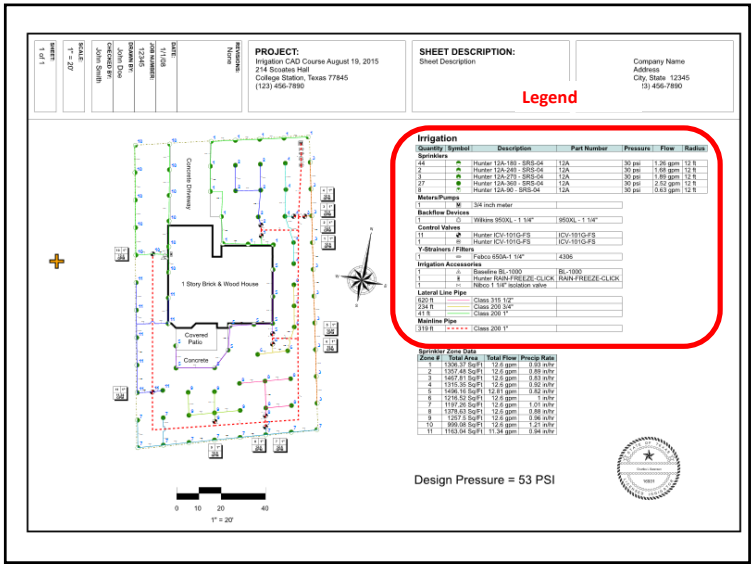
9


Physical Features and Areas to be Watered
PROJECT:
Irrigation CAD Course August 19, 2015
214 Scoates Hall
SHEET DESCRIPTION:
Sheet Description
Company Name
Address
Irrigation
Design Pressure = 53 PSI

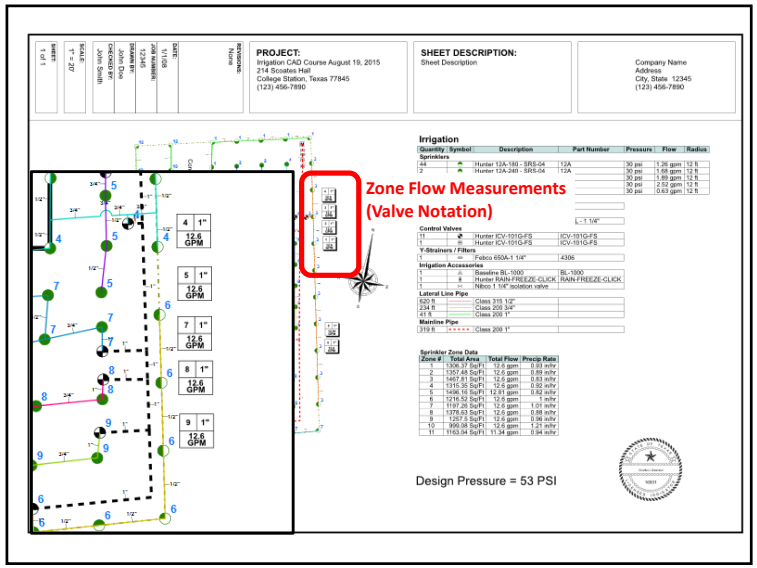
10


North Arrow
PROJECT:
Irrigation CAD Course August 19, 2015
214 Scoates Hall
College Station, Texas 77845
(123) 456-7890
SHEET DESCRIPTION:
Sheet Description
Company Name
Address
City, State 12345
(123) 456-7890
Irrigation
Design Pressure = 53 PSI

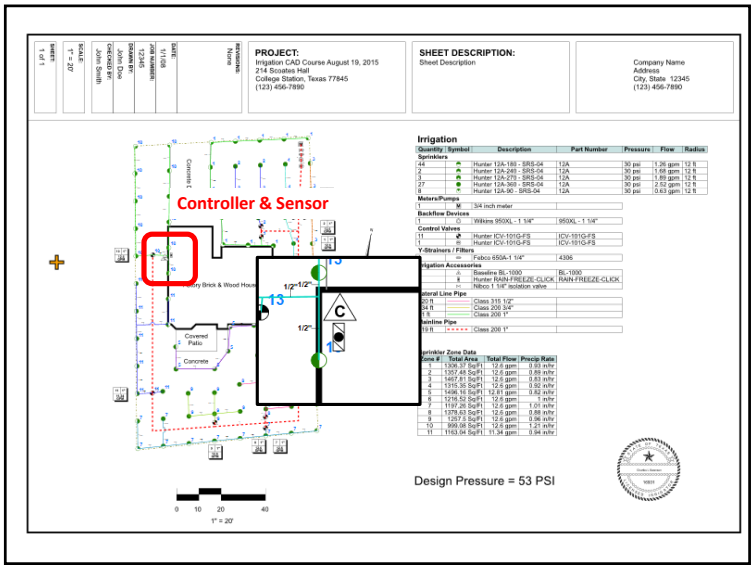
11


Legend
PROJECT:
Irrigation CAD Course August 19, 2015
214 Scoates Hall
College Station, Texas 77845
(123) 456-7890
SHEET DESCRIPTION:
Sheet Description
Company Name
Address
City, State 12345
Irrigation
Design Pressure = 53 PSI

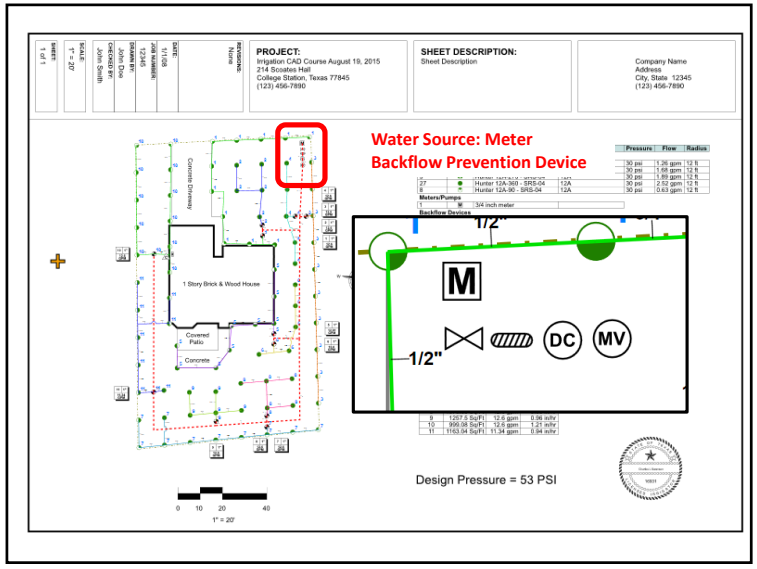
12


Zone Flow Measurements
(Valve Notation)
Design Pressure = 53 PSI

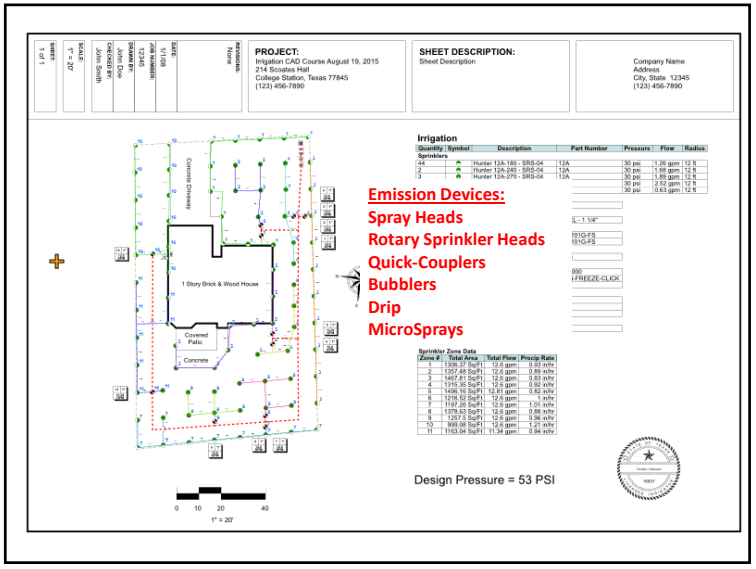
13


Controller & Sensor
Design Pressure = 53 PSI

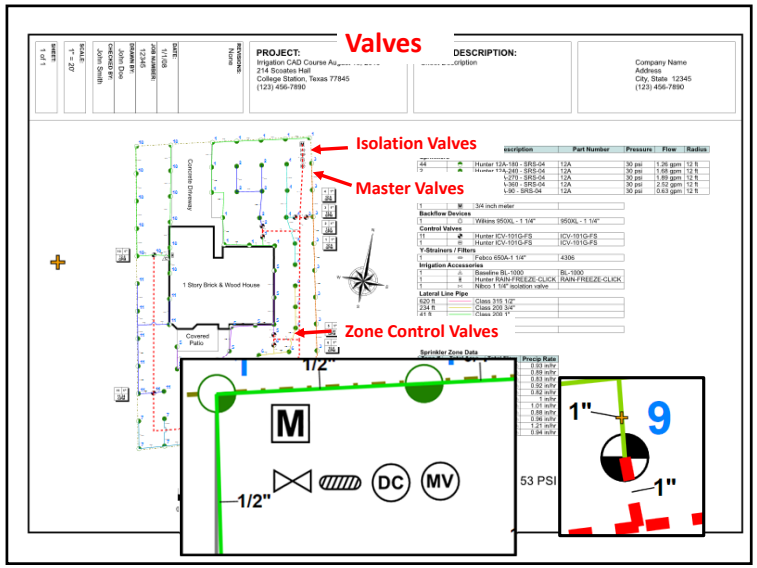
14


Water Source: Meter
Backflow Prevention Device
M
1/2"
DC
MV
Design Pressure = 53 PSI

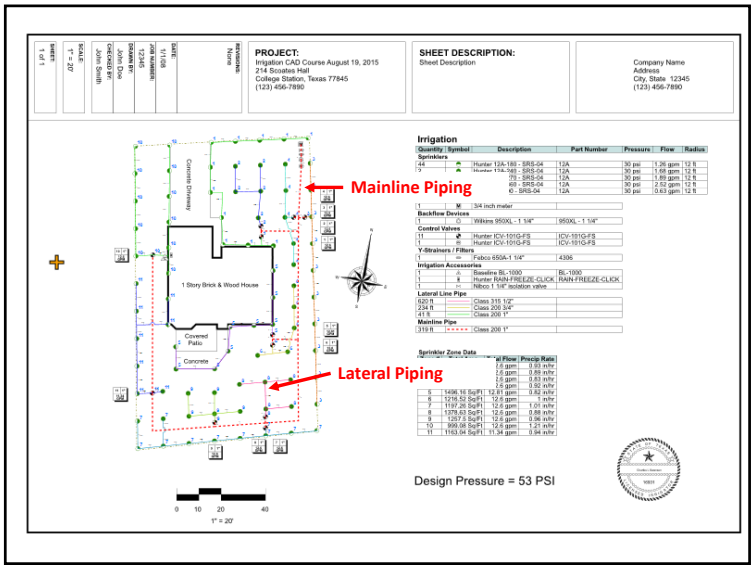
15


Emission Devices:
Spray Heads
Rotary Sprinkler Heads
Quick-Couplers
Bubblers
Drip
MicroSprays
Design Pressure = 53 PSI

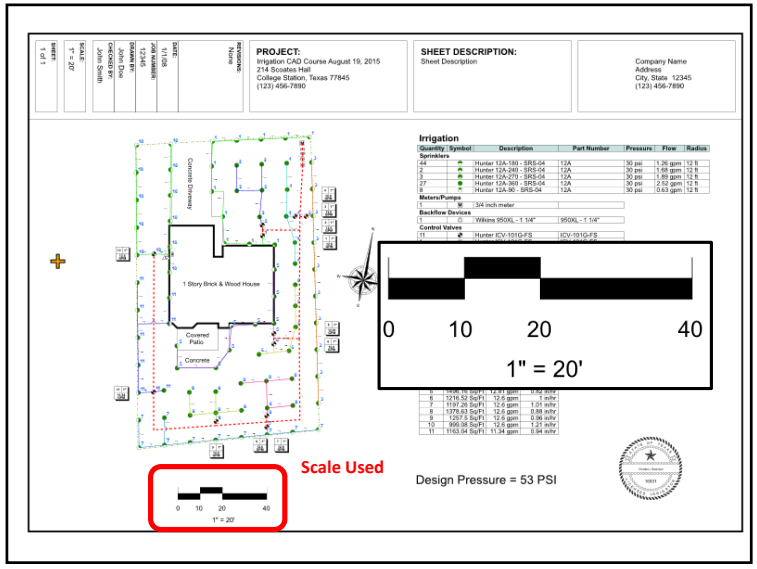
16


Valves
Isolation Valves
Master Valves
Zone Control Valves
1 Story Brick & Wood House
Covered Patio
Concrete Driveway
1/2"
M
1/2"
DC
MV
53 PSI
1"
9
1"

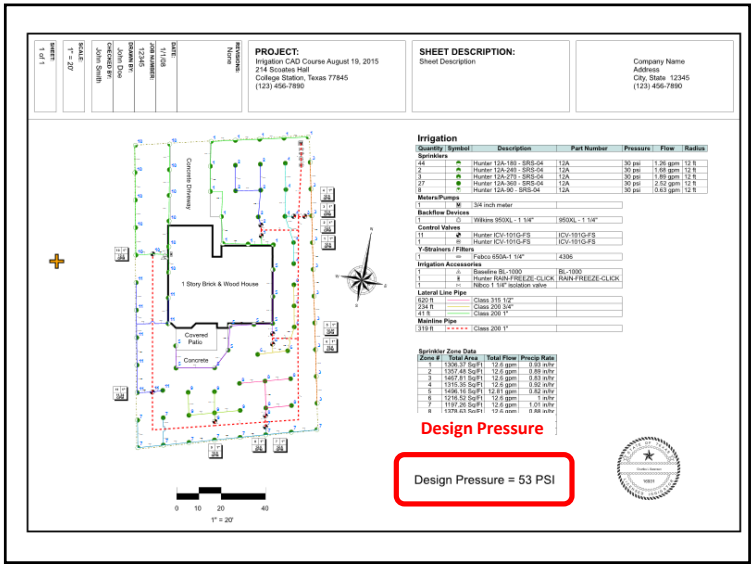
17


Mainline Piping
Lateral Piping
1 Story Brick & Wood House
Covered Patio
Concrete
Design Pressure = 53 PSI

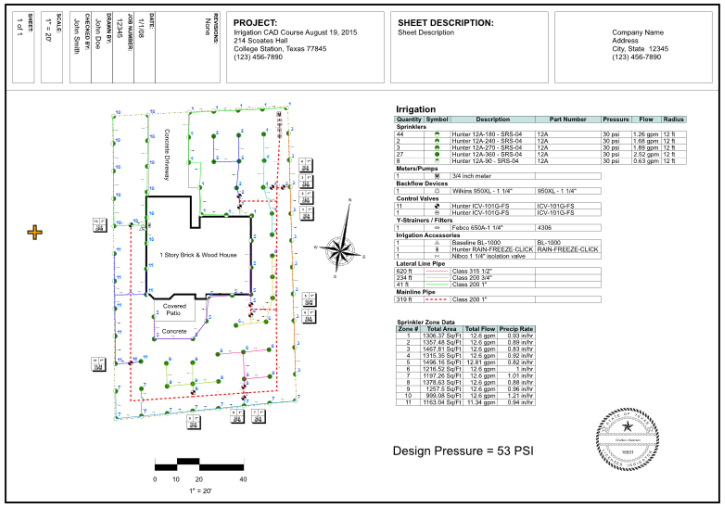
18


1 Story Brick & Wood House
Covered Patio
Concrete
0
10
20
40
1" = 20'
Scale Used
Design Pressure = 53 PSI

19


1 Story Brick & Wood House
Covered Patio
Concrete
Design Pressure
Design Pressure = 53 PSI

20



21

Minimum Standards for the Design of the Irrigation Plan

- Defined by TCEQ Chapter 344.61
- Local Ordinances may have more stringent standards
  - All Cities over 20,000 must have irrigation ordinances
  - Contact water provider or municipality for a copy

22

Minimum Design and Installation Requirements

- Defined by TCEQ Chapter 344.62
  - No irrigation design or installation shall require the use of any component, including the water meter, in a way which exceeds the manufacturers published performance limitations for the component
    - Be familiar with manufacturers product literature

23

Minimum Design and Installation Requirements

- Spacing
  - Must not exceed manufacturers published radius or spacing of a device
  - No above ground spray devices in areas less than 48 inches
    - Many ordinances exceed this
  - Some areas may be exempt if the runoff drains into a landscaped area

24

48 Inch Rule, 5+ ft Rule?

- Example: the landscape between roads and sidewalks




25

Minimum Design and Installation Requirements

- Water Pressure
  - Must operate at the minimum and not above the maximum based on the nozzle and spacing used
- Piping
  - Designed not to exceed 5 ft/s for PVC pipe

26

Minimum Design and Installation Requirements

- Irrigation Zones
  - Irrigation system shall have separate zones based on:
    - Plant Material Type
    - Microclimate Factors
    - Topographic Features
    - Soil Conditions
    - Hydrological requirements
  - Often referred to as “hydrozones”

27

Minimum Design and Installation Requirements

- Matched Precipitation Rate
  - Zones must be designed so all devices in the zone irrigate at the same precipitation rate

28

Minimum Design and Installation Requirements

- Overspray
  - Cannot spray over surfaces made of :
    - Concrete
    - Asphalt
    - Brick
    - Wood
    - Stone set in mortar
    - Or any other impervious material (walls, fences, sidewalks, streets, ect….)

29

ZONING

30

ZONE VS STATION

31

Zoning

- Zone (regulations refer to as HYDROZONING) defines:
  - Plant water needs
  - Soil characteristics
  - Seasonal growth response
  - Maintenance requirements
  - Exposure to sun
  - Size & Shape of landscape

32

How many zones?

33

Station

- A station is defined by
  - Available Flow (GPM)
  - Available Pressure (PSI)
  - Application device
    - Spray, rotor, drip, ect?

34

Zoning

- Poor designs will often have multiple zones located within a station
  - Example
    - Irrigating Shrubs, flowers and turf on the same zone
  - Often results in something being over or under watered

35

Zoning

- Characteristics of a poorly zoned landscape:
  - Impractical turf areas
  - Impractical shrub or tree plantings

36

Poor Zoning

37

37

Poor Zoning

38

38

Irrigation Of Hardscapes

- Shall not spray water over surfaces made of concrete, asphalt, brick, wood, stone set in motor or any other impervious material

39

Zoning – Plant Material

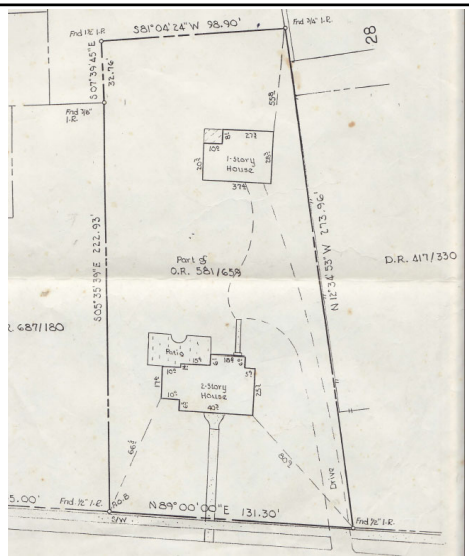
- Often established plants (non-turf) can be zoned into one of 3 categories
  - Frequent Watering
    - Annual Flowers
  - Occasional Watering
    - Perennial Flowers, groundcovers, tender woody shrubs and vines
  - Natural Rainfall
    - Tough woody shrubs and vines, shade trees

40

Site Plans

- Site plans can be useful tools for starting the design process
  - Property CAD / Survey
  - Aerial Photos
    - Ex. Google Earth
    - City Sites
- May be limiting if installing irrigation system prior to landscape design/plant selection
  - Ex. Designing irrigation for builder at new home site.

41



42

Sources: Examples of where to get Orthophotos and GIS Data

- Internet Search Engines – Google it!
  - http://maps.google.com/
- City Pages
  - North Central Texas Council of Governments
    - http://www.nctcog.org/index.asp
    - http://www.dfwmaps.com/
  - City of Austin
    - http://map.mapnetwork.com/destination/austin/

43

Sources: Where to get Aerial Photography and GIS Data

City Pages

- TAMU - http://campusmaps.tamu.edu/
- College Station - http://www.cstx.gov/home/index.asp?page=1996
- Dallas/Fort Worth - http://www.dfwmaps.com/
- San Antonio - http://maps.sanantonio.gov/
- Houston - http://pwegis.pwe.ci.houston.tx.us/
- Austin - http://www.ci.austin.tx.us/maps.htm

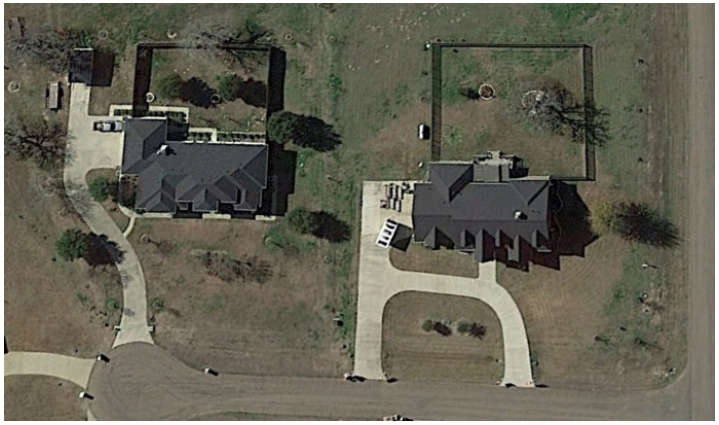
44

Aerial Photography and GIS Data Links

- TNRIS – Texas Natural Resources Information System
  - http://www.tnris.state.tx.us/
- U.S. Census Bureau
  - http://www.census.gov/geo/www/cob/bdy_files.html
- U.S. Geological Survey

45

46



47

48

Defining Plant Watering Needs

- Seasonal Based Irrigation Schedule
  - A seasonal (spring, summer, fall, winter) watering schedule based on either current/real time evapotranspiration or monthly historical reference evapotranspiration data, monthly effective rainfall estimates, plant landscape coefficient factors and site factors
- TexasET Network
  - http://TexasET.tamu.edu

49

Landscape Plant Coefficients

For irrigation scheduling, plants may be classified as:

1) Frequent watering = 0.8
2) Occasional watering = 0.5
3) Natural rainfall = 0.3

50

ASABE Standard Landscape Coefficients

Table 1 – Annual average fraction of ET_o for acceptable appearance of established landscape plants

Plant Type	Recommended Plant Factor
Turf, cool season	0.8
Turf, warm season	0.6
Annual flowers	0.8
Woody plants and herbaceous perennials, wet [1)]	0.7
Woody plants and herbaceous perennials, dry	0.5
Desert plants	0.3

[1)] Tropical plants: for tropical plants with precipitation the majority of months, a plant factor of 0.7 applies. Where monsoonal climates are present, 0.7 applies for the wet season, and 0.5 during the dry season.

51

Landscape Plant Coefficients

- Annual Flowers
  - Grown in a usually formal, high-visibility area for seasonal display of colorful flowers or attractive foliage; often referred to as bedding plants.
- Woody Plants & Herbaceous Perennials
  - Trees, Shrubs, vines, ground cover, and herbaceous perennials adapted to grow in a wet environment (≥ 20 in. of average annual precipitation)
- Desert Plants
  - Plants that can survive a very dry (<10 in. of annual precipitation) environment.

52

TexasET-Historic ETo

Average Monthly ETo (PET)
(inches/month)

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Abilene	2.08	2.57	4.14	5.48	6.47	7.65	8.36	7.46	5.48	4.21	2.67	2.08	**58.65**
Amarillo	1.84	2.27	3.73	5.06	5.89	7.51	8.08	7.29	5.61	4.05	2.4	1.78	**55.51**
Austin	2.27	2.72	4.34	5.27	6.39	7.15	7.22	7.25	5.57	4.38	2.74	2.21	**57.51**
Brownsville	2.65	3.03	4.48	5.17	6.03	6.32	6.68	6.65	5.21	4.34	3.01	2.59	**56.16**
College Station	2.2	2.71	4.22	5.2	6.25	6.89	7.1	6.85	5.6	4.3	2.8	2.2	**56.32**
Corpus Christi	2.42	2.95	4.28	5.17	5.95	6.43	6.68	6.65	5.21	4.34	3.01	2.59	**55.68**
Dallas/Ft. Worth	2.0	2.46	3.96	5.14	6.21	7.06	7.40	7.25	5.49	4.19	2.59	2.10	**55.85**
Del Rio	2.47	3.01	4.76	6.01	6.98	7.41	7.57	7.41	5.77	4.35	2.91	2.36	**61.01**
El Paso	2.74	3.53	6.07	8.19	9.83	11.12	9.19	8.94	7.69	5.89	3.58	2.49	**79.26**
Galveston	2.2	2.6	4.1	5.0	6.11	6.6	6.2	6.0	5.5	4.2	2.8	2.3	**53.61**
Houston	2.36	2.83	4.32	5.01	6.11	6.57	6.52	6.08	5.57	4.28	2.9	2.35	**54.9**
Lubbock	2.35	2.63	4.41	5.53	6.93	7.73	7.63	7.2	5.54	4.19	2.61	2.33	**59.08**
Midland	2.2	2.78	4.46	5.91	7.21	8.2	9.23	8.62	6.95	4.31	2.78	2.16	**64.81**
Port Arthur	2.25	2.63	3.95	5.09	6.12	6.6	5.81	5.61	5.46	4.18	2.76	2.23	**52.69**
San Angelo	2.88	3.13	5.31	7.01	8.48	9.16	9.29	8.49	6.60	5.08	3.37	2.54	**71.34**
San Antonio	2.42	2.9	4.42	5.47	6.47	6.97	7.31	6.99	5.64	4.44	2.85	2.36	**58.24**
Uvalde	2.44	2.95	4.62	5.85	6.7	7.21	7.5	7.31	5.7	4.4	2.89	2.36	**59.93**
Victoria	2.35	2.87	4.29	5.77	6.39	6.7	6.92	6.7	5.36	4.41	2.93	2.33	**57.02**
Waco	2.13	2.62	4.03	5.31	6.45	7.15	7.40	7.5	5.7	4..41	2.7	2.17	**53.16**
Weslaco	2.5	2.57	3.96	4.9	6.12	6.53	7.0	6.58	4.79	3.96	2.85	2.29	**54.05**
Wichita Falls	1.94	2.46	4.07	5.50	6.7	7.54	7.97	7.72	5.79	4.3	2.62	1.95	**58.56**

Averages were computed using climatic data over the entire period of record available from the National Weather Service and compared to ETo rates based on the standardized Penman-Monteith equation where available. (August 2005)

53

TexasET-Historic Rainfall

Average Rainfall
(inches/month)

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Abilene	1.01	1.10	1.19	2.09	3.31	2.90	2.09	2.45	2.75	2.48	1.28	1.04	**23.68**
Amarillo	0.59	0.58	0.93	1.24	2.74	3.40	2.88	2.99	1.89	1.41	0.62	0.57	**19.84**
Austin	2.11	2.41	2.05	3.01	4.38	3.46	2.05	2.23	3.38	3.35	2.28	2.46	**33.16**
Brownsville	1.33	1.31	0.90	1.63	2.31	2.85	1.69	2.46	4.95	3.36	1.61	1.18	**25.58**
College Station	2.87	2.88	2.50	3.77	4.73	3.79	2.24	2.43	4.30	3.64	3.07	3.15	**39.37**
Corpus Christi	1.57	1.88	1.33	2.06	3.09	3.19	1.84	3.33	5.30	3.54	1.56	1.60	**30.30**
Dallas/Ft. Worth	1.94	2.44	3.12	3.15	5.43	3.18	2.09	2.10	2.42	4.01	2.43	2.50	**34.82**
Del Rio	0.53	0.91	0.86	1.89	2.39	1.90	1.54	1.72	2.59	1.94	0.85	0.65	**17.76**
El Paso	0.42	0.41	0.30	0.21	0.33	0.72	1.559	1.48	1.42	0.72	0.35	0.62	**8.57**
Galveston	3.33	2.58	2.43	2.55	3.46	4.14	3.77	4.23	5.36	3.17	3.32	3.59	**41.93**
Houston	3.70	2.99	3.48	3.49	5.22	5.13	3.25	3.79	4.45	4.65	3.89	3.64	**47.70**
Lubbock	0.52	0.61	0.82	1.26	2.62	2.67	2.12	2.07	2.53	1.99	0.62	0.64	**18.47**
Midland	0.54	0.61	0.47	0.77	2.02	1.59	1.83	1.65	2.04	1.56	0.58	0.53	**14.18**
Port Arthur	4.86	3.96	3.30	3.86	5.02	5.68	5.31	5.04	5.77	4.20	4.22	5.13	**56.34**
San Angelo	0.83	1.05	0.93	1.68	2.86	2.20	1.16	1.77	2.78	2.21	0.96	0.78	**19.20**
San Antonio	1.61	1.90	1.68	2.53	3.99	3.57	1.83	2.58	3.29	3.29	2.11	1.72	**30.09**
Victoria	2.28	2.12	2.08	2.93	4.95	4.77	3.03	3.08	5.37	3.72	2.51	2.33	**39.17**
Waco	2.07	2.39	2.51	3.43	4.59	2.80	1.88	1.66	3.07	2.91	2.48	2.49	**32.28**
Wichita Falls	1.08	1.31	1.91	2.72	4.59	3.36	2.05	2.16	2.94	2.69	1.55	1.56	**27.93**

54

Scheduling Site Factors

- Schedules may have to be adjusted for various site factors
  - Soil Type effects irrigation frequency
  - Sun/Shade can reduce water requirement
    - Use Adjustment Factors

55

Site Factors: Adjustment Factor, Af

- A modification to the crop coefficient
- Used to reduce water application for allowable stress

Plant Quality Adjustment Factor, Af	
Plant Quality	Af
Maximum	1.0
High	0.8
Normal	0.6
Low	0.5
Minimum	0.4

56

Equation for Calculating Water Requirements (WR)

WR = ETo x Kc x Af

- Example:
  - ETo = 1.59 inches (1st week of August 2007 in Dallas)
  - Kc = 0.6 (warm season turf)
  - Af = 0.5 *("Low plant quality"* adjustment)
- WR = 1.59 x 0.6 x 0.5
- WR = 0.48 inches (1st week in Aug)

57

Water Requirements with Rainfall

- Problem: during the 1st week in Aug 2007, Dallas received 0.04 inches of rainfall, what is our total WR (previous example)
- Since the total rainfall is less than 0.1 inches, we use a RAINf = 0
- WR = (ETo x Kc x Af) – $RAIN_f$
- WR = (0.48 inches) – 0
- WR = 0.48 inches

58

Slides available for future reference

PRESSURE LECTURE

59

Pressure

- The BIGGEST variable in irrigation systems
- Determines how well sprinklers and drip components perform
- ALL manufacturers publish recommended operating pressures for their products

60

Types of Pressure

- Dynamic Pressure
  - Pressure at a point when water is moving
  - Also referred to as “operating pressure”
- Static Pressure
  - Pressure at a point when there is no water moving

61

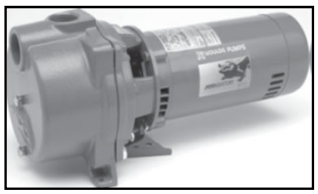
Determining Pressure

- Pressure Gauges (either Static or Dynamic)

62

How is pressure created?

- Weight of the Water (Gravity)
- Mechanical Means (Pump)



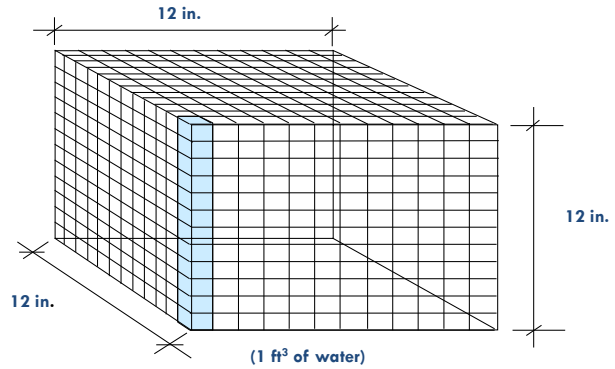
63

How do we measure pressure?

- PSI
  - Pounds Per Square Inch
- Feet of Head
  - Height of Water in a column

64

Column of Water



65

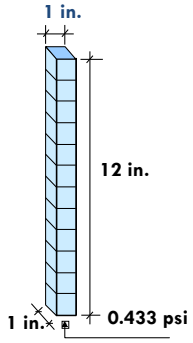
Relationship between PSI & Feet of Head

- 1 PSI = 2.31 Feet of Head
- 1 Foot of Head = .433 PSI

66

Water Pressure from 1 Foot of Water

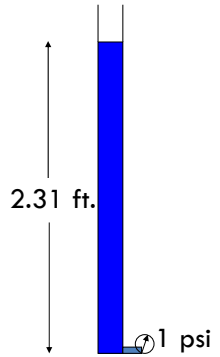
- **1 Foot of head = 0.433 psi**



67

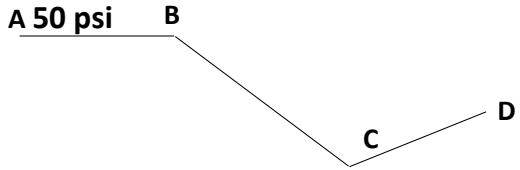
Feet of Head from 1 psi

- **1 psi = 2.31 ft. of head**



68

Static Pressure and Elevation



- **A and B are at same elevation: static pressure at B = A**
- **C is lower in elevation than B: static pressure at C is higher that at B**
- **D is at higher elevation than C: static pressure at D is lower than at C**

69

Determining Pressure On Site

- 2 Methods to determining available water pressure on site
  - Contact local water purveyor
  - Measure on site with a pressure gauge
    - Typically at hose bib closest to the meter

70

PRESSURE REGULATION

71

High Pressure

72

Low Pressure

73

Low Pressure….

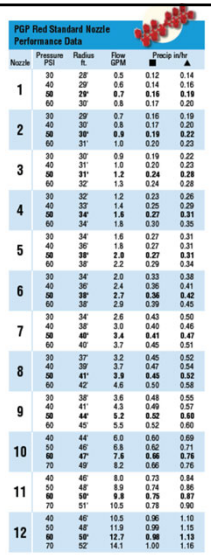
High Pressure…..

74

Pressure Regulation

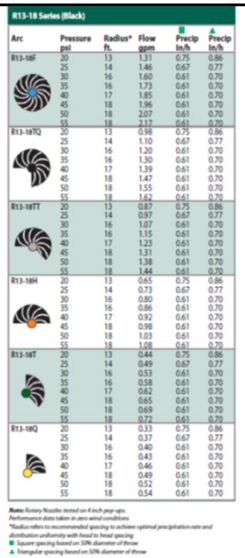
- Landscape Irrigation Systems often face challenges of too high of operating pressure than too low
- For sprinklers to operate efficiently they must operate within their pressure boundaries
  - see manufacturers product literature

75



PGP Red Standard Nozzle Performance Data

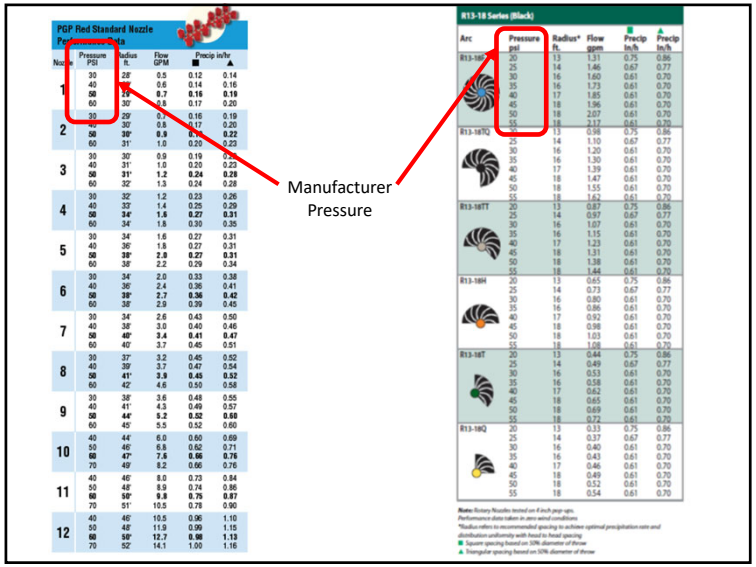
Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
1	30	28'	0.5	0.12	0.14
	40	29'	0.6	0.14	0.16
	50	**29'**	**0.7**	**0.16**	**0.19**
	60	30'	0.8	0.17	0.20
2	30	29'	0.7	0.16	0.19
	40	30'	0.8	0.17	0.20
	50	**30'**	**0.9**	**0.19**	**0.22**
	60	31'	1.0	0.20	0.23
3	30	30'	0.9	0.19	0.22
	40	31'	1.0	0.20	0.23
	50	**31'**	**1.2**	**0.24**	**0.28**
	60	32'	1.3	0.24	0.28
4	30	32'	1.2	0.23	0.26
	40	33'	1.4	0.25	0.29
	50	**34'**	**1.6**	**0.27**	**0.31**
	60	34'	1.8	0.30	0.35
5	30	34'	1.6	0.27	0.31
	40	36'	1.8	0.27	0.31
	50	**38'**	**2.0**	**0.27**	**0.31**
	60	38'	2.2	0.29	0.34
6	30	34'	2.0	0.33	0.38
	40	36'	2.4	0.36	0.41
	50	**38'**	**2.7**	**0.36**	**0.42**
	60	38'	2.9	0.39	0.45
7	30	34'	2.6	0.43	0.50
	40	38'	3.0	0.40	0.46
	50	**40'**	**3.4**	**0.41**	**0.47**
	60	40'	3.7	0.45	0.51
8	30	37'	3.2	0.45	0.52
	40	39'	3.7	0.47	0.54
	50	**41'**	**3.9**	**0.45**	**0.52**
	60	42'	4.6	0.50	0.58
9	30	38'	3.6	0.48	0.55
	40	41'	4.3	0.49	0.57
	50	**44'**	**5.2**	**0.52**	**0.60**
	60	45'	5.5	0.52	0.60
10	40	44'	6.0	0.60	0.69
	50	46'	6.8	0.62	0.71
	60	**47'**	**7.5**	**0.66**	**0.76**
	70	49'	8.2	0.66	0.76
11	40	46'	8.0	0.73	0.84
	50	48'	8.9	0.74	0.86
	60	**50'**	**9.8**	**0.75**	**0.87**
	70	51'	10.5	0.78	0.90
12	40	46'	10.5	0.96	1.10
	50	48'	11.9	0.99	1.15
	60	**50'**	**12.7**	**0.98**	**1.13**
	70	52'	14.1	1.00	1.16



R13-18 Series (Black)

Arc	Pressure psi	Radius* ft.	Flow gpm	■ Precip in/h	▲ Precip in/h
R13-18F	20	13	1.31	0.75	0.86
	25	14	1.46	0.67	0.77
	30	16	1.60	0.61	0.70
	35	16	1.73	0.61	0.70
	40	17	1.85	0.61	0.70
	45	18	1.96	0.61	0.70
	50	18	2.07	0.61	0.70
	55	18	2.17	0.61	0.70
R13-18TQ	20	13	0.98	0.75	0.86
	25	14	1.10	0.67	0.77
	30	16	1.20	0.61	0.70
	35	16	1.30	0.61	0.70
	40	17	1.39	0.61	0.70
	45	18	1.47	0.61	0.70
	50	18	1.55	0.61	0.70
	55	18	1.62	0.61	0.70
R13-18TT	20	13	0.87	0.75	0.86
	25	14	0.97	0.67	0.77
	30	16	1.07	0.61	0.70
	35	16	1.15	0.61	0.70
	40	17	1.23	0.61	0.70
	45	18	1.31	0.61	0.70
	50	18	1.38	0.61	0.70
	55	18	1.44	0.61	0.70
R13-18H	20	13	0.65	0.75	0.86
	25	14	0.73	0.67	0.77
	30	16	0.80	0.61	0.70
	35	16	0.86	0.61	0.70
	40	17	0.92	0.61	0.70
	45	18	0.98	0.61	0.70
	50	18	1.03	0.61	0.70
	55	18	1.08	0.61	0.70
R13-18T	20	13	0.44	0.75	0.86
	25	14	0.49	0.67	0.77
	30	16	0.53	0.61	0.70
	35	16	0.58	0.61	0.70
	40	17	0.62	0.61	0.70
	45	18	0.65	0.61	0.70
	50	18	0.69	0.61	0.70
	55	18	0.72	0.61	0.70
R13-18Q	20	13	0.33	0.75	0.86
	25	14	0.37	0.67	0.77
	30	16	0.40	0.61	0.70
	35	16	0.43	0.61	0.70
	40	17	0.46	0.61	0.70
	45	18	0.49	0.61	0.70
	50	18	0.52	0.61	0.70
	55	18	0.54	0.61	0.70

76



77

In Line Pressure Regulators

- Both pre-set and adjustable inline pressure regulators are available for use in landscape irrigation system

78

Pressure Compensating Sprinklers

- Manufacturers are starting to offer sprinkler bodies with built in pressure regulators
  - Examples: Rainbird PRS Series

79

Pressure Regulating Valves

- Options are available to control pressure on the control valve
  - Example: Hunter Accu Sync

80

Pressure Devices

- Contact your local irrigation equipment supplier for more information on what type of pressure regulating or pressure compensating devices are available.

81

Slides for reference

PIPING LECTURE

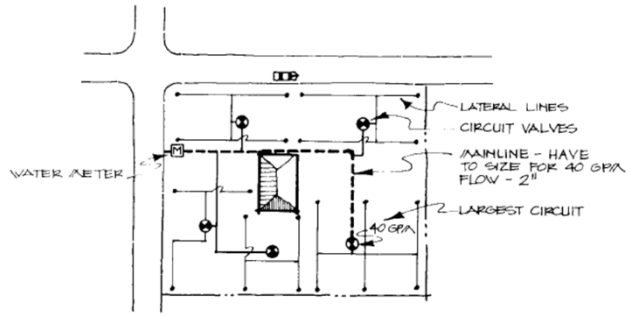
82

Pipe Layouts

- 2 methods for pipe layouts
  - In-Line Method
  - Looped Method
- Decision to Loop or In-Line is typically considered when designing the mainline

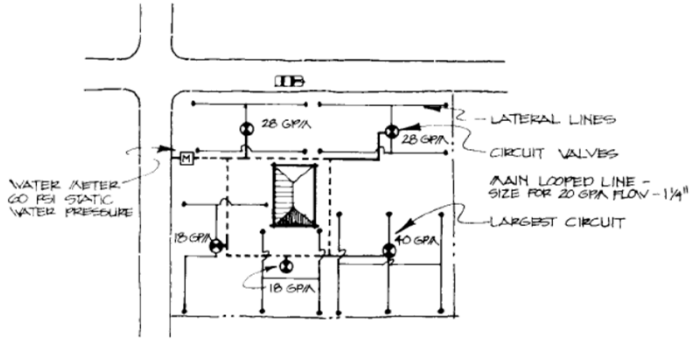
83

Example: In Line Mainline



84

Example: Looped Mainline



85

Looped Mainline

- Advantages
  - Pressure Loss is less than using the same size pipe as in an inline system
  - Pressure loss can be held at a desired level using smaller pipe
  - Can result in lower cost with use of smaller pipe
- Disadvantage
  - Uses More Pipe

86

Water Movement in the System

- **Flow**: amount (volume) of water moving per unit of time. Measured in:
  - Gallons per minute (gpm)
  - Gallons per hour (gph)
- **Velocity**: speed of moving water. Measured in:
  - Feet per second (fps)

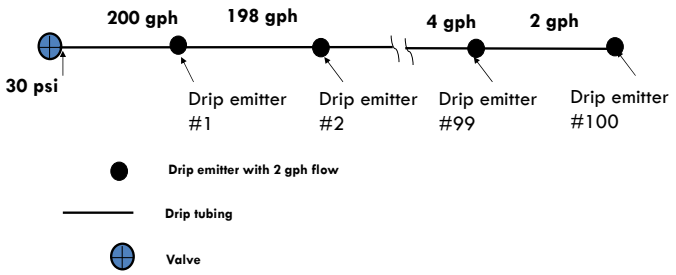
87

Flow

- **Flow** in a system is dependent upon the number of sprinklers or drip emitters working at the same time
- **Flow** in various pipe segments of an irrigation system can be different
- **Flow** is commonly measured in gpm for sprinkler systems and in gph for drip irrigation systems

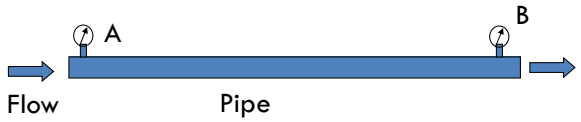
88

Flow for a Basic Drip System



89

Introduction to Friction Loss (Pressure Loss)



- When water is **not moving** there is **no friction loss** – this is static pressure
- When water **is moving** there is **some loss of pressure due to friction**.

90

What Affects Friction Loss?

- **Velocity (flow)**
- **Inside diameter of pipe (ID)**
- **Roughness of material**
- **Length of pipe**

91

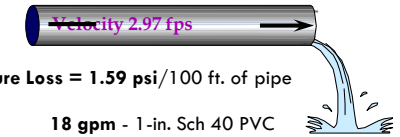
Classifications of Pipe (PVC)

- Schedule Pipe
  - Pipe wall thickness is fairly constant for all diameters
  - Pressure Rating Decreases as Diameter Increases
- Class/SDR Pipe
  - Has a constant pressure rating per class for all diameters of pipe
  - Wall thickness changes with pipe diameter

92

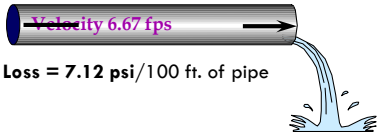
Velocity (flow)

8 gpm - 1-in. Sch 40 PVC



Pressure Loss = 1.59 psi/100 ft. of pipe

18 gpm - 1-in. Sch 40 PVC

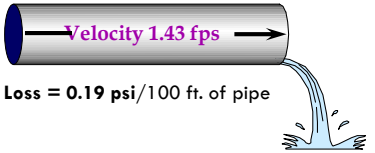


Pressure Loss = 7.12 psi/100 ft. of pipe

93

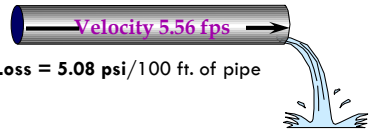
Inside Diameter

15 gpm - **2-in. (2.067 in. Inside Diameter)** Sch 40 PVC



Pressure Loss = 0.19 psi/100 ft. of pipe

15 gpm - **1-in. (1.049 in. Inside Diameter)** Sch 40 PVC

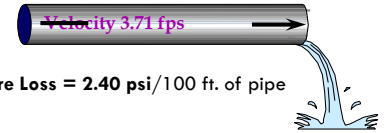


Pressure Loss = 5.08 psi/100 ft. of pipe

94

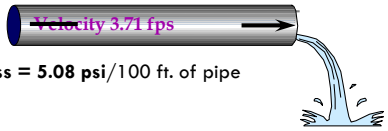
Roughness

10 gpm - 1-in. **Sch 40 PVC (Roughness C=150)**



Pressure Loss = 2.40 psi/100 ft. of pipe

10 gpm - 1-in. **Sch 40 Standard Steel Pipe (Roughness C=100)**

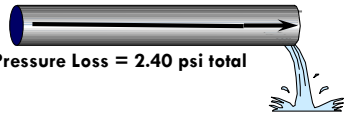


Pressure Loss = 5.08 psi/100 ft. of pipe

95

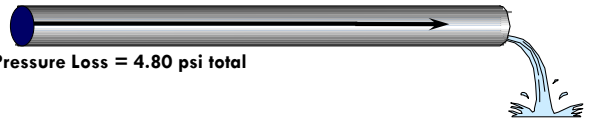
Length

10 gpm - 1-in. Sch 40 PVC **100 feet of pipe**



Pressure Loss = 2.40 psi total

10 gpm - 1-in. Sch 40 PVC **200 feet of pipe**



Pressure Loss = 4.80 psi total

96

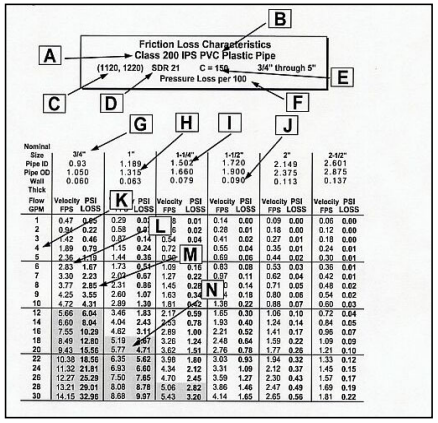
How to Find Friction Losses

- **Use Formula**
  - Hazen-Williams
  - Darcy-Weisbach
  - Manning (mainly used for open channel flow)
  - Others
- **Use Tables**
  - Generally calculated using Hazen-Williams formula

97

Friction Loss Table

- **A, B = Type of pipe**
- **F = Pressure loss/ 100 ft. of pipe**
- **G = Nominal size of pipe**
- **H – J = Actual sizes of pipe**
- **K = Flow quantities, gpm**
- **L = Velocity in fps**
- **M = PSI loss/ 100 ft. of pipe**



98

To Use Friction Loss Tables:

- **Find proper page for pipe material and type.** Note - all tables are for 100-ft. pipe length.
- **Find the flow (gpm)**
- **Find the size of pipe**
- **Find the psi loss** corresponding to pipe size under psi loss column
- **Find the corresponding row for flow**

99

Example: Friction Loss Calculation Using the Tables

Find the friction loss in:

- **100 ft. length of Class 200 PVC pipe**
- **Flow is 6 gpm.**
- **Nominal pipe size is ¾ in. diameter**

100

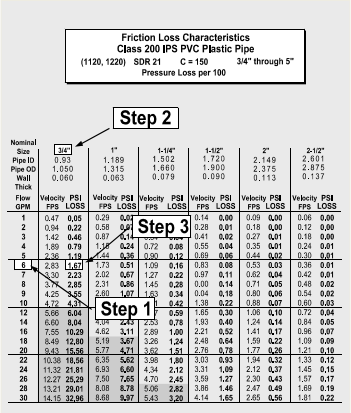
Example: Solution

- Use Class 200 PVC table
- Length of pipe is 100 ft.

Step 1: Find 6 gpm in first column

Step 2: Find ¾ in. pipe diameter column

Step 3: Read 1.67 psi loss per 100 ft. of pipe



101

Introduction to Dynamic Pressure

- Pressure when water is moving
- Uniformity of the irrigation system is dependent upon the correct dynamic pressure

102

Factors Affecting Dynamic Pressure

- **Change in elevation**
  - Same as in static pressure
- **Friction loss in various components**
  - Loss of pressure as water flows in pipes and other irrigation components
- **Others factors**
  - velocity head and entrance losses (not covered in this presentation)

103

Dynamic Pressure Calculation

- When calculating dynamic pressure, consider:
  - Pressure at the water source
  - Changes in elevation
  - Friction losses in irrigation system components

104

Friction Losses for Pipe Fittings

- Separate tables are available for friction losses in fittings
- Sometimes a certain percentage (10% - 20%) of pipe friction loss is used to account for fittings friction losses

105

Friction Losses for Other System Components

- See tables and charts in manufacturer's catalogs for other components such as valves, filters etc.
- Use a water meter table for finding friction loss through the water meter (if there is one in your system)

106

Typical Pressures and Flows for Sprinkler Irrigation

Sprinkler Type	Radius of Throw	Pressure Ranges	Flow Ranges
Spray	5 to 16 ft.	15 to 30 psi	Up to 4 gpm
Small Rotors	15 to 30 ft.	25 to 55 psi	Up to 6 gpm
Medium Rotors	30 to 50 ft	25 to 65 psi	Up to 10 gpm
Large Rotors	50 ft. +	50 to 120 psi	10 to 40+ gpm
Guns	100 ft. +	100 psi +	80 gpm +

107

Typical Pressures and Flows for Drip Irrigation

Drip Type	Pressure Ranges	Flow Ranges
On-line Drip Emitters	10 to 50 psi	0.5 to 24 gph
Inline Drip Emitters	10 to 50 psi	0.4 to 0.9 gph
Mini sprays/ Spitters	10 to 50 psi	0 to 30 gph
Drip Tape	8 to 20 psi	10 to 60 gph per 100 ft. of tape

108

Design Considerations: Pressure/Flow

- Balance each stations design for pressure and flow
  - Ex. Station 1: Flow = 12 GPM
    Station 2: Flow = 6 GPM
    If Possible balance each station to 9 GPM
- Balancing Pressure and flow can reduce pipe size and reduce friction loss

109

COMPARISON OF EMISSION DEVICES
SPRAY VS ROTOR

110

Emission Devices

- Spray Heads
- Rotary Heads
  - Single Stream
  - Multi Stream
- Impacts
- Bubblers
- Microsprays
- Drip

111

Matched Precipitation Rates

- Zones must be designed so that all devices in that zone irrigate at the same precipitation rate
- Runtime varies per sprinkler method
  - Sprays: 1.0-1.6 in/hr
  - Rotors: 0.25 - 0.75 in/hr
  - Multi-Stream: 0.37 – 0.61 in/hr
  - Drip (Turf): 0.20 – 0.99 in/hr

112

Spray Heads

113

Spray Heads

- Preset spray patterns
  - such as 45, 90, 180, 270, 360 degrees
- Have a high precipitation rate
- Work best in smaller areas and areas with tight, curving edges

114

Rotary Heads

- Can rotate from 0 to 360 Degrees
- Have a lower precipitation rate than sprays
- Easily adjusted for different flows
- Good for irrigating larger areas
  - Golf courses, sports fields & parks

115

Rotors – Single Stream

116

Rotors – Multi Stream


117

Impacts

- Sprinkler which rotates using a weighted or spring loaded arm which is propelled by the water stream and hits the sprinkler body, causing movement
- Usually arc pattern is 40-360 degrees
- Covers large areas
  - 20 – 150 feet
- Precipitation rate varies considerably
  - 0.1 – 1.5 inches per hour

118

Impacts – Common Heads


119

120

Designing Sprinkler Systems

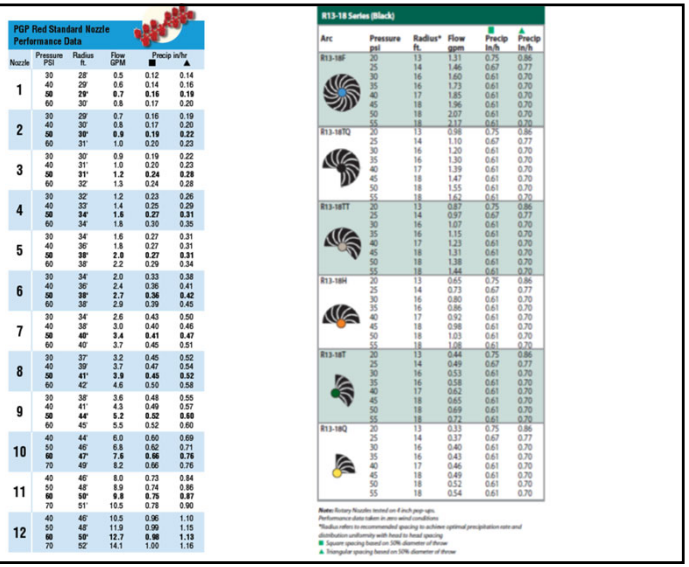
- Design Considerations
  - Triangular vs Square Spacing
  - Wind
  - Looped vs Non Looped Systems

121

Manufactures Spec Sheets

- Manufacturers specification tell us what sprinkler spacing should be based on:
  - Nozzle
  - Arc Pattern
  - Pressure
- Once these have been found, we can identify each sprinklers flow rate and estimated precipitation rate

122



PGP Red Standard Nozzle Performance Data

Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
1	30	28'	0.5	0.12	0.14
	40	29'	0.6	0.14	0.16
	50	**29'**	**0.7**	**0.16**	**0.19**
	60	30'	0.8	0.17	0.20
2	30	29'	0.7	0.16	0.19
	40	30'	0.8	0.17	0.20
	50	**30'**	**0.9**	**0.19**	**0.22**
	60	31'	1.0	0.20	0.23
3	30	30'	0.9	0.19	0.22
	40	31'	1.0	0.20	0.23
	50	**31'**	**1.2**	**0.24**	**0.28**
	60	32'	1.3	0.24	0.28
4	30	32'	1.2	0.23	0.26
	40	33'	1.4	0.25	0.29
	50	**34'**	**1.6**	**0.27**	**0.31**
	60	34'	1.8	0.30	0.35
5	30	34'	1.6	0.27	0.31
	40	36'	1.8	0.27	0.31
	50	**38'**	**2.0**	**0.27**	**0.31**
	60	38'	2.2	0.29	0.34
6	30	34'	2.0	0.33	0.38
	40	36'	2.4	0.36	0.41
	50	**39'**	**2.7**	**0.36**	**0.42**
	60	38'	2.9	0.39	0.45
7	30	34'	2.6	0.43	0.50
	40	38'	3.0	0.40	0.46
	50	**40'**	**3.4**	**0.41**	**0.47**
	60	40'	3.7	0.45	0.51
8	30	37'	3.2	0.45	0.52
	40	39'	3.7	0.47	0.54
	50	**41'**	**3.9**	**0.45**	**0.52**
	60	42'	4.6	0.50	0.58
9	30	38'	3.6	0.48	0.55
	40	41'	4.3	0.49	0.57
	50	**44'**	**5.2**	**0.52**	**0.60**
	60	45'	5.5	0.52	0.60
10	40	44'	6.0	0.60	0.69
	50	46'	6.8	0.62	0.71
	60	**47'**	**7.6**	**0.66**	**0.76**
	70	49'	8.2	0.66	0.76
11	40	46'	8.0	0.73	0.84
	50	48'	8.9	0.74	0.86
	60	**50'**	**9.8**	**0.75**	**0.87**
	70	51'	10.5	0.78	0.90
12	40	46'	10.5	0.96	1.10
	50	48'	11.9	0.99	1.15
	60	**50'**	**12.7**	**0.98**	**1.13**
	70	52'	14.1	1.00	1.16

R13-18 Series (Black)

Arc	Pressure psi	Radius* ft.	Flow gpm	■ Precip in/h	▲ Precip in/h
R13-18F	20	13	1.31	0.75	0.86
	25	14	1.46	0.67	0.77
	30	16	1.60	0.61	0.70
	35	16	1.73	0.61	0.70
	40	17	1.85	0.61	0.70
	45	18	1.96	0.61	0.70
	50	18	2.07	0.61	0.70
	55	18	2.17	0.61	0.70
R13-18TQ	20	13	0.98	0.75	0.86
	25	14	1.10	0.67	0.77
	30	16	1.20	0.61	0.70
	35	16	1.30	0.61	0.70
	40	17	1.39	0.61	0.70
	45	18	1.47	0.61	0.70
	50	18	1.55	0.61	0.70
	55	18	1.62	0.61	0.70
R13-18TT	20	13	0.87	0.75	0.86
	25	14	0.97	0.67	0.77
	30	16	1.07	0.61	0.70
	35	16	1.15	0.61	0.70
	40	17	1.23	0.61	0.70
	45	18	1.31	0.61	0.70
	50	18	1.38	0.61	0.70
	55	18	1.44	0.61	0.70
R13-18H	20	13	0.65	0.75	0.86
	25	14	0.73	0.67	0.77
	30	16	0.80	0.61	0.70
	35	16	0.86	0.61	0.70
	40	17	0.92	0.61	0.70
	45	18	0.98	0.61	0.70
	50	18	1.03	0.61	0.70
	55	18	1.08	0.61	0.70
R13-18T	20	13	0.44	0.75	0.86
	25	14	0.49	0.67	0.77
	30	16	0.53	0.61	0.70
	35	16	0.58	0.61	0.70
	40	17	0.62	0.61	0.70
	45	18	0.65	0.61	0.70
	50	18	0.69	0.61	0.70
	55	18	0.72	0.61	0.70
R13-18Q	20	13	0.33	0.75	0.86
	25	14	0.37	0.67	0.77
	30	16	0.40	0.61	0.70
	35	16	0.43	0.61	0.70
	40	17	0.46	0.61	0.70
	45	18	0.49	0.61	0.70
	50	18	0.52	0.61	0.70
	55	18	0.54	0.61	0.70

123

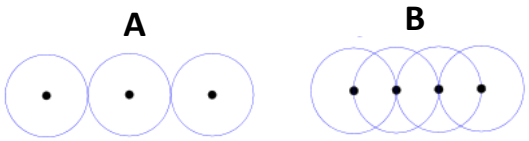
Sprinkler Layout/Spacing

- Sprinkler spacing is typically a function of sprinkler nozzles based on pressure and flow
- Choosing a layout maybe simple for areas with regular geometry (square or rectangular areas)

124

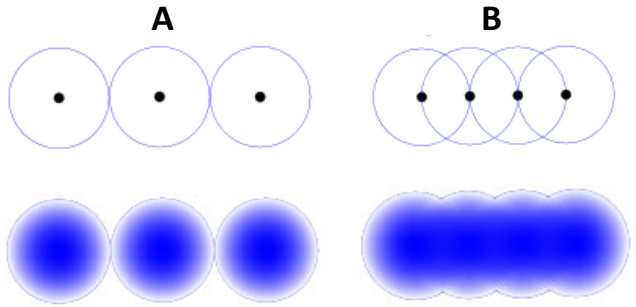
Spacing

- Most sprinklers and emitters are designed to be used “head to head”
- Which layout shows “head to head” coverage?



125

Spacing



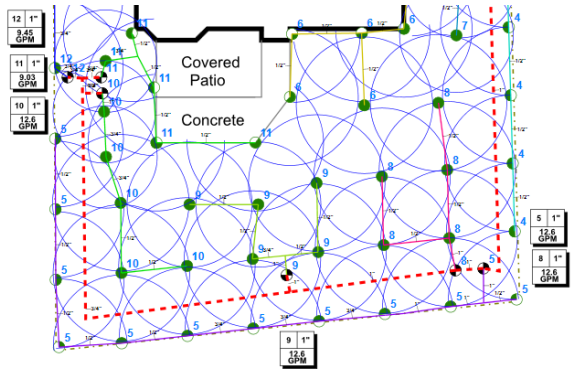
126

Sprinkler Layout

- Often to achieve good distribution a combination of spacing layouts is needed
  - Square
  - Triangular
  - Fill In
    - Uses no pattern but places sprinklers in areas with poor distribution, usually a result of irregularly shaped areas

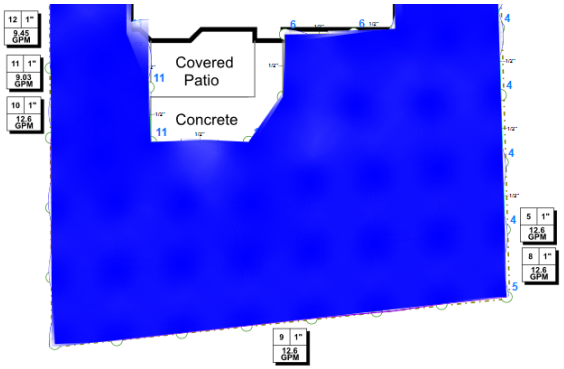
127

Spacing (Head to Head)



128

Spacing (Head to Head)



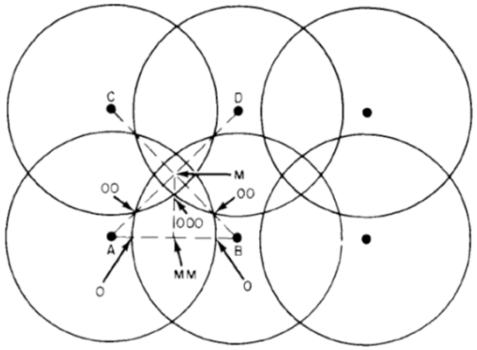
129

Square Layouts

- Fairly simple
  - Sprinkler heads are spaced “head to head” (50% radius)
  - Heads are parallel and perpendicular to each other
    - Head to head spacing = line to line spacing

130

Square Layout



131

Triangular Layouts

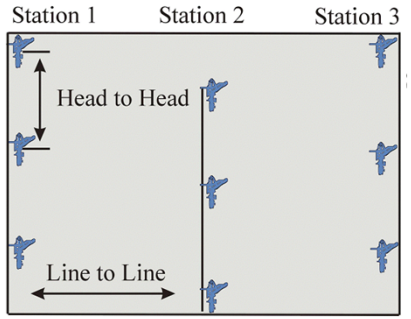
- Typically more practical in larger areas
- Sprinkler spacing is head to head along the lateral section
- Line to Line (Row) distance is equal to 86.6% of the head spacing
  - Example: Head to head spacing of 35 ft

    Line to Line Distance = 35 ft x .866 = 30.3 ft

132

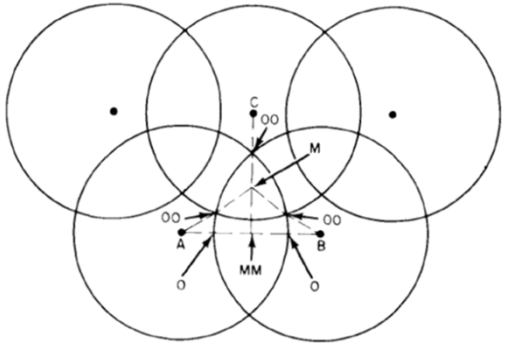
Triangular Layouts

- Only basic disadvantage of triangular spacing maintaining uniform coverage along the borders.



133

Triangular Layout

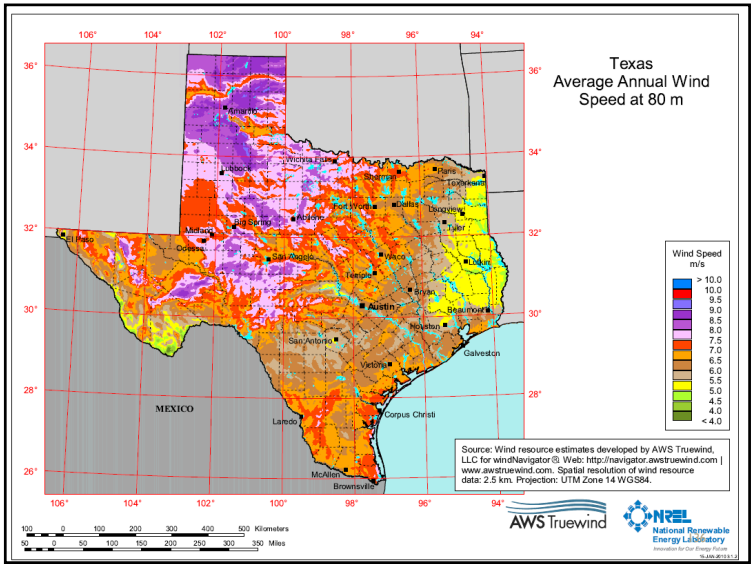


134

Designing Around Wind

- Wind distorts sprinkler patterns and can carry off fine sprinkler drops.
- How windy is a concern?
  - 0-3 mph are considered calm
  - 4-7 mph is a light breeze
    - Can feel on your face, causes leaves on trees to rustle
  - 8-12 mph is a gentle breeze
    - Leaves and twigs in constant motion, will extend a flag
  - 15+ mph is Windy!

135



136

Wind Speed Units and Conversion Factors

	m/s	Km/hr	mph	knots
1 m/s	1.000	3.600	2.337	1.994
1 km/hr	0.278	1.000	0.622	0.540
1 mph	0.447	1.609	1.000	0.869
1 knot	0.514	1.853	1.151	1.000

137

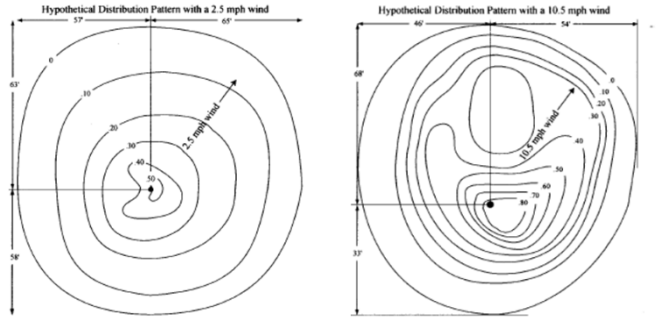
137

Designing For Wind

- Sprinkler spacing can be decreased to account for windy conditions
- Rules of Thumb:
  - 0-3 mph use 50% spacing (head to head)
  - 4-7 mph use 45% spacing (5% overlap)
  - 8-12 mph use 40% spacing (10% overlap)
  - 12+ mph very difficult to manage wind effects with design
    - Multiple approaches of spacing and low trajectory, low drift nozzles should be used.
    - Consider drip irrigation?

138

Sprinkler Distribution in Wind



139

Square Spacing Wind Distortion

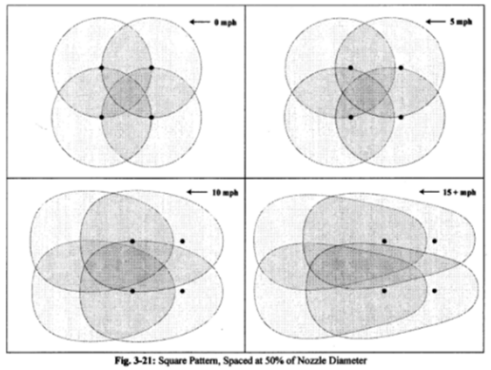


Fig. 3-21: Square Pattern, Spaced at 50% of Nozzle Diameter

140

Triangular Spacing Wind Distortion

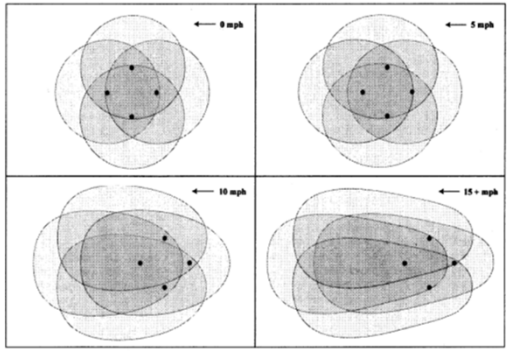


Fig. 3-22: Triangular Pattern, Spaced at 50% of Nozzle Diameter

141

DESIGNING DRIP IRRIGATION

142

Drip Irrigation

- Irrigation water is applied through emitters either above or below the soil surface
- Precipitation rates vary with length, pressure and flow.

143

Drip Irrigation (cont.)

- Long history in agricultural applications
- Promoted as an "efficient" alternative to sprinkler irrigation
- In truth:
  "**Only as efficient as the person behind the design and management**"

144

Drip Products – Drip Tubing With Embedded Emitters

- Durable Thick Wall Tubing
- Usually contain pressure compensating embedded emitters
- Can operate under higher pressures

145

Drip Selection

- Use products from major manufacturers if possible
- Thinner material (wall thickness) and smaller diameters are less expensive
- Thicker products are more durable
- For drip under plastic mulch, the thinner products are typically used

146

Drip Specification Charts

- Charts typically give the following for each drip tape product:
  - diameter (inch, mm)
  - in-let pressure
  - flow rate

147

Drip Specification Charts

- In-let pressures are listed usually as a range from the minimum to the maximum for each tape product (psi, bar)
- Flow rates are usually given as:
  - GPH/100’ (gallons per hour per 100 ft of tape) or
  - GPH per emitter

148

Maximum Length of Run

- EU (emission uniformity) is a measurement of how evenly water is distributed along the tape
- the longer tape is run, the lower the EU
  - Due to friction loss in the product
- If possible, use row lengths that maintain 90% EU

149

Maximum Length of Run

- The maximum distance that the drip tape can be run varies according to
  - diameter
  - in-let pressure
  - flow rate
  - slope (%)

150

Rainbird Example

Inlet Pressure psi	XF Dripline Maximum Lateral Lengths (Feet)					
	12″ Spacing		18″ Spacing		24″ Spacing	
	Nominal Flow (GPH)		Nominal Flow (GPH)		Nominal Flow (GPH)	
	0.6	0.9	0.6	0.9	0.6	0.9
15	255	194	357	273	448	343
20	291	220	408	313	514	394
30	350	266	494	378	622	478
40	396	302	560	428	705	541
50	434	333	614	470	775	594

XF-SDI Dripline Flow (per 100 feet)				
Emitter Spacing	0.6 GPH Emitter		0.9 GPH Emitter	
12″	61.0 GPH	1.02 GPM	92.0 GPH	1.53 GPM
18″	41.0 GPH	0.68 GPM	61.0 GPH	1.02 GPM
24″	31.0 GPH	0.51 GPM	46.0 GPH	0.77 GPM

151

Rainbird Example

OPERATING RANGE

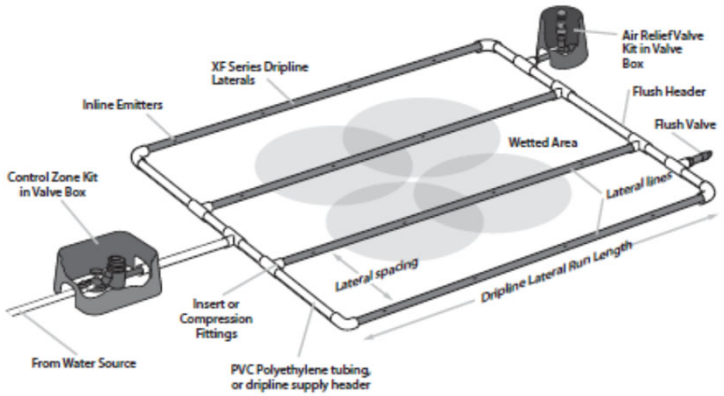
- Pressure: 8.5 to 60 psi (,58 to 4,14 bar)
- Flow rates: 0.6 and 0.9 gph (2,3 l/hr and 3,5 l/hr)
- Temperature:
  Water: Up to 100°F (37,8° C)
  Ambient: Up to 125°F (51,7° C)
- Required Filtration: 120 mesh

152

DRIP LAYOUT OPTIONS

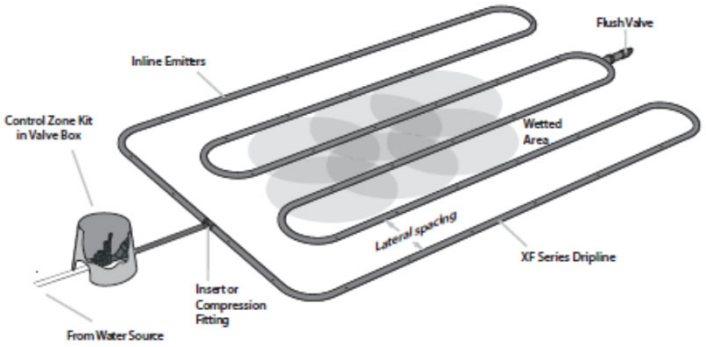
153

Manifold - End Feed Layout



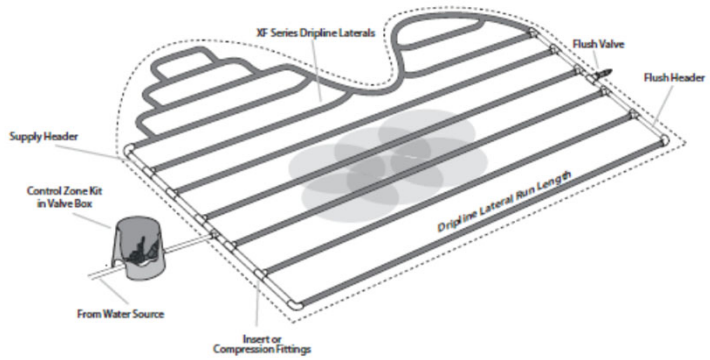
154

"Quick" Layout



155

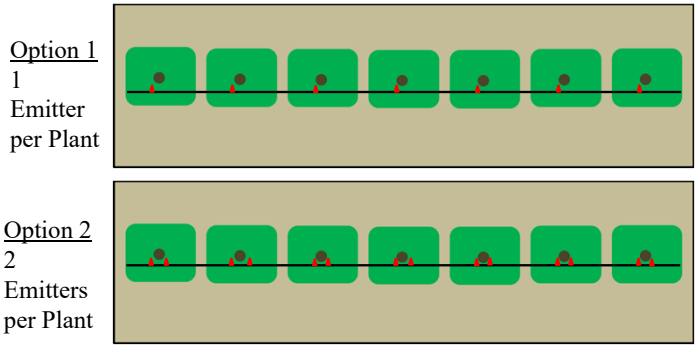
Curved (Edge) Layout???



156

Other Drip Layouts

- Example: Shrub Drip Design



157

Precipitation Rate

$$PR = \frac{96.25 \times GPM}{A}$$

PR – Station Precipitation Rate, in/hr

96.25 – Constant Converts GPM to inches per hour

GPM – Total Flow Rate through the station

A – Area of Coverage, ft^2

158

Precipitation Rate

$$PR = \frac{231.1 \times \text{Dripper Flow Rate}}{\text{Dripline Row Spacing} \times \text{Dripper Spacing}}$$

- ☐PR = Station Precipitation Rate, in/hr
- ☐231.1 = Constant Converts GPH to in/hr
- ☐Dripper Flow Rate, GPH
- ☐Dripline Row Spacing, inches
- ☐Dripper Spacing, inches

159

Example Problem

$$PR = \frac{96.25 \times GPM}{Area}$$

- GPM = Total Flow = 2.58 GPM
- Area = Length x Width = 50ft x 5 ft = 250 ft^2

$$PR = \frac{96.25 \times 2.58GPM}{250\ ft^2}$$

PR = .99 inches / hr

160

SOFTWARE

161

Software Demonstrations

- Space Pro
- ProContractor Studio

162

Review:
TCEQ Standards for Designing

- In TCEQ Rules there are 5 primary design considerations that if followed will produce efficient and effective irrigation systems
  - Sprinkler Spacing
  - Pressure
  - Zoning
  - Matched Precipitation Rate
  - Avoid Irrigation of Hardscapes

163

Review Design

- State has MINIMUM rules for Landscape Irrigation, however local municipalities may have MORE STRINGENT Rules
  - Know your local regulations!
- Time and costs should not be excuses for poor design practices
- Affordable software packages available for landscape irrigation make it very simple to follow state rules and produce quality irrigation designs

164