Optimizing sprinkler uniformity with an irrigation audit

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outline

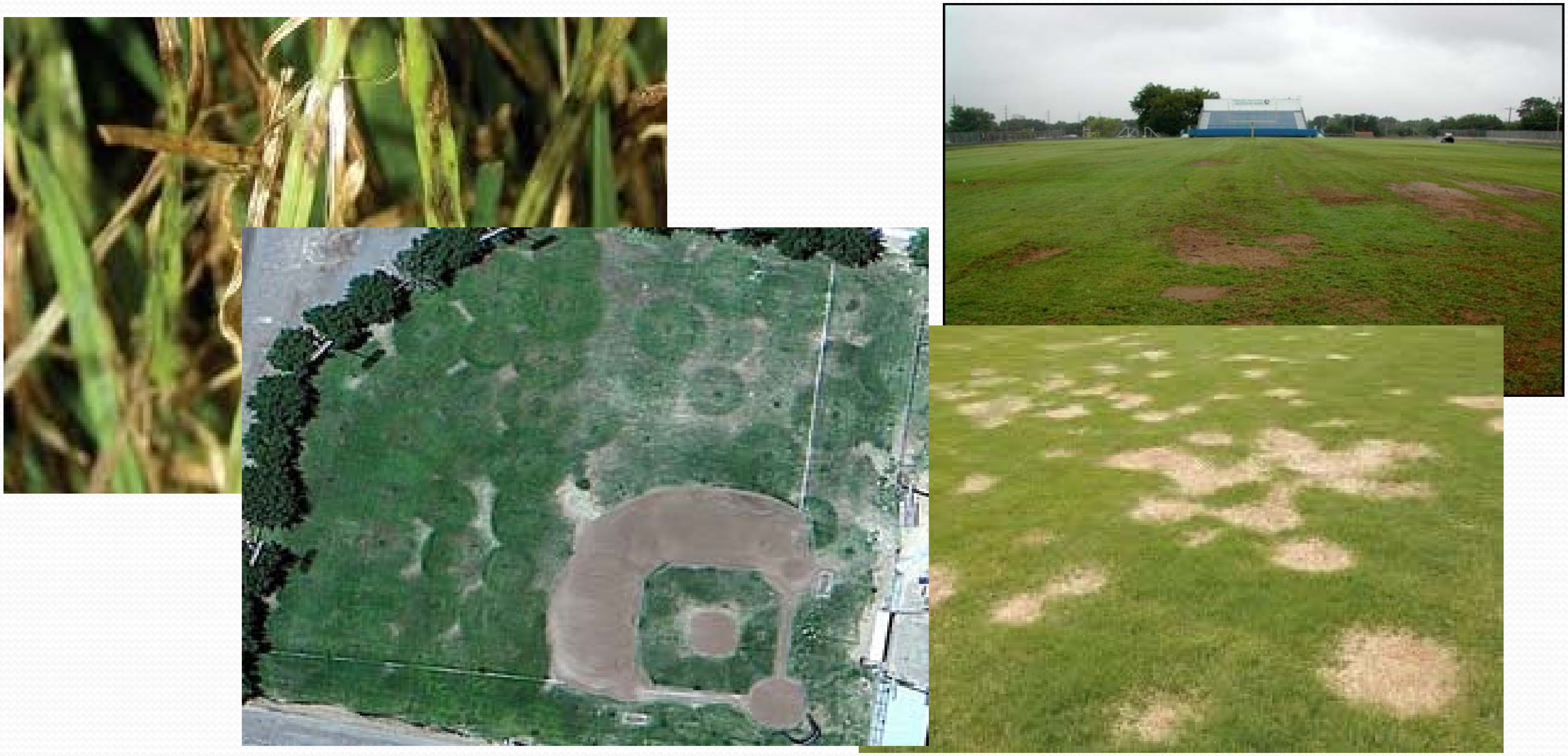
- Reasons for conducting an audit
- Precipitation & precipitation rate
- System optimization

Why?

- **Player safety**
  - More consistent/predictable field conditions

Turfgrass Health

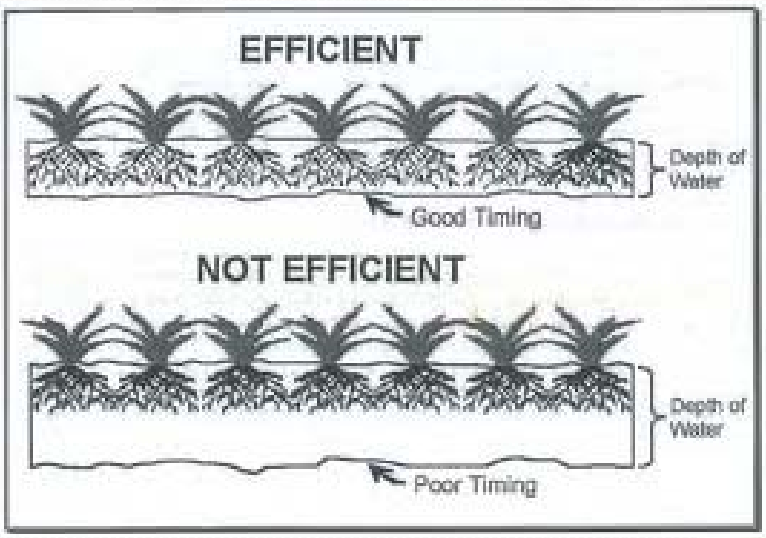
- Reduce biotic & abiotic plant problems



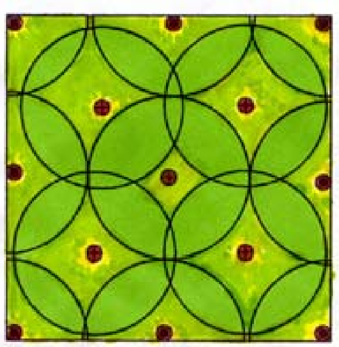
*there really isn't any 100% abiotic problems

Apply water more efficiently

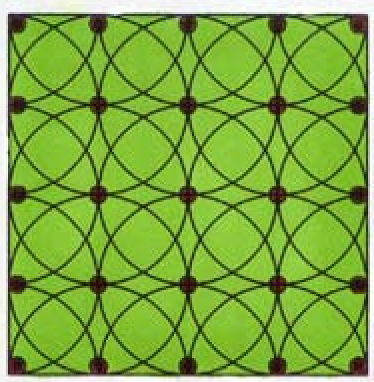
- Minimize areas that are too wet or too dry
  - Limit operating cost associated with pumping
  - Reduce excessive watering times
  - Avoid runoff



Maximize Distribution Uniformity - DU



SPACING IS NOT HEAD-TO-HEAD. NOT FULL COVERAGE. MANY WEAK SPOTS.



FULL COVERAGE: HEAD-TO-HEAD SPACING. SPRAY FROM EACH HEAD TOUCHES THE NEXT SPRINKLER OVER ENTIRE AREA.

How?

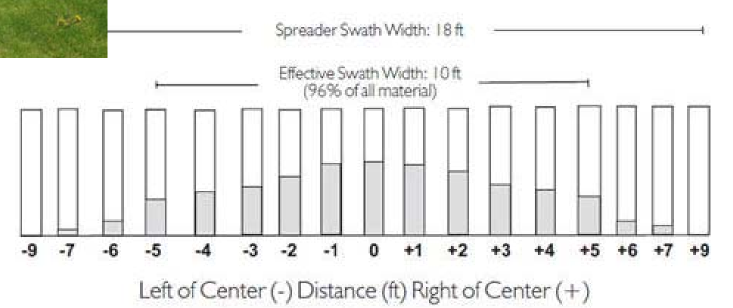
- **Calibration**
  - **Similar to fertilizer spreader of sprayer**
    - All calibration basically uses the same calculations
    - All have AREA in common.
    - To determine rate include time.
  - **Sprinkler system used much more often than either spreader or sprayer**

Fertilizer Spreader

- Product (pounds) per area (ft^2)

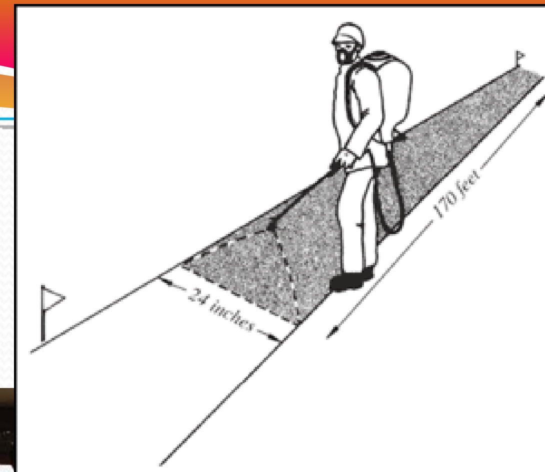
* Swath width important for even distribution

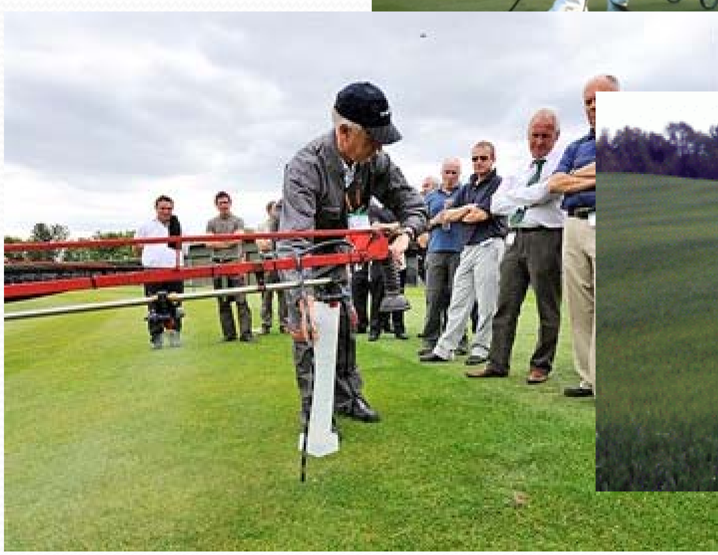
Actual fertilizer material distribution pattern using a rotary spreader

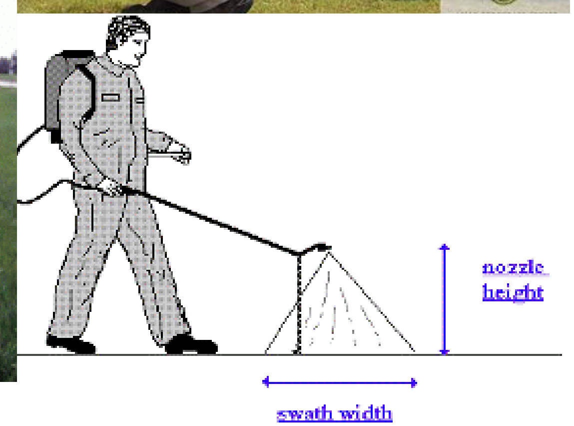


Sprayer

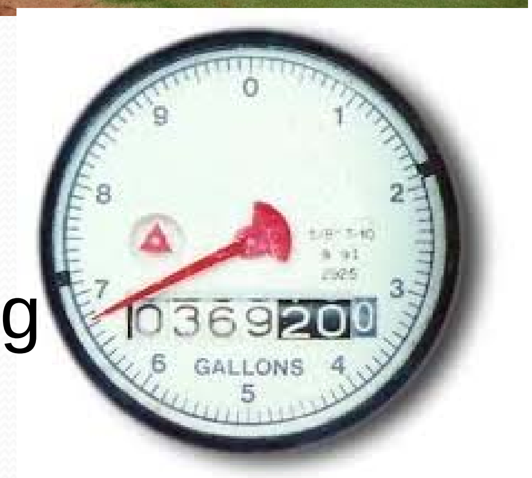
- Gallons per area (ft^2)
- Operating pressure is an important factor
- Swath width important for even distribution
- Nozzle size and spacing important







Calibrate Irrigation System



- Sprinkler spacing
- Nozzle size
- Operating pressure

Why Calibrate?

Applying Water to Turf

- Only real reason for having a sprinkler system
- This is “where the rubber meets the road”
- More important than:
  - ‘smart’ controller
  - Rain sensor
  - Getting ET from a satellite

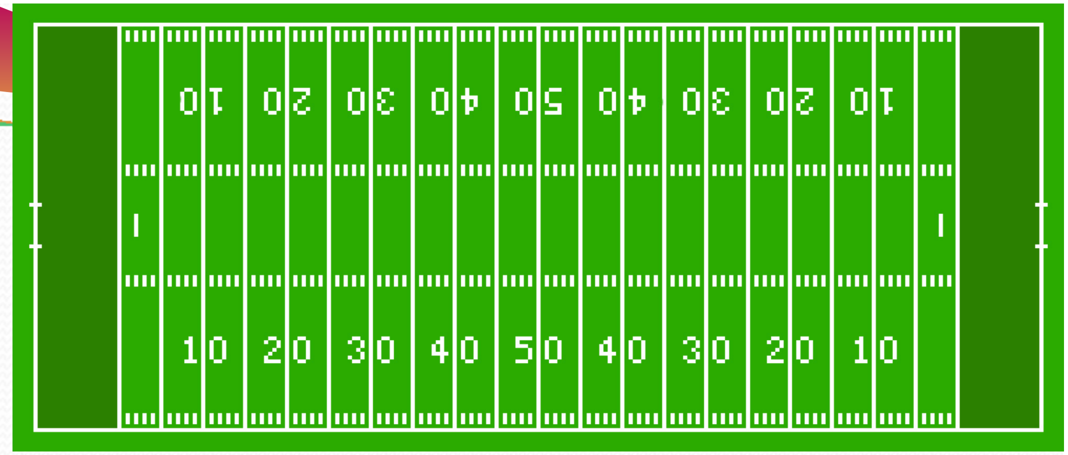
Precipitation

- Gross Precipitation
  - Total amount of water applied over a given area.

$$inches\ depth = \frac{1.604 \times gallons}{ft2}$$

$$1.604 = \frac{ft3}{7.48gal.} x \frac{12in.}{ft} x \frac{1}{ft2}$$

example



- Given:

Football field plus surrounding turf

= 385’ x 220’

or 84700 square feet (ft²)

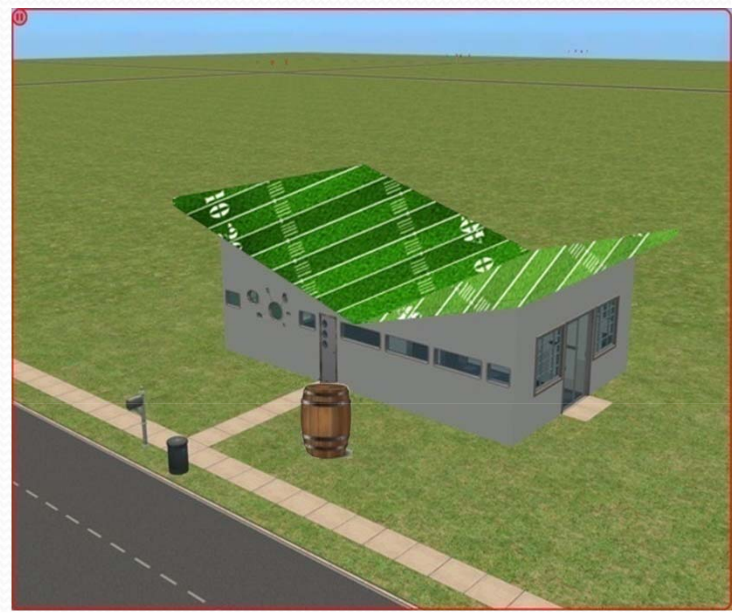
Measured volume through meter

= 10,000 gallons

Average applied depth <u>over entire field</u>

≅ 0.19 inches

$$0.19'' = \frac{1.604 \times 10{,}000}{84700\ ft2}$$



Average Depth Gross Precipitation Rate for entire field

- Doing this type of calculation is useful for budgeting but offers little help for scheduling irrigation or improving overall distribution of water.

Example 2

- Given:

  Baseball turfgrass infield

  (usually a single irrigation zone)

  = 80' x 80' or 6400 ft^2

  Measured volume through meter

  = 750 gallons

  Average applied depth for this zone

  ≅ 0.19"

$$0.19'' = \frac{1.604 \times 750\,gal.}{6400\,ft2}$$

Gross precipitation for single zone

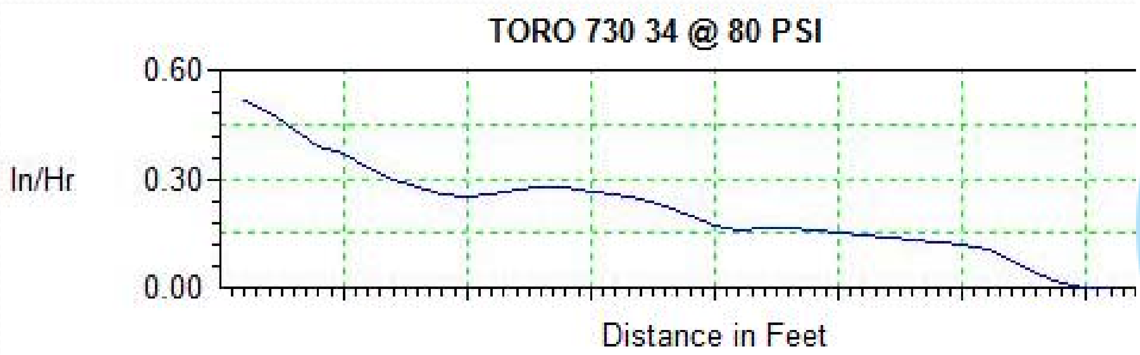
- This is a useful measurement and can be helpful for scheduling irrigation. But this is still 'gross' precipitation and does not account for water losses between the meter and the turf.
- Not precipitation rate
- Does not show how the water is distributed over the field/zone.

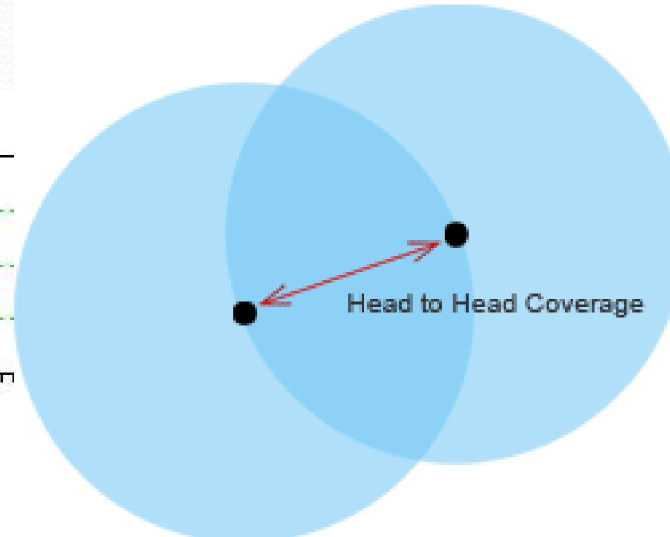
Precipitation Rate

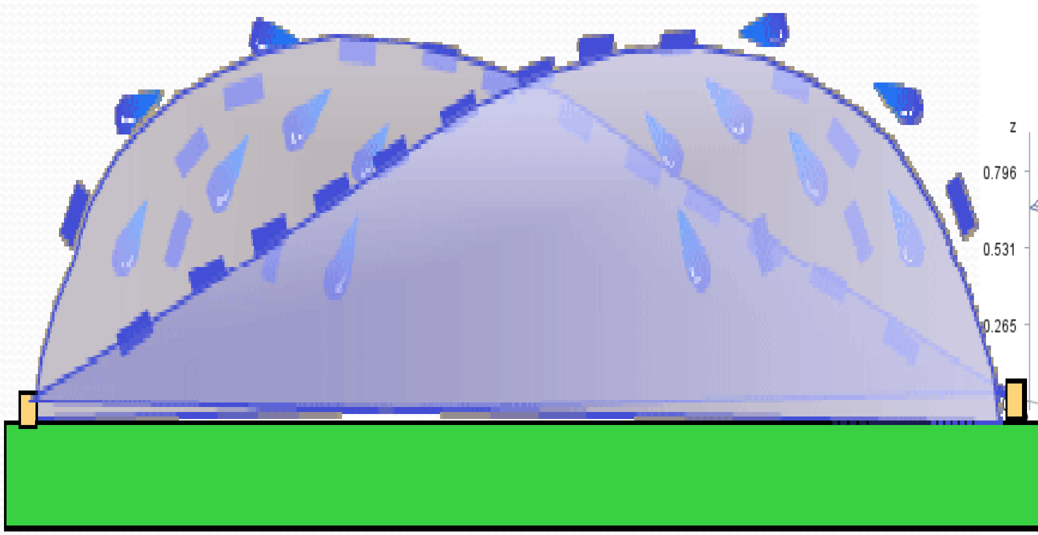
- Rate at which a sprinkler system applies water to a given area.
- Precipitation rate for a system is the average precipitation rate of all sprinklers in a given area regardless of the arc, spacing, or flow rate of each head.
- PR is a function of the total sprinkler discharge applied to the area between the sprinklers.

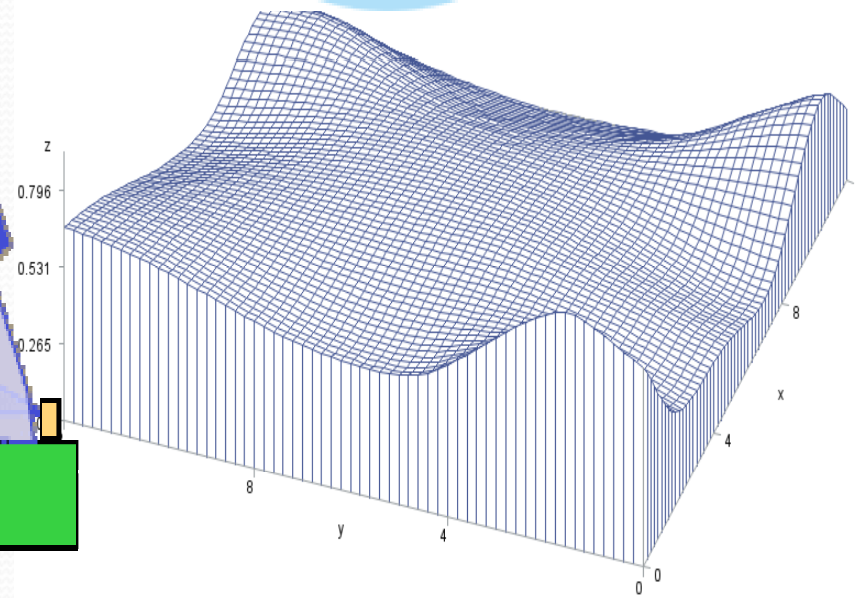
Head-to-head

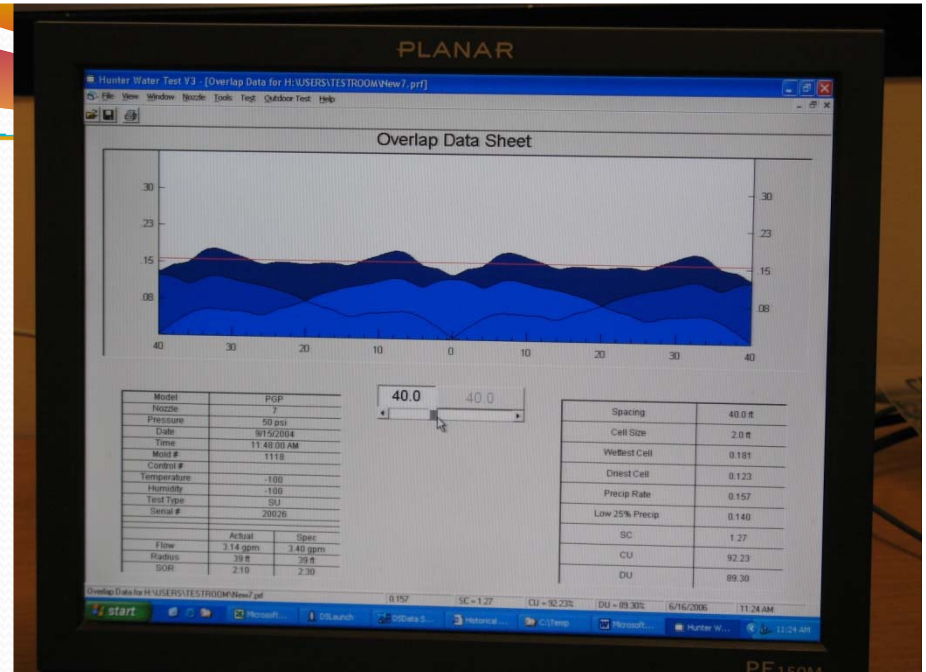
50% or diameter










PLANAR
Overlap Data Sheet
Model PGP
Nozzle 7
Pressure 50 psi
Date 9/15/2004
Time 11:48:00 AM
Mold # 1118
Control #
Temperature -100
Humidity -100
Test Type SU
Serial # 20026
Actual Spec
Flow 3.14 gpm 3.40 gpm
Radius 39 ft 39 ft
SOR 2.10 2.30
40.0
Spacing 40.0 ft
Cell Size 2.0 ft
Wettest Cell 0.181
Driest Cell 0.123
Precip Rate 0.157
Low 25% Precip 0.140
SC 1.27
CU 92.23
DU 89.30
start

Full-Circle (360º)

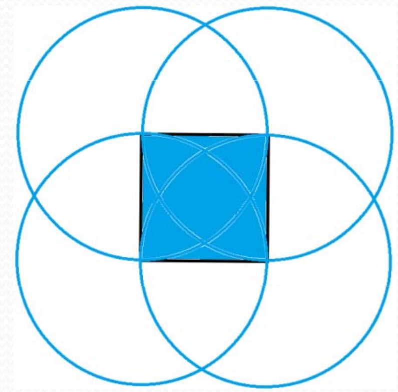
$$IPH = \frac{96.3 \times GPM}{Ft2}$$

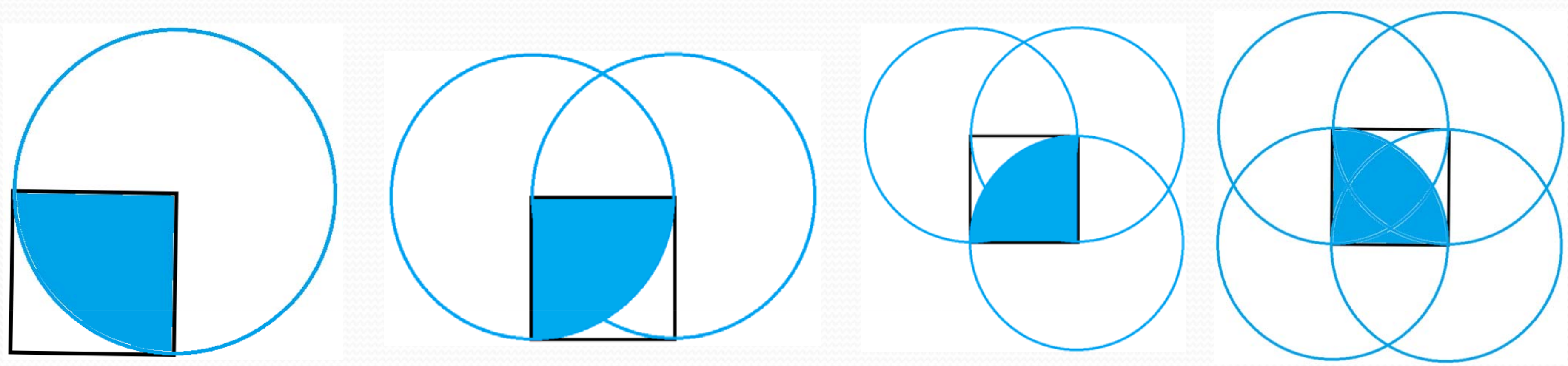
$$96.3 = \frac{ft3}{7.48gal.} \times \frac{60\,\text{min.}}{hour} \times \frac{12inches}{foot}$$

- This is used to determine gross precipitation rates

IPH Square Spacing

$$iph = \frac{96.3 \times gpm}{Row \times sprinkler}$$





Total area equivalent to full-circle sprinkler or 360°
90° + 90° + 90° +90°

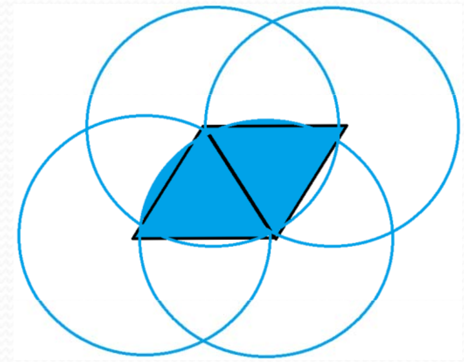
Example

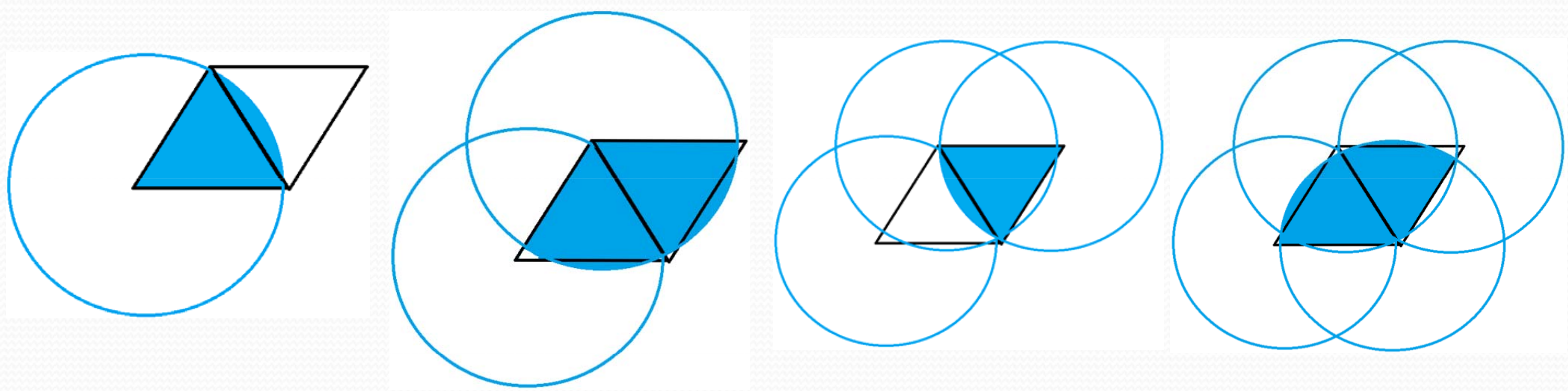
- Each sprinkler has a flow rate of 14 gpm
- Spacing between sprinklers is 60'
- Spacing between rows is 60'
  - square spacing

$$iph = \frac{96.3 \times 14}{60 \times 60} = 0.37'' / hour$$

IPH Triangular Spacing

$$iph = \frac{96.3 \times gpm}{Row \times 0.866 \times sprinkler}$$





Total area equivalent to full-circle sprinkler or 360°

60° + 120° + 60° +120° 0.866 = sine of 60°

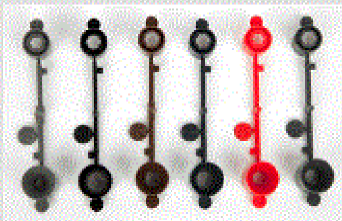
Example

- Each sprinkler has a flow rate of 14 gpm
- Spacing between sprinklers is 60'
- Spacing between rows is 52' (60'x0.866)
  - triangle spacing

$$iph = \frac{96.3 \times 14}{60 \times 52} = 0.43'' / hour$$

Why is the precipitation rate higher with triangle spacing?

I-40 DUAL OPPOSING NOZZLE PERFORMANCE DATA



I-40 Dual Opposing Nozzle Performance Data

Nozzle	Pressure (PSI)	Radius (ft.)	Flow (GPM)	Precip in/hr ■	Precip in/hr ▲
15 Gray	50	52	13.0	0.46	0.53
	60	54	13.2	0.44	0.50
	70	56	14.4	0.44	0.51
	80	57	15.5	0.46	0.53
18 Red	50	58	13.7	0.39	0.45
	60	59	15.2	0.42	0.49
	70	60	16.6	0.44	0.51
	80	62	17.8	0.45	0.51
20 Dk. Brown	60	63	19.1	0.46	0.53
	70	64	20.9	0.49	0.57
	80	66	22.3	0.49	0.57
	90	66	23.9	0.53	0.61
23 Dk. Green	60	65	20.4	0.46	0.54
	70	66	22.3	0.49	0.57
	80	67	24.0	0.51	0.59
	90	68	25.6	0.53	0.62
25 Dk. Blue	60	66	22.0	0.49	0.56
	70	68	24.0	0.50	0.58
	80	69	25.9	0.52	0.60
	90	70	27.2	0.53	0.62
28 Black	70	70	28.9	0.57	0.66
	80	72	30.9	0.57	0.66
	90	74	32.9	0.58	0.67
	100	76	33.7	0.56	0.65

* Factory-installed nozzle

Note: All preciptation rates calculated for 180-degree operation.

For the precipitation rate for a 360-degree sprinkler, divide by 2.

Precipitation rates for the 36S model are calculated at 360 degrees.

I-40 Dual Opposing Nozzle Performance Data

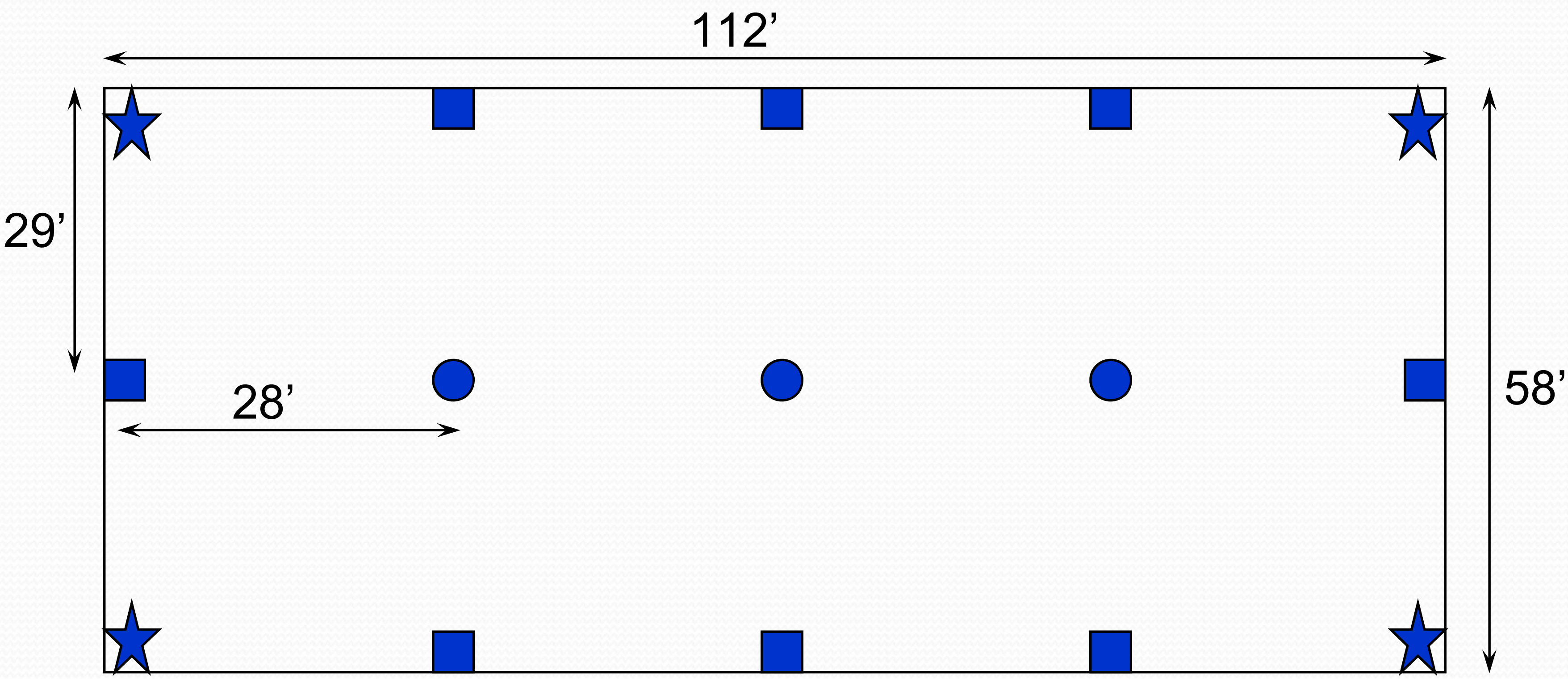
Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
15 Gray	50	53'	13.0	0.45	0.51
	60	54'	14.3	0.47	0.55
	70	56'	15.5	0.48	0.55
	80	58'	16.3	0.47	0.54
18 Red	50	60'	15.3	0.41	0.47
	60	61'	16.3	0.42	0.49
	70	62'	17.3	0.43	0.50
	80	64'	18.8	0.44	0.51
20 Dk. Brown	60	66'	18.8	0.42	0.48
	70	67'	20.0	0.43	0.50
	80	68'	21.5	0.45	0.52
	90	68'	22.4	0.47	0.54
23 Dk. Green	60	67'	21.5	0.46	0.53
	70	68'	23.0	0.48	0.55
	80	69'	25.1	0.51	0.59
	90	70'	26.0	0.51	0.59
25 Dk. Blue*	60	68'	21.0	0.44	0.50
	70	70'	25.0	0.49	0.57
	80	72'	26.2	0.49	0.56
	90	74'	27.2	0.48	0.55
28 Black	70	72'	26.7	0.50	0.57
	80	74'	27.9	0.49	0.57
	90	76'	30.1	0.50	0.58
	100	78'	32.0	0.51	0.58

A couple Practice Problems

Precipitation applied to a zone

What would be the total gallon flow for a 10 minute run from all sprinklers? What is the total depth applied?

★ 90°- 1.4 GPM ■ 180°- 2.9 GPM ● 360°- 5.5 GPM



Whole Zone Precipitation

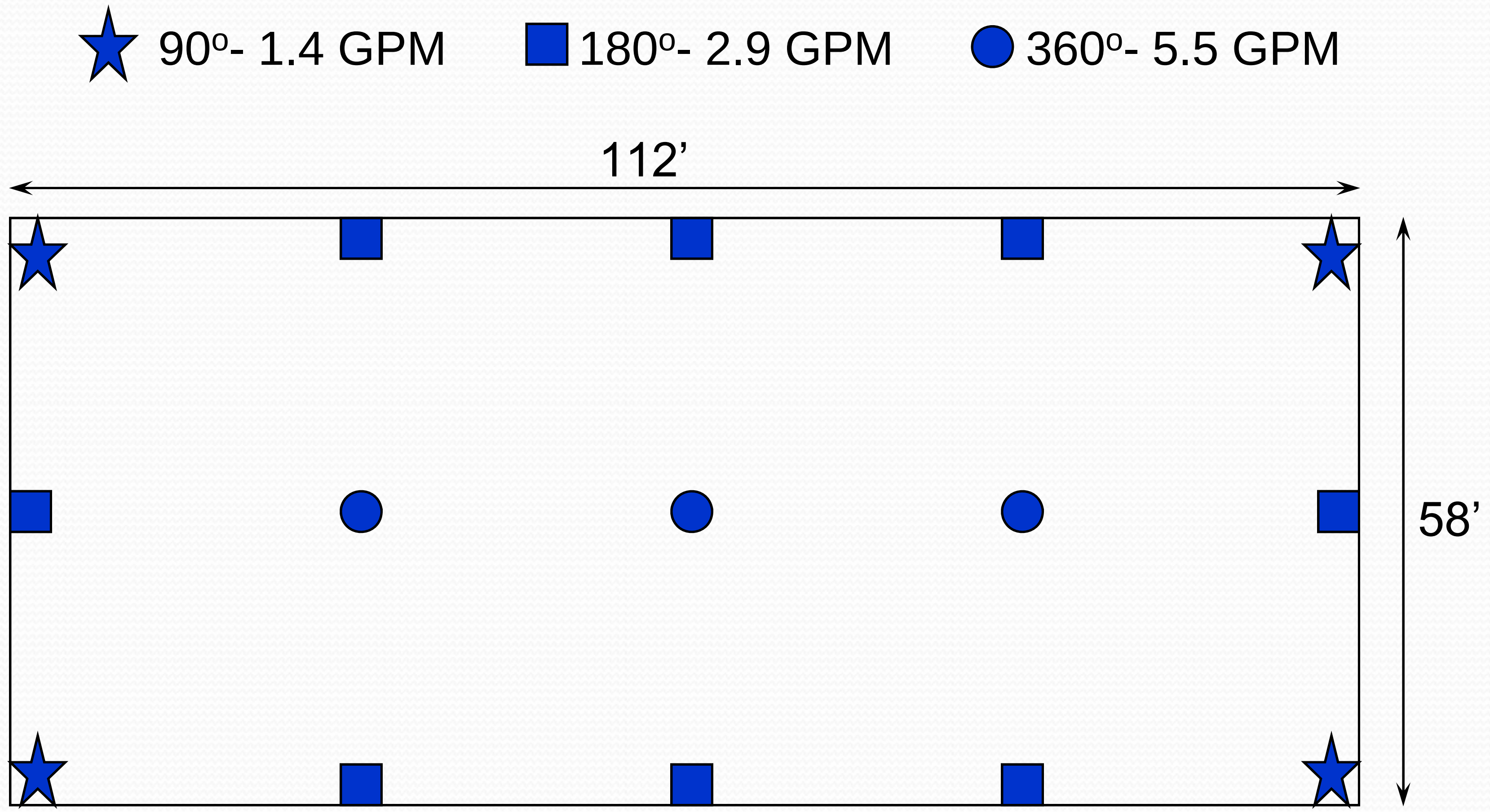
$$1.4gpm \times 4Q = 5.6gpm$$
$$2.9gpm \times 8H = 23.2gpm$$
$$5.5gpm \times 3F = 16.5gpm$$

$$5.6 + 23.2 + 16.5 = 45.3$$

$$45.3gpm \times 10\min = 453gallons$$

$$"depth = \frac{1.604 \times 453gal}{112' \times 58'} = 0.11"$$

Calculate the Precipitation Rate for an entire zone



Whole zone precipitation rate

$$1.4gpm \times 4Q = 5.6gpm$$
$$2.9gpm \times 8H = 23.2gpm$$
$$5.5gpm \times 3F = 16.5gpm$$

$$5.6 + 23.2 + 16.5 = 45.3$$

$$112' \times 58' = 6496\,ft2$$

$$\frac{96.3 \times 45.3}{6496\,ft2} = 0.67'' / hr.$$

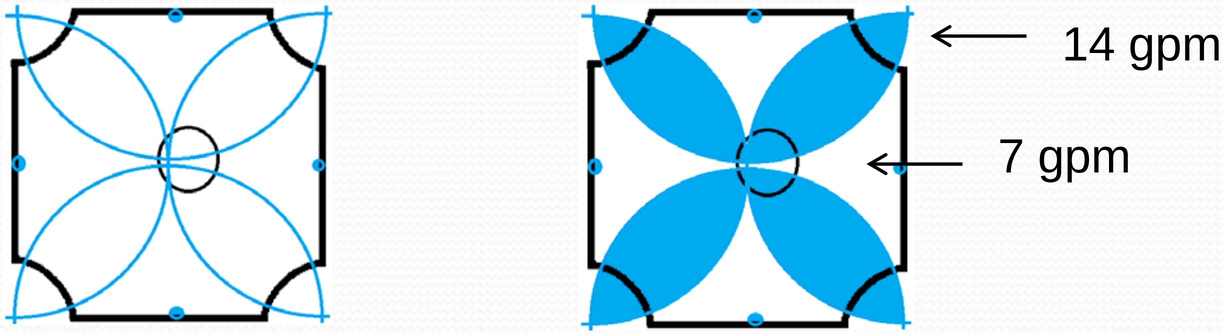
Run Time

- How many minutes would be needed to apply 0.25”?

$$\frac{60\,\text{min.}}{hour} \times \frac{hour}{0.67''} \times 0.25''$$

$$\frac{60\,\text{min.}}{h\phi ur} \times \frac{h\phi ur}{0.67\not{''}} \times 0.25\not{''} = 22.4\,\text{min.}$$

So, What is the precipitation rate for a baseball infield?



- Each 360° sprinkler has a flow rate of 14 gpm
- Spacing between sprinklers is 80'
- Spacing between rows is 80'
  - Square spacing?

$$iph = \frac{96.3 \times 14}{80 \times 80} = 0.21'' / hour \qquad iph = \frac{96.3 \times 7}{80 \times 80} = 0.11'' / hour$$

Probably somewhere between these two values – need to test

Gross precipitation rates

- All ideal values
  - no actual measure of real distribution
- All water is assumed to reach the turf
- Pressure at each nozzle all as designed and all the same
  - Differences in nozzle pressure can vary iph significantly
- Turf area covered by any sprinkler or zone assumed.
  - Also based on ideal operating pressure
- Every sprinkler level & to-grade
- All spacing installed/maintained as designed

Net Precipitation

- Net
  - Measure of the amount of water that actually reaches the landscape.
  - The net precipitation rate is the gross precipitation rate minus the losses that occur between the sprinkler and the landscape surface.
  - The real deal

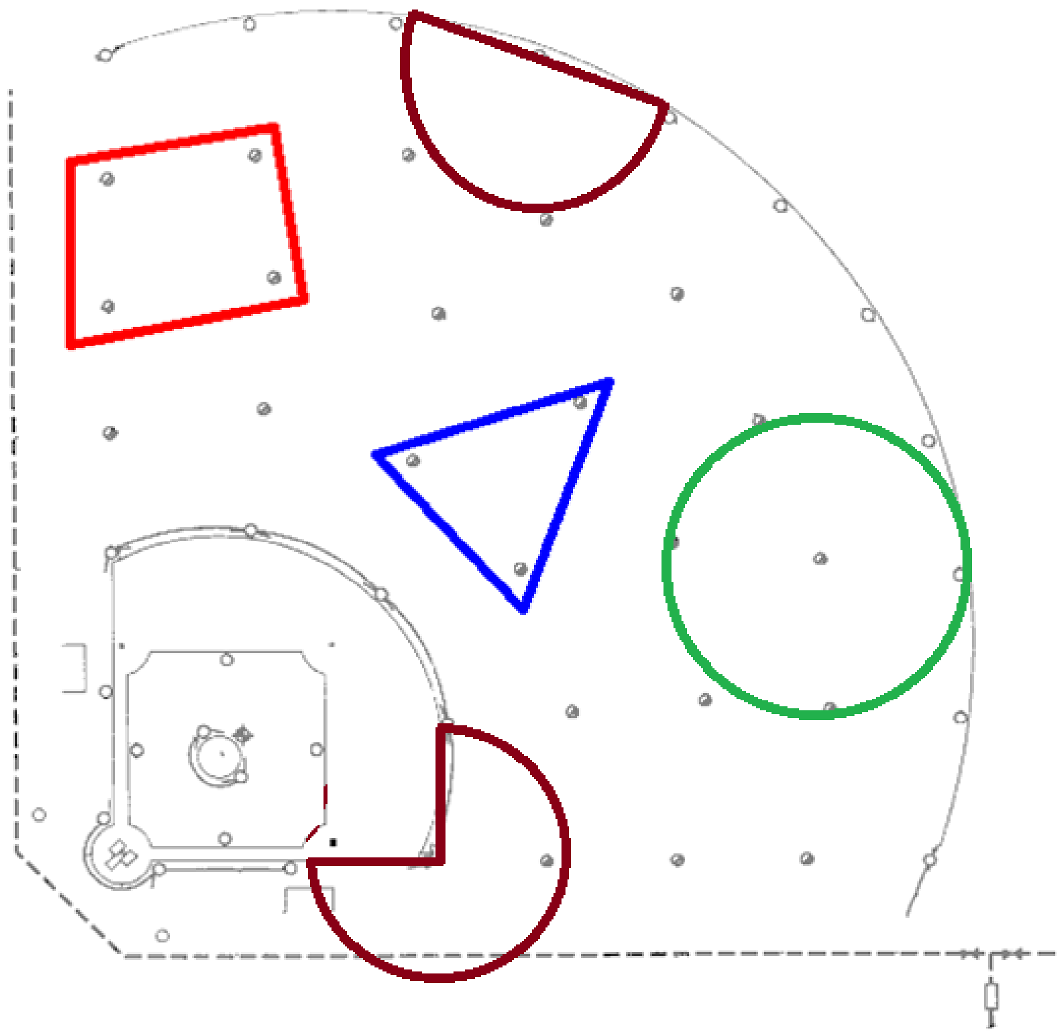
How?

- **Use catchment devices to determine actual precipitation rates**

Determine the precipitation rate of a baseball outfield

- Each zone surrounded by other zones
- Spacing, pressure all variable
- Arcs mixed

Baseball Field Has both Triangle & Square spacing, full and part-circle arcs

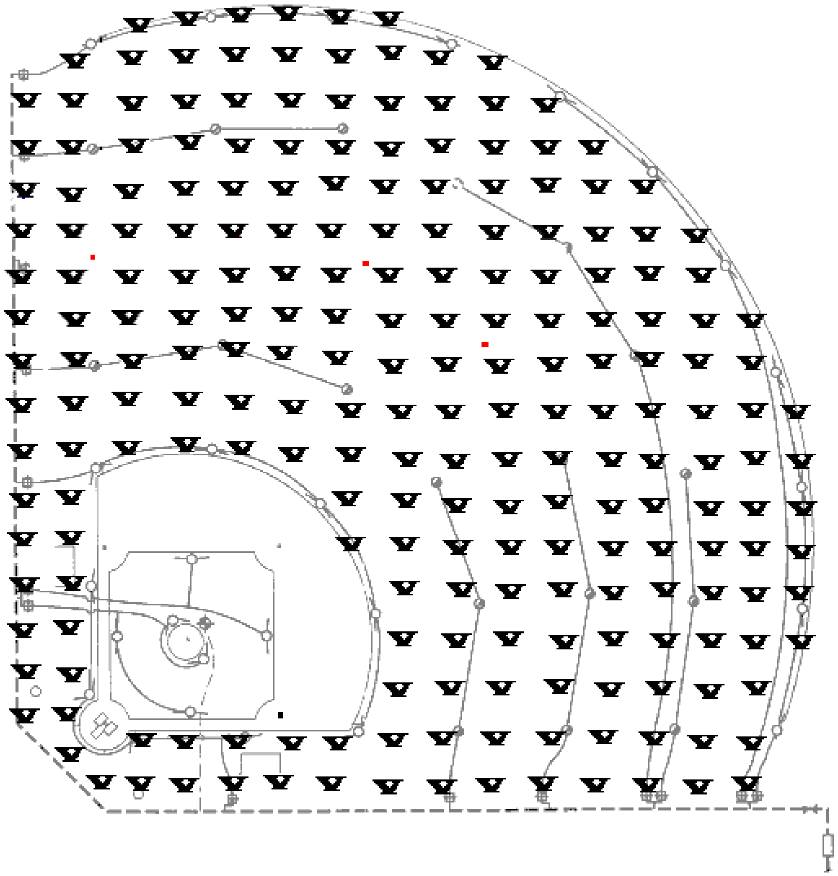


How?

- Arrange catch cups in grid pattern
- Usually measure along 3rd base line
- Want to have at least 3 cups between each sprinkler
  - For 60’ head spacing, the cups would need to be about 15’ to 19’ apart

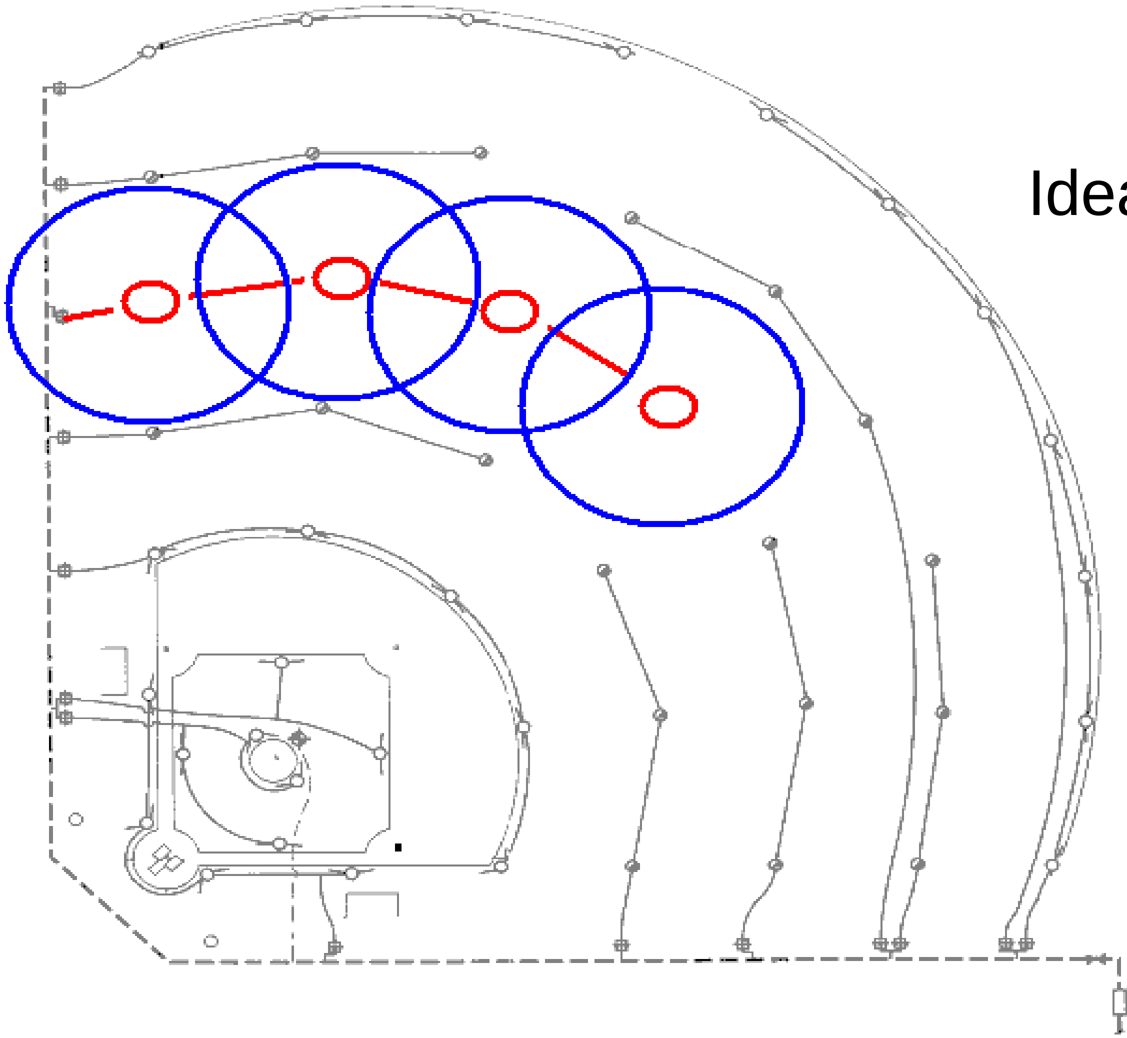
The number of cups used depends on desired detail

Catch cup Grid



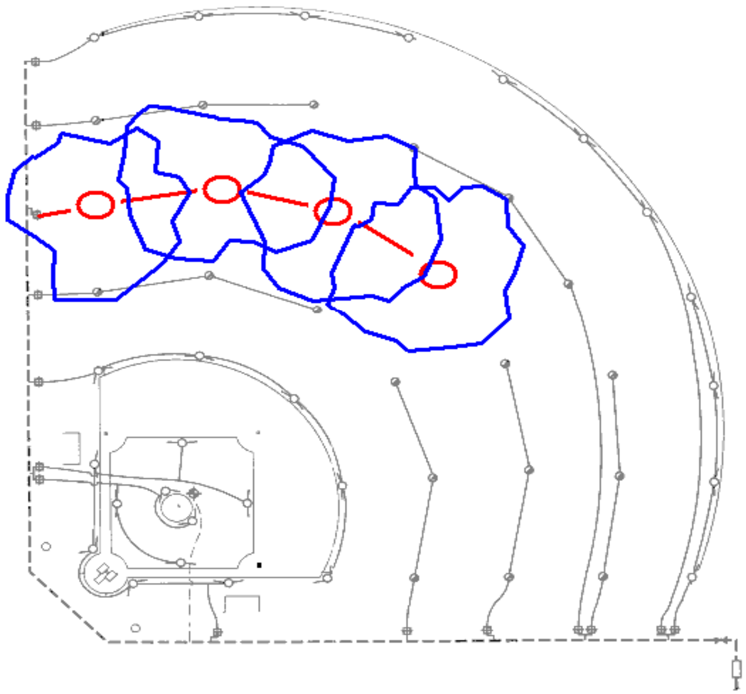
Need ~250+ cups

Start with one zone

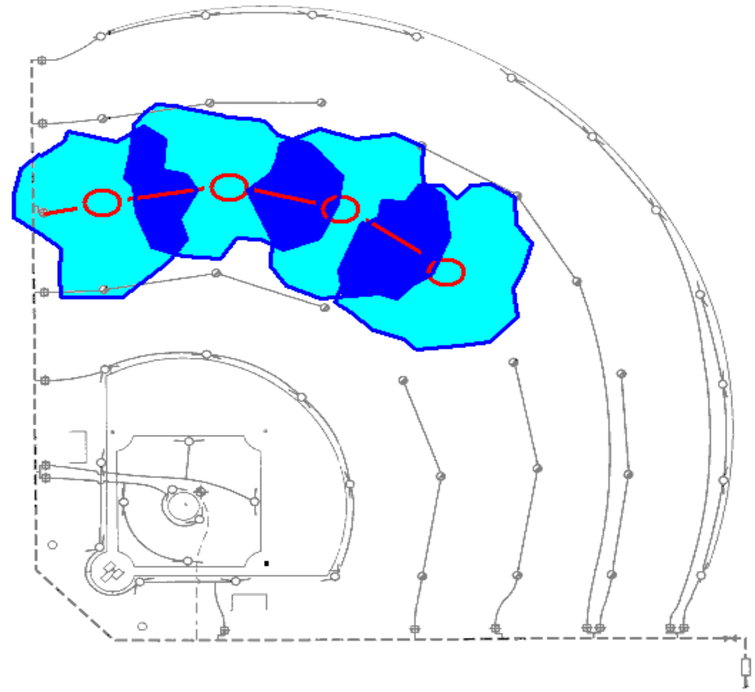


Ideal sprinkler coverage

Operate zone for 15-20 minutes, or more



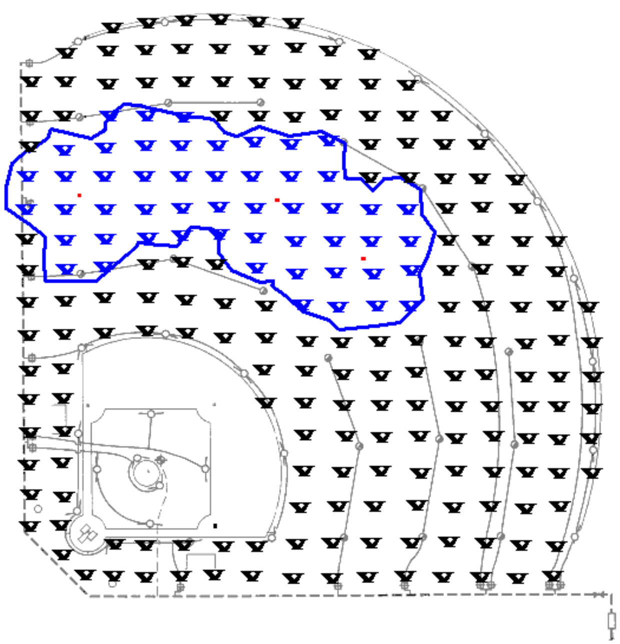
More realistic coverage

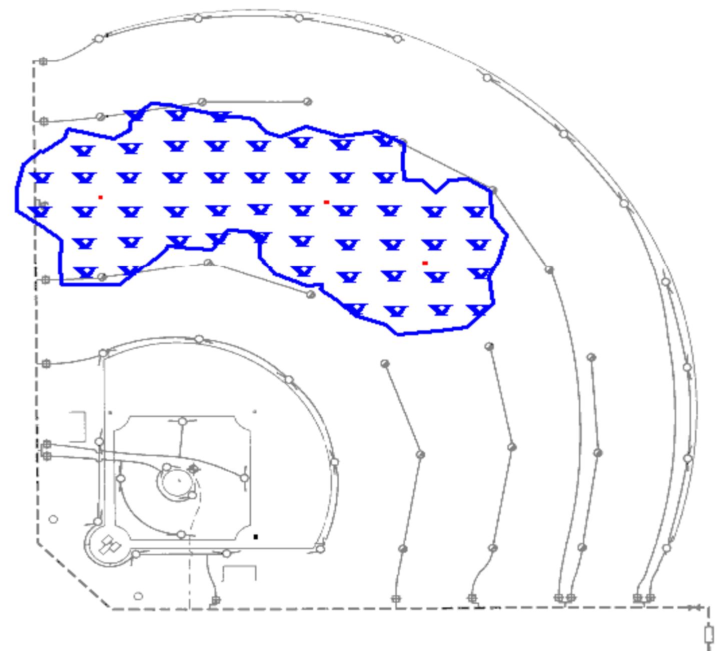


Overlap coverage

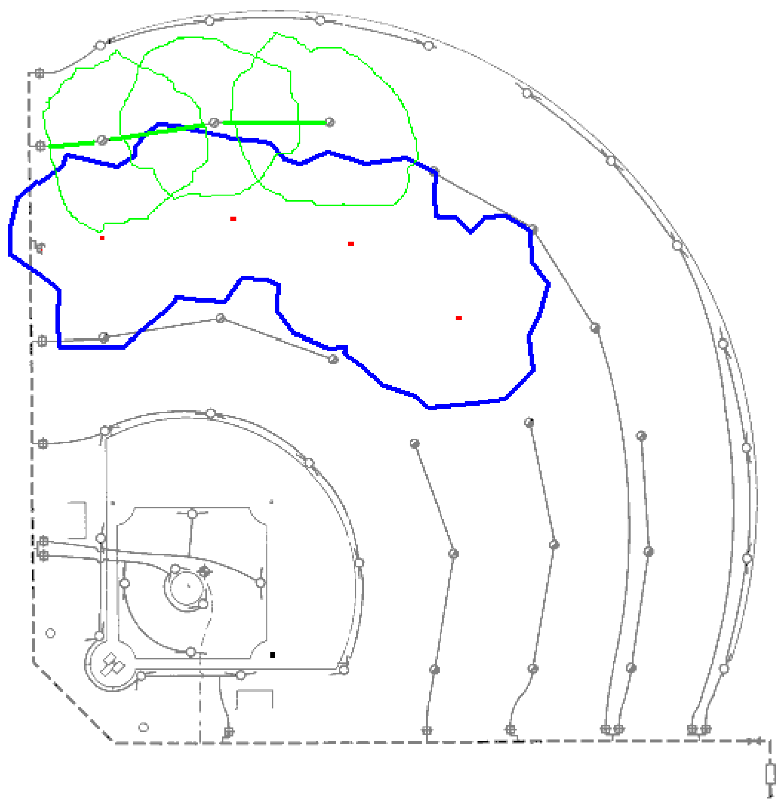
Catch cups covered by single zone

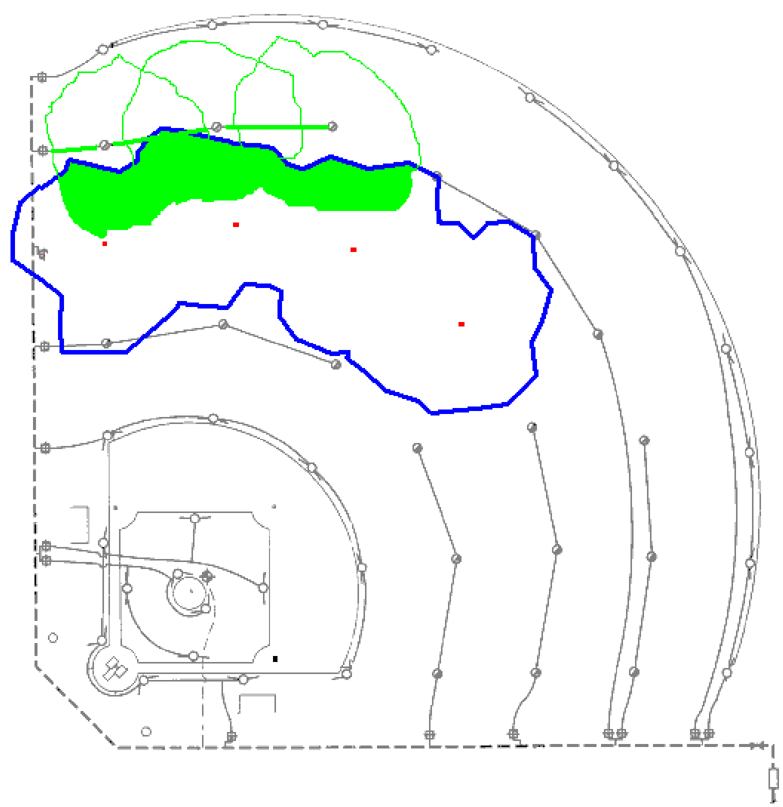
- Record catch volumes from single zone
- Mark cups that get water from this single zone
- Identify all adjacent zones that contribute water to this first zone area
- Operate each adjacent zone for the <u>same time</u> used on first zone
- Record catch values from all other adjacent zones



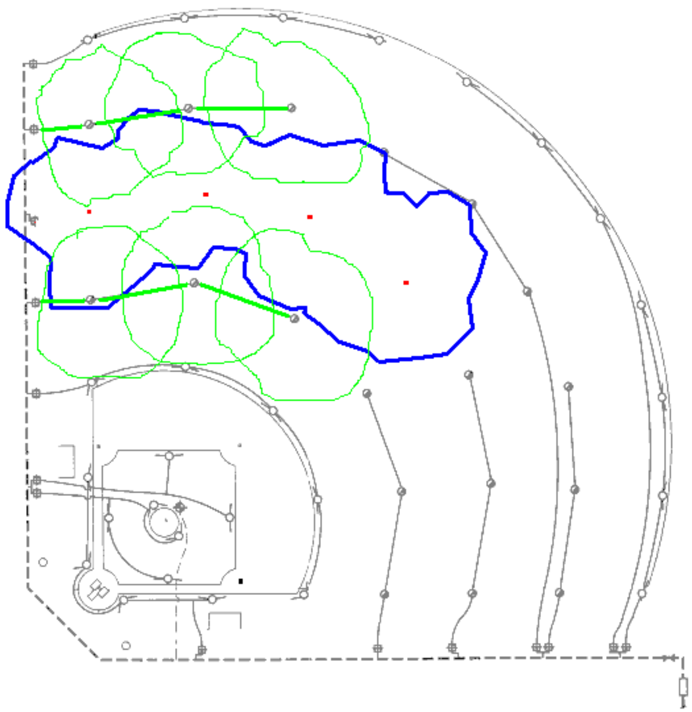


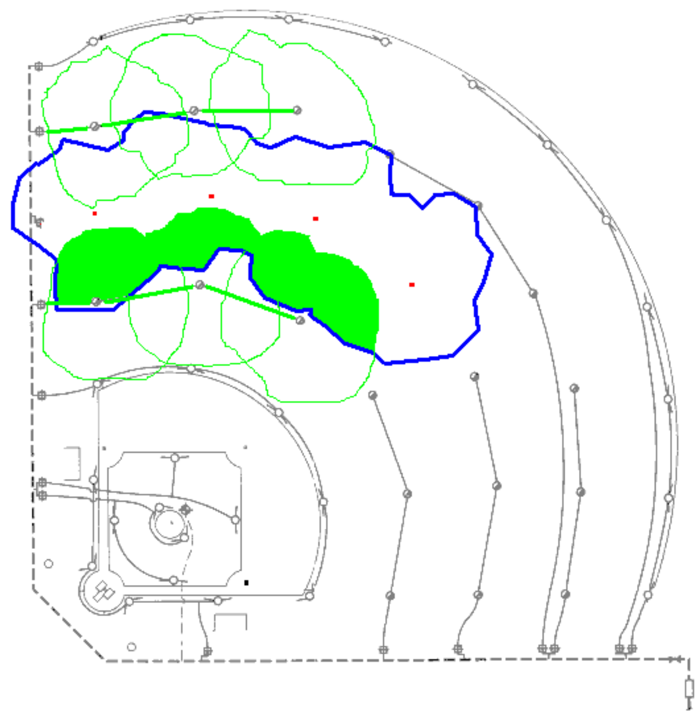
First Adjacent Zone



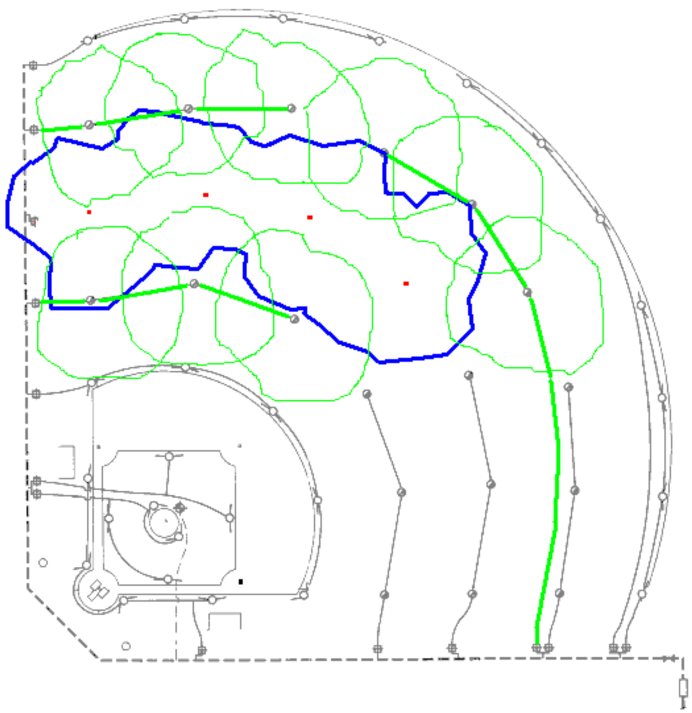


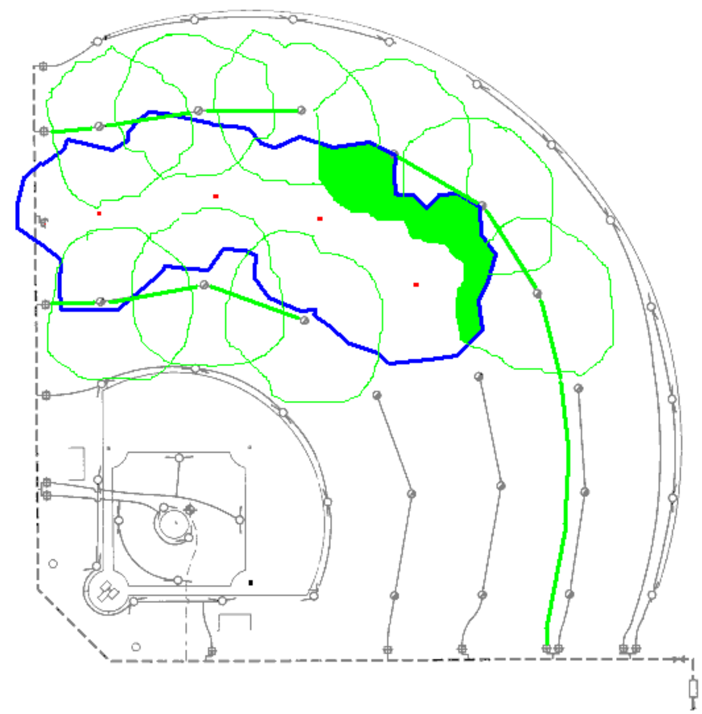
Second Adjacent Zone



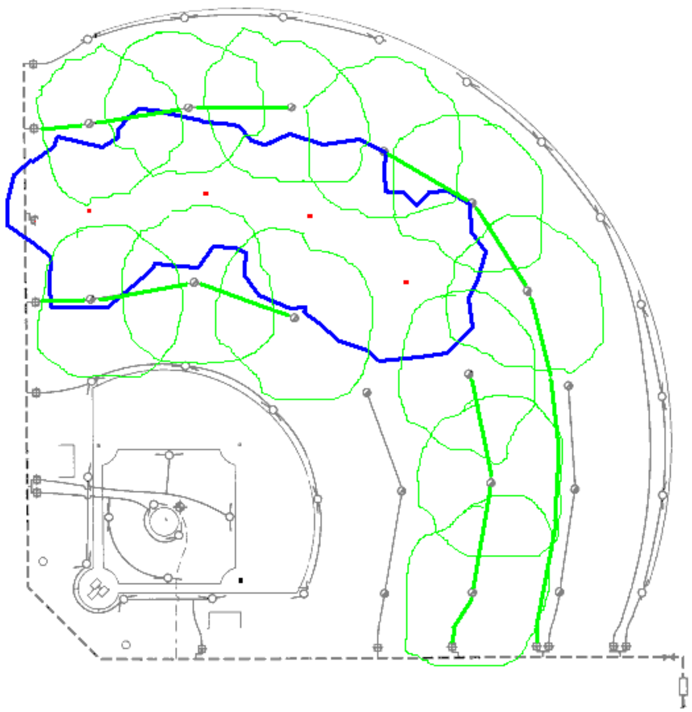


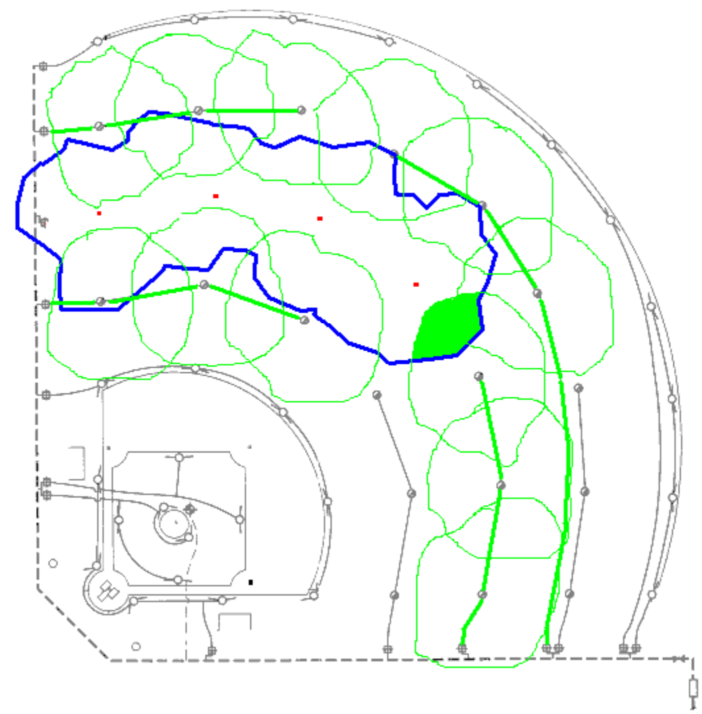
Third Adjacent Zone



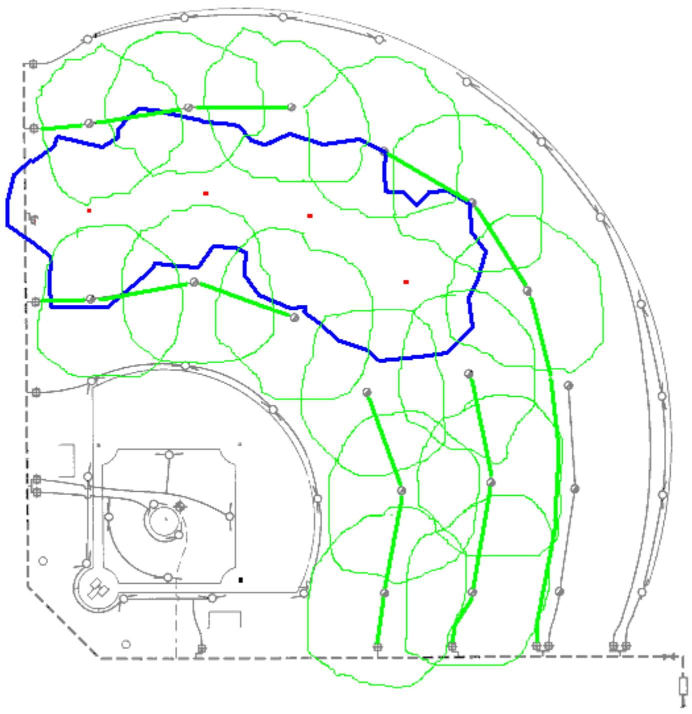


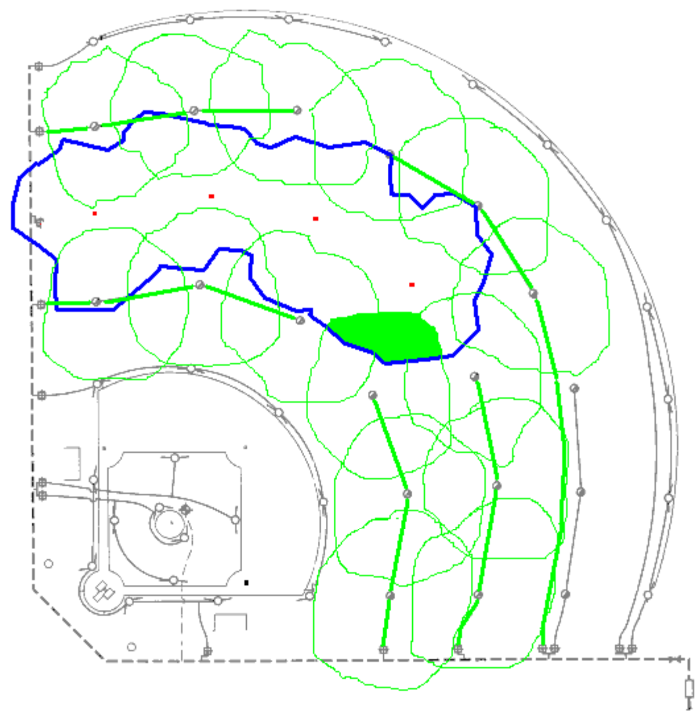
Fourth Adjacent Zone



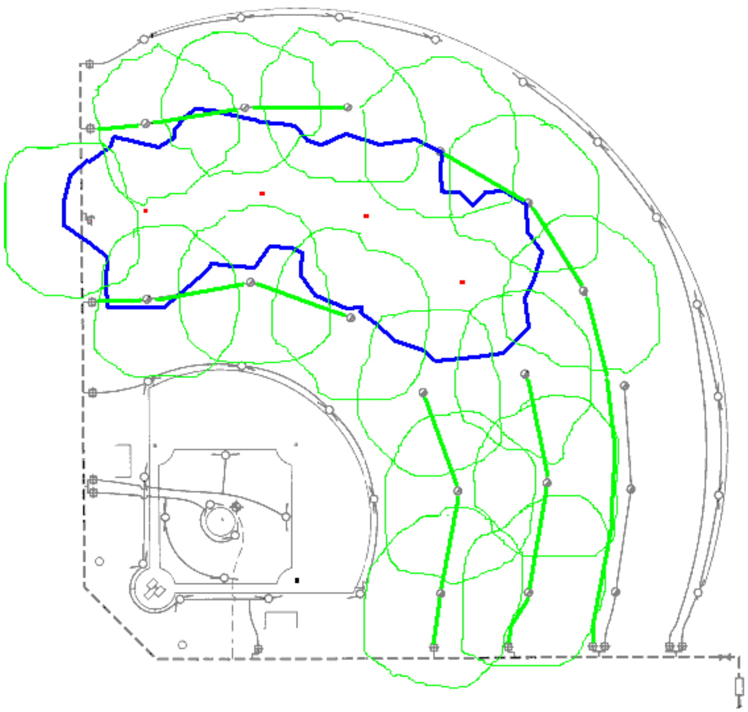


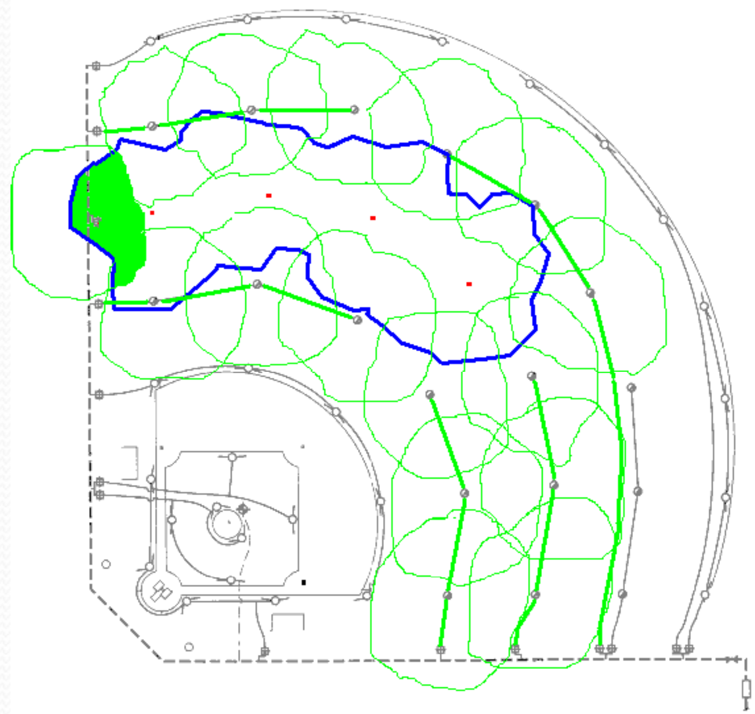
Fifth Adjacent Zone





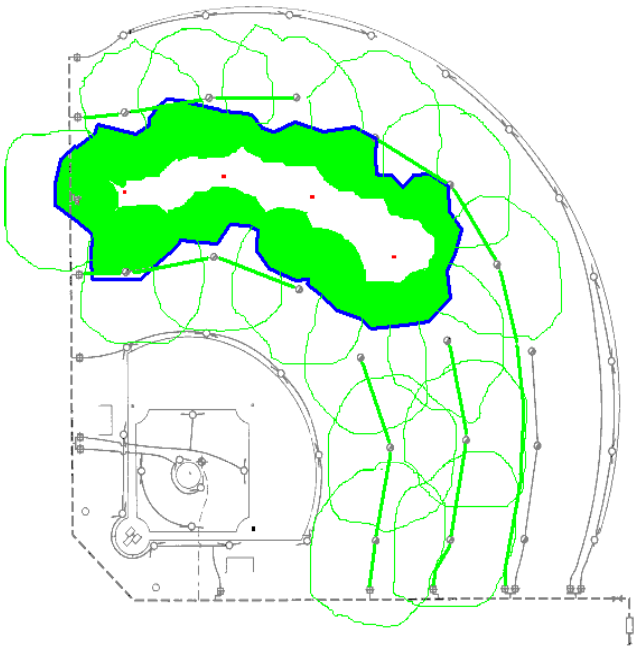
Sixth Adjacent Zone



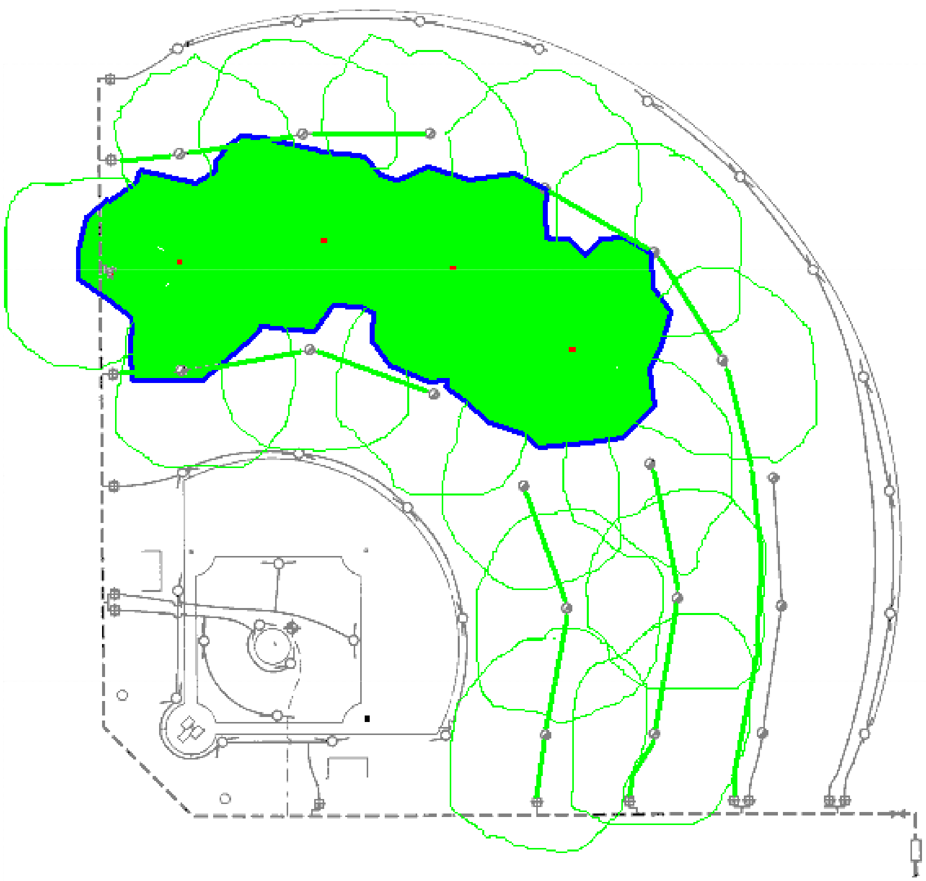


Why include all surrounding zones?

- Just like all precipitation rates covered earlier.
- Coverage needs to add up to an even multiple of 360º if truly head-to-head spacing
- Independent of whether spacing is square or triangle



All contributing zones



$$4 \times 360^\circ = 1440^\circ$$
$$3 \times 180^\circ = 540^\circ$$
$$3 \times 180^\circ = 540^\circ$$
$$3 \times 180^\circ = 540^\circ$$
$$1 \times 180^\circ = 180^\circ$$
$$1 \times 180^\circ = 180^\circ$$
$$1 \times 180^\circ = 180^\circ$$
$$= \frac{3600^\circ}{360^\circ}$$

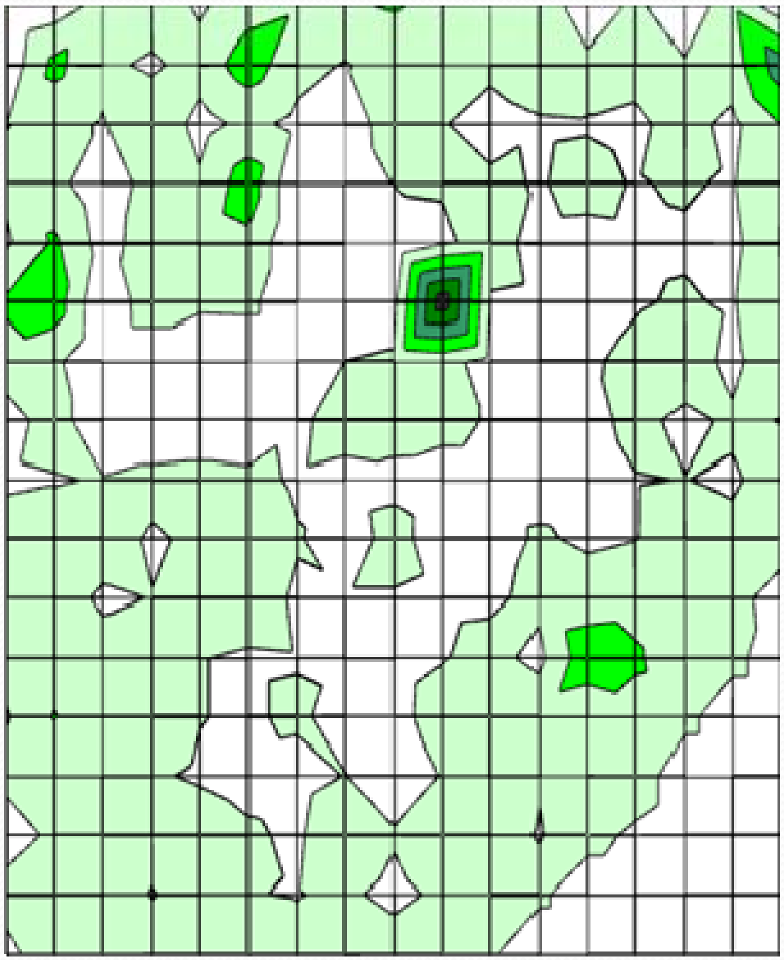
Or, 10 full-arc sprinklers

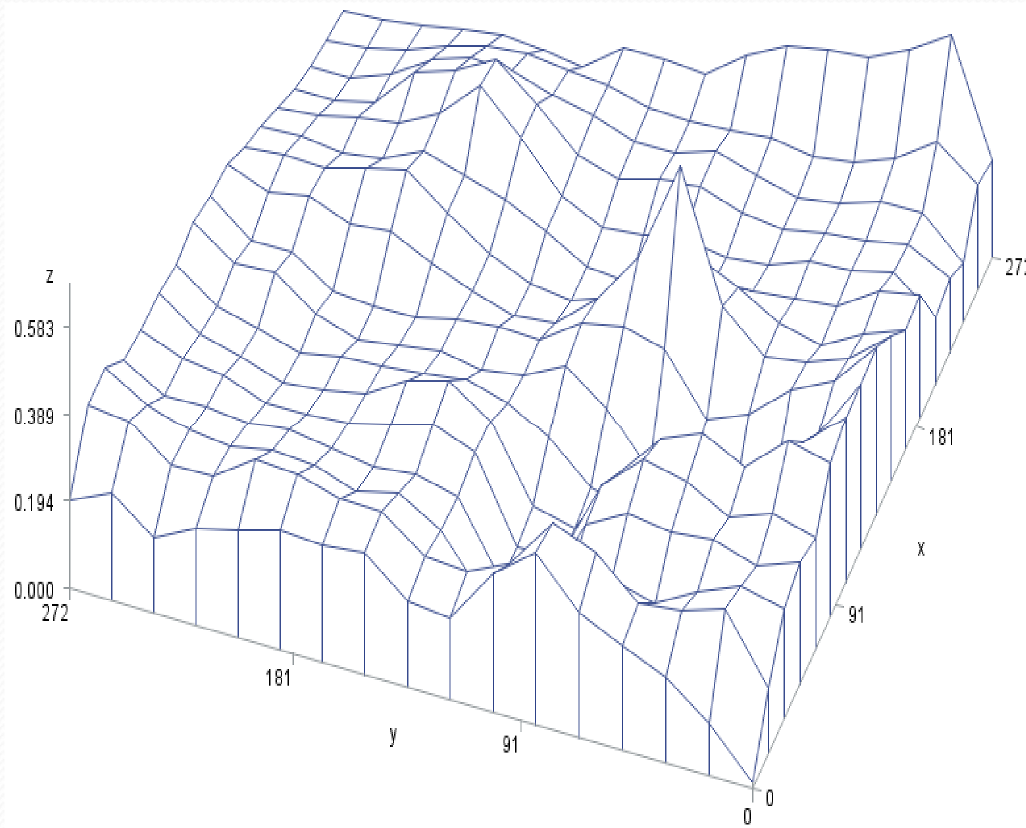
Combine all catch volumes

- Add catch cup values together, cup by cup
- Get average
- Determine precipitation rate
- Then, REPEAT with all other zones.
  - For example

Sta. #	1	2	3	4	5	6	7	8	9	10	11	12
IPH	0.71	0.81	0.57	0.71	0.59	0.65	0.56	0.46	0.59	0.66	0.71	0.59

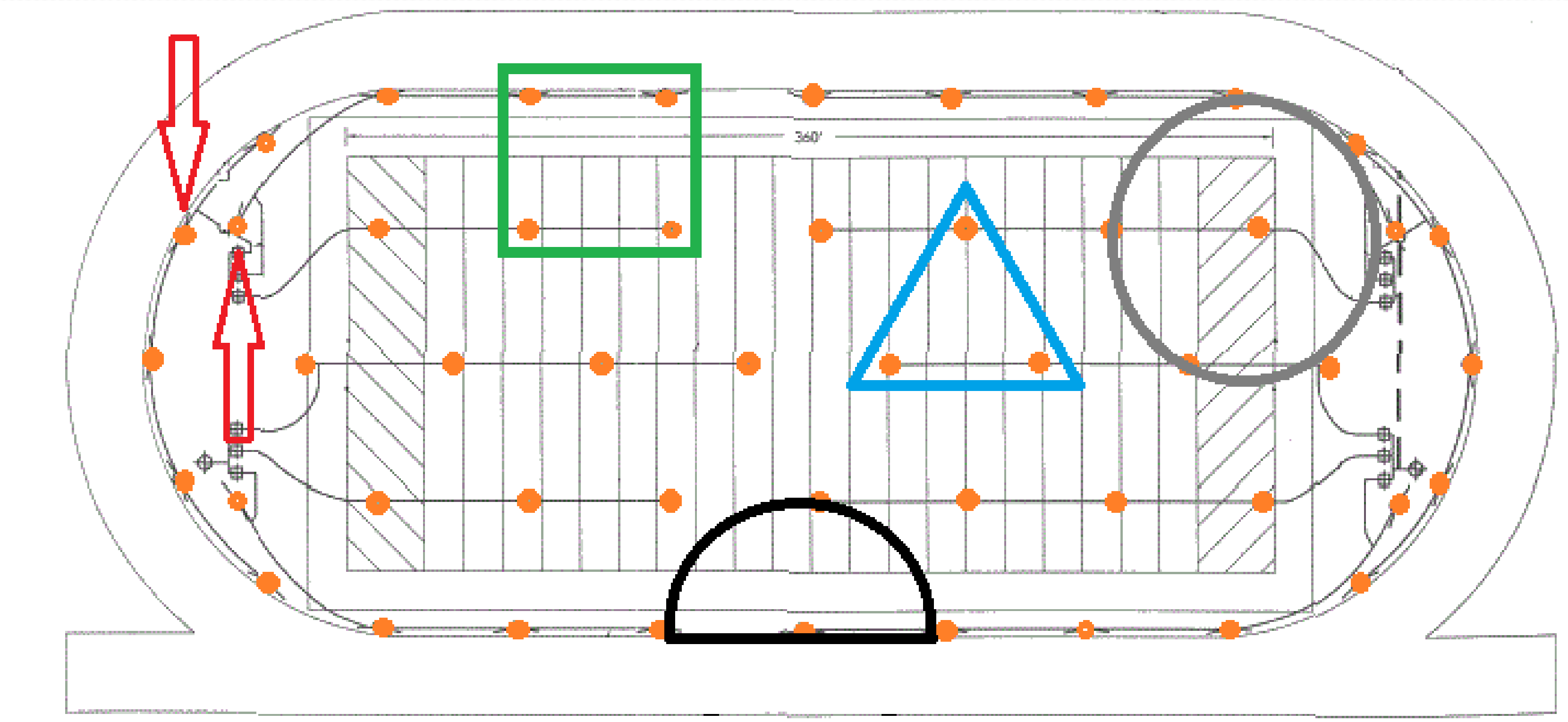
Surface plot of catch cup data





The reason for placing cups on a grid pattern

Football field with mixed sprinkler spacing & arcs

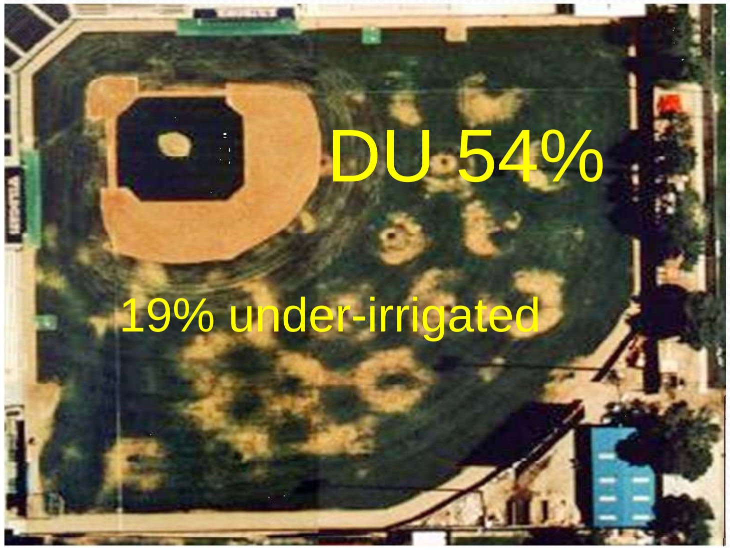


And, now can include *Calibration* when repairing these items to improve DU

- Misaligned sprinklers
- Tilted sprinklers
- Improper pressure
  - High or low
- Non-rotating sprinkler
- Blocked spray pattern
- Low head drainage
- Missing sprinklers
- Improper spacing
- Clogged nozzles
- Leaks in laterals or main
- Incorrect pipe size
- Inadequate flow
- Slow valves
- Mixed nozzles
- Damaged nozzles
- Matched precipitation
  - At least w/in zone
- Mixed brands

Benefits of zone-by-zone calibration

- Apply desired depth at each irrigation event
  - Very difficult to determine IPH on baseball field
  - Do not rely on catalog iph values for scheduling which can result in deficit irrigation
- Increase overall DU & player Safety



end

Thank You


ARIZONA BASEBALL
AT BAT
AVG.
TIME OF DAY
BALL
STRIKE
OUT
H/E
1 2 3 4 5 6 7 8 9 10 R H E
O'Rielly CHEVROLET
WATSON
Bashas'
375
ARIZONA BASEBALL
NCAA College World Series Appearances
1954 · 1955 · 1956 · 1958 · 1959
1960 · 1963 · 1966 · 1970 · 1976
1979 · 1980 · 1985 · 1986 · 2004