Pivot Design

Oregon NRCS Engineering Meeting

January 11-14, 2005

United States Department of Agriculture
NRCS Natural Resources Conservation Service

Everything you need to know about Center Pivots, but didn't really want to know

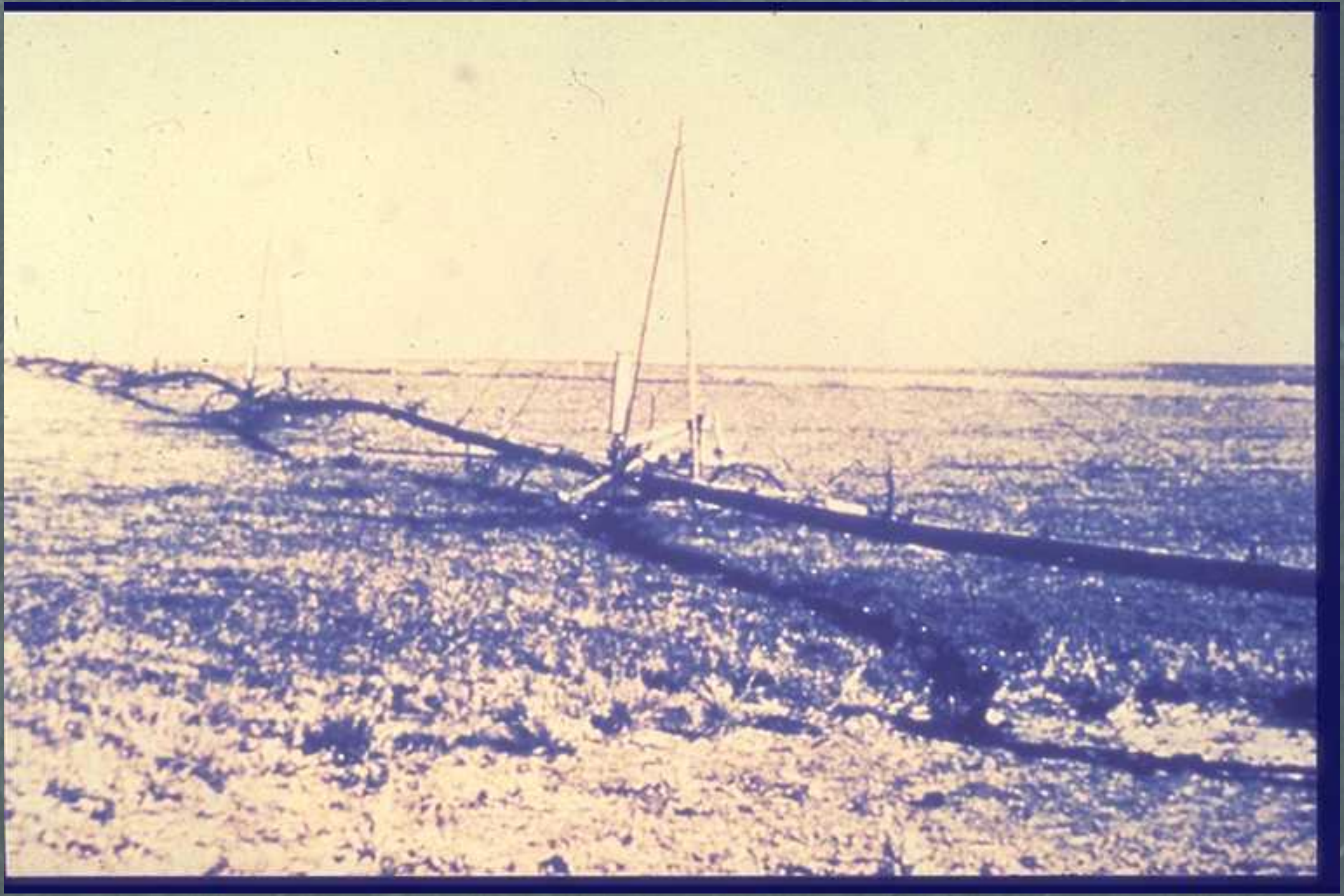
Topics

- Brief Overview
- Parts and Pieces
- Water requirements – System flow rate
- Pressure requirements – Friction loss
- Nozzle type – Selection
- Application – Rate, Timing
- Runoff management

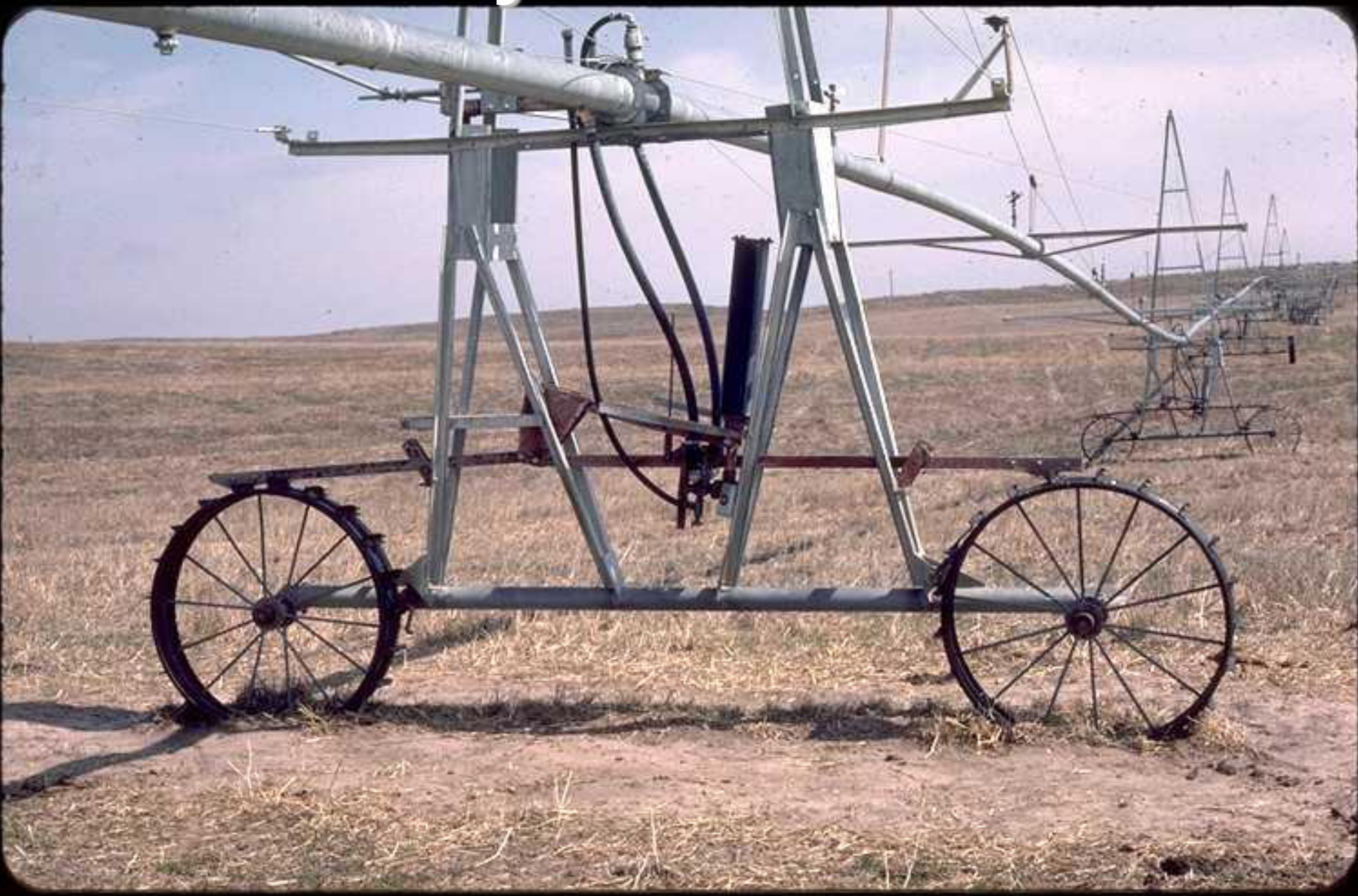
Who is Frank Zybach?

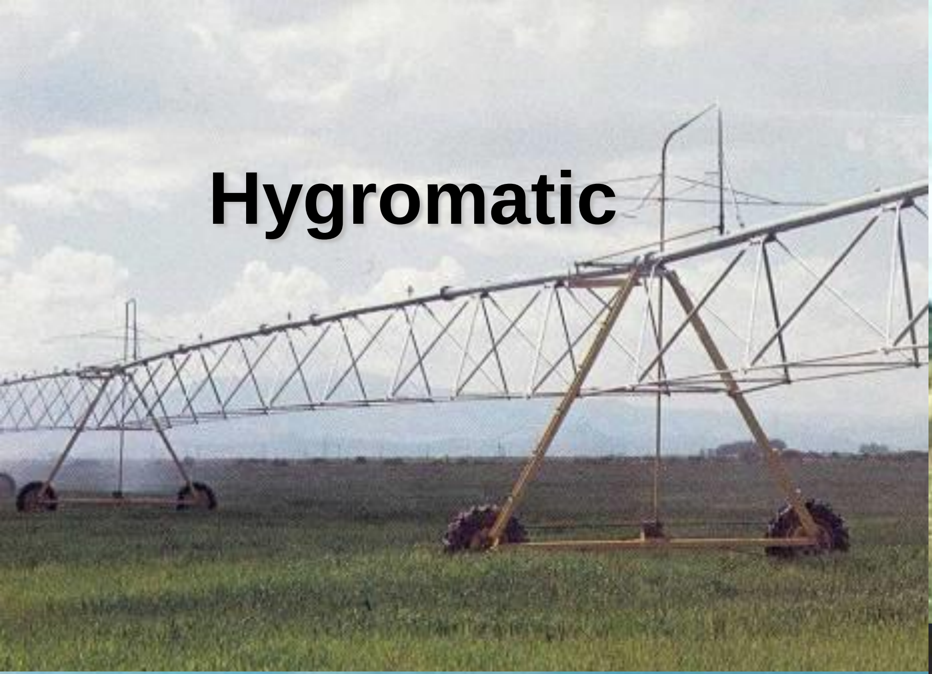
- Inventor of the Center Pivot in the year 1951

First Pivot



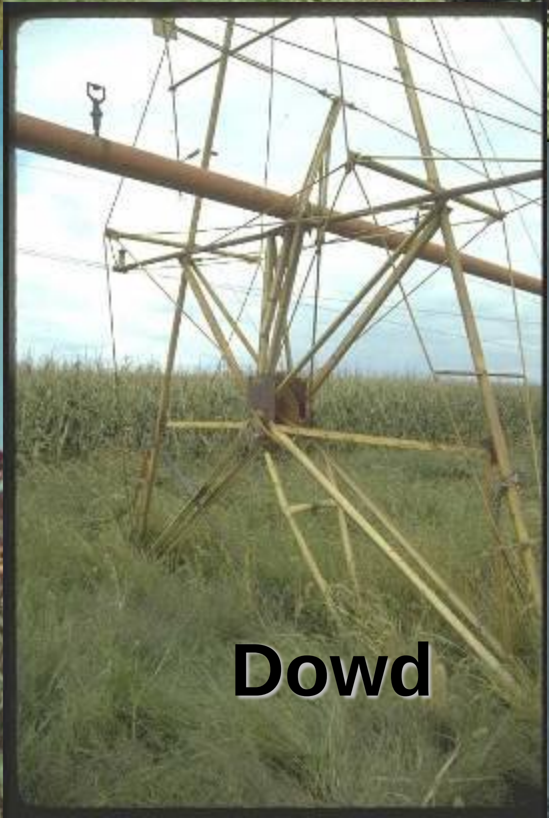
Valley - Model 1972




Hygromatic


Raincat


Olson
OLSON
OIL
HYDRAULIC PROPELLED


Dowd

Towable pivot

Multi purpose Machines

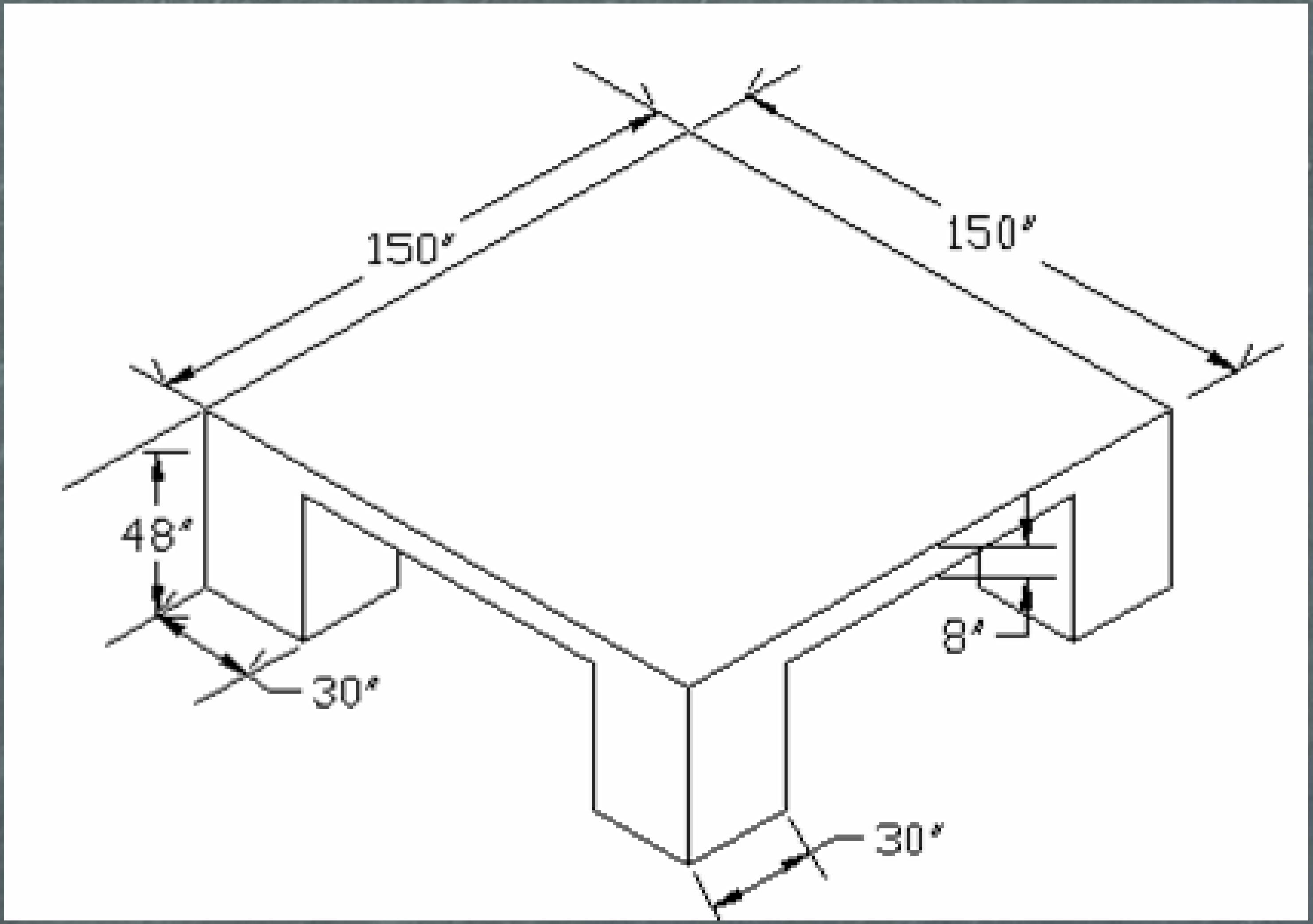
Parts and Pieces

- Parts of a Pivot
- Physical Span Features
- Span Crop Clearance
- Overhang Length
- Tire Type and Drive Unit
- Slope Limitations
- Options

Parts of the Pivot

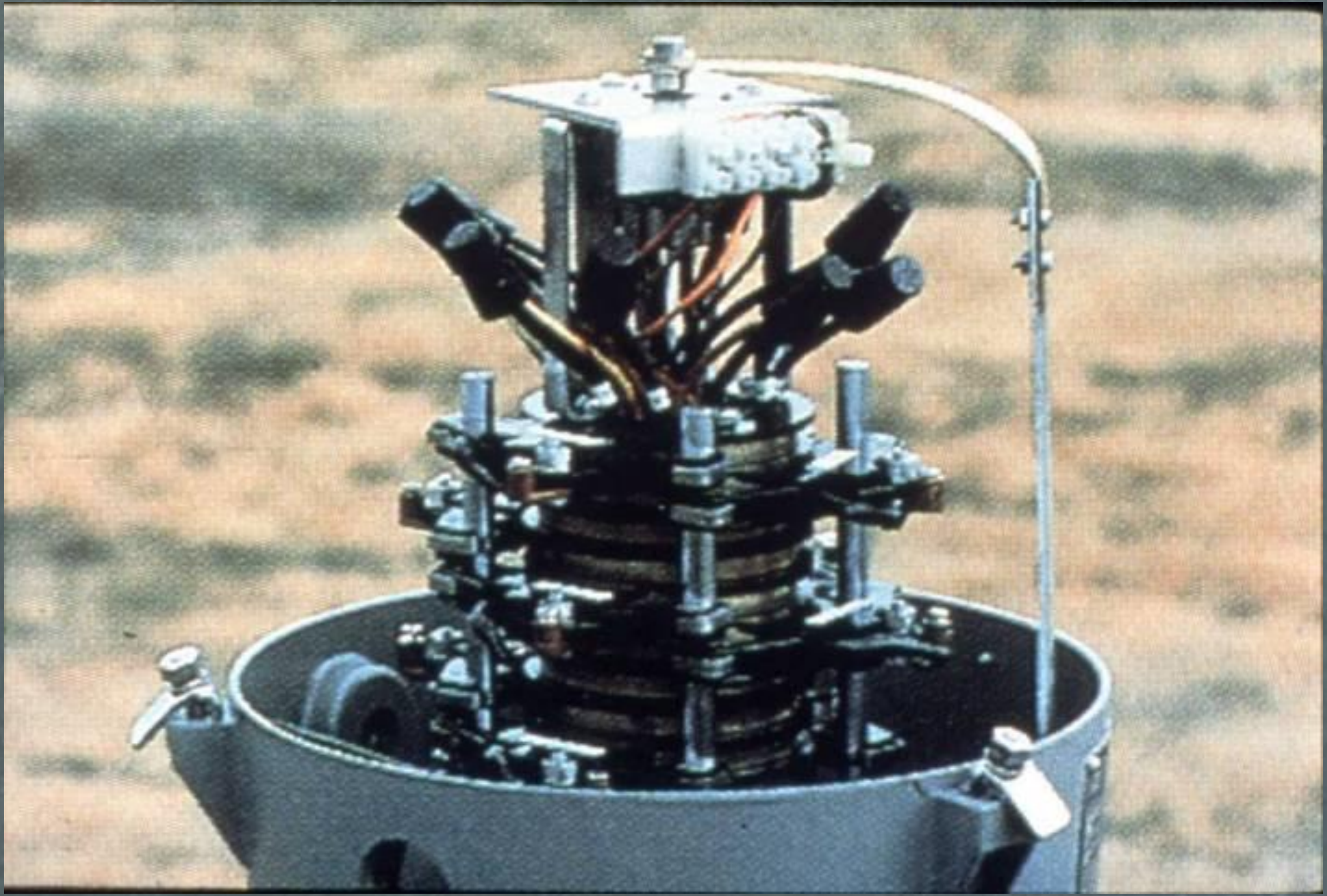
- Pad
- Pivot point
- Pivot Span
- Add Span
- Transition Span
- Last Span
- Over Hang
- End Gun

Pivot Pad



Pivot Point

Electric Collector Ring at Pivot



Pivot Point with Stop Device

Physical Span Features

Pipe size

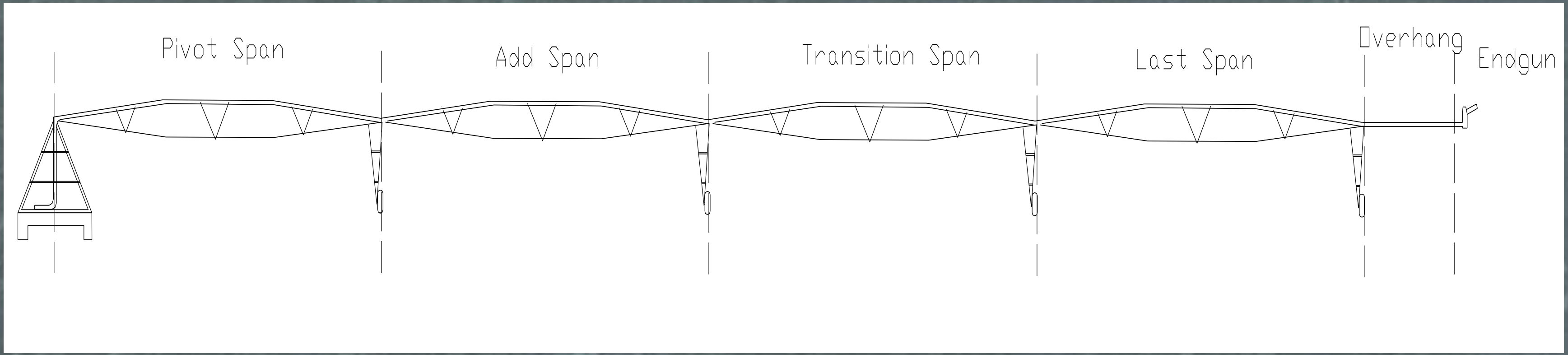
Pipe Diameter
5”, 6”, $6^{5/8}$”, $8^{5/8}$”, 10”

Overhang
4” and 5”

The Tower

The Span

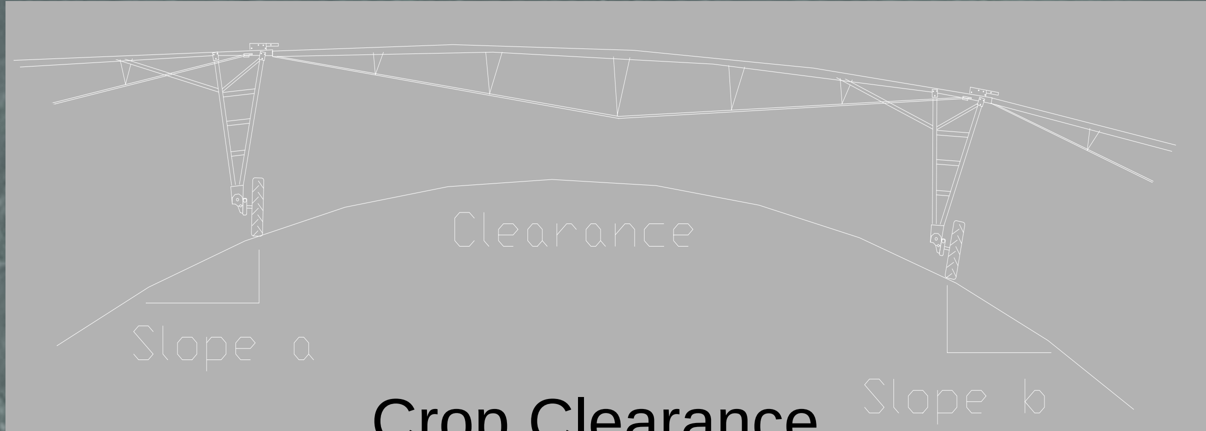
Span Type



Span Length - depends on pipe size and Span type
Number of Trusses - based on length
Other consideration:
Shorter spans- less weight on wheels - less rutting problems
Smaller pipe less weight

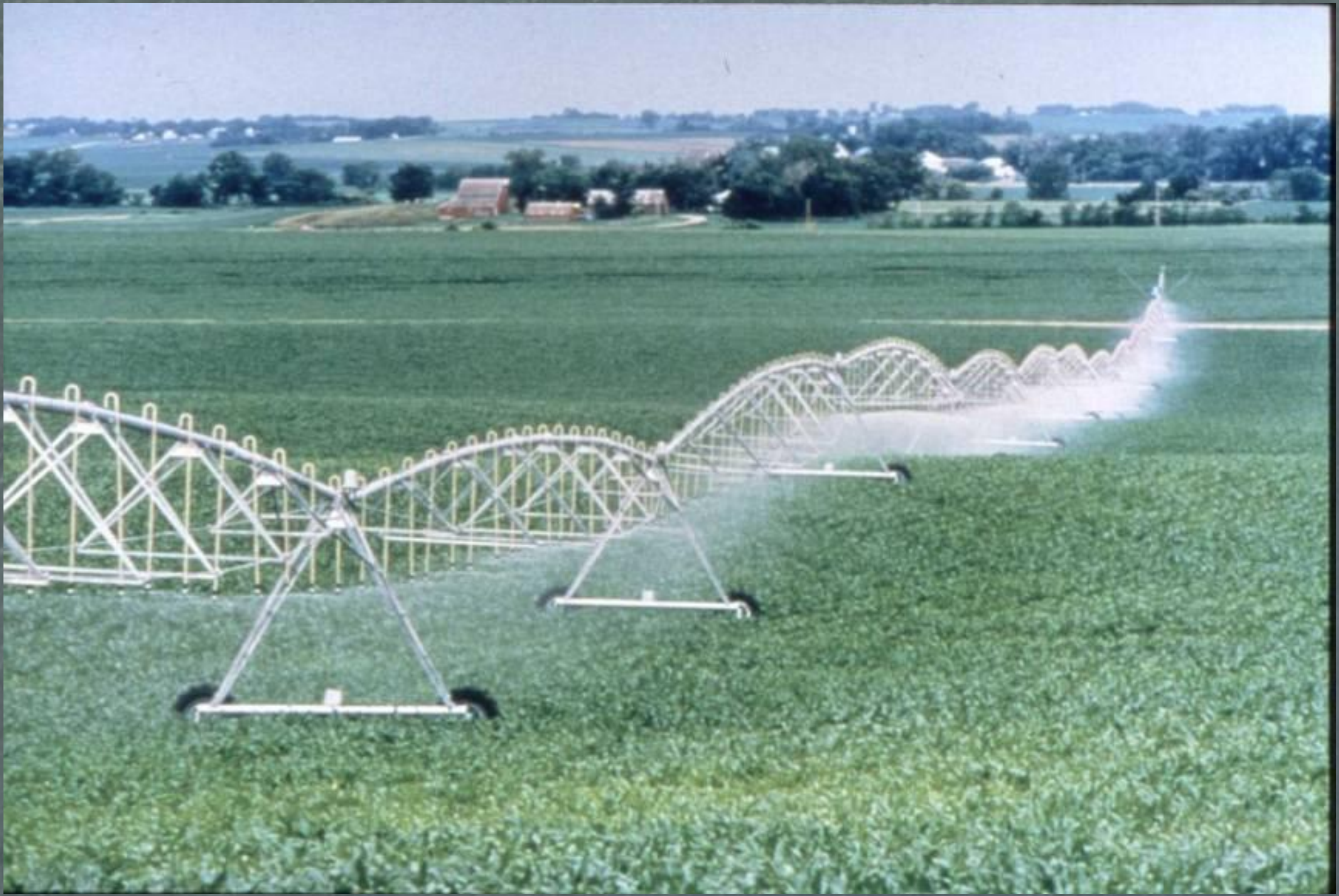
Slope Limitation

- Allowable Slope
  - depends on profile (low, standard high), span length, pipe diameter, and tire size
  - range 7% to 18%
- Crop clearance
- Slope absorption
- Pivot Flex



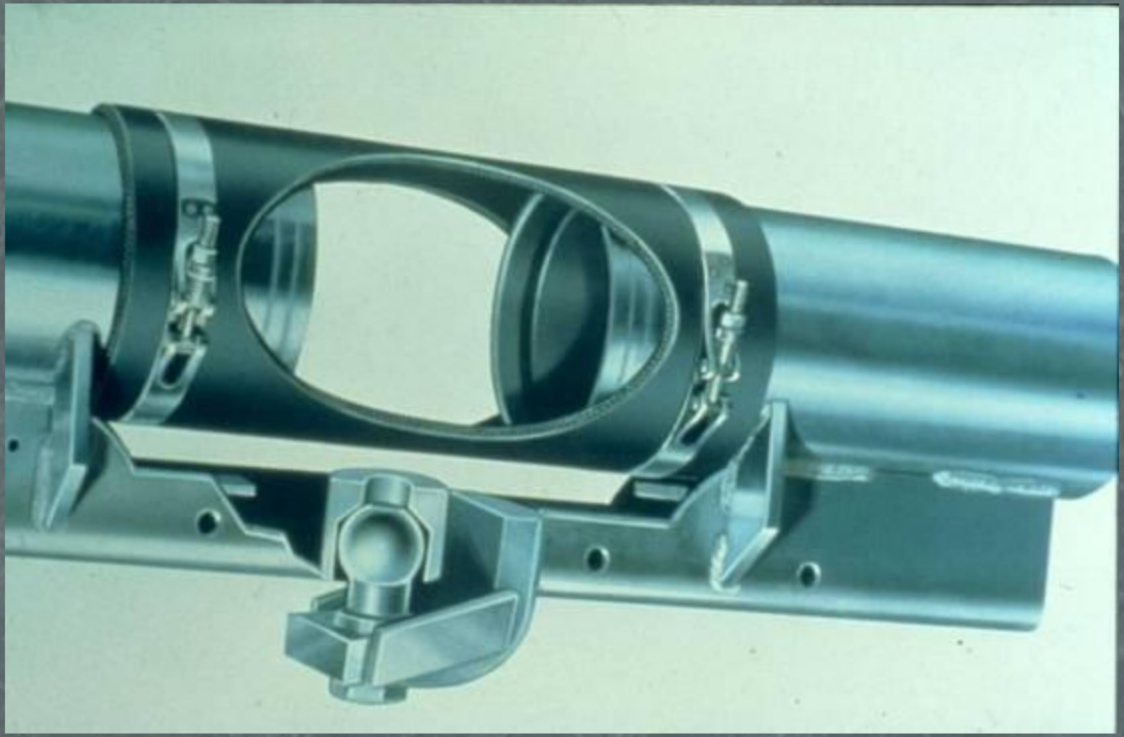
Crop Clearance

Slope Adsorption

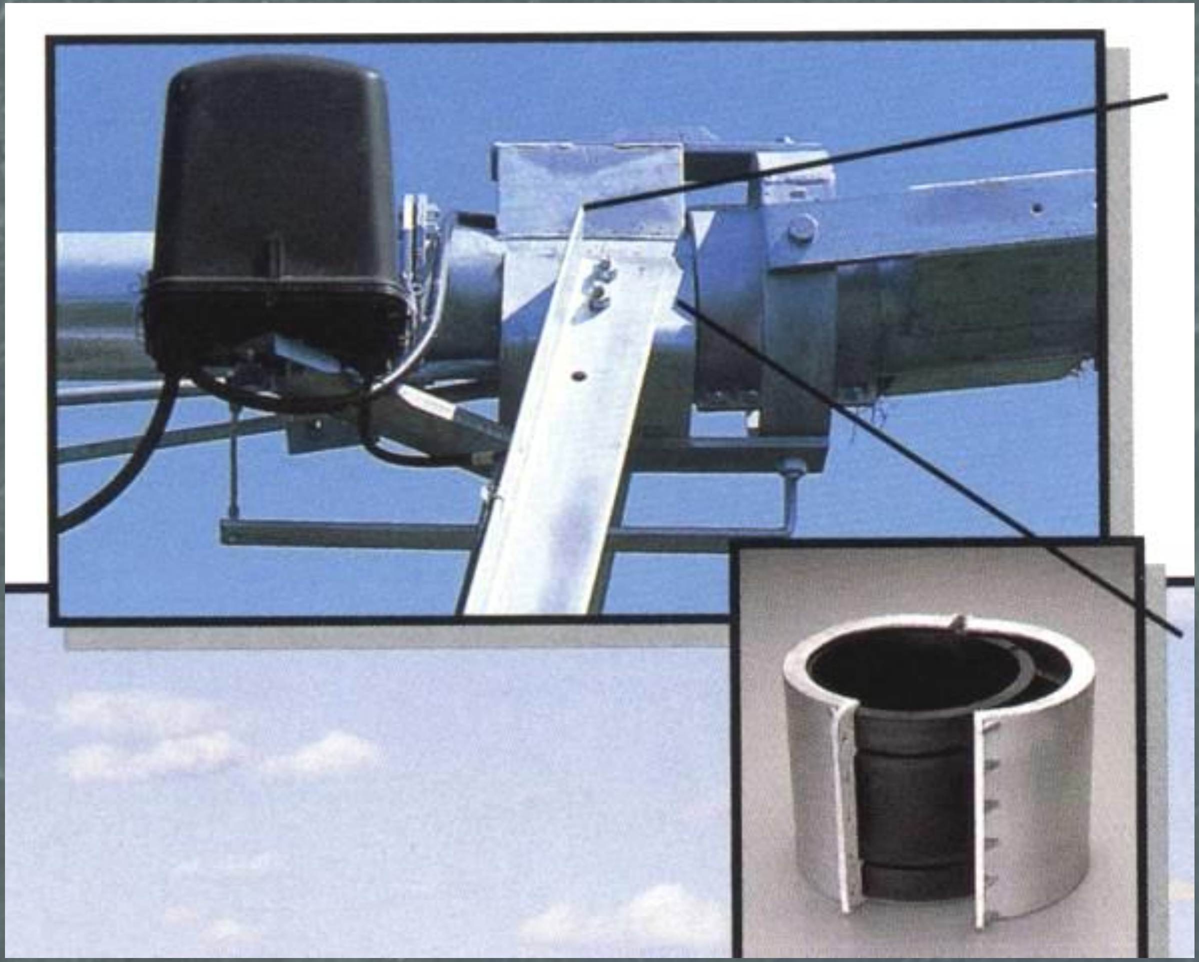


Tower -Span connection

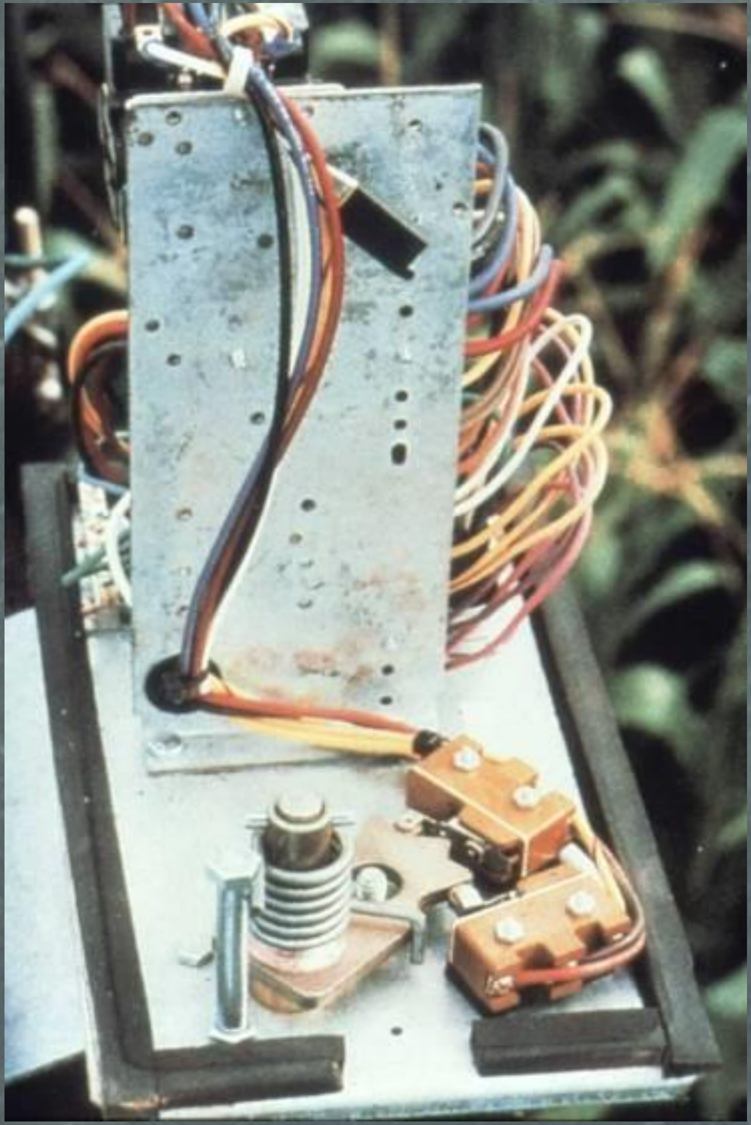
Joint Boot



Span Alignment



Alignment Switch



Drop/Outlet Connections

Span Crop Clearance

- Four Profiles
  - – Low profile 5.1 - 7.2’ depends on pipe size
  - – Standard Profile 8.6 - 10.7’
  - – High profile 11.9 - 14.0’
  - – Ultra high profile 15’

High profile with sugar cane

Overhangs

Overhang Length

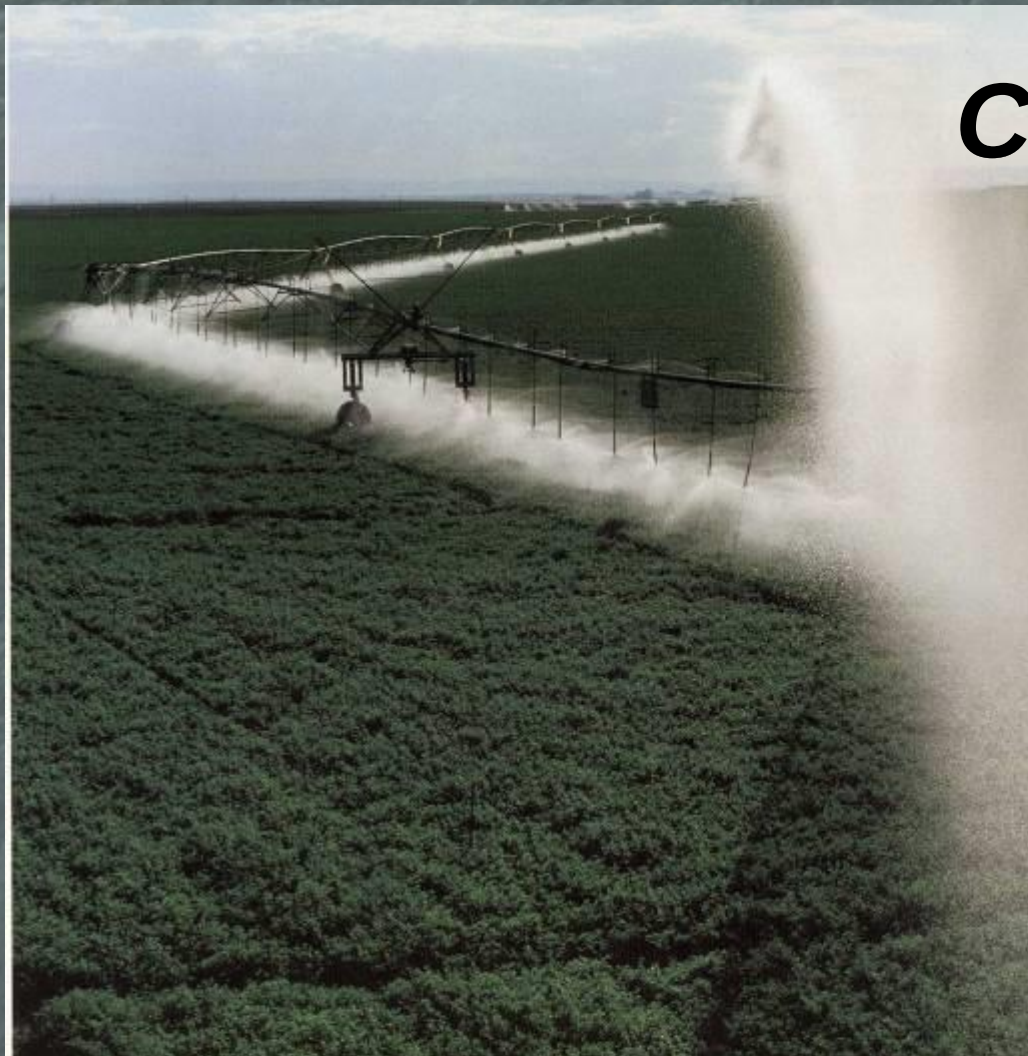
- Depends some what on pipe size
  - 18.1 - 82.3 ft
  - And manufacture

End Guns

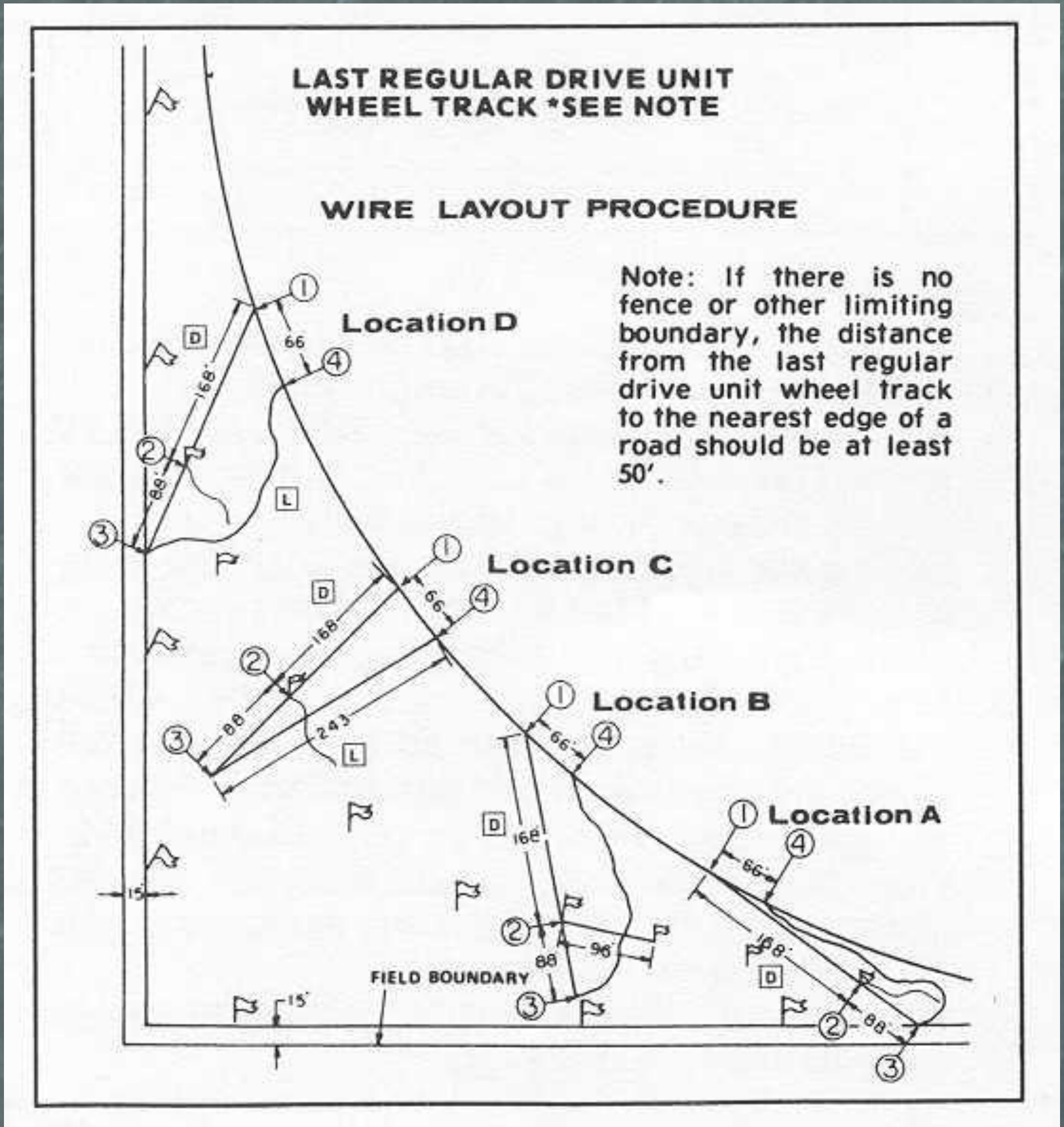
With Booster


With out Booster

Corner System



Corner Guidance System



Tire Type & Drive Units

- Tire type
  - Standard, Retread, High float, Maxi float, Track, 11.2x38
- Drive Units
  - Standard 30 rpm
  - Optional 37 rpm
  - Hi Speed 56 rpm

Large thin tires seem to be preferred

Additional add ons

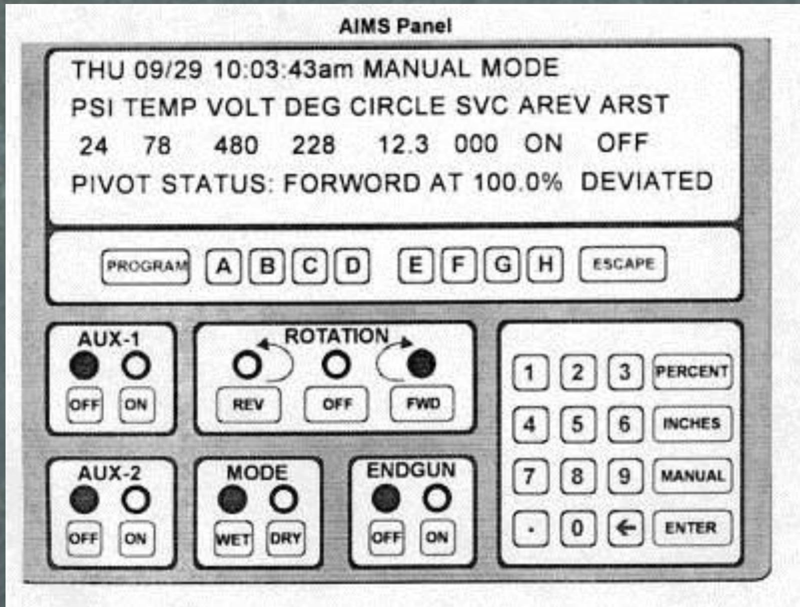
Tire and Gear box

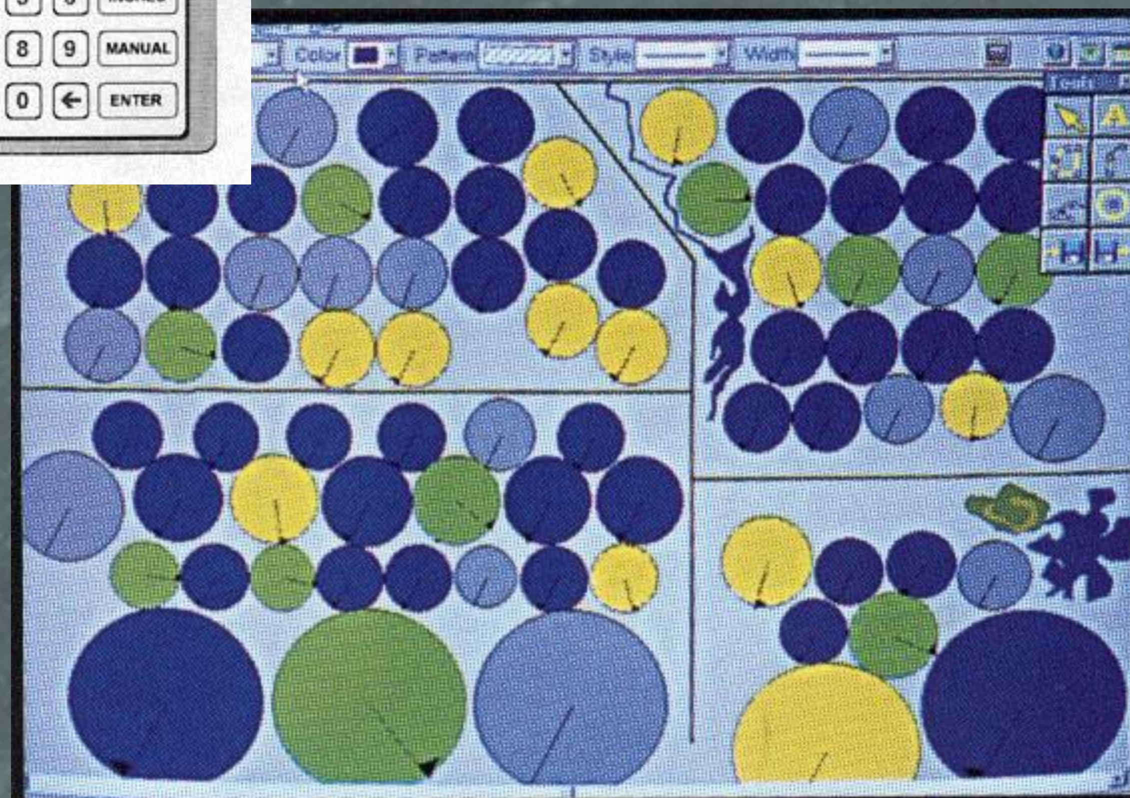
Motor and Driveline

Stop at the end

Panels

Remote control





Options & Accessories

- Pivot Flex
- Booster Transformer
- 45 amp package
- Drive unit fuse packages
- Automatic Reverse
- Pivot stop-in-slot
- Auxiliary control (for controlling other electrical devices)
- Automatic end gun shutoff
- End gun override
- Remote panel mount
- End-of-field stop
- Low pressure shut-offs
- High voltage surge protection
- Phase loss protection
- Slow down timer
- Low voltage monitor
- Modified alignment
- Flow Meter
- Check Valve

Options continued

- Automatic rain shut-off
- Severe duty gearboxes
- Heavy duty pivot
- Hydraulic system control
- High or low profile
- High speed motors
- Motor covers
- Traction rim
- Drops - steel, PVC, flexible hose
- Dry wheel track packages
- End guns
- Booster pumps

Water requirements - System flow rate

What influences the System Flow rate?

- Area irrigated
- Crop requirement
- Climatic Conditions
- Soil type
- Terrain
- Efficiency
- Leaching, germination, pre-water, harvest
- Treat Pivot, end gun, and corner systems as separate

Base Pivot flow rate

$$Q = \frac{453Ad}{ft}$$

Q = flow rate (gpm)

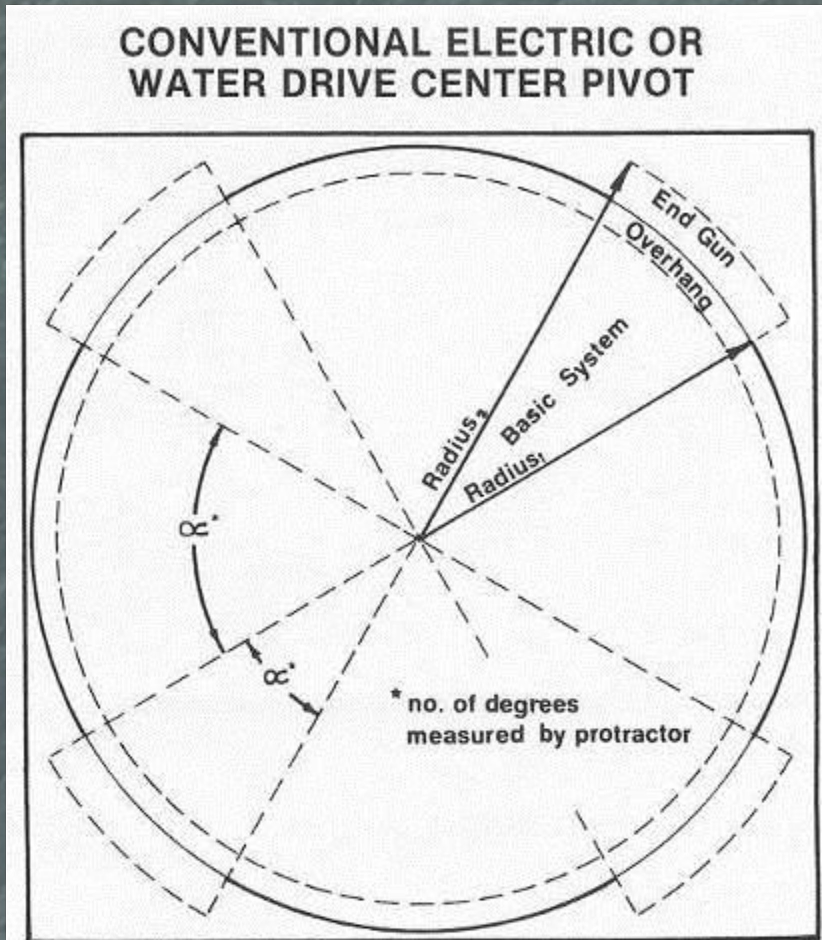
A = Area of pivot (ac)

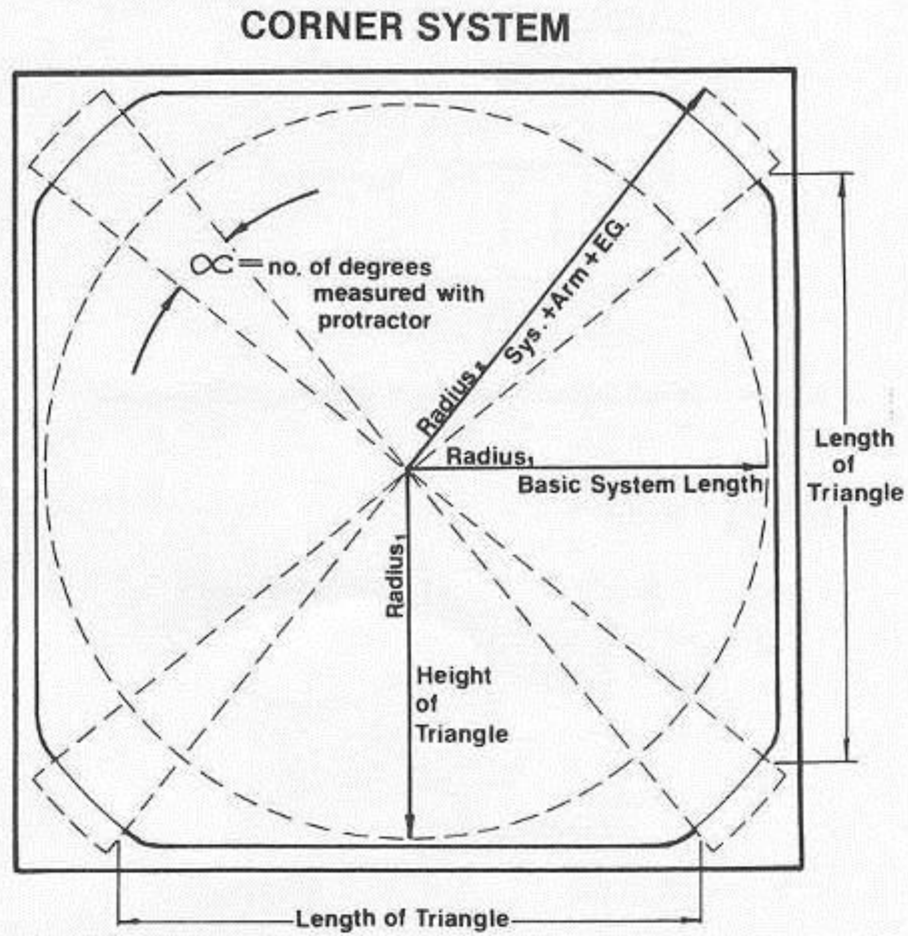
d = applied water (in/d)

f = days between irrigation

t = the fraction of time that the system is turned on for a typical day or

$$Q_b = \left[\frac{\pi * L^2 * GIR}{2310 f * t} \right] \frac{AO}{360}$$

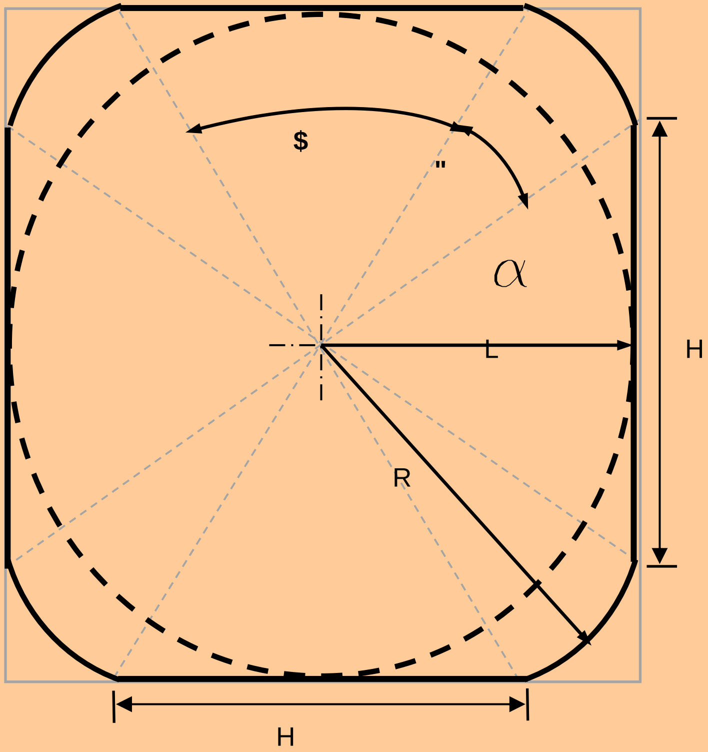




The effective lengths of the Corner System swing arms are:

170' Span = 243'
185' Span = 258'
plus
effective E.G. Coverage (See Water Application Section)

Methods of determining area



FULL CIRCLE WITH CORNER SYSTEM

For Example if the Angle during full Corner Extension is 14.7 degrees, L = 1295 ft, R = 1636 ft and H = 2000 ft

.

$$AREA = \frac{4\left(\frac{L \times H}{2}\right) + \pi\left(\frac{\alpha}{90}\right)R^2}{43560}$$

$$AREA = \frac{4\left(\frac{1295 \times 2000}{2}\right) + \pi\left(\frac{14.7}{90}\right)1636^2}{43560}$$

$$AREA = 150.4 \text{ acres}$$

Depth to apply

- Need to determine daily crop water
- NRCS endorses four methods
  - Penman-Monteith
  - Radiation method
  - Temperature Method
  - Class A evaporation pan

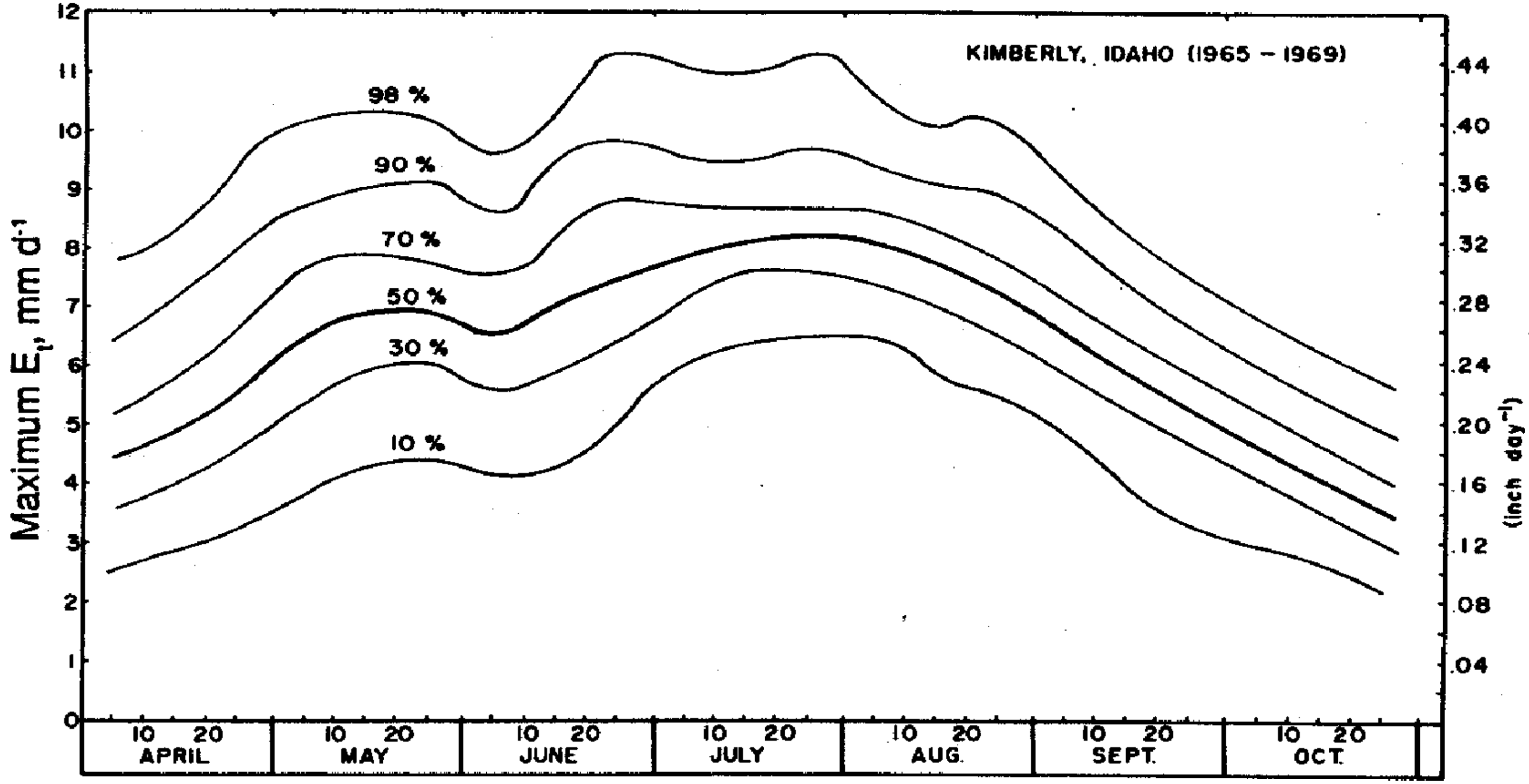


FIG. 5.5. Frequency Distributions for Estimated Daily Maximum E_t for Well-Watered Crop of Alfalfa with Full Cover Calculated for Kimberly, Idaho (from Wright and Jensen, 1972).

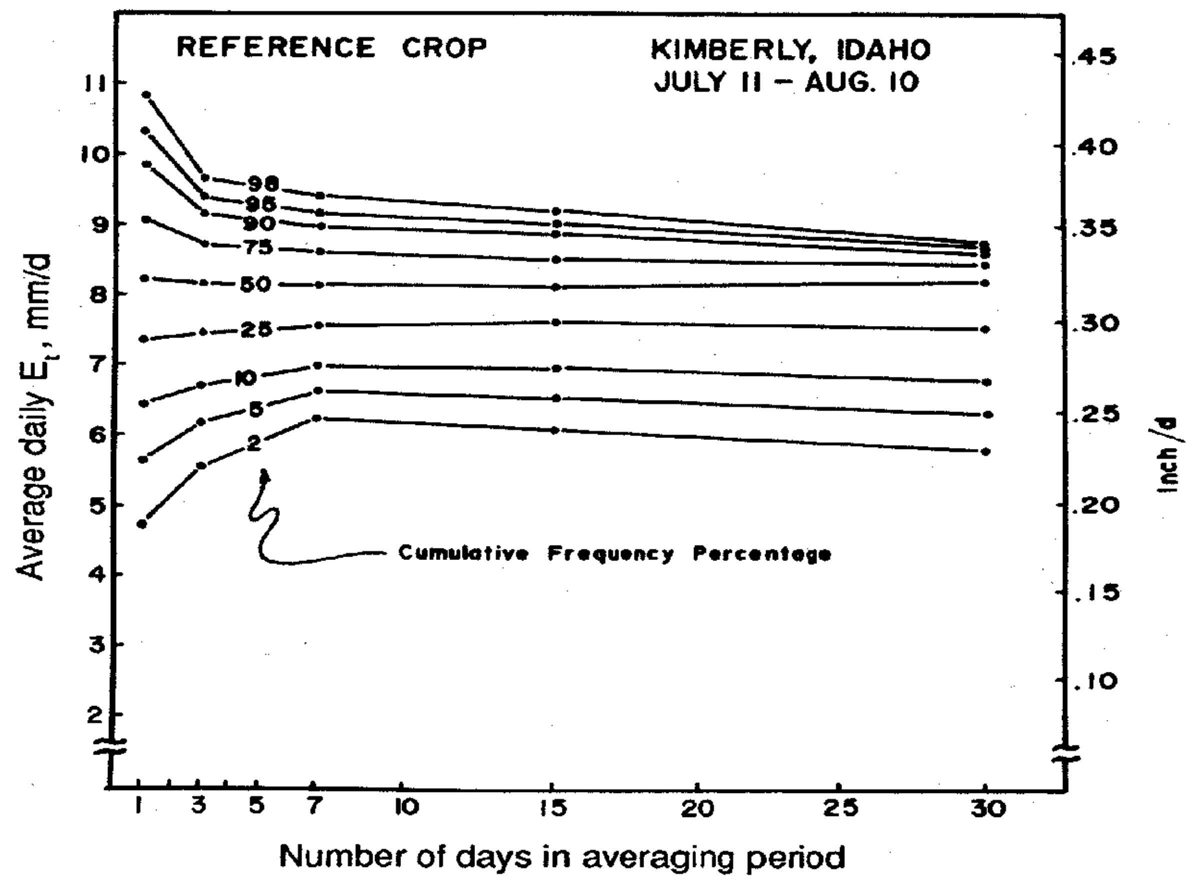
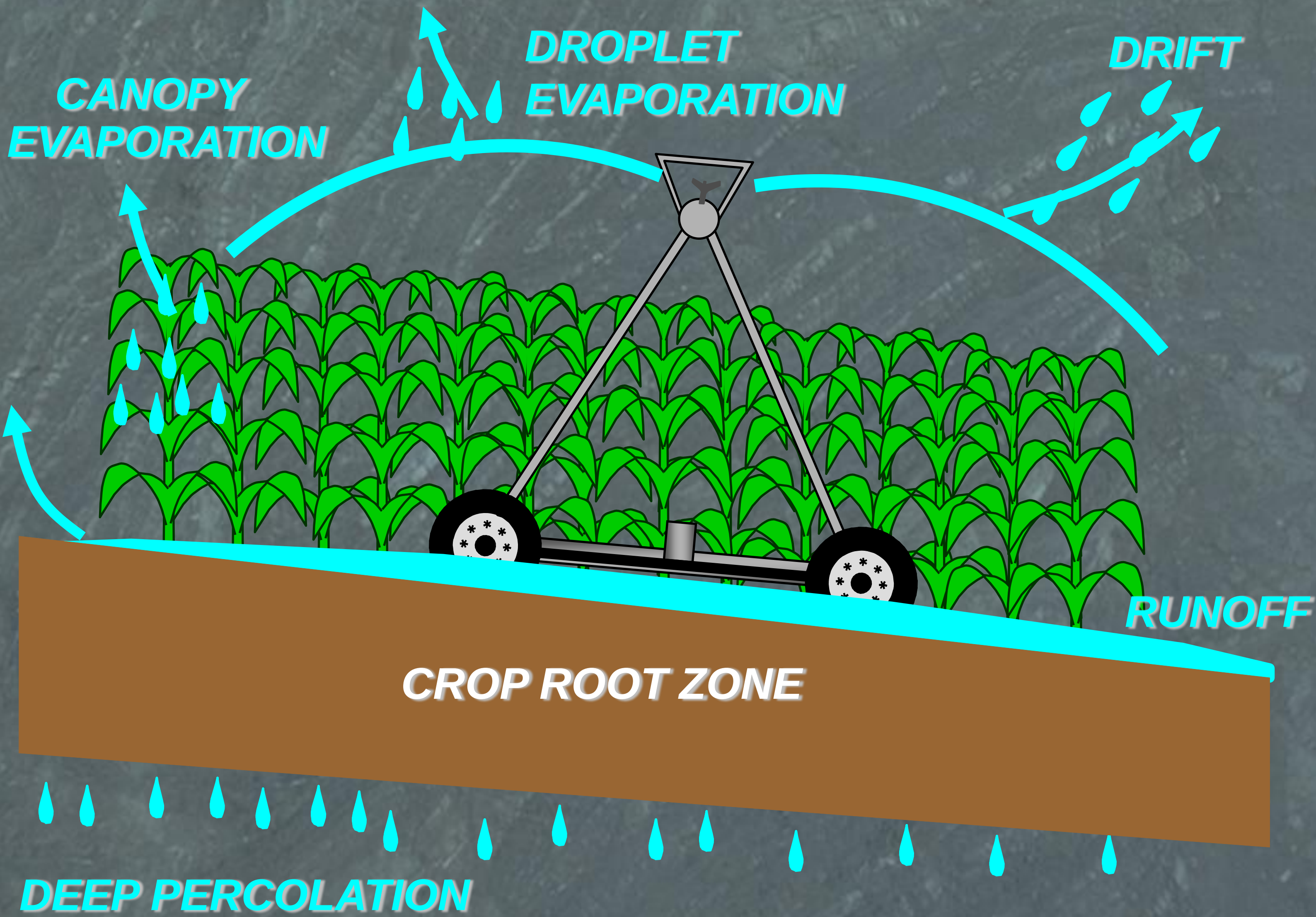


FIG. 5.6. Cumulative Frequency Percentages of Average Daily E_t Estimated from Meteorological Data with Combination Equation for 1-Day, 3-Day, 7-Day, 15-Day, and 30-Day Averaging Periods for the Peak Period at Kimberly, Idaho (from Wright and Jensen, 1972).

ET wetting adjustment factor K_f

Crop Type	Irrigation interval, f, days						Percentage of ET that is Transpiration
	⩽1	2	3	5	7	10	
During Peak Period							
Vegetables and Fruit	1.15	1.1	1.05	1.02	1	1	80
Row Crops	1.1	1.07	1.05	1.02	1	1	90
Small Grains	1.05	1.02	1	1	1	1	100
Forage Crops	1.05	1.02	1	1	1	1	100
Pasture	1.1	1.07	1.05	1.02	1	1	90
For the Growing Season							
Vegetables and Fruit	1.2	1.15	1.1	1.05	1	1	70
Row Crops	1.15	1.1	1.07	1.05	1	1	80
Small Grains	1.05	1.02	1	1	1	1	95
Forage Crops	1.1	1.06	1.04	1.02	1.01	1	90
Pasture	1.2	1.15	1.1	1.05	1.03	1	80

Water Losses from Pivots



Losses/Application efficiencies

- Losses generally range between 5-20%
- Most accepted range is 5-10%

d or GIR value determined by

$$\text{Gross peak daily depth} = \frac{ET_c * K_f - P_e}{\left(1 - \frac{\%loss}{100}\right)}$$

t value

- In design, t=0.90 is often used
- For example t=0.9 would indicate that the system operates for 21.6 hrs out of every 24 hrs. or 3.6 days out of a 4 day cycle

Total flow is calculated by

$$Q_{total} = Q_{base} + Q_{endgun} + Q_{corner}$$

Example

- A 1320 ft pivot with no end gun irrigating alfalfa with a Et_c = 0.33in/d, t=0.9, Irrigation frequency 3 days
- Find system flow rate

Solution:
From Kf table Kf =1.04

$$Qs = \frac{\left(\pi \cdot 1320^2 \cdot .33 \cdot 1.04\right)}{2310 \cdot 1 \cdot .9} \cdot \frac{360}{360} = 904 gpm$$

Example 2

- Same pivot only operator wants to add a corner system with a radius of 180ft and a end gun with radius of 120ft

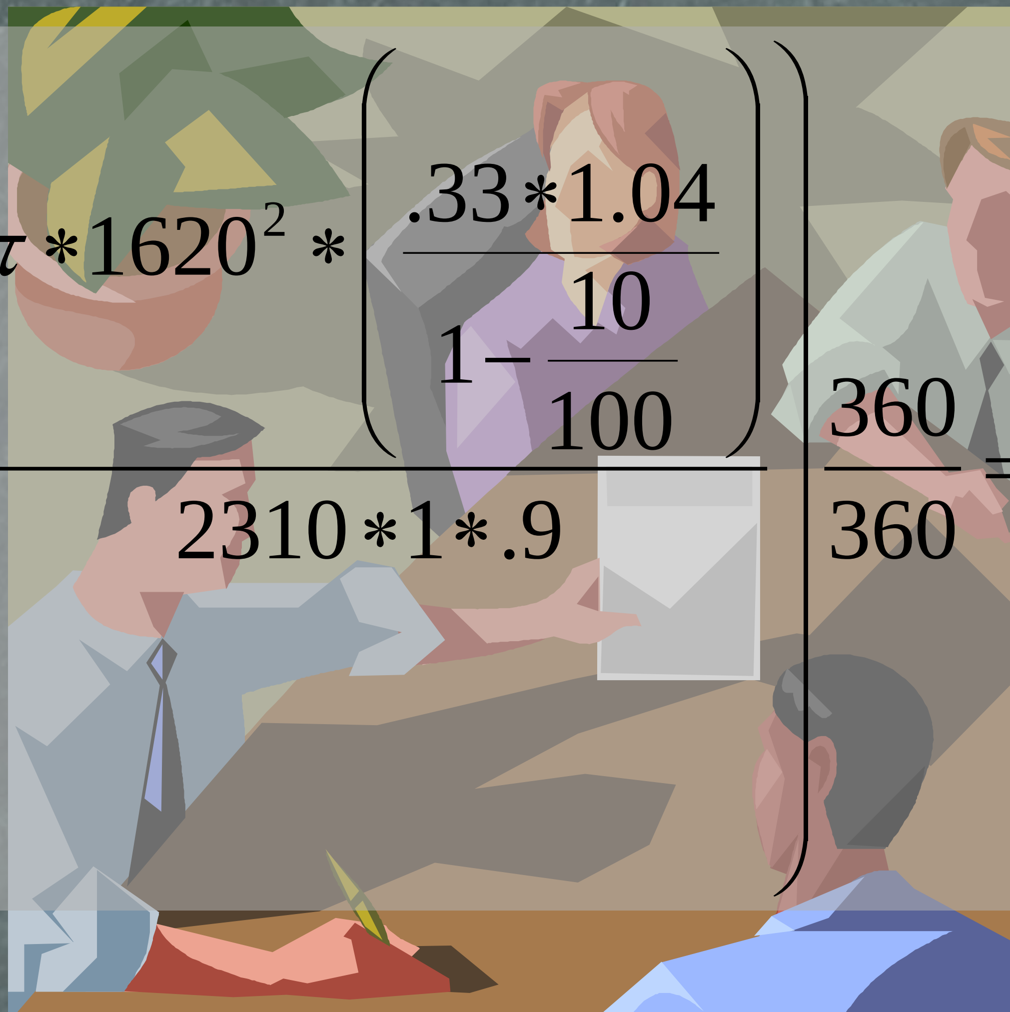
- Find the system flow rate

  Et_c = 0.33in/d, t=0.9, Irrigation frequency 3 days, 10% losses

$$Q_b = \left[\frac{\pi * L^2 * GIR}{2310 f * t} \right] \frac{AO}{360}$$

$$GIR = \frac{ET_c * K_f - P_e}{\left(1 - \frac{\%loss}{100}\right)}$$

Work Example



$$Q_s = \left(\frac{\pi * 1620^2 * \left(\frac{.33 * 1.04}{1 - \frac{10}{100}} \right)}{2310 * 1 * .9} \right) \frac{360}{360} =$$

1512gpm

Frequency

- 2.5 days for sandier soils
- 3.5 to 4.5 days for medium textured soils
- Always use faction of a day

System Pressure

- Nozzle or base pressure
- Pressure regulators
- Boom back losses
- Friction Loss
- Elevation change of field
- Height of pivot
- Local losses (valves, elbows, screens, etc.)

Base pressure

- Use operating pressure of nozzle obtained from manufacture literature
- If Pressure regulators are used, the base pressure of the regulator

Pressure Regulators

- Regulators have hysteresis
- Regulators have friction losses

- For design use 5psi over the threshold pressure

Friction Loss

- Calculate outlet to outlet or use multiple outlet factor. For Center pivot use 0.555 for Linear use 0.36
- Several friction equation may be used. Hazen-Williams is most common

$$h_f = 10.5 * \left(\frac{Q}{C}\right)^{1.852} * D^{-4.87} * L_h$$

- L_h= equivalent hydraulic length

$$L_h = L\sqrt{\frac{Q_s}{Q_b}}$$

Friction Factors

- Hazen-Williams c factors range 130-148
  - Typical 140
- Material roughness for galvanized pipe
  - e= 0.006 inches
- Use Swanee-Jain Equation to find f factor for Darcy-Weisbach

Friction Loss with two pipe sizes

$$H_f = H_{f\,smaller} - H_{f\,I-r\,smaller} + H_{f\,I-r\,larger}$$

- where:

  Hf = total pipe-friction loss along the combined lateral, ft (or m)

  Hf *smaller* = total pipe-friction loss along the lateral when comprised only of the smaller pipe (from Equation 4-4 using Hf per 100 for the smaller pipe), ft (or m)

  Hf I-r *smaller* = pipe-friction loss between the pivot inlet and radial distance *r* for the smaller pipe (from Equation 4-9 or Figure 4-1 or Table 4-2 using Hf small), ft (or m)

  Hf I-r *larger* = pipe-friction loss between the pivot inlet and radial distance *r* for the larger pipe (from Equation 4-9 or Figure 4-1 or Table 4-2 using Hf large), ft (or m)

  r = distance from center pivot inlet to where the transition from large pipe to small pipe occurs, ft (or m)

Simplified Method

$$H_f = K_{dual} \; H_{f\ smaller}$$

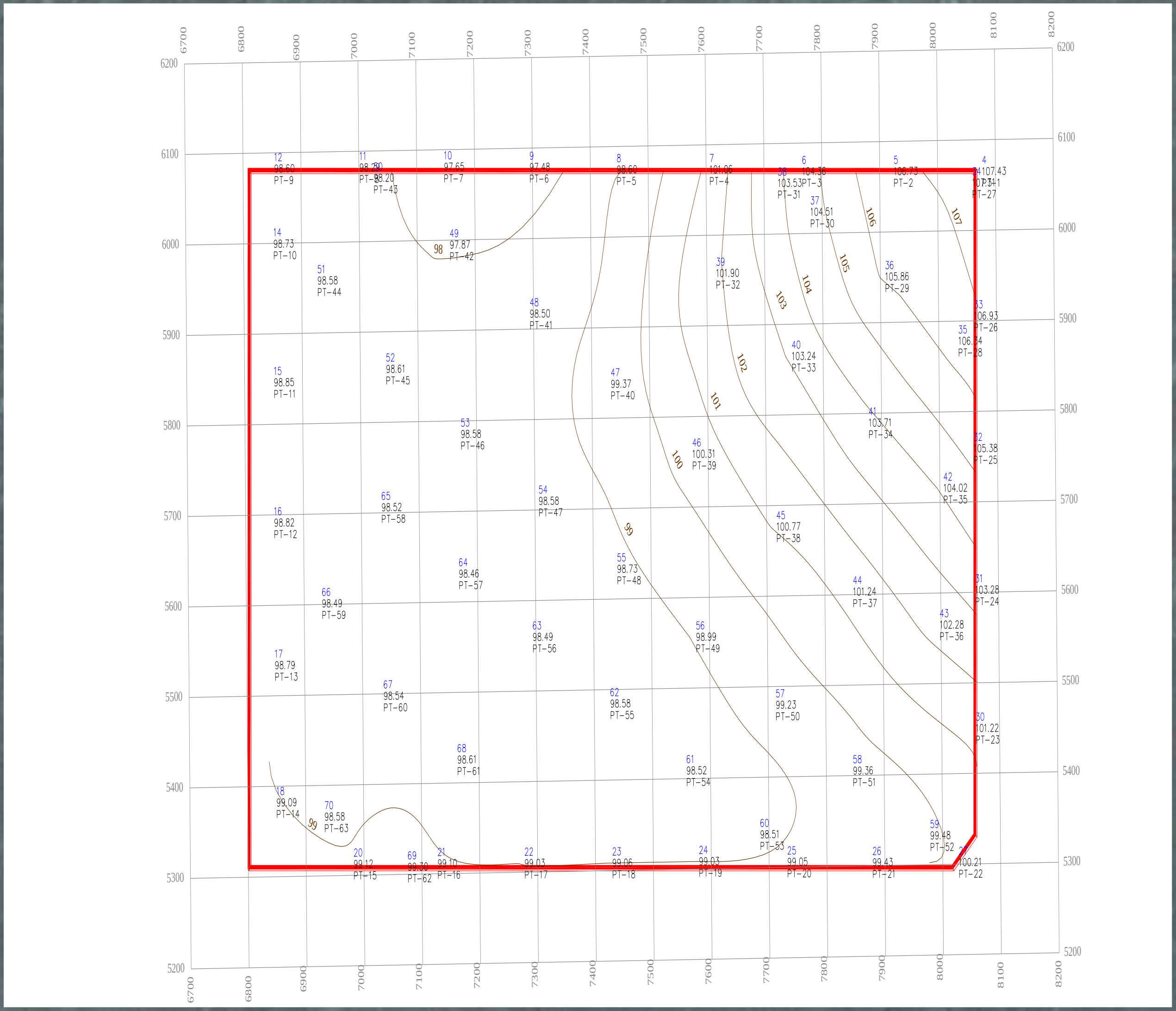
$$K_{dual} = 1 + \left[\left(\frac{D_{smaller}}{D_{l\arg er}} \right)^{4.87} - 1 \right] \left(\frac{15}{8} \right) \left[\frac{r}{L_h} - \frac{2}{3} \left(\frac{r}{L_h} \right)^3 + \frac{1}{5} \left(\frac{r}{L_h} \right)^5 \right]$$

$H_f = H_{f\,smaller} - H_{f\,I-r_2\,smaller} + H_{f\,I-r_2\,medium} - H_{f\,I-r_1\,medium} + H_{f\,I-r_1\,larger}$

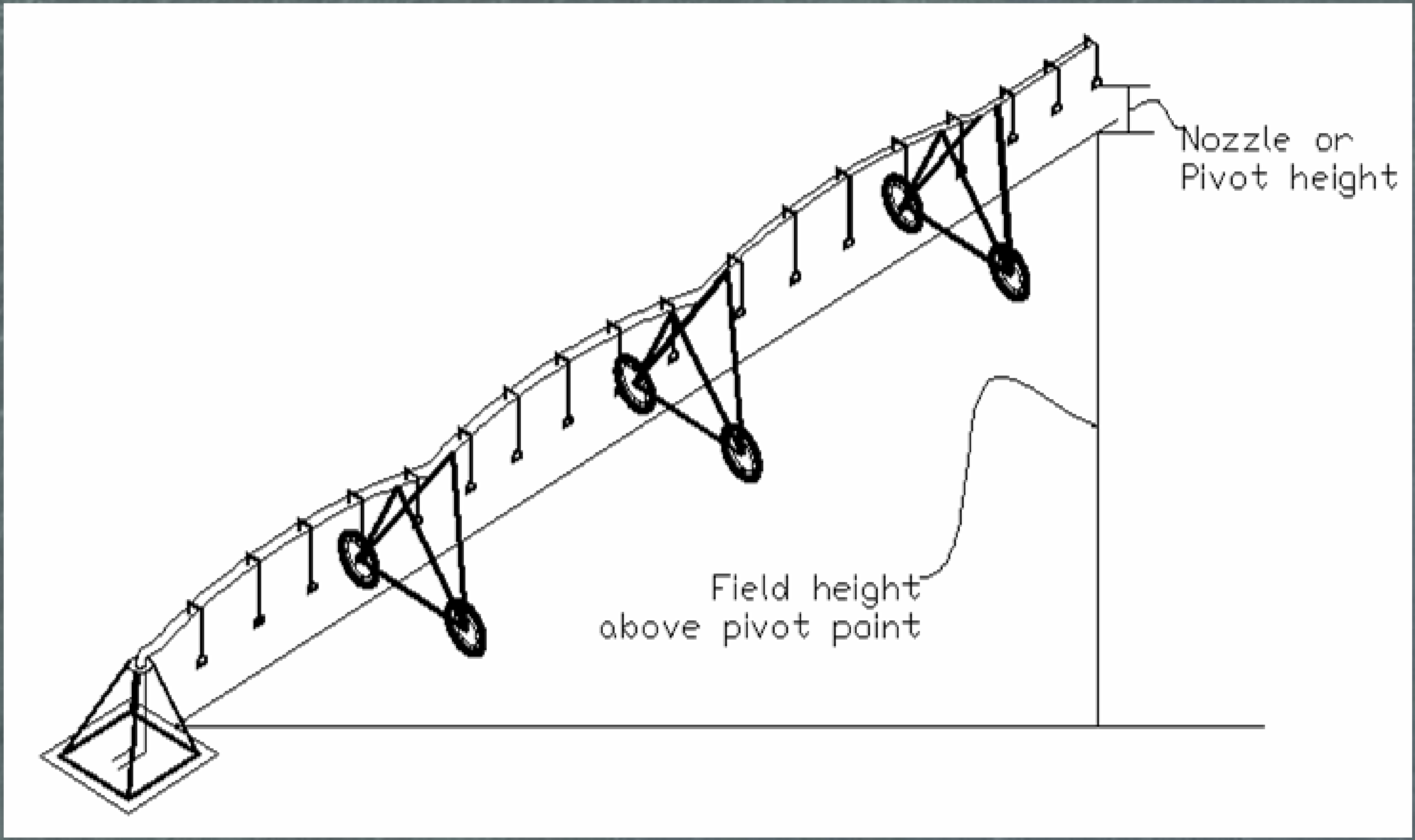
More than two pipes

$$H_f = H_{f\,smaller} - H_{f\,I-r_2\,smaller} + H_{f\,I-r_2\,medium} - H_{f\,I-r_1\,medium} + H_{f\,I-r_1\,larger}$$

Topography



Elevation



Required Pressure at Pivot point

Pressure at pivot point =

$P_{noz} + P_{reg} + 0.43(H_{fbb} + H_{f} + \Delta El_{f} + El_{p} + h_{flocal})$

Example

- Given:
  - 1400ft pivot –8” pipe
  - Qb=1200 gpm - Qg=120gpm
  - Nozzle operating pressure 20-30 psi
  - 25psi regulators- Nozzle height 6’
  - ΔZ for field 50’ –local losses 5psi
- Find: Required pressure at pivot point

Solution

$$L_h = 1400\sqrt{\frac{1320}{1200}} = 1468$$

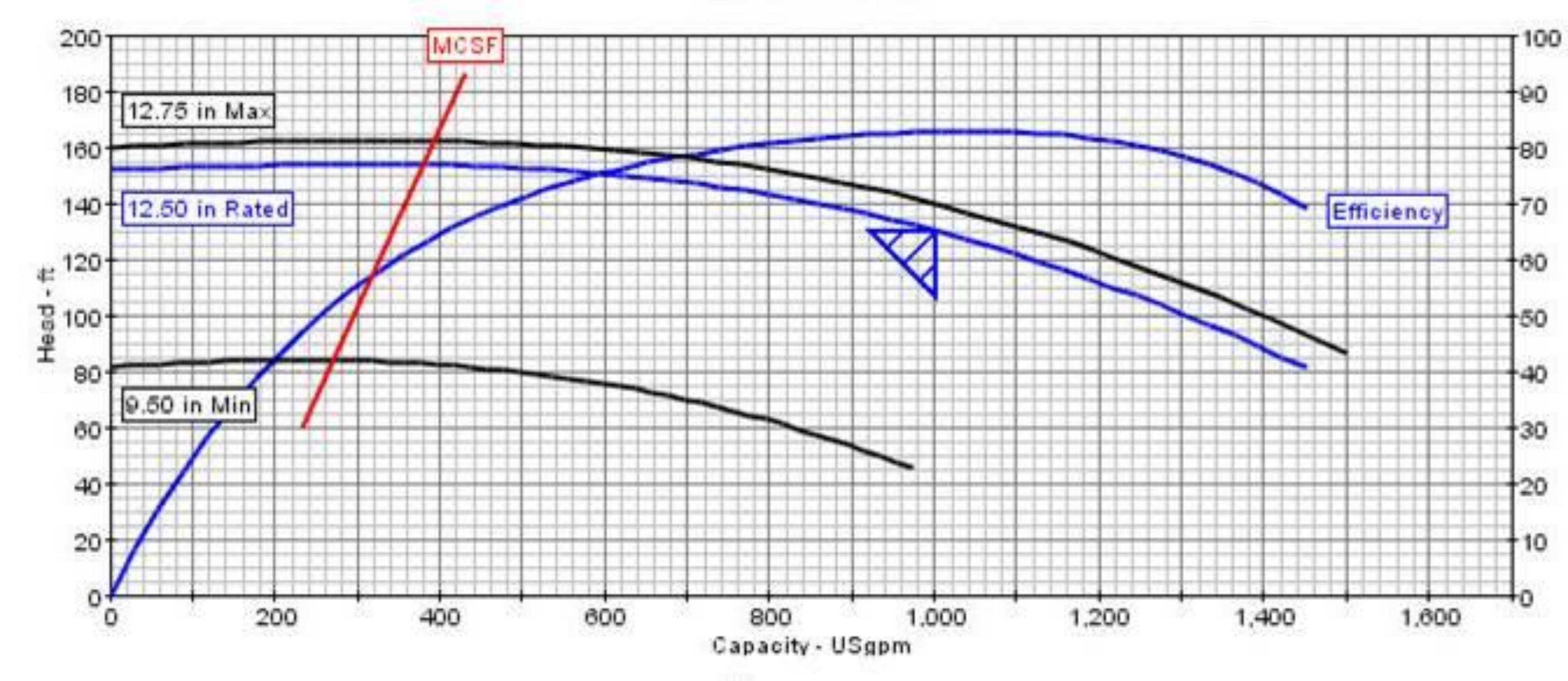
$$H_f = 10.5\left(\frac{1320}{140}\right)^{1.852} 7.755^{-4.87} 1468 = 45.74$$

$$P_{pp} = 25 + 5 + 5 + .43 * (45.74 + 50 + 6) = 79\,psi$$

End Guns

- Effects on
  - Pressure
  - Flow
  - Pump selection

Flat curve



MCSF
12.75 in Max
12.50 in Rated
9.50 in Min
Efficiency
Head - ft
Capacity - USgpm
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1,000
1,200
1,400
1,600
100
90
80
70
60
50
40
30
20
10
0

Sprinkler Nozzles

Distribution Patterns, Nozzle Spacing and Height.

- Pivot system (Heermann-Hein) or Linear (Christensen) CU shall not be less than 85% (76% DU), except as noted in criteria for a Low Energy Precision Application (LEPA) system.

Selecting Nozzle Packages

- Pressure requirements
- Wetted diameter
- Drop size
- Peak application rates

Sprinkler Discharge

- Sprinklers are sized using the following equation

r - distance from pivot

Sr – sprinkler spacing

$$q_r = \frac{2rS_r}{L^2} Q_b$$

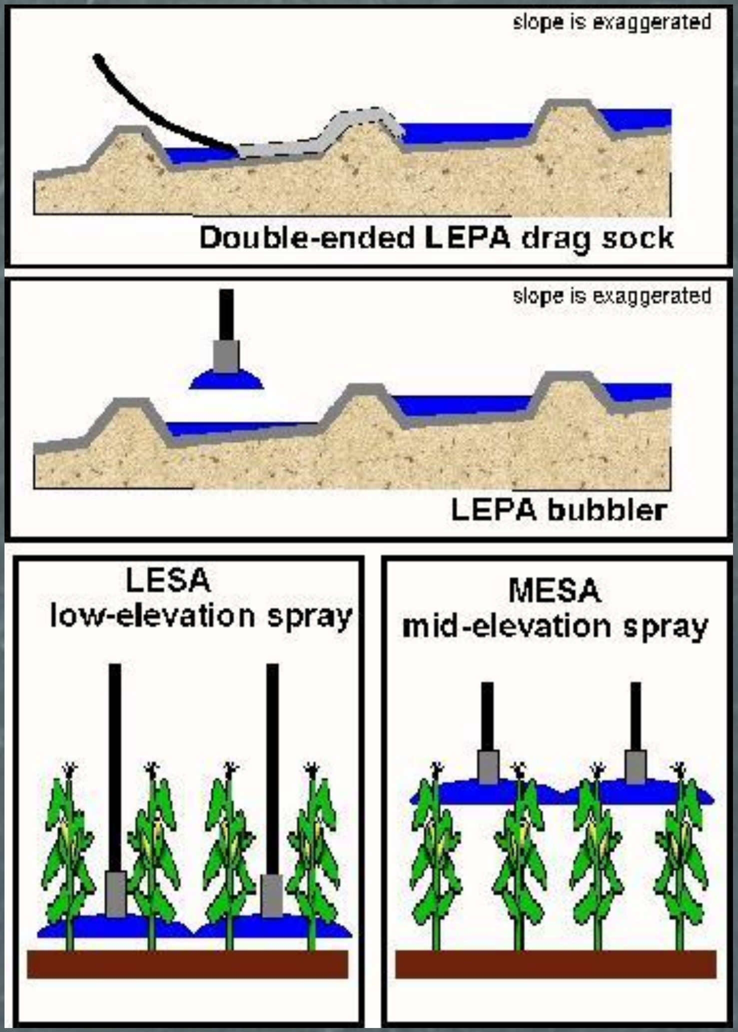
Sprinkler spacing

- Rule of Thumb
  - $W/2 \leqslant S_r \leqslant W/4$
- W is the wetted diameter of the sprinkler

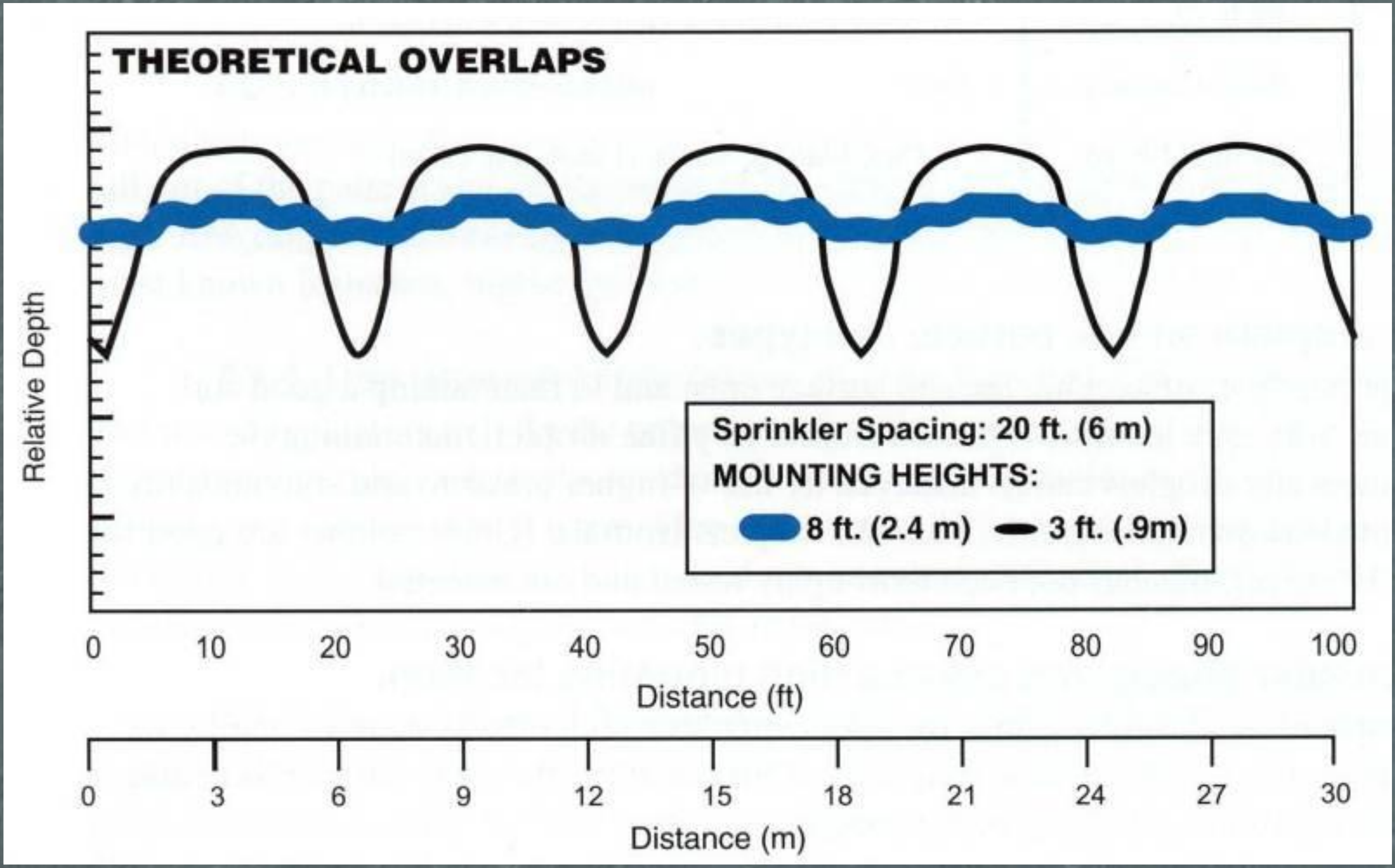
- From a point midway between the first and second tower to the distal end of a center pivot, spray nozzle spacing along lateral lines shall not exceed 25% of the effective wetted diameter and impact sprinkler spacing shall not exceed 50 percent of the effective wetted diameter

Height above the Ground

- New terms
  - LEPA
  - LESA
  - LPIC
  - MESA



Effects of height

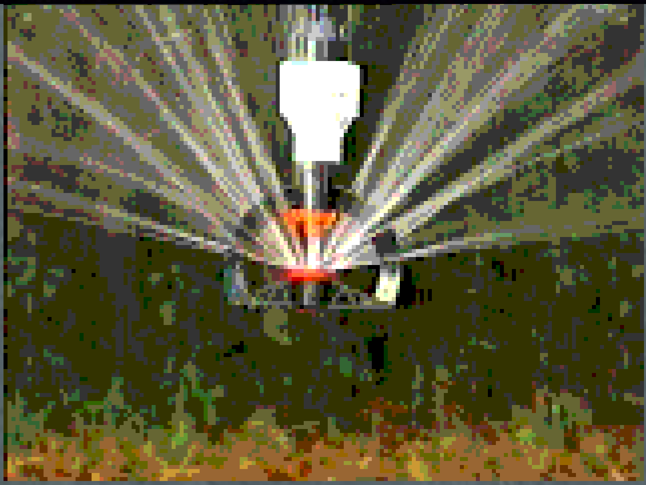


Low pressure Low drift

- 6, 10, 15 psi end pressure
- Small atomized droplets are practically eliminated thus reducing evaporation
- Mainly spinner and spray types
- Placement height 3, 6, 9, 12 foot
- outlet spacing 30, 80, 90, 108 inches

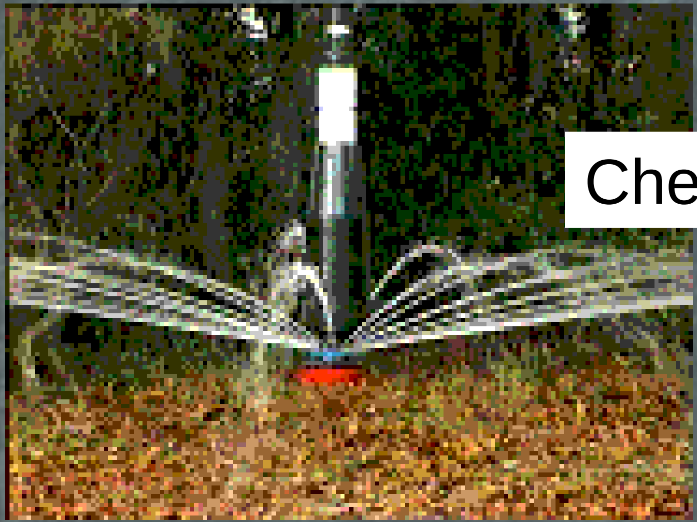
- High application rates - Not good for heavy soils or steeper slopes

Sprays

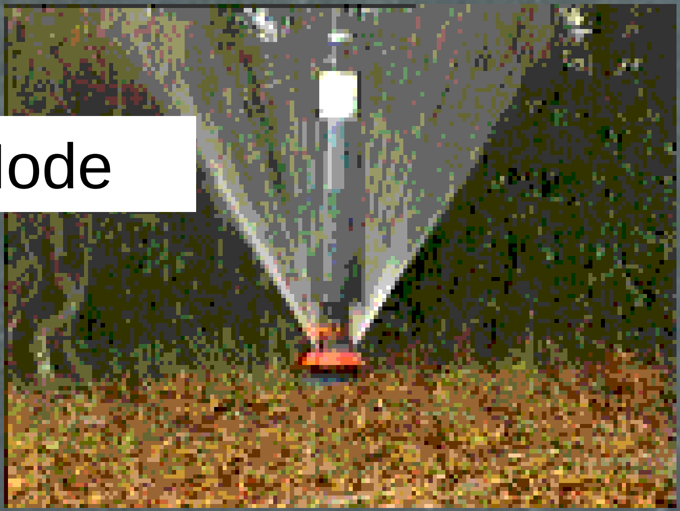


Low Pressure LEPA Bubblers

Irrigation Mode



Chemigation Mode



Small Droplet - High Uniformity

- 15 to 25 psi end pressure
- Droplets size can be adjusted with different pads
  - fine droplets for heavy, flat soils and delicate crops where wind drift is minimal, or
  - large droplets with good wind resistance for coarse soils
- Iwob, Spinners, some sprays

- Medium on application rate, wind fighting, and drop energy

Wobbler - Iwob

Spinner - Nutator

Large Droplet – High Uniformity

- 15 to 25 psi end pressure
- Droplets size can be adjusted with different pads
  - Larger droplets further throw
  - Good wind fighting
- Rotators

- Lower application rate, higher drop energy, and stream energy, may cause surface sealing

Rotator Style

- Low pressure impact
  - 25 to 35 psi end pressure
  - equal size nozzles spaced progressively closer 27, 18, and 9’
  - saves energy, controls drift, increases efficiency
  - On lighter soils where adequate pressure is not available for high pressure or where spray nozzles would cause excessive runoff

- Intermediate spaced impacts
  - 50 to 55 psi end pressure
  - High and low angle sprinklers
  - spaced progressively closer 27,18, and 9’
  - on heavy soils and severe slopes where the system is used for supplemental irrigation

- Variable Spaced Impacts
  - 50 to 55psi end pressure
  - smaller high and low angle sprinklers
  - nearly equal size, spaced progressively closer
  - On soils where the system is required to have maximum uniformity and rolling terrain with low intake rates, on rolling terrain where runoff could be a problem.

IMPACT SPRINKLERS

Volume Gun

High Pressure Impact

Medium Pressure Plastic Impact

Low Pressure Impact

Distribution Pads

- Smooth Spray Pads
  - smallest droplet
  - minimum soil disturbance or soil compaction
  - infiltrates best on heavy soil
  - susceptible to wind and evaporation
  - 6 - 25 psi

- Medium Groove Spray Pads
  - larger drops, slightly wider spray pattern
  - minimizes wind drift
  - still infiltrates moderately heavy soils
  - General propose average conditions and pressure
  - less than 40 psi

- Deep Grooved Spray Pads
  - large droplets in small direct streams
  - greatest wind resistance reduces evaporation
  - unsuitable for sensitive crops and light soils where water does not move laterally
  - uniformity reduced under calm conditions
  - pressures above 15 psi

Pad configurations

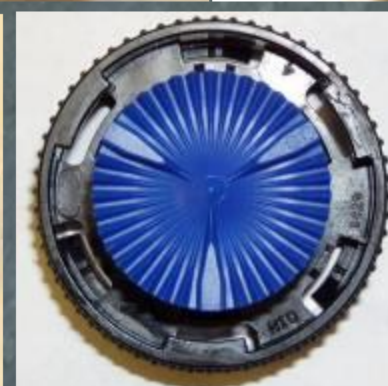
- Available in
  - flat
  - concave
  - convex

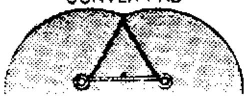
Pad style



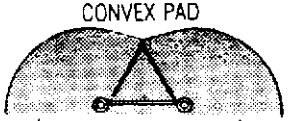






Spray Nozzles @ 10 PSI	Uniformity (No Wind	Application Rate	Spray Nozzles @ 10 PSI - 48" Drop	Uniformity (No Wind	Application Rate
FLAT PAD 	GOOD	MEDIUM-HIGH	FLAT PAD 	GOOD-FAIR (Subject to Wind)	HIGH
CONVEX PAD 	GOOD (Subject to Wind)	MEDIUM-HIGH	CONCAVE PAD 	GOOD-FAIR (Subject to Wind)	HIGH
CONCAVE PAD 	GOOD-FAIR	HIGH	CONVEX PAD 	FAIR-POOR (Good Wind Fighter)	VERY HIGH (Sandy Soils Only)

Drops are normally used in high wind or evaporation areas.

Spray Nozzles @ 20 PSI	Uniformity (No Wind	Application Rate	Spray Nozzles @ 20 PSI - 80" Drop	Uniformity (No Wind	Application Rate
FLAT PAD 	GOOD	MEDIUM	FLAT PAD 	FAIR	HIGH
CONVEX PAD 	GOOD (Subject to Wind)	MEDIUM	CONCAVE PAD 	FAIR (Subject to Wind)	HIGH
CONCAVE PAD 	GOOD-FAIR	MEDIUM-HIGH	CONVEX PAD 	POOR (Good Wind Fighter)	VERY HIGH (Sandy Soils Only)

Application

- Rates shall be selected such that runoff, translocation, and unplanned deep percolation are minimized

Water Applied

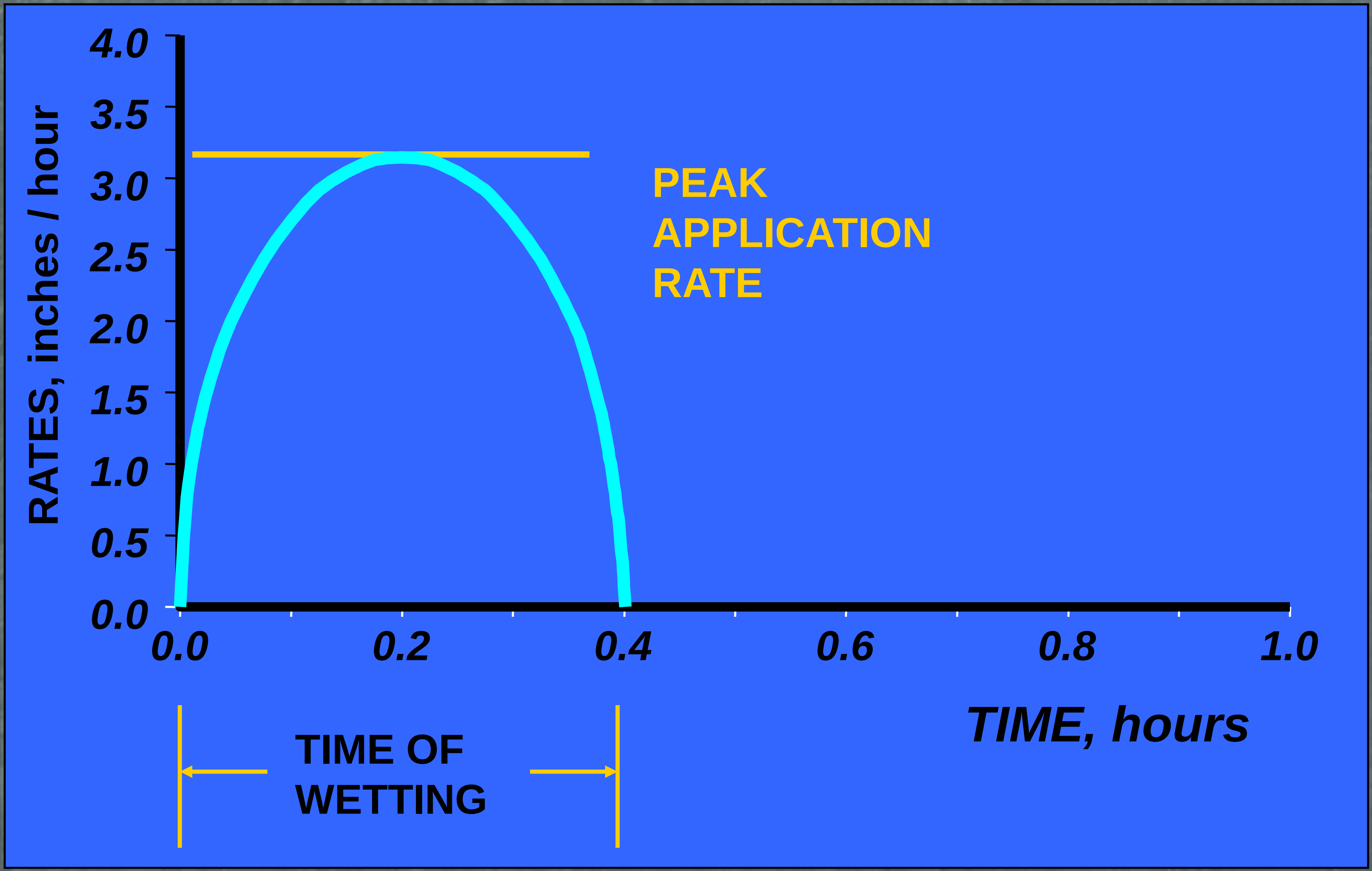
- Just how much water are You putting on?
  - hours/revolution at 100% = $\dfrac{(.105)\ (\text{DLRDU})}{\text{Speed}}$
  - DLRDU = Distance from Pivot to last regular drive unit (feet)
  - Speed = Travel speed of Last Regular Drive Unit at 100%
  - Applic.rate = $\dfrac{(\text{GPM})\times(735.3)}{(\text{Sys Length to last twr+O/H length+E.G.RAD})^2}$
  - In./rev @100% = $\dfrac{(\text{Hrs./Rev.@100\%})\times(\text{In./Day})}{24}$

Application Rates & Application

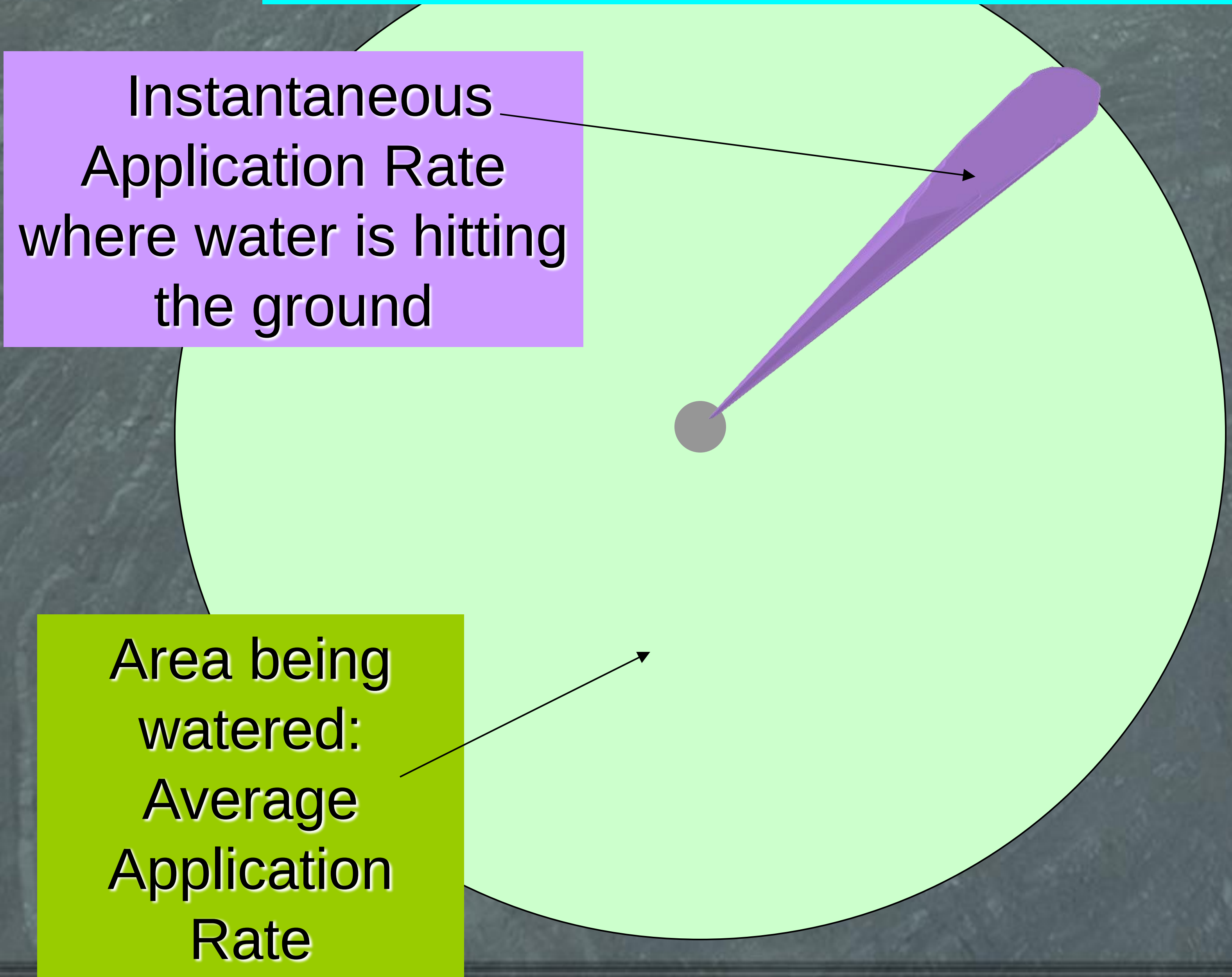
- Instantaneous
- Average
- Total Application

RATES

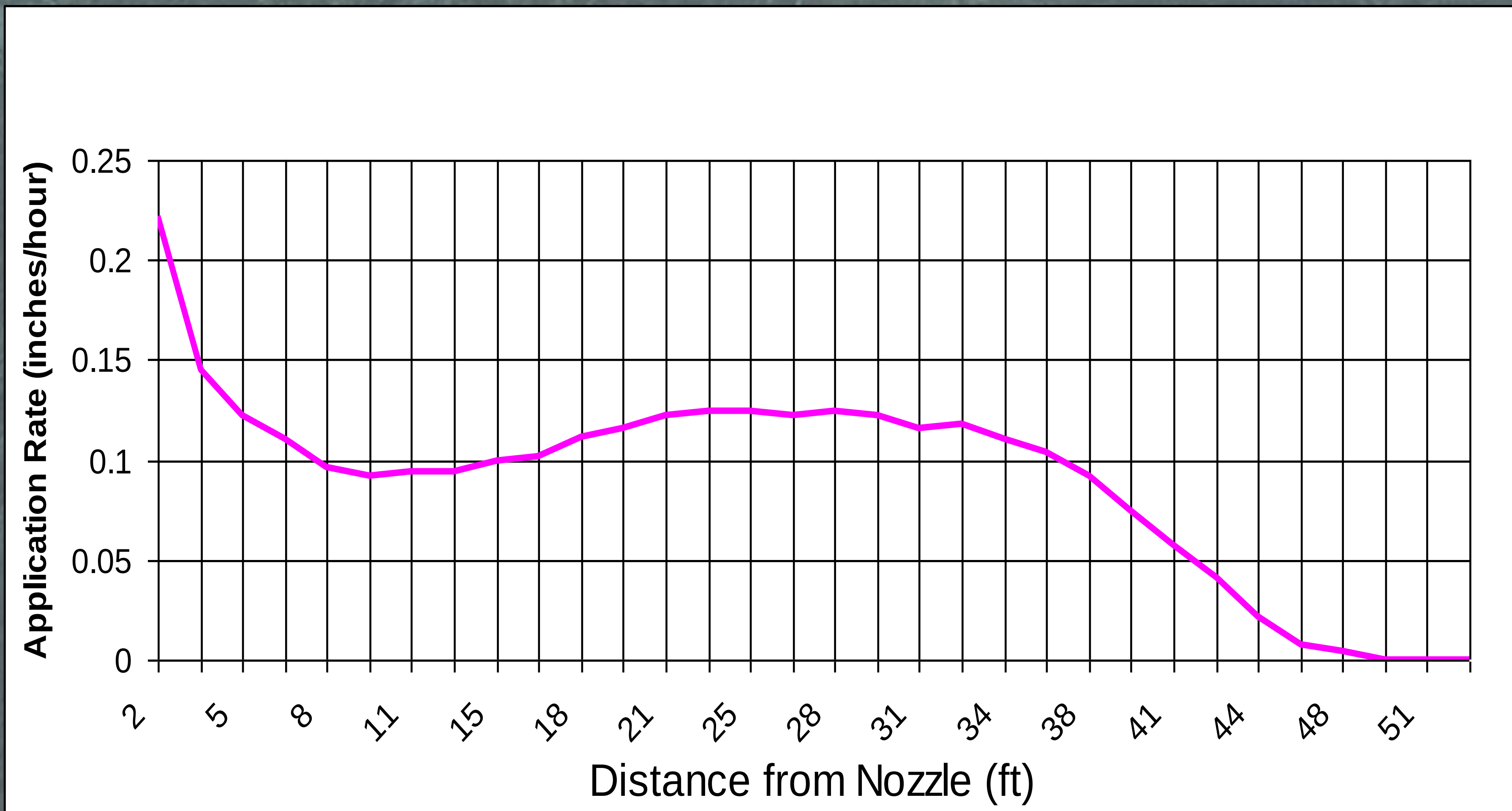
WATER APPLICATION RATE



Impact Sprinkler Pattern



Impact Sprinkler: Pattern Profile of Average Application Rate



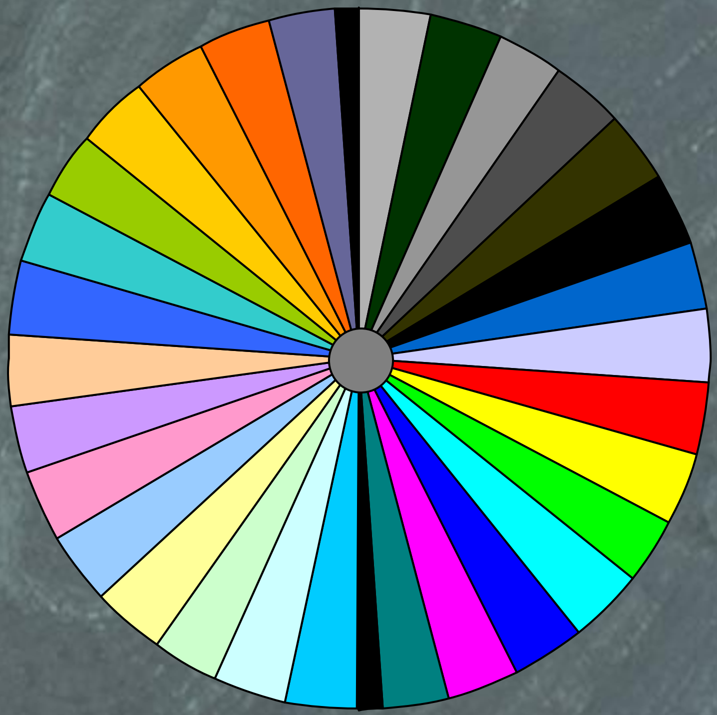
Total Application for a Single Impact Sprinkler

Total Application = Average Rate x Run Time

- IF
  - Nozzle q = 5 gpm
  - Nozzle throw = 45 ft
- THEN
  - The average application rate over the area to which water is applied (the green circle) is 0.076 inches/hour (if all the water makes it to the ground)
- AND SO
  - If the sprinkler is run for 10 hours TOTAL APPLICATION is 0.76 inches

Pivot & Linear-move Application Devices

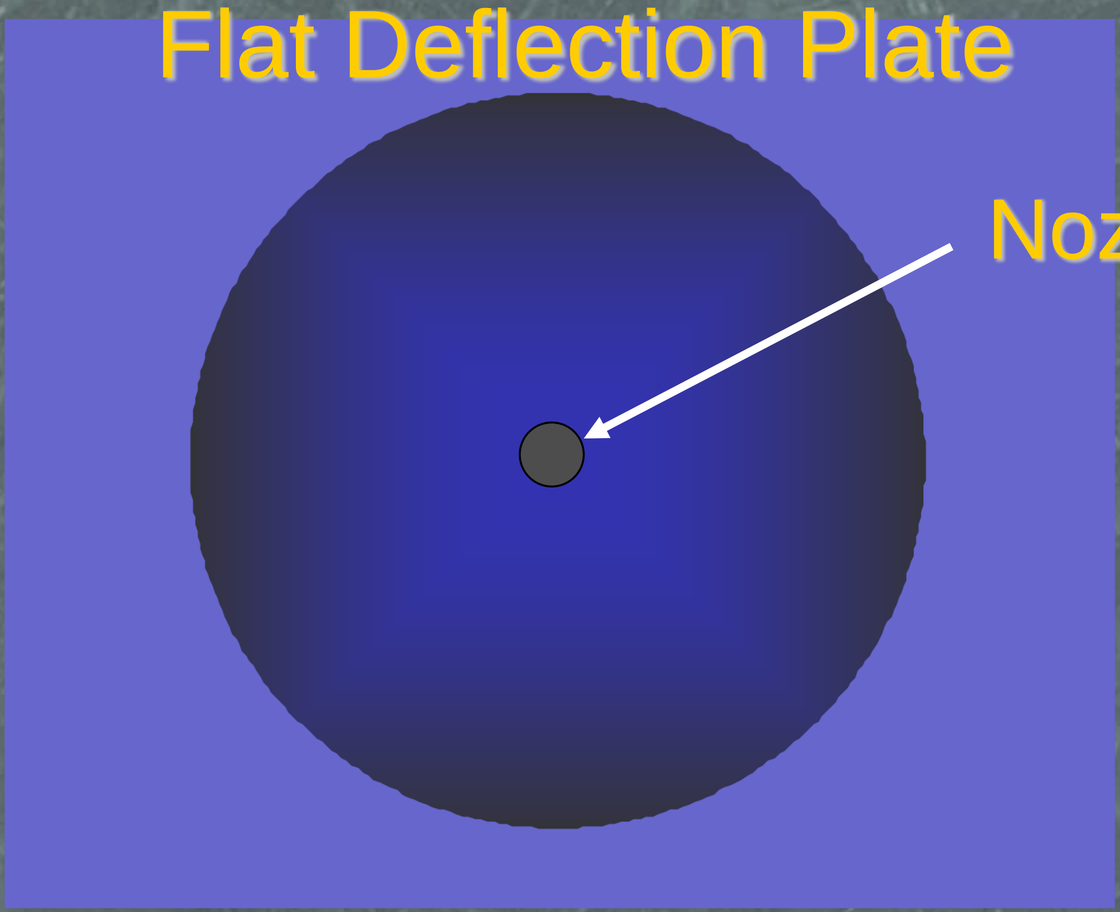
Instantaneous Application Rate



Depends on Where The Evaluation Point is

Serrated Deflection Plate

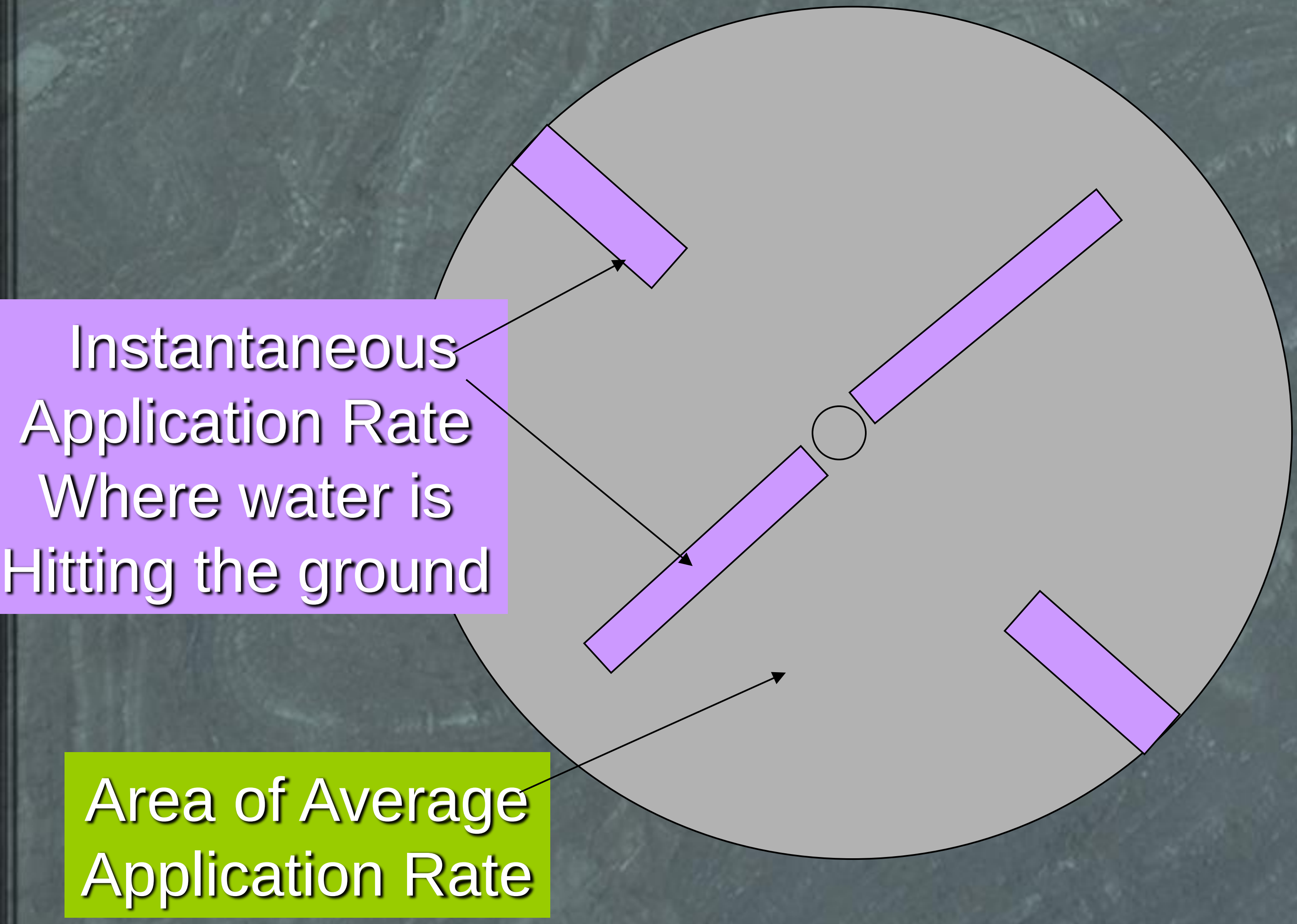
Instantaneous Application Rate



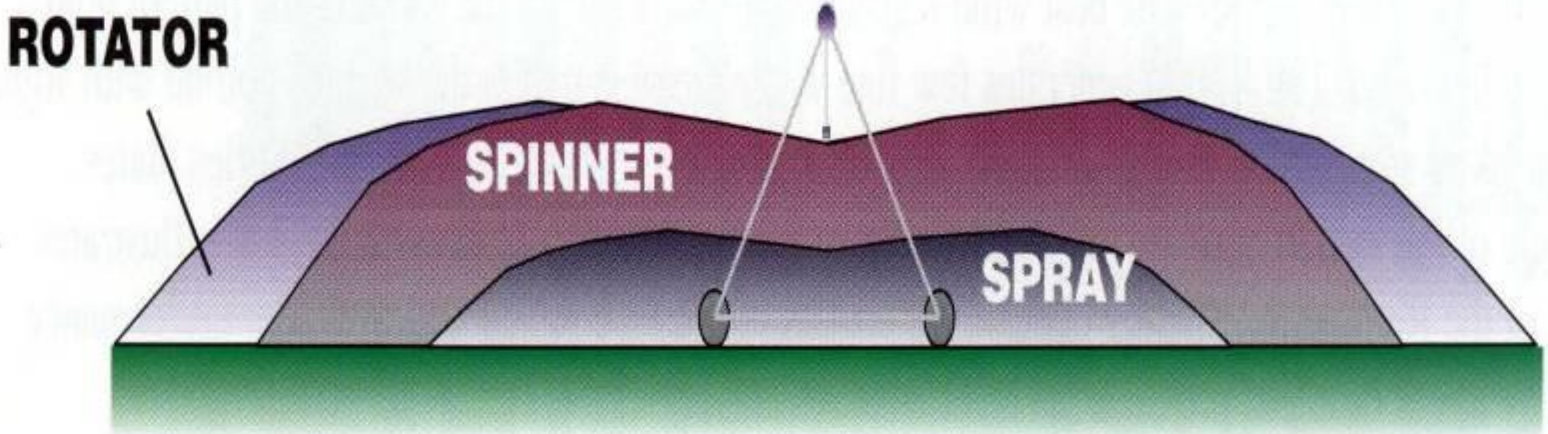
Water hitting ground in most of outside part of area

Application Devices with Distinct Strea

Exaggerated Rotator-style Pattern w/ 4 individual streams



Pattern Profile Illustrations



PRODUCT	THROW	SPECIFICATIONS
ROTATOR	68 ft. (20.7 m)	D4 Green Plate @ 30 psi (2 bar); 6 ft. (1.8m)
SPINNER	54 ft. (16.5 m)	D6 Purple Plate @ 15 psi (1 bar); 6 ft. (1.8 m)
SPRAY	38 ft. (11.6 m)	Blue Plate @ 15 psi (1 bar); 3 ft. (.9 m)

Total Application for a Single Applicator

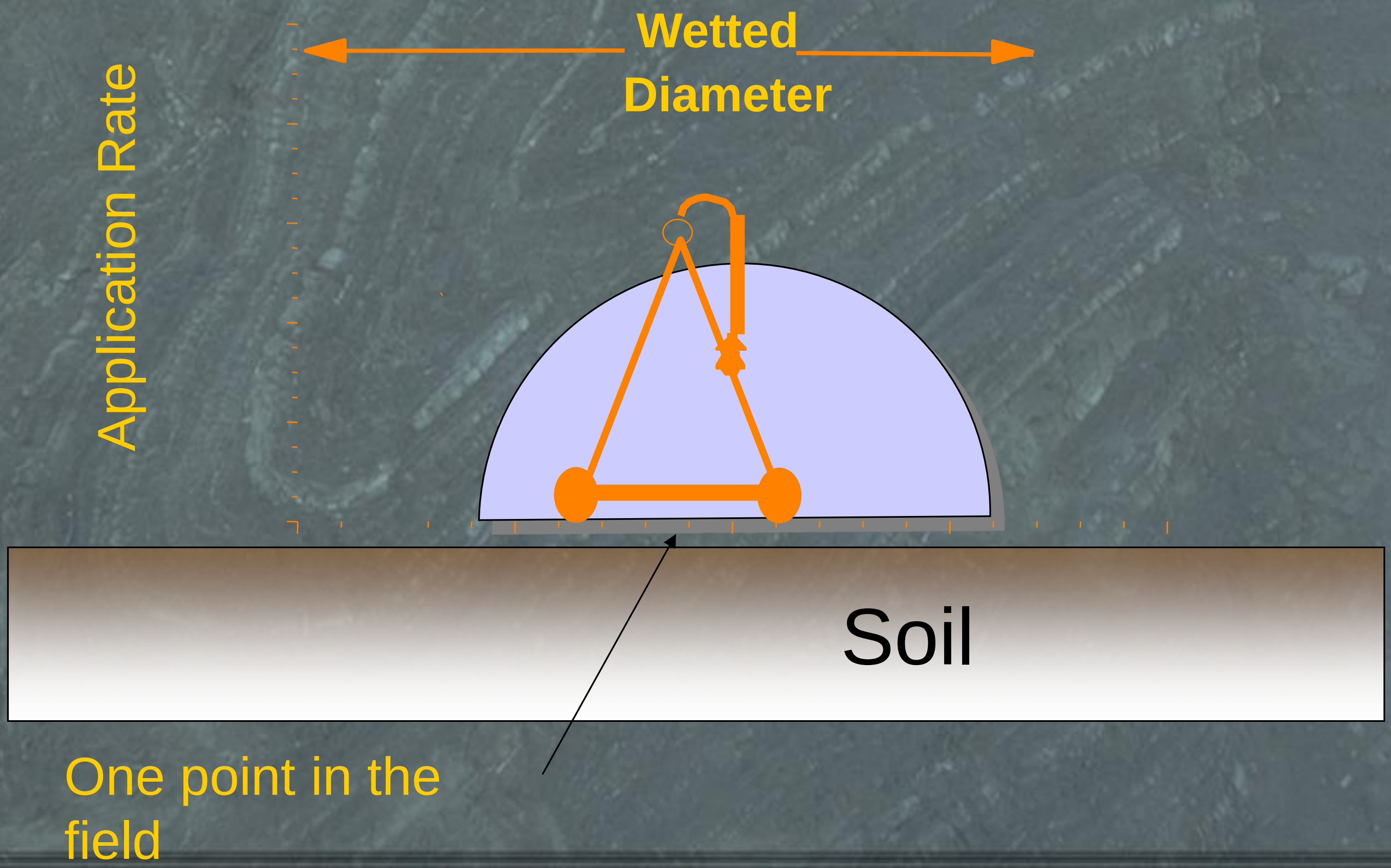
Total Application = Average Rate x Run Time

- IF
  - Nozzle q = 5 gpm
  - Nozzle throw = 25 ft
- THEN
  - The average application rate is 0.245 inches/hour
- AND SO
  - If the sprinkler is run for 10 hours TOTAL APPLICATION is 2.45 inches (if all the water makes it to the ground)

Consider Overlap & Sprinkler Movement

- Individual Patterns are Overlapped for Uniformity
  - Typical hand/wheel line spacing of 40’ (& 50’ or 60’ in solid sets)
  - Adjacent applicators on a pivot/linear-move
- Consider the movement of the pattern as the pivot/linear-move advances
  - the instantaneous application rate the soil “sees” will change because the overlapped pattern is not perfectly uniform
  - Initially the soil “sees” a small rate, gradually getting more intense until it peaks, then gradually decreases again as the machine moves away

Instantaneous Application Rate Varies as Machine Moves over the field



Application Rate Summary

- Instantaneous Application Rate is the rate "seen" by the soil at one point in the field at one point in time – *NOT influenced by speed of machine*
- Average Application Rate is the average rate "seen" by the soil at one point in the field over the time it receives water– *NOT influenced by speed of machine*

- Total Application is total "depth" of water received by the soil in the field. Equal average rate x time watered

Methods of calculating

$$I_{\text{ave at r}} = \frac{2r}{L^2}\frac{Q_b}{W}$$

$$I_{\text{peak at r}} = \frac{4}{\pi}\frac{2r}{L^2}\frac{Q_b}{W}$$

True only for elliptically shaped application patterns

Newer nozzles

- $R_a=0.26 *Q*X_p/W$
- $r= R_p/R_a$, $(1<r<2)$
- $M=q_n\sqrt{P}$
- $W=a(H^cM)^b$

Ra = average application rate

Rp= peak application rate

q_n =nozzle flow

P = nozzle pressure

H = mounting height

W = pattern width

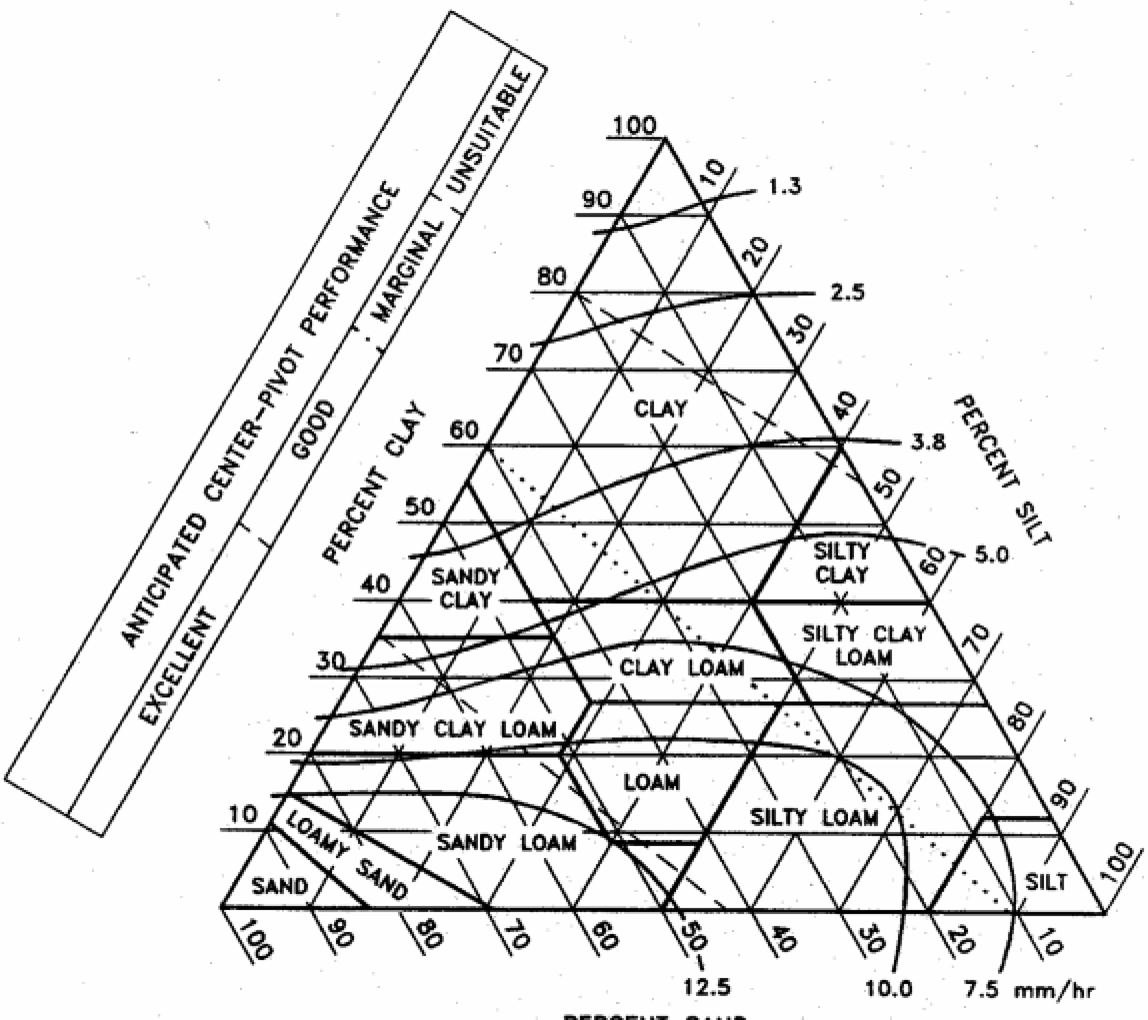
a, b, c, are empirical coefficients determined for each spray device type

Reference

- “Application Rates from Center Pivot Irrigation with Current Sprinkler Types”. by Dennis Kincaid
- http://asae.frymulti.com/request.asp?JID=8&AID=17585&CID=smppnr&T=1

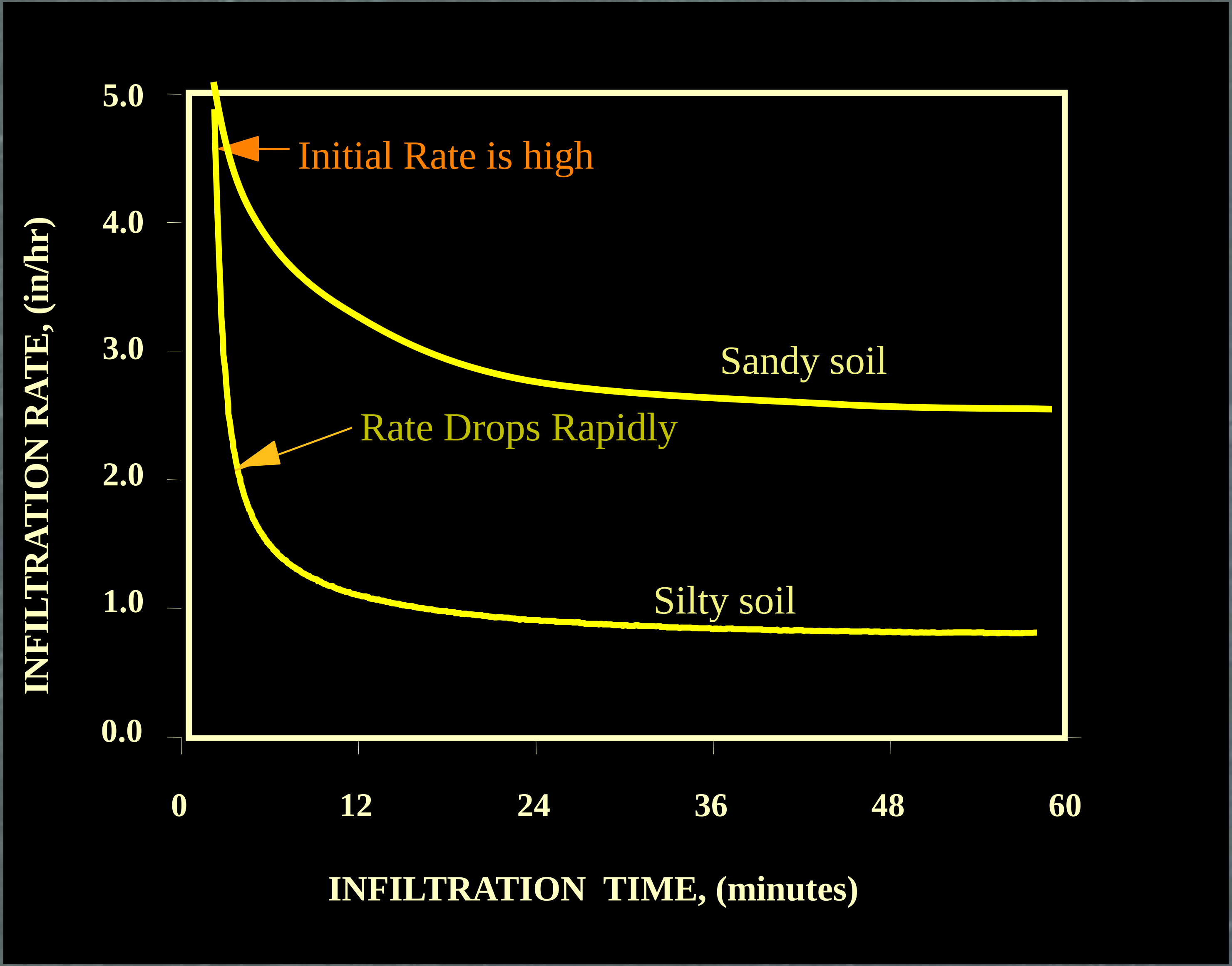
Soil Sprinkler Interaction

- Why is the application rate a concern?



ANTICIPATED CENTER-PIVOT PERFORMANCE
EXCELLENT
GOOD
MARGINAL
UNSUITABLE
PERCENT CLAY
PERCENT SILT
PERCENT SAND
CLAY
SANDY CLAY
SILTY CLAY
SILTY CLAY LOAM
CLAY LOAM
SANDY CLAY LOAM
LOAM
SILTY LOAM
SANDY LOAM
LOAMY SAND
SAND
SILT
1.3
2.5
3.8
5.0
12.5
10.0
7.5 mm/hr

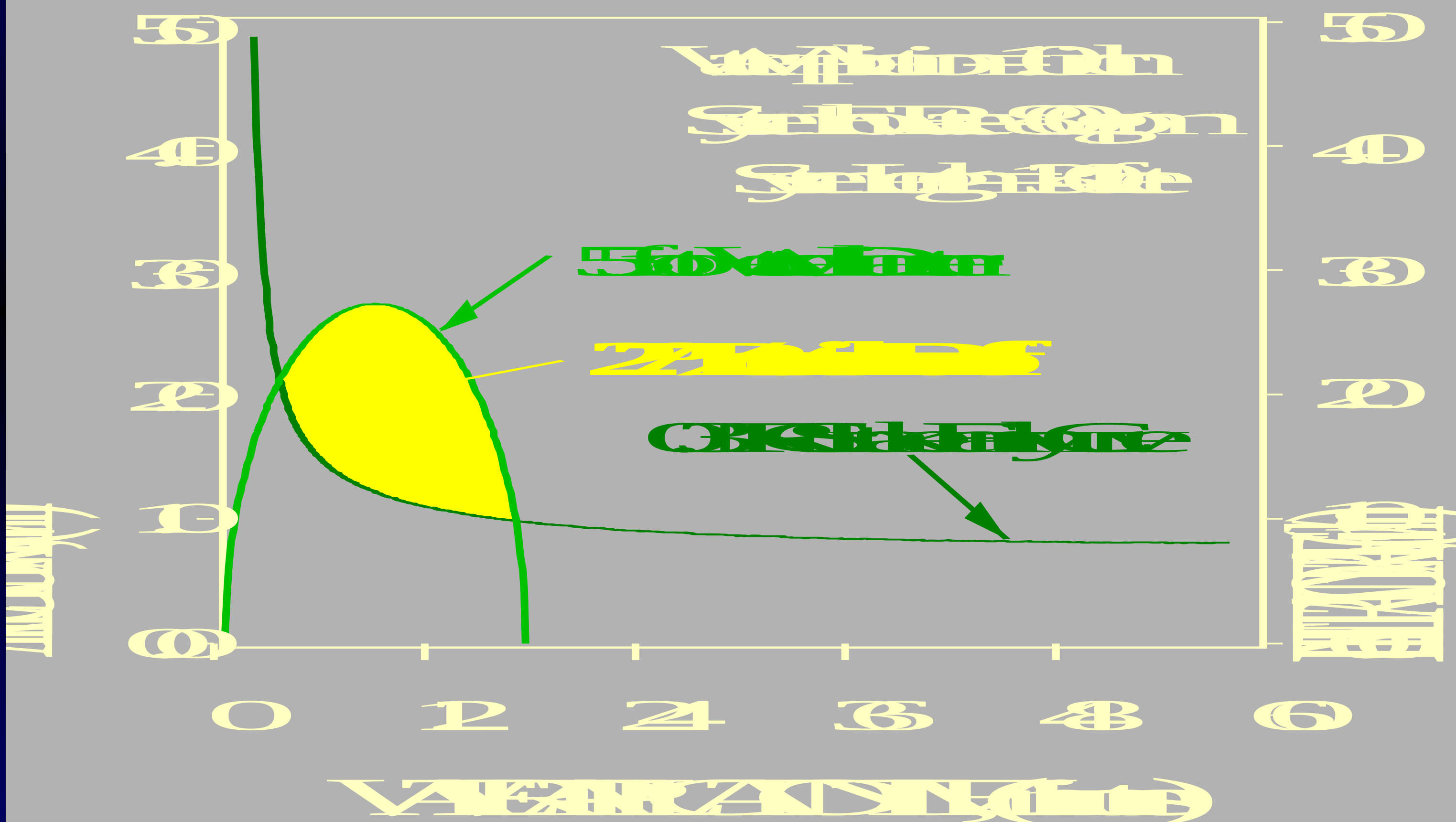
Infiltration Rate Varies With Time



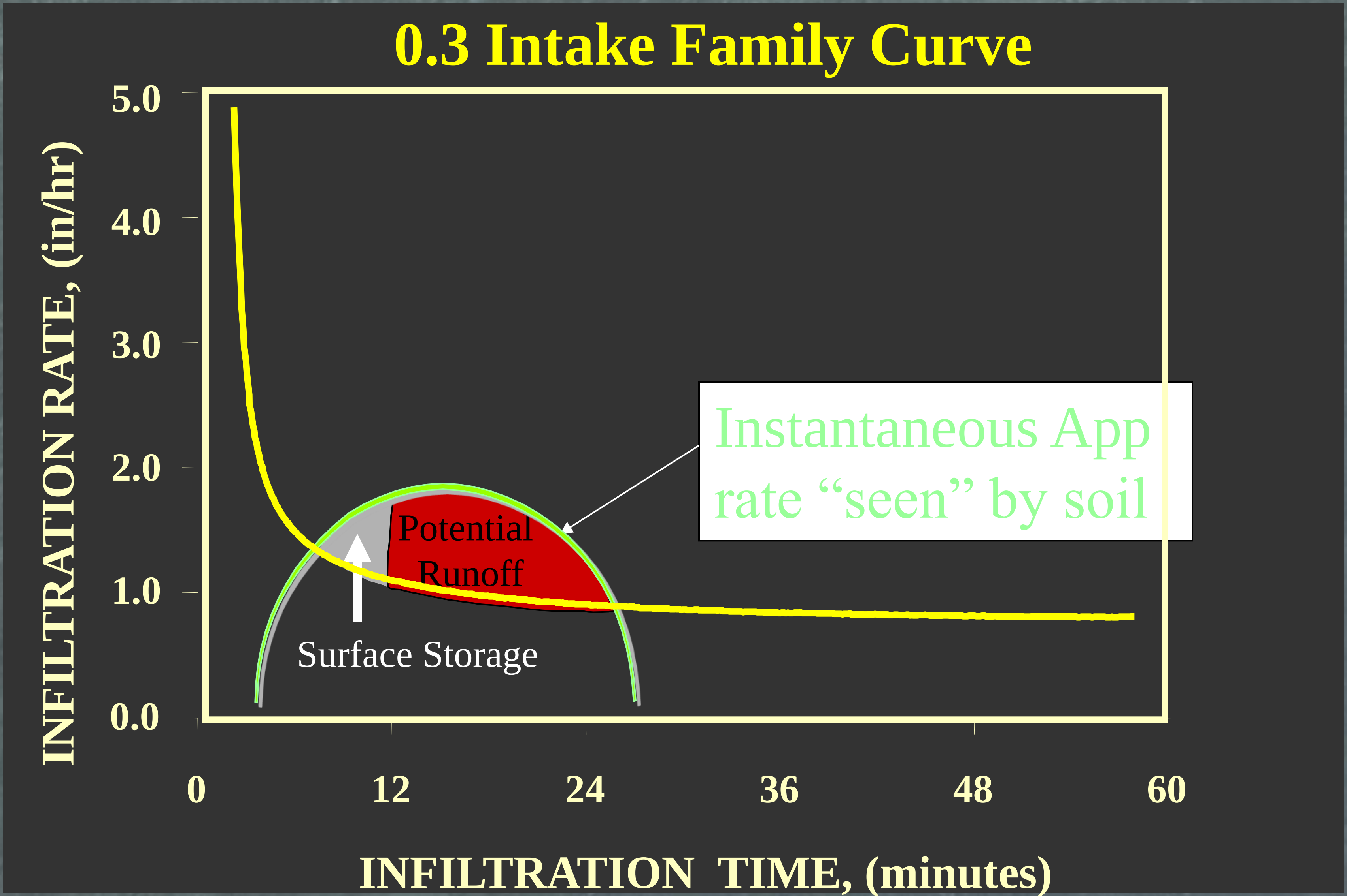
Application vs. Infiltration = Runoff ?

- There is *potential* for runoff when Application Rate exceeds Infiltration Rate.

- Runoff will occur if "surface storage" cannot temporarily hold the water not being infiltrated.



Runoff Potential



FACTORS AFFECTING RUNOFF

1. SYSTEM CAPACITY - GALLONS/MINUTE PER ACRE

   780 GPM / 130 ACRES = 6 GPM/ACRE

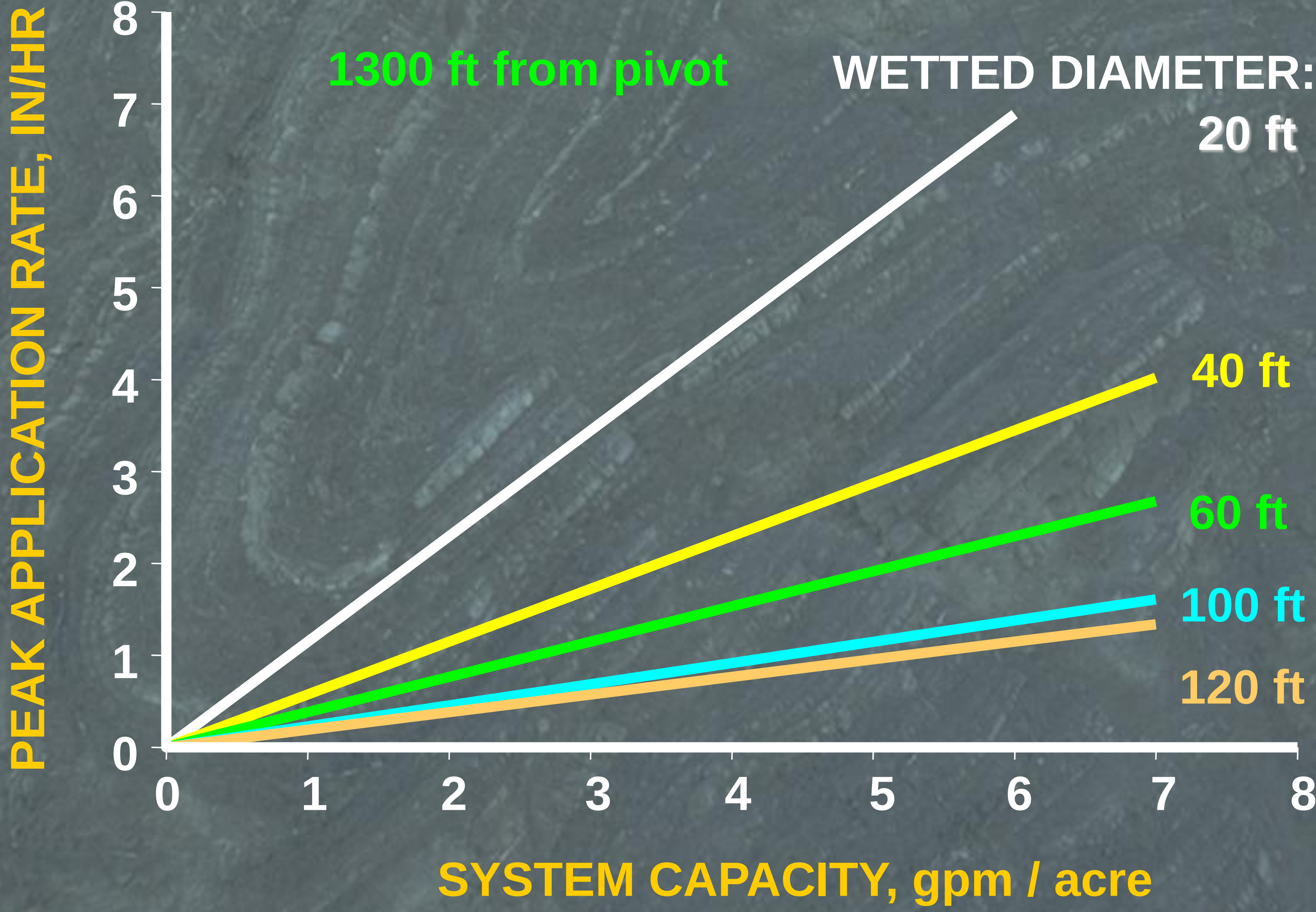
2. DEPTH OF APPLICATION PER REVOLUTION - INCHES

3. SPRINKLER PACKAGE - SPRAY, IMPACT, LEPA

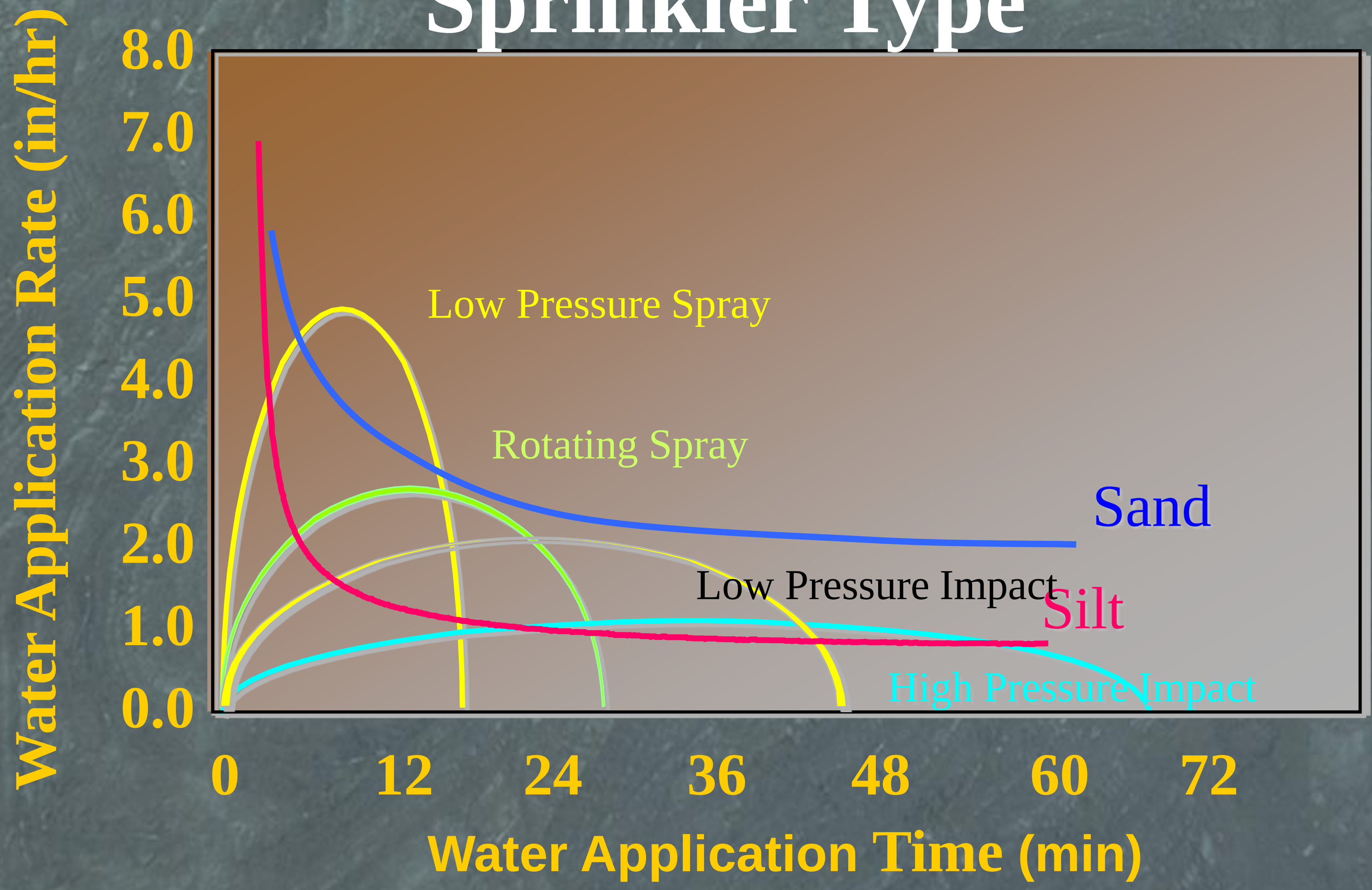
4. SOIL SURFACE CONDITIONS -

   AMOUNT OF WATER THE SOIL SURFACE WILL HOLD

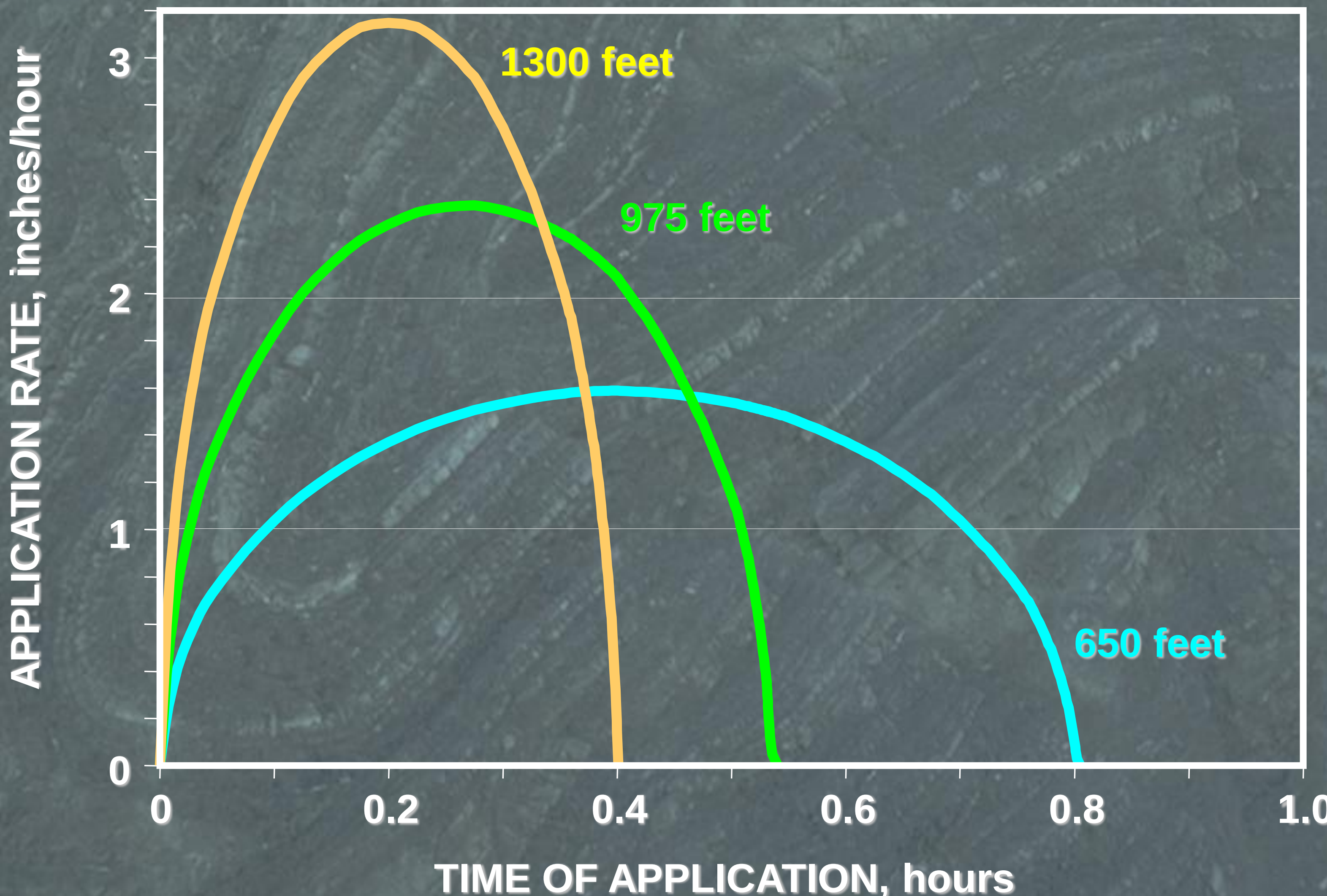
EFFECT OF CAPACITY ON PEAK APPLICATION RATE



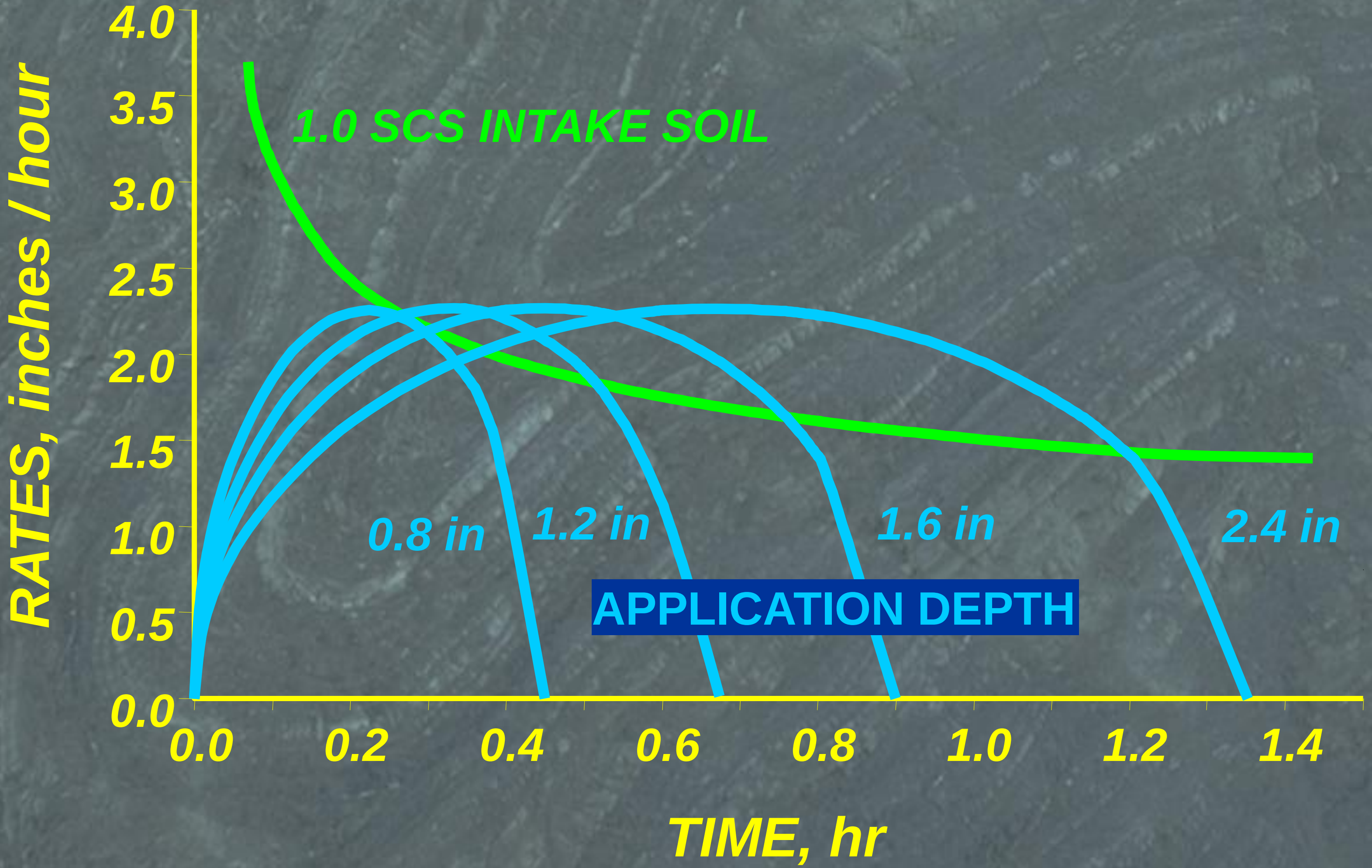
Application Rates by Sprinkler Type



Rate also varies along machine



EFFECT OF APPLICATION DEPTH ON RUNOFF



SURFACE STORAGE

HOW TO REDUCE RUNOFF?

1. REDUCE SYSTEM CAPACITY
- irrigate more hours per year
- increase chances of getting behind

2. REDUCE APPLICATION DEPTH

– make more revolutions per year

3. CHANGE SPRINKLER PACKAGE

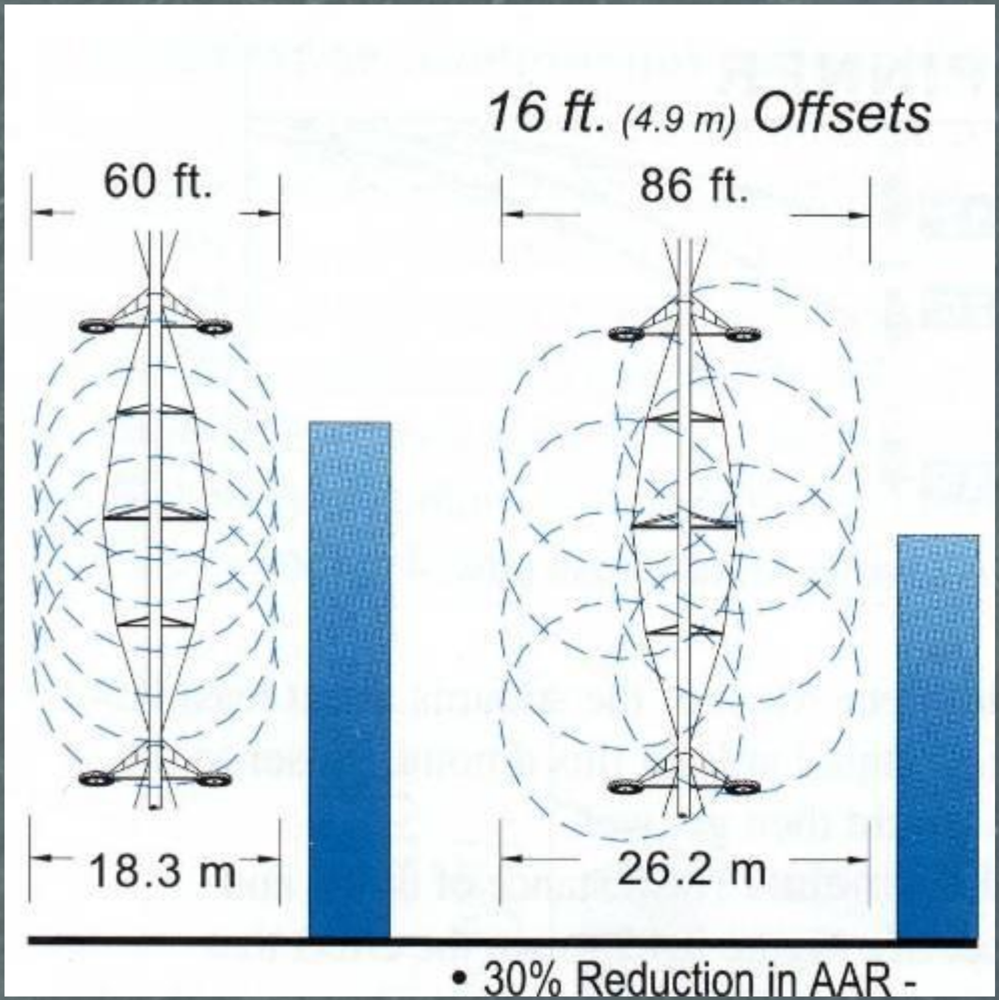
- increase wetted radius
  - may need higher pressure
  - make changes to pump

Offset Nozzles

Boom backs

Booms Behind Towers

Effects of Booms



Booms: Reduction of Peak Application Rate

Boom Offset from Pipe Zig-Zag Configuration	Reduction* (%)
10 ft	5 – 15%
15 ft	15 – 30%
20 ft	30 – 40%

4. INCREASE SURFACE STORAGE

– extra tillage, fuel, time, weed control

Methods of increasing Surface Storage

- Basin Tillage
- Dammer-diker
- Subsoiler
- Field cultivator
- Rough cloddy ground (slope dependent)
- Organic residue

Dammer-Diker

Ways to analyze Runoff

- Field test
- CPnozzle
- Guess?

Input Data | **Results**

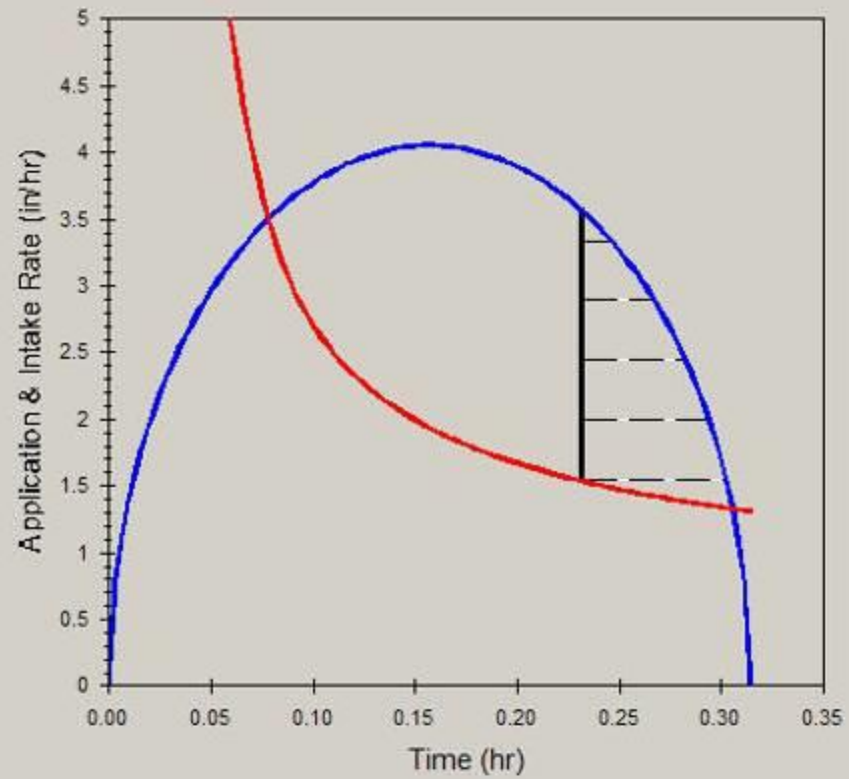
Percent Potential Runoff

0.5 NRCS Intake Family

System Length (feet)	Wetted Diameter (feet)	Surface Storage (in)	1100 (gpm)	1200 (gpm)	1300 (gpm)
132	55	0.3	0.0	0.0	0.0
264	55	0.3	0.0	0.0	0.0
396	55	0.3	0.0	0.0	0.0
528	55	0.3	0.0	0.0	0.0
660	55	0.3	0.0	0.0	0.0
792	55	0.3	0.0	0.0	0.0
924	55	0.3	0.0	0.0	0.0
1056	55	0.3	0.0	0.0	2.4
1188	55	0.3	0.7	3.6	6.2
1320	55	0.3	4.2	7.0	9.5

	1100 (gpm)	1200 (gpm)	1300 (gpm)
Weighted Average Percent Runoff	0.3	1.3	2.2
Hours per Revolution	51.7	47.4	43.7
Peak Water Application Rate	3.7	4.1	4.4
Water Application Time	0.34	0.32	0.3

0.3 Intake | 1.0 Intake



Location

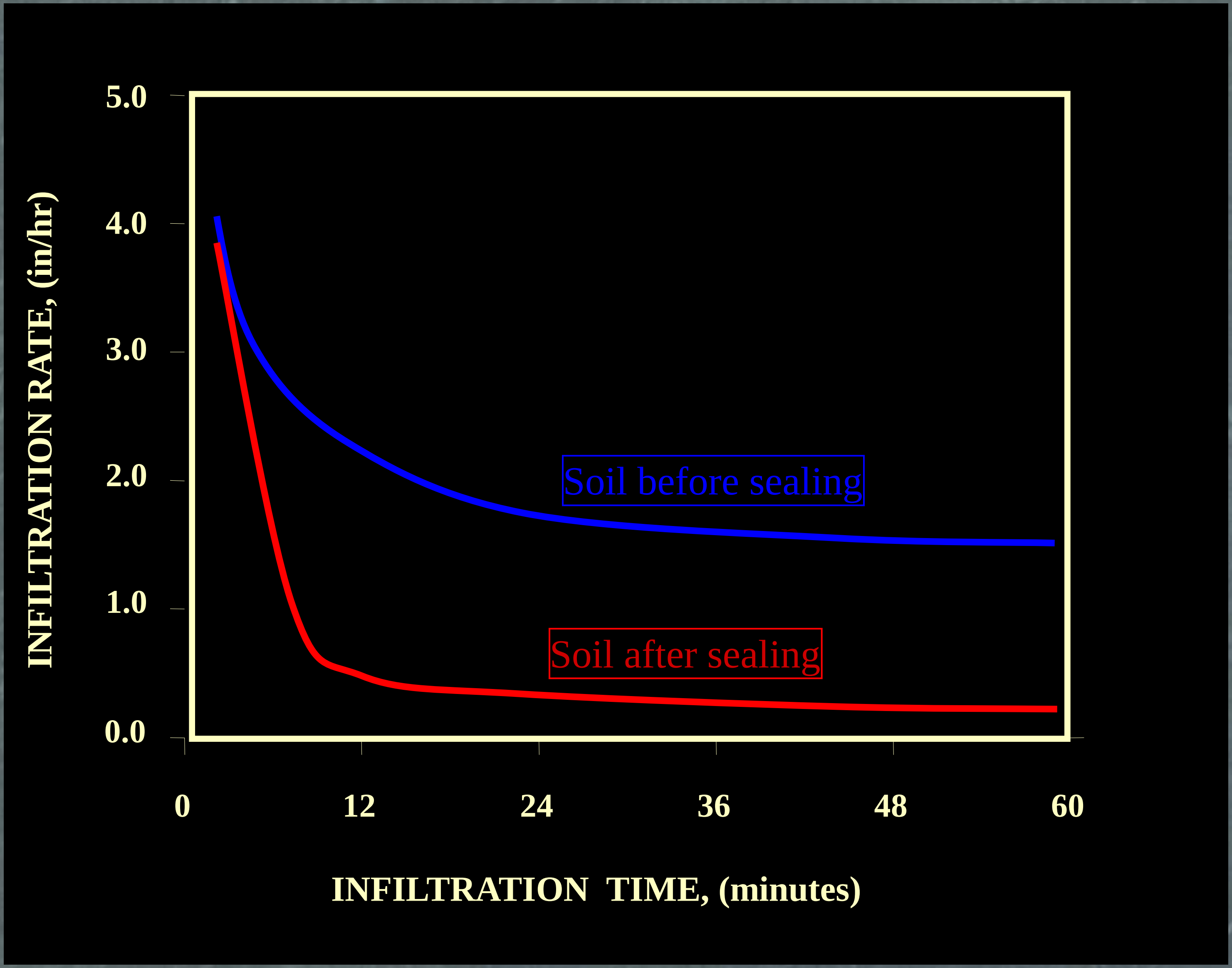
Peak Application Rate	4.1
Time to Saturation	0.08
Time to Peak Application	0.16

Conditions that May Produce Surface Sealing

- Salts
  - Sodium tends to break down structure and produce “dispersed” conditions which lead to reduced infiltration rates
  - Calcium tends to bind particles together, improving soil structure and, thus, infiltration rates
  - These impacts typically seen in soils with large percentages of clay particles

- Compaction/Sealing
  - By Equipment
  - By impact of water particles with soil
    - Intense rainstorm
    - Application Rate & Energy of Sprinkler Droplet; energy is basically a function of size of droplet
    - Silty soils more susceptible; aggregates broken down and the silt particles “float” on top, producing a seal
    - Effect is progressive, getting worse throughout the irrigation season
  - Organic or other material added to soil surface

Sealing Effect on Infiltration Rate



Special Application

- Fertilizer application
- Pesticide application
- Waste Water Application

Linears or Laterals

- Require Guidance system
- Limited by water source
- Harder to match frequency with crop and field limitations
- More problems with runoff
- More expensive

LEPA with Sock

Question?

Thanks

Electrical

- Electrical design of a system is dependent on a number of factors . These include length of system, number of drive units, options (hi-speed and or booster pump) and voltage available at the pivot.
- Electrically driven components (motors) require a certain quantity of electricity called Amps and the electricity must be a certain pressure (Volts) much the same as the hydraulic supply to a system.

- Several things are needed for the electrical design of a Pivot
  - amp load
  - voltage drop with given wire size
  - voltage supply at the pivot and end tower voltage requirement
- System amperage is based on electrical load of the system, i.e., number of drive motors, hi speed, booster pumps, etc.

Example

- Given:
  - Length - 5 spans X160 ft + 36ft overhang
  - High speed
    - 3 drive units high speed, 2 drive units standard
  - No booster pump
  - Helical gear center drive motors
- Solution:
  - Amp Load = (1.8*A*0.85) + (1.1*B*0.60) +2.25
    - 6.63 amps

Determining System Voltage Drop

- Voltage drop for the system is calculated to insure a minimum of 440 volts on pivots at the last drive unit
  - 440 + system voltage drop = Minimum pivot supply voltage

Example

- Given: High speed model with 2Hp booster pump, 180’ spans (1260’), 3 standard speed drive units, 4 high speed drive units, and a 13.7 amp load.
- Solution: from graph #2 for 12ga. wire

voltage drop = 30 volts

440+30 = 470 volts at pivot

Probably need some 10ga wire to be safe

- How about voltage drop from Transformer out to the pivot point