



Manual for Designing Surface Application of OSSF W/W Effluent

by

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March 5, 2008

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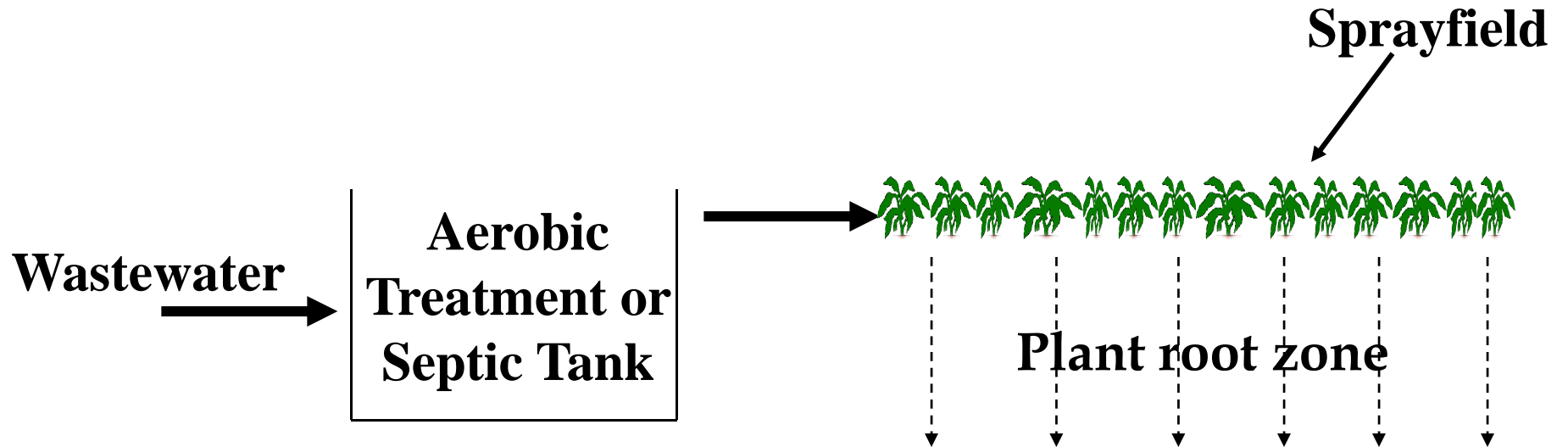


Surface treatment of wastewater is accomplished through the **controlled application onto a land surface such that a **designed degree of treatment** through natural physical, chemical, and biological processes occurs in the plant-soil-water matrix.**



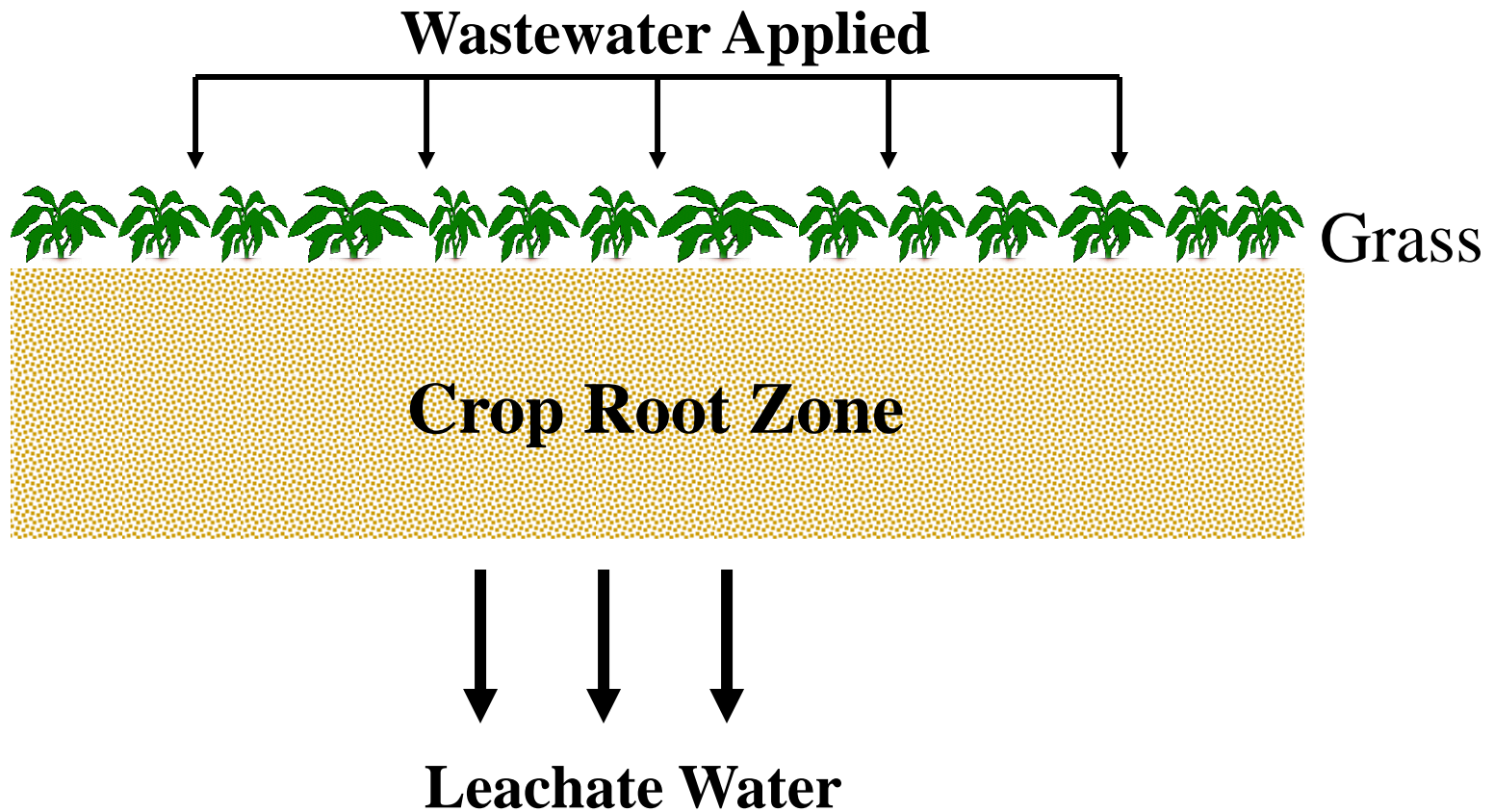


Basic System





Surface Application System



Surface Application System

Principle Design Parameters:

Evapotranspiration/Evaporation

Deep Percolation/Leaching

Soil Properties

water intake rate

Crop Selection

nutrient uptake/removal

active growth period

Wastewater Application

drip

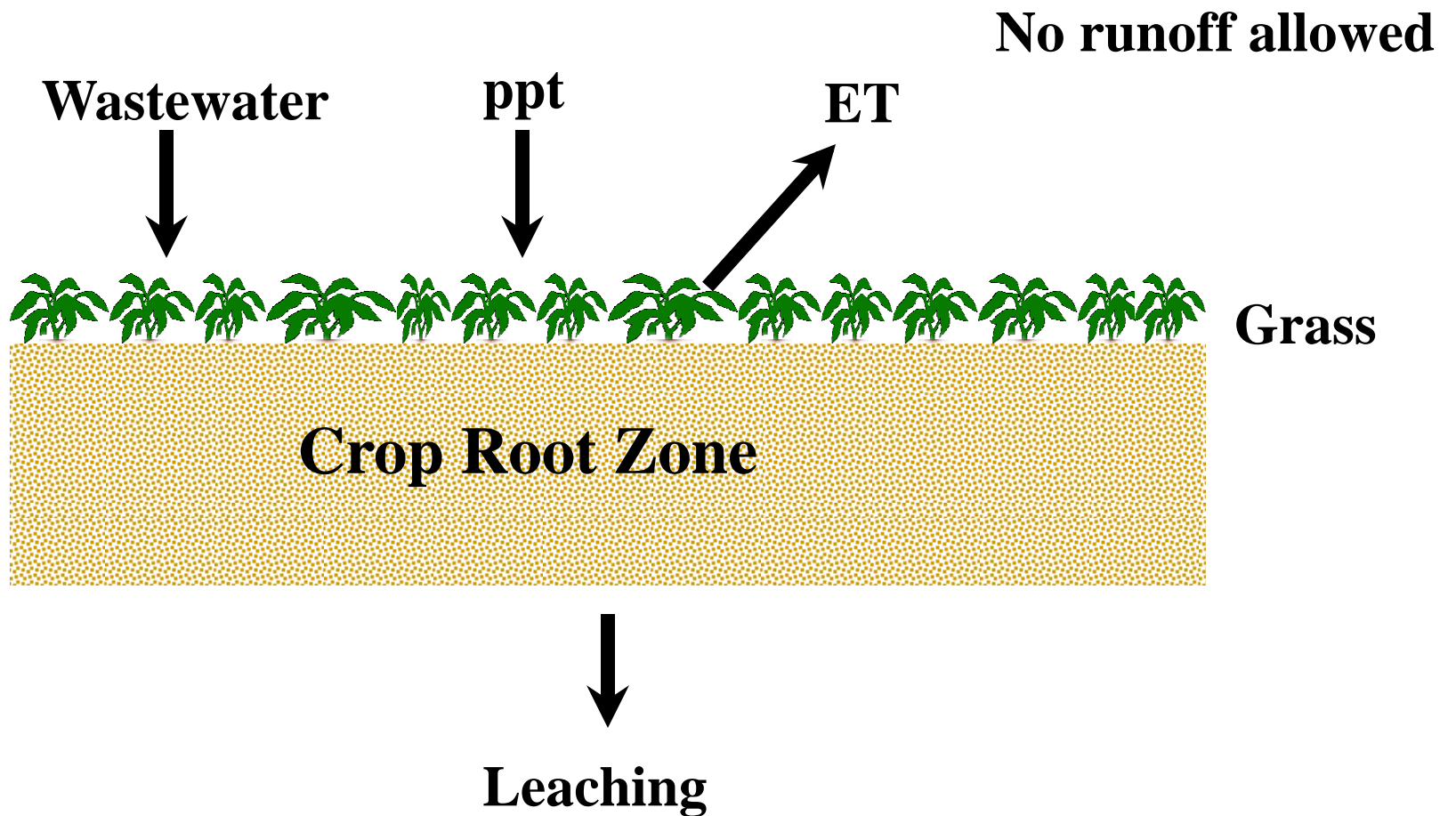
sprinkler

Runoff Control

Storage

Design Components

Water, Nitrogen & Salt Balance





What affects the Water Balance?

Wastewater application rate

Evapotranspiration (crop)

Precipitation

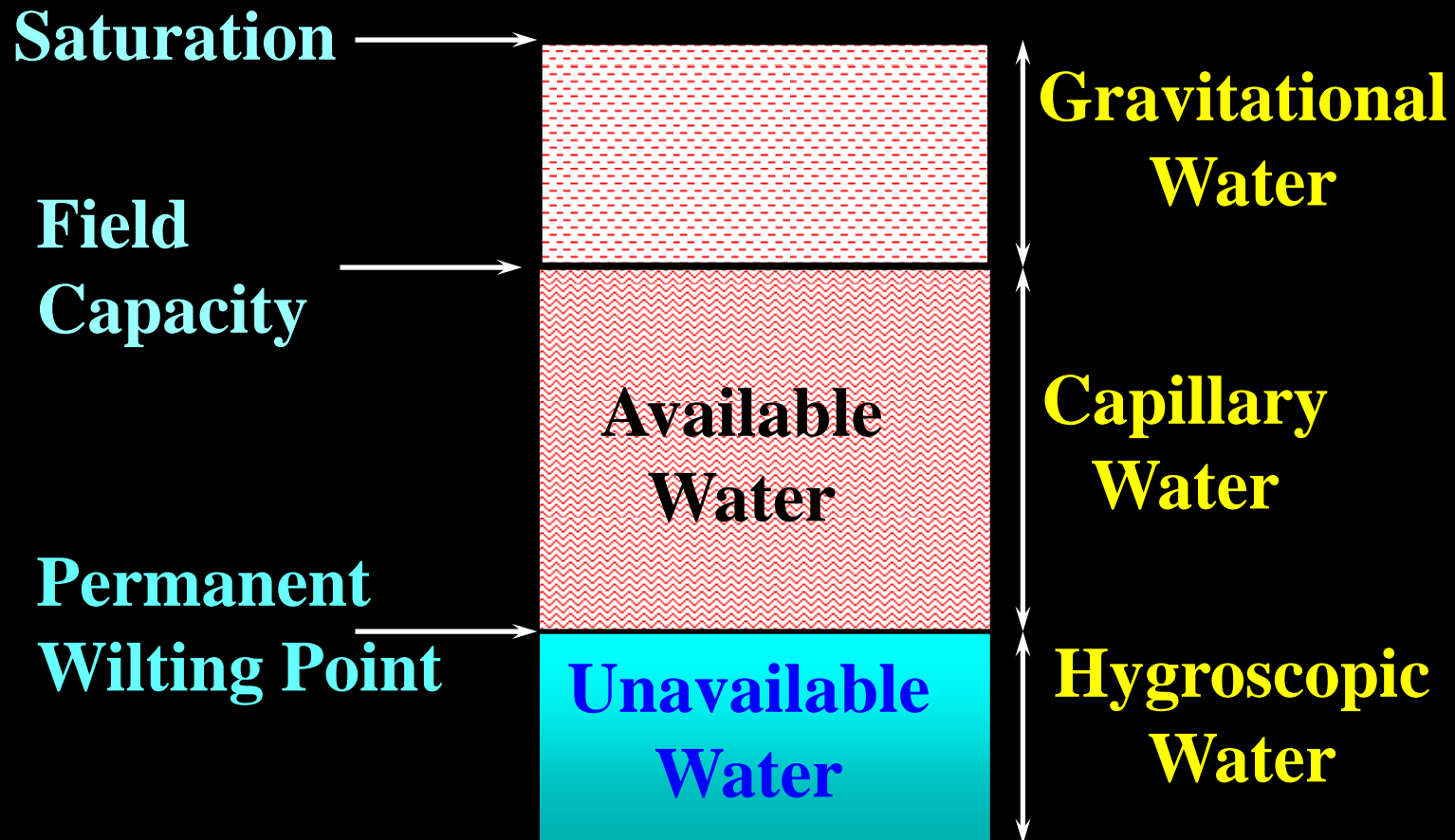
Soil water storage

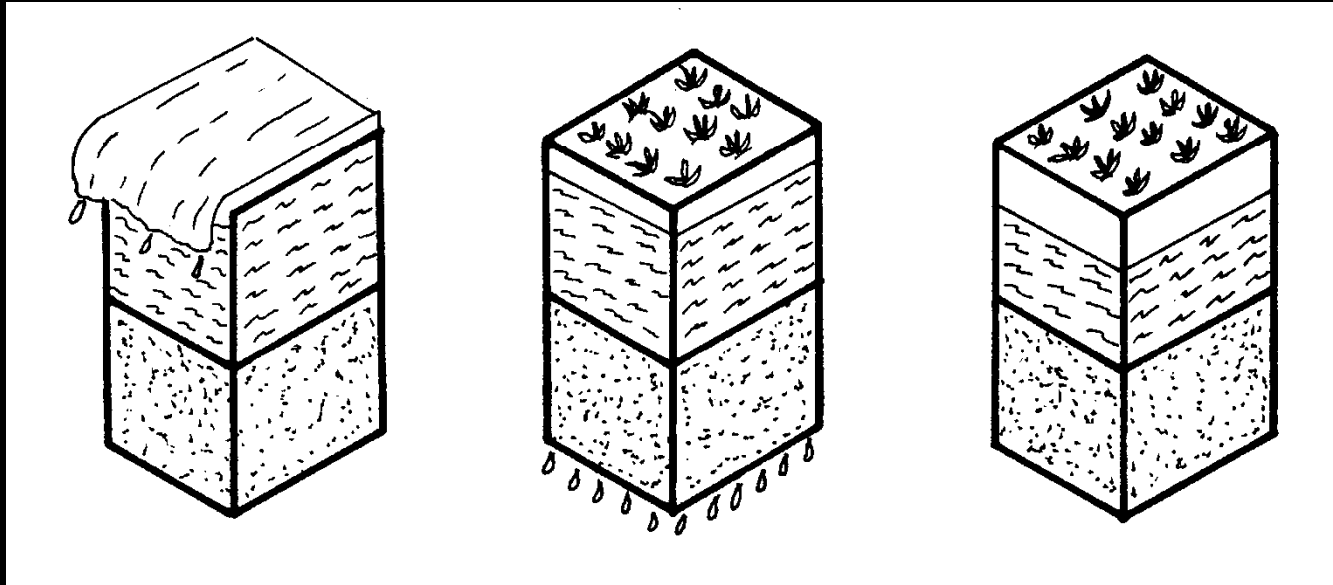
Leaching

Runoff



The Soil-Water System





**Saturated
Conditions**

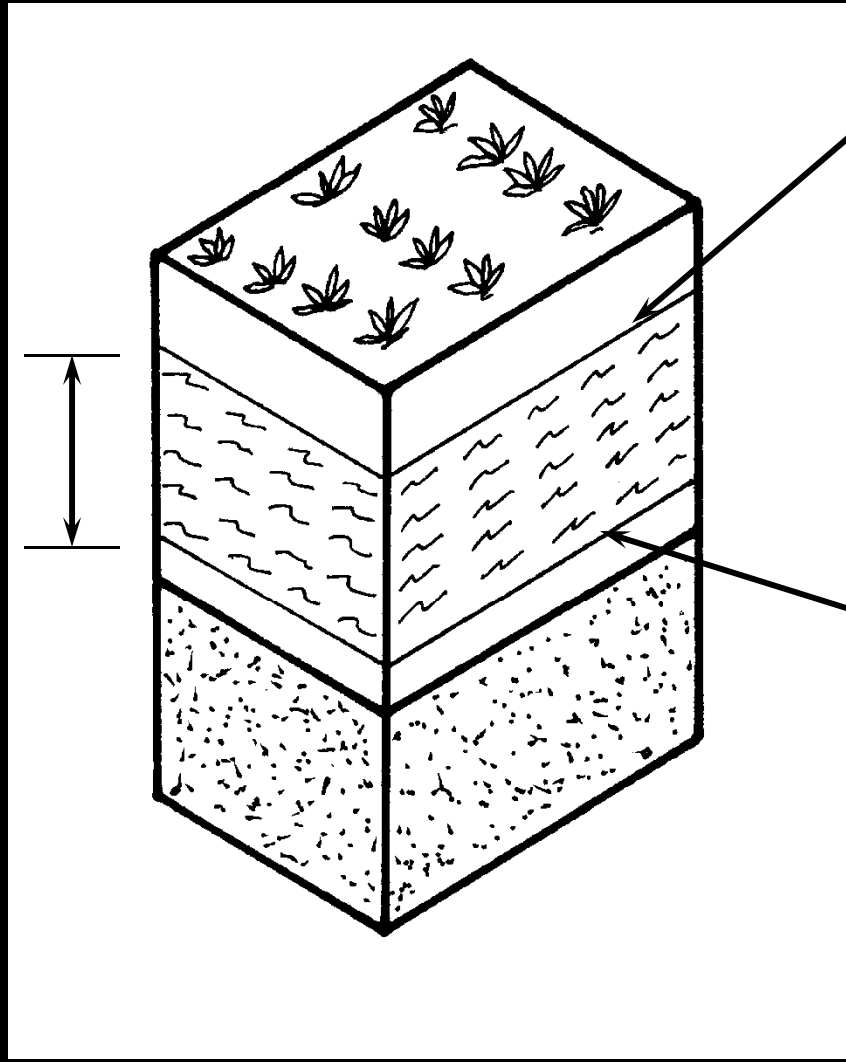
**Draining
Conditions**

**Field
Capacity**





**Available
Moisture**



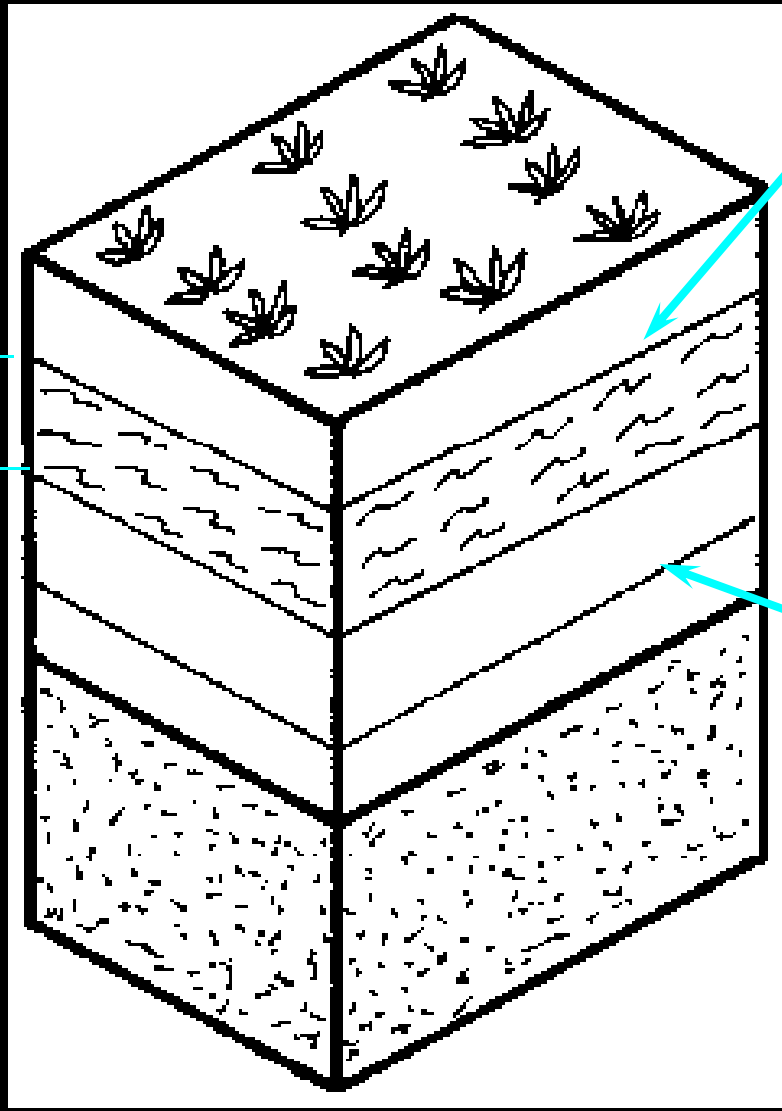
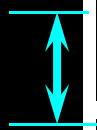
**Field
Capacity**

**Wilting
Point**





Readily Available Moisture




Field Capacity

Wilting Point



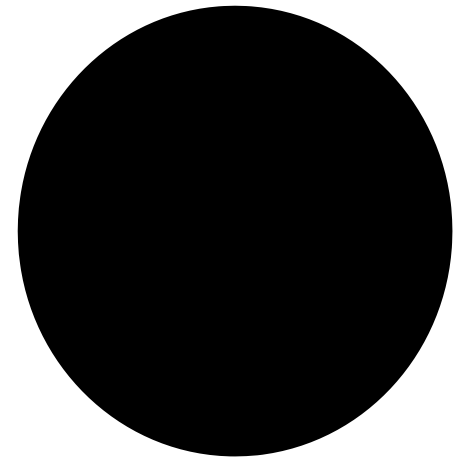
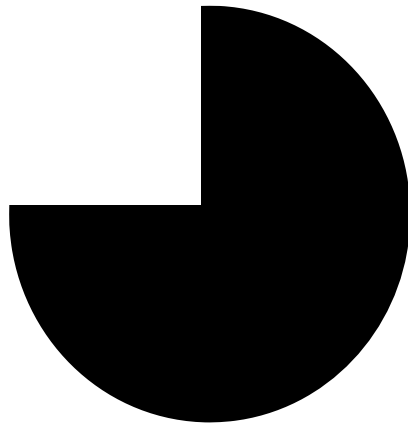
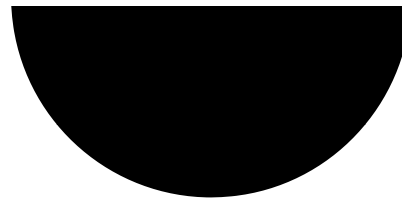
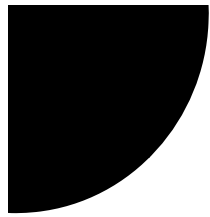


Main Design Components Required

- **Sprinkler Spacing**
 - **Operating Pressure**
 - **Selection of Sprinkler Heads**
 - **Pressure Losses in Main Pipeline**
 - **Risers**
 - **Application Rate**
 - **Soil Infiltration Rate**
 - **Time of Application**
- 



Typical sprinkler patterns





UCC

UCC is Christiansen's coefficient of uniformity. It is used to quantify the uniformity of water application by sprinklers.





Water Application Efficiency

Water application uniformity under irrigation depends on uniformity of the sprinklers and not on soil properties, so long as the application rate does not exceed the intake rate of the soil.





Water Application Efficiency

$$E_a = 100(d_r/d_a)$$

d_r = Average depth of irrigation water stored in the root zone.

d_a = Average depth or net application rate.

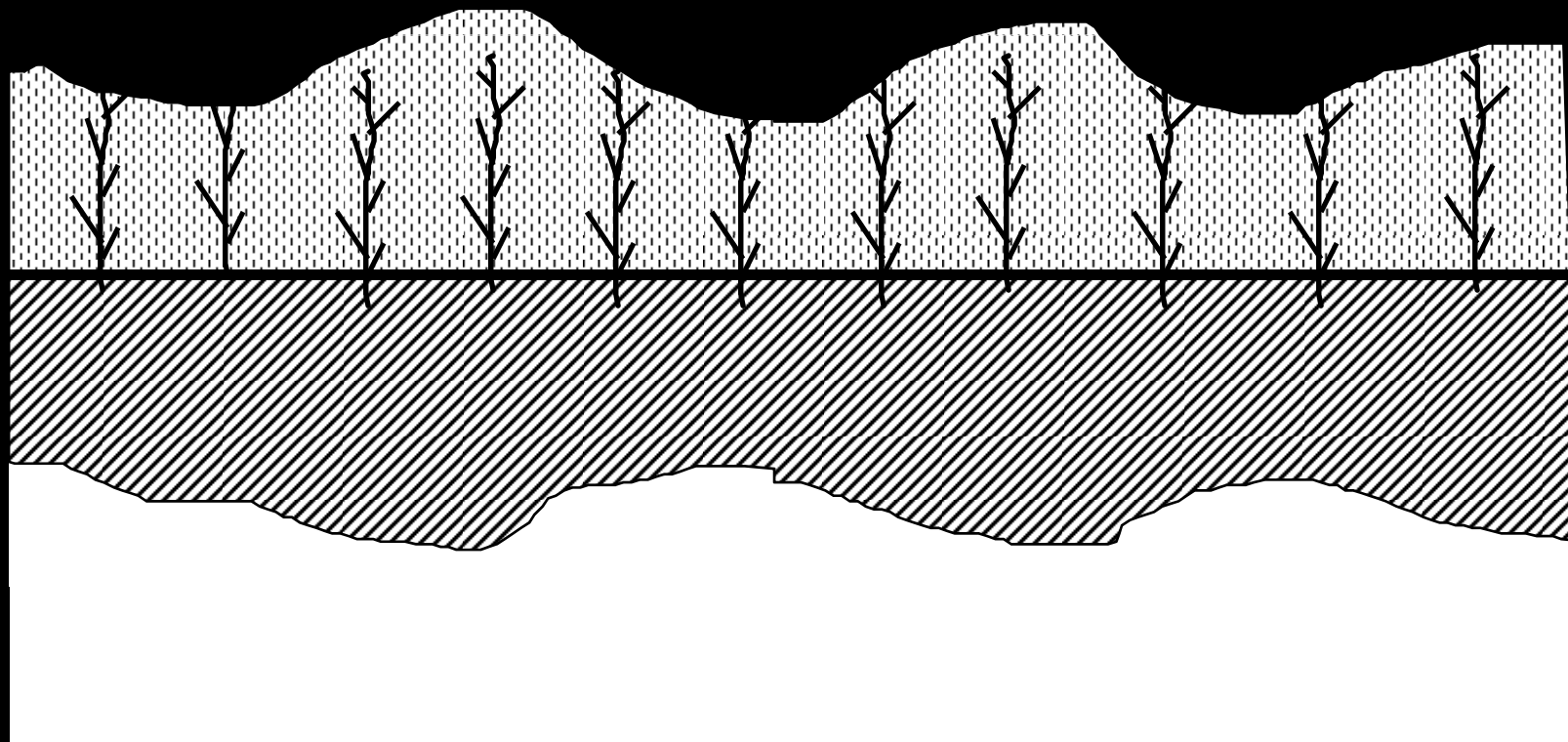




Irrigation Efficiency

$$E_s = \frac{\text{Avg Depth of Irr. Water Beneficially Used}}{\text{Average Depth Applied}}$$

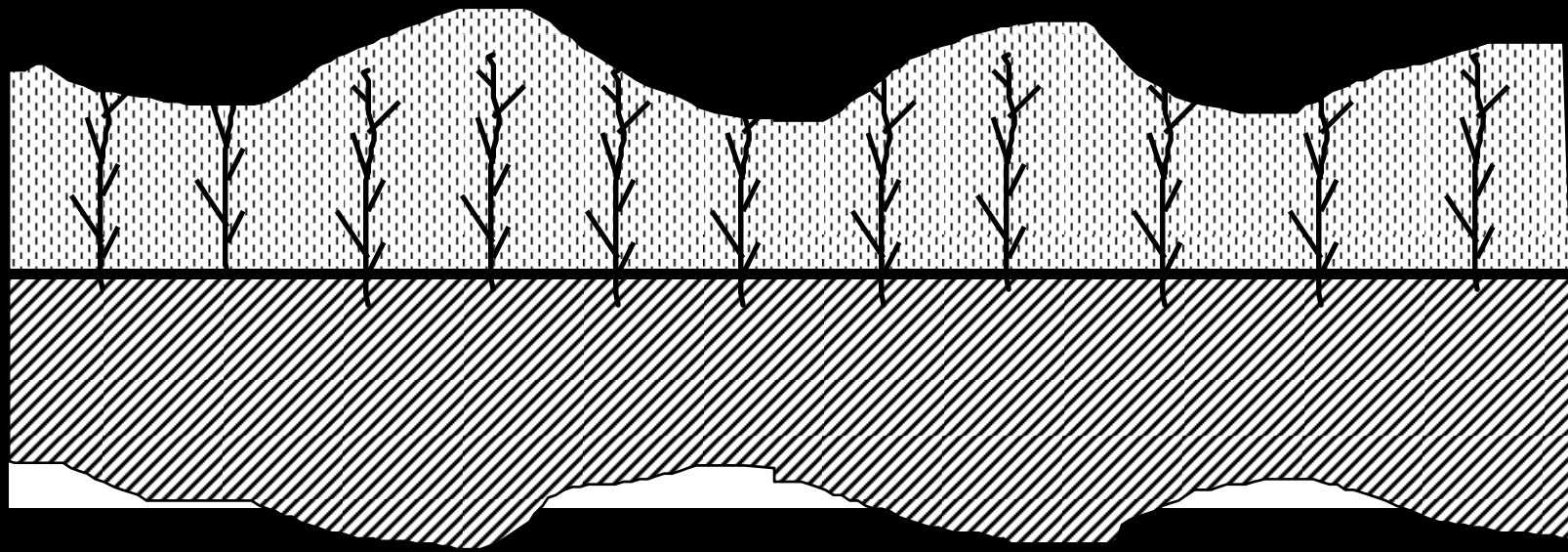




$E_a = 100\%$

$E_s = 50\%$

$UCC = 75\%$

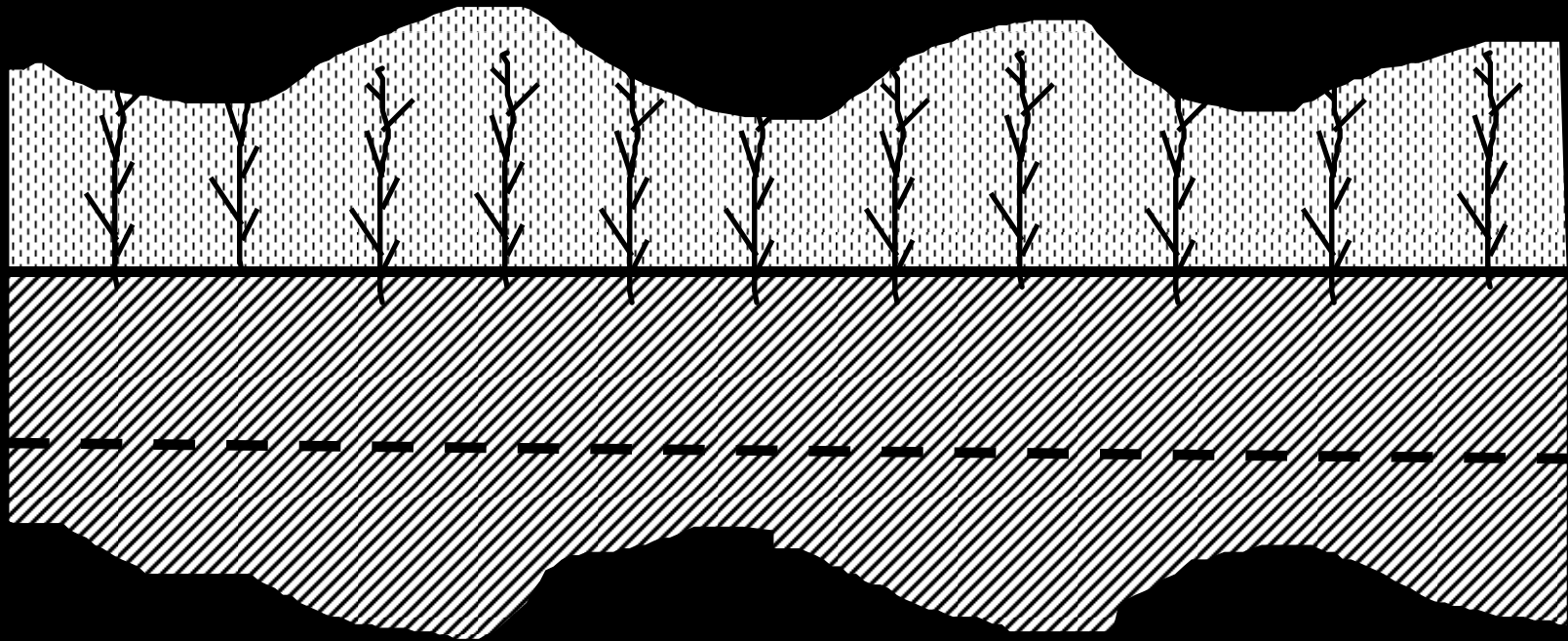


$E_a = 90\%$

$E_s = 90\%$

$UCC = 85\%$



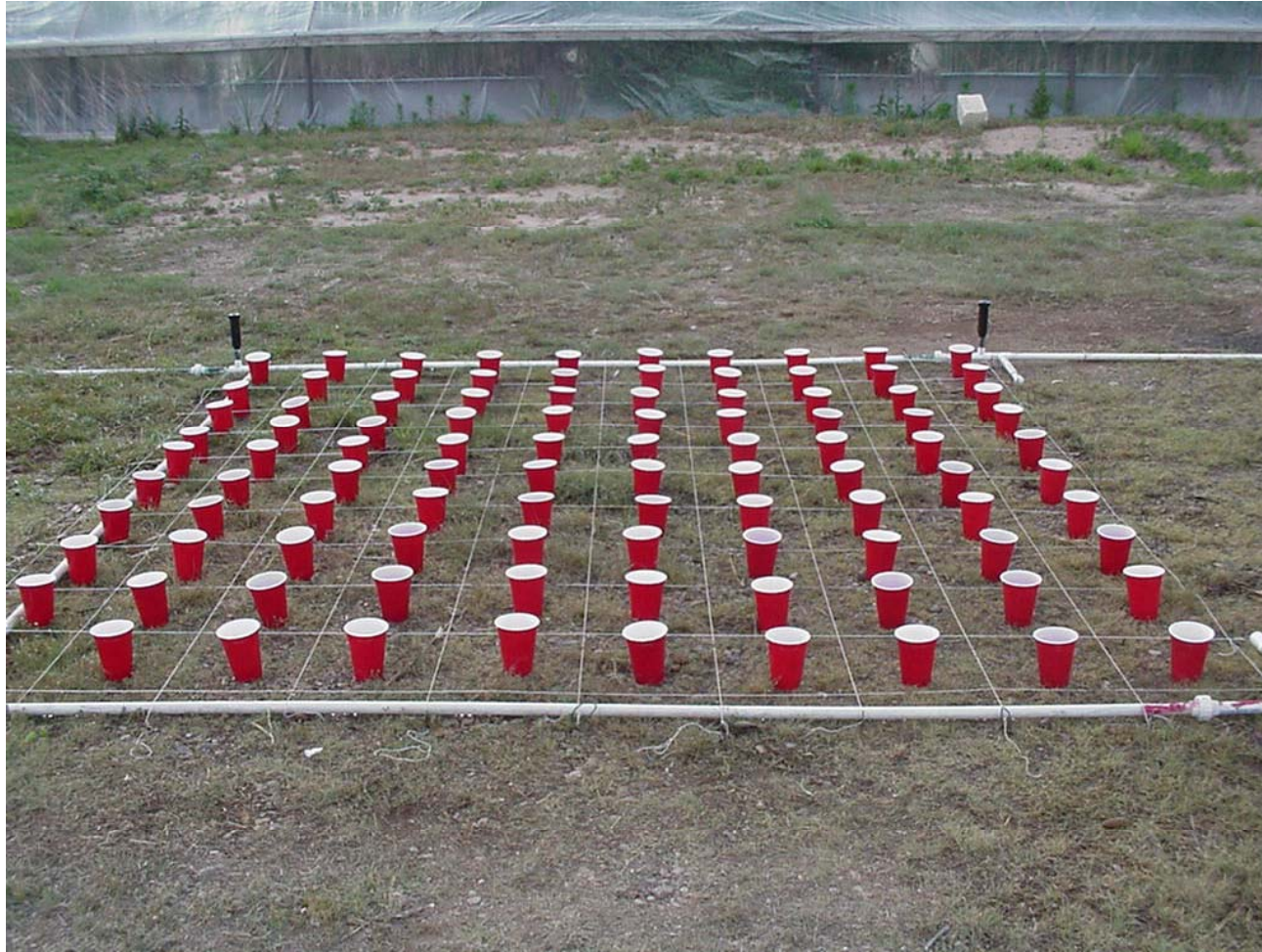


$E_a = 60\%$

$E_s = 100\%$

$UCC = 95\%$





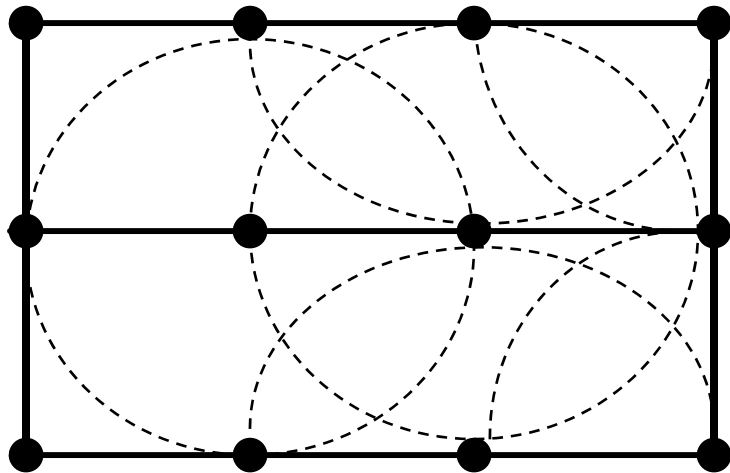
Irrigation Efficiency testing setup



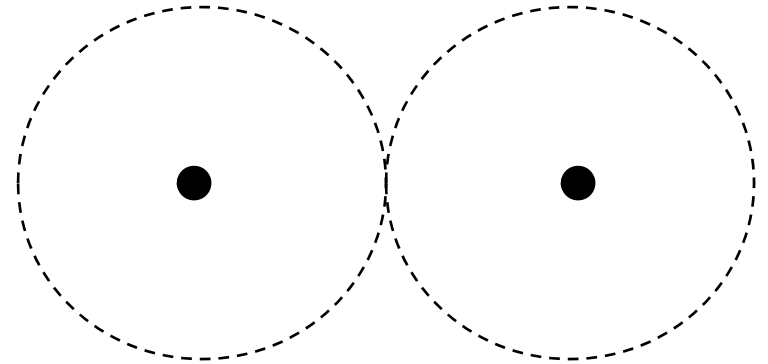




Use the Square Block Design With head-to-head overlap

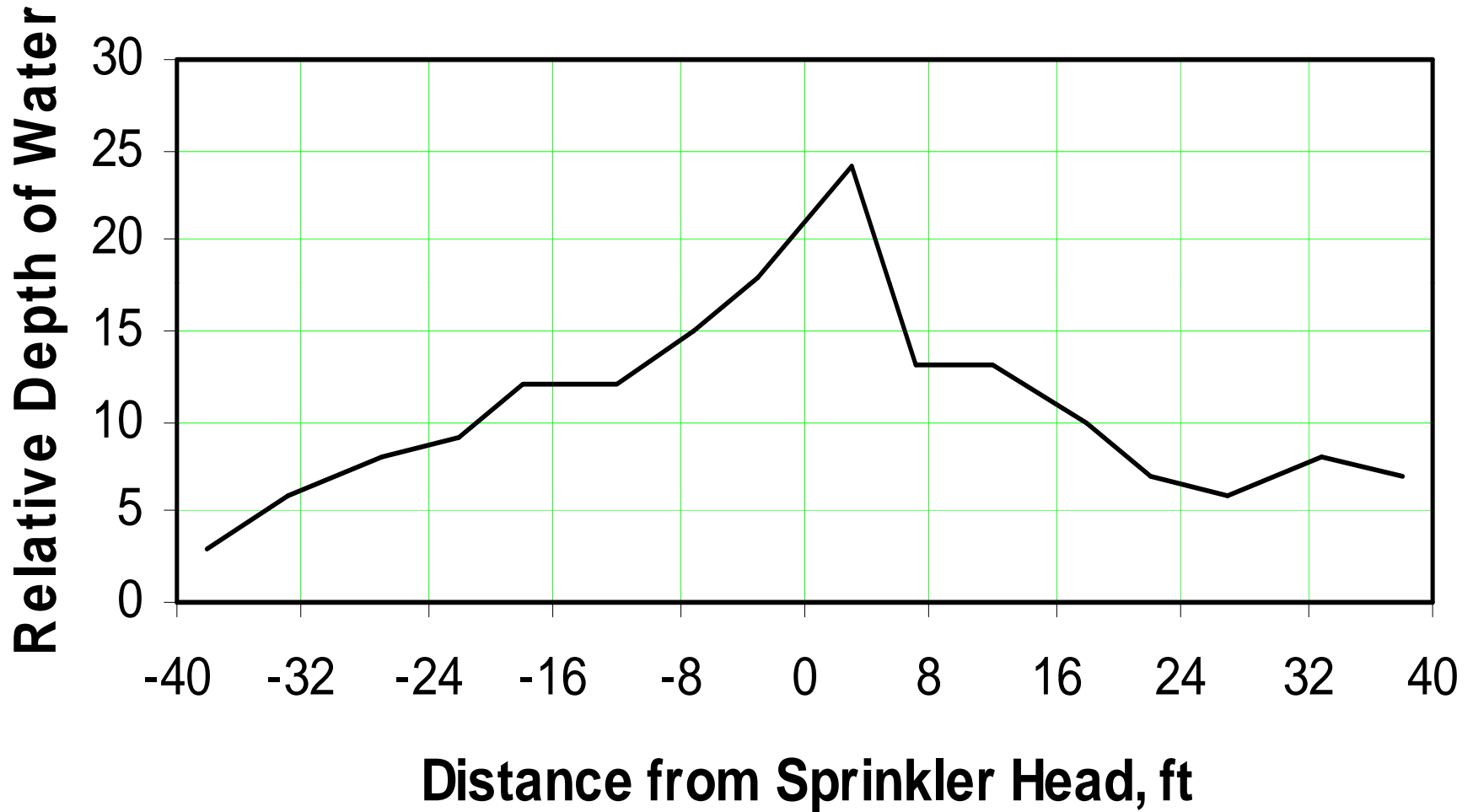


vs.

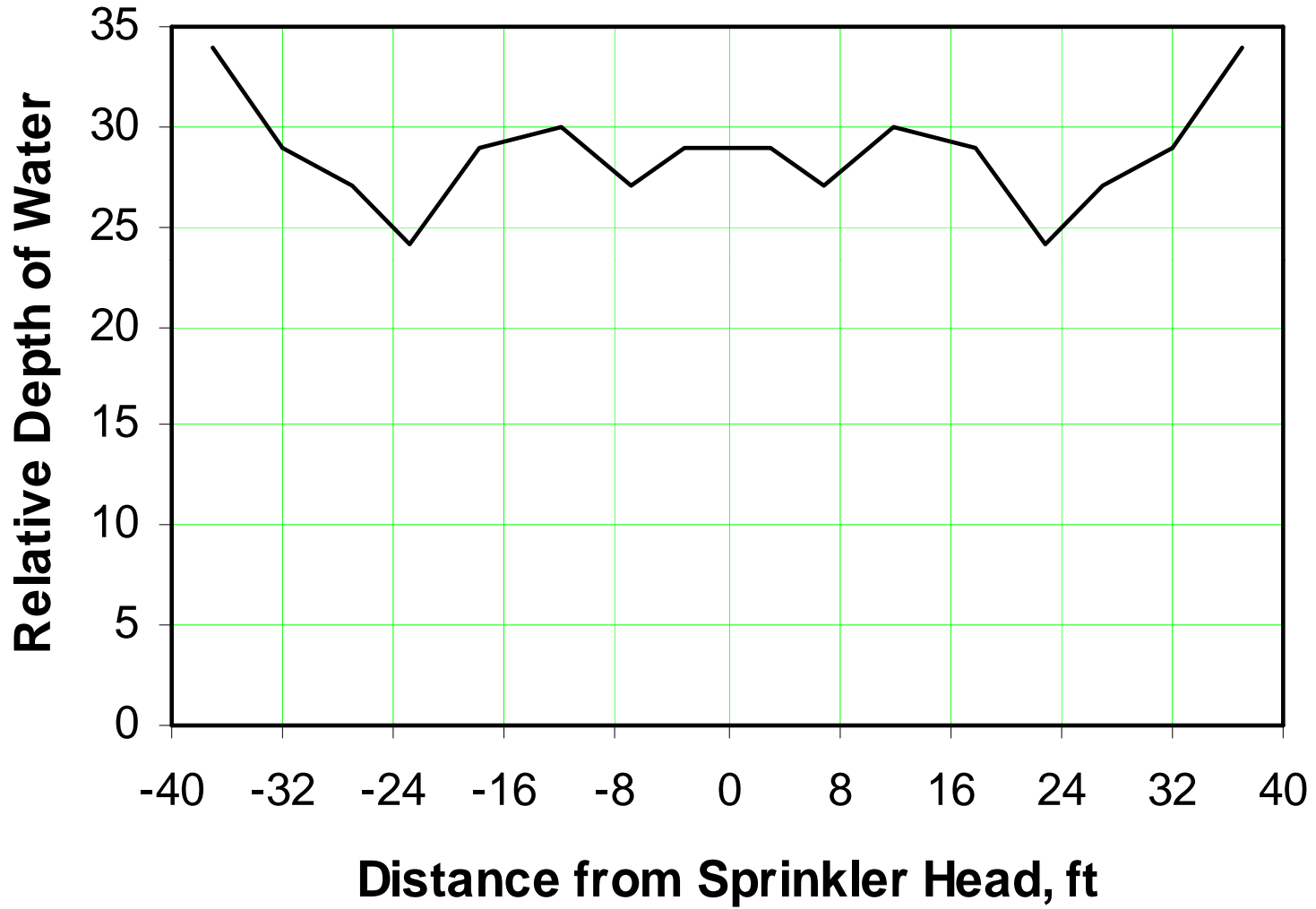




Single Sprinkler Pattern



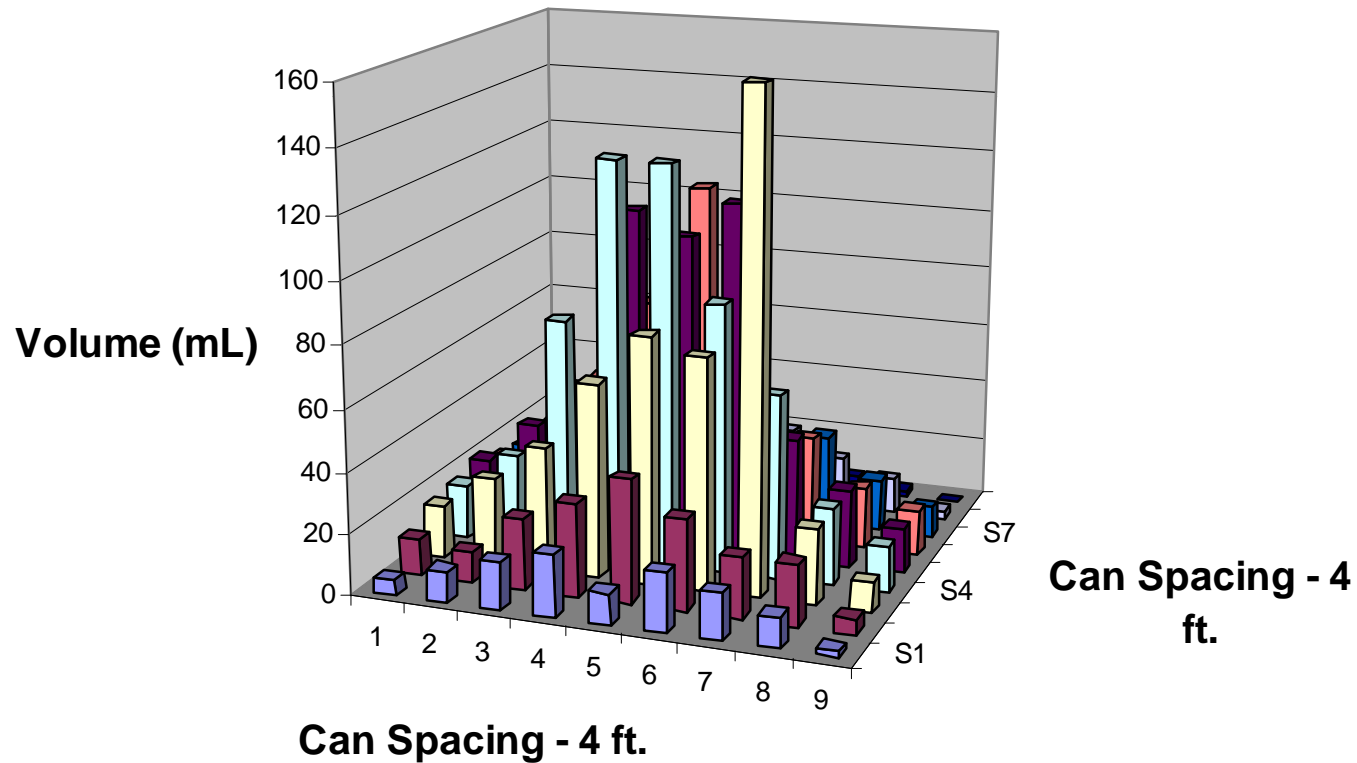
Overlapping Sprinkler Pattern





Impact Sprinkler Type: Burgess 503, UCC=51%

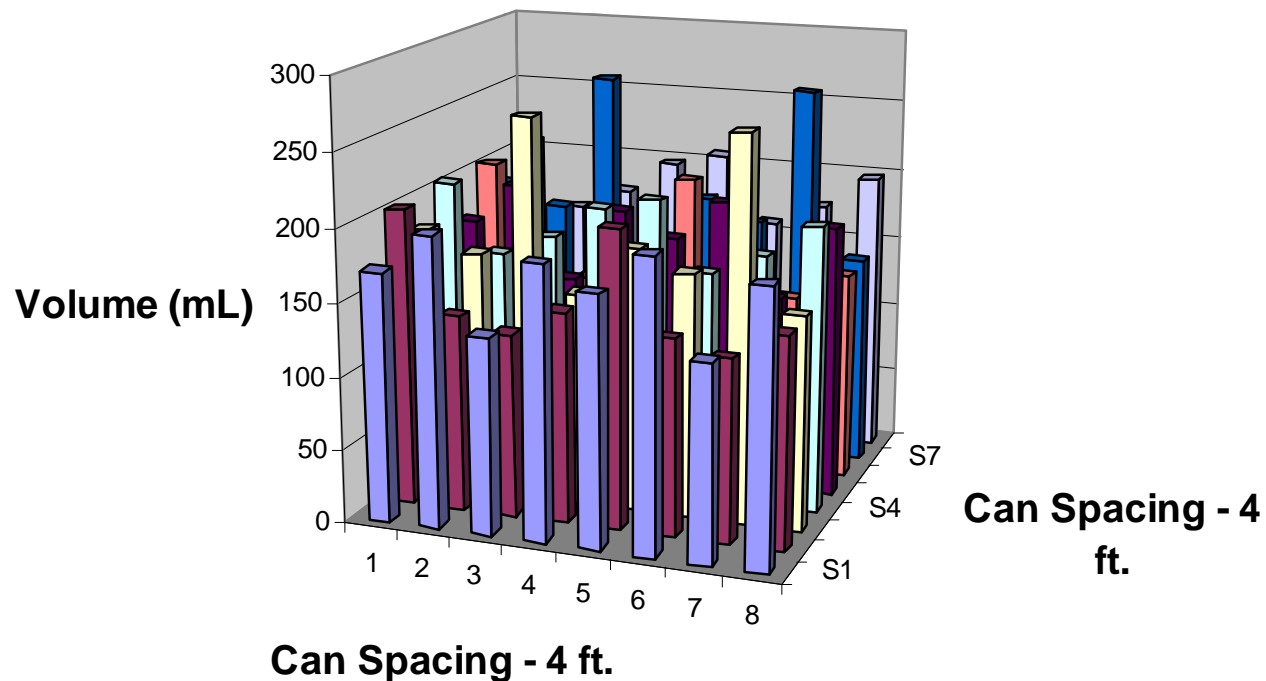
Single Sprinkler Distribution, No Overlap





Impact Sprinkler Type: Burgess 503 UCC: 84.68, 16x16 spacing

Multiple Sprinkler Distribution, Head-to-Head Spacing

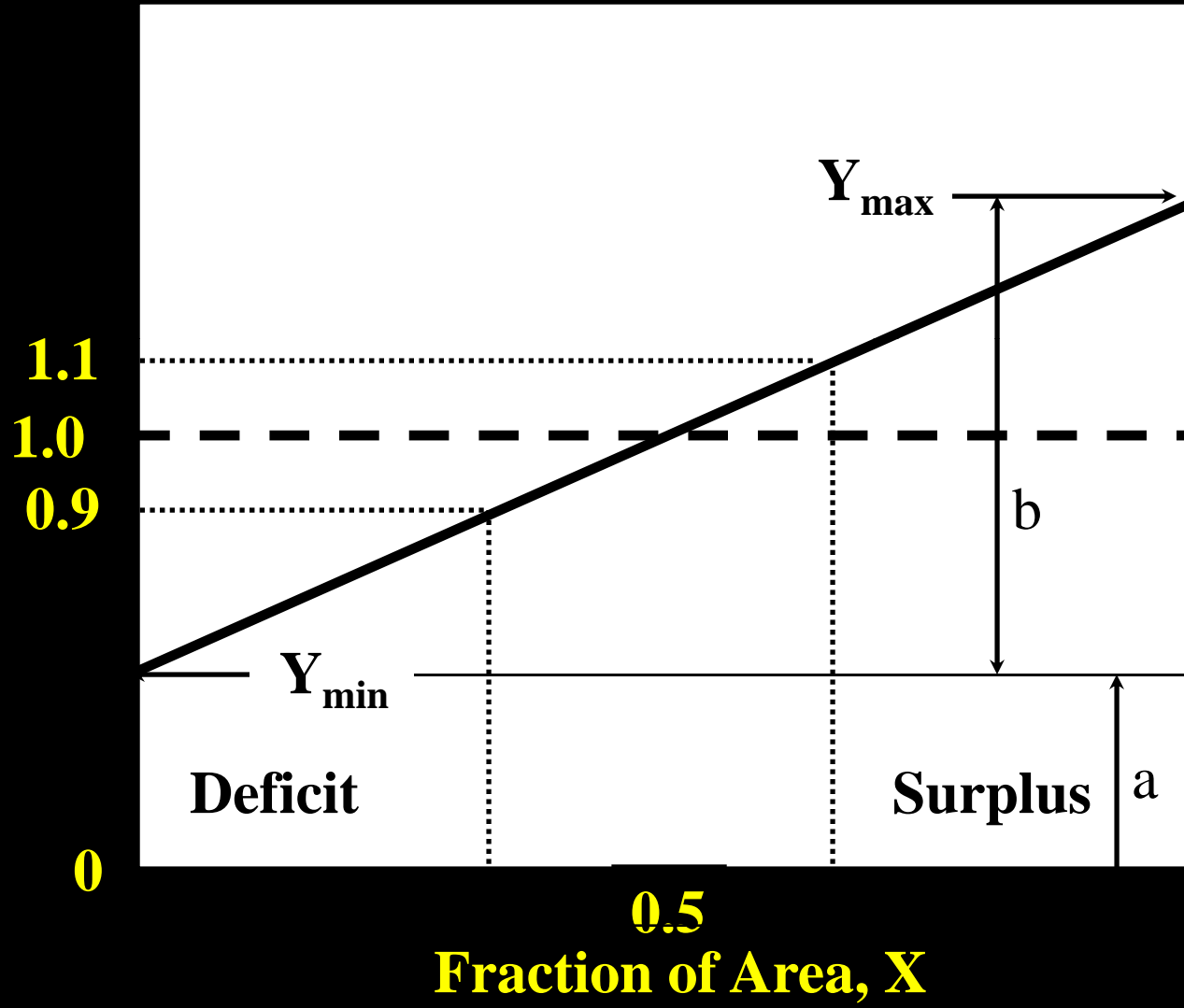


UCC of Sprinklers- Effect of Pressure

Model	Type	Pressure (psi)	UCC (%)
Toro s700 N3	Impact	30	75.36
Toro s700 N4.5	Impact	30	50.90
Toro s700 N3	Impact	40	86.67
Toro s700 N4.5	Impact	40	74.22
Toro s700 N3	Impact	50	90.40
Toro s700 N4.5	Impact	50	79.96

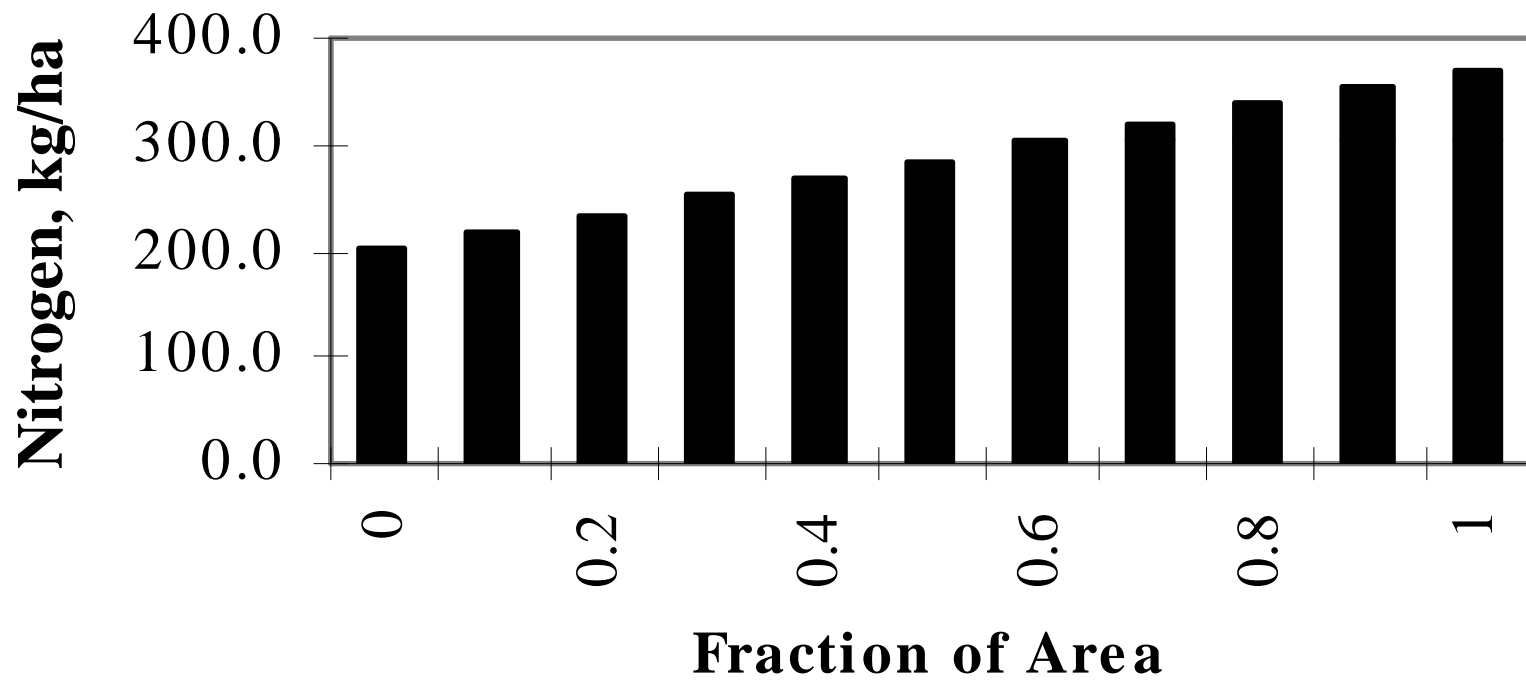
$$As = 1 - \frac{Ys - a}{b}$$

Diminshionless depth, $Y=y/y$





Distribution of Nitrogen





Where does the nitrogen go?

**In a surface application system,
nitrogen is largely consumed by crop**

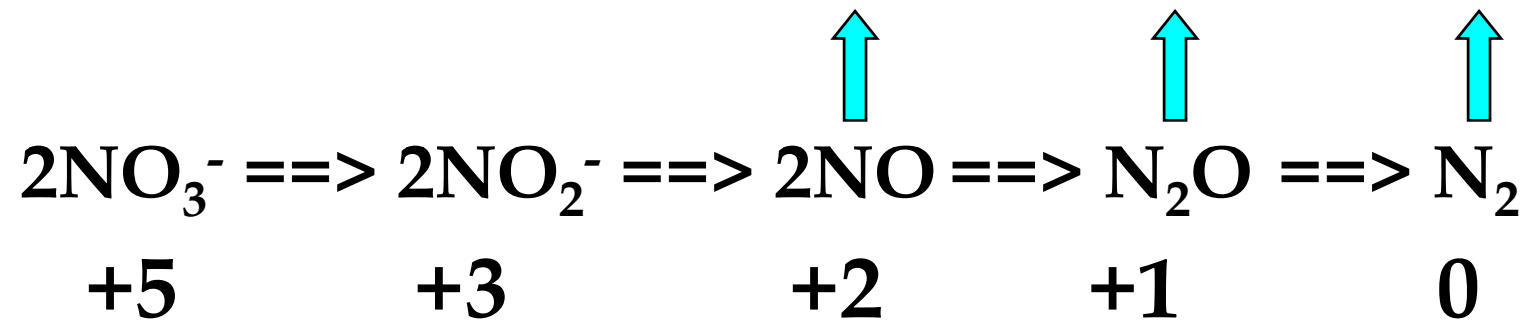
**Some nitrogen percolates below the
root zone**

**Some nitrogen is lost by
denitrification**





Denitrification





Denitrification is dependent on:

- **Moisture Content**
- **Temperature**
- **Nitrogen concentration**
- **Carbon concentration**





Examples of Nitrogen Consumption

Crops	Annual Nitrogen Uptake (lb/ac)
Pioneer Succession Vegetation	223
Mixed Hardwoods	178
Alfalfa	340
Coastal Bermudagrass	479
Kentucky Bluegrass	209
Pasture	68
Corn	167





What makes a crop selectable?

Bermuda Grass

Has medium consumptive water use

Has high nitrogen requirements

Does not fix nitrogen

Has high tolerance for salts

Cannot be maintained wet for long periods

Can grow 12 months/year (some areas)

Produces a saleable product





Accumulation of Salts

- **Upward movement of water**
 - high evaporative demand in arid and semi arid regions
 - insufficient rainfall to leach salts
- **Poor drainage**
 - salts must be leached from the root zone to prevent their accumulation





Salinity and Plant Growth

- Salt stress increases the amount of energy that a plant must spend to take water from the soil
- This energy is not available for normal plant growth
- This results in an overall reduction in plant growth



Wastewater

Water

Salt

Nitrogen

Water

Nitrogen



Water

Salt

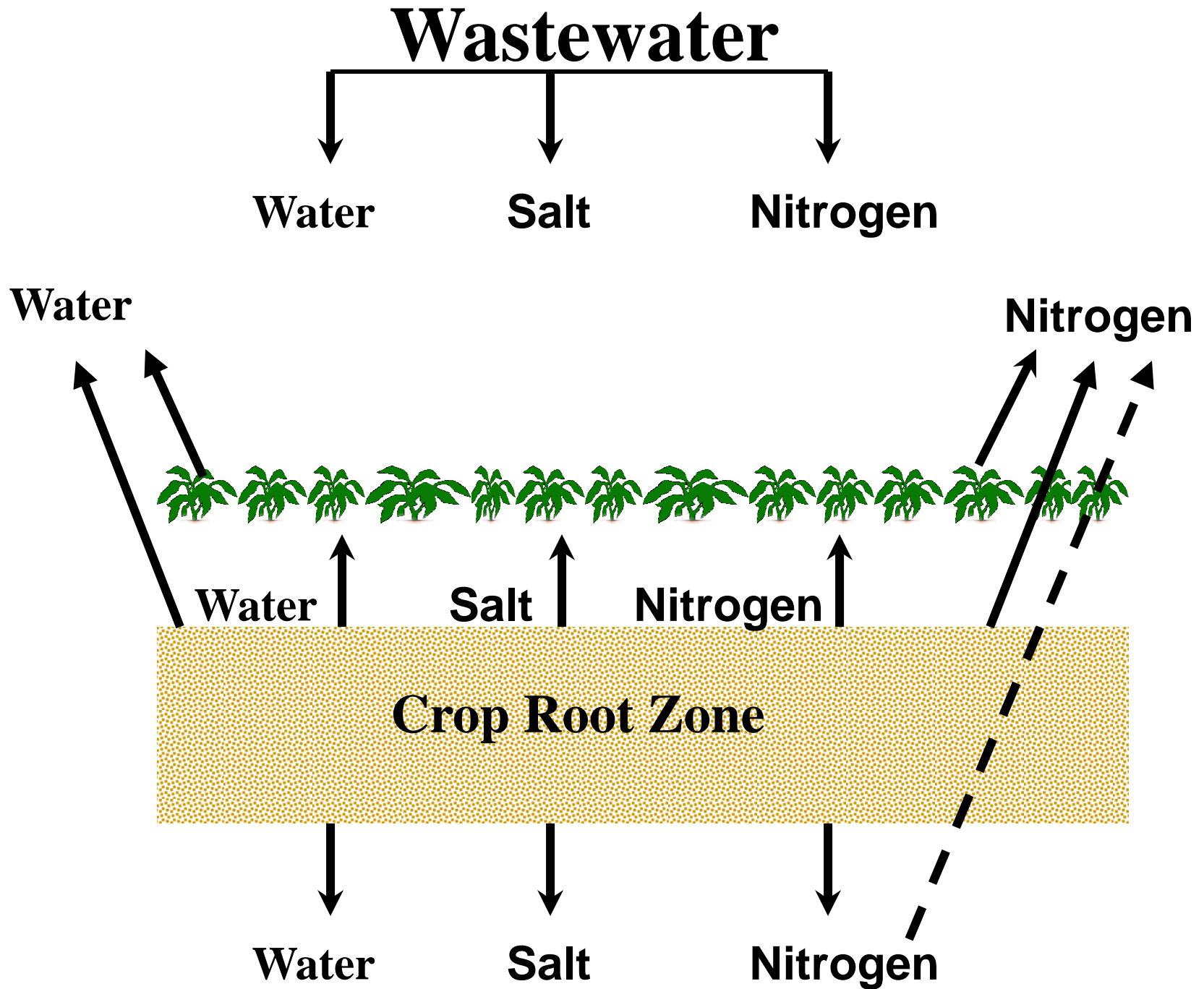
Nitrogen

Crop Root Zone

Water

Salt

Nitrogen





Design Recommendations

- **The discharge rate between the sprinkler with the lowest rate and the sprinkler with the highest rate for a set should be less than 10%.**
- **Design pressure should be mid-range of specified pressure.**





Design Recommendations

- **Sprinklers should be spaced head-to-head**
- **The pressure difference between the sprinkler with the highest pressure and the sprinkler with the lowest pressure in a set should be less than 20%.**





Design Recommendations

- The layout in a block pattern for head-to-head overlap or a seasonal uniformity coefficient $> 80\%$.
- Gear head type sprinklers should be used and not spray head type sprinklers.





Design Recommendations

- Risers of 6 inches should be used when the discharge rate is < 12 gpm and 12 inches for discharge rates between 12 and 26 gpm.
- The application rate \leq the base water intake rate of the soil plus 0.1 inches for interception.





Design Recommendations

- **The base soil infiltration rate should be set equal to the saturated hydraulic conductivity of the top 18 inches of soil.**
- **A check-off list of design considerations should be developed and used on all new and renovated systems.**





Design Recommendations

- All designs should consider both a water balance and a nutrient balance.



OSSF Surface Application System

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Soil Properties

water intake rate

soil water storage

Crop Selection

nutrient uptake/removal

active growth period

Wastewater Application

Runoff Control

Effect of PPCP's and bacteria movement

Thank you for your attention



One World