Drip Irrigation for Small Plots
(a low-tech, low-cost, gravity system)

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Overview

- Brief introduction to drip irrigation.
  - Definition/Characteristics
  - Components
  - Advantages/Disadvantages
- Description of a Low-Cost, Low-Tech, Gravity System
  - Set-Up and Management
    - Irrigation Scheduling
    - Fertilization
- Design Considerations
- Summary

Drip Irrigation

- The slow, frequent application of small volumes of irrigation water to the base or root zone of plants.
- Also referred to as trickle or micro irrigation.
- Not new: Modern use began in the late 1960's to early 1970's after the introduction of plastic pipe

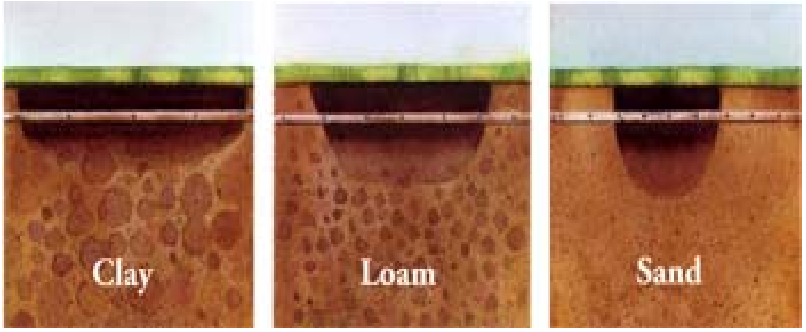
Characteristics
Low Volume & Low Pressure

- Drip flow rates generally range from 0.5 to 2.0 **gallons per hour** (gph) per outlet (can exceed 20 gph).
- Operating pressures range from 2 to 6 pounds per square inch (psi) in gravity systems up to 15 to 30 psi (high pressure systems).

- Standard impact or pop-up spray sprinklers:
  - Flow rates can range from 2 to 20 **gallons per minute** (gpm).
  - At pressures ranging from 25 – 100 psi.
  - Large guns can have flow rates approaching 100 gpm.

Characteristics
Localized Application of Water

- Soil Wetted Area (diameter)
  - Coarse Sand: 0.5 to 1.5 feet
  - Fine Sand: 1.0 – 3.0 feet
  - Loam: 3.0 to 4.5 feet
  - Heavy Clay: 4.0 – 6.0 feet
- As opposed to sprinkler or flood where the entire soil surface is wetted.




Drip Irrigation on a
Sandy Loam Soil

Characteristics
Frequent Applications Required

- Drip: Every day to every-other day in summer.
- In contrast to…
  - Sprinklers (1-3 times per week)
  - Or flood (once per week or less)

Characteristics

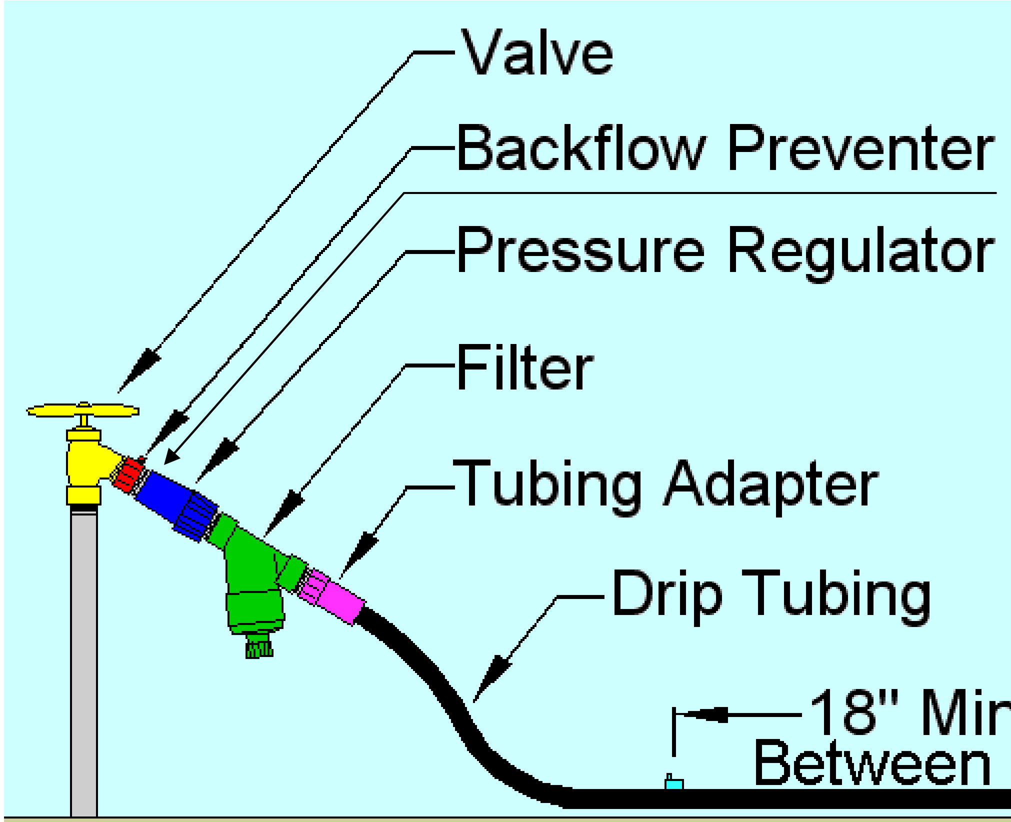
- Drip lines can be above ground or buried (subsurface drip or SDI).

Gophers can reek havoc!

Typical Drip System Components

- Pump or pressure source
- Control valve (to turn system on and off)
- Check valve (to prevent backflow into water source)
- Fertilizer injector (to apply fertilizer directly into irrigation water)
- **Filter**
- Pressure regulator (to reduce pressure down to 30 or below)
- Main line and sub-main lines/header (to carry water to drip lines)
- Laterals or drip lines (distributes water to the outlets at base of plants)
- Emitters (outlets to plants)
- Other: Air vents, meters, timers, controllers, drains

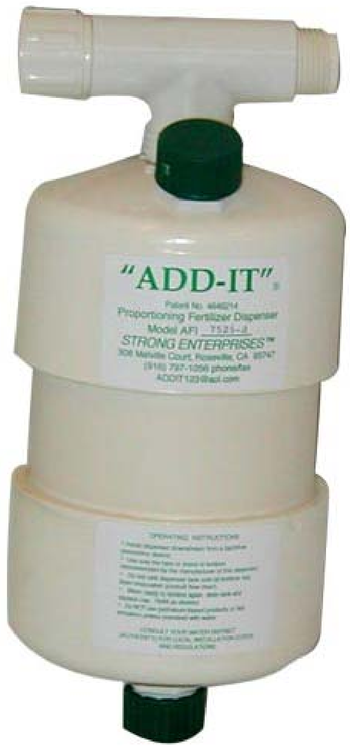
Components



Fertilizer Injector: downstream of the backflow but upstream of the filter

Source: Jay Stryker's Drip Tutorial: http://www.irrigationtutorials.com/dripguide.htm.

Fertilizer Injectors



Photos Courtesy of Joran Viers

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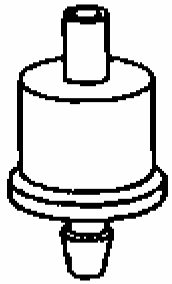
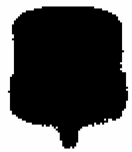
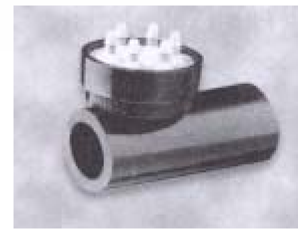
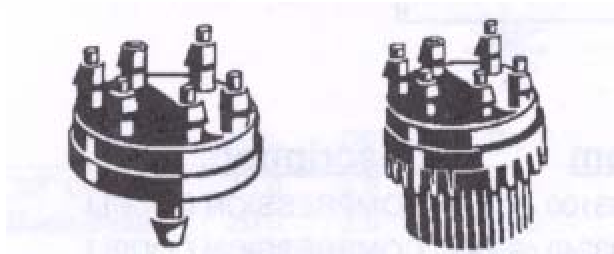
Drip Emitters

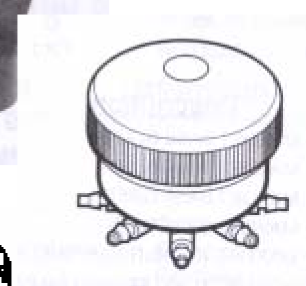






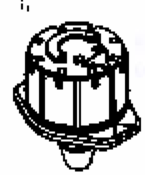
Single and multi-outlet emitters

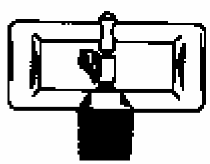


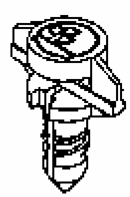


Distributors or Manifolds

Micro sprinklers & bubblers







Pressure Regulating or Compensating Emitters

Spaghetti Tubing

- Carries water from emitter or manifolds to base of plants.

Typical Advantages of Drip Irrigation

- **Potential** water savings over other irrigation methods.
  - Small wetted area (less evaporation)
  - No runoff (reduced soil erosion)
  - Limited deep water drainage (**with proper irrigation scheduling**)
  - Good water distribution uniformity (esp. w/ pressure compensating emitters)
    - Unaffected by wind, etc.
- Adaptable to any shape, size and slope of field.

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Typical Advantages of Drip Irrigation

- Weed growth is reduced!
- High fertilizer efficiency.
  - Injected fertilizer (fertigation) is applied directly to root area and can be applied at any time and any dosage without wetting plant foliage.
  - Improved uptake of phosphorus and ammonium N from frequently wetted upper soil layer.
- Yields are typically increased.
  - Soil moisture and fertility in root zone can be maintained at optimum levels

Typical Disadvantages of Drip

- Filtration is critical
  - Emitter clogging can disrupt distribution uniformity
  - Algae growth and scale build-up (usually $CaCO_3$) must be controlled
- Drip tape and other components can be easily damaged by vandals, rodents, etc.
- Increased management skills required

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Typical Disadvantages of Drip

- High initial costs (compared to flood).
- Water must be available on a regular basis.
- Potential salt build-up in arid region soils.
  - May require periodic leaching with sprinkler system

Low-Cost, Low-Tech, Low Pressure (Gravity) Drip Systems

- The KB-Drip System (KB = "Krishak Bandhu" = "farmer's friend")
  - Developed in India by International Development Enterprises (IDE). Headquarters in Lakewood, CO.
- The Chapin Bucket Kit
  - Chapin Watermatics, Watertown, NY
- The Netafim LPS System (Cost ?)

Components of a 2000 sq. ft. (200 m^{2}) KB Kit: Cost < \$20 (FOB India)

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
	Cloth 1 m x 1 m	1		Polytube 16 mm	22 mtr.
	Tap & Check Nut	1		Easy Tape Roll	220 mtr.
	Filter	1		Microtube 25 cm.	630
	Tee 16 mm	22		Thumb Punch	5
	End Cap	2		Sleve 16 mm	22

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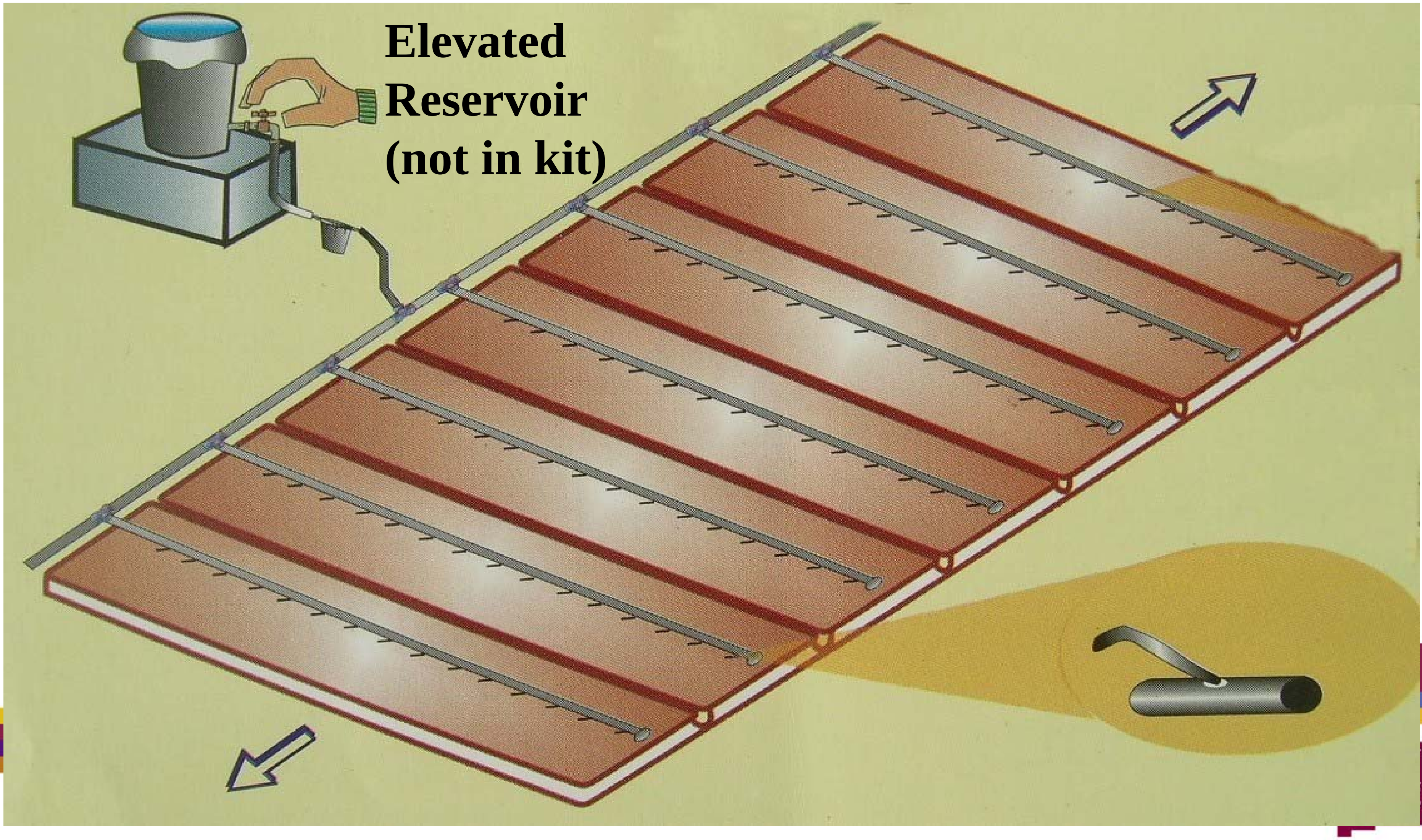
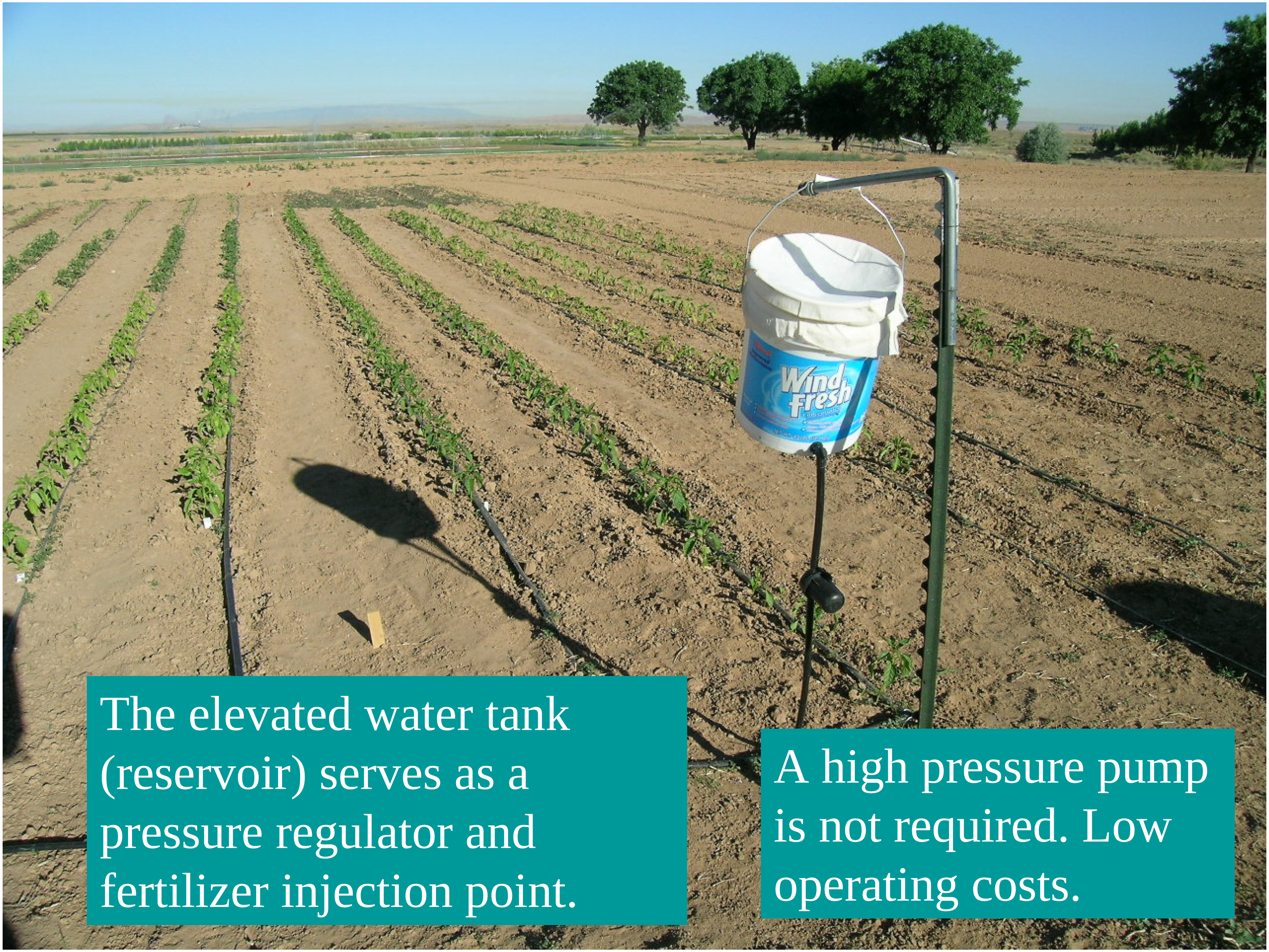
Basic Layout



Advantages of the Low-Pressure Drip System over Conventional Drip System



The elevated water tank (reservoir) serves as a pressure regulator and fertilizer injection point.

A high pressure pump is not required. Low operating costs.

Low-cost materials;
Easy to understand,
operate, and maintain.

Backflow prevention is
usually not required.


Generally Safe; High pressure clamps, fittings, etc. not required; blow-outs usually not an issue.

Disadvantages

- Simple, low-cost emitters are not pressure compensating.
  - Application uniformity will vary with topography
  - Usually not a concern with small plots
- Cheap (6-mil) drip tape may only last one or two growing seasons.
- Somewhat labor intensive.

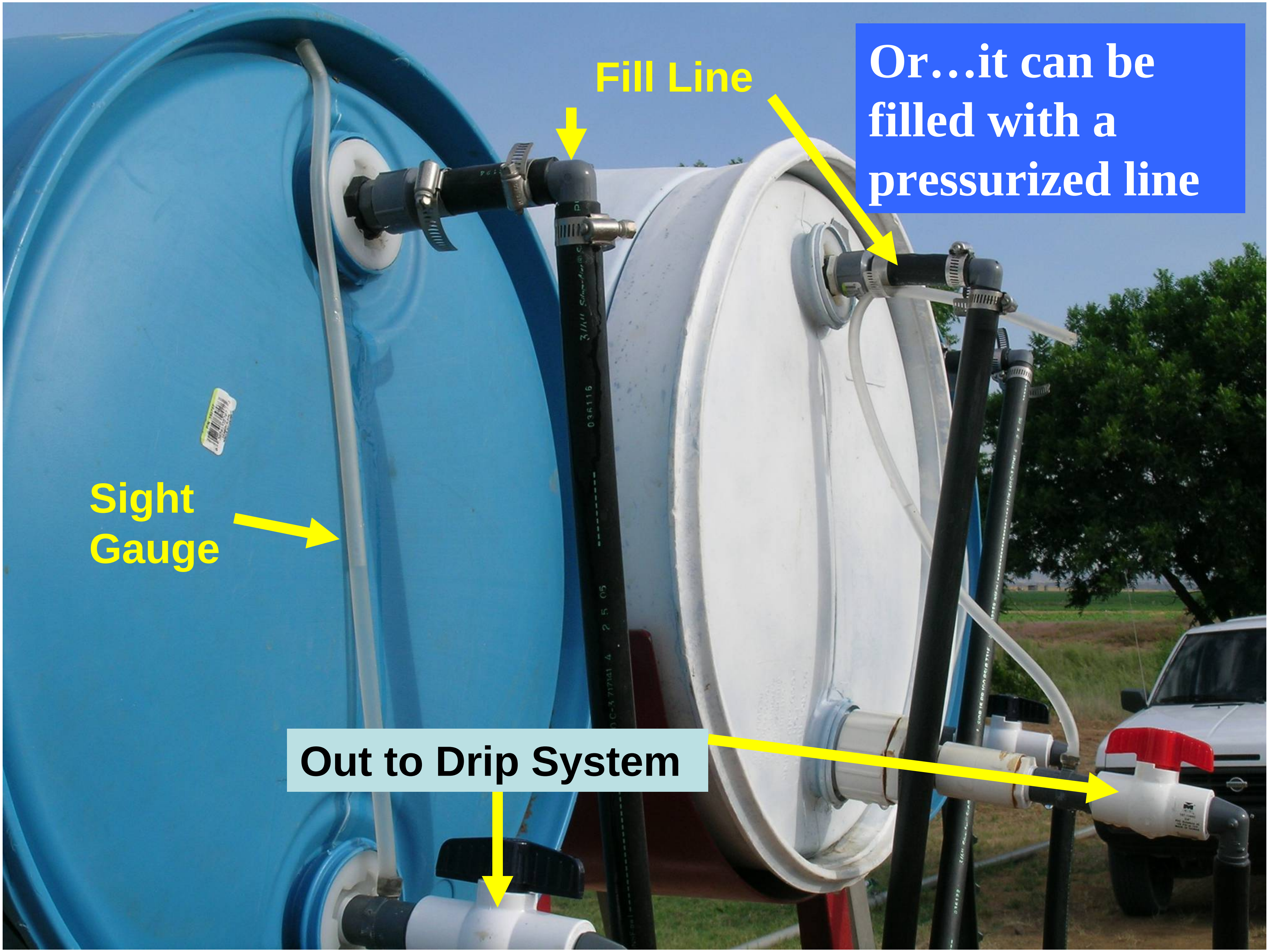
Success at Farmington using 55 gallon plastic barrels.


Elevated Reservoir
Simple, Low-Cost Stand
(fence posts and baling wire)
STOP

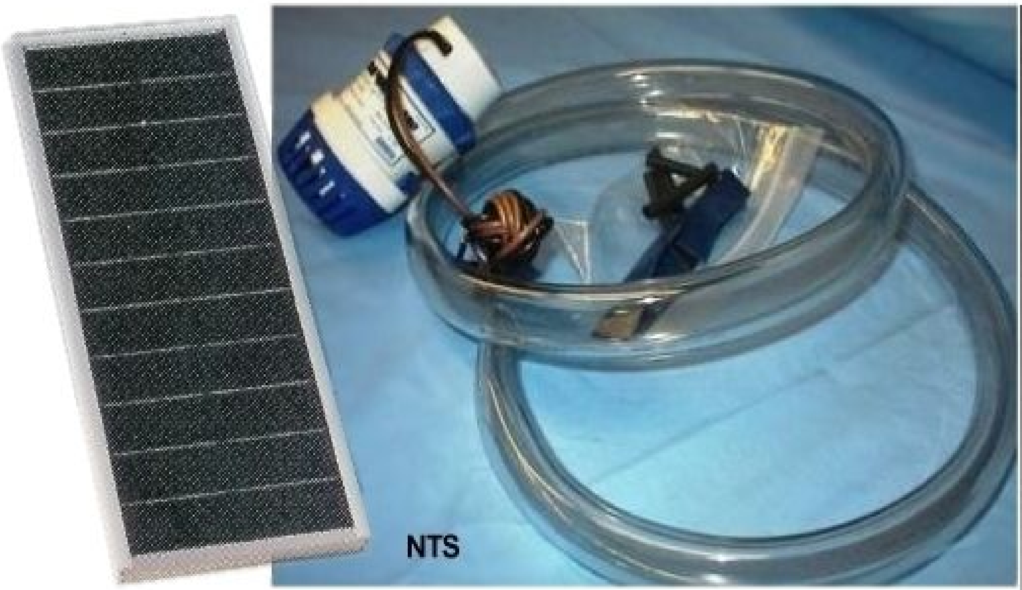
Converting Head (water height above water discharge point) to Pressure

- Water height in feet (head) x 0.433 = pounds per square inch (psi)
- Inversely:
  - Water pressure (psi) x 2.31 = feet of head
- Example:
  - Water level in tank is 6 feet above drip emitter outlet (i.e. 6 foot of head).
  - Pressure = 6 x 0.433 = 2.6 psi

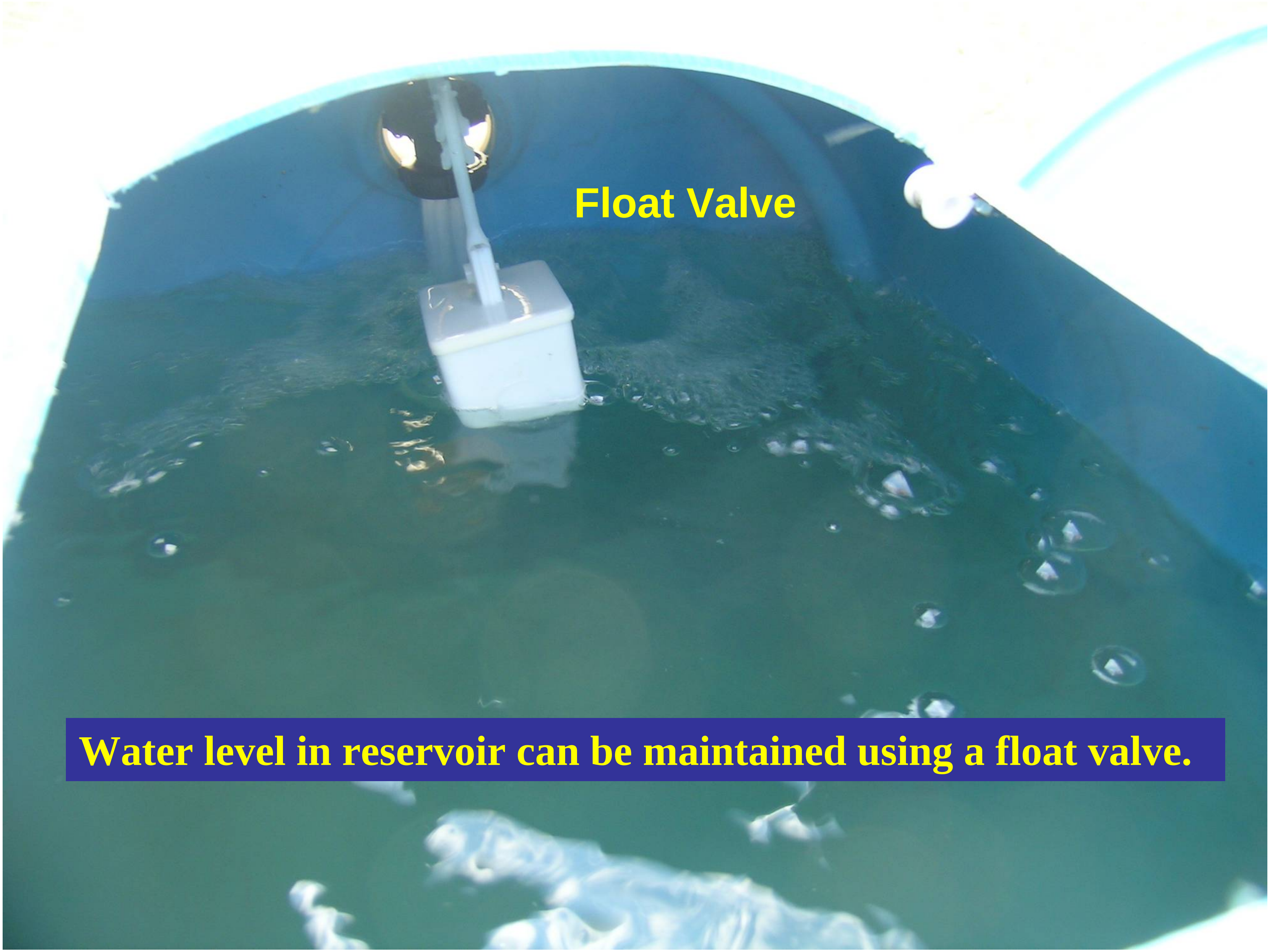

Reservoir can be filled by hand, with hose, etc.
Door for Adding Water, Fertilizer, etc.
NMSU


Fill Line
Or…it can be filled with a pressurized line
Sight Gauge
Out to Drip System

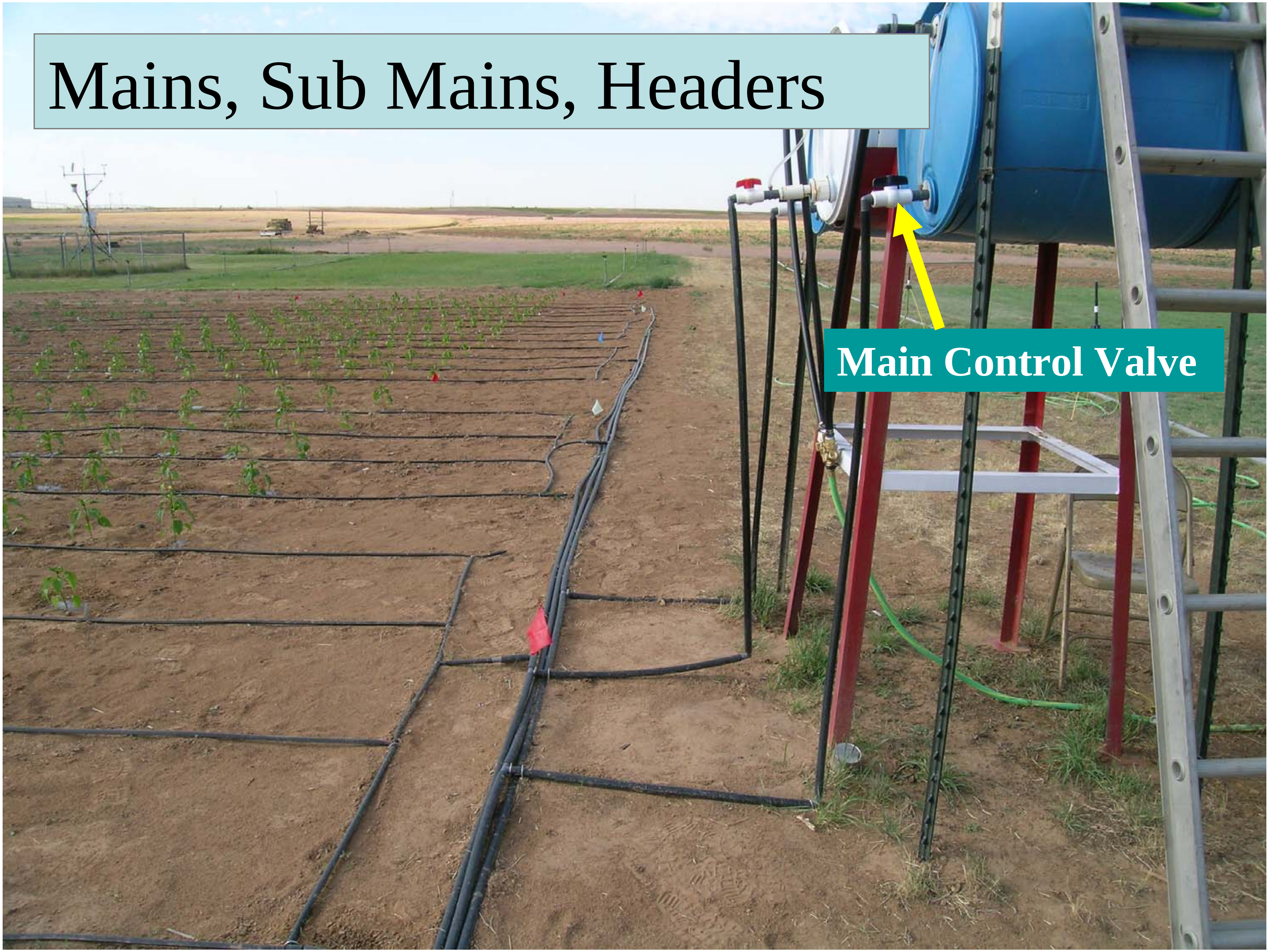
Alternate Pressure Sources

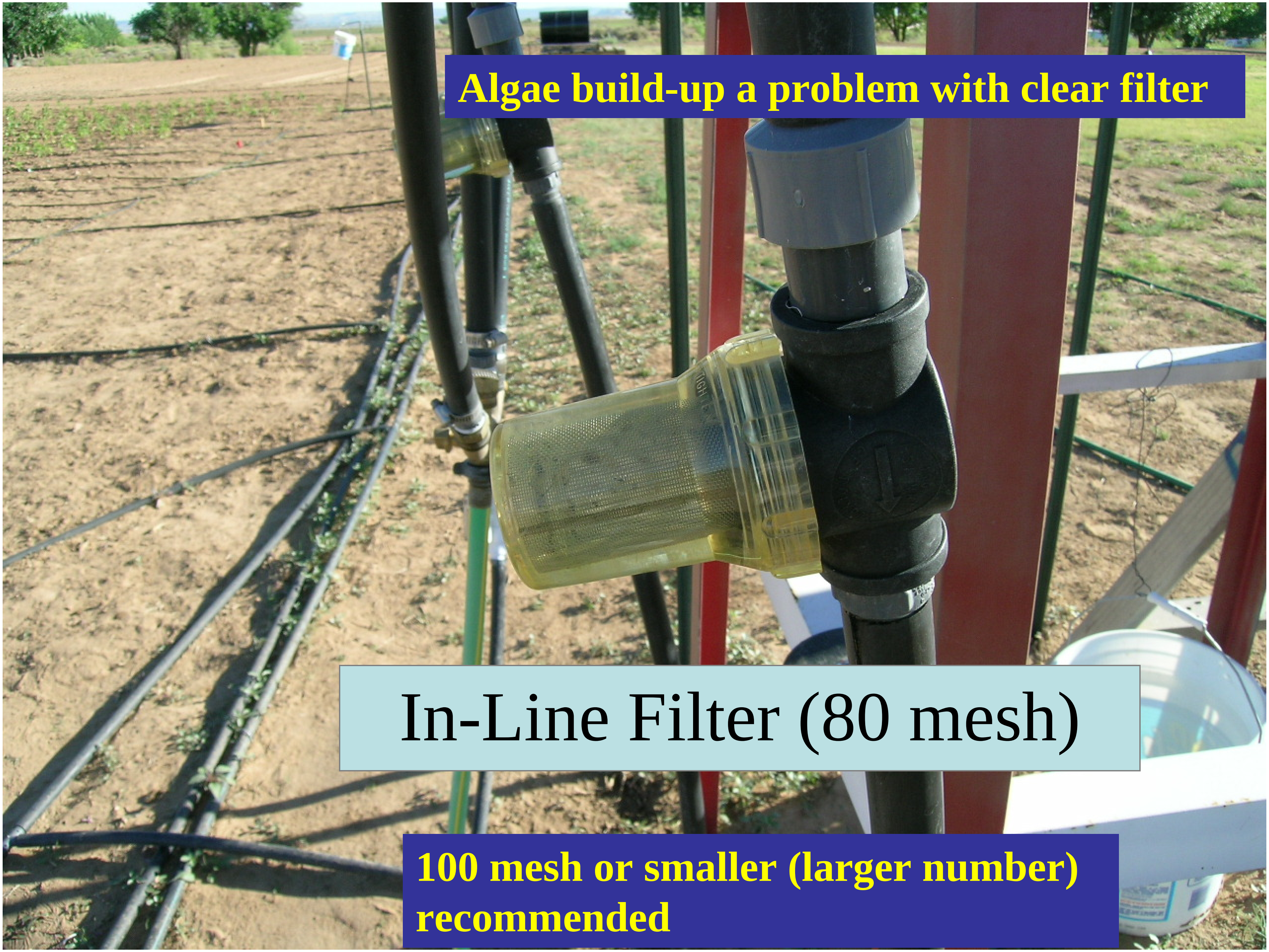


Solar or Wind-
Powered Pumps

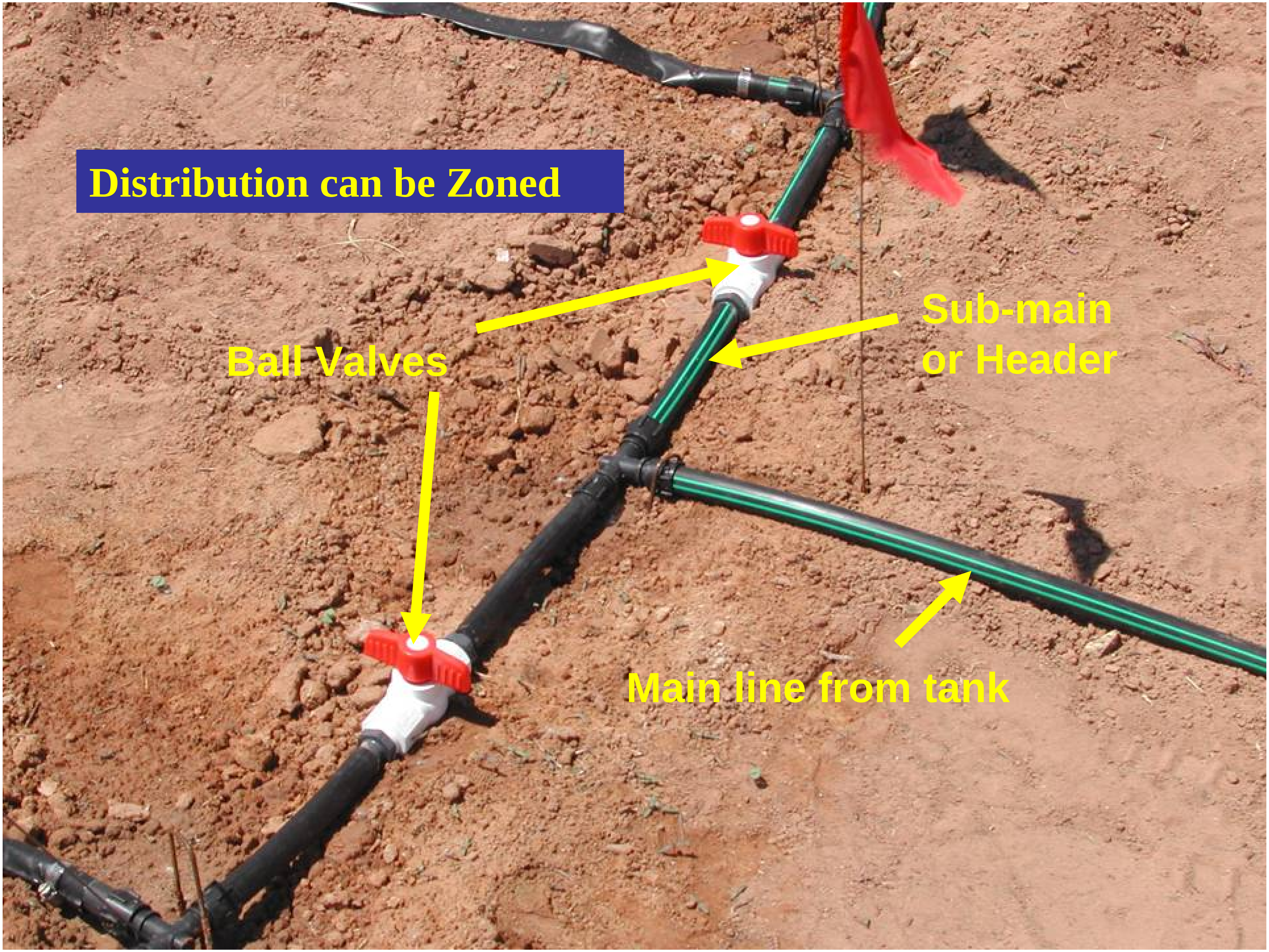

Float Valve
Water level in reservoir can be maintained using a float valve.

Mains, Sub Mains, Headers

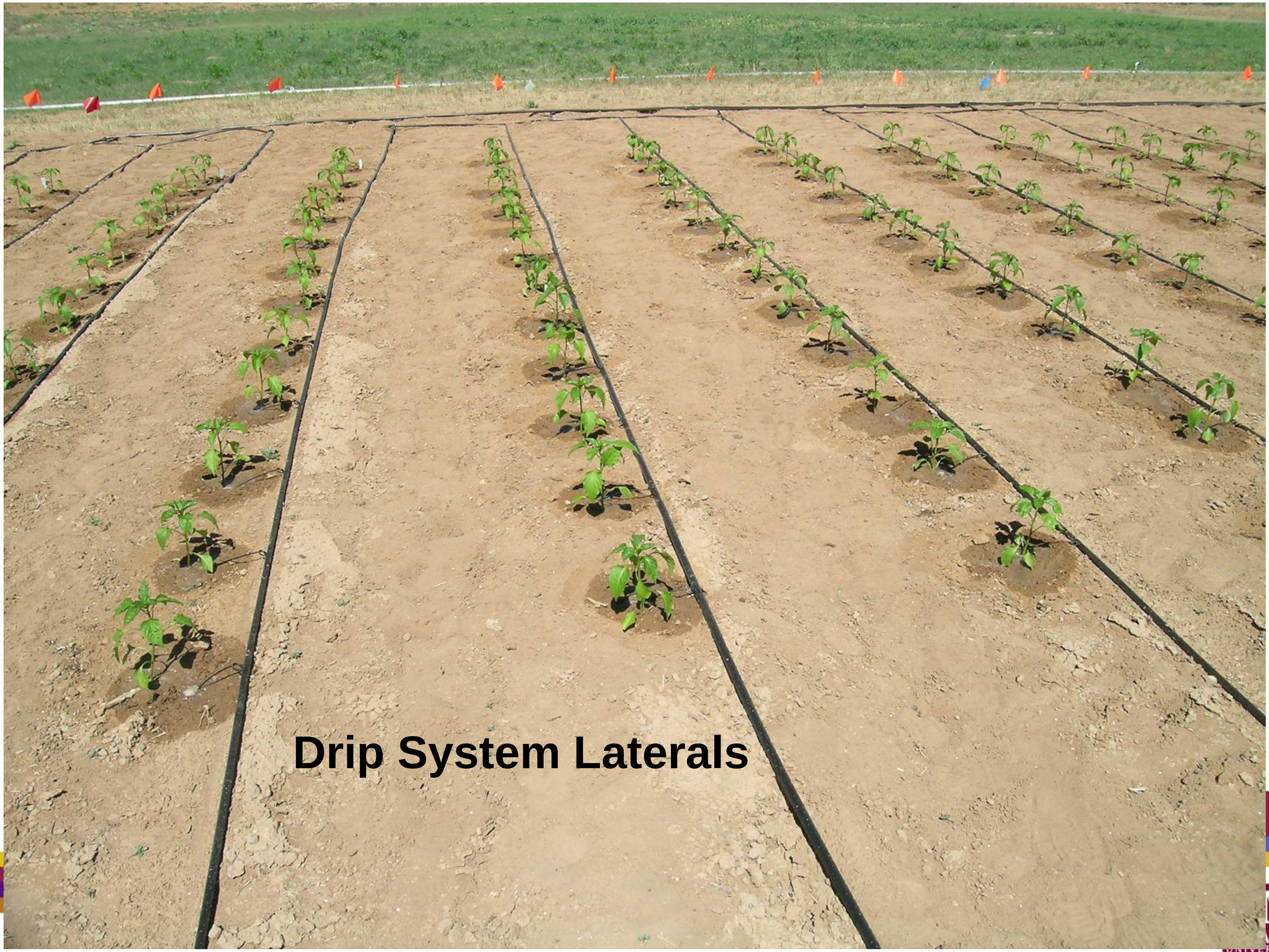



Algae build-up a problem with clear filter
In-Line Filter (80 mesh)
100 mesh or smaller (larger number) recommended


Standard
In-Line Filter


Distribution can be Zoned
Ball Valves
Sub-main
or Header
Main line from tank

Plastic T's and Sleeves (Clamps)

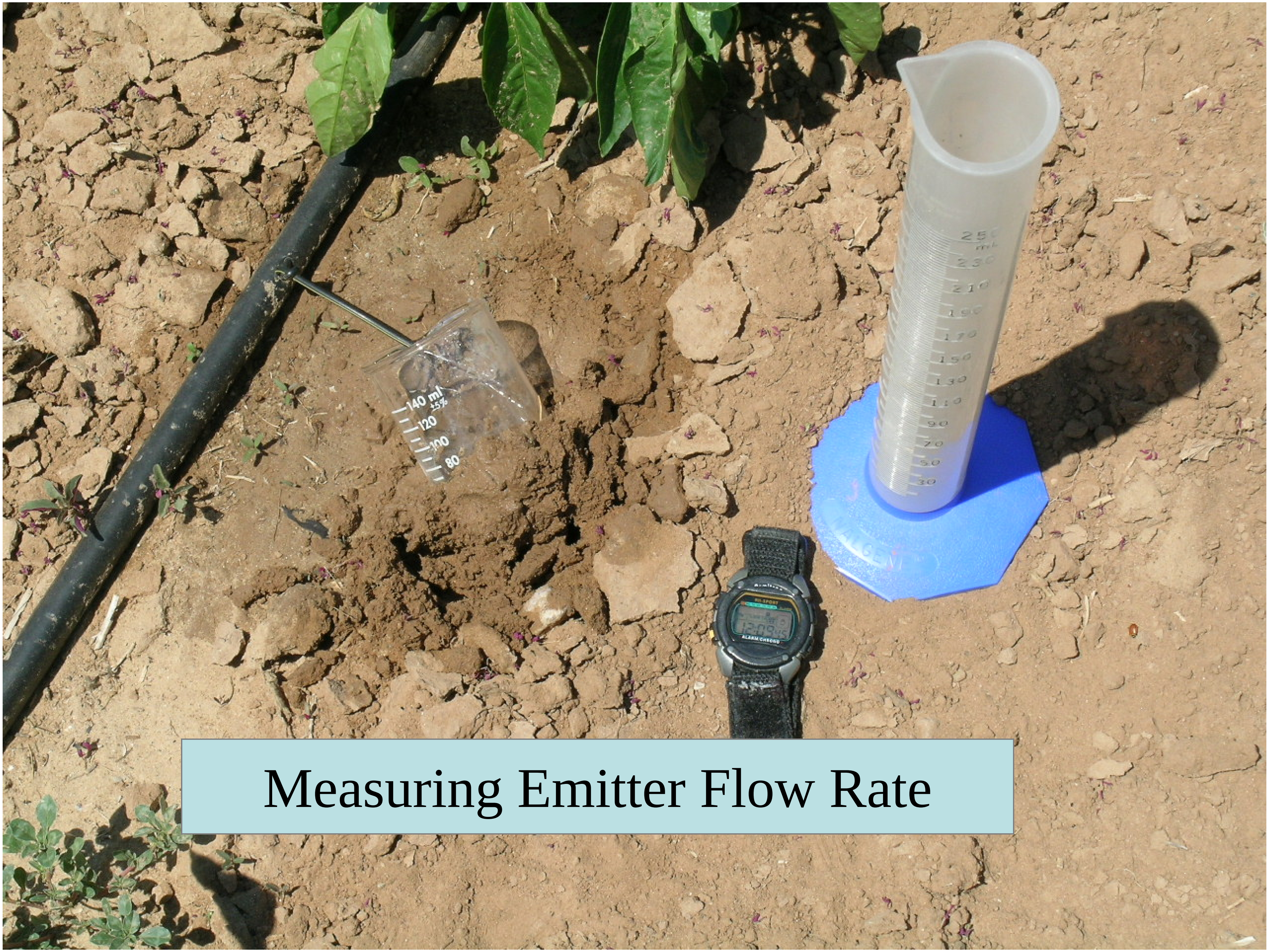

Drip System Laterals


Cheap wire loops (i.e. from coat hangers) can be used to hold drip line in place when empty.
WIND and EXPANSION-CONTRACTION.
Wire Loops

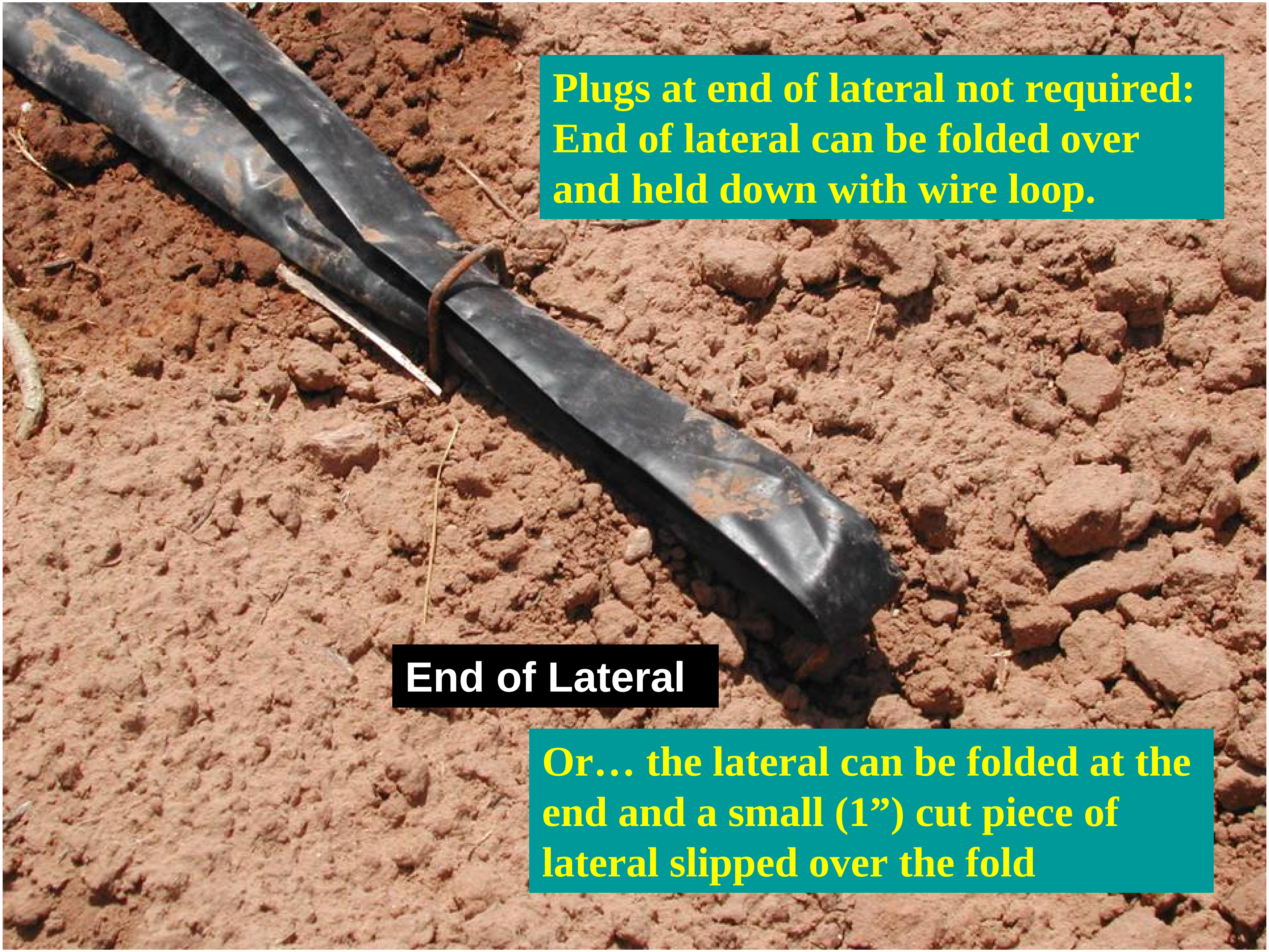
Microtubule Emitter

Laterals must be pressured up with water before punching holes and installing emitters!

Output = ~ 0.55 gph per emitter (with 480 emitters)



Measuring Emitter Flow Rate


Plugs at end of lateral not required: End of lateral can be folded over and held down with wire loop.
End of Lateral
Or… the lateral can be folded at the end and a small (1”) cut piece of lateral slipped over the fold


It’s a good idea to flush out each lateral periodically prior to operating the system

Specifications per Plot (Tank) in the Farmington Study

- Head: 5 ft. 10 in. (2.6 psi)
- Total Irrigated Area = 2340 sq. ft.
  - Laterals per plot: 12 (spaced 36 in. apart)
  - Lateral length: 65 feet
- Emitters per lateral: 40
- Emitters per plot: 480
- Flow rate per emitter: ~ 1.2 fl. oz. per minute (0.54 gph)
- Flow rate per plot: ~ 4.5 gpm (270 gph)

Total Water Applied and Yield of Sweet Corn, Chile Peppers, and Tomatoes at Farmington

Sweet Corn (12” spacing in 36” or 34” rows):

- 35 gallons per plant (11, 667 gals per 1000 sq. ft.)
- 700 ears per 1000 sq. ft. (30,492 ears per acre)

58 dozen @ $2.50/doz. = $145.00

Chile Peppers (18” in 36” rows or 12” inch in 34” rows)

- 48 to 34 gallons per plant (10,667 to 12,014 gals/1000 sq. ft.)
- 740 to 820 lbs per 1000 sq. ft. (16.1 to 17.9 tons/acre)

20 sacks (40#)
@ $14.00/sack
= $280.00

Tomatoes (24” spacing in 34” rows)

- 36 gallons per plant (12,720 gals/1000 sq ft)
- 1,525 lbs. per 1000 sq. ft. (33.2 tons/acre)

58 lugs (26#)
@ $14.00/lug
= $800.00

System Design Considerations based on Irrigation Needs

- Prior to planning your drip-irrigated garden determine the volume of water available to you and the maximum flow rate of that water.
- One way to do this is to determine how long it takes to fill a 5-gallon bucket.
- This will be important in determining how many plants you can safely irrigate without imposing water stress.

In our study for example…

- It took only 10 minutes to empty the reservoir (45 gals.)
- In summer, chile and tomatoes may require 0.4 to 0.5 gallons of water per plant per day
- Assuming an average plant density of 220 plants per 1000 sq. feet, total average daily needs would be about 100 gallons (2-3 fills of the 55 gallon reservoir) or... **200 gallons for the entire 2000 sq. ft. plot!**

Irrigation Scheduling

- To effectively schedule irrigations you must know:
  - The flow rate of each emitter.
  - The crop (or plant) canopy area.
  - An estimate of the plant's daily water-use (evapotranspiration or ET)

Scheduling Irrigations
The Irrigation Requirement

- The equation used to estimate the irrigation requirement (IR) per plant is:

$$IR = (0.623 \times CA \times \text{Plant Factor} \times ETr) \div IE$$

Where:

IR = the irrigation requirement in gallons

0.623 = gallons of water required to fill 1 sq. foot 1 inch deep

CA = plant canopy area in square feet (see slide for explanation)

Plant Factor = 0.85 for tomatoes, chile and sweet corn (may be higher for melons, squash, cucumbers, etc.)

ETr = reference ET (refer to chart next page or see http://weather.nmsu.edu for your specific location)

IE = irrigation efficiency (assume 90% or 0.90 for low-tech drip system)

Irrigation Scheduling (calculating the crop canopy area)

- In drip irrigation, the amount of water to apply is usually indexed to the crop canopy area.
  - Formula: Area of a circle = d^2 x 0.785

    (diameter x diameter x 0.785)

    - Example: Plant diameter = 18 inches or 1.5 feet.

      Area = 1.5 x 1.5 x 0.785 = 1.77 square feet

Average Daily ETr (inch/day) Estimates for Different NM Sites

	Month						
Site	**May**		**June**	**July**	**Aug**	**Sept**	
Days	**1-15**	**16-31**	**1-30**	**1-31**	**1-31**	**1-15**	**16-30**
Farmington	0.35	0.40	0.42	0.38	0.28	0.25	0.22
Albuquerque	0.37	0.41	0.44	0.40	0.29	0.26	0.23
Las Cruces	0.39	0.42	0.46	0.43	0.31	0.28	0.25

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Example

- Formula: IR = (0.623 x CA x Plant Factor x ETr) ÷ IE
  - Scenario:
    - Location – Albuquerque
    - Date: May 25 (ETr = 0.41 inch)
    - Chile plant (plant factor = 0.85)
    - Measured (circular) plant diameter = 1 foot
    - Estimated irrigation efficiency (IE) = 90% or 0.9
  - Calculations:
    - CA = 1x1x0.785 = 0.785
    - IR = (0.623 x 0.785 x 0.85 x 0.41) ÷ 0.90 = 0.170 ÷ 0.90 =
      0.19 gallons (24 fluid ounces) per plant per day

Calculating Peak Daily Water Requirements for Planning & Design

- IR = (0.623 x CA x Plant Factor x ETr) ÷ IE
- Scenario:
  - Location – Albuquerque
  - Peak daily ETr = 0.44 in mid-June
  - CA = full (assuming chile is planted on 30-inch rows and plant spacing is 1 foot, full canopy = 2.5 x 1 = 2.5 sq. feet.
  - Plant factor (chile) = 0.85
  - IE = 0.90
- Calculation:
  - IR = (0.623 x 2.5 x 0.85 x 0.44) ÷ 0.90 = 0.65 gallons (83 fluid ounces) per plant per day

More Irrigation Tips

- There is no need to water the same plants every day (we watered every-other day).
- You could split the 2000 sq. ft. garden into two sections – watering one-half at a time, for example.
- Keep in mind however, that to satisfy crop ET, you'll need to apply 2x the water per application than you'd apply if irrigating every day.

Example: 83 chile plants (32 gals. per day) = 7 fills per day (during peak ET)

Fertilization

- We used dry powder, soluble Miracle Grow type products (15-30-15 or 20-20-20) and applied between 1 and 1.5 lbs. per tank about every 10 days between June 1 and mid-August.
- In addition, we applied about 1 pint of liquid N (32-0-0) per tank every-other week.
- Each tank irrigated about 460 plants.

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Fertilization

- Many organic products are available.
- See Peaceful Valley Catalog for example:
  - http://www.groworganic.com/cgy_347.html
- These products are not cheap.

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Organic Products

Courtesy: Joran Viers, NMSU CES, Bernalillo County

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For Organic Certification

- You may be able to make your own compost or manure tea.
- Check with the New Mexico Organic Commodity Commission for more information.

Common Problems and Remedies

- Emitter plugging (especially after heavy rain)
  - Remove and blow-out or replace emitter.
  - Add bleach periodically to control microorganism (i.e. algae) growth.
  - Add vinegar or weak acid to control calcium carbonate build-up.
- Expansion/Contraction of drip tape with temperature changes
  - Pull tape taught at end before irrigation to remove kinks.
  - Irrigate in early morning when drip line is contracted.

Gopher Damage

(minor)

Other Tips

- Irrigate early in morning:
  - Drip tape will be contracted.
  - Avoid irrigating with hot water.
- Tie microtube emitter in one overhand, loose knot and point opening downstream when inserting in drip line.
- Check filter and wash screen often.
- If water is dirty, pre-filter or settle before adding to reservoir.

- Avoid using transparent or translucent drums to prevent algae growth.

Lateral Length

- Maximum lateral length will depend on number of emitters.
- In our evaluation, with 40 emitters per lateral, we would not recommend a lateral length of more than 75 feet.


Summary: If carefully designed, managed, and maintained, low-tech, low-cost, gravity-fed drip irrigation systems can be used effectively in organic vegetable production!

Thank You!

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