

Troubleshooting and Problem-Solving When Things Go Wrong

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What Can Possibly Go Wrong?

- Water quantity and quality
- Crop water needs and timeliness
- Poor system design
 - Pipe sizing and length of runs
 - Inadequate filtering
 - Pump failure and backup plan
- Lack of maintenance
 - Not checking equipment
 - Failure to winterize

The Two Major Factors in Irrigation System Planning

1. How much water do you need?



2. How much time do you have?



Plants are 80-95% Water

- Water shortages early in crop development = delayed maturity and reduced yields
- Water shortages later in the growing season = quality often reduced, even if yields not hurt
- Short periods of 2-3 days of stress can hurt marketable yield
- Irrigation....
 - increases size and weight of individual fruit
 - helps prevent defects like toughness, strong flavor, poor tipfill and podfill, cracking, blossom-end rot and misshapen fruit



Water Needs Vary Widely

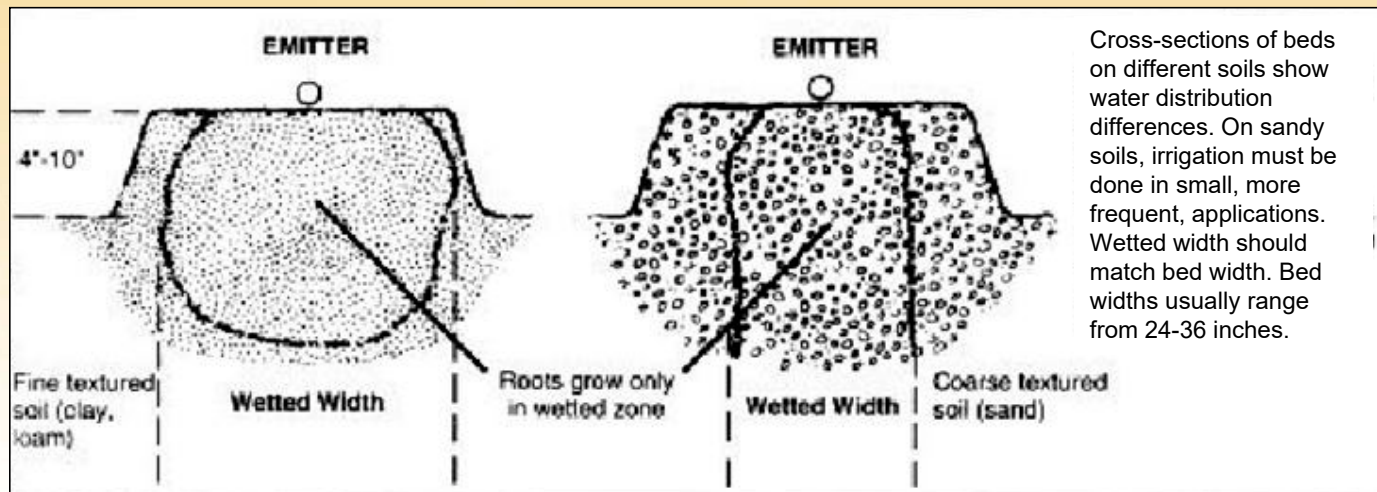
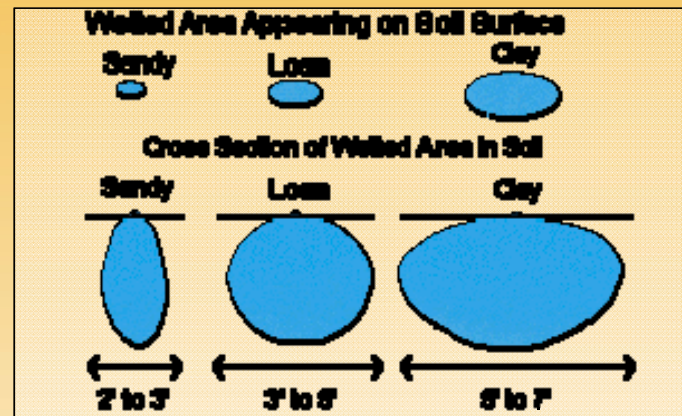
- By species & within species by age of crop
- By soil type and time of year
- By location: outdoors vs. indoors

- Example: Tomatoes in high tunnels
 - 12 oz./plant/day when first set
 - Climbs gradually to 75 oz./plant/day upon maturity
- Example: Greenhouses (container production)
 - A general rule is to have available from 0.3 to 0.4 gallons/sq. ft. of growing area per day as a peak use rate

- **Size irrigation system for peak use**



Know the Soil Rooting Depth & How Water Will Re-Distribute



Cross-sections of beds on different soils show water distribution differences. On sandy soils, irrigation must be done in small, more frequent, applications. Wetted width should match bed width. Bed widths usually range from 24-36 inches.

Effective Rooting Depth of Selected Vegetables

Shallow (6-12")	Moderate (18-24")	Deep (>36")
Beet	Cabbage, Brussels Sprouts	Asparagus
Broccoli	Cucumber	Lima Bean
Carrot	Eggplant	Pumpkin
Cauliflower	Muskmelon	Sweet Potato
Celery	Pea	Watermelon
Greens & Herbs	Potato	Squash, Winter
Onion	Snap Bean	
Pepper	Squash, Summer	
Radish	Sweet Corn	
Spinach	Tomato	



Most of the active root system for water uptake may be in the top 6"-12"

Vegetable Crops & Growth Period Most Critical for Irrigation Requirements

Crop ¹	Most Critical Period
Broccoli, Cabbage, Cauliflower, Lettuce	Head development
Carrot, Radish, Beet, Turnip	Root enlargement
Sweet Corn	Silking, tasseling, and ear development
Cucumber, Eggplant, Pepper, Melon, Tomato	Flowering, fruit set, and maturation
Bean, Pea	Flowering, fruit set, and development
Onion	Bulb development
Potato	Tuber set and enlargement
¹ For transplants, transplanting & stand establishment represent a most critical period for adequate water.	

Reference: irrigationtraining.tamu.edu/docs/irrigation-training/south/crop-guidelines/estimatedwaterrequirementsvegetablecrops.pdf

Water Source Quality

Good



Poor

- Well = check pH and hardness
- Municipal = may be expensive
- Spring = may not be dependable
- River or stream = depends on runoff
- Lake or pond water = sand filters
- Pump to tank on hill = limited use



Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids (<500 ppm)
 - Carbonates (calcium)
 - Iron & Manganese
 - Sulfates & Chlorides
- pH (5.8-6.8 preferred)
- Hardness (<150 ppm or <9 gpg)



PVC Casing



Steel Casing

Resource: <http://soilplantlab.missouri.edu/soil/water.aspx>

Domestic suitability test = Hardness, pH, nitrate-N, sulfate, chloride, sodium, carbonate, bicarbonate, iron, manganese, copper, electrical conductivity, total dissolved solids

Plugging Potential of Drip Irrigation Systems

Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

* ppm = mg/L

** pH is unitless

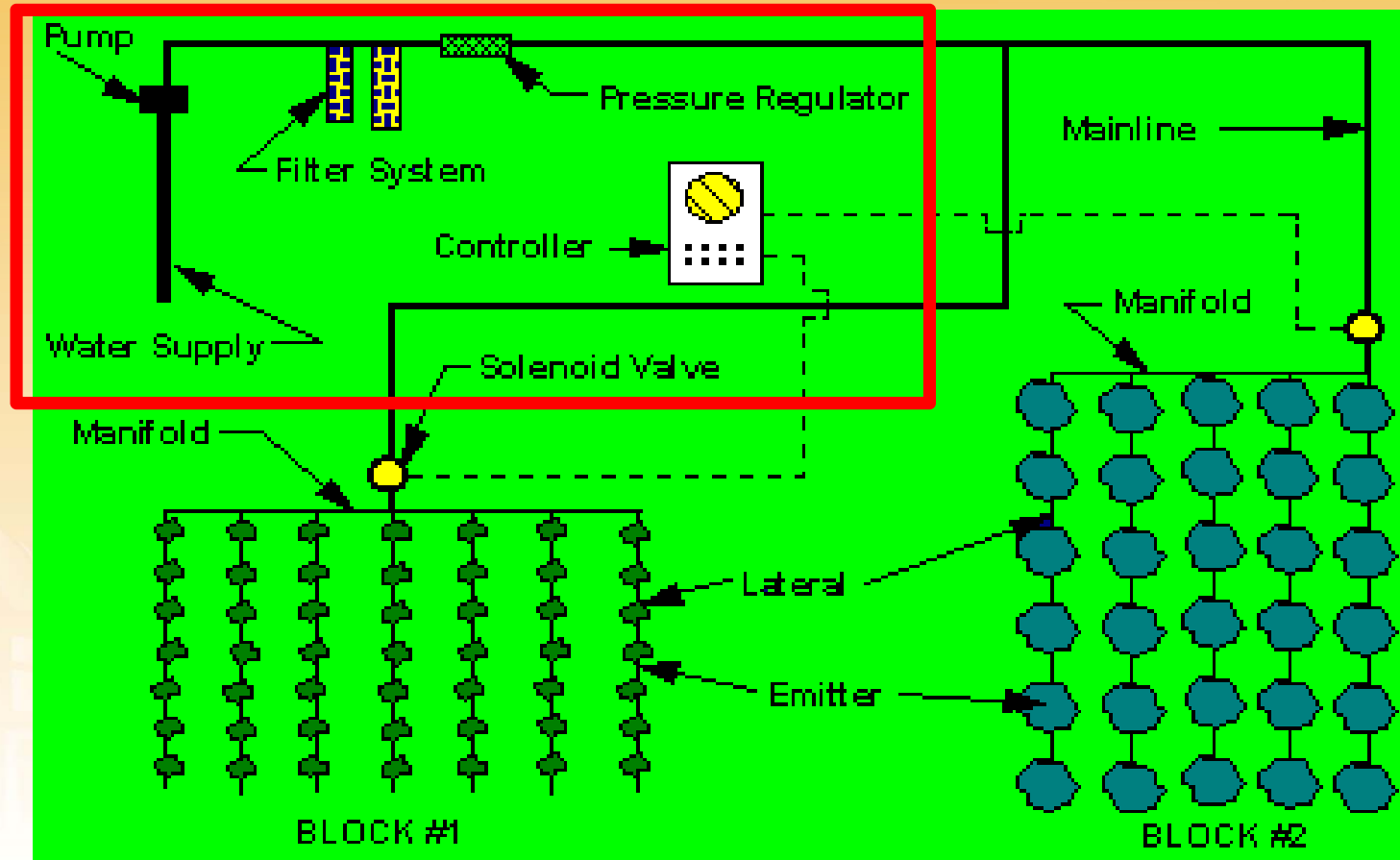
*** Hardness: ppm = gpg x 17

Good Agricultural Practices - Irrigation Water

- Pathogens that contaminate the surface of produce are difficult to remove
- Irrigation water can be a vehicle for foodborne pathogens
 - E. coli 0157:H7 in spinach
 - Salmonella in peppers
- GAPs program looks at food safety practices
 - Irrigation water quality
 - Manure management
 - Worker hygiene
 - Harvesting, transportation & storage practices

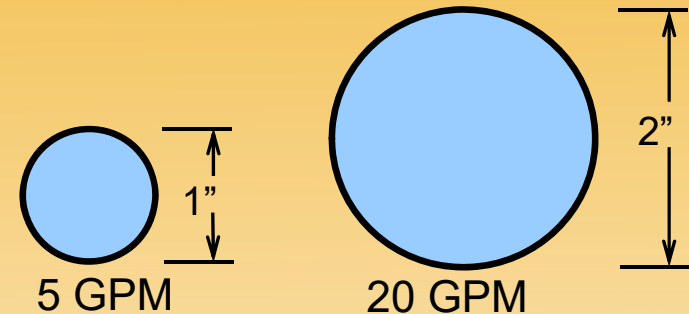


Example Layout of Drip Irrigation System



Friction Loss Design

- Size piping for 1 psi or less pressure loss per 100 feet
 - Pipe diameter x 2 = 4X flow rate
- Pipe friction may replace pressure regulators on downhill runs
- Vary flowrate no more than 20% (+/- 10%) within each block of plants
- Manifolds attached to mainline...
 - at center if < 3% slope
 - at high point if 3+% slope



Plastic Pipe Friction Loss

GPM	Pipe Diameter, inches			
	0.75"	1"	1.5"	2"
	PSI Loss per 100 ft. of pipe			
5	2.8	0.8	0.1	--
10	11.3	3.0	0.4	0.1
15	21.6	6.4	0.8	0.2
20	37.8	10.9	1.3	0.4
25	--	16.7	1.9	0.6
30	--	--	2.7	0.8

Design Considerations: Drainage of the System

- If possible, design system to allow for gravity drainage
- Bury supply lines and manifolds below the frost line
- Include drains whenever possible
 - Upstream and downstream of each control valve
 - At each low point in the system
 - Allow for air entry at high points in the system
 - Make sure that drains are accessible
 - Make sure that water from drains has somewhere to go!
- Include a port for compressed air – install downstream of backflow prevention and pressure regulators/vacuum breaks



Filter Selection

- Screen filter
 - 150-200 mesh, 3/4" to 6" dia.
 - Slotted PVC, perf. or mesh stainless steel or nylon mesh
 - Manual or automatic flush
- Disc filter
 - Stack of grooved wafers
 - Provides more filter area than screen of same size
 - Cannot handle sand well



Filter Selection

- Sand media
 - 14" to 48" diameter
 - Use swimming pool filter for smaller systems
 - Use pairs of canisters for larger systems
 - #16 silica sand = 150-200 mesh screen
 - Work best at < 20 GPM flow per square foot of media
 - Follow with screen filters
 - Backflush to clean



Pump Cycling Rate, Max.

Horsepower Rating	Cycles / Hour
0.25 to 2.0	20
3 to 5	15
7.5, 10, 15	10



Beginning of Season Maintenance

- Check controls and clean filters
- Flush the system
- Leak check the system
- Check emitters and wetting patterns

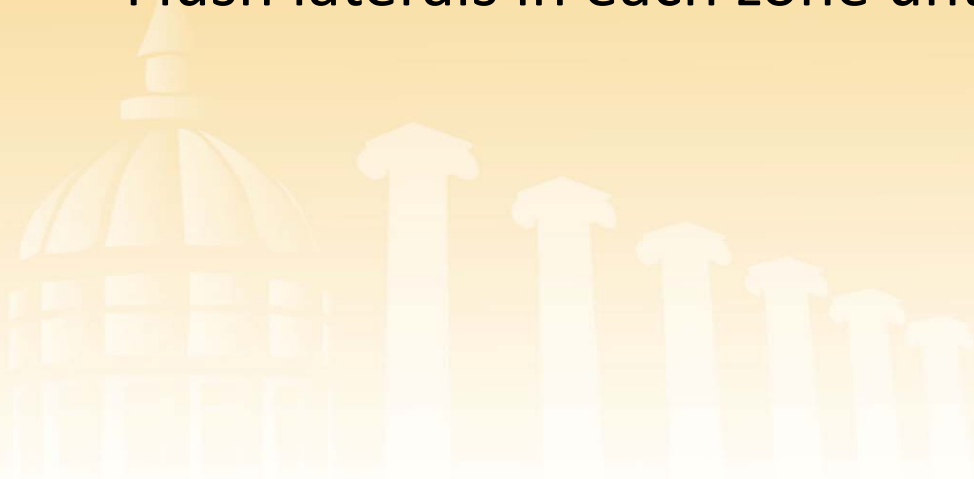


Beginning of Season Maintenance: **Check Controls & Clean Filters**

- Place controls in system, if removed
- Check each component for proper function as per manufacturer's guidelines
- Make sure that filters are clean
- Replace cartridges or media if needed

Beginning of Season Maintenance: **Flush the System**

- Flush mainline for 20 minutes, with manifold valves closed
- Flush each manifold for 5-10 minutes
- Open ends of each lateral in a zone
- Flush laterals in each zone until water runs clear



Beginning of Season Maintenance: **Leak Check the System**

- Close lateral ends
- Run system with water for 20 min to remove air
- Check pressure throughout the system – note any areas with more than 20% variation in flow rate and correct
- Walk field, noting plugged emitters, leaks and breaks; repair any problems

Growing Season Maintenance

- Water supply
- Flush physical contaminants
 - Cleaning the filter (150-200 mesh)
 - Flushing the system
- Check for excessive leakage
- Repair breaks or lost emitters
- Fertilizer injection



Growing Season Maintenance: **Fertigation**

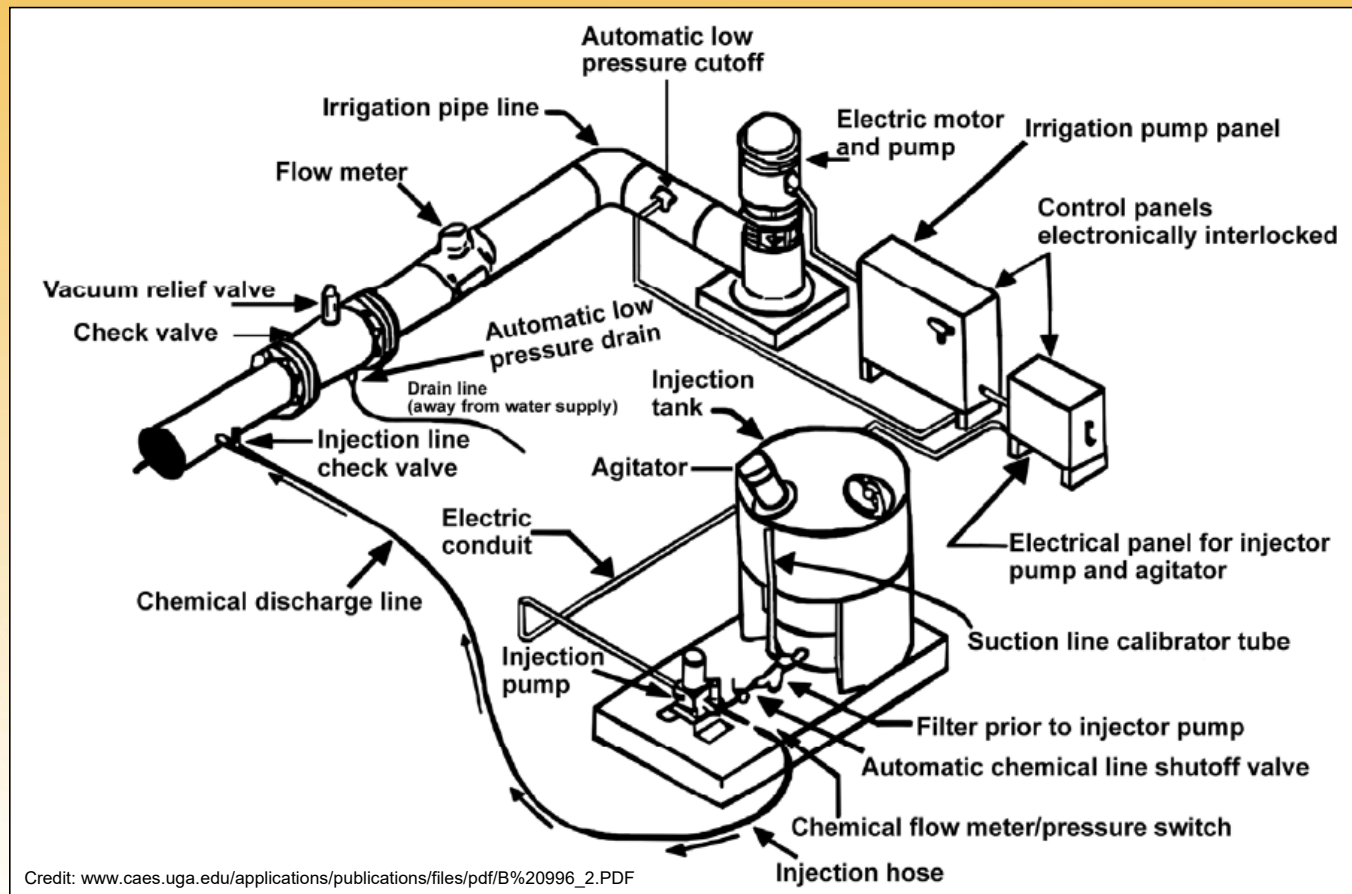
- Drip irrigation can supply soluble materials such as fertilizers by chemigation
- Analyze water source for precipitate potential through water/fertilizer interactions
- Test fertilizers for solubility, especially P sources
- Use vacuum breaker or backflow preventer to protect water supply

Growing Season Maintenance: Fertigation Procedure

- Completely pressurize the drip irrigation system before starting fertigation
- Inject fertilizer two elbows upstream of the filter to ensure good mixing
- Inject fertilizer for at least as long as time required to pressurize the entire system
- Flush lines at the end of injection to remove residue

Reference: www.ksre.ksu.edu/bookstore/pubs/mf1092.pdf

Typical Chemigation System (electrically-driven)



Growing Season Maintenance: Water Troubleshooting Guide

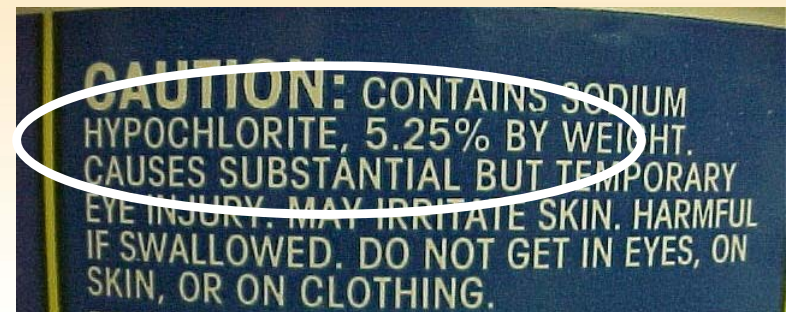
Problem	Cause
Green or slimy matter in surface water	Algae or fungi
Turbidity (muddy water)	Suspended clay and silt; inadequate filtration
White precipitate or film on tape or around emitters	Calcium salts or carbonates
Reddish-brown precipitate or slime around emitters	Oxidized (ferric) iron precipitation
Water initially clear (no oxygen), but turns red/orange in presence of air	Clear water dissolved (ferrous) iron
Black sandy particles	Iron sulfide precipitation
Black precipitate	Manganese precipitation
Reddish brown slime near emitters	Bacteria feeding on iron
White stringy masses of slime near emitters	Bacteria feeding on sulfur

Growing Season Maintenance: **Chemical Water Treatment**

- Useful to manage both inorganic and organic problems
- Goals of chemical treatment
 - Cause some particles to settle out or precipitate
 - Cause some particles to remain soluble or to dissolve
- Place filtration after chemical treatment
- Backflow prevention is critical

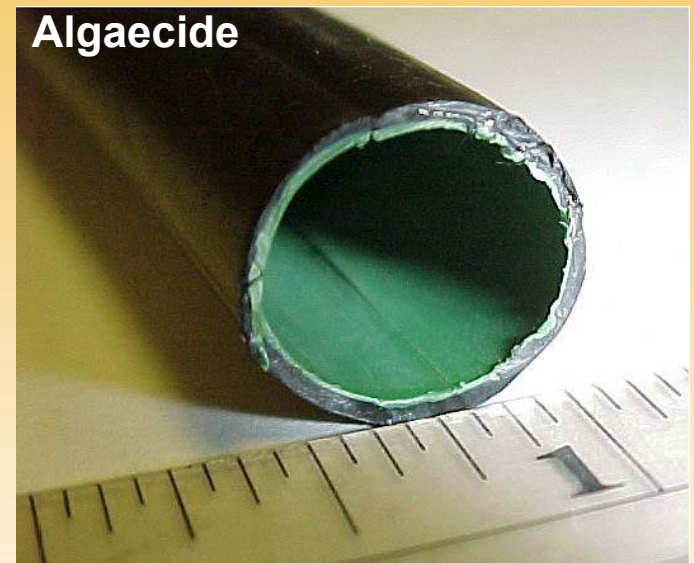
Growing Season Maintenance: Chemical Water Treatment

- Chlorine
 - Kills microbial activity (algae, bacteria)
 - Decomposes organic materials
 - Oxidizes soluble minerals, causing them to precipitate out of solution
 - Chlorine (<6 mo. old) needs “contact time”
 - Powdered HTH can plug emitters



Growing Season Maintenance: Chemical Water Treatment

- Chlorine
 - Chlorine concentration of 10-20 ppm for 30-60 minutes daily
 - Work by sections through the system, flushing out lines after treatment
 - If emitters are plugged, higher concentrations of chlorine may be needed to decompose organic matter



Growing Season Maintenance: Chemical Water Treatment

- Acid treatment
 - Lowers water pH
 - Help acidify soil for plants (blueberries)
 - Maintains solubility or dissolves manganese, iron, and calcium precipitates
 - Make chemicals work better
- Potassium permanganate
 - Oxidizes iron, causing it to precipitate



Growing Season Maintenance: Chemical Water Treatment

- Acid injection rate calculation
 - Amount of acid needed to treat a system
 - Strength of acid used
 - Buffering capacity of the irrigation water
 - Desired pH of water
 - Perform a titration to determine the acid volume : water volume ratio
- Calibration of injection pumps is critical

Resource: www.caes.uga.edu/applications/publications/files/pdf/B%201130_2.PDF

Growing Season Maintenance: Chemical Water Treatment

- Calcium salts (carbonates, phosphatics)
 - Water pH >7.5, bicarbonate levels >100ppm
 - Acid injection
 - Target pH 4.0 or lower for 30 to 60 minutes/daily
 - Hydrochloric, phosphoric, or sulfuric acid used
 - Flush and clean injector
 - Water softening (household systems)

Growing Season Maintenance: Three Steps for Iron Removal

- An **oxidizer** is added to the water, which induces **precipitation** of the iron and hydrogen sulfide, and the precipitated contaminant is then **filtered** out of the water
- pH control
 - Low pH (2.0) – iron dissolves
 - High pH (7.2+) – iron precipitates



Growing Season Maintenance: Iron Removal Options

- Iron bacteria
 - Chlorine + retention + filtration
- Ferric (red rust) iron
 - Filter, but may require use of coagulant
- Ferrous (clear water) iron < 5 ppm
 - Ion exchange with resin bed, fouls easily



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Growing Season Maintenance: Iron Removal Options

- Ferrous (clear water) iron 5+ ppm
 - Aeration + retention + filtration
 - Hydrogen peroxide + retention + filtration
 - Ozone (strong oxidizer) + retention + filtration
 - Chlorine (as a gas, calcium hypochlorite, or sodium hypochlorite at 1 part Cl : 1 part Fe) + retention + filtration (by manganese greensand, anthracite/greensand or activated carbon)
Greensand is then regenerated by using potassium permanganate (at 0.2 parts of pot. perm. : 1 part of iron)
 - Oxidizing filter media (pyrolusite ore) + backwash it at 25 to 30 gallons per sq. ft.
 - Manganese greensand (high capacity & high flow). Regenerate it with potassium permanganate at 1.5 to 2 oz. per cubic foot of greensand



Growing Season Maintenance: Control Area

- Regularly check each component for proper function as per manufacturer's guidelines
- Remember – pressure gauges are your indicators!

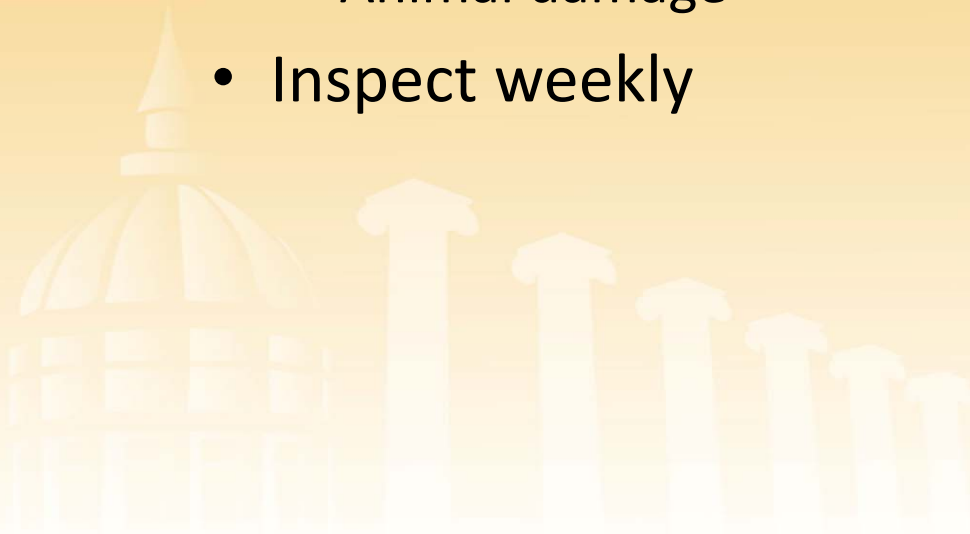


Growing Season Maintenance: **Filters**

- Filters must be cleaned when pressure loss across filter exceeds 5-10 psi
- Screen filter - manual or automatic flush
- Disc filter – flush
- Sand media - backflush to clean

Growing Season Maintenance: **Supply Lines and Laterals**

- Flush lines at intervals
- Repair breaks and areas of leakage
 - Animal damage
- Inspect weekly



Growing Season Maintenance: **Emitters**

- Check frequently for plugging
- Check for lost emitters
- Control weed growth
 - Weeds compete for water
 - Weeds compete for injected fertilizers
 - Weeds interfere with wetting patterns
 - Weeds make maintenance more difficult

Growing Season Maintenance: **Emitters**

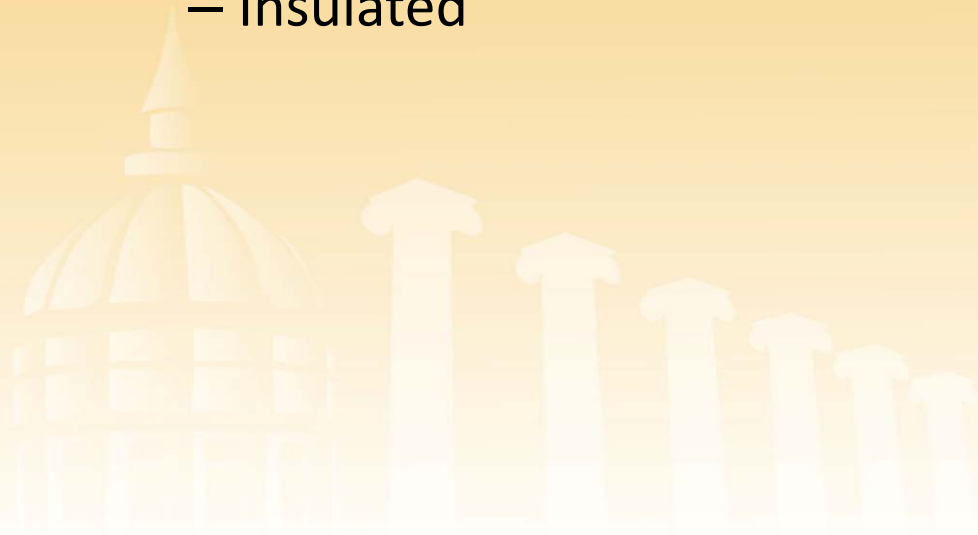
- Root intrusion
 - Cl injection at 100 ppm for 1 hour
 - Injection of trifluralin or copper sulfate
- Soil ingestion
 - Install vacuum relief valves on submains and manifolds, especially at high points
 - Soil surface installations – place emitter orifices up

End of Season Maintenance

- Turn off the water source
- Winterize the control area
- Drain all lines
 - Open manual drains
 - Remove plugs at ends of laterals
 - Use compressed air to remove water if needed
 - Replace end coverings and close drains

End of Season Maintenance: **Turn Off the Water Source**

- The main shut off valve must be freeze-proof!
 - Below frost line
 - In heated room
 - Insulated



Frost Protection of Plumbing

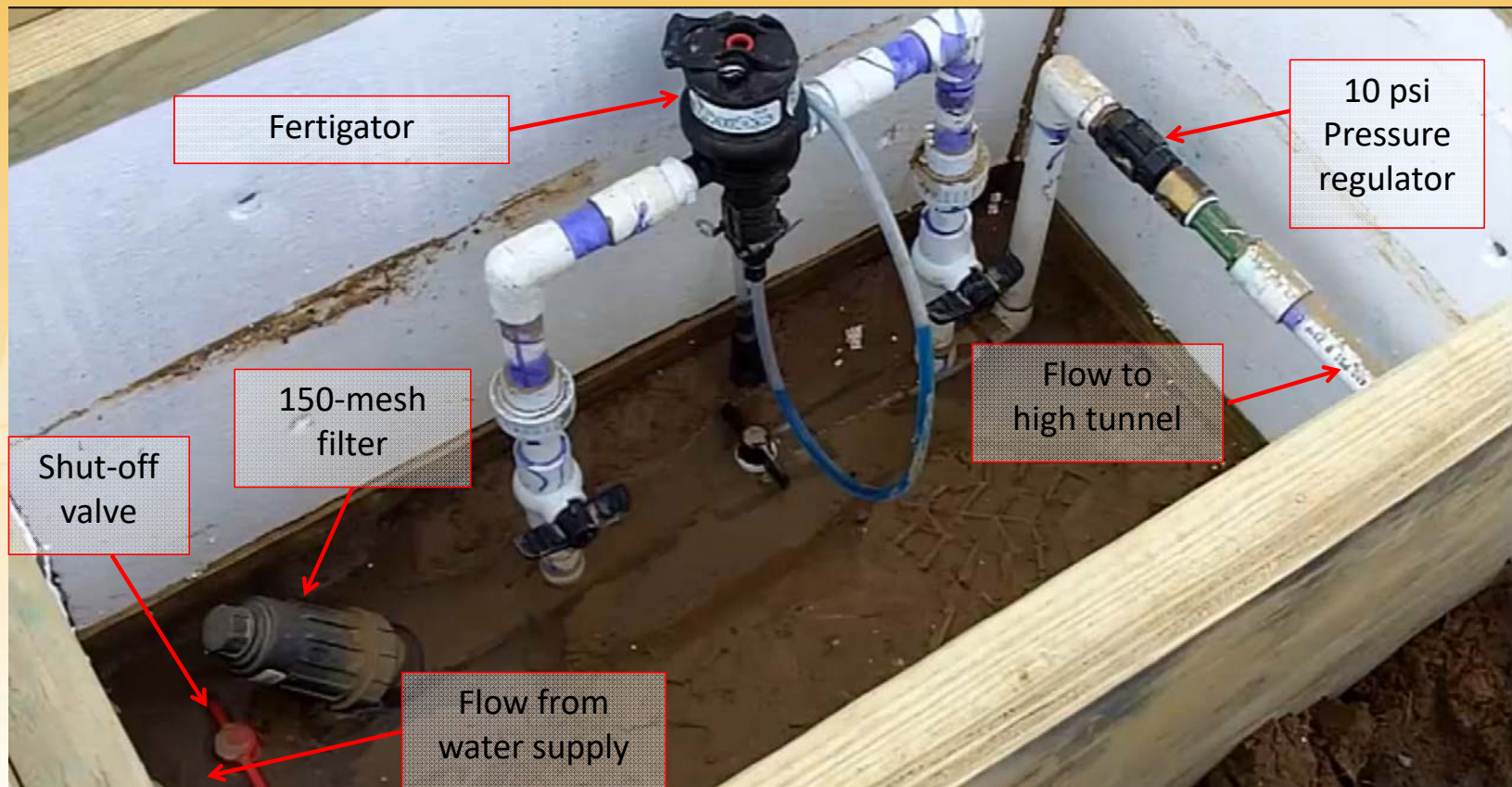


Photo credit: University of Arkansas -- www.youtube.com/watch?v=4J1p2UQo2jE

End of Season Maintenance: **Winterize the Control Area**

- Disconnect power if needed
- Remove controls (backflow prevention, filters, gauges, injection equipment)
- Drain water from everything!
- Consider storing controls in a heated protected area

End of Season Maintenance: **Drain All Lines**

- Two methods
 - Drain valves
 - Blowing out the system
- Drain valves
 - Open all drain valves, allow water to drain
- Remember to leave all valves open!

End of Season Maintenance: Drain All Lines

- Blowing out the system
 - Use the proper compressor - need a large volume (50-125 cubic feet per minute is usual)
 - Remove backflow prevention
 - Turn on the control valve that is on the zone furthest from the backflow prevention; close down other zones
 - Connect the compressor, slowly increase the pressure, never exceed 50 psi
 - Run until all water is blown out (don't run longer than 2-3 minutes), then turn off the control valve
 - Repeat procedure for each zone
 - Repeat the entire process again
- Remember to leave all valves open!

Irrigation Resources on the Web

- Irrigation System Planning & Management Links
extension.missouri.edu/webster/irrigation.aspx
- Ag Site Assessment Tool
agsite.missouri.edu



Questions??

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- MU Extension AA/EEO Office
109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
130 Heinkel Bldg, Columbia, MO 65211

USDA

- Office of Civil Rights, Director
Room 326-W, Whitten Building
14th and Independence Ave., SW
Washington, DC 20250-9410

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