



# Managing Your Irrigation System

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Presentation will be available at: <http://ucanr.org/schwankl>

# Managing Your Irrigation System

- Sprinkler Systems
- Microirrigation Systems

# Application Rate: What's the big deal?

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- We provide tree water use (ET) information in units of “inches of water use per day (or per week.....)”

# Application Rate: What's the big deal?

- We provide tree water use information in units of “inches of water use (per day or per week.....)”.
- Need to know the system application rate in order to know **how long to run the system.**

# Sprinkler Application Rate



REDUCING RUNOFF FROM IRRIGATED LANDS

PUBLICATION 8216

## Soil Intake Rates and Application Rates in Sprinkler-Irrigated Orchards

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Available as a free download at:

<http://anrcatalog.ucdavis.edu/SoilWaterIrrigation/8216.aspx>

# Sprinkler Application Rate

- Sprinkler application rates usually given in units of “inches per hour”.
- Works great with crop water use (ET) info. which is given in “inches per day” or “inches per week”.

# Sprinkler application rate:

$$i \text{ (in/hr)} = \frac{96.3 \times (\text{nozzle discharge in gpm})}{\text{Spacing along lateral (ft.)} \times \text{Spacing between laterals (ft.)}}$$

# Sprinkler Application Rate:

Table 2. Sprinkler discharge rates (gpm) for various nozzle sizes (in) and pressures (psi)

Pressure (psi)	Nozzle size (in)										
	3/32	7/64	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4
20	1.17	1.60	2.09	2.65	3.26	3.92	4.69	5.51	6.37	7.32	8.34
25	1.31	1.78	2.34	2.96	3.64	4.38	5.25	6.16	7.13	8.19	9.32
30	1.44	1.95	2.56	3.26	4.01	4.83	5.75	6.80	7.86	8.97	10.21
35	1.55	2.11	2.77	3.50	4.31	5.18	6.21	7.30	8.43	9.69	11.03
40	1.66	2.26	2.96	3.74	4.61	5.54	6.64	7.80	9.02	10.35	11.79
45	1.76	2.39	3.13	3.99	4.91	5.91	7.03	8.30	9.60	10.99	12.50
50	1.85	2.52	3.30	4.18	5.15	6.19	7.41	8.71	10.10	11.58	13.18
55	1.94	2.64	3.46	4.37	5.39	6.48	7.77	9.12	10.50	12.15	13.82
60	2.03	2.76	3.62	4.50	5.65	6.80	8.12	9.56	11.05	12.68	14.44
65	2.11	2.88	3.77	4.76	5.87	7.06	8.45	9.92	11.45	13.21	15.03
70	2.19	2.99	3.91	4.96	6.10	7.34	8.78	10.32	11.95	13.70	15.59
75	2.27	3.09	4.05	5.12	6.30	7.58	9.08	10.66	12.32	14.19	16.14

Note: Metric conversions: 1 gal = 3.785 l; 1 in = 2.54 cm; 1 psi = 6.89 kPa.

# Sprinkler Application Rate



Determining Pressure



# Sprinkler application rate:

$$i \text{ (in/hr)} = \frac{96.3 \times (\text{nozzle discharge in gpm})}{\text{Spacing along lateral (ft.)} \times \text{Spacing between laterals (ft.)}}$$

# Sprinkler Application Rate



# Sprinkler Application Rate

## Catch Can Test



# Managing Your Microirrigation System

## The California Microirrigation Pocket Guide

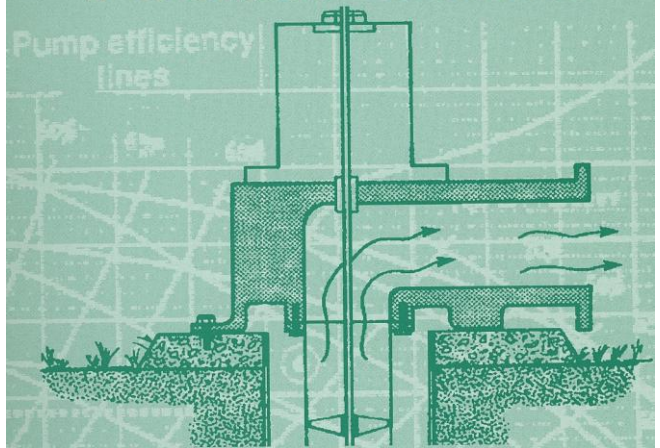


System Management  
& Maintenance



NCAT National Center for Appropriate Technology

## The California Microirrigation Pocket Guide



Pumps, Motors,  
& Engines



National Center for  
NCAT Appropriate Technology

ISBN: 978-0-9817745-0-3



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# Microirrigation Irrigation Scheduling

- Crop water use (ET) info. provided in units of “in/day”.
- Microsprinkler and drip system applications measured in units of “gal/hour” (gph).

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$$\text{Water use by the tree (gal/day)} = \text{Tree spacing (ft}^2\text{)} \times \text{Tree water use (in/day)} \times 0.623$$

## Adjusting ET for Young Trees

Because of their smaller canopy, young trees have lower ET rates than mature trees. You can estimate the ET of young trees using the tables above and Figure 4 below. Mature tree ET levels are achieved when ground shading reaches 60 to 70 percent.

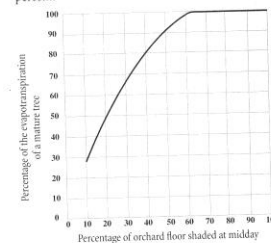


Figure 4. Evapotranspiration of young trees.

## Converting ET to Gallons per Day per Plant

To convert ET amounts from Tables 1-10 (inches per day) to gallons per day per plant, use Table 11 below or do a simple calculation with the following formula:

$$\text{Water use (gals/day)} = \text{crop spacing (ft}^2\text{)} \times \text{ET (in/day)} \times 0.623$$

**Example:** ET is 0.25 inch per day

Tree crop spacing 15 feet x 15 feet = 225 square feet

Water use per tree = 225 x 0.25 x 0.623 = 35.0 gallons per day

Table 11. Converting ET rates to gallons per day per plant

		Evapotranspiration (inches per day)									
		0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4		
Crop Spacing (ft <sup>2</sup> ) = row spacing x plant spacing	100	3	6	9	12	16	19	22	25		
	200	6	12	19	25	31	37	44	50		
	400	12	25	37	50	62	75	87	100		
	600	19	37	56	75	93	112	131	150		
	800	25	50	75	100	125	150	174	199		
	1000	31	62	93	125	156	187	218	249		
	1200	37	75	112	150	187	224	262	299		
	1400	44	87	131	174	218	262	305	349		
	1600	50	100	150	199	249	299	349	399		
	1800	56	112	168	224	280	336	392	449		
2000	62	125	187	249	311	374	436	498			
2200	69	137	206	274	343	411	480	548			
2400	75	150	224	299	374	449	523	598			

From Larry Schwankl, Blaine Hanson, and Terry Prichard, *Low-Volume Irrigation*, University of California, Davis, 1993.

## Using Real-Time ET Information: CIMIS

Real-time ET estimates are generally more accurate than historical averages, but they are also somewhat harder to use. Of course, it's not an either-or choice. You can look at both historical averages and real-time estimates.

California irrigators are fortunate to have access to CIMIS, the California Irrigation Management Information System. Managed by the California Department of Water Resources, CIMIS includes over 125 active weather stations, providing real-time ET estimates for much of the state, free of charge. (Another 60 inactive stations provide historical information.) You'll find these estimates at [www.cimis.water.ca.gov](http://www.cimis.water.ca.gov). Real-time ET estimates may also be available from local newspapers, radio stations, and websites, or from local water districts or University of California Cooperative Extension offices.

# Microirrigation Application Rate

- Use mobile lab

## 3. Determining Your Application Rate

This chapter explains

- how to determine your system's application rate from flowmeter readings
- how to determine your system's application rate from direct measurements
- how to determine your system's emission uniformity

Anyone who operates a microirrigation system must know their system's application rate in inches per hour. If you don't know this number, you are guessing or blindly following instructions, not making informed decisions.

The application rate in your original design specifications may be fairly accurate, especially if you have a newer system. But all systems change over time, because of wear, aging, clogging, leaks, and other problems. This chapter explains how to check your system's actual application rate.

Chapter 2 explained how to determine the amount of water you need to apply. Remember that once you know your application rate, your daily and weekly management decisions will largely boil down to dividing one number by another:

$$\text{water you need to apply} \div \text{application rate} = \text{time you need to run the system}$$

### Having a Professional Evaluation

A professional evaluation, including your application rate, is strongly recommended if you have access to the services of a trained irrigation system auditing team. These teams, sometimes called Mobile Irrigation Labs or Eco-Labs, are often available through your Irrigation District or Resource Conservation District, or through private consultants. Inquire at your local NRCS or Cooperative Extension office.

# Microirrigation Application Rate

- Use mobile lab
- Use flow meter
  - Head of system

## Using Flowmeters to Find Your Application Rate

Every properly designed microirrigation system includes at least one flowmeter. Most often, this is a propeller flowmeter installed at the head of the system, in the main supply line—after the filters and on a straight section of pipe. Small flowmeters may also be installed on individual lateral lines.



Figure 5. Saddle-type propeller flowmeter

### Flowmeter at the Head of the System

If your flowmeter gives instantaneous readings in gallons per minute (gpm) or cubic feet per second (cfs), simply convert these readings into inches per hour as follows:

$$\frac{\text{gpm}}{\text{irrigated area (acres)}} \times 0.0022 = \text{application rate (inches per hour)}$$

$$\frac{\text{cfs}}{\text{irrigated area (acres)}} \times 0.992 = \text{application rate (inches per hour)}$$

If (unfortunately) there is no flowmeter on the system, you can still use the formulas above if you've recently had a pump test.

Instead of giving instantaneous readings, your flowmeter may record "totalized" flow in gallons, acre-feet, or acre-inches. To find your application rate, record the meter reading and time

# Microirrigation Application Rate

- Use mobile lab
- Use flow meter
  - Head of system
  - On laterals



## Flowmeters on Lateral Lines

Your system may have small totalizing flowmeters installed on individual lateral lines throughout the system. While not very common in California, these flowmeters do have advantages. They normally cost less than \$100 apiece and provide good information about emission uniformity. On the other hand, they may be less convenient to install and maintain than a single flowmeter at the head of the system.

To determine the application rate on the lateral line, record the meter reading and time at the beginning and end of your irrigation set. Then follow the three steps below to find your application rate in inches per hour:

*Step 1: Divide acre-inches by the number of hours, to determine application rate in acre-inches per hour.*

If meter readings are in gallons or acre-feet, use one of the conversion formulas on the previous page.

*Step 2: Determine irrigated area of the lateral line in acres, using the following formula.*

$$\frac{\text{lateral length (feet)}}{\text{lateral spacing (feet)}} \times \frac{\text{lateral spacing (feet)}}{43,560} = \frac{\text{irrigated area (acres)}}{\text{acres}}$$

*Step 3: Divide applied water (Step 1) by irrigated area (Step 2) to find application rate.*

$$\frac{\text{applied water (ac-in/hr)}}{\text{irrigated area (acres)}} = \frac{\text{application rate (in/hr)}}{\text{in/hr}}$$

# Microirrigation Application Rate

- Use mobile lab
- Use flow meter
  - Head of system
  - On laterals
- Sample the Microsprinklers

## Direct Measurement Method for Surface Drip and Microsprinklers

You can directly measure the application rate of any surface drip or microsprinkler system in the field, using the following three-step process:

*Step 1: Sample the flow rates of individual emitters.*

After the irrigation system reaches a steady pressure, take carefully timed 30-second flow measurements. A 100-ml graduated cylinder works well for drip systems, and a 1,000-ml graduated cylinder works well for microsprinkler systems.

Then calculate the flow rate for each emitter in gallons per hour (gph):

$$\frac{\text{ml water collected in 30 seconds}}{\text{ml water collected in 30 seconds}} \times 0.0317 = \frac{\text{discharge rate}}{\text{(gallons per hour)}}$$

See the center section of this guidebook, if necessary, for conversions. 1 fluid ounce = 29.5 ml and 1 pint = 472 ml.

If possible, check the flow rates of 30 to 50 emitters. By starting at one corner and moving diagonally through the field, you'll get samples from the head, middle, and ends of lateral lines. Pay special attention to the ends of laterals: reduced flow rates here indicate plugging upstream.

Measurements will vary because of friction losses, elevation changes, and other factors. If you see a lot of variation, you have a problem with uniformity, most likely caused by a poorly designed system or clogging.

# **Microirrigation Management**

## **Orchard Irrigation**

### **Determining the Application Rate & Uniformity of a Microirrigation System**

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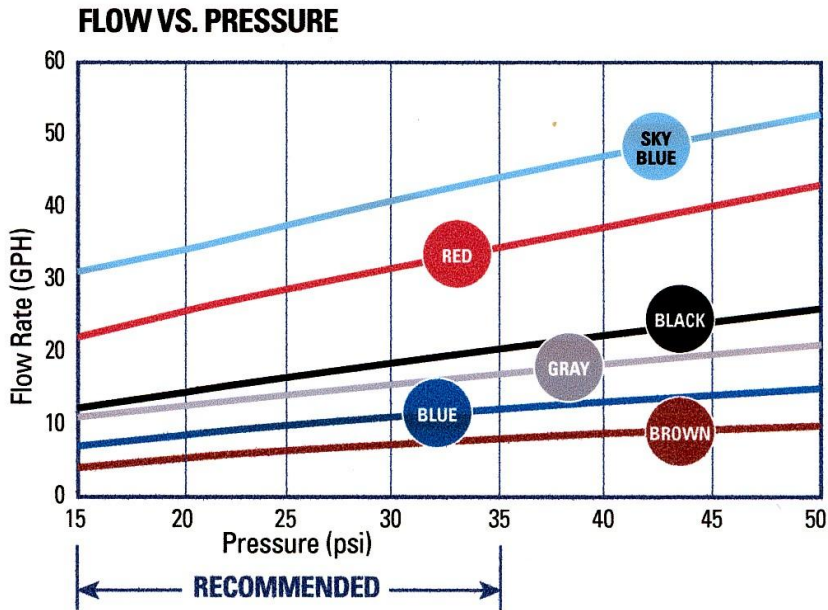
# Microirrigation Management

- Pressure variations
- Clogging

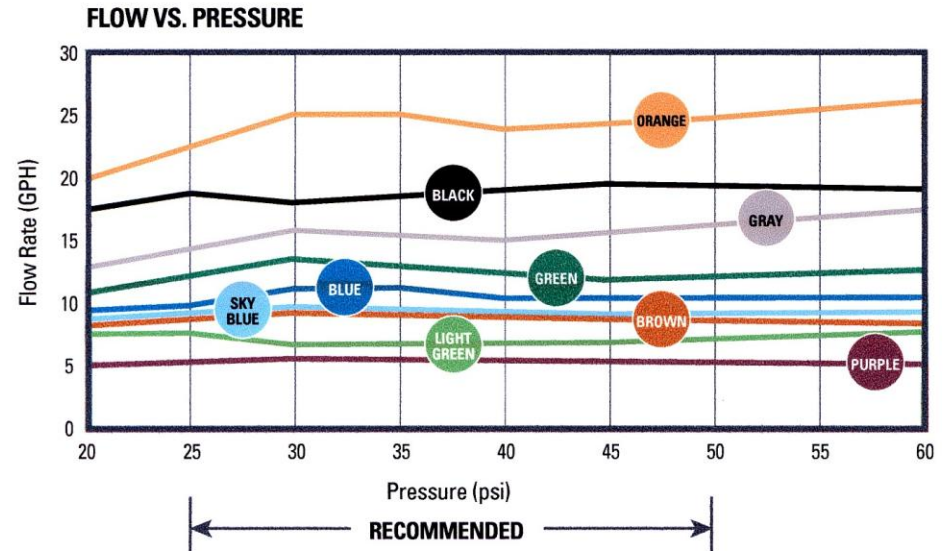
# Microirrigation – Pressure variations

- Impact

## Non-pressure compensating Micro



## Pressure compensating (PC) Micro



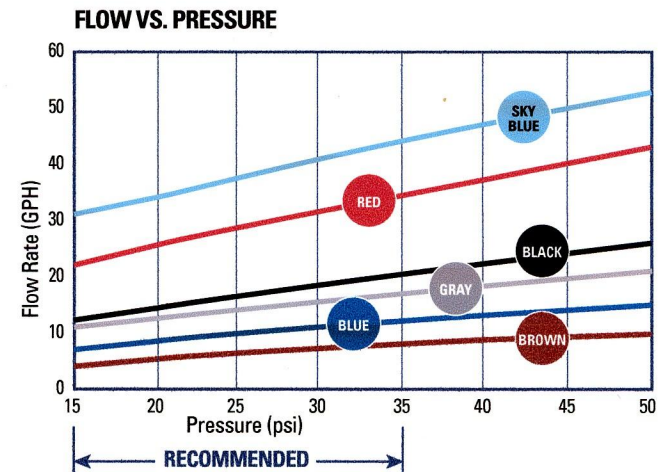
# Microirrigation – Pressure variations

- Impact
- Causes
  - Design issues



# Microirrigation – Pressure variations

- Impact
- Causes
  - Design issues
  - Maintenance issues
    - Filters – if filters are dirty, there is greater pressure drop across them.



# Maintenance of Microirrigation

Clogging is the greatest “threat” to microirrigation systems.



# **Clogging of Microirrigation Systems**

Source: Physical Clogging - Particulates

# Clogging of Microirrigation Systems

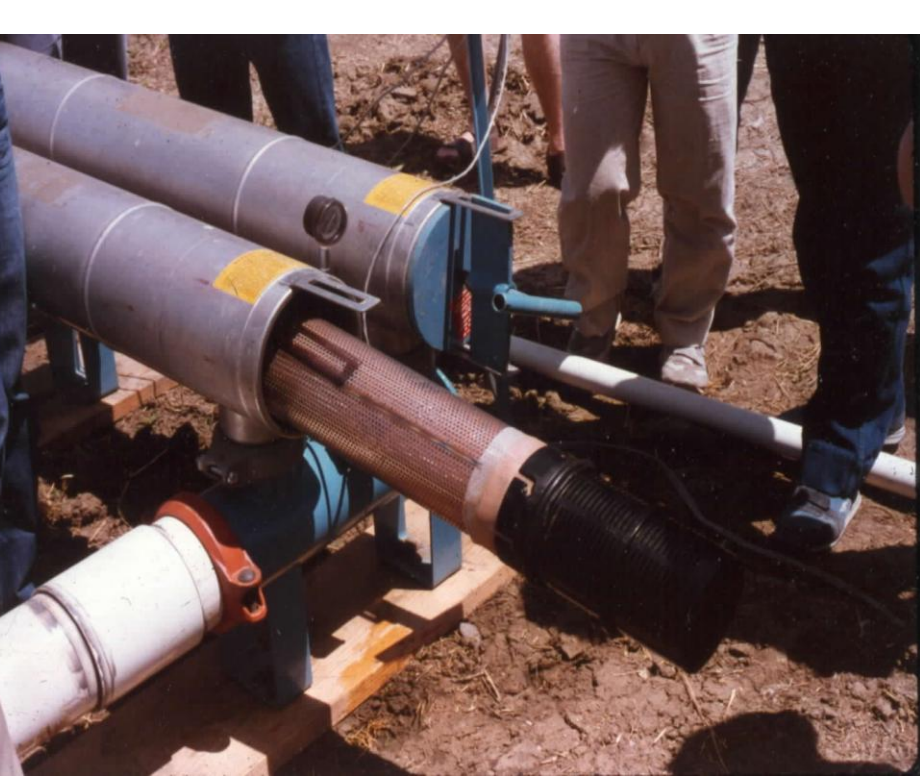
Source: Physical Clogging - Particulates

Solution: Filtration



# Filters:

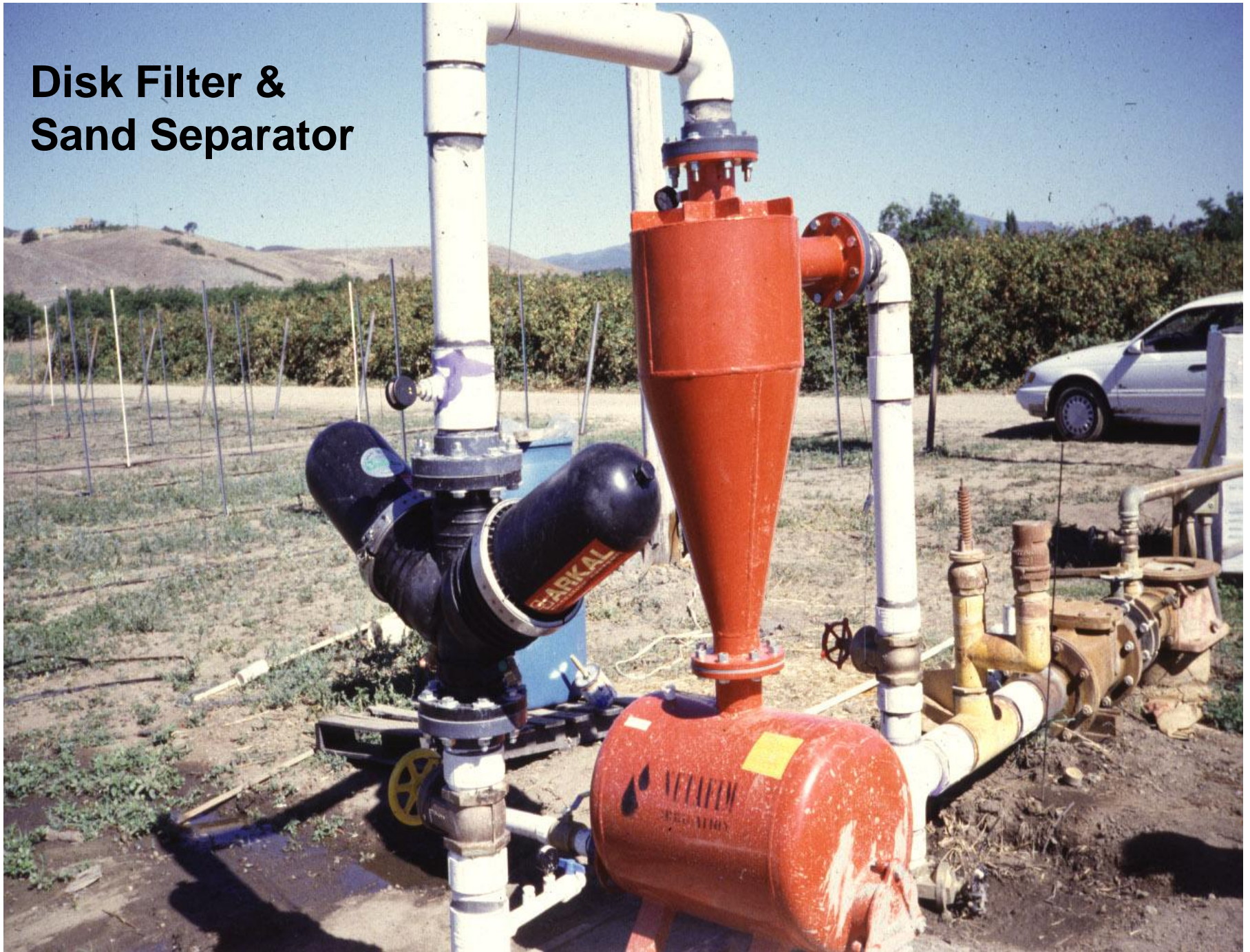
- Screen, disk, and sand media filters are all available.
- They can all filter to the same degree  
BUT  
they req. different frequency of cleaning.



# Screen Filters



# Disk Filter & Sand Separator



# Sand Media Filters



## Cleaning Filters

Filters need to be cleaned regularly. Dirty filters allow clogging, reduce system pressure, and lower application rates.

Good quality (preferably liquid-filled) pressure gauges should be installed on upstream and downstream sides of filters. A dirty filter will cause an increased pressure differential. Follow the manufacturer's guidelines for an acceptable pressure drop.

Screen and disc filters are well suited to removing inorganic materials from groundwater, including sand. Sand media filters, typically more expensive, can be used in almost all situations because of their three-dimensional filtering capability. They always include at least two tanks and are suited to removing organic material and biological contaminants commonly found in surface water, such as algae, moss, and bacterial slimes.

Filters are available in various mesh or media sizes. Consult the emitter manufacturer for particle size filtering requirements. Note that filtering particles smaller than required by the emitters will cause higher pressure losses across filters without adding any benefit.

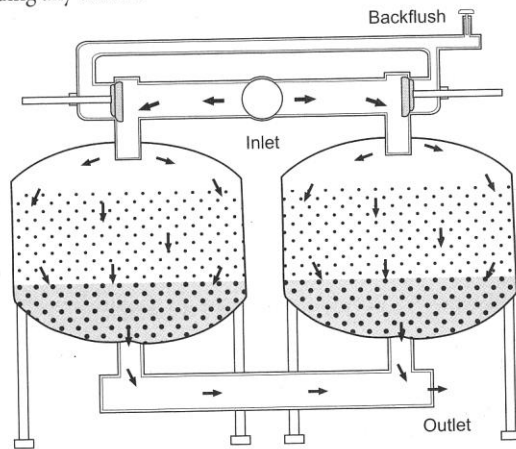


Figure 12. Media filter



*Backwashing* reverses the flow of water through a filter to clean it. Screen, disk, and sand media filter systems are all available with automatic backwash capability—cleaning filters on a regular schedule or whenever the pressure drop across the filter reaches a certain level. Automatic backwash systems cost more initially, but save maintenance time.

You'll need to design a means to dispose of backwash water. Usually a small diameter PVC pipeline extending from an outlet below the filters returns backflush water to the canal or holding pond, or conveys it to the field for disposal. Some growers use this water to irrigate windbreaks.

On sand media filters, a throttle valve is usually installed on the flush line to optimize flow. A sock can be used to determine how much media (sand) is leaving during a flush cycle. This should be adjusted so the media just starts to discharge.

Replace filter media when it begins to cake together. Also add media periodically to replace any lost during backwashing.

## Flushing Lines

Many small contaminants will pass through filters or precipitate out. Periodically flush lines to remove silt, clay, and other small particles that can join together and clog emitters.

First flush mainlines and submains. Then open the lateral lines and allow them to flush clean. For most tree and vine crop systems, lateral line flushing is done by hand, a few lines at a time. Row crop systems often have their ends plumbed together in flushing manifolds to save time.

Most systems should be flushed about every two weeks. If the lines seem clear, you can probably flush less often. If it takes more than a minute or two to flush the lines clean, you may need to flush more often. Notice what is coming out of the lines. Organic matter may indicate a need for better water treatment. Large amounts of debris can indicate filter failure.

# Clogging of Microirrigation Systems

Source: Chemical Precipitates

- Lime (calcium carbonate) and iron are the most common problems.





# Chemical Precipitate Clogging of Microirrigation Systems

Water quality levels of concern:

- Calcium: pH > 7.5 and 2.0 meq/l (120 ppm) of bicarbonate
- Iron: pH > 4.0 and 0.5 ppm iron

# Clogging of Microirrigation Systems

Source: Lime

Solution: pH Control (Acidification)

+

filtration

# Dealing with Iron Precipitation:

1. Aerate and precipitate iron in a pond / reservoir



# Dealing with Iron Precipitation:

1. Precipitate iron in a pond / reservoir
2. Chemicals (e.g. phosphonic acid, phosphonate) may keep iron in solution
  - Maintenance, not clean-up products

Automatic flush valves may be installed on the ends of your laterals. These are designed to stay open until pressure gets high enough to close them. They work well in some systems but don't always provide a long enough flushing period to completely clear the laterals.

## Inspecting Emitters

Microsprinklers are easy to inspect, since even slight clogging will be obvious in the spray pattern. Partly clogged drip emitters are hard to identify without catching and measuring flows to determine discharge rates. (See Chapter 3.) Completely clogged drip emitters should be cleaned or replaced. Most are sealed, however, and can't be taken apart for cleaning.

## Preventing and Solving Clogging Problems

**!** Before injecting any chemical, make sure your system has appropriate check valves, low pressure drain, vacuum relief valve, pressure switch, and interlocking system controls, as well as solenoid valves on chemical injection lines, to prevent backflow and contamination of water supplies. Check with your County Agricultural Commissioner's office to make sure you are in compliance with all federal and state laws. For equipment diagrams and a directory of offices, visit [www.cdpr.ca.gov](http://www.cdpr.ca.gov).

### Lime Precipitates

Various dissolved minerals in irrigation water precipitate when they are exposed to air and can clog emitters. Groundwater generally causes more precipitation problems than surface water.

Lime (calcium carbonate) is a crusty white precipitate. A drop of muriatic (hydrochloric) acid will cause lime to fizz. To check the hazard of lime clogging, test your water for pH, calcium, and bicarbonate. If calcium and bicarbonate are present at 2.0 milli-



equivalents per liter (approximately 100 ppm), and pH is 7.5 or more, there is a danger of precipitation. Higher levels of calcium and bicarbonate mean higher risk of precipitation and clogging.

Lime clogging can be prevented, and often remediated, by injecting acid to lower pH to 6 to 6.5. (Measure with pH strips or a pool/spa test kit.) Sulfuric acid is most commonly used. For water with moderate lime risk, injecting acid every two to four weeks may solve the problem. The injection should last through most of the irrigation application.

Many organic growers use vinegar to prevent and remediate lime clogging. See the caution on page 68.

For water with high lime hazard, you may need to inject acid for a couple hours during each irrigation cycle, or even continuously. Drip emitters that are completely clogged with lime require strong treatment. Try injecting enough acid to lower the pH to 5.0. Wait 24 hours and then thoroughly flush the system.

### Iron Precipitates

Iron appears as reddish staining. Iron levels of 0.5 ppm or higher pose a risk of iron precipitate clogging. Iron levels of 1 ppm or higher are a particular risk.

Iron precipitate clogging is a more serious problem than lime, and acid injections will not solve it. The accepted prevention is to aerate water by pumping it into a reservoir where the iron is allowed to settle out. Note, however, that holding water in a reservoir increases the chance of biological clogging from algae, slimes, fungi, and aquatic weed seeds and plant parts.

### Root Intrusions

Root hairs can grow into orifices, clogging emitters and even growing into the tubing. Root clogging is most likely to happen with permanent crops such as trees and vines, and especially in the spring and fall, when the irrigation system is not being used.

# Clogging of Microirrigation Systems

Source: Biological Sources



# Clogging of Microirrigation Systems

Source: Biological Sources

Solution: Filtration (usually media filters)

+

Biocide

# Biological Clogging

**Acid may deter  
but not eliminate**

**biocide**

**chlorine    copper**

# Chlorine

- Sources:
  - Liquid - sodium hypochlorite.
  - Solid - calcium hypochlorite.
  - Gas chlorine.



# Chlorine as a Biocide

	Free Chlorine
prevent growth	1 - 2 ppm
periodic injection	10 - 20
super chlorination (reclamation)	500 - 1000

Test for chlorine using a pool / spa test kit

# Chlorine: Injection Rates

## ■ Sodium hypochlorite (liquid)

- Example: household bleach w/ 5.25% active chlorine.

$$\text{Chlorine injection rate (gal/hr)} = \frac{\text{System flow rate (gpm)} \times \text{Desired Cl Conc. (ppm)} \times 0.006}{\text{Strength of Cl soln (\%)}}$$

## ■ Calcium hypochlorite (solid)

- 65-70% available chlorine.
- 12.8 lbs. of calcium hypochlorite added to 100 gallons of water forms a 1% solution.
- Use above formula.

During the irrigation season, daily irrigation creates saturated conditions that discourage root growth. Celery poses a special risk, however, since its roots thrive in saturated conditions.

To diagnose possible root intrusions, watch flowmeters closely for a drop in flow rate that signals clogging. To cope with root intrusion, try frequently flushing the laterals with water injected with chlorine (100 ppm). Copper, which binds tightly to soil particles, can be injected through subsurface drip systems in tree crops, forming a copper-impregnated zone surrounding the emitters that is inhospitable to root growth. Drip irrigation products are also available with an herbicide, trifluralin, impregnated in the emitters to prevent root intrusion.

### Biological Contaminants

Surface waters often contain algae, bacterial slimes, protozoa, fungi, and many other exotic creatures. Wells may also be contaminated by iron bacteria. All can clog emitters or (worse) grow in pipelines and laterals.

Good filtration, especially with sand media filters, will remove most biological contamination. You may also need to treat your system with a biocide, however—most commonly chlorine. Some trial and error may be required until you find the right treatment. You want to use the smallest amount of chemical that will keep your system clean.

Many growers use hydrogen peroxide as a biocide. See the caution on page 68.

Water with moderate biological contamination may require monthly or more frequent treatment, with 10-20 ppm free chlorine, measured at the most distant point from the pump. (Use a pool/spa test kit to measure chlorine levels, and make sure the indicator chemicals are fresh.) The injection should last four to six hours or more. A good time to inject is at the end of the irrigation set. Allow the chlorinated water to sit in the system until the start of your next irrigation.



### The Microsprinkler Advantage

In some cases, biological contaminants that clog drip emitters may easily pass through microsprinklers, because the water moves through orifices at a higher velocity.

Severe biological contamination may require continual low-level chlorine injection: 1-2 ppm chlorine, measured at the point in the system farthest from the pump.

Drip emitters that are completely clogged with biological contaminants require strong treatment. Try injecting 50-100 ppm chlorine. Wait 24 hours and then thoroughly flush the system.

Liquid chlorine (sodium hypochlorite) is most commonly used—either household bleach (5.25% available chlorine) or pool chlorine (up to 15% available chlorine). Granular chlorine (calcium hypochlorite), with up to 70% available chlorine, is easier to store than liquids but takes longer to mix. Gas chlorine is 100% available chlorine but poses serious health hazards.

To calculate the correct amount of liquid chlorine, use the following formula.

$$\text{chlorine injection rate (gal/hr)} = \text{system flow rate (gpm)} \times \text{desired chlorine concentration (ppm)} \times 0.006 \div \text{strength of chlorine solution (\%)}$$

**Example:** Your system flow rate is 275 gallons per minute. You want a concentration of 10 ppm free chlorine. You are using pool chlorine with 15% available chlorine.  
 $275 \text{ gpm} \times 10 \text{ ppm} \times 0.006 \div 15 = 1.1 \text{ gallons per hour}$   
You need to inject chlorine at 1.1 gallons per hour.

For use in the formula above, 12.8 pounds of calcium hypochlorite mixed in 100 gallons of water will make a one-percent available chlorine solution.

# Flushing of microirrigation systems:

- Silts and clay particles pass through even the best filters.

## Cleaning Filters

Filters need to be cleaned regularly. Dirty filters allow clogging, reduce system pressure, and lower application rates.

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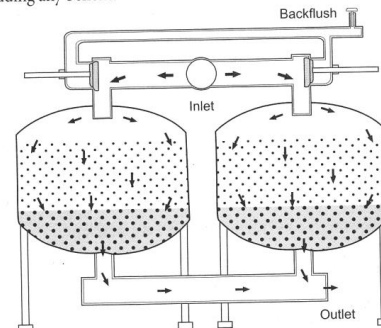


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Replace filter media when it begins to cake together. Also add media periodically to replace any lost during backwashing.

## Flushing Lines

Many small emitters will pass through filters or precipitate out. Periodically flush lines to remove silt, clay, and other small particles that can join together and clog emitters.

First flush mainlines and submains. Then open the lateral lines and allow them to flush clean. For most tree and vine crop systems, lateral line flushing is done by hand, a few lines at a time. Row crop systems often have their ends plumbed together in flushing manifolds to save time.

Most systems should be flushed about every two weeks. If the lines seem clear, you can probably flush less often. If it takes more than a minute or two to flush the lines clean, you may need to flush more often. Notice what is coming out of the lines. Organic matter may indicate a need for better water treatment. Large amounts of debris can indicate filter failure.



# Flushing

- Silts and clay particles pass through even the best filters.
- Need to flush the system - mainlines, submains, and laterals (in that order).

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- Silts and clay particles pass through even the best filters.
- Need to flush the system - mainlines, submains, and laterals (in that order).
  - Flush laterals by hand or use automatic flushing end caps.





# Questions?



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