Getting Started in Water Circularity: How To Really Achieve 90% Water Savings

February 28, 2024

RESOURCE INNOVATION INSTITUTE

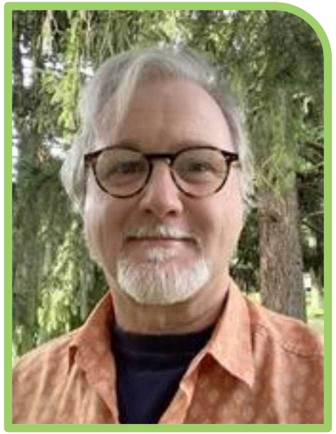
USDA United States Department of Agriculture

Natural Resources Conservation Service

CLEAN WATER³

REDUCE·REMEDIATE·RECYCLE

Today's Experts



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BLUEWTR

A division of

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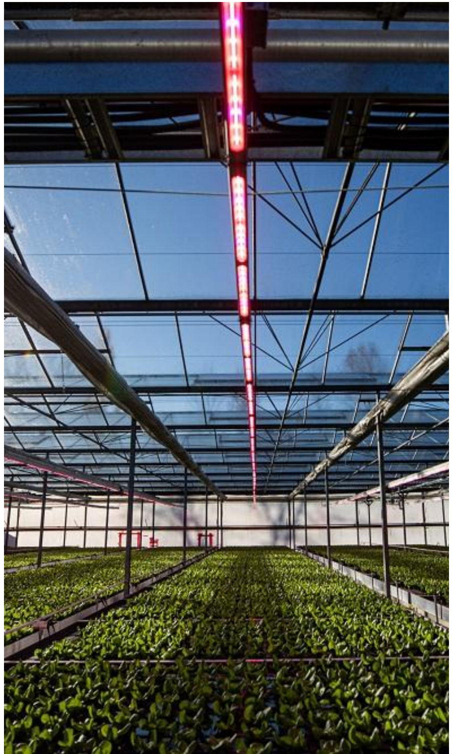
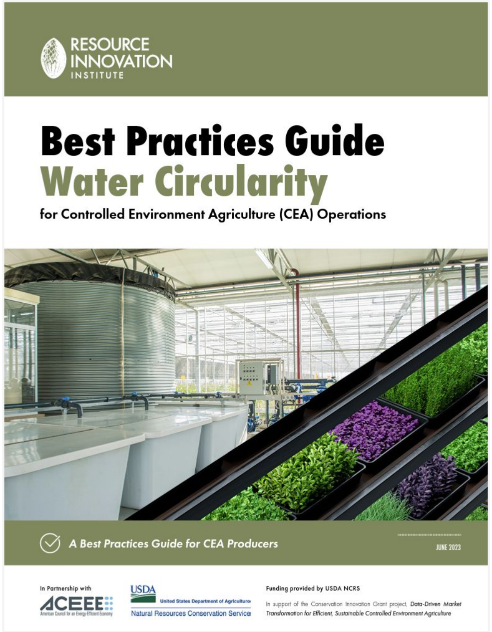
Grodan®

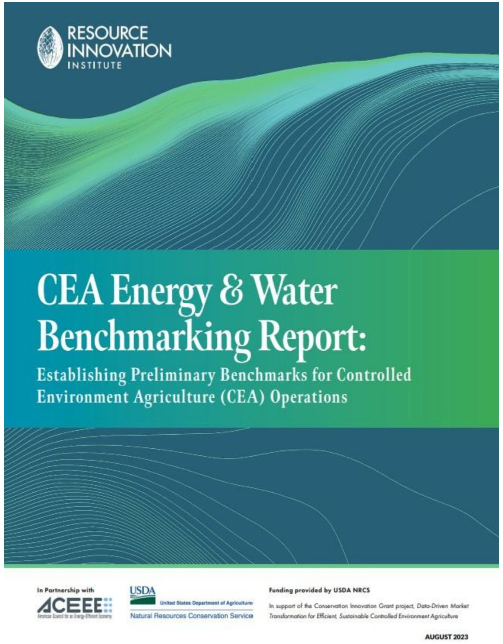
About RII

- Objective, data-driven, not-for-profit, public-private partnership funded by USDA and DOE
- Founded 2016 in Portland, Oregon
- Benchmark grower production and resource efficiency with our Powerscore platform
- Establish working groups from industry, government and academia to develop Best Practices Guides
- Webinars, workshops, articles, training for industry



CEA Water Circularity Resources



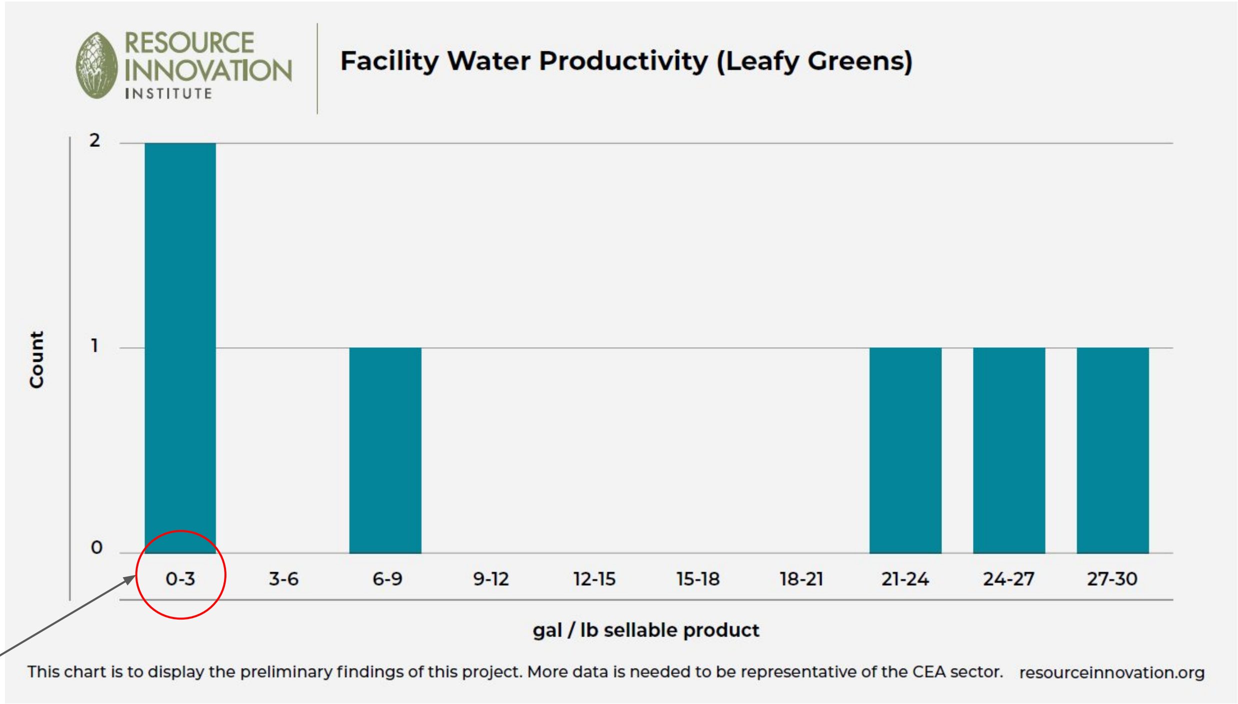


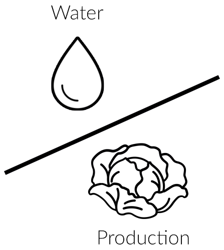
Best Practices Guide Featuring contributions from 15 Working Group member companies

Benchmarking Report Featuring annual resource consumption and productivity of twelve producers growing a variety of crops in greenhouse and indoor facilities across the US.

Access the reports for free on the RII catalog

Benchmarking Report Highlights





90% savings over field

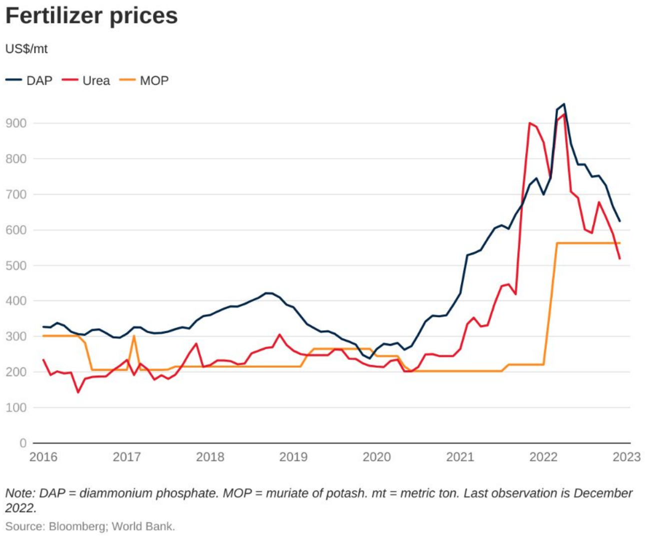
Water Waste in CEA Operations

Priority Rank	Type of Water Waste	Relevant To All Facilities	Potential High Waste Volume	Release Causes Environmental Harm	Potential Crop Damage	Substitute for RO Water	Potential to Improve ROI on Treatment Costs	Difficult to Remediate
1	Over Irrigation and Leaks	X	X	X	X		X	
2	Irrigation Leachate	X	X	X			X	
3	Pesticide Drench/ Overspray	X		X				X
4	RO Reject Water		X					X
5	Evaporative Cooling Pad Bleed-Off		X					X
6	Condensate		X			X		
7	Washdown Water	X						X
8	Blowdown Water							X

Economic Rationale For Reducing Water Consumption

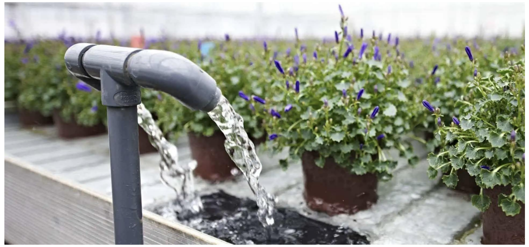
Reducing irrigation water has been shown to reduce fertilizer costs by **40%-50%**

CEA producers report ROI in as little as **two years** due to fertilizer cost reduction



Source: Mohammed, N. (2019). The Advantages of a Closed Hydroponic System in Commercial Greenhouses [Slide show; Powerpoint]. Government of Alberta. https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/green14458/$FILE/Nabeel%20J%20M-%20Oct%202017.pdf

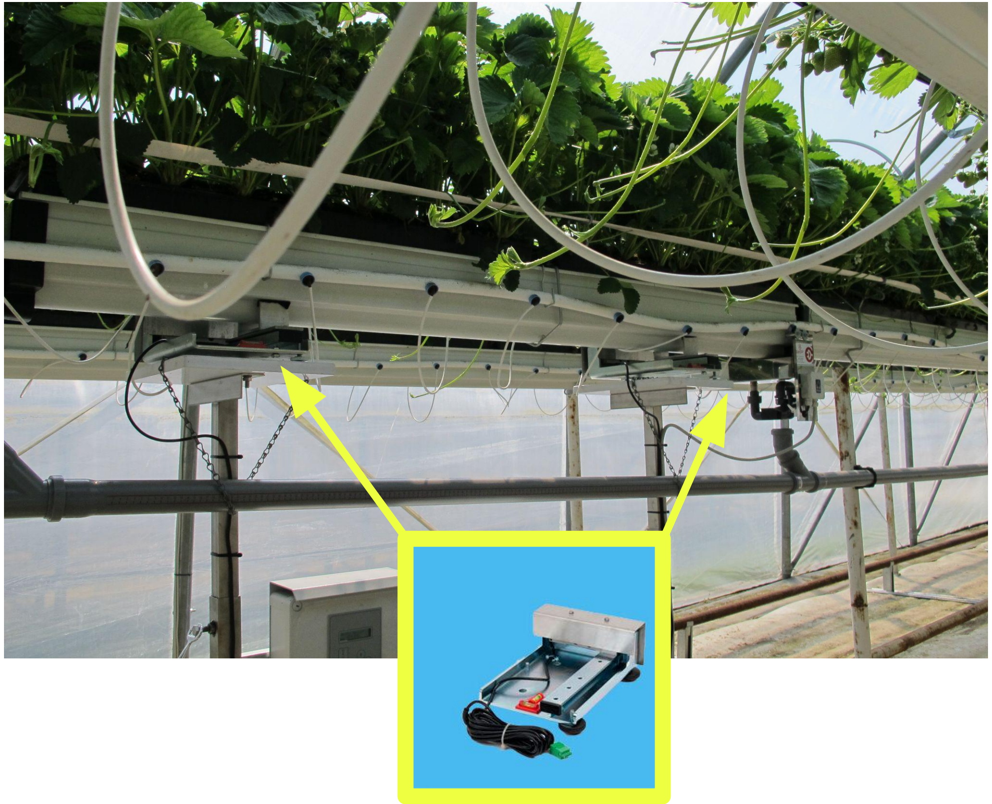
Reducing Irrigation Waste in Hort Substrate Culture



Staal Plast

Netafim

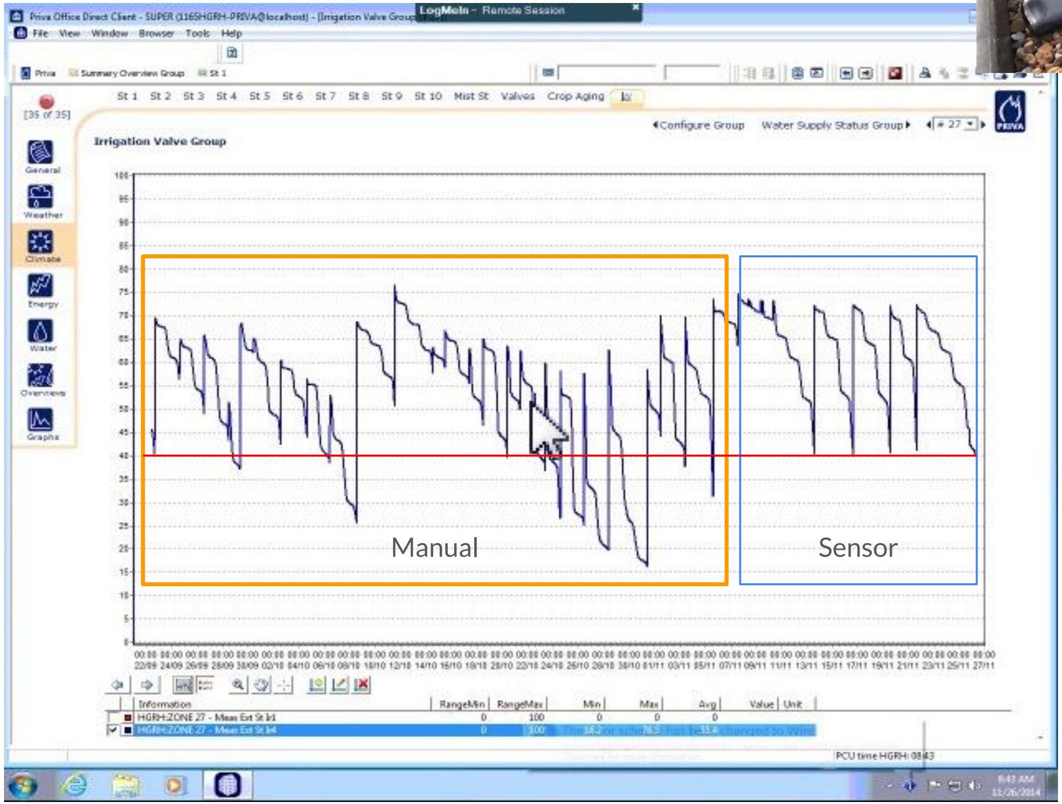
Reducing Irrigation Waste by Weight Scale Measurement



Powerplants Australia

Drain Sensors (volume, EC)

Reducing Irrigation Waste by Water Content Sensing



Reducing Irrigation Waste by Water Content Sensing

Image credit: Grodan

24-hour cycle for stone wool irrigation

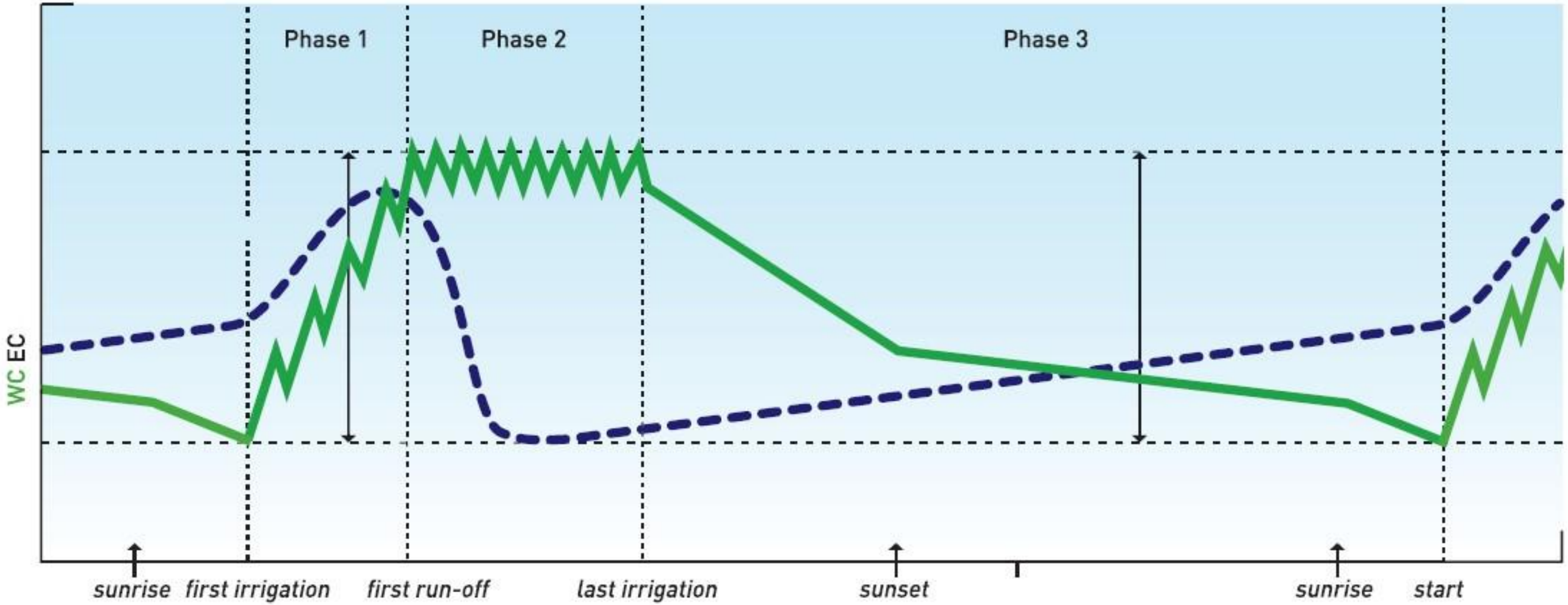
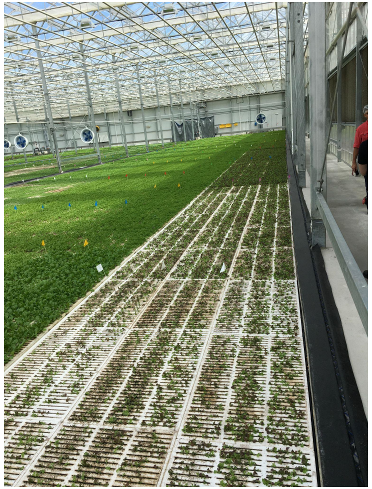


Image credit: Grodan and Priva

Reducing Irrigation Waste by Using Recirculating Systems

Nutrient Film Technique



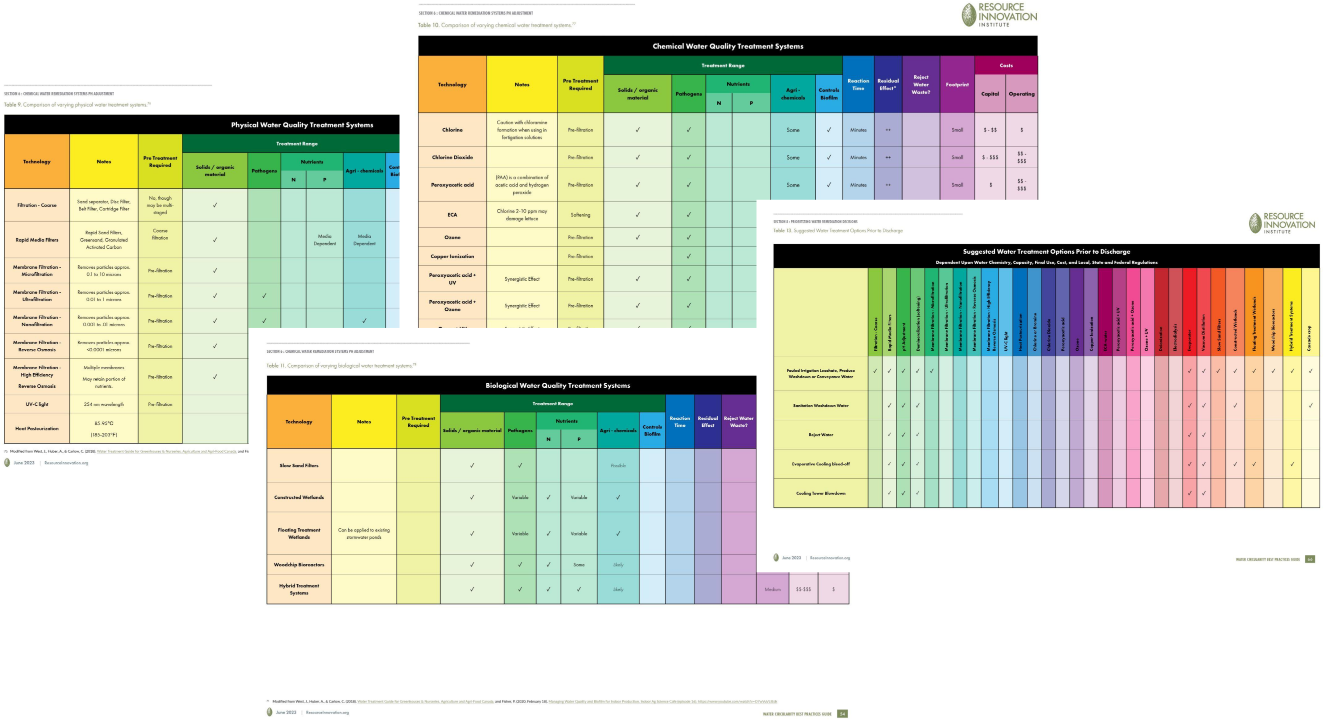
Raft Culture

Aeroponics

Deep Water Culture

Vertical NFT/Aeroponics

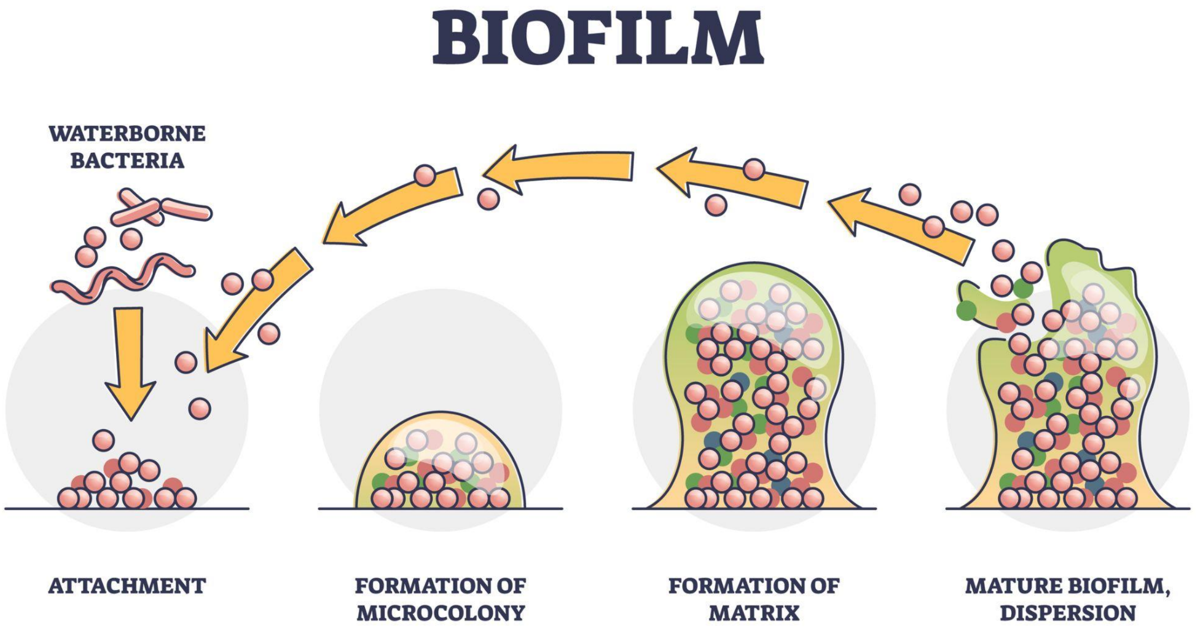
Water Treatment: Physical, Chemical and Biological



Your approach will be layered: filtration, instantaneous and residual controls

One example: cartridge filter, UV-C light, ozone

Biofilm



Control options:

- Ozone
- ECA-water
- Peroxyacetic acid
- Chlorine dioxide
- Nanobubbles

Alternative Water Source: HVACD Condensate

Research published in 2020 showed condensate water recovery accounted for 67% of the annual water demand for lettuce in a vertical farm

Inspire Transpiration Solutions

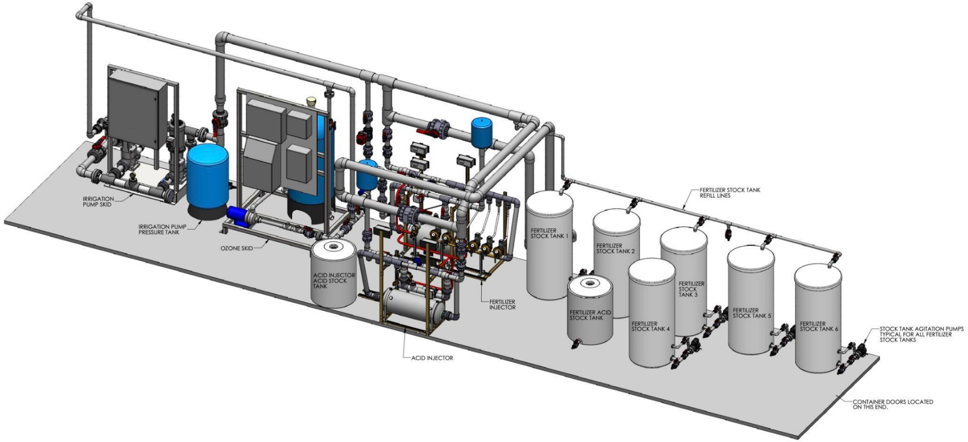
Source: Pacak, A., Jurga, A., Drag, P., Pandelidis, D., & Kaźmierczak, B. (2020). A Long-Term Analysis of the Possibility of Water Recovery for Hydroponic Lettuce Irrigation in Indoor Vertical Farm. Part 1: Water Recovery from Exhaust Air. Applied Sciences, 10(24), 8907.

Alternative Water Source: Rainwater

Metrolina Greenhouses in Huntersville, NC has been reclaiming rainwater for more than 20 years. They do not draw on the local water table.

Water Treatment Equipment and Storage

Silver Bullet

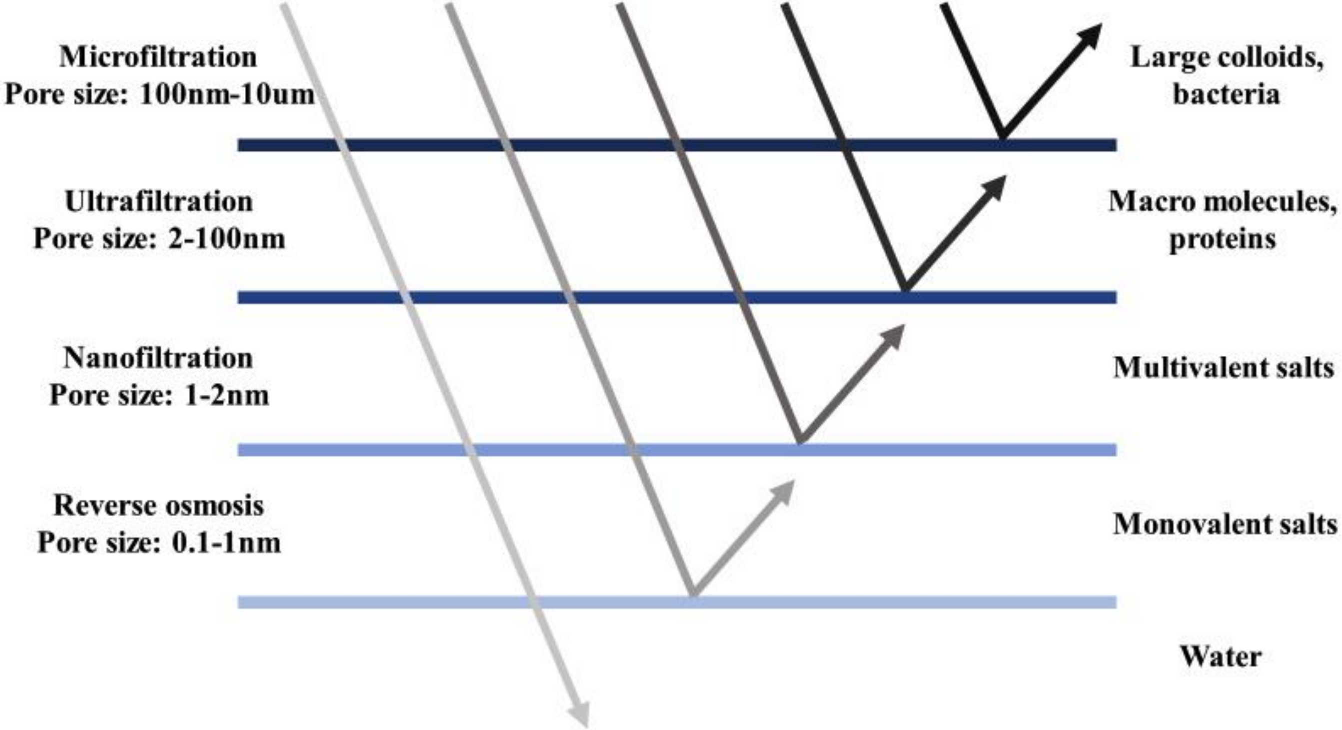


Dramm Corporation

Priva and Grodan

Discussion
Audience Q & A

Membrane Filtration



THANK YOU USDA NRCS!

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Discussion questions

1. **Kyle, I've heard you say that assessing your source water is how to get started in water circularity. How does that kind of assessment impact planning, sizing etc?**
2. **Andy, as a grower moves toward recirculating irrigation water, what water quality issues do they need to monitor more closely than before?**
3. **Kyle, how does biofilm impact water quality, and does it impact facility design?**
4. **Andy, what are some examples of water or fertilizer waste you've seen in greenhouses or indoor farms? Especially the ones that the grower was not aware of or was not addressing?**
5. **Kyle, Ultra filtration and RO are hot topics right now in water remediation. Can you explain the difference/similarities?**
6. **Andy, are precision irrigation models like the one you showed us for tomato being developed for other CEA crops?**

Water Use Efficiency by Production Method

Production Method	Country	Product water use (L/kg)	Product water use (gal/lb)
Open field, general	Israel, Spain, Turkey	100-300	12-36
Open field, drip irrigation	Israel	60	7
Greenhouse, unheated plastic	Spain	40	5
Glasshouse, unheated	Israel	30	4
Greenhouse, regulated ventilation, plastic	Spain	27	3
Glasshouse, advanced controls, CO_2	Netherlands	22	3
Glasshouse, advanced controls, CO_2, closed hydroponic system	Netherlands	15	2
Closed Greenhouse, advanced controls, CO_2, closed hydroponic system	Netherlands	4	0.5
Greenhouse, evaporative cooling	Mexico	Estimated: 100	Estimated: 12

Modified from Nederhoff, Elly & Stanghellini, Cecilia. (2010).

An Often Overlooked Source of GH Water Waste…

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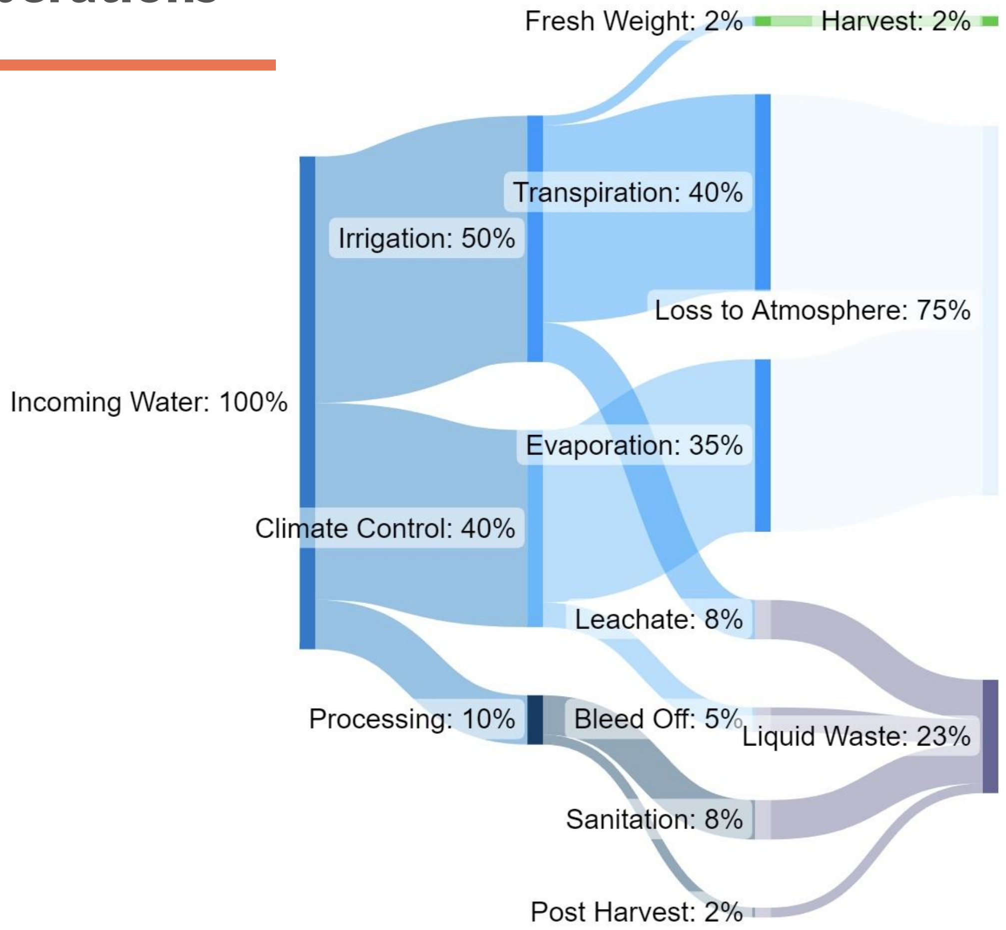
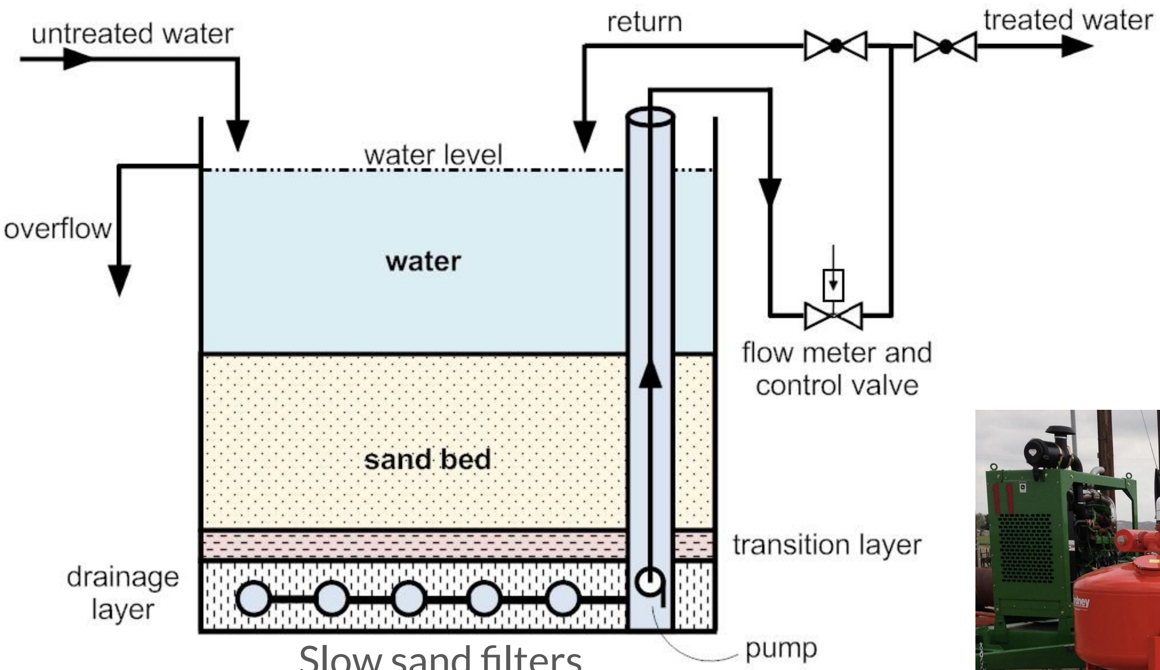
Fate of Water in CEA Operations

Standard Greenhouse



Biological Remediation



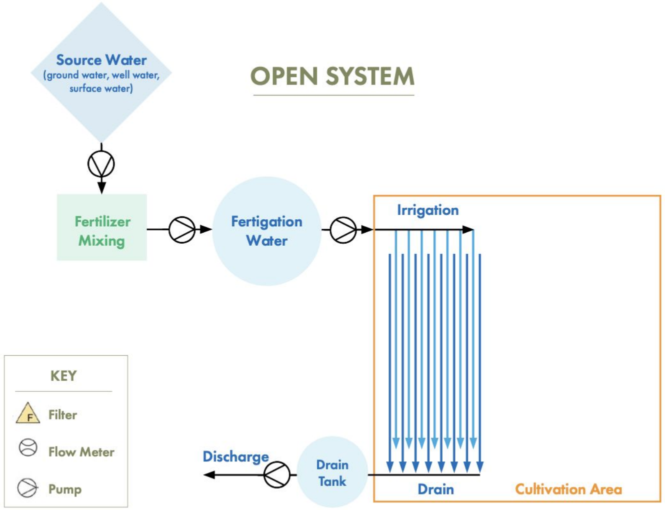
Slow sand filters

Constructed wetlands

Image credit: Netafim, Inc.

Containerized slow sand filters

Putting It All Together



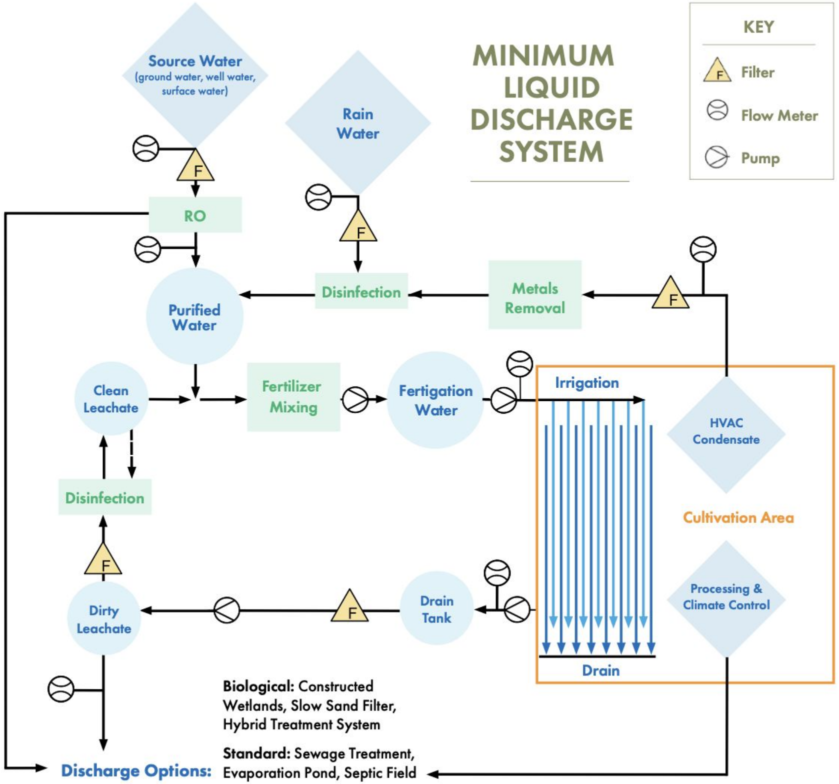


Table 10. Comparison of varying chemical water treatment systems.[77]

Chemical Water Quality Treatment Systems														
Technology	Notes	Pre Treatment Required	Treatment Range						Reaction Time	Residual Effect*	Reject Water Waste?	Footprint	Costs	
			Solids / organic material	Pathogens	Nutrients		Agri - chemicals	Controls Biofilm					Capital	Operating
					N	P								
Chlorine	Caution with chloramine formation when using in fertigation solutions	Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$ - $$	$
Chlorine Dioxide		Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$ - $$$	$$ - $$$
Peroxyacetic acid	(PAA) is a combination of acetic acid and hydrogen peroxide	Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$	$$ - $$$
ECA	Chlorine 2-10 ppm may damage lettuce	Softening	✓	✓				✓	Minutes	+		Small		
Ozone		Pre-filtration	✓	✓			Some	✓	Minutes	+		Medium	$$$	$
Copper Ionization		Pre-filtration		✓					Hours	++		Small	$$$	$
Peroxyacetic acid + UV	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	Minutes	++		Medium	$$$$	$$$ - $$$$
Peroxyacetic acid + Ozone	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	MInutes	++		Medium	$$$$	$$$ - $$$$
Ozone + UV	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	Minutes	+		Medium	$$$$$	$$
Deionization	Higher purity than typically needed	Pre-filtration and Reverse Osmosis to reduce cost	✓	✓	✓	✓	✓		Minutes		+++	Medium	$$$$$	$$$

*All technologies other than point treatments such as membrane filtration or UV have potential for phytotoxicity at high doses. Make sure to follow label and manufacturer recommendations on dose, monitoring, and maintenance.

77 Modified from West, J., Huber, A., & Carlow, C. (2018). Water Treatment Guide for Greenhouses & Nurseries. Agriculture and Agri-Food Canada. and Fisher, P. (2020, February 18). Managing Water Quality and Biofilm for Indoor Production. Indoor Ag Science Cafe (episode 16). https://www.youtube.com/watch?v=O7wVuVLIEdk

Recycling Rain/Condensate

Quality level	EC (mS/cm)	Na (ppm)	Cl (ppm)	Suitability for hydroponics	Suitable use
1	< 0.5	< 34	< 53	++	Suitable for all crops
2	0.5 - 1.0	34 - 57	53 - 87	+	Some discharge required in recirculating systems
3	1.0 - 1.5	57 - 92	87 - 142	±	Not suitable for salt-sensitive crops or recirculated closed systems

Hydroponic producers commonly purify source water using reverse osmosis, with a typical 50% efficiency, meaning they create **1 gallon of brine waste for 1 gallon of purified water**.

High-efficiency RO units can increase efficiency to 85% or higher.

Alternatively, rainwater or HVAC condensate can be used as near-pure water sources.