

Natural Systems Technologies: Old and New

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Brown and Caldwell

Natural Treatment Systems

Onsite systems

Ponds

Land treatment

Constructed wetlands

Aquatic treatment systems

Land Treatment Systems

Irrigation

Soil aquifer treatment

Overland flow

Land Treatment History

- 1846 – Land farming in England and Europe
- 1881 – Pullman, Illinois spray irrigation system
- 1897 – Werribee Farm developed in Melbourne
- 1935 – Survey in US – Bakersfield, San Antonio, Fresno, Woodland, CA
- 1946 – Sprinkler irrigation of food processing and pulp and paper wastewater
- 1960's - Penn State Living Filter
- 1970's – Muskegon and Clayton County



Nitrogen Removal in Land Treatment

- Slow Rate
 - Plant uptake
 - Nitrification/denitrification
 - Volatilization
 - Soil Storage as humus
- Soil Aquifer treatment
 - Nitrification/denitrification
- Overland Flow
 - Nitrification/denitrification
 - Plant uptake

Nitrogen Removal in Slow Rate Land Treatment

Location	Applied Wastewater, mg/L	Process Effluent, mg/L
Dickinson, N.D.	12	3.9
Hanover, N.H.	28	7.3
Roswell, N.M.	66	10.7
San Angelo, TX	35	6.1
Yarmouth, MA	30.8	1.8

Phosphorus Removal in Land Treatment

Slow Rate

- Adsorption
- Precipitation (Chemical)
- Plant uptake
- Soil Storage as humus

Soil Aquifer Treatment

- Adsorption
- Precipitation (Chemical)

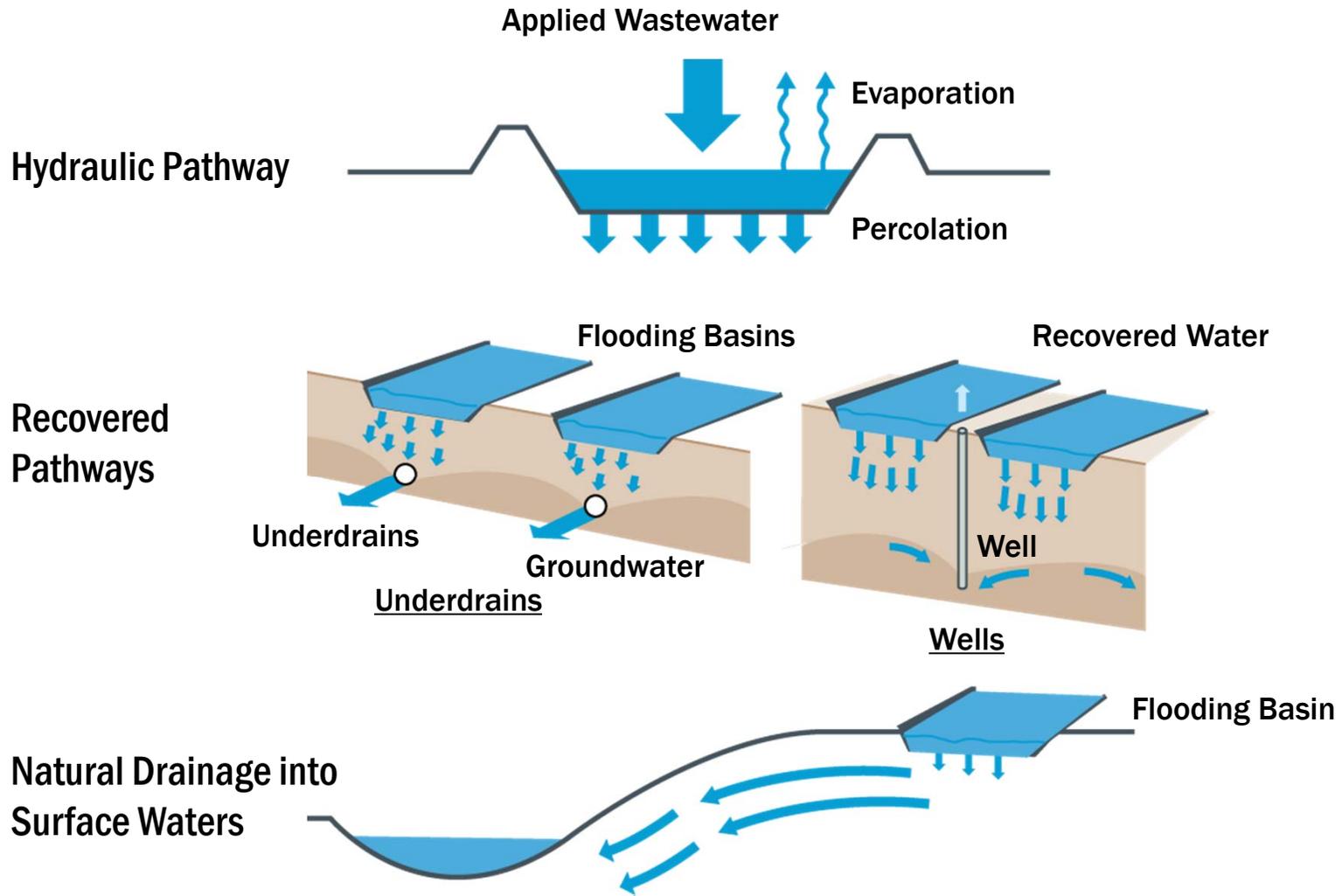
Overland Flow

- Adsorption
- Plant uptake
- Limited to 40-50% removal

Phosphorus Removal in Slow Rate Land Treatment

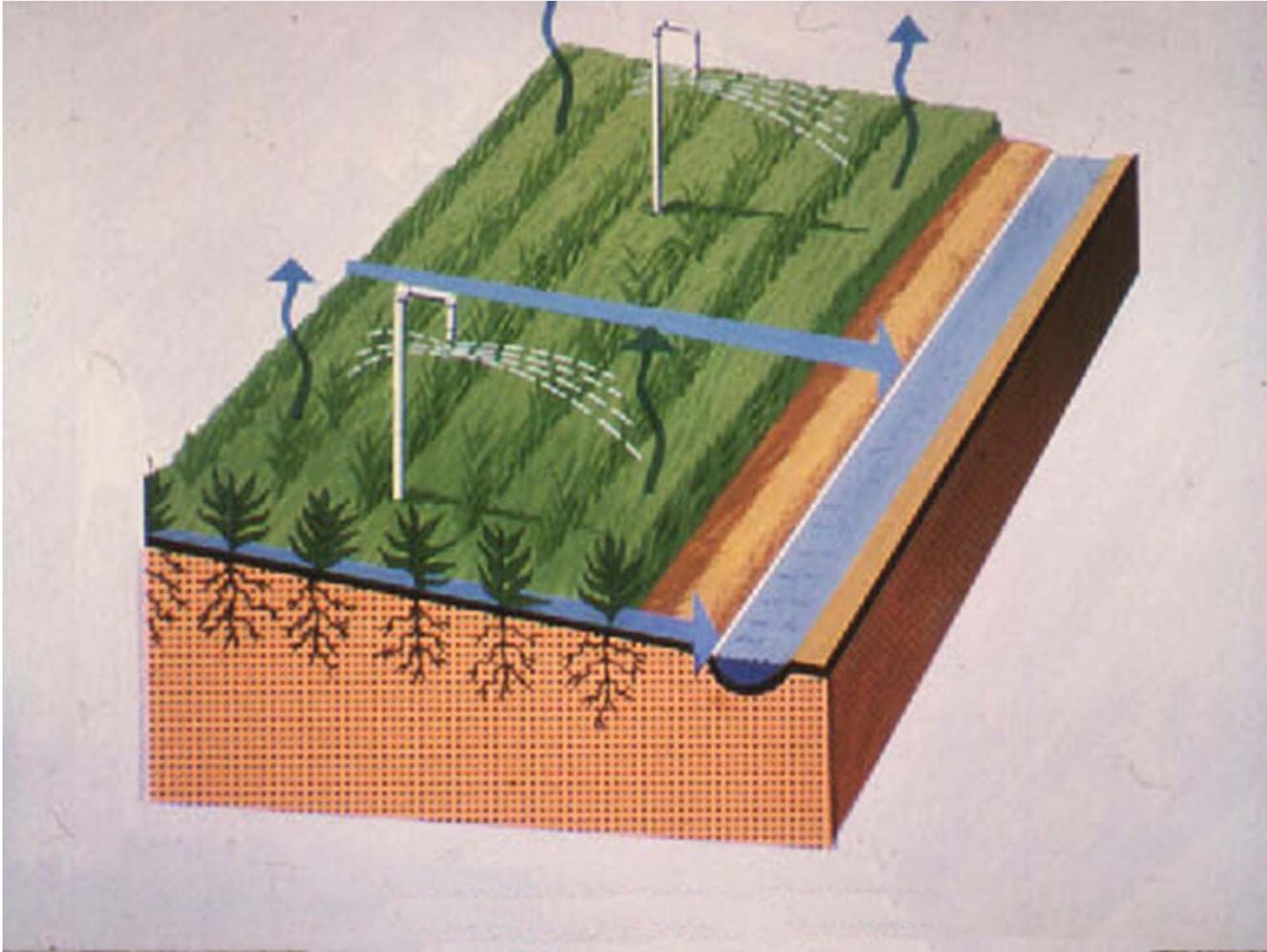
Location	Applied Wastewater, mg/L	Percolate (Effluent), mg/L
Helen, GA	13.1	0.22
Penn State, PA	5.6	0.08
Hanover, NH	7.1	0.03
Wolfeboro, NH	3.3	0.02
Clayton Co. GA	4.9	0.02

Soil Aquifer Hydraulic Pathways





Overland Flow





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Nitrogen Removal in Overland Flow

Location	Applied Wastewater, mg/L	Process Effluent, mg/L
Ada, OK		
Raw Wastewater	34	7
Primary Effluent	19	5
Secondary Effluent	16	8
Easley, S.C.	7	2
Utica, MS	20	7

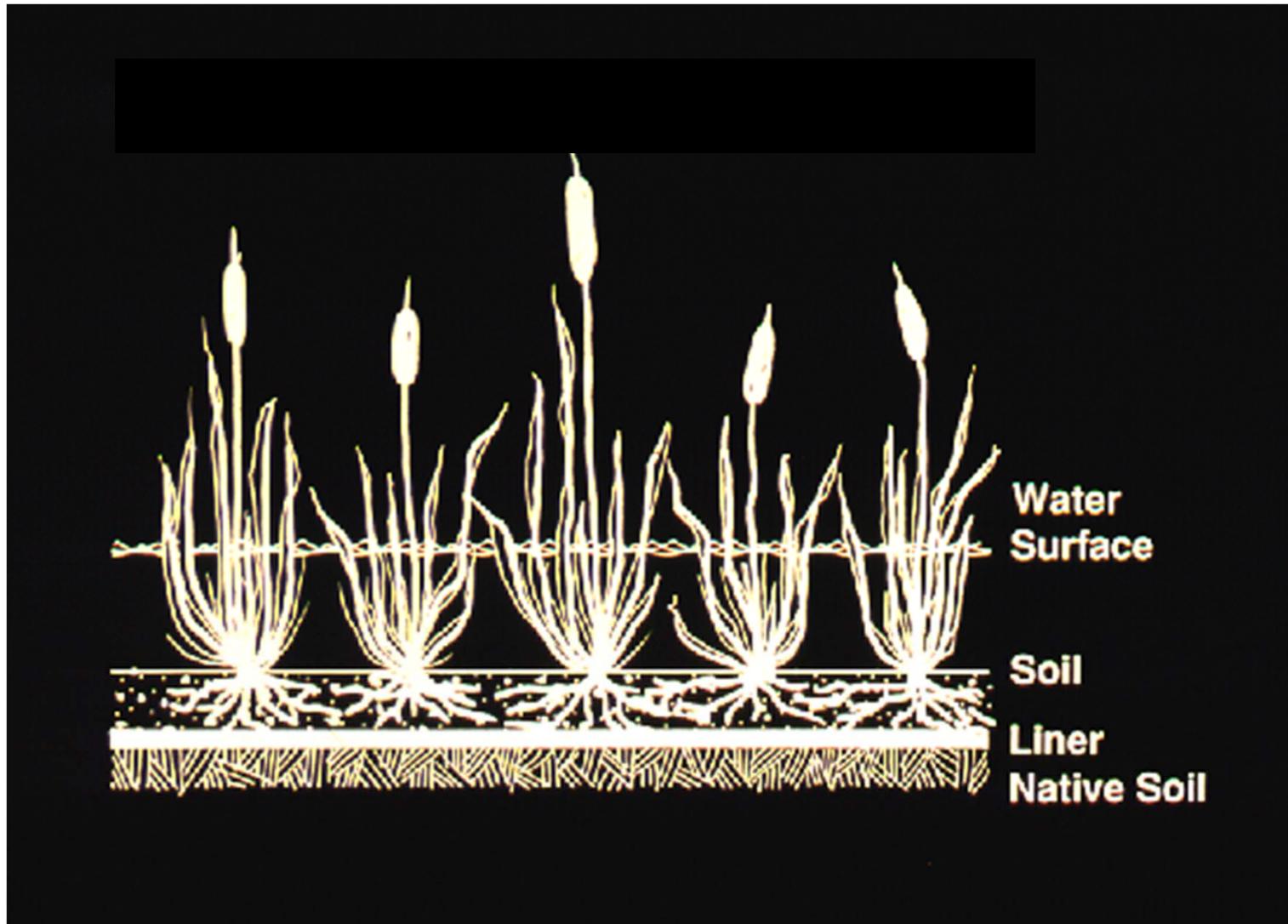
Types of Constructed Wetlands

Free water surface (FWS)

Subsurface flow (SSF)

Vertical flow (VF)

Free Water Surface Wetland











Uses of Constructed Wetlands

Wastewater Treatment

Nutrient Removal

Toxics Removal

Temperature Reduction

Habitat Creation

Stormwater Management



Role of Plants in Wetland System

Plant Uptake of Pollutants

Substrate for Microorganisms

Oxygen Source

Restrict Sunlight and Wind

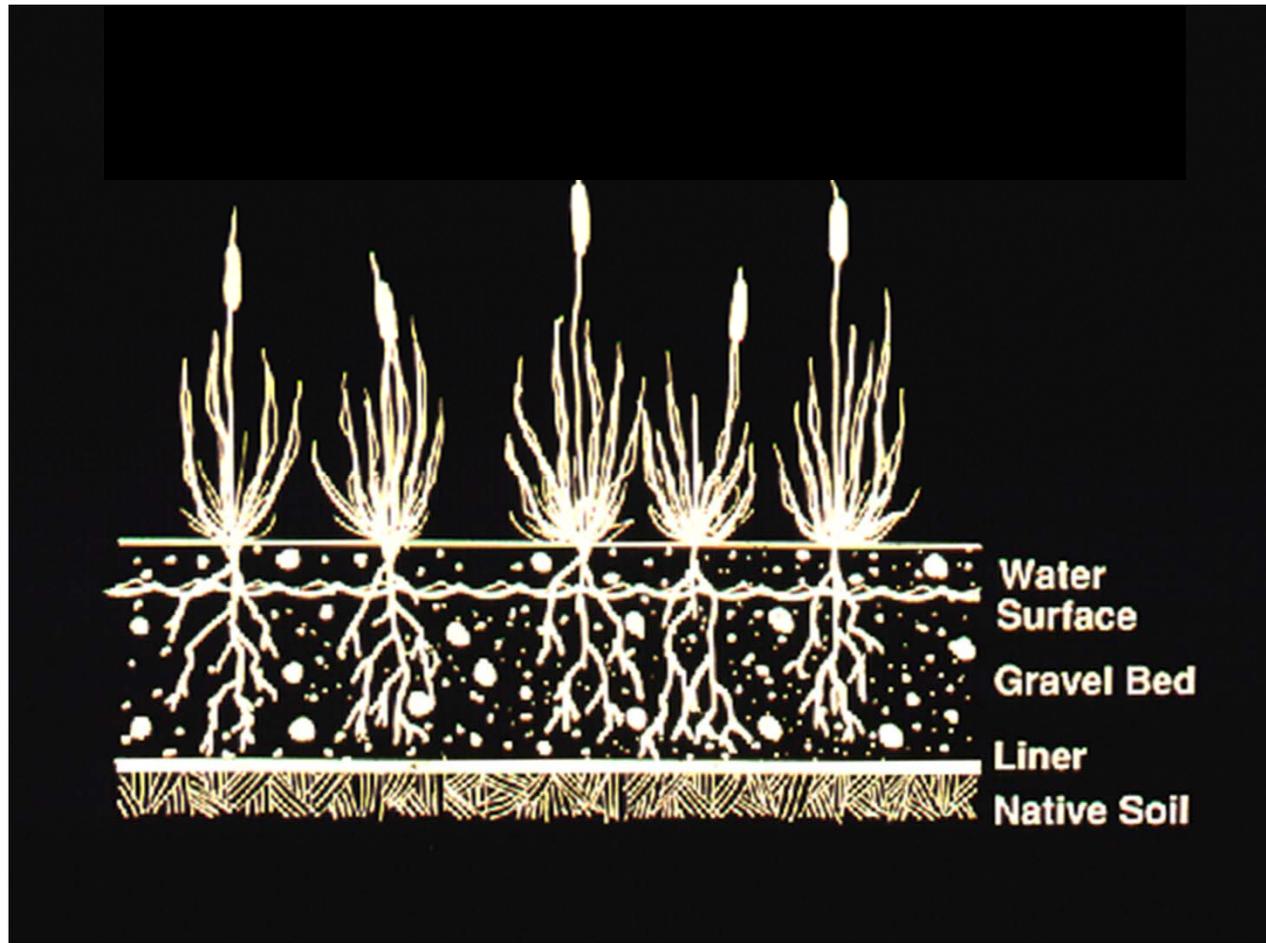
Habitat for Wildlife

Source of Litter and Carbon





Subsurface Flow Wetland



Denham Springs, LA SSF Wetlands







Nitrogen Removal in Wetlands

FWS and SSF

- Nitrification/denitrification
- Plant Uptake

Vertical Flow

- Nitrification

Nitrogen Removal in FWS Wetlands

Location	Applied mg/L	Process Effluent, mg/L
Blue-Collar Wetlands		
Kingman, AZ	33.0	13.0
Sacramento, CA	16.9	11.0
Listowel, ONT	19.0	9.0
Lightly-Loaded Wetlands		
Imperial, CA	6.6	3.8
Tres Rios, AZ	5.6	2.4
Brawley, CA	7.6	2.3
Lakeland, FL	10.4	2.0
Orlando, FL	3.0	0.8

Phosphorus Removal in Wetlands

- Free Water Surface
 - Plant uptake and burial in detritus
 - Adsorption
- Subsurface Flow
 - Adsorption
 - Plant Uptake
- Vertical Flow
 - Adsorption
 - Plant uptake

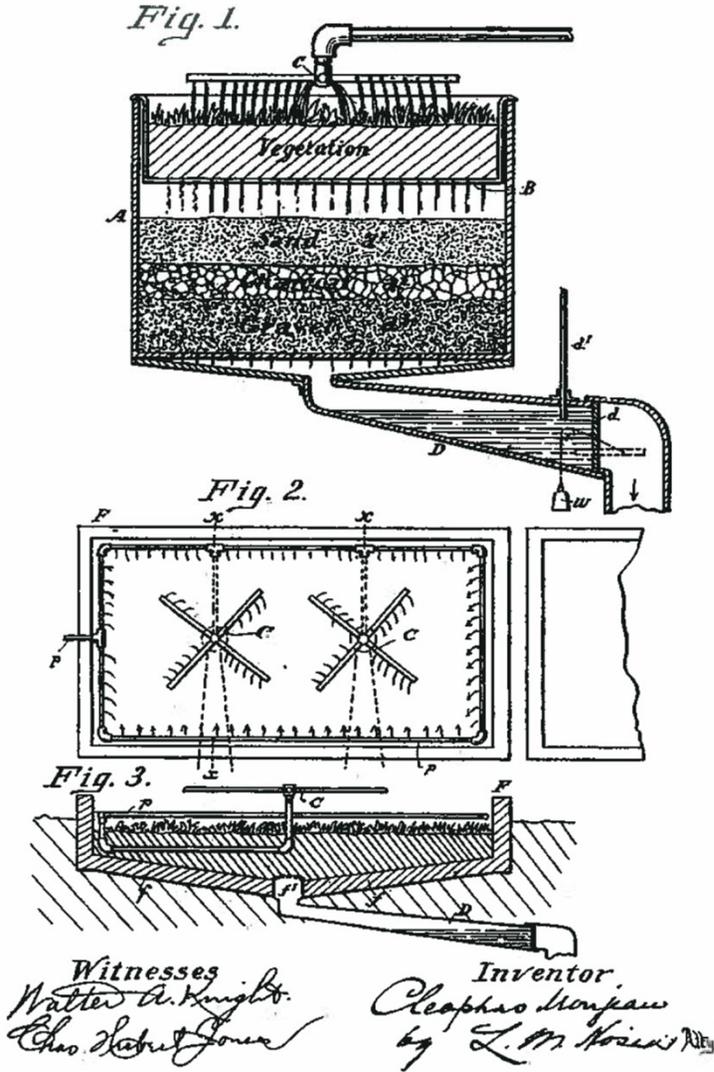
Phosphorus Removal in FWS Wetlands

Location	Applied Wastewater, mg/L	Percolate (Effluent), mg/L	Percent Removal, %
Sea Pines, S.C.	3.9	3.4	14
Leaf River, MS	5.2	4.0	23
Lakeland, FL	6.5	5.7	13
Sacramento, CA	2.4	2.1	13
Benton, KY	4.5	4.1	10
Listowel, ONT	1.9	0.7	62
Brookhaven, NY	11.1	2.3	79
Clermont, FL	9.1	0.2	98
Salem, OR	2.2	1.0	55
Pembroke, KY	3.0	0.1	96

Orlando Easterly Wetlands



VF Wetland 1901

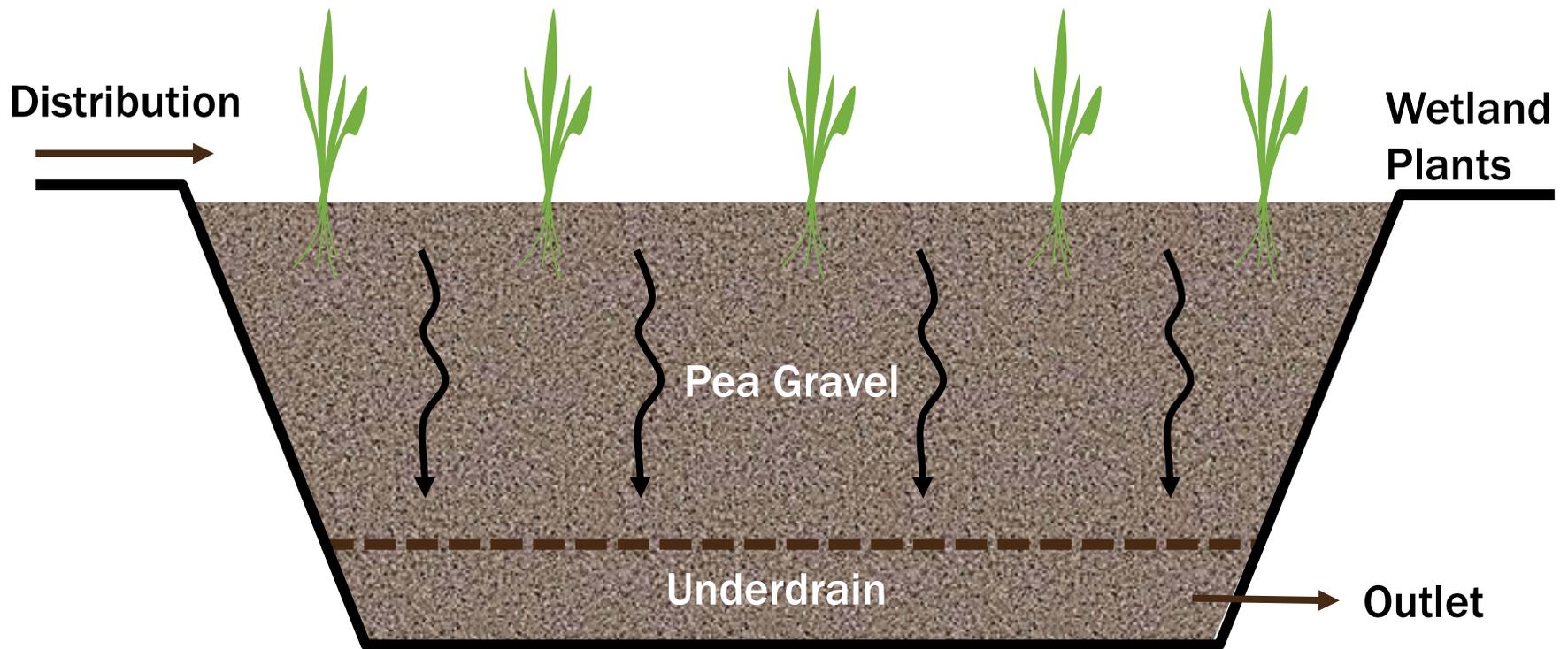


Recirculating gravel filters





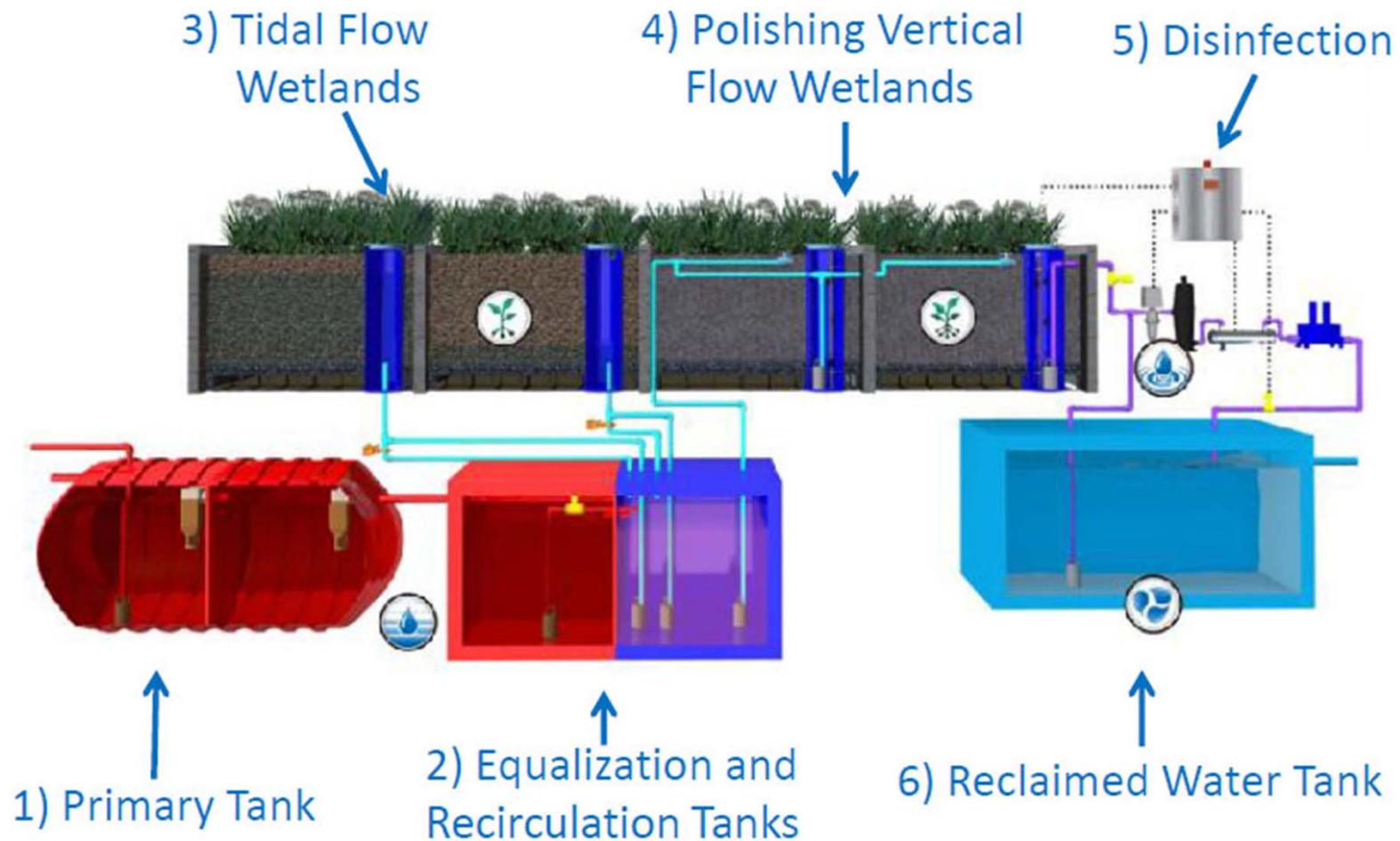
Vertical Flow Wetlands



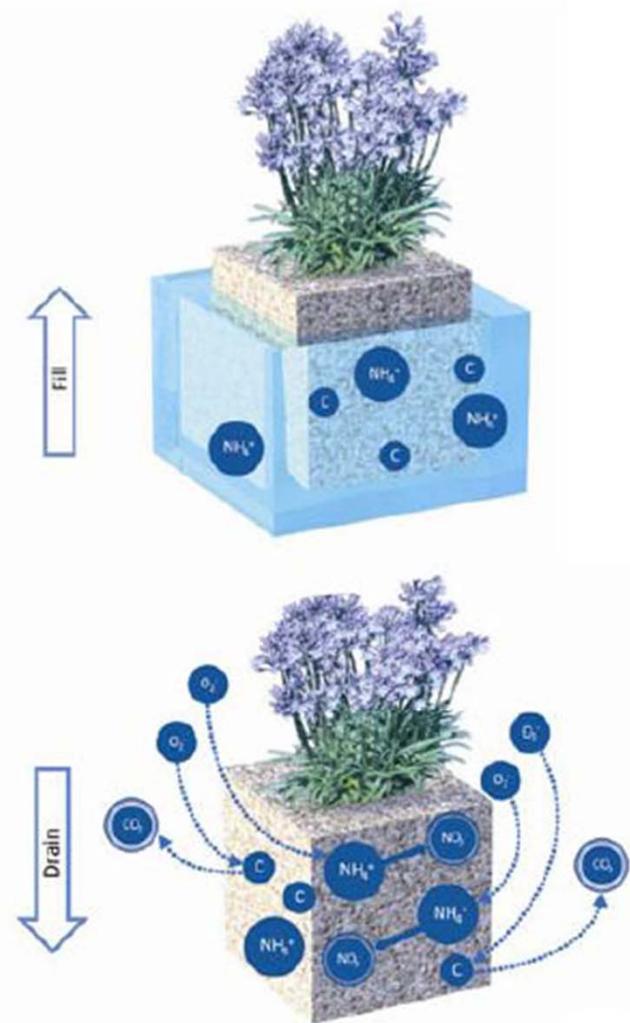




Living Machine



Tidal flow Wetland



Polishing Vertical Flow Wetlands



Questions?

