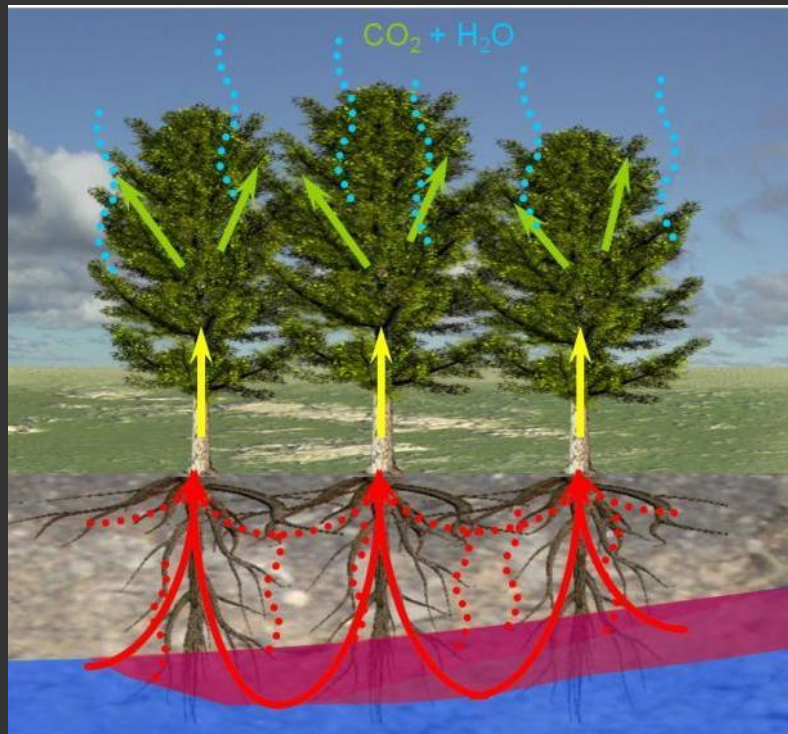


Spray and Sub-surface Effluent Irrigation as a Treatment Strategy

Bart Sexton



Providing further effluent treatment while eliminating surface water discharges

WHY CONSIDER IRRIGATION?

1. Anticipation of future regulations
2. Additional treatment of effluent
3. Cost considerations

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National Water-Quality Assessment (NAWQA) Program

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Nitrate in the Mississippi River and its tributaries, 1980 to 2010: Are we making progress?

Trends in Nitrate from 1980-2010

★ [Nitrate in the Mississippi River and Its Tributaries, 1980–2010: An Update \(Press Release | Report\)](#)

★ [Article describing trends from 1980-2008](#)



U.S. Geological Survey personnel collecting a water quality sample at the Missouri River at Hermann, Missouri in July, 2011. Photo by Kelly Brady, USGS

Nitrate Trends (1980-2010)

[Mississippi River at Clinton, IA](#)

[Iowa River at Wapello, IA](#)

[Illinois River at Valley City, IL](#)

[Mississippi River below Grafton, IL](#)

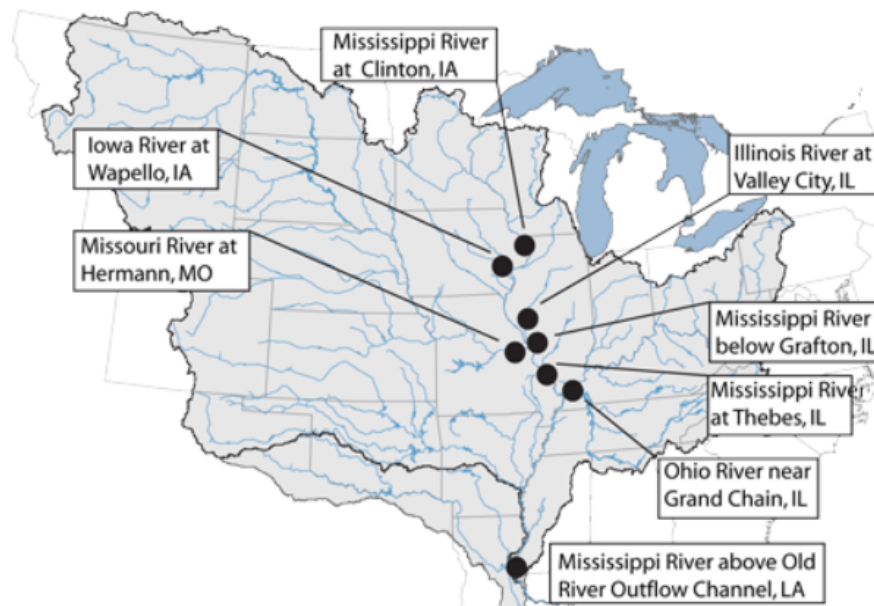
[Missouri River at Hermann, MO](#)

[Mississippi River at Thebes, IL](#)

[Ohio River near Grand Chain, IL](#)

[Mississippi River above Old River Outflow Channel, LA](#)

[Channel, LA](#)



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Hormone-Mimicking Chemicals Found throughout Great Lakes

Chemicals that make it through sewage treatment are found throughout Great Lakes waterways

March 23, 2015 | By [Brian Bienkowski](#) and [Environmental Health News](#)

Larry Barber spent ten years testing water and fish in the Great Lakes region. But he wasn't looking for the pollutants everyone's heard of.

Mercury ... PCBs ... these are still problems. But there's a lesser-known class of contaminants, which have insidious and concerning health impacts on aquatic creatures.

Barber, a research geologist with the U.S. Geological Survey, was looking for, and found, hormone-disrupting compounds – called alkylphenols - making it through wastewater treatment plants and [contaminating rivers and fish](#) in the Great Lakes and Upper Mississippi River regions.



Meanwhile, scientists fear the biologically active contaminants and their metabolites may alter the hormones of fish and other aquatic creatures, leading to reproductive, behavioral and developmental problems.

Credit: US Army Corps of Engineers

Water: Total Maximum Daily Loads (303d)

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You are here: [Water](#) » [Laws & Regulations](#) » [Laws & Executive Orders](#) » [Clean Water Act](#) » [Impaired Waters and Total Maximum Daily Loads](#)

Impaired Waters and Total Maximum Daily Loads

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- [Drinking Water](#)
- [Education & Training](#)
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- [Science & Technology](#)
- [Water Infrastructure](#)
- [What You Can Do](#)

Quick Finder

Air Deposition	New Vision for Implementing the Program	TMDL Recent Additions	Water Quality Standards
Healthy Watersheds	Nonpoint Source Pollution	TMDL Regulations	Water Quality Trading
How's My Waterway?	NPDES Permits	TMDL Technical Resources	Watershed Academy
Nitrogen and Phosphorus	Recovery Potential	Tribal Consultation	Webcasts
Pollution Data Access Tool	TMDL Guidance	Water Quality Inventory Report to Congress	Watershed Central
Integrated Reporting (ATTAINS)	TMDL Litigation	Water Quality Monitoring and Assessment	

Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.

On December 5, 2013, EPA announced a new collaborative framework for implementing the Clean Water Act Section 303(d) Program with States [A Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303\(d\) Program](#). This Vision reflects the successful collaboration among States and EPA, which began in August 2011. While the Vision provides a new framework for implementing the CWA 303(d) Program, it does not alter State and EPA responsibilities or authorities under the CWA 303(d) regulations.

Basic Information

- [National Summary of Impaired Waters and TMDLs](#)
- [Geographic Information Systems \(GIS\) Data Downloads](#)
- [How's My Waterway](#) local search tool

Example TMDLs

- [Pathogens](#)
- [Nutrients](#)
- [Sediment](#)
- [Mercury](#)
- [Metals \(other than mercury\)](#)
- [More Example TMDLs...](#)

Features

- [Water Quality Modeling Workgroup](#)
- [Tribal Consultation: Rulemaking to Provide More Opportunities for Tribes to Engage in Clean Water Act Section 303\(d\)](#)

Regulatory Challenges to Surface Water Discharge

1. Increasing regulation
 - a. Phosphorus
 - b. Ammonium
 - c. Pharmaceuticals
 - d. TMDL designations, room for growth

**DUCK CREEK
TOTAL PHOSPHORUS**

Sub-basin Loading Summary (lbs/yr)	
Baseline	63,172
TMDL	23,252
Reduction	39,920
% Reduction Needed	63.2%
Daily TMDL (lbs/day)	63.66

Land Use	Acres			% of Total
	State	Oneida	Total	
Agriculture	30,098	18760	48,858	56.0%
Urban (non-regulated)	5,407	3585	8,992	10.3%
Urban (MS4)	7,512	4570	12,082	13.8%
Construction	214	131	345	0.4%
Natural Background	8,972	8020	16,992	19.5%
TOTAL	52,203	35,066	87,269	100.0%

Sources from State Land	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	30,382	7,028	23,354	76.9%	19.24
Urban (non-regulated)	2,070	2,070	-	-	5.67
Natural Background	790	790	-	-	2.16
LOAD ALLOCATION	33,242	9,888	23,354	70.3%	27.07
Urban (MS4)	4,076	2,853	1,223	30.0%	7.81
Construction	532	532	-	-	1.46
General Permits	224	224	-	-	0.61
WWTF-Industrial	74	74	-	-	0.20
WWTF-Municipal	542	542	-	-	1.48
WASTELOAD ALLOCATION	5,448	4,225	1,223	22.4%	11.56
TOTAL (WLA + LA)	38,690	14,113	24,577	63.5%	38.63

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	2	1.40	0.60	30.0%	-
Ashwaubenon	302	211.39	90.61	30.0%	0.58
Green Bay	474	331.79	142.21	30.0%	0.91
Hobart	-	-	-	-	-
Howard	2,790	1,952.92	837.08	30.0%	5.35
Suamico	508	355.58	152.42	30.0%	0.97

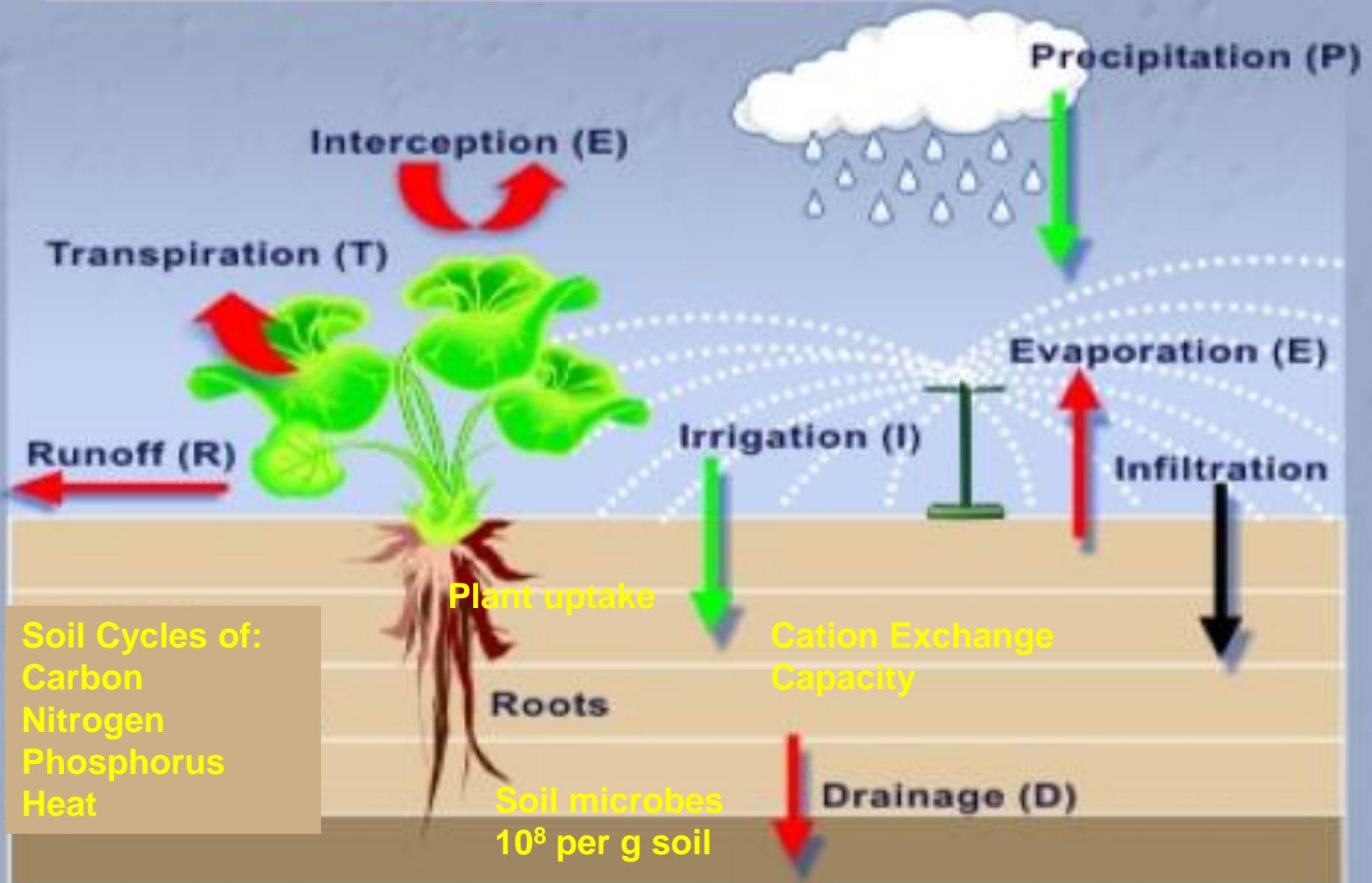
WWTP-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Provimi Foods - Seymour	74	74	-	-	0.20

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Freedom San. Dist. #1	542	542	-	-	1.48

WHY CONSIDER IRRIGATION?

1. Anticipation of future regulations
2. Additional treatment of effluent
3. Cost considerations

Soil - Plant - Atmosphere Interactions



Additional Treatment of Effluent Via Irrigation



Filtering physical & electrochemical

Plant uptake of nutrients

Microbe nutrient uptake & sequestration

Microbial degradation nitrate, VOCs, Pharms



Like any WWTF process,
irrigation requires management

1. Nutrient Loading
2. Hydraulic Loading

Effluent Irrigation Management

1. Nutrient Loading:

a. crop uptake

b. soil processes (sequestration & breakdown)

2. Hydraulic Loading

a. evapotranspiration (May-mid October)

b. soil drainage

Groundwater Discharge via Hybrid Tree Plantations



Hydraulics

Plant Evapotranspiration (ET)

Storage, a function of soil texture and structure

Drainage, a function of soil texture and structure

Why hybrid trees?



1. High evapotranspiration (ET) rates
2. Earlier start than most agronomic crops
3. High nutrient requirements
4. Enhanced microbial activity in rhizosphere*
5. Specifically planted for effluent treatment
6. Easily expanded in the future
7. Perennial with 25 – 50+ year lifespan

Crop Pros/Cons

1. Corn and alfalfa can uptake 200 lbs N/acre
2. Corn only has high evapotranspiration (ET) rates ' late June - August
3. Irrigation of corn and alfalfa in a wet year may promote disease, especially fungal infections
4. Maximization of crop yield may not be in line with effluent irrigation requirements
5. Better economic return than trees, but requires greater acreage and frequent site tillage/planting

Hybrid Poplar or Willow Trees

1. High evapotranspiration (ET) rates May - September
2. High nutrient uptake and sequestration
3. Poplar and willows are phreatophytes,
“water loving plants”, water is typically limiting factor to their growth
4. Tree plantations established to treat effluent



2022



Example: Woodburn, OR



Northern Alberta, Canada



Willow cuttings



3rd year willow plantation



From Abrahamson et al. 2002
SUNY

Salix dasycarpus, From
Abrahamson et al. 2002- SUNY

Limiting Factors Tree Plantation Outfalls

Available land with

Sufficient offsets

Suitable soils

Nutrient loading

Limiting Factors as per NR 206

Hydraulic Loading

Up to 10,000 gal/ac/day

DNR recommends 2,000 – 7,000 gal/ac/day

Crop not required to ET all water

Limiting Factors

Nutrient Loading (primarily N)

Must be at an agronomic rate

Hybrid poplar in WI can
uptake/denitrify/sequester

275+ lbs N/ac/year



Plantation Management

Control of grasses/weeds first 3 growing seasons

Irrigation System O&M

Forest Management Plan

Product outlet(s)



Willow: biomass (Domtar plant, Rothschild)

Poplar: biomass, pulp, lumber

WHY CONSIDER IRRIGATION?

1. Anticipation of future regulations
2. Additional treatment of effluent
3. Cost considerations

Cost

Planting (farm field)*	\$ 2,000/ac
Irrigation (spray)	\$ 4,000/ac
Irrigation (in ground)	\$ 10,000/ac
Holding Pond	\$ 70,000/ac
Deer Fencing	\$ 8/foot

* Land clearings costs can be more than the cost of agricultural land

Costs example

A 50,000 gallon/day lagoon treatment system with a fill and draw discharge regime (has holding pond with 7 month volume)

25 MG annual design discharge using spray irrigation

Costs example

25 acres of land required (@ 1 MG/ac/year)

Land 40 ac @ \$5,000/ac	\$ 200,000
Plant/irrigate 25 ac @ \$6,000/ac	\$ 150,000
5,000 ft of fencing @ \$8/ft	\$ 40,000
Pump, filter, controls, electrical	\$ 200,000
Monitoring wells	\$ 15,000
PM/Mobe/Insurance	\$ 50,000
10% Contingency	\$ 42,000
<u>Engineering</u>	<u>\$ 100,000</u>
	\$ 797,000
<i>If sufficient suitable land already owned</i>	<i>\$ 597,000</i>

SOIL TREATMENT PERFORMANCE AND COLD WEATHER OPERATIONS OF DRIP DISTRIBUTION SYSTEMS

R. M. Bohrer and J. C. Converse^{*}

ABSTRACT

As the population increases, suitable land for wastewater treatment and dispersal decreases. Drip distribution of wastewater is becoming more popular as an alternative form of on-site wastewater dispersal. This method of dispersal distributes the wastewater in small uniform doses, allowing the soil system more opportunity to treat the wastewater before it reaches the groundwater, even on less suitable soil types. This protects the environment as well as human health.

With proper design and maintenance, sub-surface drip systems can be operated year 'round.

Five Soil Forming Factors

1. Parent Material
2. Climate
3. Relief/Topography/Aspect
4. Biota Plants, animals, microbes
5. Time

Subsurface Drip Irrigation

1. 12 inch depth with good ground cover, in most cases, is sufficient to prevent freezing
2. Drainage of laterals between dosings critical
3. Loading based on soil texture and structure (think septic systems). **Plants help to maintain and improve soil structure & drainage**
4. Reduces acreage required
5. Reduces storage volume requirements

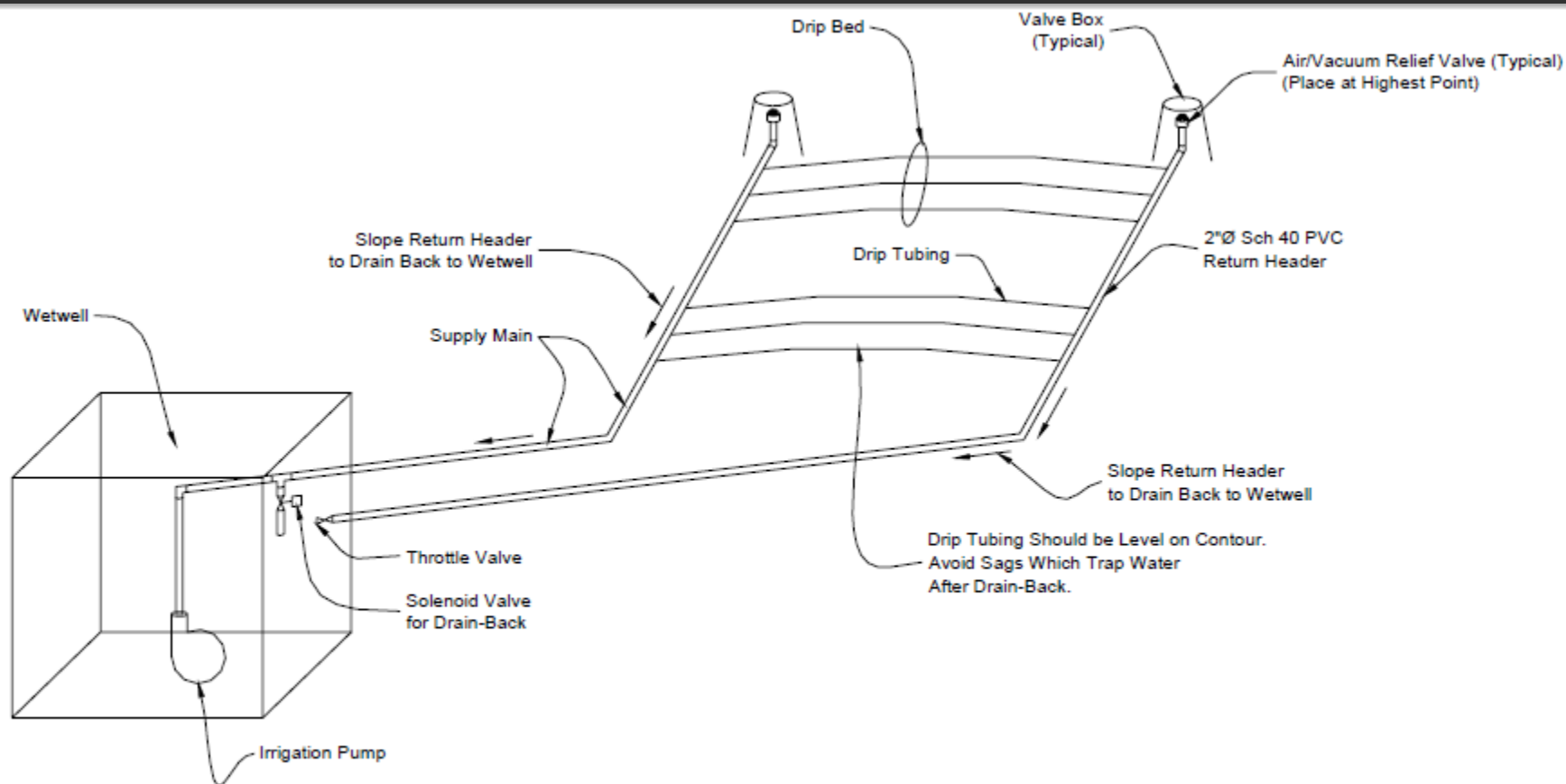


Figure 1. NAWE Cold-Climate Drip System Schematic.

Year 'round drip system, North American Wetland Engineers (NAWE)

Subsurface example

A 30,000 gallon/day recirculating sand filter needs to expand to 50,000 gallon/day and wishes to forego surface water phosphorus regulations. The Sanitary District owns 20 acres of land with suitable soils (sandy loam with moderate subangular blocky structure).

25 MG annual design discharge using in ground drip irrigation

10 acres of drip at 50,000 gpd = 0.076 gal/ft²/day

Table 383.44-2

Maximum Soil Application Rates Based Upon Morphological Soil Evaluation (in gals./sq. ft./day)

Soil Characteristics			Maximum Monthly Average			
Texture ^d	Structure ^e		BOD ₅ >30 ≤220mg/L TSS >30 ≤150mg/L		BOD ₅ ≤30 mg/L ^c TSS ≤30 mg/L ^c	
	Shape	Grade				
COS, S, LCOS, LS	---	0	0.7 ^a	0.5 ^{b,c}	1.6 ^a	0.5 ^b
FS, LFS	---	0	0.5		1.0	
VFS, LVFS	---	0	0.4		0.6	
COSL, SL	---	0M	0.2		0.6	
	PL	1	0.4		0.6	
		2, 3	0.0		0.2	
	PR, BK, GR	1	0.4		0.7	
		2, 3	0.6		1.0	
FSL, VFSL	---	0M	0.2		0.5	
	PL	2, 3	0.0		0.2	
	PL, PR, BK, GR	1	0.2		0.6	
		2, 3	0.4		0.8	
	L	0M	0.2		0.5	
	PL	2, 3	0.0		0.2	
	PL, PR, BK, GR	1	0.4		0.6	
		2, 3	0.6		0.8	
	SIL	0M	0.0		0.2	
	PL	2, 3	0.0		0.2	
	PL, PR, BK, GR	1	0.4 ^c		0.6	
		2, 3	0.6		0.8	
SI	---	---	0.0		0.0	
SCL, CL, SICL	---	0M	0.0		0.0	
	PL	1, 2, 3	0.0		0.2	
	PR, BK, GR	1	0.2		0.3	
		2, 3	0.4		0.6	
SC, C, SIC	---	0M	0.0		0.0	
	PL	1, 2, 3	0.0		0.0	

Costs example

Land	\$ 0
Plant/irrigate 15 ac @ \$12,000/ac*	\$ 180,000
5,000 ft of fencing @ \$8/ft	\$ 40,000
Pump, filter, controls, electrical	\$ 200,000
Monitoring wells	\$ 15,000
PM/Mobe/Insurance	\$ 50,000
10% Contingency	\$ 62,000
<u>Engineering</u>	<u>\$ 100,000</u>
	\$ 637,000

* Alternate 5 acre pond @ \$350,000, plus additional 15 acres for spray irrigation @ \$90,000

Challenges to Tree WW Effluent Plantations

1. Sufficient land with proper offsets
2. Suitable soils
3. Plantation O&M first 3 growing seasons
4. Irrigation system O&M
5. 4 years to fully establish plantation

BENEFITS

1. Lower capital costs than mechanical plant
2. 25 – 50+ year lifespan
3. Easily expandable
4. Future surface water standards irrelevant
5. Additional treatment of effluent

BENEFITS

6. Reduced energy needs
7. Carbon sequestration
8. Can be combined with other technologies
9. May provide TMDL “margin” for growth