GET THE MOST BAM FOR YOUR BUCK WITH RECIRCULATING BIOSORPTION ACTIVATED MEDIA FILTERS!

A UNIQUE SOLUTION FOR ADDRESSING EXTERNAL AND INTERNAL NUTRIENT LOADS TO LAKES.

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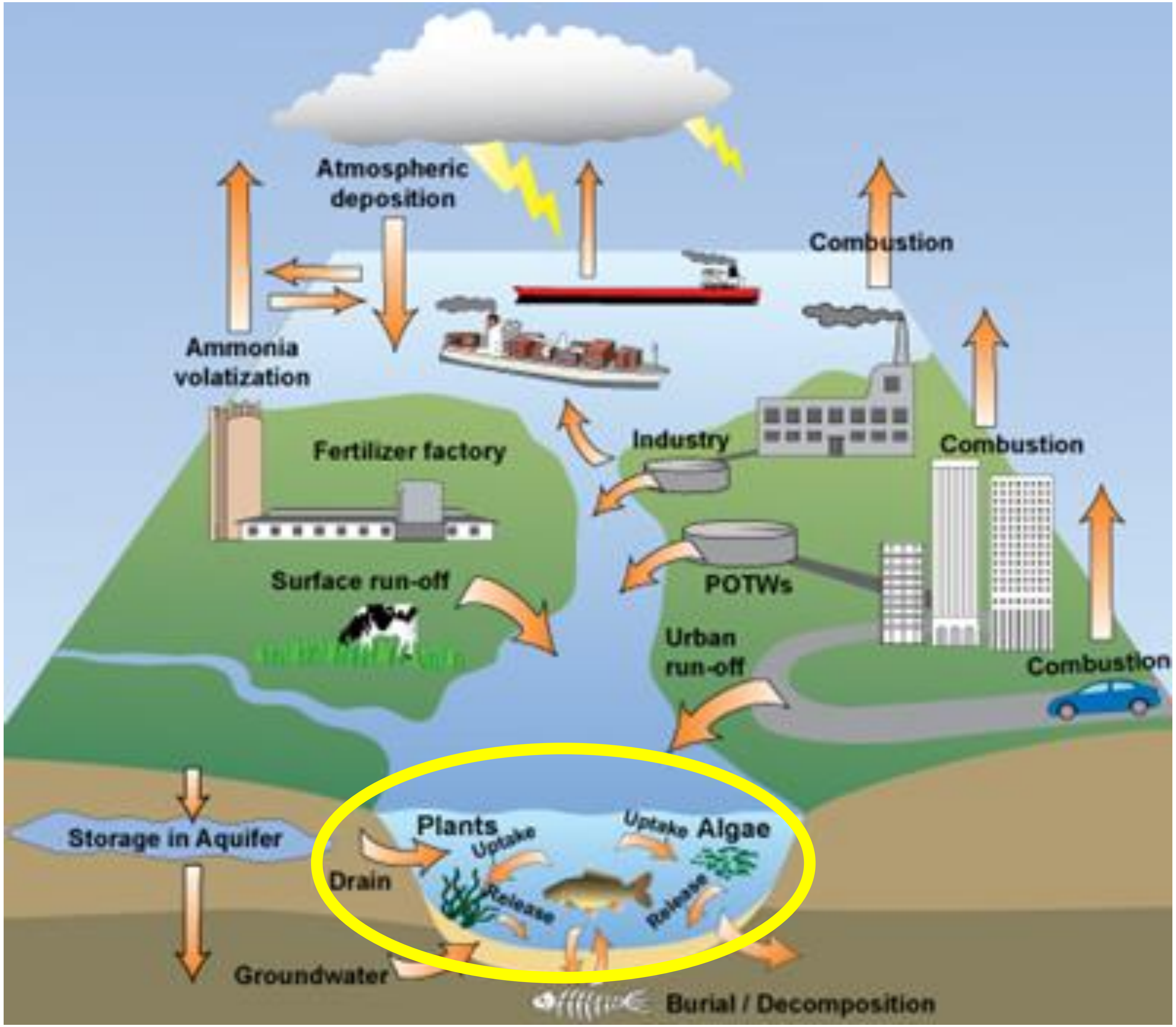
Lake Pollutant Sources

External

- Stormwater/non-point sources
- Point Sources
- Septic Systems
- Seepage
- Atmospheric Deposition

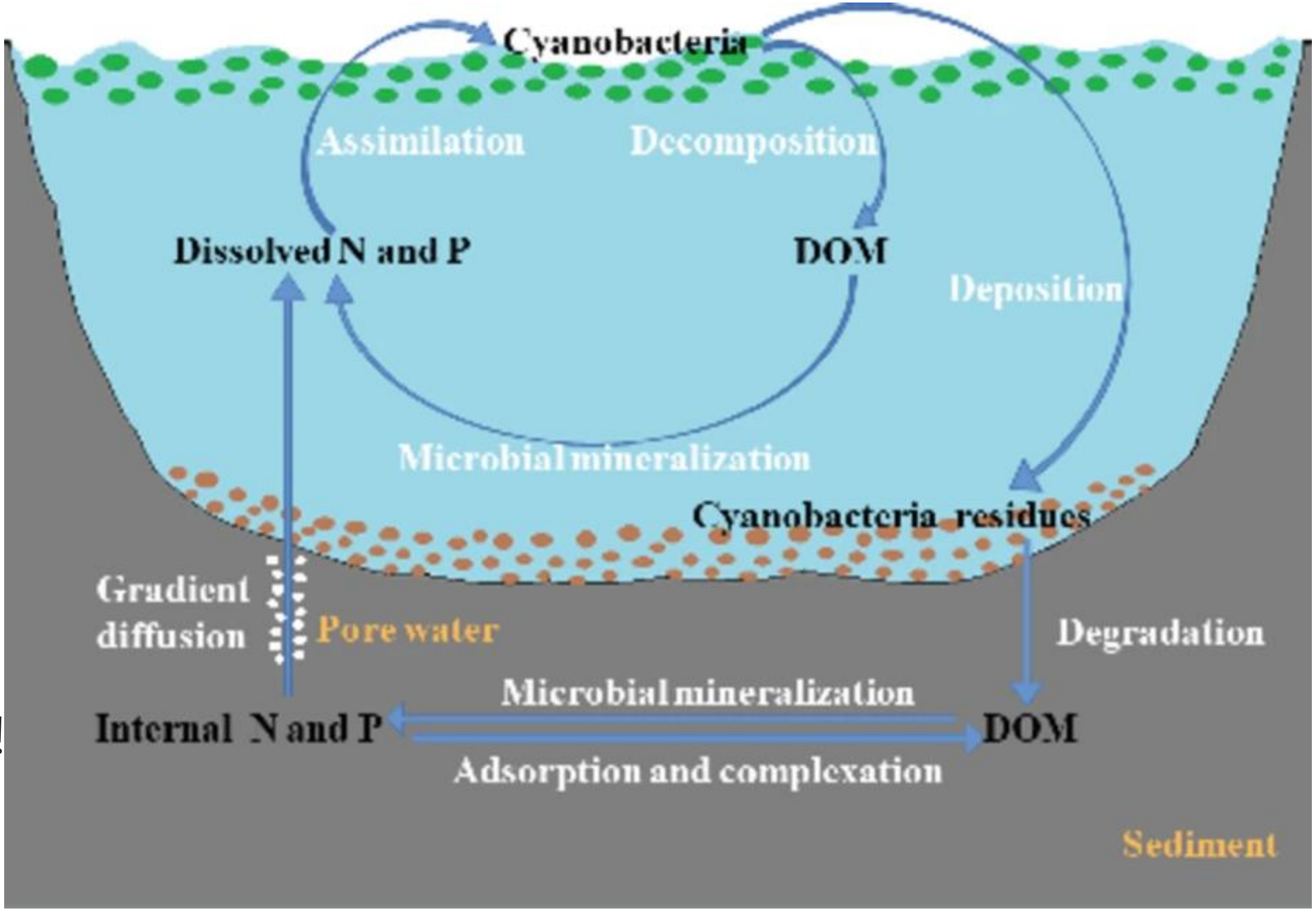
Internal

- Nutrient Sediment Flux
    - *Legacy loads*
    - *Internal Recycling*



Internal Loading

- Occurs in:
  - *water column*
  - *sediment*
- Physiochemical and Biochemical Processes
  - *Mineralization*
  - *Desorption*
  - *Dissolution* *(reverse of precipitation)*
- Can be the dominant nutrient loading source!
  - *Lake remains in algae- dominated "stable state"*



Internal loading is often an issue with an "impaired water"

Internal Load Management

- **Reduction of watershed loading** is the primary focus of most regulatory agencies and programs including FDEP (TMDL, BMAP, etc.)
- If ALL unnatural watershed loading is eliminated, the lake is expected to eventually re-balance naturally – that's a big "IF"
- The reality is that 100% elimination of human made external pollutant loading in an urban area is not likely so we need to **co-develop** strategies for addressing **internal loading** when it is identified as a significant source of the TP/TN loading budget
- Projects aimed at reducing internal load are intended to accelerate water quality benefits of watershed load reduction projects

City of Casselberry:
Lake Jesup Total Nitrogen BMAP

Client's Needs:

- BMAP requires an overall TN load reduction of 2,956 lb/year as N by 2030
  - City has other projects already underway.
- City wants improvement to lakes within the city as to benefit their residents.
  - Meaning that a system at the end of the watershed is not an option.

Scope:

- Preformed stormwater Pollutant Load Analysis (PLA) to determine high annual load areas.
- Provided 3 conceptual BMPs that put significant dents in the TN BMAP requirement.
- Evaluated location options based on:
  - TN loading from PLA.
  - Basins & Drainage infrastructure
  - City owned land.
  - Benefits to lakes within the city.

How to accomplish this?

- Need a BMP that treats a large annual volume of water, the higher the TN concentration the better.
- Stormwater flows tend to be spread out and large attenuation means massive BMP.
- Time to Think Outside the Box…. or *TANK*

Think about a fish tank

- Like a lake, just no outflow
- Fish food = nutrients in stormwater
- Nutrients released from decaying poop = internal loading

How does a fish tank stay healthy?

Why doesn’t the fish tank go eutrophic?

It has a biosorption filtration system!

1. Water flows down through the gravel.
    - Physical filtration.
    - Biofiltration by biofilms on the gravel.
2. Water flows up the columns and then through carbon filters.
    - Sorption onto the carbon.
    - Biofiltration by biofilms on the carbon.

Treat a Lake with Recirculating BAM System!

- Downflow BAM system with wetland plants.
- Assume lake water and wet detention pond water are similar.
  - BAM removal efficiencies for treating wet detention pond effluent will apply to lake water.

DESCRIPTION OF MEDIA		PROJECTED TREATMENT PERFORMANCE *			TYPICAL OPERATING LIMITING FILTRATION RATE (in/hr)
Media and Typical Location in BMP Treatment Train	MATERIAL	TSS REMOVAL EFFICIENCY	TN REMOVAL EFFICIENCY	TP REMOVAL** EFFICIENCY	
B&G ECT (ref A) Follows a BMP Stand alone first BMP	Tire Chips[1] Expanded Clay[2]	60% 70%	25% 45%	25% 45%	96 in/hr
IFGEM (ref B) down flow or upflow filters pervious pave, tree well, rain garden, swale, VFS, side filter	Iron[8] Tire Crumb[5] Clay[6] and Sand[7]	95%	80%	95%	5 in/hr
B&G ECT3 (ref C) After Wet Detention using Up-flow Filter Stand alone first BMP	Expanded Clay[4] Tire Chip[1]	60% 70%	25% 45%	25% 45%	96 in/hr
SAT (ref D) A first BMP, as a Down-flow Filter (FILTRATION)	Sand[3]	85%	30%	45%	2 in/hr
B&G CTS (ref E,F) Bottom of dry basin 12" depth*** use rate = 1 in/hr pervious pave, tree well, rain garden, swale, VFS, side filter	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[9]	90%	60%	90%	5 in/hr
B&G CTS (ref E,F) Bottom of dry basin 24" depth*** use rate = 1 in/hr pervious pave, tree well, rain garden, swale, VFS, side filter	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[8]	95%	75%	95%	5 in/hr

Treat a Lake with Recirculating BAM System!

- Option #1: Control Contact time with effluent orifice.
  - Stormwater treatment is primary goal, lake recirculation is a bonus.
  - Advantage: Ensures stormwater has proper EBCT for design removal efficiencies.
  - Disadvantage: Modifying EBCT requires physically changing the effluent orifice.

- Option #2: Control Contact time with pump, no effluent orifice.
  - Lake recirculation is primary goal:
  - Advantage: Ability to vary EBCT to find best performance for lake recirculation.
  - Disadvantage: Stormwater will have an EBCT lower than manufacturer specification.

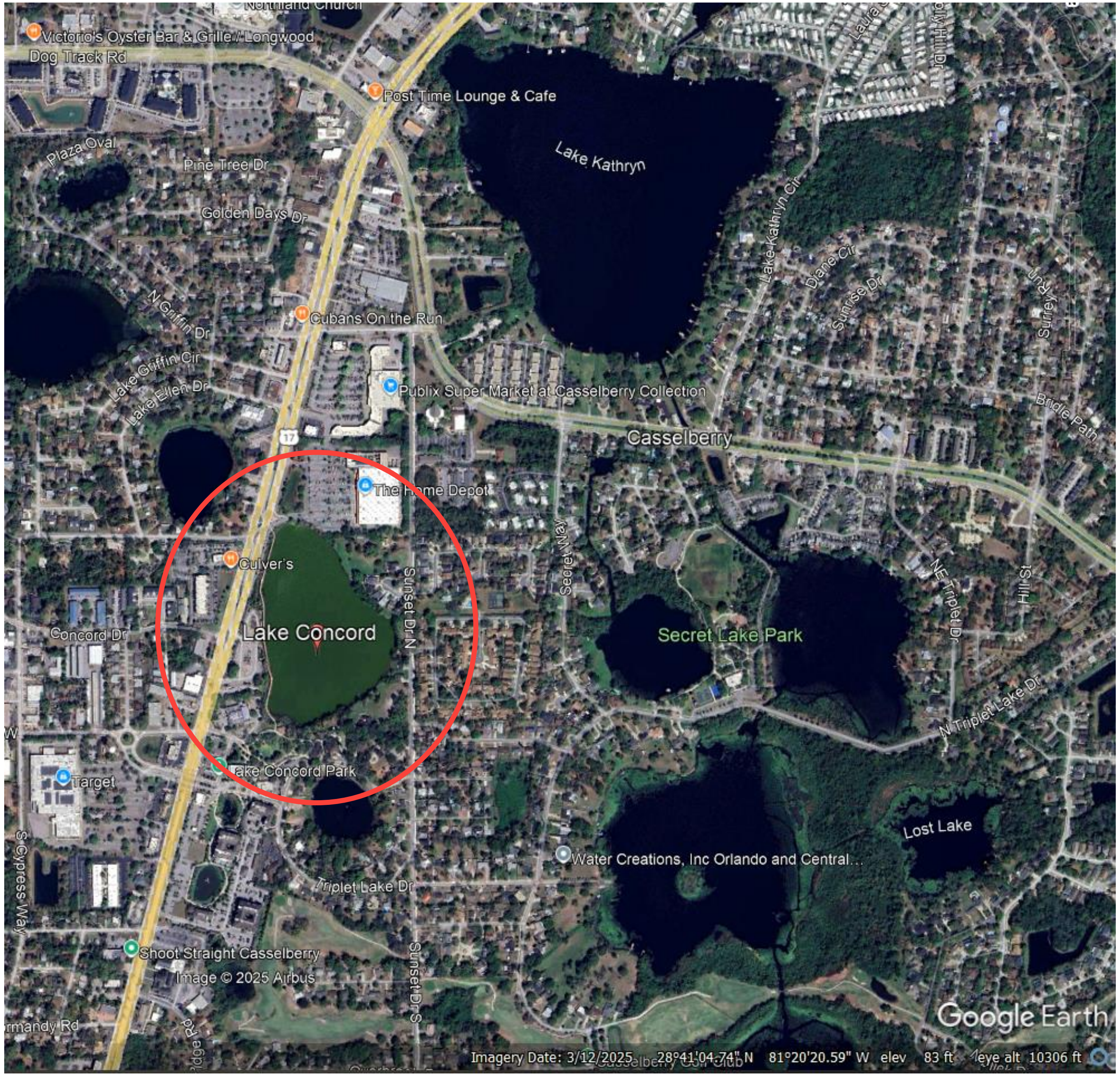
Lake Concord

- High stormwater TN load basin per PLA.
- No good area to capture stormwater for treatment.

- FDEP Classification = Impaired
- Look how GREEN IT IS!
  - Aerial Imagery from 3/12/2025
- Limiting nutrient = BALANCED
  - Decreasing either TN or TP should improve water quality.

Parameter	Mean	Median	Start Date	End Date
Total N (mg/L as N)	0.767	0.720	1/25/2017	3/30/2023
TKN (mg/L as N)	0.725	0.650	1/25/2017	6/19/2019
NOx (mg/L as N)	0.009	0.004	1/25/2017	3/13/2023
Total P (mg/L as P)	0.032	0.032	1/25/2017	3/30/2023
Orthophosphate (mg/L as P)	0.004	0.004	9/23/2014	3/13/2023

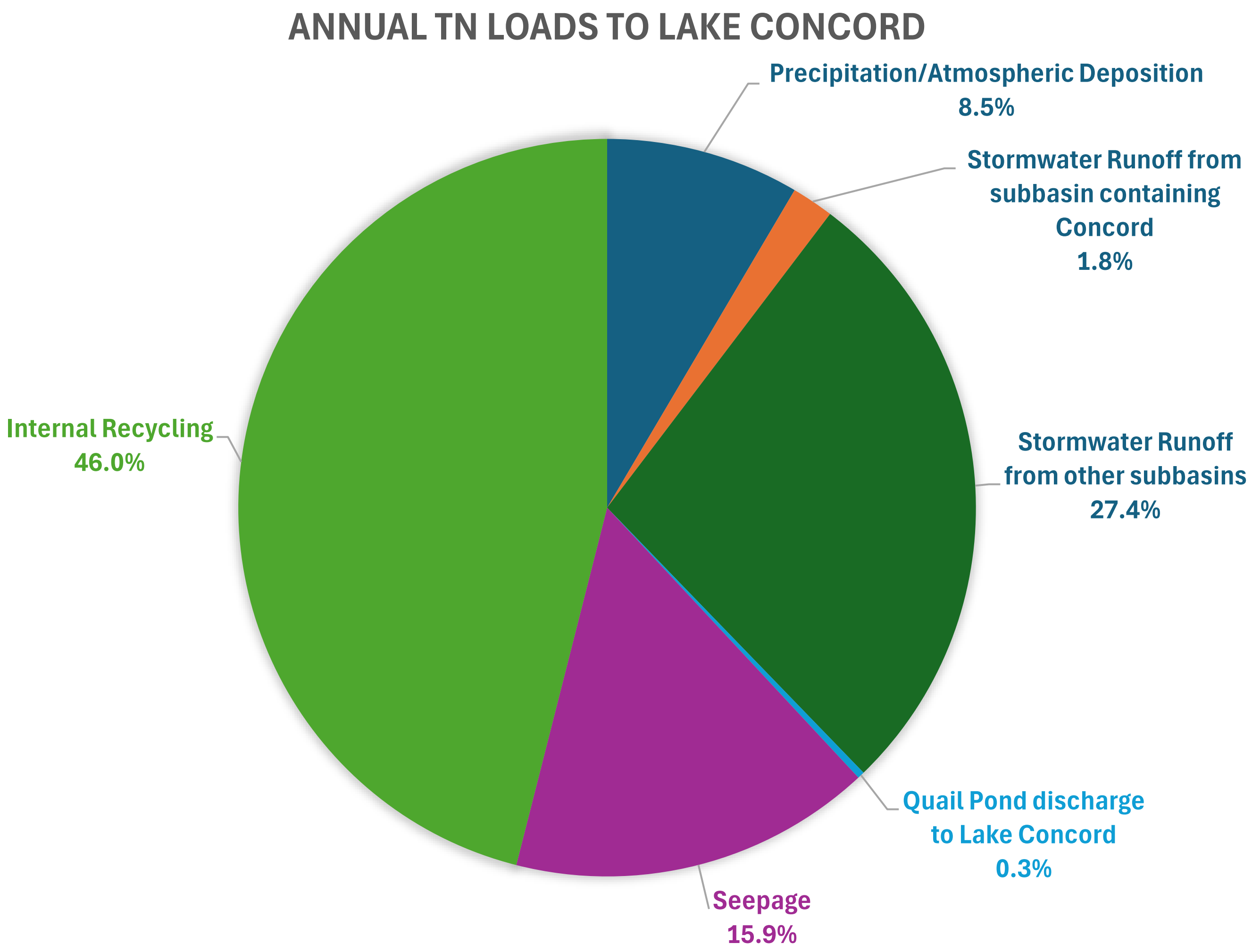
Reference: USF. Lake Concord. *Seminole County Water Atlas.* [Online] 2023. https://seminole.wateratlas.usf.edu/waterbodies/lakes/7528/lake-concord.



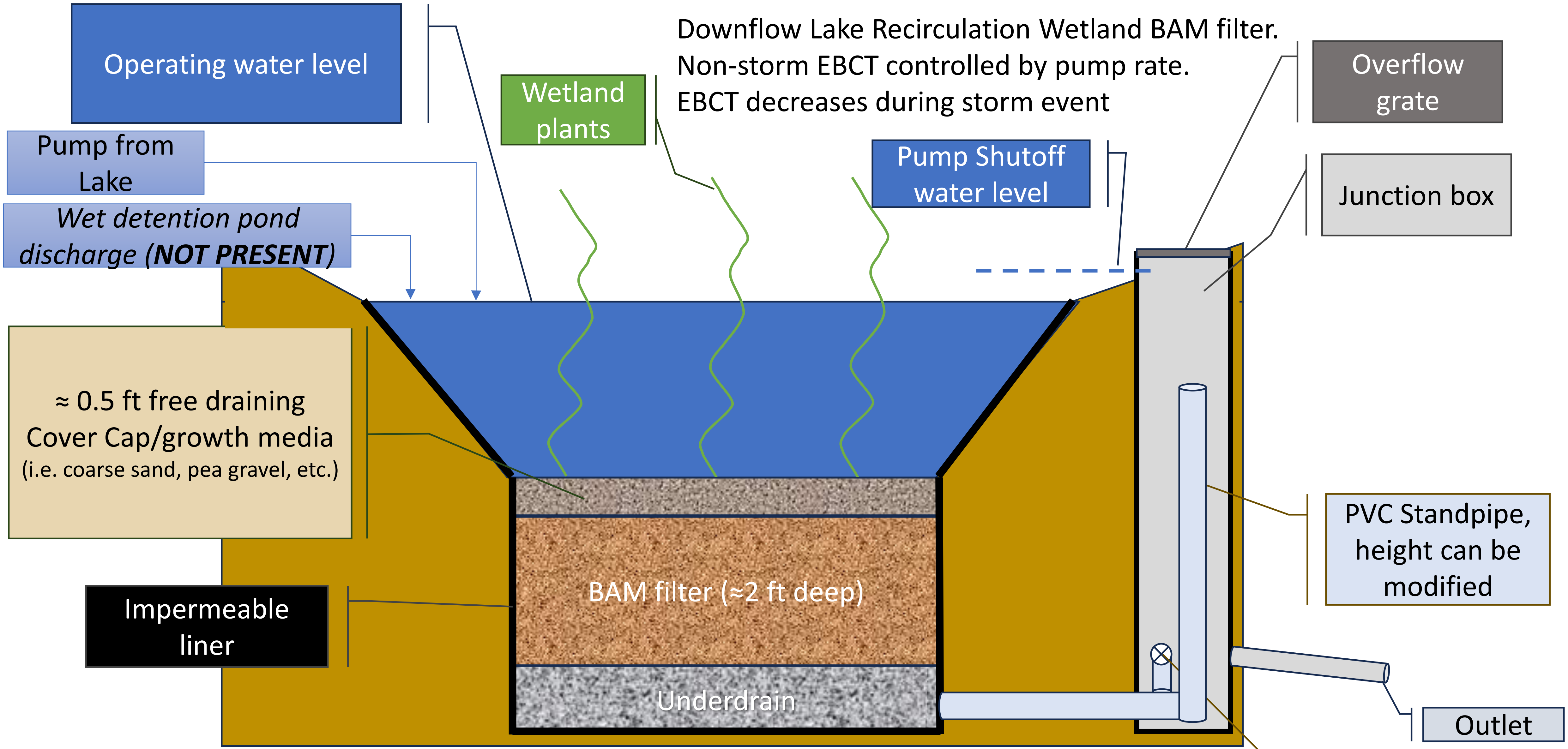
Estimating TN Inputs to Lake

Description	TN Mass Flow Rate (lb/year as N)
Precipitation/Atmospheric Deposition	182.54
Runoff from subbasin containing Concord	39.68
Runoff from other subbasins	589.74
Quail Pond discharge to Lake Concord	6.61
Seepage	341.72
Internal Recycling	989.88
Total	**2,150.17**

Citation:
Lake Concord Hydrologic / Nutrient Budget Evaluation
Prepared by ERD, 2020

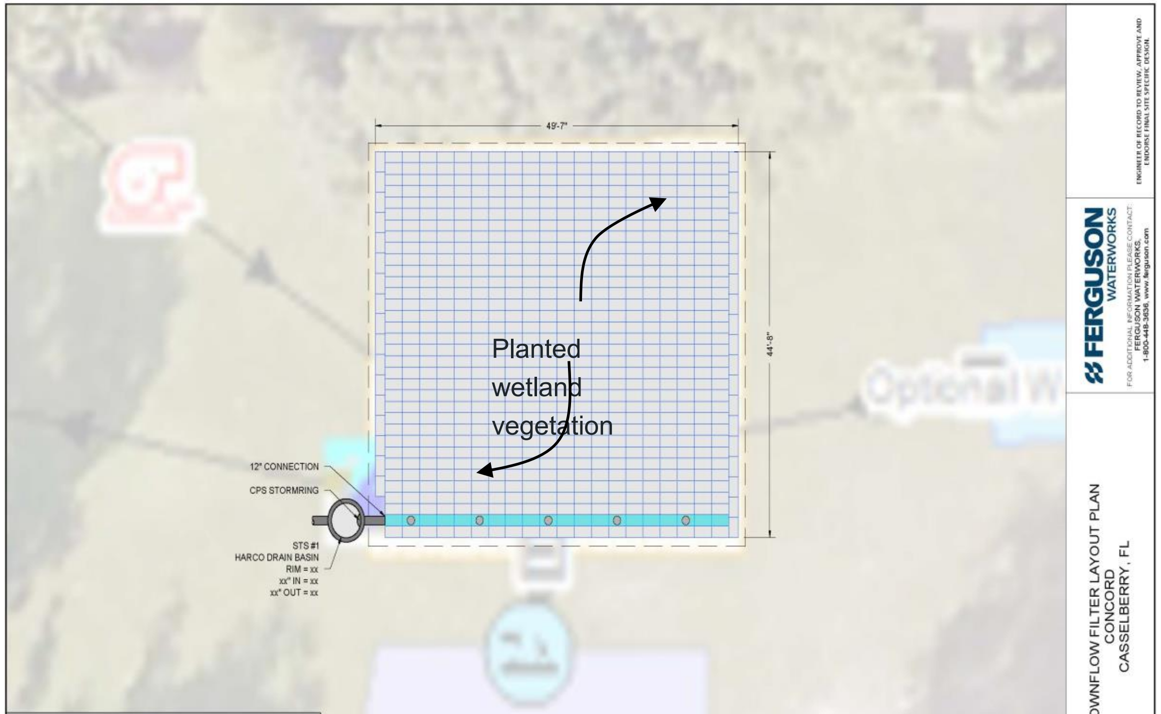


Annual TN load from Internal Recycling (46.0%) is GREATER than Stormwater (29.2%)!!!!



- Non-storm event EBCT is controlled by pump rate
- When wet detention pond discharges to BAM wetland filter, EBCT will decrease.
    - Depending on the size of the BAM filter, the additional flow may have minimal impact on EBCT
- Water level sensor turns lake recirculation pump on if water level is at, or below, *Operating water level*.
- If wet detention pond discharge is entering the wetland BAM filter, the water level will rise until it reaches the *Pump Shutoff water level* sensor.
- The shutoff water level must be lower than the upstream wet detention pond.
- Not to scale.

Lake Concord BAM Downflow Treatment Wetland Layout



FILTER MATERIAL QUANTITIES	
# OF R-TANK^{HD} - SINGLE UNITS	696
# OF R-TANK^{HD} - SINGLE ACCESS UNITS	20
30 MIL PVC LINER	383 SY
N080 NON-WOVEN LINER PROTECTION WRAPS	766 SY
M200 WOVEN GEOTEXTILE TREATMENT ROW FABRIC	43 SY
SR-18 MICROGRID	1133 SY
BOLD AND GOLD MEDIA	4403 CF
12" INSPECTION PORTS	5
GEOTEXTILE PIPE BOOTS (12")	3 | 3
30 MIL PVC LINER PIPE BOOTS (12")	1 | 1
STORMRING CPS (12")	1
NOTE: GEOTEXTILE / LINER QUANTITIES INCLUDE A 15% WASTE FACTOR.	
SEE SHEETS 2 TO 4 FOR DETAILS AND ADDITIONAL INFORMATION	

R-TANK ELEVATIONS	
DESCRIPTION	ELEVATION
BASE INV.	0.00
TANK INV.	0.25
TOP OF R-TANK^{HD}	1.71
MEDIA INV.	1.96
TOP OF MEDIA	3.96
TOP OF FREE DRAINING MATERIAL	4.46

Selecting a BAM to Use

- TN is the concern not TP.
  - Not concerned with phosphorus sorption capacity.
- Impaired lake → assume lots of algae → clogging a fine media might be an issue.
  - Choose a very coarse media, like Bold & Gold® ECT3

DESCRIPTION OF MEDIA		PROJECTED TREATMENT PERFORMANCE *			TYPICAL OPERATING LIMITING FILTRATION RATE (in/hr)
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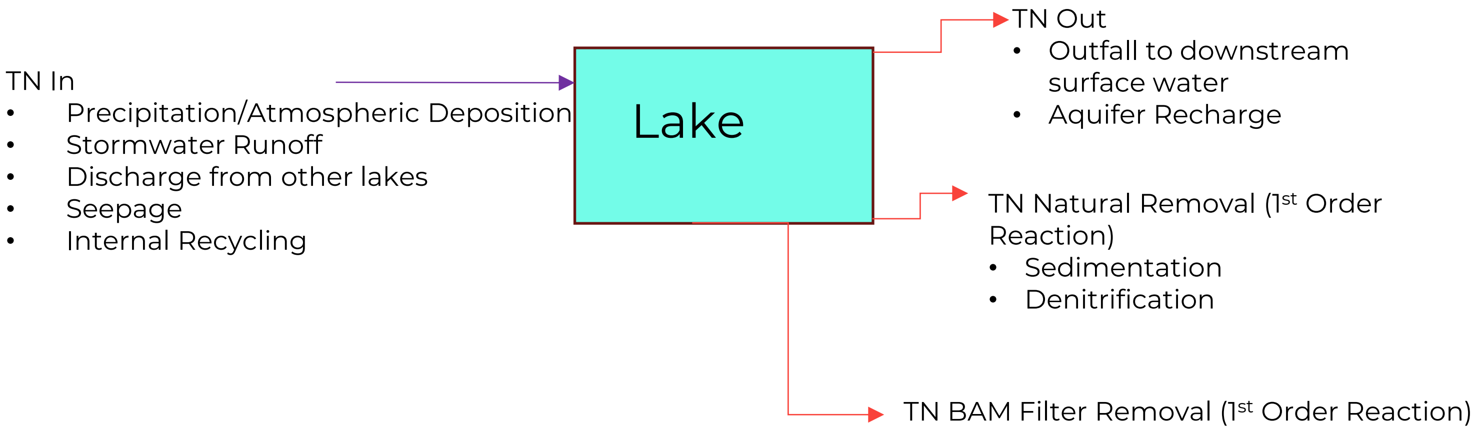
TN Modeling: Get ready for Calculus!

The following simplifying assumptions are made:

- The lake is assumed to behave as a CSTR.
  - $Accumulation\ Rate = Mass\ Inflow - Mass\ outflow - Removal\ Rate$
- 1st order reaction kinetics are assumed.
  - *Removal rate = k*C*
- Existing condition = steady state with respect to TN.
  - *The Natural Removal rate constant (k_{NR}) is determined during the steady state existing condition..*
- Per BMPTrains Manual ECT3 media after a wet detention pond achieves 25% TN removal.
  - *Assume lake TN speciation is similar to a wet detention pond and same removal efficiencies apply.*



What is Steady State vs Non-Steady State

- Steady State = Concentration in Lake is always the same.
- Non-Steady State = Concentration in Lake varies with time
  - Natural Removal Rate and BAM Filter Removal Rate will vary with time since 1st order reactions are concentration dependent.
  - CALCULUS NEEDED
- Once the BMP is activated, the lake will become a non-steady state CSTR until the new steady state lake TN concentration is reached.

Assumption:
N speciation of Wet Detention Pond is similar to a Lake

Lake Concord					
Parameter	Median	% of TN	Start Date	End Date	# of Samples
Total N (mg/L as N)	0.720	100.0%	1/25/2017	3/30/2023	141
NOx (mg/L as N)	0.004	0.6%	1/25/2017	3/13/2023	27
TKN (mg/L as N)	0.716	99.4%	1/25/2017	3/13/2023	CALCULATED
TKN (mg/L as N)	0.650	90.3%	1/25/2017	6/19/2019	17

Reference: USF. Lake Concord. *Seminole County Water Atlas.* [Online] 2023. https://seminole.wateratlas.usf.edu/waterbodies/lakes/7528/lake-concord.

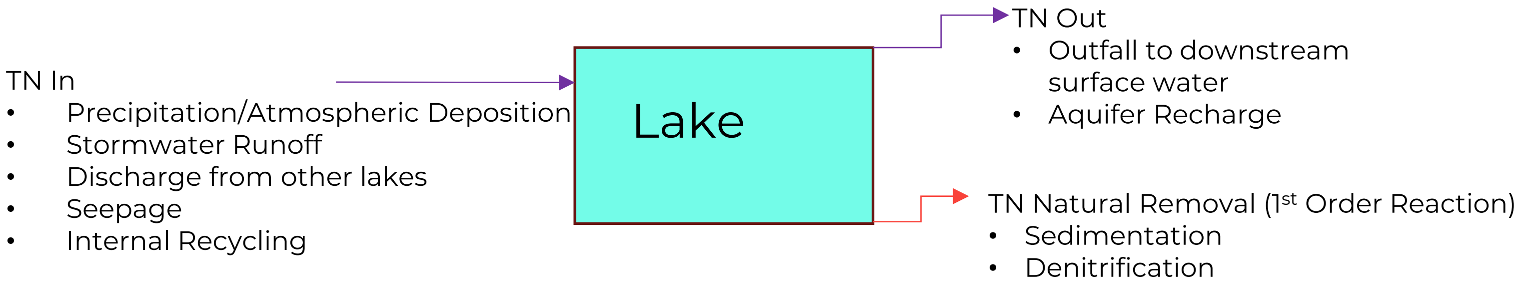
Wet Detention Pond in Martin County, FL				
Parameter	Median	% of TN	Start Date	End Date
Total N (mg/L as N)	1.54	100%	1/25/2017	3/30/2023
TKN (mg/L as N)	1.42	92.21%	1/25/2017	6/19/2019
NOx (mg/L as N)	0.12	7.79%	1/25/2017	3/13/2023

Yes, ratios are in the same ballpark.

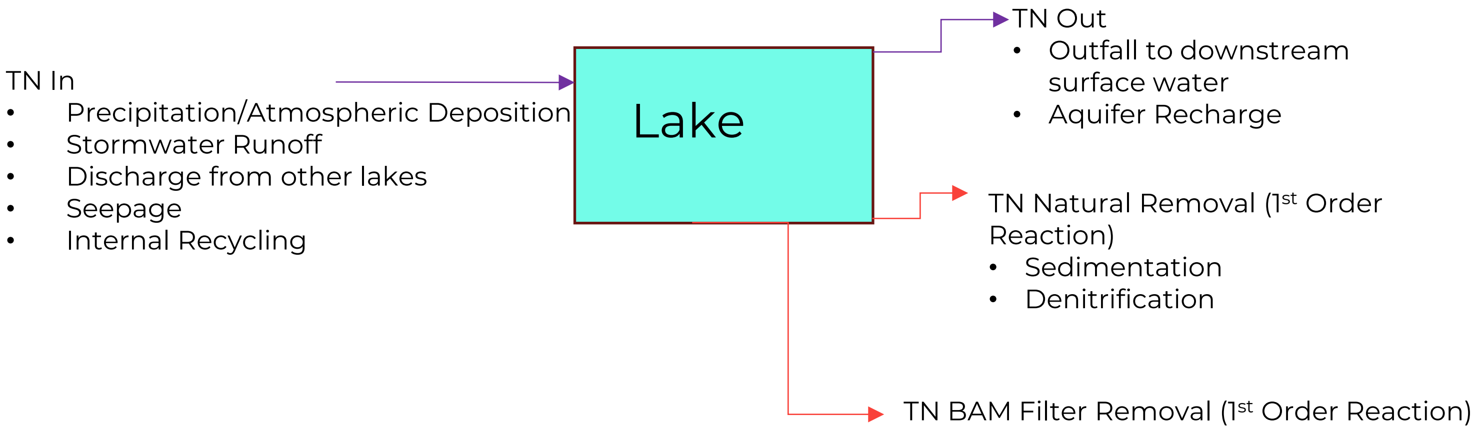
General Mass Balance for CSTR

$$Accumulation\ Rate = Mass\ Inflow - Mass\ outflow - Removal\ Rate$$

Existing Conditions



Proposed Conditions



Existing Steady State Conditions: Determine known Mass Inflow, Outflow, & Removal

Volumetric Flow Rates and TN Mass Flow Rates into Lake Concord

Description	TN Mass Flow Rate (kg/year as N)	TN Mass Flow Rate (lb/year as N)	Volumetric Flow Rate (acre*ft / year)
Precipitation/Atmospheric Deposition	82.8	182.54	NA
Runoff from subbasin containing Concord	18.0	39.68	11.3
Runoff from other subbasin	267.5	589.74	197.9
Quail Pond discharge to Lake Concord	3.0	6.61	4.7
Seepage	155.0	341.72	NA
Internal Recycling	449.0	989.88	0.0
Total	**975.3**	**2,150.17**	**213.9**

Volumetric Flow Rates and TN Mass Flow Rates Leaving Lake Concord

Description	TN Mass Flow Rate (kg/year)	TN Mass Flow Rate (lb/year as N)	Volumetric Flow Rate (acre*ft / year)
Outfall to Secret Lake	194	427.7	230
Aquifer Recharge	10.4	22.9	12.3
Total Outflow	**204.4**	**1,699.5**	**242.3**
Natural Removal Rate (Sedimentation & Denitrification)	**770.9**	**450.6**	NA

Existing Steady State Conditions:
Solving for the Natural Removal Rate Constant "k_{NR}"

$$Rate\ of\ Change\ of\ TN\ in\ Lake = Mass\ Inflow - Mass\ Outflow - Natural\ Removal\ Rate - BAM\ Filter\ Removal\ Rate$$

Existing conditions are assumed to be steady state.
Existing $Rate\ of\ Change\ of\ TN\ in\ Lake = 0$

$$0 = \dot{M}_{IN} - \dot{M}_{Out\ flow_t} - \dot{M}_{NR_t}$$
$$0 = \dot{M}_{IN} - \dot{M}_{Out\ flow_{exist}} - C_{L_{exist}} * k_{NR} * V_L$$
$$C_{L_{exist}} * k_{NR} * V_L = \dot{M}_{IN} - \dot{M}_{Out\ flow_{exist}}$$
$$k_{NR} = \frac{\dot{M}_{IN} - \dot{M}_{Out\ flow_{exist}}}{C_{L_{exist}}}$$

Where:

$V_L = Volume\ of\ Lake$

$C_{L_t} = TN\ Concentration\ of\ Lake\ at\ time\ t$

$\dot{M}_{IN} = Total\ TN\ Mass\ Inflow\ Rate$

$\dot{M}_{Out\ flow_t} = Total\ TN\ Mass\ Outflow\ Rate\ at\ time\ t$

$\dot{M}_{NR_t} = TN\ Mass\ Natural\ Removal\ Rate\ time\ t$

$\dot{M}_{filter_t} = TN\ Mass\ Removal\ Rate\ by\ BAM\ downflow\ treatment\ wetland$

$Q_{Out\ flow} = Total\ Volumetric\ Flow\ Rate\ out\ of\ the\ Lake\ that\ contains\ nutrients.$

$Q_{Out\ flow} = (Aquifer\ Recharge\ Volumetric\ Flow\ Rate) + (Downstream\ Discharge\ Volumetric\ Flow\ Rate)$

$k_{NR} = Natural\ Removal\ rate\ constant$

Determining the Natural Removal Rate Constant of Lake Concord

Known or Result	Variable	Value	Units	Description
Known	$\dot{M}_{IN}$	2,672.05	gram TN / day as N	Mass Flow rate of Total Inflow
Known	$C_{L_{exist}}$	0.000683	gram TN / L as N	Existing Lake TN concentration, pre-BAM filter conditions
Known	V_L	207,224,948.71	L	Volume of Lake
Known	$Q_{Out\ flow}$	818,829.18	L / day	Total Outflow Volumetric flow rate
Known	$\dot{M}_{Out\ flow_{exist}}$	559.26	gram TN / day as N	Mass Flow rate of Total Outflow at existing, pre-BAM filter conditions
Known	$Fil_{Rem_{Eff}}$	25%	na	BAM TN Removal Efficiency
Result	k_{NR}	0.01493	1/day	Natural Removal Rate Constant

Determining Optimum Filter Flow Rate at Proposed Steady State Conditions

Steady State Condition Mass Balance Equation for Lake with both Natural TN Removal and Recirculating BAM Downflow Treatment Wetland TN Removal

$$Rate\ of\ Change\ of\ TN\ in\ Lake = Mass\ Inflow - Mass\ Outflow - Natural\ Removal\ Rate - BAM\ Filter\ Removal\ Rate$$

Existing conditions are assumed to be steady state.

$Rate\ of\ Change\ of\ TN\ in\ Lake = 0$

Solving for $C_{L_{steady\ state}}$ as a function of Q_F

$$0 = \dot{M}_{IN} - \dot{M}_{Out\ flow_t} - \dot{M}_{NR_t} - \dot{M}_{filter_t}$$

$$0 = \dot{M}_{IN} - C_{L_{steady\ state}} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)$$

$$C_{L_{steady\ state}} = \frac{\dot{M}_{IN}}{Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F}$$

Where:

$V_L = Volume\ of\ Lake$

$C_{L_t} = TN\ Concentration\ of\ Lake\ at\ time\ t$

$\dot{M}_{IN} = Total\ TN\ Mass\ Inflow\ Rate$

$\dot{M}_{Out\ flow_t} = Total\ TN\ Mass\ Outflow\ Rate\ at\ time\ t$

$\dot{M}_{NR_t} = TN\ Mass\ Natural\ Removal\ Rate\ time\ t$

$\dot{M}_{filter_t} = TN\ Mass\ Removal\ Rate\ by\ BAM\ downflow\ treatment\ wetland$

$Q_{Out\ flow} = Total\ Volumetric\ Flow\ Rate\ out\ of\ the\ Lake\ that\ contains\ nutrients.$

$Q_{Out\ flow} = (Aquifer\ Recharge\ Volumetric\ Flow\ Rate) + (Downstream\ Discharge\ Volumetric\ Flow\ Rate)$

$Q_F = Volumetric\ Flow\ Rate\ through\ BAM\ downflow\ treatment\ wetland.$

$k_{NR} = Natural\ Removal\ rate\ constant$

$Fil_{Rem_{Eff}} = Removal\ Efficiency\ of\ the\ ECT3\ BAM\ at\ 15\ minute\ EBCT\ as\ specified\ in\ BMP\ Trains\ Manual\ (3)$

Maximum Flow Rate through filter is Based on:

- minimum required filter EBCT
- filter size

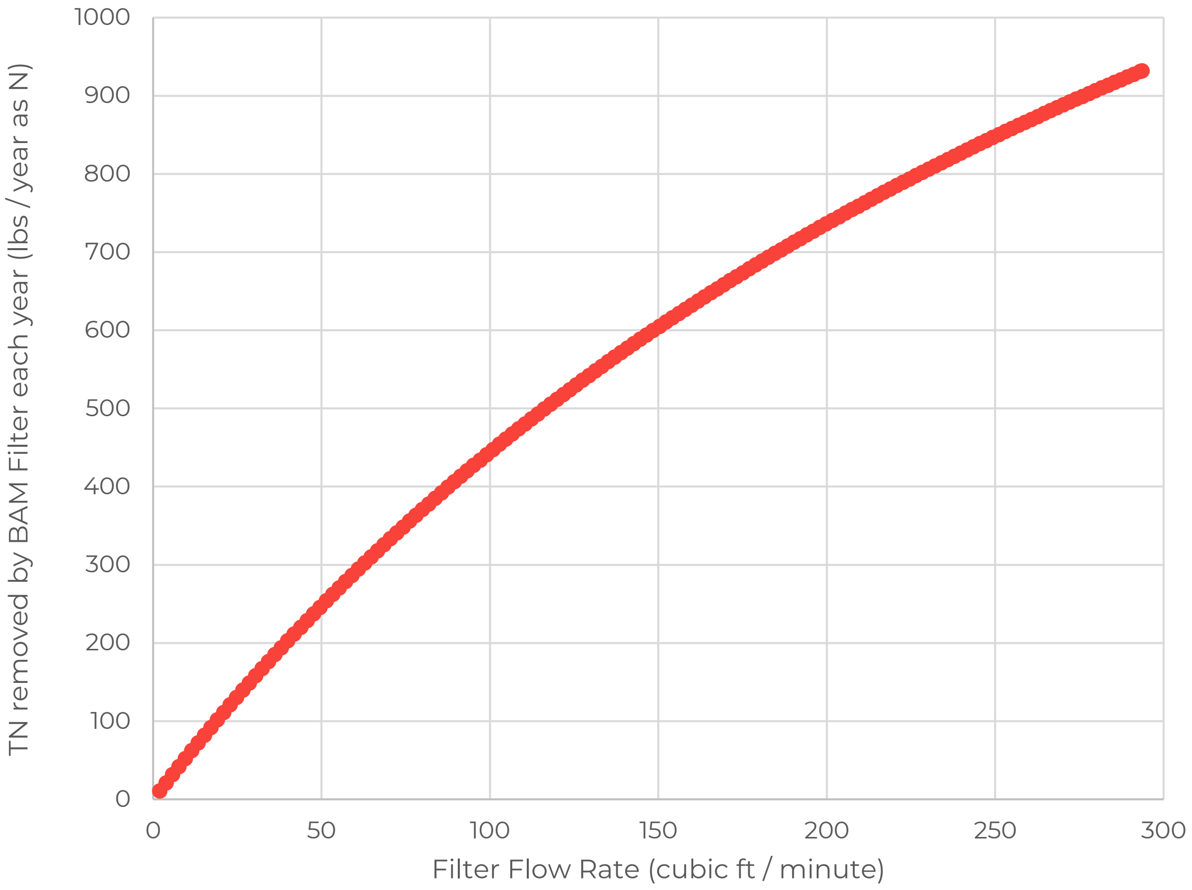
Potential Diminishing Return of Removal:

- Decreasing TN concentration in the lake (and entering filter) as filter flow rate increased.
- Plot Lake concentration as a function of Filter Flow rate to determine if design flow rate should be less than maximum allowed by minimum required EBCT

Determining Optimum Filter Flow Rate at Proposed Steady State Conditions

- Diminishing Return of TN removal does not occur prior to maximum filter flow rate.

Annual Filter TN removal as a function of Filter Flow Rate



With the Filter turned on, when does the lake reach new steady state conditions & what is the steady state TN concentration?

Non-Steady State Condition Mass Balance for Lake with both Natural TN Removal and Recirculating BAM Downflow Treatment Wetland TN Removal

$$\text{Rate of Change of TN in Lake} = \text{Mass Inflow} - \text{Mass Outflow} - \text{Natural Removal Rate} - \text{BAM Filter Removal Rate}$$

$$\frac{dC_L}{dt} * V_L = \dot{M}_{IN} - \dot{M}_{Out\ flow_t} - \dot{M}_{NR_t} - \dot{M}_{filter_t}$$

$$\frac{dC_L}{dt} = \frac{\dot{M}_{IN}}{V_L} - \frac{C_{L_t}}{V_L} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)$$

$$dC_L = \left[\frac{\dot{M}_{IN}}{V_L} - \frac{C_{L_t}}{V_L} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)\right] dt$$

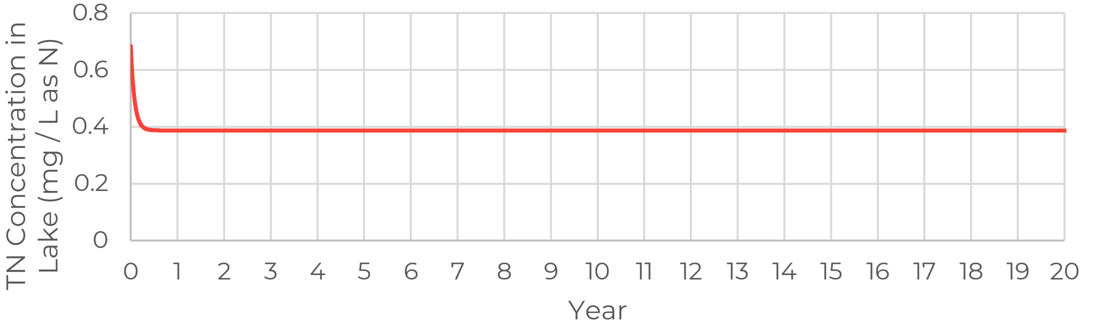
$$\int_{C_{L_{exist}}}^{C_{L_T}} \frac{dC_L}{\frac{\dot{M}_{IN}}{V_L} - \frac{C_{L_t}}{V_L} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)} = \int_0^T dt$$

$$C_{L_T} = \frac{-\dot{M}_{IN} + \left\{\left[\dot{M}_{IN} - C_{L_{exist}} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)\right] * e^{\left[\frac{-1}{V_L} * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F) * T\right]}\right.}{-1 * (Q_{Out\ flow} + k_{NR} * V_L + Fil_{Rem_{Eff}} * Q_F)}$$

Where:

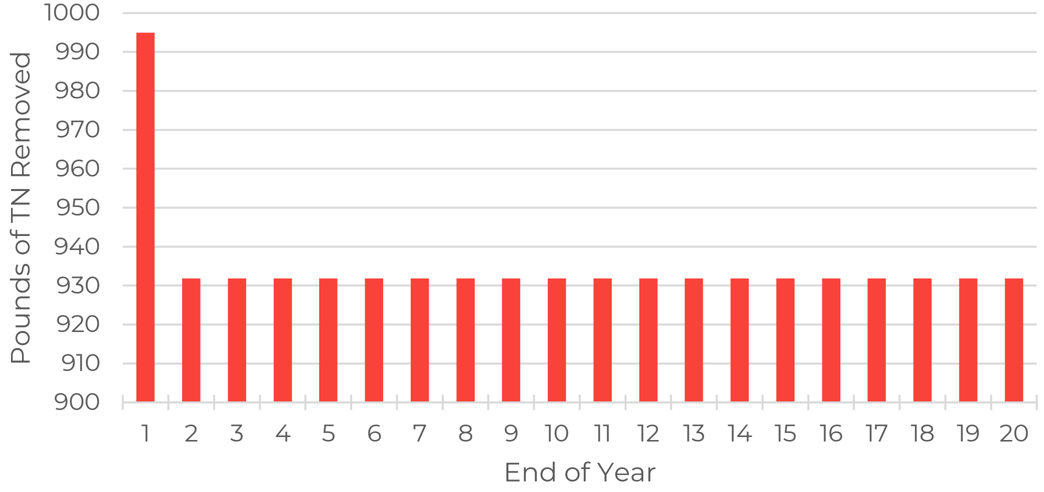
V_L = *Volume of Lake*
C_{L_t} = *TN Concentration of Lake at time t*
$\dot{M}_{IN}$ = *Total TN Mass Inflow Rate*
$\dot{M}_{Out\ flow_t}$ = *Total TN Mass Outflow Rate at time t*
$\dot{M}_{NR_t}$ = *TN Mass Natural Removal Rate time t*
$\dot{M}_{filter_t}$ = *TN Mass Removal Rate by BAM downflow treatment wetland*
$Q_{Out\ flow}$ = *Total Volumetric Flow Rate out of the Lake that contains contains nutrients.*
Q_F = *Volumetric Flow Rate through BAM downflow treatment wetland.*
$Q_{Out\ flow}$ = *(Aquifer Recharge Volumetric Flow Rate) + (Downstream Discharge Volumetric Flow Rate)*
k_{NR} = *Natural Removal rate constant*
$Fil_{Rem_{Eff}}$ = *Removal Efficiency of the ECT3 BAM at 15 minute EBCT as specified in BMP Trains Manual (3)*

TN Concentration of Lake Concord,
Transition From Unsteady State To Steady State Conditions At Optimum Q_F



New steady state conditions effectively reached by end of year 1, at filter flow rate of 293.5 cfm.

TN Removal Each Year by System,
Transition From Unsteady State To Steady State Conditions At Optimum Q_F



Lake Recirculation Filter Address Internal Recycling Load

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TN removal by Lake Concord BAM downflow treatment wetland, Transition From Unsteady State To Steady State Conditions At Optimum Q_F

During Year	Mass of TN removed each year by BAM downflow treatment wetland (lbs / year as N)
1	994.96
2	931.8441
3 through 20	931.8438

- Largest Single Load is Internal Recycling
  - Annual Filter Removal = 94% of Internal Recycling Load
- Total Stormwater Runoff Input = 629.4 lb TN / year
  - Annually Removes more TN than Stormwater Runoff Load

If a system is configured to ALSO treat Stormwater, assuming stormwater is at higher concentration, then even more removal can occur!

Cost Performance

Present Worth Cost, with 20% Contingency	Amount
Construction	$475,822
Engineering	$157,896
Operating (20 years)	$571,925
TOTAL (20 year lifespan)	$1,205,643

20-year Lifespan		
Total Cost	TN removed (lb as N)	$\frac{\$}{\text{lb TN removed as N}}$
$1,205,643	18,700	$64.5

Comparison to 2 Stormwater ONLY BAM BMPs

- $132/lb TN removal
- $187/lb TN removal

Wrap It up!

Requirements & Accomplishments:

- BMAP requires TN load reduction of 2,956 lb/year as N by 2030.
  - Accomplished 31.5% of this with a SINGLE PROJECT.

- City wants improvement to lakes within the city as to benefit their residents.
  - Lake Concord initial TN = 0.720 mg/L as N
  - Modeled new TN = 0.387 mg/L as N
  - 54% Decrease!!!!!!!

- TN Removal Cost of $64.5/lb
  - Significantly cheaper than a stormwater only BAM filter

Bring on the Questions!

Myra loves stormwater BMPs too!

Additional Reference Slides

Usage Description	FDOT Item # (as of 2023/10/23)	Quote	Quantity	Unit	Unit Price (includes install unless otherwise stated)	Estimated Costs
Type P8 Manhole, P-8, <10'	0425 2 61	0	2	Each	$18,188	$18,188
Mittered end section, 12"	0430982121	0	2	Each	$2,796	$2,796
Mittered end section, 24"	0430982129	0	1	Each	$3,409	$3,409
Floating skimmer from lake to filter	NA	0	1	Each	$2,095	$2,095
Install of skimmer from lake to filter	NA	0	1	Each	$2,095	$2,095
Recirculation Pump, 3175 gpm	NA	unit cost $30,000	1	Each	$60,000	$60,000
Pump slide rail coupling system for manhole installation	NA	unit cost $1,231	1	Each	$2,462	$2,462
Pump Control box, water level sensors, and Alarms	NA	unit cost $5,000	1	Each	$10,000	$10,000
Install Electrical Power Service	0639 1111	0	1	Each	$2,594	$2,594
PIPE CULVERT,OPTIONAL MATERIAL,ROUND, 24"S/CD	0430174124	0	378	ft	$76,133	$76,133
Flow regulation valve (vortex valve)	NA	0	1	Each	NA	NA
Downflow BAM filter system from VENDOR	NA	45265	1	Each	$116,515	$116,515
Installation of VENDOR BAM filter system (50% of system cost)	NA	12/5/2023. Use 0.5 * (Total System cost)	1	Each	$58,258	$58,258
grass/ground cover over BAM filter	0570 1 2	0	245	sqyd	$1,076	$1,076
					CONSTRUCTION SUB-TOTAL	*$355,622*
Mobilization and Demobilization			1	% of Construction Sub-Total	10%	$35,562
Construction Surveys			1	% of Construction Sub-Total	1.5%	$5,334
					CONSTRUCTION TOTAL	$396,518
Survey and Testing			NA	% of Construction Sub-Total	10%	$35,562
Design			NA	% of Construction Sub-Total	20%	$71,124
Permitting			NA	% of Construction Sub-Total	2.0%	$7,112
Construction Inspection & Oversight			NA	% of Construction Sub-Total	5%	$17,781
					ENGINEERING TOTAL	$131,580
Present Worth of Electricty over 20 years, assuming 2.2% Discount Rate			NA	Present Worth Lump Sum		$395,388.47
Present Worth of Wetland Maintenance over 20 years, assuming 2.2% Discount Rate			NA	Present Worth Lump Sum		$15,743.70
Present Worth of Pump Maintenance over 20 years, assuming 2.2% Discount Rate			NA	Present Worth Lump Sum		$10,000.00
Present Worth of Water Quality Pump (item & labor) replacement over 20 years, assuming 2.2% Discount Rate. Life span of pump assumed to be every 10 years.			NA	Present Worth Lump Sum		$48,266.11
Present Worth of Engineering Recertification of BMP over 20 years, assuming 2.2% Discount Rate.			NA	Present Worth Lump Sum		$7,206.16
					Present Worth OPERATING COST TOTAL based on 20 year lifespan with 2.2% Discount Rate	$476,604
Contingency Adjusted CONSTRUCTION TOTAL			NA		20%	$475,822.05
Contingency Adjusted ENGINEERING TOTAL			NA		20%	$157,896.11
					Contingency Adjusted CAPITAL COST TOTAL	$633,718.15
Contingency Adjusted PRESENT WORTH OPERATIONAL COSTS TOTAL			NA		20%	$571,925.34
					ESTIMATED PRESENT WORTH TOTAL COSTS with CONTINGENCY	**$1,205,643**

Operational costs

Annual Operating cost, without contingency

Cost Item	Amount
Electricity	$24,650
Wetland maintenance	$7,154
TOTAL	$31,804

Present Worth of Life Span Operating Cost, with contingency

Assumptions							
Discount Rate (for PW analysis)	2.2%	Accounts for interest and inflation					
Life Span	20						
		Lifetime Present Worth of Electricity Cost	Lifetime Present Worth of Replacement Water Quality Pump: Item Cost	Lifetime Present Worth of Wetland Maintenance	Lifetime Present Worth of Pump Maintenance	Lifetime Present Worth of Engineering Recertification of BMP	Total Lifetime Operational Costs
		$395,388.47	$48,266.11	$15,743.70	$10,000.00	$7,206.16	$476,604.45

Backwashing option

- Backwash with either fire hydrant or collected filtered water.
- Backwash to sanitary sewer preferred.

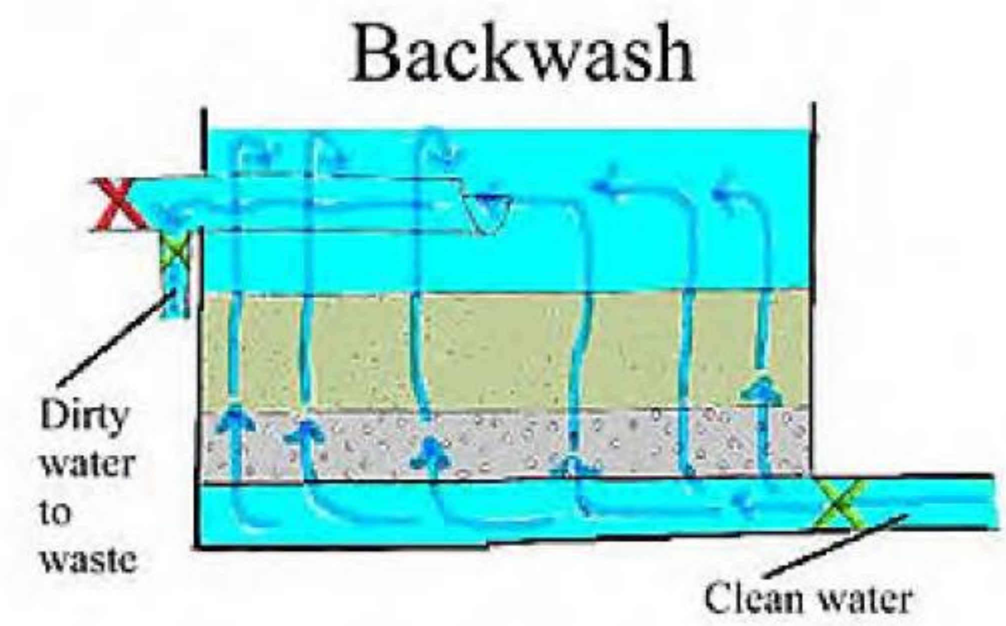

Image Credit:
https://www.cocoafl.gov/DocumentCenter/View/15448/Water-Filtration-Grades-8-12

Another Configuration Option: Horizontal Subsurface flow

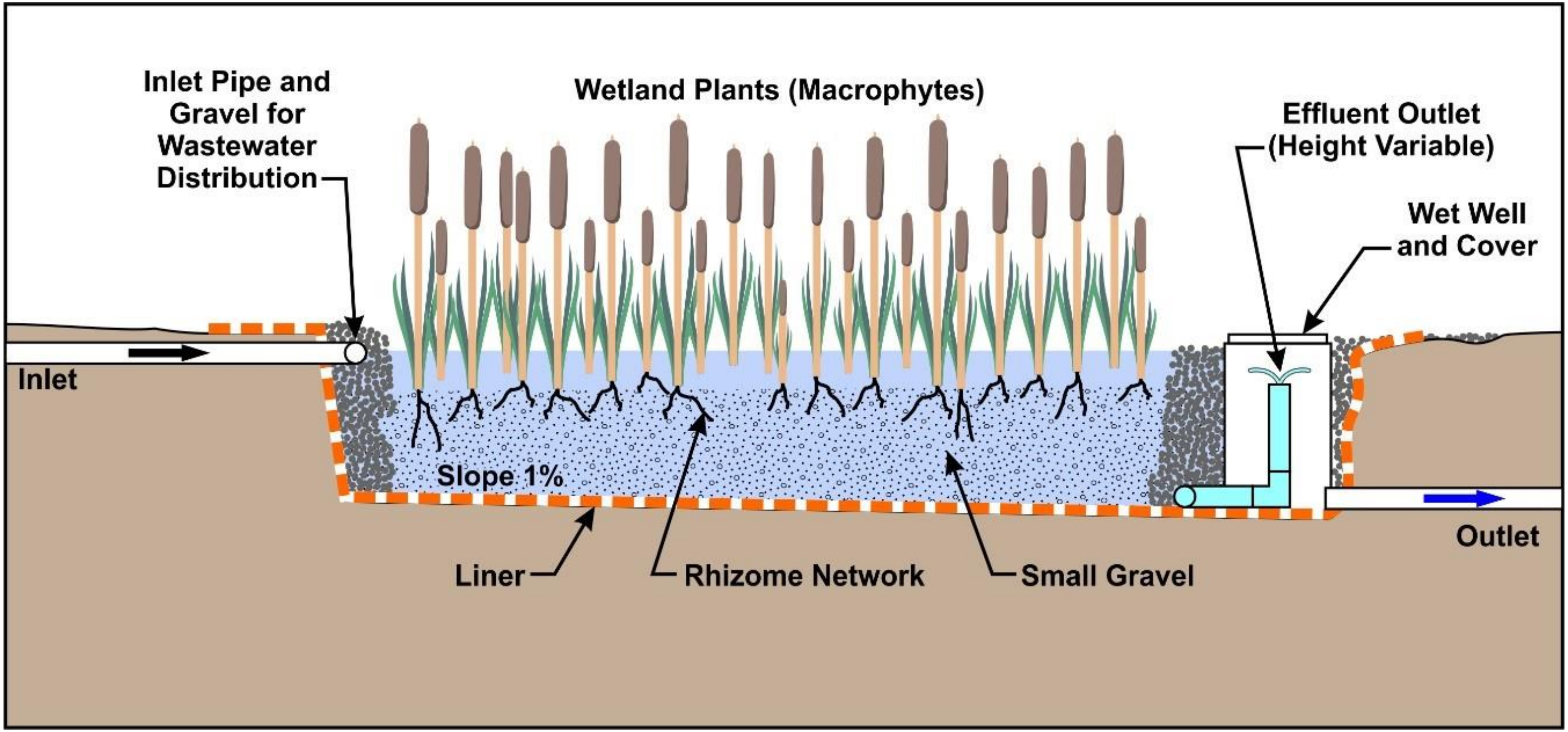

Image credit:
Federal Remediation Technologies Roundtable, 2019
Constructed Wetlands
https://www.frtr.gov/matrix-2019/Constructed-Wetlands/