

Calculations to adjust for upstream retention depth as it affects downstream wet detention removal performance. January 2026

Retention in series with Wet Detention in same Catchment				by Marty Wanielista and Harvey Harper		12/20/2025
Maximum reductions in TN and TP in % =		10	20	Updated		Current
with upstream particles removed		Annual Average Residence Time (days)		200	31	31
note: retention is on-line and thus		EDTN Stand-alone wet pond TN removal % =		43	38	38
particle removal in retention		MTN Max reduction in TN removal %		10	10	6.3
		EDTP Stand-alone wet pond TP removal % =		80	65	65
		MTP Max reduction in TP removal %		20	20	10.8
On-line	Off line	why? reduction is a % of the total with chem + bio greater fraction with TP.				
Retention	Retention	ER		Adjusted		
Removal %	Removal %	ART = 200 d:		TN Performance		TP Performance
Variable retention %		Retention + Detention		Total	Retention + Detention	Total
Detention after ret %		90	3.40	93.40	90	6.20
		80	7.00	87.00	80	12.80
		70	10.80	80.80	70	19.80
		60	14.80	74.80	60	27.20
		50	19.00	69.00	50	35.00
		40	23.40	63.40	40	43.20
		30	28.00	58.00	30	51.80
		20	32.80	52.80	20	60.80
		0	43.00	43.00	0	80.00
Example Calculations						
Equation 9.5 ART = 200 days						
50% ret: TN=50+0.43(50)=71.5%						
20% ret: TN=20+0.43(80)=54.4%						
90% ret: TN=90+0.43(10)=94.3%						
50% ret: TP=50+0.8(50)=90.0%						
20% ret: TP=20+0.8(80)=84.0%						
90% ret: TP=90+0.8(10)=98.0%						
		ER		Adjusted		
		ART = 31 d:		TN Performance		TP Performance
		Retention + Detention		Total	Retention + Detention	Total
		90	2.90	92.90	90	4.70
		80	6.00	86.00	80	9.80
		70	9.30	79.30	70	15.30
		60	12.80	72.80	60	21.20
		50	16.50	66.50	50	27.50
		40	20.40	60.40	40	34.20
		30	24.50	54.50	30	41.30
		20	28.80	48.80	20	48.80
		0	38.00	38.00	0	65.00
Wet pond annual removal charts						
Total Nitrogen		Total Phosphorus				

example TN for ART = 31 days

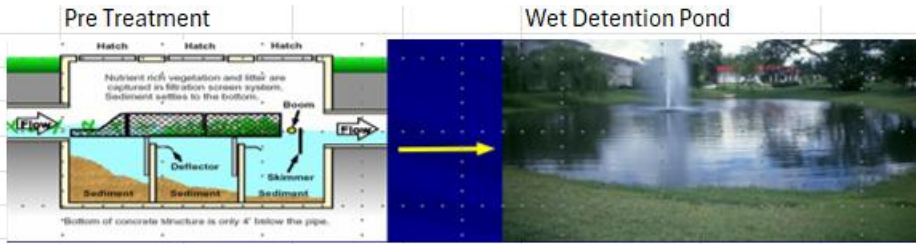
for ER = 80

EDTN = 38

and MTN = 10

$$E \text{ of detention after retention} = \frac{(100-ER) \times ((EDTN/100) - (MTN/100) \times (ER/100))}{6}$$

E of detention after retention =



Removes Gross Solids

Removes Particulates and Dissolved Nutrients

Upstream BMPs do not affect downstream removal mechanisms: can use series equation A.H. Vol 1 eq 9.5



On-Line Swales, Rain Gardens, Tree Wells



Upstream BMPs do affect downstream removal: thus use new mechanisms and then use series equation A.H. Vol 1 eq 9.5

Annual Average Residence Time (ART) = 31 days

2020 Removal Calculation*		2025 Removal Calculation*		Upstream particles not remove		Upstream particles removal			
TN Performance			TP Performance			TN	TP	TN	TP
Retention + Detentio	Total	Retention + Detentio	Total	Retention + Detentio	Total				
90	3.17	93.17	90	5.42	95.42	93.80	96.50	92.90	94.70
80	6.60	86.60	80	10.83	90.83	87.60	93.00	86.00	89.80
70	9.90	79.90	70	16.25	86.25	81.40	89.50	79.30	85.30
60	13.20	73.20	60	21.67	81.67	75.20	86.00	72.80	81.20
50	16.50	66.50	50	27.08	77.08	69.00	82.50	66.50	77.50
40	19.80	59.80	40	32.50	72.50	62.80	79.00	60.40	74.20
30	23.10	53.10	30	37.92	67.92	56.60	75.50	54.50	71.30
20	26.40	46.40	20	43.33	63.33	50.40	72.00	48.80	68.80
0	38.00	38.00	0	65.00	65.00	38.00	65.00	38.00	65.00

* Using the series equation in the A.H. Vol 1, equation 9.5. or: $Eff1 + [(1 - Eff1) \times Eff2]$

Past considerations for a reduction in wet pond removal were a constant 22% for TN and 12% for TP.

Current wet pond % reduction is 17% (E/6) for both TN and TP and not a function of upstream retention size.

Some BMPs (street sweeping, pre treatment boxes) remove gross solids and a small amount of particulates,

thus downstream removal mechanisms (mathematical functions) are not effected.

Gross solids are not the same as particulate TN and TP and are not a measure of effectiveness.

When using upstream off-line BMPs, the by-pass mix of particles and dissolved materials do not change.

Thus downstream removal mechanisms (mathematical functions) are not effected.

Wet pond removal depends on the upstream retention capture of particles that are easily settled.

Overall removal must consider the on-line upstream fraction of annual capture or retention.

Removal can use equation 9.5 after it adjusts the pond removal effectiveness, making a new removal function.

There is no surface runoff input between the upstream BMPs and the downstream wet pond.

Remember these are annual removal effectiveness values as shown in the wet pond charts.

Application: For on-line retention upstream of a wet detention pond downstream

Use the percentage of particulates in the runoff = 50

Consider the upstream capture of particles for the reduction in wet pond effectiveness

Thus, adjust the wet pond detention removal by the annual fraction captured upstream

% annual load for TN particles (from charts) removed upstream 20

thus, TN maximum reduction is = 10 the % particles in runoff x fraction annual load

% annual load for TP particles (from charts) removed upstream 40

thus, TP maximum reduction is = 20 the % particles in runoff x fraction annual load

Notes: 1. The easily settled particles do not include gross heavy solids as they are usually not measured.

2. It is recognized that a negligible amount of particles

may be released from on-line retention, but the amount is not sufficient to restore the mix of TN and TP particles in the runoff.

3. The annual removal of TN and TP for the retention is:

4. This analysis is consistent with the language in A.H. Vol 1 which

states: Where BMPs are used in series, the calculated overall efficiency of the treatment train must account for the reduced loading or concentrations that are available for removal by the subsequent downstream treatment device.



