

Rapid Infiltration of Wastewater in Maryland



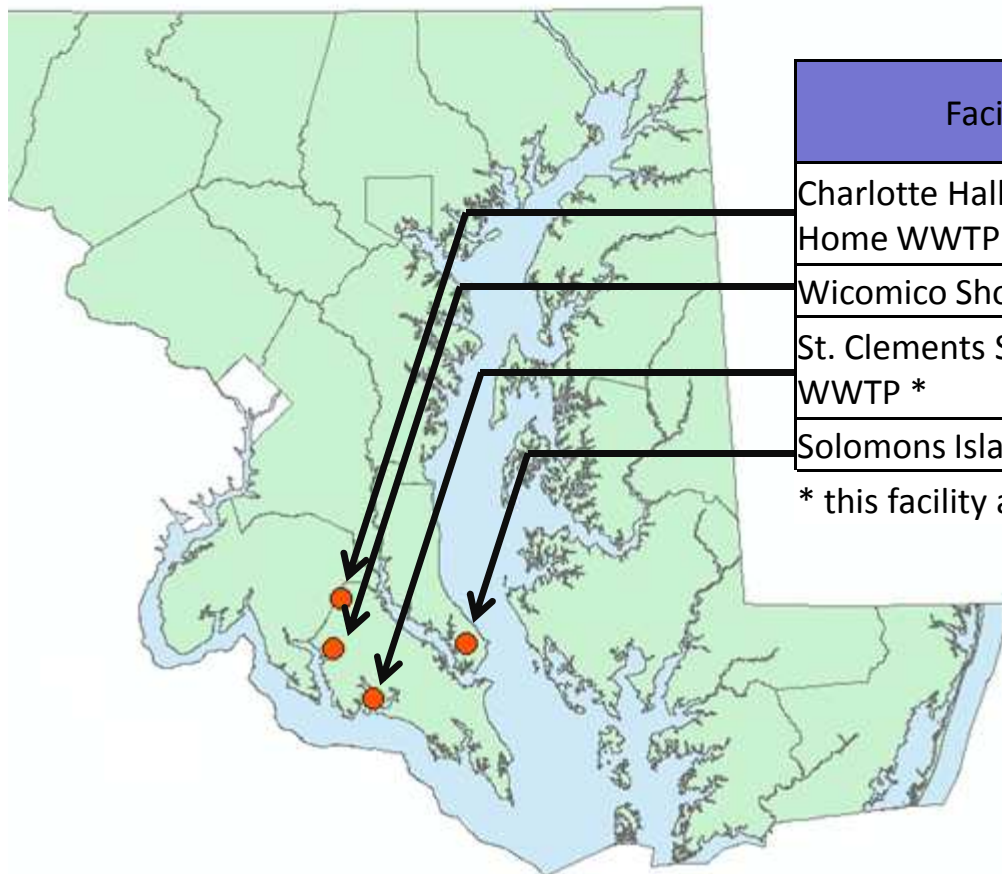
Maryland Department of the Environment

Greg Busch, P.E. – gregory.busch@maryland.gov

Ching-Tzone Tien, Ph.D., P.E. – ching-tzone.tien@maryland.gov

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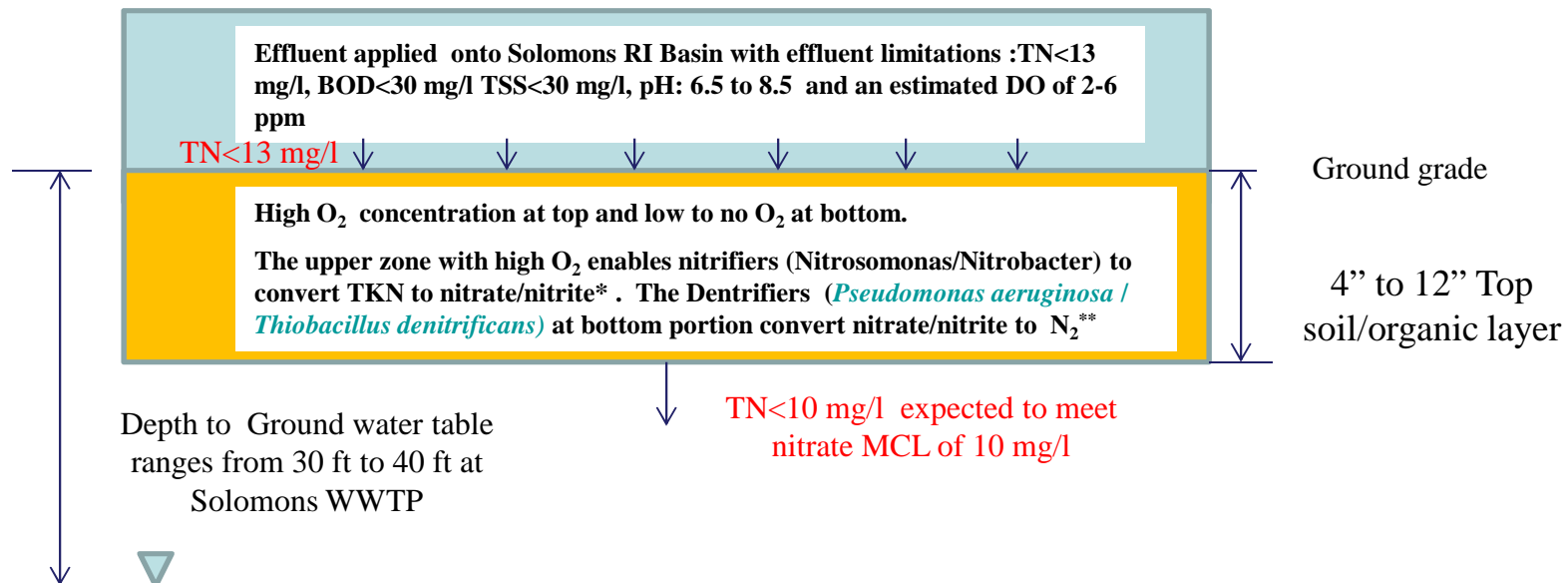
WWTPs that use RI



Facility	City	County	Design Flow (MGD)
Charlotte Hall Veterans Home WWTP *	Charlotte Hall, MD	St Mary's	0.067
Wicomico Shores WWTP	Chaptico, MD	St Mary's	0.141
St. Clements Shores WWTP *	Leonardtown, MD	St Mary's	0.1
Solomons Island WWTP	Lusby, MD	Calvert	0.7

* this facility also incorporates spray irrigation treatment

Nitrogen Removal Mechanisms in a Rapid Infiltration Basin



*Overall Nitrification Reaction



For every gram (g) of NH₄⁺ nitrified, it requires 4.25 g of O₂, 7 g of alkalinity (as CaCO₃) and 0.08g of inorganic carbon

**Overall Denitrification Reaction

- Carbon source from wastewater (C₁₀H₁₉O₃N)

$$\text{C}_{10}\text{H}_{19}\text{O}_3\text{N} + 10 \text{NO}_3^- \rightarrow 5\text{N}_2 + 10\text{CO}_2 + 3 \text{H}_2\text{O} + \text{NH}_3 + 10\text{OH}^-$$
- Carbon source from Methanol (CH₃OH) remained in the effluent, if any.

$$5\text{CH}_3\text{OH} + 6 \text{NO}_3^- \rightarrow 3\text{N}_2 + 5\text{CO}_2 + 7\text{H}_2\text{O} + 6\text{OH}^-$$

Nutrient Removal Assumptions

- EPA's "Process Design Manual for Land Treatment of Municipal Wastewater" states that nitrogen removal efficiencies for these systems are typically 50%
- Based on data in this report from a similar plant in Lake George, NY, Maryland estimated the removal efficiency of Solomons Island WWTP to be 30%
- Assumes full removal of phosphorus in the soil

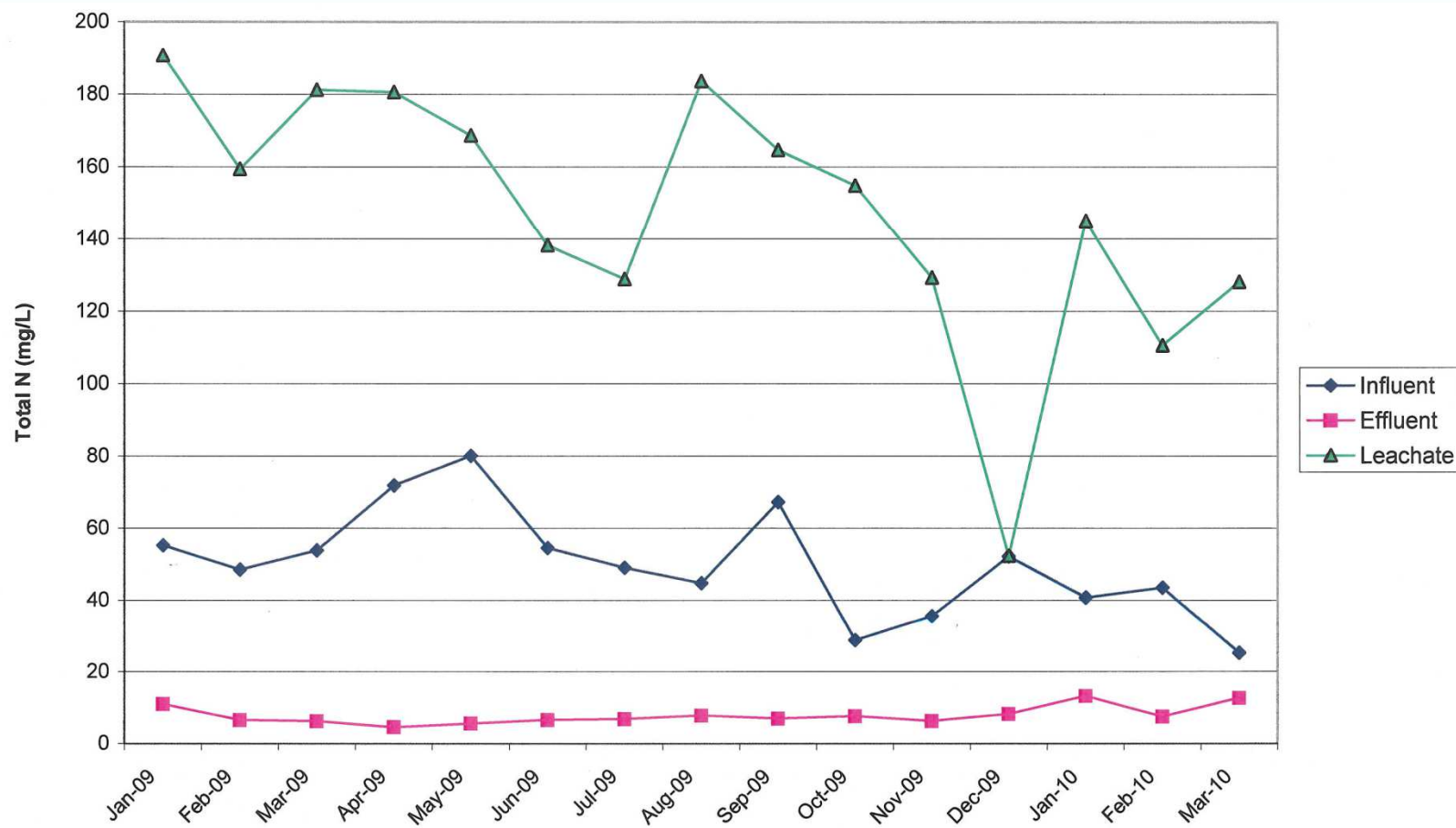


TABLE 5-2
NITROGEN REMOVAL DATA FOR SELECTED RI
SYSTEMS [1,2,4,6-9]

Location	Concentration in applied wastewater: total N, mg/L	Loading rate, m/yr	BOD:N ratio	Flooding to drying time ratio	Concentration in renovated water, mg/L		Removal, % of total N
					NO ₃ -N	Total N	
Boulder, Colorado	16.5	48.8	2.3:1	1:3	6-16	9-16	10-20
Brookings, South Dakota	10.9	12.2	2:1	1:2	5.3	6.2	43
Calumet, Michigan	24.4	17.1	3.6:1	1:2	3.4	7.1	71
Disney World, Florida	--	54.9	0.3:1	150:14	--	--	12
Fort Devens, Massachusetts	50	30.5	2.4:1	2:12	13.6	19.6	61
Hollister, California	40.2	15.2	5.5:1	1:14	0.9	2.8	93
Lake George, New York	11.5 12.0	58.0 58.0	2:1 2:1	1:4 1:4	-- --	7.70 7.50	33 38
Phoenix, Arizona	27.4	61.0	1:1	9:12	6.2	9.6	65

At some sites the goal of RI may be only nitrification (for example, Boulder, Colorado).

Total Nitrogen Concentrations – Solomons Island WWTP (2009-2010)



Leachate from a nearby landfill site is a small portion of the influent flow to the Solomons Island WWTP



2009 Average Nitrogen and Orthophosphate Concentrations in 10 Solomons Island Groundwater Monitoring Wells *

Well No. N&P	1	2	3	4	5	6	7	8	9	10
TKN (mg/l)	<0.3	<0.28	0.7	<0.2	2.73	<0.1	<0.2	<0.18	<0.43	<0.23
Nitrate (mg/l)	7.5	6.8	6.43	4.81	4.4	2	6.5	5.9	5.8	5.6
Total N (mg/l)	<7.8	<7.08	7.13	<5	7.13	<2.1	<6.7	<6.08	<6.23	<5.83
PO ₄ ⁻³ (mg/l)	0.45	0.15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Average of 4 sampling events on 11/30; 8/17; 6/1;
and 3/16 in 2009





2014 Average Nitrogen and Orthophosphate Concentrations in 8 Solomons Island Groundwater Monitoring Wells *

Well No. N&P	1	2	3	4	5	6	7	8	9	10
TKN (mg/l)	<0.5	<0.5	<0.5	<0.5	N/A	N/A	<0.5	<0.5	<0.5	<0.5
Nitrate (mg/l)	5.2	6.8	7.4	6	N/A	N/A	5.93	7.85	5.95	5.5
Total N (mg/l)	<5.7	<7.3	<7.9	<6.5	N/A	N/A	<6.43	<8.35	<6.45	<6.0
PO ₄ ⁻³ (mg/l)	0.55	<0.1	<0.1	<0.1	N/A	N/A	<0.13	<0.2	<0.2	<0.2

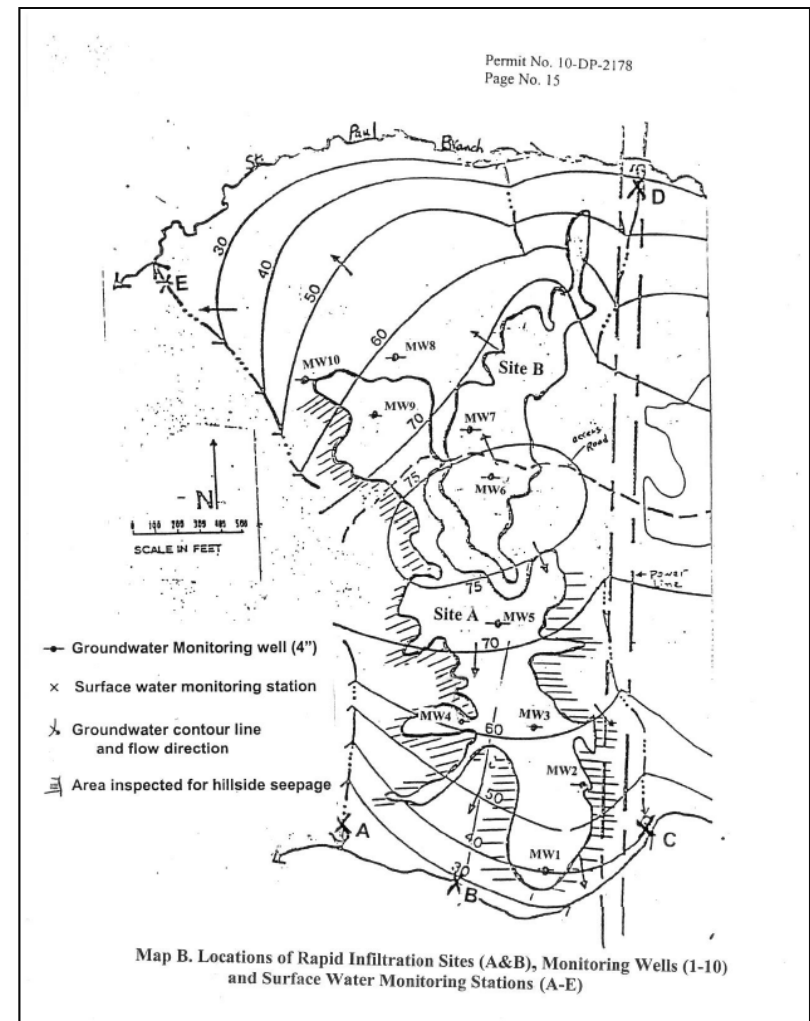
*Average of 4 sampling events on 12/1; 8/18; 6/9; and 3/10 in 2014.

N/A: Data not available



Solomons Island Permit Limits

- Limits prior to discharge
 - Flow: 0.7 MGD
 - Total Nitrogen: 13 mg/L (weekly)
- Limits from down gradient monitoring wells
 - *grab samples taken once every 3 months*
 - Total Nitrogen: 10 mg/L
 - approx 30% reduction in soil from 13 mg/L
 - Nitrate: 10 mg/L



Solomons Island DMR

- DMR data from October 2011 to February 2014 show:
 - Average monthly discharge: 0.392 MGD
 - Average TN concentration: 8.2 mg/L
 - Annual TN load: 9,802 lbs/yr
- Nitrogen delivery to groundwater, assuming a 30% attenuation in the soil column
 - Average TN concentration: 5.7 mg/L
 - Annual TN load: 6,861 lbs/yr

Groundwater attenuation

- Most of the RI basins at Solomons Island WWTP are located within 1,000 feet of a perennial stream
 - It is reasonable to use a 50% attenuation factor
 - Combining the 30% soil attenuation with the 50% groundwater attenuation yields a 65% attenuation (35% delivery)
- $(1 - 0.3) \times (1 - 0.5) = 0.35$
- This would yield an average total nitrogen loading of 3,431 lbs/yr primarily (>90%) in the form of nitrate



Outfall to EOS Delivery factors

For plants within 1,000 feet of a perennial stream:

$$1 - (1 - 0.3 \text{ soil attenuation}) \times (1 - 0.5 \text{ groundwater attenuation}) = 0.65 \text{ total attenuation to EOS}$$

For plants more than 1,000 feet from a perennial stream:

$$1 - (1 - 0.3 \text{ soil attenuation}) \times (1 - 0.7 \text{ groundwater attenuation}) = 0.79 \text{ total attenuation to EOS}$$

Facility	City	County	Design Flow (MGD)	Attenuation	Delivery	notes
Charlotte Hall Veterans Home WWTP *	Charlotte Hall, MD	St Mary's	0.067	79%	21%	Over 1,000 feet from a perennial stream
Wicomico Shores WWTP	Chaptico, MD	St Mary's	0.141	79%	21%	Over 1,000 feet from a perennial stream
St. Clement's Shores WWTP *	Leonardtown, MD	St Mary's	0.1	65%	35%	Within 1,000 feet of a perennial stream
Solomons Island WWTP	Lusby, MD	Calvert	0.7	65%	35%	Within 1,000 feet of a perennial stream

* this facility also incorporates spray irrigation treatment

Note: These factors are subject to change based on the findings of the Onsite Wastewater Nutrient Attenuation Expert Panel