Rapid Infiltration of Wastewater in Maryland

Maryland Department of the Environment

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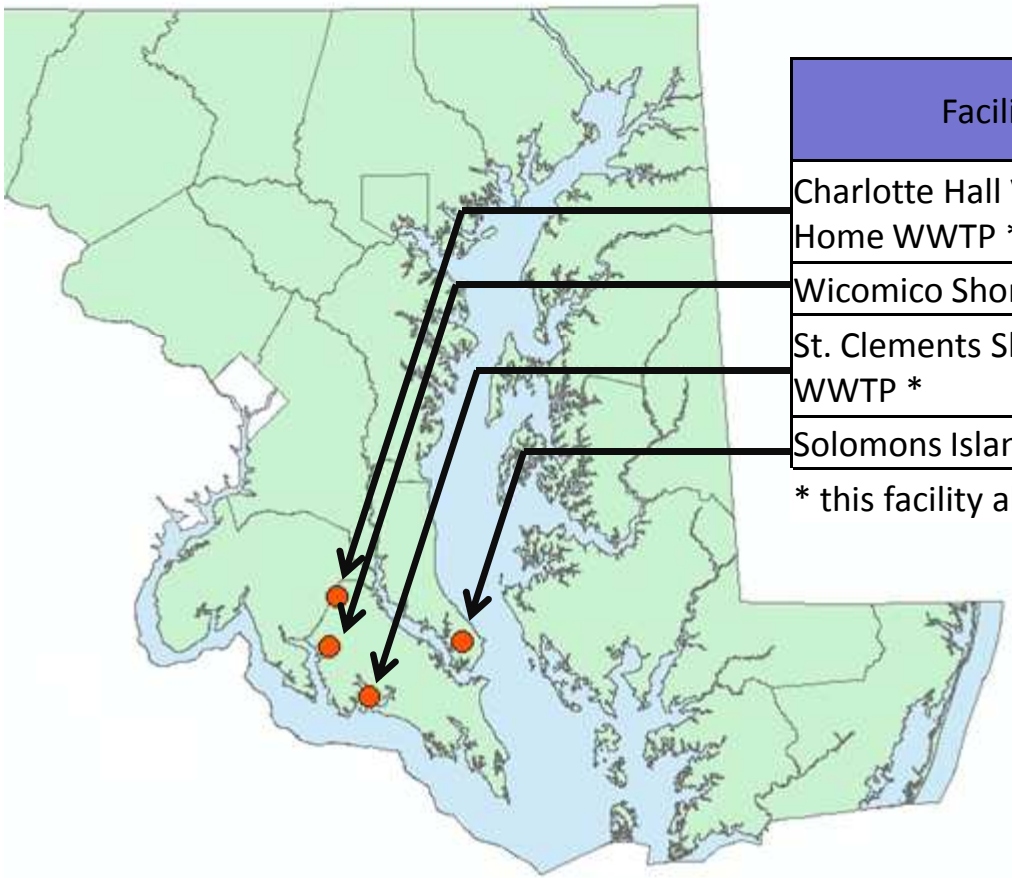
WWTPs that use RI

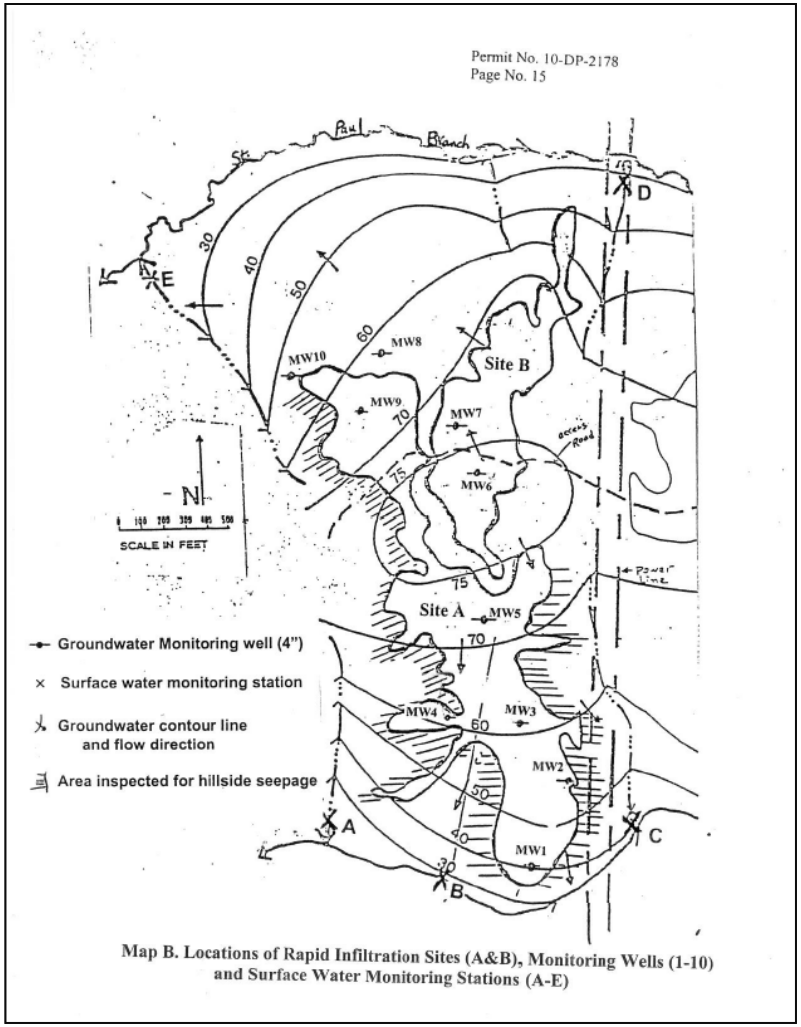


Facility	City	County	Design Flow (MGD)
Charlotte Hall Veterans Home WWTP *	Charlotte Hall, MD	St Mary's	0.067
Wicomico Shores WWTP	Chaptico, MD	St Mary's	0.141
St. Clements Shores WWTP *	Leonardtown, MD	St Mary's	0.1
Solomons Island WWTP	Lusby, MD	Calvert	0.7

* this facility also incorporates spray irrigation treatment

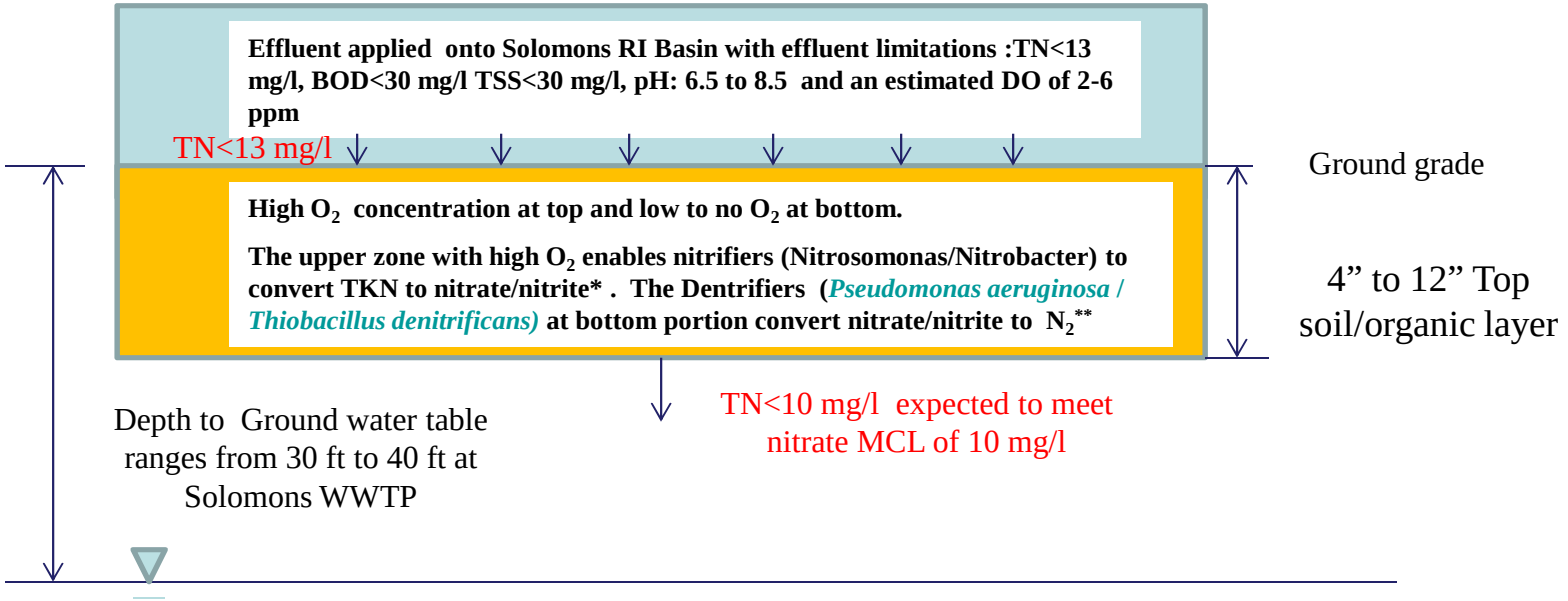
Solomons Island Permit Limits

- 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



Map B. Locations of Rapid Infiltration Sites (A&B), Monitoring Wells (1-10) and Surface Water Monitoring Stations (A-E)

Nitrogen Removal Mechanisms in a Rapid Infiltration Basin



***Overall Nitrification Reaction**

$NH_4^+ + 1.863\ O_2 + 0.098CO_2 \rightarrow 0.0196\ C_5H_7NO_2 + 0.98\ NO_3^- + 1.98\ H^+ + 0.094\ H_2O$

For every gram (g) of NH_4^+ nitrified, it requires 4.25 g of O_2, 7 g of alkalinity (as $CaCO_3$) and 0.08g of inorganic carbon

****Overall Denitrification Reaction**

1. **Carbon source from wastewater ($C_{10}H_{19}O_3N$)**

   $C_{10}H_{19}O_3N + 10\ NO_3^- \rightarrow 5N_2 + 10CO_2 + 3\ H_2O + NH_3 + 10OH^-$

2. **Carbon source from Methanol (CH_3OH) remained in the effluent, if any.**

   $5CH_3OH + 6\ NO_3^- \rightarrow 3N_2 + 5CO_2 + 7H_2O + 6OH^-$

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

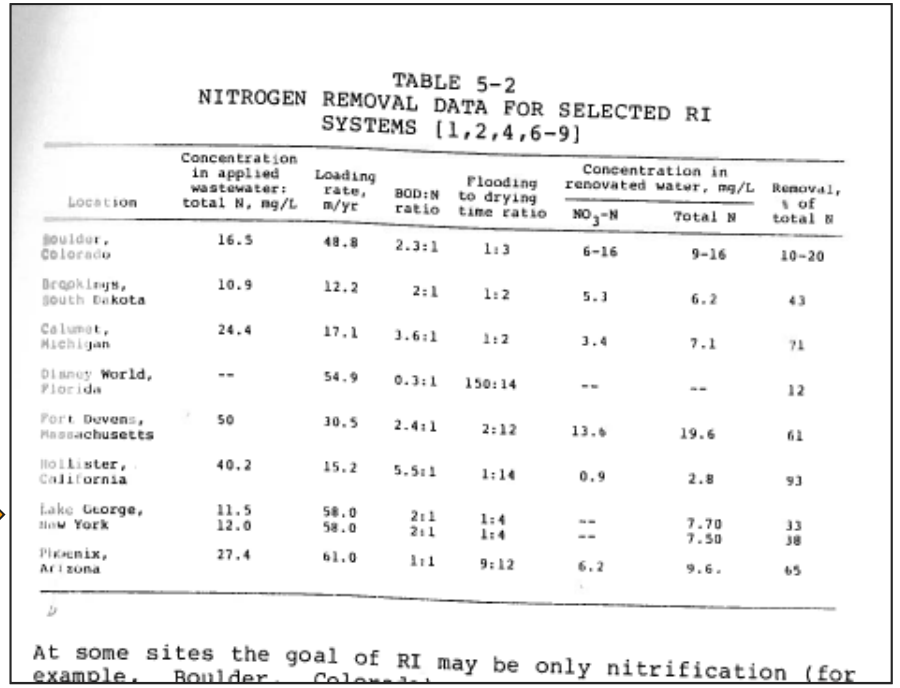
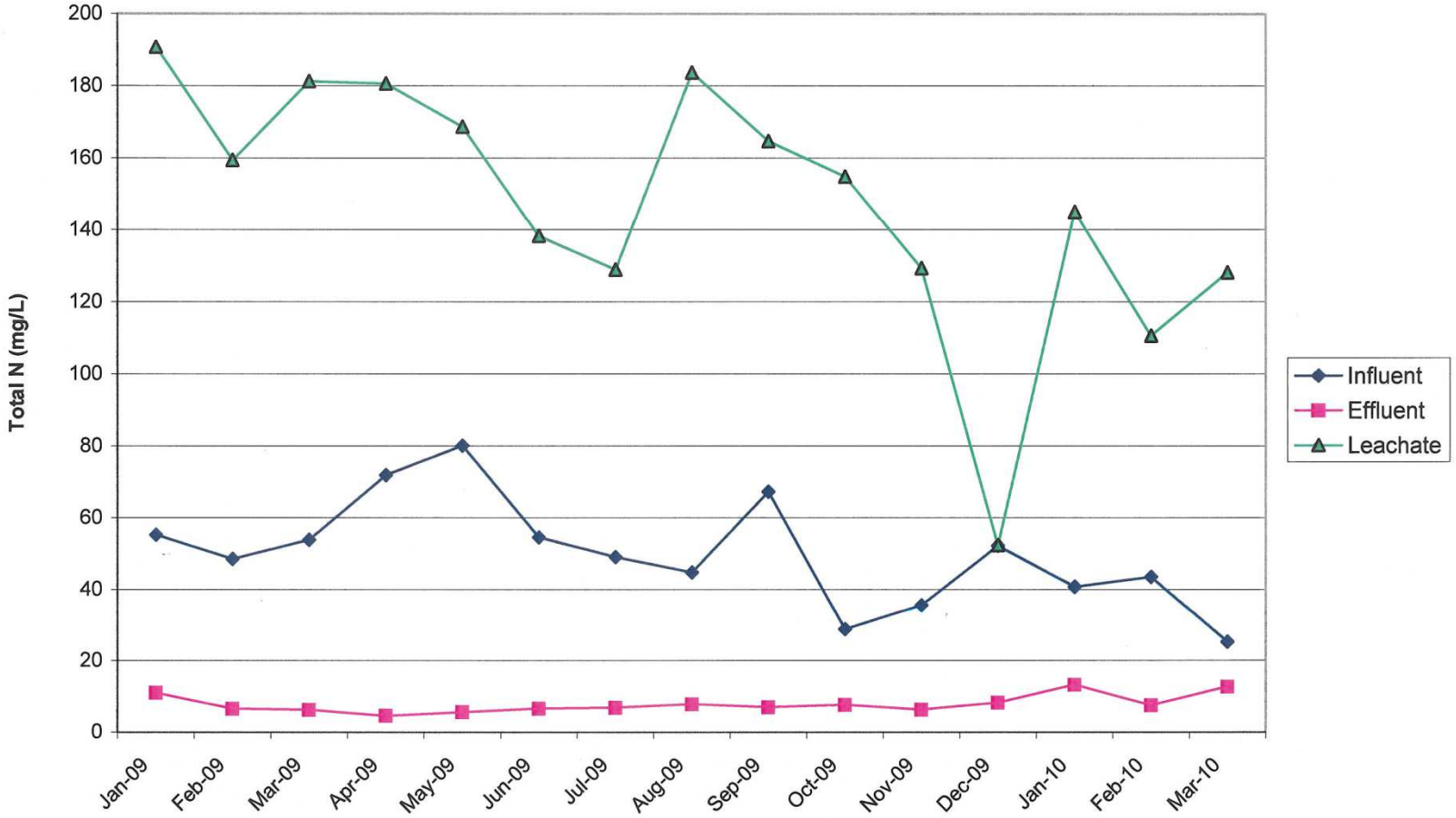


TABLE 5-2
NITROGEN REMOVAL DATA FOR SELECTED RI SYSTEMS [1,2,4,6-9]

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.

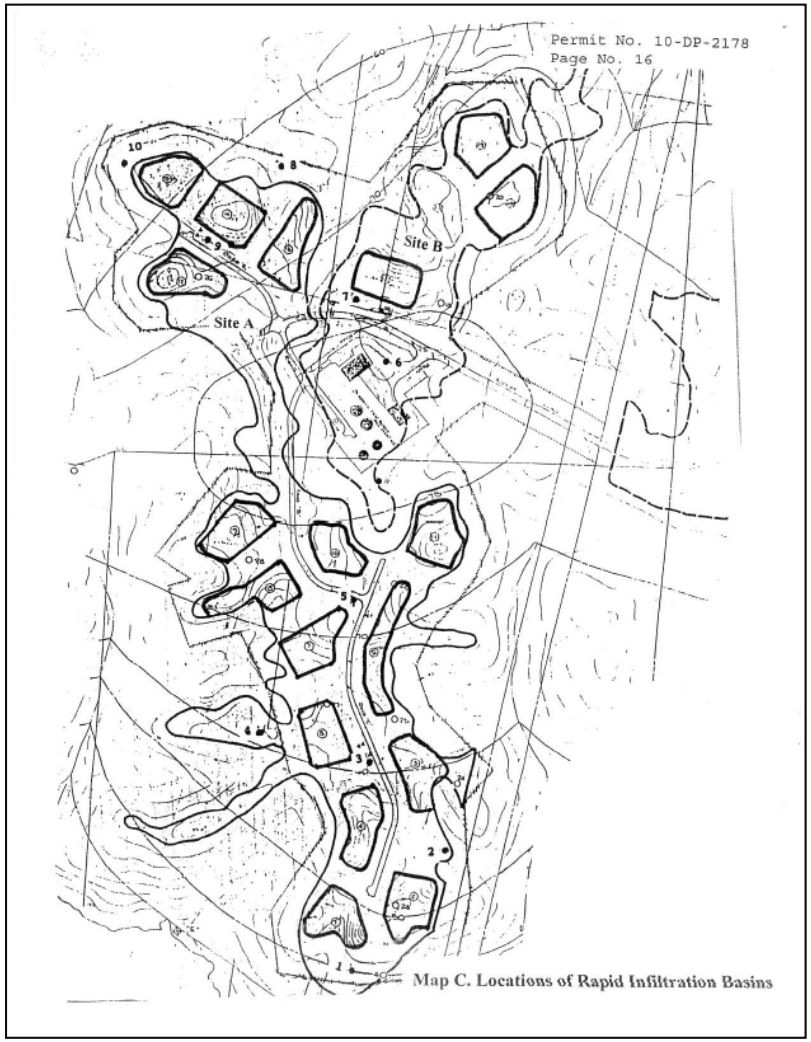
N/A: Data not available

Solomons Island 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
    - 50% accounts for both the soil and groundwater losses
    - Therefore the 30% soil attenuation would be included in the 50%
    - This would yield an average total nitrogen loading of 4,901 lbs/yr primarily (>90%) in the form of nitrate



Delivery factors

Facility	City	County	Design Flow (MGD)	Attenuation	Delivery	notes
Charlotte Hall Veterans Home WWTP *	Charlotte Hall, MD	St Mary's	0.067	70%	30%	Over 1,000 feet from a perennial stream
Wicomico Shores WWTP	Chaptico, MD	St Mary's	0.141	70%	30%	Over 1,000 feet from a perennial stream
St. Clement's Shores WWTP *	Leonardtown, MD	St Mary's	0.1	50%	50%	Within 1,000 feet of a perennial stream
Solomons Island WWTP	Lusby, MD	Calvert	0.7	50%	50%	Within 1,000 feet of a perennial stream

* this facility also incorporates spray irrigation treatment

Modeling Questions

- If RI is modeled as a nonpoint source, what land use is it applied to?
- Or should RI be modeled like onsite wastewater treatment systems (OWTS) as a daily load in the river reach?