Riparian Buffer Nutrient Credit Yield

Subcommittee Meeting

May 4, 2009

Buffer Nutrient Credit Yield

- Overview of current calculation
- Identification of issues
- Draft calculation revisions and policy guidelines
- Discussion

Current Credit Yield Calculation

- Based on three water quality benefits:
  - Land use change
  - Nutrient removal from NPS runoff
  - Nutrient removal from overbank flooding
- Nitrogen credit = Benefit 1+2+3
- Phosphorous credit = Benefit 1+2

NC Division of Water Quality - Methodology and Calculations for determining Nitrogen Reduction associated with Riparian Buffer Establishment

Water Quality Benefits for Riparian Buffer Restoration

1). Benefit of Land Use Change
2). Benefit of Nutrient Removal from Nonpoint Source Runoff
3). Benefit of Nutrient Removal from Periodic Overbank Flood

General Assumptions:

1. Life expectancy of Riparian Buffer is assumed to be 30 years. (Life expectancy for stormwater detention pond is 20 - 30 yrs)
2. Restored Riparian Buffer is assumed to be natural.

Effectiveness of Riparian Buffer	Annual Effectiveness (kg/ha/yr)	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.08	9.89	296.57
Benefit (2)	70.09	62.54	1,876.08
Benefit (3)	3.75	3.35	100.37
Total	84.92	75.77	2,273.02

Detailed Benefit Descriptions and Assumptions:

1) Benefit is due to change land use.
Assume existing land use export coefficient is a composite export coefficient with a value of 12.98 kg/ha (agriculture and urban).
Wetland export coefficient is 1.9 kg/ha.
The annual nutrient output is decreased by 11.08 kg/ha annually by land use changing.
2) Benefit is due to nitrogen removal from nonpoint source runoff.
Nutrient contribution/buffer treatment area ratio is approximately 10.8 (based on studies examined by Gannon 1997).
In flow loading is calculated by nutrient contribution area x composite export coefficient.
In flow loading is 10.8 ha x 12.98 kg/ha = 140 kg/ha/yr.
Nutrient removal due to this benefit is calculated by in flow loading x removal efficiency
*Gannon, Richard. 1997. Effectiveness of Wetland Riparian Areas for Treatment of Agricultural Pollution Sources: A Literature Review. (Draft)
The nitrogen removal efficiency is 50% based on various literature.
* Kadlec, Robert H. and Robert L. Knight. 1996. Treatment Wetland
* Moshiri, Gerald A.1993. Constructed Wetlands for Water Quality Improvement. Lewis Publi.
* Mitsch, William J. 1994. Global Wetlands: Old world and New. Elsevier
3) Benefit is due to nitrogen removal from overbank flooding
Nitrogen concentration is assumed to be 2.5 mg/L. Assume overboard is 1 ft. Flood frequency is assumed to be once every year.
Nutrient removal due to this benefit is estimated by in flow concentration x area (1 ha) x overboard height x removal efficiency.

Formula for Calculating Nitrogen Offset Reductions on Riparian Buffer Restoration Sites:

*Size (Acres) * 75.77(lbs/Acre/Year) * 30 Years = Total Pounds of Nitorgen Removed from Riparian Buffer Project*

NC Division of Water Quality - Methodology and Calculations for determining Total Phosphorus Removal associated with Riparian Buffer Establishment in Tar Pamlico River Basin

Water Quality Benefits for Riparian Buffer Restoration

1). Benefit of Land Use Change

2). Benefit of Nutrient Removal from Nonpoint Source Runoff

General Assumptions:

1. Life expectancy of Riparian Buffer is assumed to be 30 years.

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	1.73	51.90
Benefit (2)	3.15	94.50
Total	4.88	146.40

Detailed Benefit Descriptions and Assumptions:

1) Benefit is due to change land use [2,3]

Export coefficient for agricultural land is 2.15 (lb/ac/yr).

Export coefficient for riparian buffer is 0.42 (lb/ac/yr).

The annual total phosphorus (TP) output is decreased by 1.73 lb/ac annually by land use changing.

2) Benefit is due to TP removal from nonpoint source runoff [4, 5]

Mass load for TP reductions for buffer is estimated to be 3.15 lb/ac/yr.

Assumptions:

Riparian buffer restorations only occur on agricultural lands.

Width of restored riparian buffer is 50 feet, and with mixture of grass and forest.

References:

[2] NC Division of Water Quality memo 'Export Coefficients Revisited' (1996)

[3] Comparison of Selected TP Loading Coefficients (Jim Blose, 2001)

[4] Cost-Effectiveness Study of Selected Agricultural Best Management Practices in the Neuse and Tar-Pamlico River Basins (Todd Kennedy, 2001)

[5] A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation. (Seth Wenger, 1999)

Formula for Calculating Phosphorous Offset Reductions on Riparian Buffer Restoration Sites:

*Size (Acres) * 4.88(lbs/Acre/Year) * 30 Years = Total Pounds of Total Phosphorus Removed from Riparian Buffer Project*

Benefit #1
Land Use Change

- Benefit derived from converting from a land use with higher nutrient export to one with lower nutrient export

- Current method:
  - Ag/Urban export coeff. – Buffer /Wetlands export coeff.

- Assumptions
  - Ag/Urban (N) composite export coefficient = 11.57 lbs/ac
  - Wetlands (N) export coefficient = 1.76 lbs/ac
  - Agriculture (P) export export coefficient = 2.15 lb/ac
  - Riparian buffer (P) export coefficient = 0.42 lb/ac

Benefit #2
Removal from Runoff

- Benefit of removing nutrients from runoff flowing into the buffer

- Current method:
  - Inflow loading = drainage area x composite export coefficient
  - (Inflow loading) x (% removal efficiency)

- Assumptions
  - Drainage area = 10.8 ha
  - Ag/urban composite export coefficient = 11.57 lbs/ac
  - Removal efficiency = 50% (N)

Benefit #3
Nitrogen Removal from Overbank Flooding

- Benefit of removing nutrients (nitrogen only) from periodic flooding

- Current method:

(Flow concentration) x (area) x (overboard height) x (% removal)

- Assumptions
  - Flow concentration = 2.5 mg/L nitrogen
  - Area = 1 ha
  - Overboard height = 1 foot
  - Removal efficiency = 50%
  - Periodic flooding = once a year

Deficiencies of Current Method

- Composite export coefficient
  - Ag/Urban used instead of Ag/pasture
  - Export coefficient not adjusted by basin
- Drainage Area
  - 10 acre assumption does not account for variables
    - Drainage area varies by buffer width (50’ vs. 200’)
    - Varies by region (Piedmont vs. Coastal Plain)
- Removal efficiency
  - Only 50’ buffers
  - All buffer widths do not achieve same % removal

Deficiencies of Current Method

- Instream concentration
  - 2.5 mg/L (N) assumption seems high
- General Assumptions
  - All buffer projects do not achieve all three benefits for nitrogen removal credit

Draft Credit Yield Calculation Update

- Updated variables (formula remains the same)
  - Removal efficiency
    - % reduction for 50’ and 200’ buffers
  - Drainage area
    - Calculated for 50’ & 200’ buffers in Piedmont & Coastal
  - Composite Export Coefficient
    - Basin specific based on acre weighted average of Ag/pasture
  - Instream concentration
    - Updated based on recent water quality data

DRAFT NC Division of Water Quality - Methodology and Calculations for determining Nitrogen Reduction associated with Riparian Buffer Establishment

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Water Quality Benefits for Riparian Buffer Restoration

1). Benefit of Land Use Change
2). Benefit of Nutrient Removal from Nonpoint Source Runoff
3). Benefit of Nutrient Removal from Periodic Overbank Flood

General Assumptions:

1). Composite export coefficient for Tar-Pam (Ag/Pasture) = 13.78 Composite export coefficient for Neuse (Ag/Pasture) = 13.52
2). Drainaige Area for 50' Buffer = 5.62 acres (Piedmont) / 11.7 acres (Coastal Plain), 200' Buffer = 1.4 acres (Piedmont) / 2.9 acres (Coastal Plain)
3). In stream nitrogen concentration is 0.7 mg/L

50 Foot Buffer in Piedmont (Tar-Pam)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.83	354.90
Benefit (2)	38.72	1,161.60
Benefit (3)	0.95	28.50
Total	51.50	1,545.00

50 Foot Buffer in Piedmont (Neuse)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.57	347.10
Benefit (2)	37.99	1,139.70
Benefit (3)	0.95	28.50
Total	50.51	1,515.30

50 Foot Buffer in Coastal Plain (Tar-Pam)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.83	354.90
Benefit (2)	98.35	2,950.50
Benefit (3)	0.95	28.50
Total	111.13	3,333.90

50 Foot Buffer in Coastal Plain (Neuse)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.57	347.10
Benefit (2)	96.49	2,894.70
Benefit (3)	0.95	28.50
Total	109.01	3,270.30

200 Foot Buffer in Piedmont (Tar-Pam)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.83	354.90
Benefit (2)	14.97	449.10
Benefit (3)	0.95	28.50
Total	27.75	832.50

200 Foot Buffer in Piedmont (Neuse)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.57	347.10
Benefit (2)	14.69	440.70
Benefit (3)	0.95	28.50
Total	27.21	816.30

200 Foot Buffer in Coastal Plain (Tar-Pam)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.83	354.90
Benefit (2)	31.01	930.30
Benefit (3)	0.95	28.50
Total	43.79	1,313.70

200 Foot Buffer in Coastal Plain (Neuse)

Effectiveness of Riparian Buffer	Annual Effectiveness (lb/ac/yr)	Effectiveness in 30 yrs (lb/ac)
Benefit (1)	11.57	347.10
Benefit (2)	30.43	912.90
Benefit (3)	0.95	28.50
Total	42.95	1,288.50

Buffer Project Policy Guidelines

- No written policy guidelines for nutrient credit
- Buffer nutrient credit based on past project approval

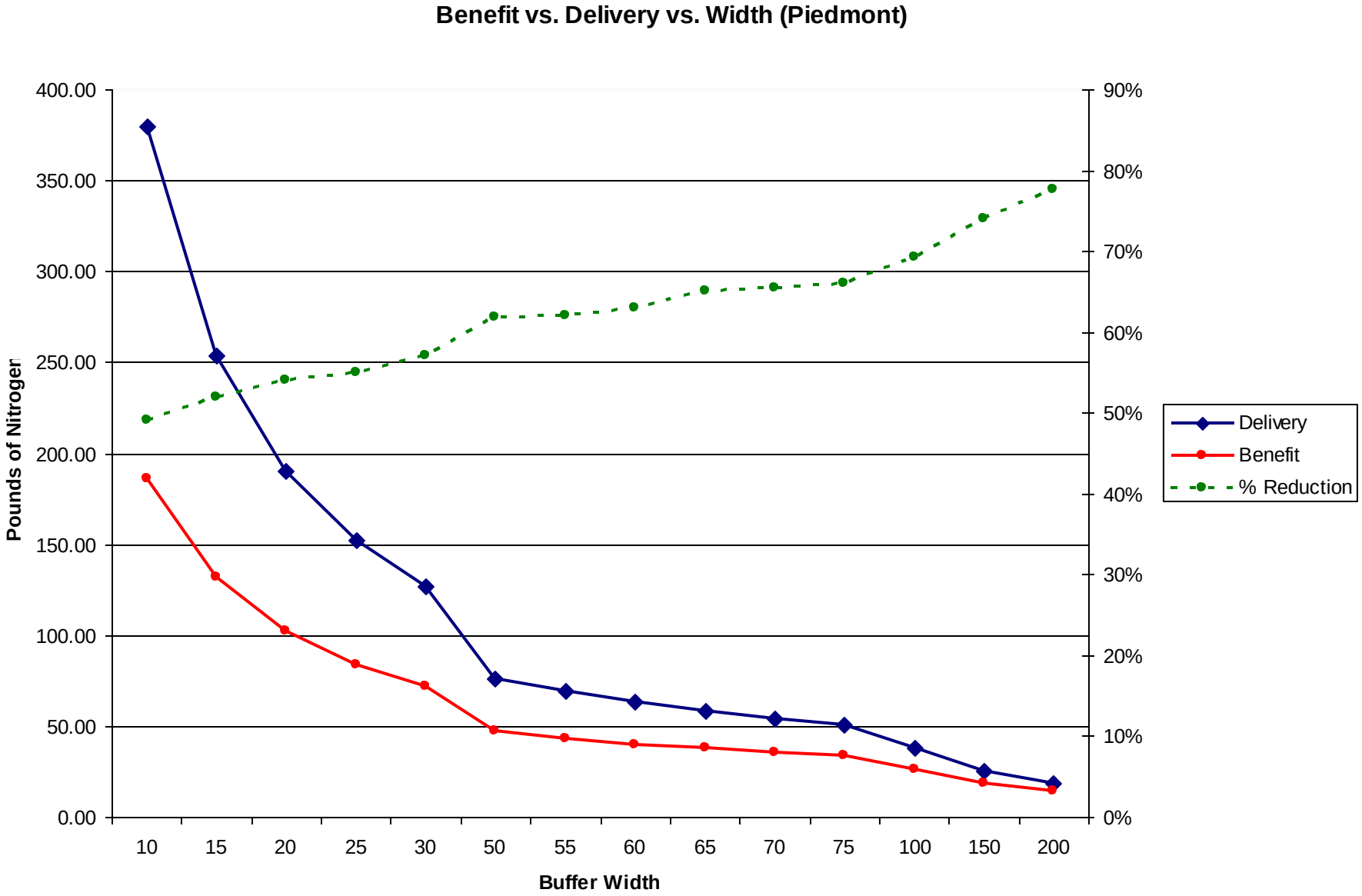
Policy Guideline Considerations for Uniform Credit Yield Method

- All projects shall meet the following criteria:
  - Located only on intermittent or perennial streams
  - In the Piedmont, projects cannot be located on unstable or modified natural streams
  - Land use in drainage area shall be agricultural.
  - Buffer width shall be 50 feet.

Discussion

- Feedback on draft calculation update
- Options
  - Leave calculation on guidelines unchanged
  - Update calculation and guidelines
  - Leave calculation unchanged / update guidelines
- Recommendations

Slides in Reserve


Benefit vs. Delivery vs. Width (Piedmont)
Pounds of Nitroger
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10
15
20
25
30
50
55
60
65
70
75
100
150
200
Buffer Width
Delivery
Benefit
% Reduction

Piedmont Region

Drainage Density (Stream miles / mi2 draiange area)	Buffer Width (Feet)	Drainage Area Conversion (Acres)	N Reduction (%)	Export Coefficient (lbs/ac)	Removal (lbs/ac)
9.39	10	28.12	49%	13.52	186.3
9.39	15	18.74	52%	13.52	131.8
9.39	20	14.06	54%	13.52	102.6
9.39	25	11.25	55%	13.52	83.6
9.39	30	9.37	57%	13.52	72.2
9.39	50	5.62	61.8%	13.52	47.0
9.39	55	5.11	62%	13.52	42.8
9.39	60	4.69	63%	13.52	39.9
9.39	65	4.33	65%	13.52	38.0
9.39	70	4.02	65.5%	13.52	35.6
9.39	75	3.75	66%	13.52	33.5
9.39	100	2.81	69.3%	13.52	26.3
9.39	150	1.87	74%	13.52	18.8
9.39	200	1.41	77.6%	13.52	14.7

Graphed Data

Buffer Width (Fee	Delivery Rate (lbs)	Removal (lbs)	% N Reduction
10	380.12	186.3	49%
15	253.41	131.8	52%
20	190.06	102.6	54%
25	152.05	83.6	55%
30	126.71	72.2	57%
50	76.02	47.0	61.8%
55	69.11	42.8	62%
60	63.35	39.9	63%
65	58.48	38.0	65%
70	54.30	35.6	65.5%
75	50.68	33.5	66%
100	38.01	26.3	69.3%
150	25.34	18.8	74%
200	19.01	14.7	77.6%