Center for TMDL and Watershed Studies

Biological Systems Engineering

*Sediment TMDL for Benthic Impairment of Abrams Creek and Lower Opequon Creek*

Final Public Meeting

July 1, 2003

**Virginia Tech Biological Systems Engineering Department**

## Project Personnel

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## Presentation Overview

- **Purpose of a TMDL**
  - **Definition**
- Watershed overview
  - Location
  - Specific impairments
- Stressor analysis review
- Sediment TMDL
  - Sources
  - Modeling
  - Allocation
- Results

## What is a TMDL?

- The maximum amount of pollutant that can enter a water body without negatively affecting its beneficial uses
  - fishing, swimming, wildlife habitat, aquatic life, shellfish harvesting
- TMDL = point sources + nonpoint sources + margin of safety
- Required when a stream is impaired

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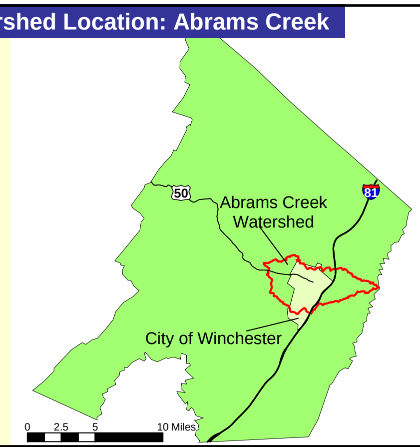
## Watershed Location: Abrams Creek

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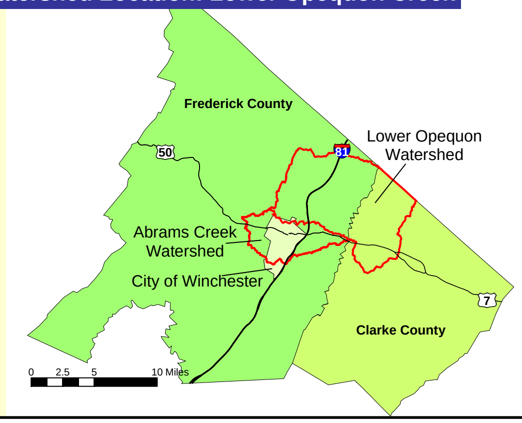
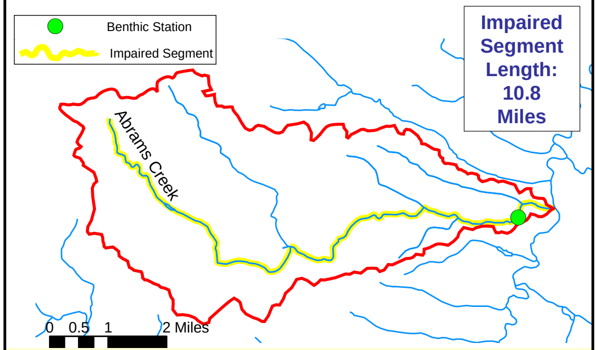
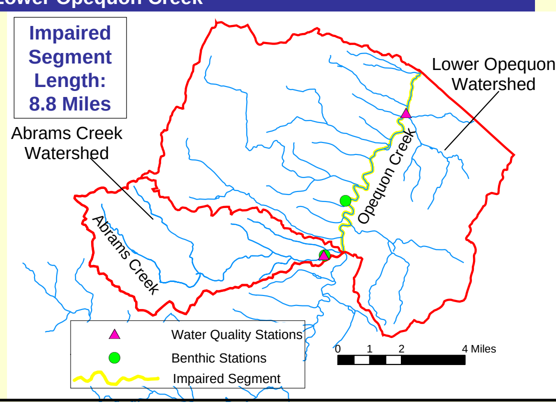
## Watershed Location: Lower Opequon Creek




## Impaired Segment and DEQ Monitoring Station Location: Abrams Creek




## Impaired Segment and DEQ Monitoring Station Location: Lower Opequon Creek




## Abrams Creek and Lower Opequon Impairments

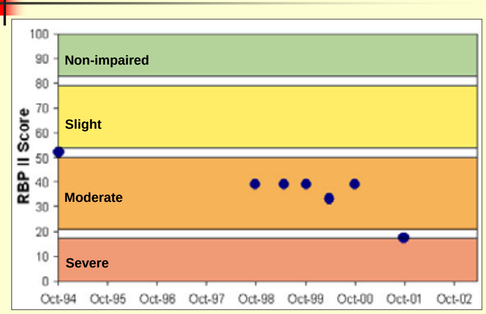
- Each stream has two impairments:
  - Bacteria Impairment
  - Benthic Impairment due to Excess Sediment
- This presentation focuses on the
  Benthic Impairment
- Bacteria Impairment Public Presentation
  July 8, 2003

## RBP II Assessment (Benthic Macro-invertebrates)

- Stream sample measurements (metrics)
  - Number
  - Diversity
  - Pollution tolerance

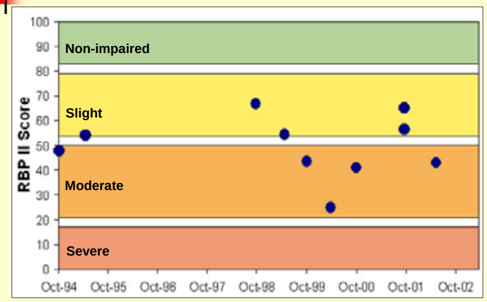
- Quantitative
  - Non-impaired, slight, moderate, severe
  - Comparison to a non-impaired stream
- Assesses compliance with Aquatic Life Use standard
- Impairment: requires 2 or more assessments of 'moderate' or worse

## RBP II Chart: Abrams Creek




Impairment = Overall Rating of Moderate or Severe

## RBP II Chart: Lower Opequon Creek




Impairment = Overall Rating of Moderate or Severe

## Presentation Overview

- Purpose of a TMDL
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- Results

## Stressors Considered

- Sediment
- Organic Matter
- pH
- Toxics
- Nutrients
- Suspended Solids
- Temperature

## Abrams Creek Stressor Analysis

- Eliminated Stressors
  - Suspended Solids
  - Temperature
  - pH
  - Nutrients
  - Toxics
- Possible Stressors
  - Organic Matter

## Abrams Creek: Most Probable Stressor

Sediment

- Low “% Haptobenthos” in MAIS
- Poor riparian vegetation
- Significant embeddedness
- Observation of streambank trampling by livestock
- Downstream scouring from armoured sections of Town Run

## Lower Opequon Creek Stressor Analysis

- Eliminated Stressors
  - Suspended Solids
  - Temperature
  - pH
  - Toxics
- Possible Stressors
  - Organic Matter
  - Nutrients

## Lower Opequon Creek: Most Probable Stressor

Sediment

- Low “% Haptobenthos” in MAIS
- Poor substrate availability
- Significant embeddedness
- Inputs from Abrams Creek, a tributary to Lower Opequon Creek

## Presentation Overview

- Purpose of a TMDL
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- Stressor analysis review
- **Sediment TMDL**
  - **Sources**
  - **Modeling**
  - **Allocation**
- Results

## Sediment Sources

- Surface Runoff
- Channel Erosion
- Streambank Erosion

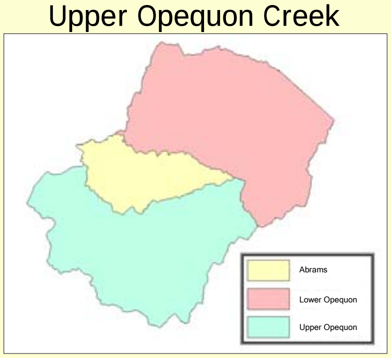
(Surface Runoff, Channel Erosion and Streambank Erosion are bracketed together:) Influenced by human activities

- Point Source TSS Loads
  - VPDES
  - General permit 1000 gpd units
  - MS4

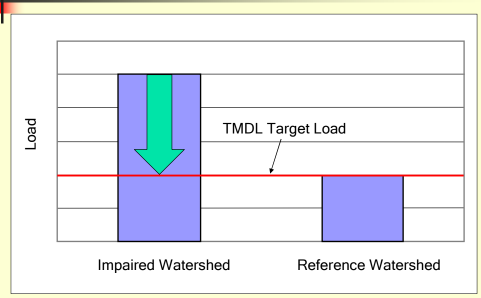
## Reference Watershed Approach

- No set standard for sediment
- Sediment Load in Reference Watershed becomes Target Load for Impaired Watersheds
- Reference Watershed
  - Not Benthically Impaired
  - Similar to Impaired Watershed

## Reference Watershed: Upper Opequon Creek




## Example Benthic TMDL




Reducing load in the impaired watershed to the target TMDL load is expected to restore the benthic community

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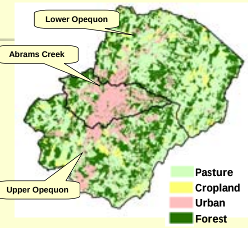
## Computer Modeling

Purpose: Determine the Sediment Loads in the Reference and Impaired Watersheds

Equations within the model simulate sediment generation and transport from the sources.

Our Choice: GWLF

## Model Input Files




- Weather
  - Rainfall
  - Temperature
- Transport
  - Land Use / Land Cover
  - Streamflow parameters
  - Stream length with livestock access
  - Sediment buildup / washoff (impervious land)
  - Soil characteristics
- Nutrients
  - Field manure application

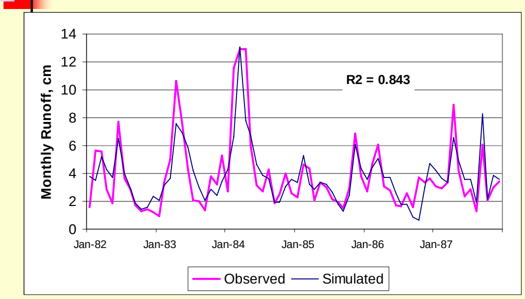
## Model Calibration

Parameter Adjustments to Match

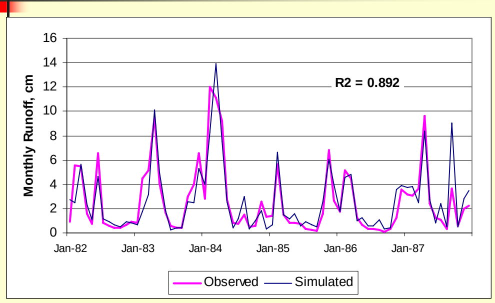
Model Output to

Observed Flow Data

## Calibration Results: Abrams Creek




## Calibration Results: Upper Opequon Creek




## Abrams Creek Sediment TMDL

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## Target TMDL Sediment Loads

| Surface Runoff Sources | Upper Opequon Creek (Mg/yr) | (%) |
|---|---|---|
| High Till | 2,626.8 | 24.4% |
| Low Till | 1,184.8 | 11.0% |
| Pasture | 764.2 | 7.1% |
| Urban grasses | 126.3 | 1.2% |
| Orchards | 17.7 | 0.2% |
| Forest | 72.3 | 0.7% |
| Transitional | 524.8 | 4.9% |
| Pervious Urban | 67.7 | 0.6% |
| Impervious Urban | 180.8 | 1.7% |
| **Channel Erosion** | 5,213.0 | 48.4% |
| **Totals** | | |
| Sum of Nonpoint Sources (LA) | 10,778.4 | |
| Sum of Point Sources (WLA) | 3.0 | 0.0% |
| **Watershed Totals** | 10,781.4 | |
| **Target Sediment TMDL Load** | **10,781.4** | **Mg/yr** |

**Upper Opequon Creek has been area-adjusted to the impaired creek.**

## Abrams Creek Existing Sediment Loads

| Surface Runoff Sources | Abrams Creek (Mg/yr) | (%) |
|---|---|---|
| High Till | 636.4 | 5.1% |
| Low Till | 203.5 | 1.6% |
| Pasture | 261.8 | 2.1% |
| Urban grasses | 321.2 | 2.6% |
| Orchards | 20.4 | 0.2% |
| Forest | 32.4 | 0.3% |
| Transitional | 588.9 | 4.7% |
| Pervious Urban | 177.4 | 1.4% |
| Impervious Urban | 448.9 | 3.6% |
| **Channel Erosion** | 9,871.0 | 78.6% |
| **Totals** | | |
| Sum of Nonpoint Sources (LA) | 12,561.8 | |
| Sum of Point Sources (WLA) | 1.5 | 0.0% |
| **Watershed Totals** | 12,563.3 | |

## Abrams Creek Future Sediment Loads

| Surface Runoff Sources | % BuildOut within UDAs and ComCntrs 25% (Mg/yr) | 50% (Mg/yr) | 100% (Mg/yr) |
|---|---|---|---|
| High Till | 613.5 | 589.6 | 541.1 |

- **Question: why doesn't this chart contain WLA values? Should it?**
- **This is Table 7.3 in the report.**

| | | | |
|---|---|---|---|
| Transitional | 589.8 | 589.8 | 589.1 |
| Pervious Urban | 211.3 | 245.1 | 312.2 |
| Impervious Urban | 533.2 | 617.4 | 786.0 |
| **Channel Erosion** | 12,057.3 | 14,389.1 | 19,487.8 |
| **Totals** | | | |
| Sum of Nonpoint Sources (LA) | 14,787.3 | 17,155.0 | 22,322.7 |
| Sum of Point Sources (WLA) | 0.0 | 0.0 | 0.0 |
| **Watershed Totals** | 14,787.3 | 17,155.0 | 22,322.7 |
| % Reductions Needed to Meet TMDL | 34.6% | 43.6% | 56.7% |

## Abrams Creek Sediment TMDL: Load Components

| TMDL | WLA | LA | MOS | |
|---|---|---|---|---|
| 10,781.4 | 27.4 | 9,675.9 | 1,078.1 | Mg/year |

**WLA + LA = 9703.3 Mg/year = Target**

- TMDL = load from reference watershed
- WLA = waste load allocation (point sources)
- LA = load allocation (non-point sources)
- MOS = margin of safety (5% of TMDL)

## Sediment Allocation Strategy

- Source categories created for allocation:
  - Agriculture
  - Urban
  - Forestry
  - Channel Erosion
  - Point Sources
- Agriculture and Forestry less than reference - No reductions
- Point Sources are Permitted – No reductions
- All reductions taken from Channel Erosion and Urban

## Sediment Allocation Scenario 1

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Abrams (Mg/yr) | TMDL Alternative 1 (% reduction) | (Mg/yr) |
|---|---|---|---|---|
| Agriculture | 4,593.4 | 1,047.2 | 0% | 1,047.2 |
| Urban | 899.6 | 1,656.0 | 0% | 1,656.0 |
| Forestry | 72.3 | 26.7 | 0% | 26.7 |
| Channel Erosion | 5,213.0 | 12,057.3 | **42%** | 6,946.0 |
| Point Sources | 3.0 | 27.4 | 0% | 27.4 |
| **Total** | **10,781.4** | **14,814.6** | | **9,703.3** |

- **All reductions to Channel Erosion**

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## Sediment Allocation Scenario 2

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Abrams (Mg/yr) | TMDL Alternative 2 (% reduction) | TMDL Alternative 2 (Mg/yr) |
|---|---|---|---|---|
| Agriculture | 4,593.4 | 1,047.2 | 0% | 1,047.2 |
| Urban | 899.6 | 1,656.0 | 37.3% | 1,038.7 |
| Forestry | 72.3 | 26.7 | 0% | 26.7 |
| Channel Erosion | 5,213.0 | 12,057.3 | 37.3% | 7,563.2 |
| Point Sources | 3.0 | 27.4 | 0% | 27.4 |
| **Total** | **10,781.4** | **14,814.6** | | **9,703.3** |

- **Equal reductions to Channel Erosion and Urban**

## Sediment Allocation Scenario 3

**Preferred Scenario**

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Abrams (Mg/yr) | TMDL Alternative 3 (% reduction) | TMDL Alternative 3 (Mg/yr) |
|---|---|---|---|---|
| Agriculture | 4,593.4 | 1,047.2 | 0% | 1,047.2 |
| Urban | 899.6 | 1,656.0 | 25.0% | 1,242.0 |
| Forestry | 72.3 | 26.7 | 0% | 26.7 |
| Channel Erosion | 5,213.0 | 12,057.3 | 39.0% | 7,359.9 |
| Point Sources | 3.0 | 27.4 | 0% | 27.4 |
| **Total** | **10,781.4** | **14,814.6** | | **9,703.3** |

- **Reductions to Channel Erosion and Urban**
- **Urban component reduced for cost efficiency**

## Sediment TMDL Allocations

- Bacteria TMDL requires greater reductions
- Attainment of phase I implementation for bacteria in Abrams Creek will fulfill the requirements of the Sediment TMDL??

## Lower Opequon Creek Sediment TMDL

## Target TMDL Sediment Loads

| Surface Runoff Sources | Upper Opequon Creek (Mg/yr) | Upper Opequon Creek (%) |
|---|---|---|
| High Till | 10,694.2 | 7.7% |
| Low Till | 3,729.5 | 2.7% |
| Pasture | 2,780.9 | 2.0% |
| Urban grasses | 453.2 | 0.3% |
| Orchards | 69.1 | 0.0% |
| Forest | 236.4 | 0.2% |
| Transitional | 1,366.2 | 1.0% |
| Pervious Urban | 277.1 | 0.2% |
| Impervious Urban | 997.1 | 0.7% |
| **Channel Erosion** | 118,744.5 | 85.2% |
| **Totals** | | |
| Sum of Nonpoint Sources (LA) | 139,348.2 | |
| Sum of Point Sources (WLA) | 21.8 | 0.0% |
| **Watershed Totals** | 139,370.0 | |
| **Target Sediment TMDL Load** | **139,370.0** | **Mg/yr** |

**Upper Opequon Creek has been area-adjusted to the impaired creek.**

## Lower Opequon Creek Existing Sediment Loads

| Surface Runoff Sources | Lower Opequon Creek (Mg/yr) | Lower Opequon Creek (%) |
|---|---|---|
| High Till | 9,678.4 | 7.0% |
| Low Till | 3,220.1 | 2.3% |
| Pasture | 2,616.9 | 1.9% |
| Urban grasses | 567.1 | 0.4% |
| Orchards | 64.3 | 0.0% |
| Forest | 128.4 | 0.1% |
| Transitional | 1,828.1 | 1.3% |
| Pervious Urban | 313.2 | 0.2% |
| Impervious Urban | 1,195.2 | 0.9% |
| **Channel Erosion** | 118,888.8 | 85.8% |
| **Totals** | | |
| Sum of Nonpoint Sources (LA) | 138,500.4 | |
| Sum of Point Sources (WLA) | 31.5 | 0.0% |
| **Watershed Totals** | 138,531.9 | |

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## Lower Opequon Creek Future Sediment Loads

| Surface Runoff Sources | % BuildOut within UDAs and ComCntrs 25% (Mg/yr) | 50% (Mg/yr) | 100% (Mg/yr) |
|---|---|---|---|
| High Till | 9,506.9 | 9,323.1 | 8,944.2 |
| Low Till | 3,163.2 | 3,102.1 | 2,976.2 |
| Pasture | 2,458.5 | 2,296.9 | 1,971.4 |
| Urban grasses | 567.7 | 567.6 | 566.7 |
| Orchards | 61.9 | 59.5 | 54.5 |
| Forest | 118.9 | 109.3 | 90.0 |
| Transitional | 1,830.1 | 1,829.7 | 1,826.6 |
| Pervious Urban | 430.8 | 548.0 | 781.2 |
| Impervious Urban | 1,699.8 | 2,204.4 | 3,213.7 |
| **Channel Erosion** | 145,735.8 | 174,135.1 | 234,836.5 |
| **Totals** | | | |
| Sum of Nonpoint Sources (LA) | 165,573.8 | 194,175.7 | 255,260.9 |
| Sum of Point Sources (WLA) | 465.3 | 465.3 | 465.3 |
| **Watershed Totals** | 166,039.1 | 194,641.0 | 255,726.2 |
| % Reductions Needed to Meet TMDL | 24.5% | 35.6% | 51.0% |

## Lower Opequon Creek Sediment TMDL: Load Components

| TMDL | WLA | LA | MOS |
|---|---|---|---|
| 139,370.0 | 350.4 | 125,082.6 | 13,937.0 |

Mg/year

**WLA + LA = 125,433.0 Mg/year = Target**

- TMDL = load from reference watershed
- WLA = waste load allocation (point sources)
- LA = load allocation (non-point sources)
- MOS = margin of safety (5% of TMDL)

## Sediment Allocation Strategy

- Source categories created for allocation:
  - Agriculture
  - Urban
  - Forestry
  - Channel Erosion
  - Point Sources
- Agriculture and Forestry less than reference - No reductions
- Point Sources are Permitted – No reductions
- All reductions taken from Channel Erosion and Urban
- Abrams Creek reductions included (ABR scenario 3)

## Sediment Allocation Scenario 1

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Lower Opequon (Mg/yr) | Future25 - Abrams TMDL Reductions | TMDL Alternative 1 (% reduction) | TMDL Alternative 1 (Mg/yr) |
|---|---|---|---|---|---|
| Agriculture | 17,273.6 | 15,190.5 | 15,190.5 | 0% | 15,190.5 |
| Urban | 3,093.6 | 4,528.4 | 4,299.0 | 0% | 4,299.0 |
| Forestry | 236.4 | 118.9 | 118.9 | 0% | 118.9 |
| Channel Erosion | 118,744.5 | 145,735.8 | 143,132.5 | **26%** | 105,474.2 |
| Point Sources | 21.8 | 350.4 | 350.4 | 0% | 350.4 |
| **Total** | **139,370.0** | **165,924.1** | **163,091.3** | | **125,433.0** |

- **All reductions to Channel Erosion**

## Sediment Allocation Scenario 2

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Lower Opequon (Mg/yr) | Future25 - Abrams TMDL Reductions | TMDL Alternative 2 (% reduction) | TMDL Alternative 2 (Mg/yr) |
|---|---|---|---|---|---|
| Agriculture | 17,273.6 | 15,190.5 | 15,190.5 | 0% | 15,190.5 |
| Urban | 3,093.6 | 4,528.4 | 4,299.0 | **25.5%** | 3,200.9 |
| Forestry | 236.4 | 118.9 | 118.9 | 0% | 118.9 |
| Channel Erosion | 118,744.5 | 145,735.8 | 143,132.5 | **25.5%** | 106,572.3 |
| Point Sources | 21.8 | 350.4 | 350.4 | 0% | 350.4 |
| **Total** | **139,370.0** | **165,924.1** | **163,091.3** | | **125,433.0** |

- **Equal reductions to Channel Erosion and Urban**

## Sediment Allocation Scenario 3

**Preferred Scenario**

| Source Category | Reference Upper Opequon (Mg/yr) | Future25 Lower Opequon (Mg/yr) | Future25 - Abrams TMDL Reductions | TMDL Alternative 3 (% reduction) | TMDL Alternative 3 (Mg/yr) |
|---|---|---|---|---|---|
| Agriculture | 17,273.6 | 15,190.5 | 15,190.5 | 0% | 15,190.5 |
| Urban | 3,093.6 | 4,528.4 | 4,299.0 | **10.0%** | 3,869.1 |
| Forestry | 236.4 | 118.9 | 118.9 | 0% | 118.9 |
| Channel Erosion | 118,744.5 | 145,735.8 | 143,132.5 | **26.0%** | 105,904.1 |
| Point Sources | 21.8 | 350.4 | 350.4 | 0% | 350.4 |
| **Total** | **139,370.0** | **165,924.1** | **163,091.3** | | **125,433.0** |

- **Reductions to Channel Erosion and Urban**
- **Urban component reduced for cost efficiency**

## Sediment TMDL Allocations

- Bacteria TMDL requires greater reductions
- Attainment of phase I implementation for bacteria in Lower Opequon Creek will fulfill the requirements of the Sediment TMDL??

## Acknowledgements, linville


- Residents of the watersheds
- Carl Wells
- Agricultural producers of Bedford and Campbell Counties
- Peaks of Otter SWCD- Brent Wills
- Robert E. Lee SWCD- Kent White
- Campbell County Utilities – Danny Hylton
- Virginia Economic Development Partnership- Jean Tingler, Stuart Blankenship
- Anderson and Associates-Andrew Karpa
- Virginia Dept. of Game and Inland Fisheries – Gary Costanzo, Matt Knox, Randy Farrar
- VADCR – Mark Bennett, Tim Ott, Bill Keeling
- VADEQ – Clint Boschen, Charles Martin, Larry Willis, George Devlin, Tim Liptak, Michael Scanlan, Michael McLeod, Roger Stewart, Stuart Torbek, Don Smith, Gary Du
- Virginia Cooperative Extension-Scott Baker
- Bedford County- John Bayliss, Dan Richardson, Gary Underwood