For technical support issues call: 703-583-3906

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Sand Branch Benthic TMDL Study

Fourth Technical Advisory Committee Meeting

June 24, 2021

Agenda

- TMDL Development
  - TMDL Targets
  - Overview of Development Process
- Setting the TMDL Endpoint
  - Total Dissolved Solids
  - Total Phosphorus and Sediment
- Modeling the TMDLs
  - Overview of HSPF
  - Model Set-Up
  - Source Assessment
- Project Timeline and Next Steps

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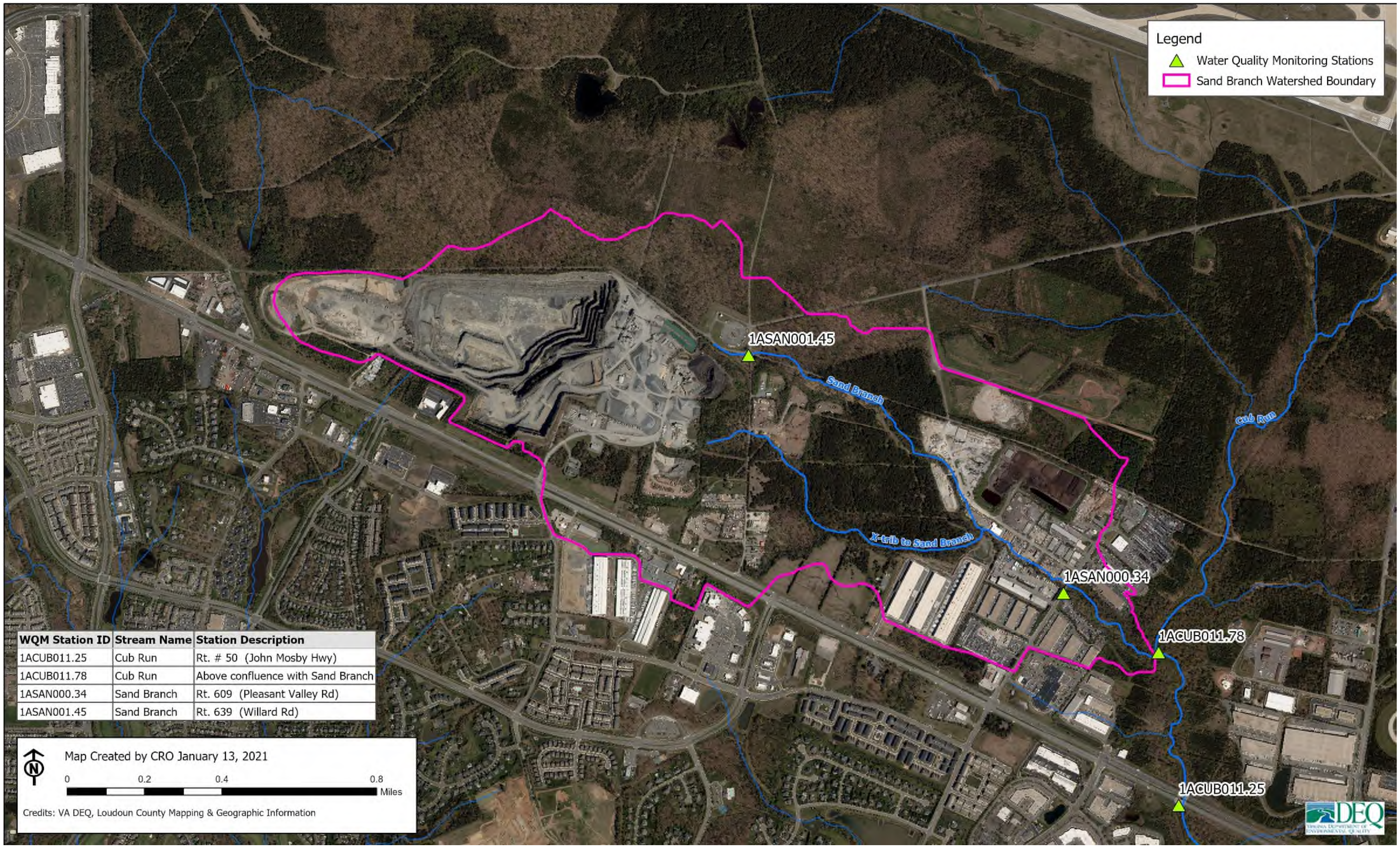
TMDL Development

TMDL Targets and Overview of the Process

Sarah K. Sivers
Water Quality Planning Team Lead
Virginia Department of Environmental Quality

TMDL Project Area



WQM Station ID	Stream Name	Station Description
1ACUB011.25	Cub Run	Rt. # 50 (John Mosby Hwy)
1ACUB011.78	Cub Run	Above confluence with Sand Branch
1ASAN000.34	Sand Branch	Rt. 609 (Pleasant Valley Rd)
1ASAN001.45	Sand Branch	Rt. 639 (Willard Rd)

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TMDL Targets and Contributing Factors

Stream	TMDL Target
Sand Branch	Total Dissolved Solids (TDS)
	Total Phosphorus
	Sediment

Stream	Contributing Factors
Sand Branch	Underlying Geology
	Land Disturbance
	Percent Imperviousness
	Degraded Riparian Buffer

- TMDL targets identified from multiple lines of evidence
- TDS will collectively address sulfate, and also ions classified as possible stressors (chloride, potassium, and sodium)
- Factors identified that contribute to the impaired benthic community, but not appropriate for TMDL development

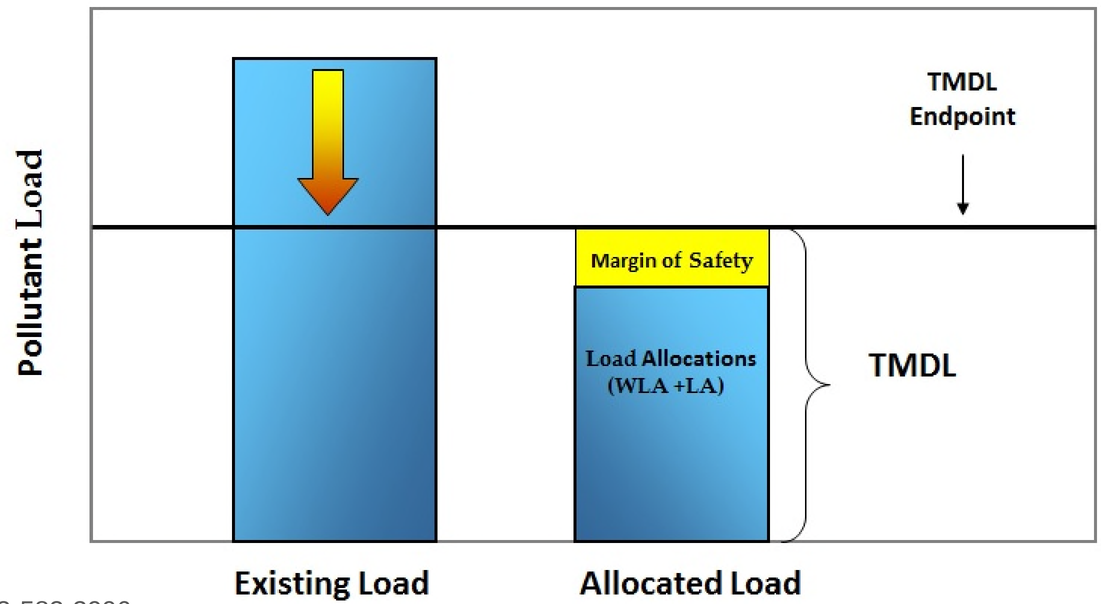
Total Maximum Daily Load (TMDL)

*A **TMDL** is the total amount of a pollutant a waterbody can receive and still meet the water quality criteria for that pollutant*

TMDL = WLA + LA + MOS

Where:

- WLA = Wasteload Allocation
- LA = Load Allocation
- MOS = Margin of Safety



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TMDL Development Process

- Characterize the watershed (e.g. land use, soils, hydrology, etc.)
- Identify pollutant sources and associated loadings
- Model the existing baseline condition and projected condition that attains the water quality endpoint
- Calculate pollutant reductions to attain the water quality endpoint
- Assign loadings to wasteload allocations (WLA) and load allocation (LA)

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Setting the TMDL Endpoint

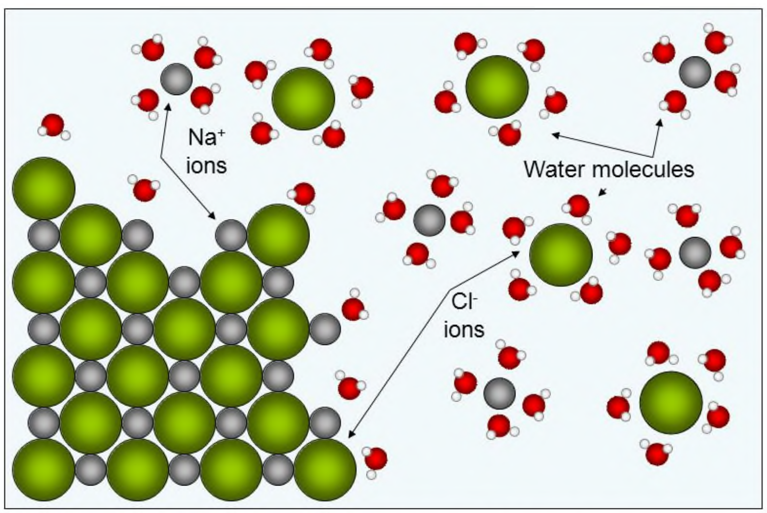
Total Dissolved Solids

Dr. Robert Brent
Professor of Aquatic Ecotoxicology
James Madison University

What is TDS?

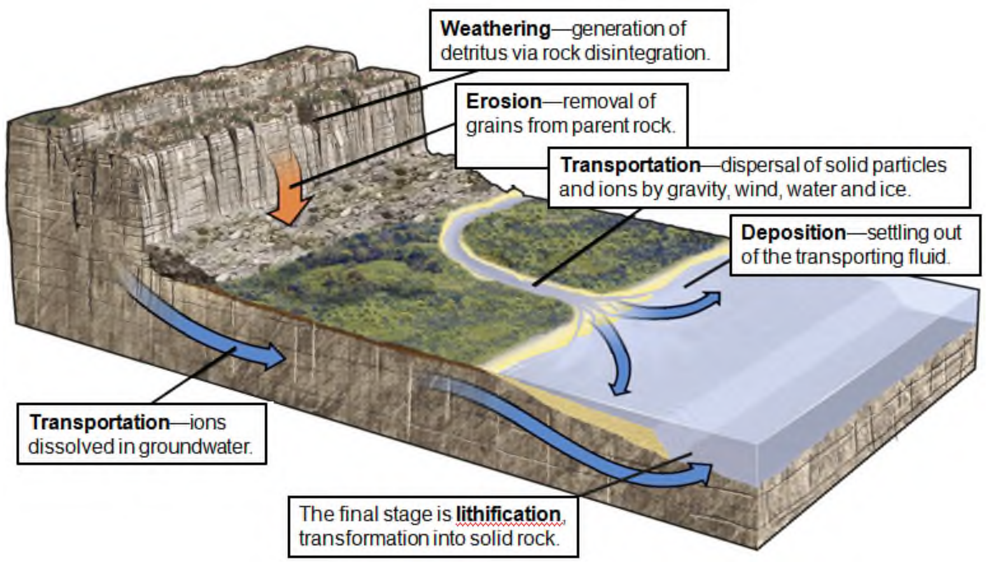
- **Total Dissolved Solids** = The sum of all of the ions dissolved in water

Molecular Scale



$NaCl(s) + H_2O \rightarrow Na^+(aq) + Cl^-(aq)$

Geologic Scale



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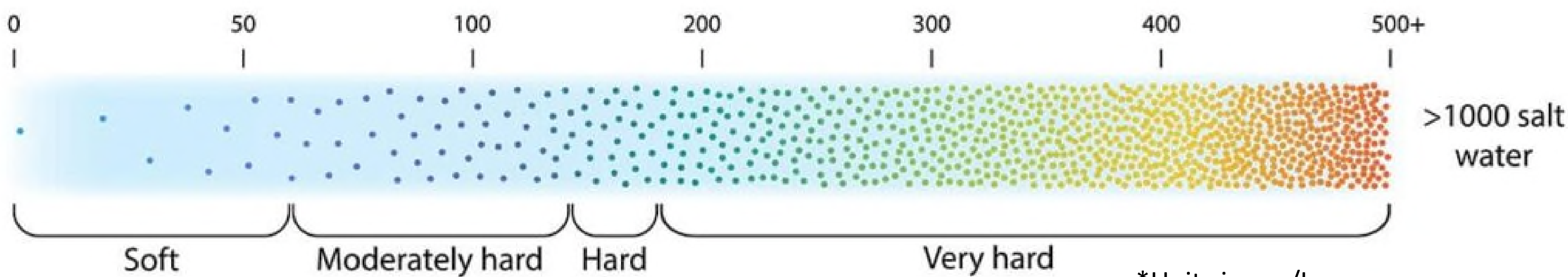
Major Mineral Ions

As concentrations of these individual ions increase, TDS increases

Major Cations (+)	Major Anions (-)
Calcium (Ca^{2+})	Bicarbonate (HCO_3^-)
Magnesium (Mg^{2+})	Sulfate (SO_4^{2-})
Sodium (Na^+)	Chloride (Cl^-)
Potassium (K^+)	Nitrate (NO_3^-)



*Units in mg/L

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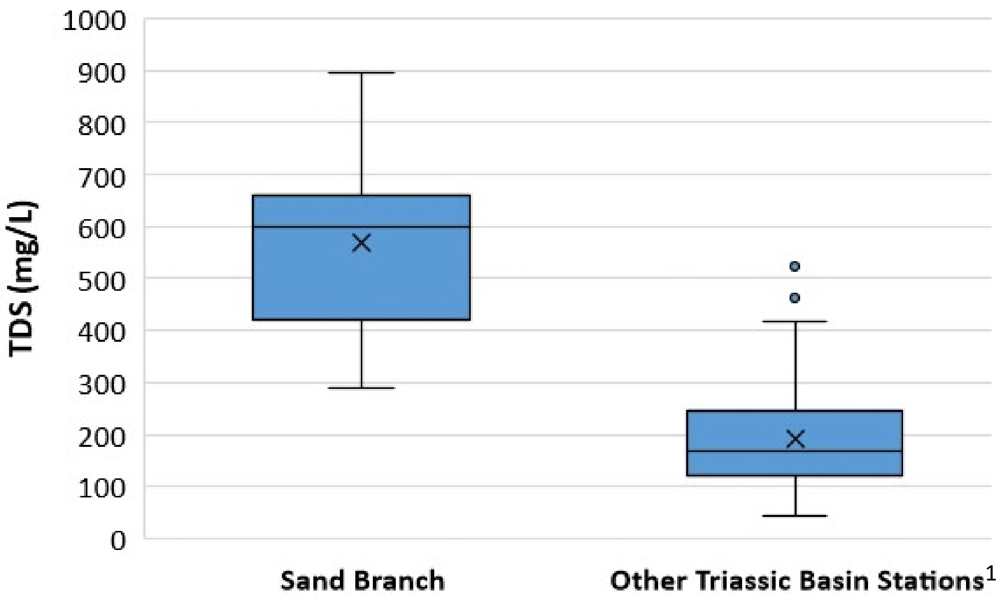
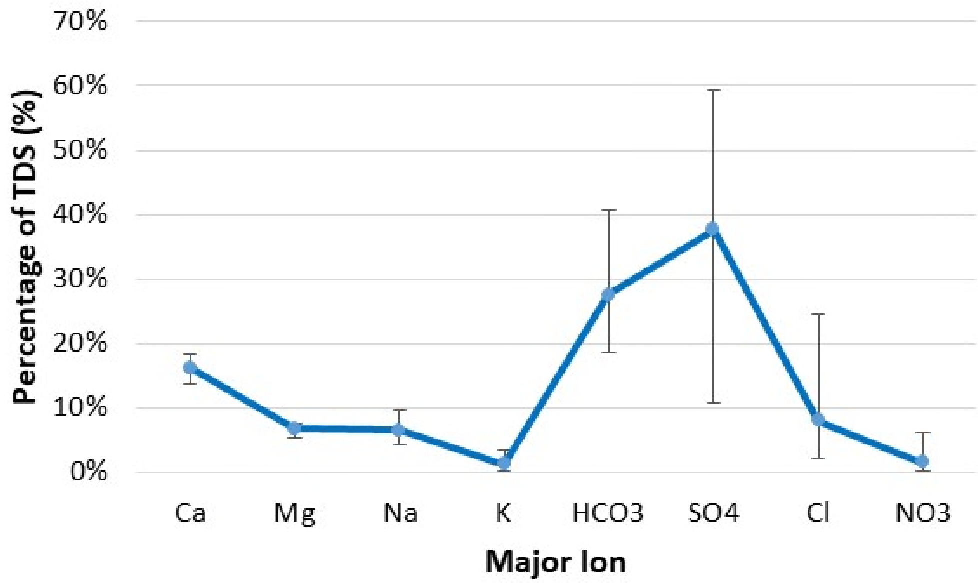
TDS in Sand Branch





[1] Based on average conductivity converted to TDS.

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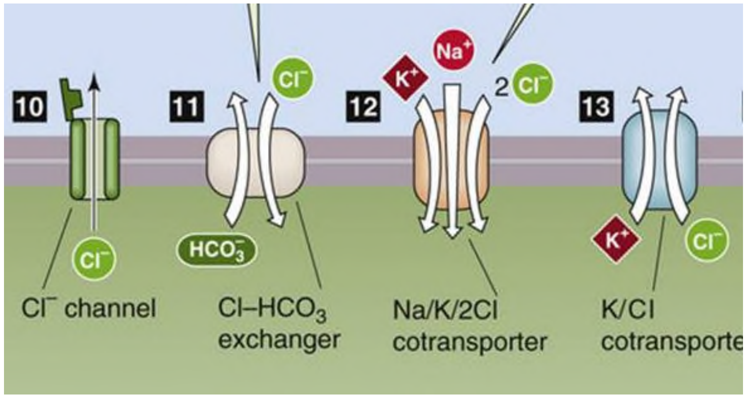
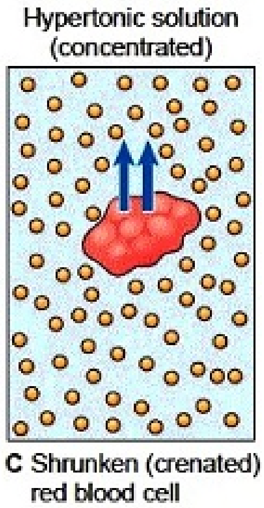
Toxicity of TDS – 3 Primary Mechanisms

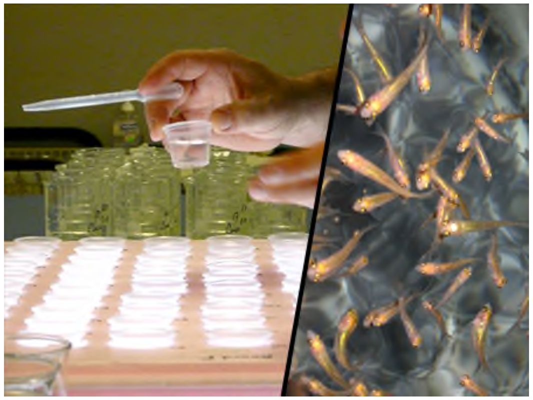
- Changes in ion composition



- Osmotic imbalance



- Toxicity of individual ions



- This means that TDS toxicity depends on the level of TDS and the concentrations of individual ions

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How Do You Set a Protective TDS Level?

1. **Literature-Based Approach**
   - Search scientific and policy literature for TDS limits that have been applied in similar situations
2. **Reference Watershed Approach**
   - Set TDS level based on modeling of a nearby unimpaired watershed
3. **Site-Specific Toxicity Approach**
   - Set TDS level based on toxicity data specific to Sand Branch chemistry

How Do You Set a Protective TDS Level?

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3. **Site-Specific Toxicity Approach** **Selected**
   - Set TDS level based on toxicity data specific to Sand Branch chemistry

How Do You Set a Protective TDS Level?

1. Literature-Based Approach

- Search scientific and policy literature for TDS limits that have been applied in similar situations

Pros	Cons
Simple	Literature values vary greatly based on ion composition
Based on other well-established methods	Difficult to find similar situations

How Do You Set a Protective TDS Level?

2. Reference Watershed Approach

- Set TDS level based on modeling of a nearby unimpaired watershed

Pros	Cons
Uses local comparisons	Difficult to find unimpaired reference
Well-established approach in Virginia (coal mining TMDLs)	Difficult to find similar underlying geology, watershed conditions and land uses

How Do You Set a Protective TDS Level?

3. Site-Specific Toxicity Approach

- Set TDS level based on toxicity data specific to Sand Branch chemistry

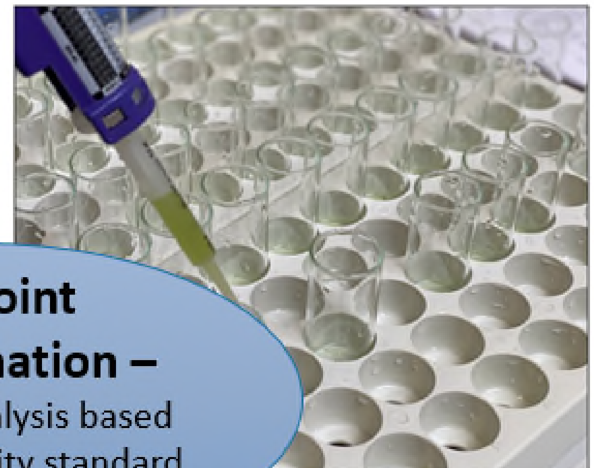
Pros	Cons
Directly linked to toxicity data and effects on freshwater invertebrates	Expensive and time consuming to develop site-specific toxicity data
Specific to Sand Branch chemistry	

Site-Specific Toxicity Approach

Phase 1 –
Ambient toxicity testing on field collected Sand Branch samples

Phase 2 –
Repeated ambient toxicity testing with UV treatment to control pathogens

Phase 3 –
Toxicity testing of laboratory prepared samples to match Sand Branch chemistry



Endpoint Determination –
Statistical analysis based on water quality standard development guidance

Protective TDS Level

TMDL

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Phase 1

- Conducted March 2020
- Field collected Sand Branch sample
- *C. dubia* Results
  - No toxicity
- *P. promelas* Results
  - NOEC of 50%
  - IC10 of 63.9%

Water flea
(Ceriodaphnia dubia)

Fathead minnow
(Pimephales promelas)

Phase 2

- Anticipated June 2021
- Field collected Sand Branch sample
- *C. dubia* and *P. promelas* chronic tests anticipated
- UV treatment used to kill naturally present pathogens that could interfere with test results

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Phase 3

Test Organisms

- 4 test organisms

Water flea (Ceriodaphnia dubia)

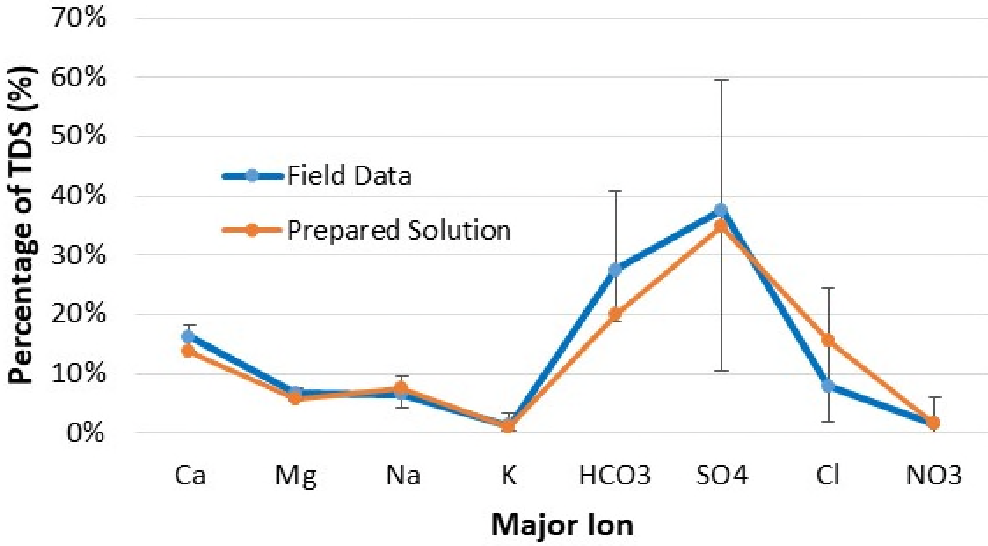
Fathead minnow (Pimephales promelas)

Scud (Hyalella azteca)

Mayfly (Isonychia bicolor)

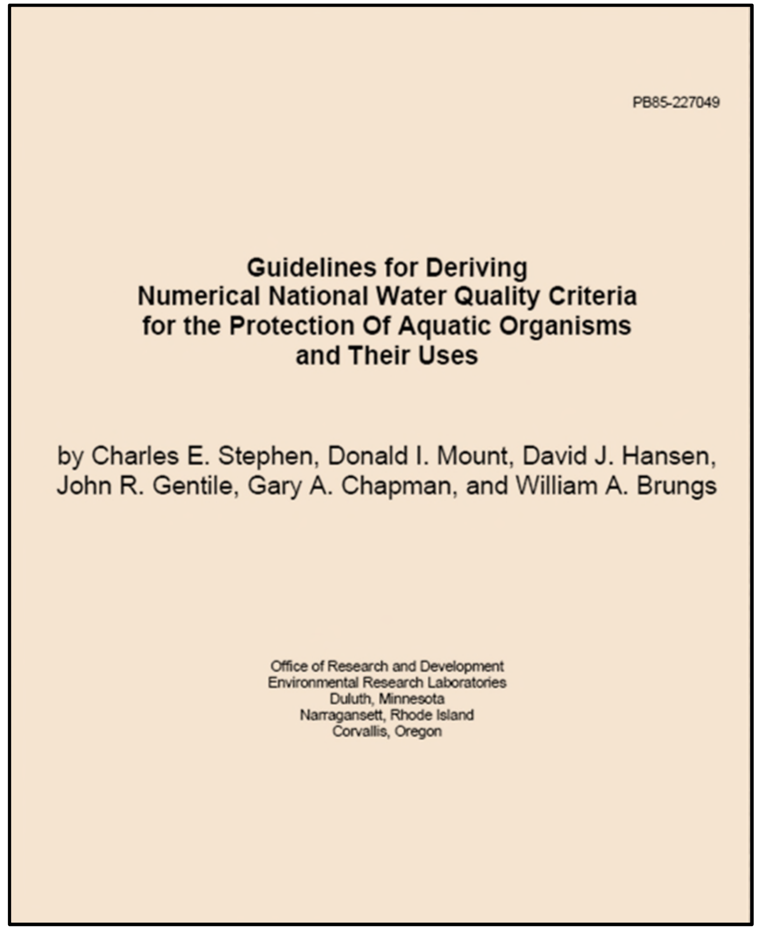
Lab Prepared Sample

- Prepared at a range of TDS concentrations
- Prepared to match Sand Branch chemistry



TMDL Endpoint Determination

- **Approach**
  - Statistical approach and calculations will be based on EPA Guidance for Water Quality Criteria Development
  - Sets a protective <u>site-specific</u> TDS level to use as the TMDL endpoint
    - Does <u>not</u> establish water quality criteria for TDS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Guidelines for Deriving
Numerical National Water Quality Criteria
for the Protection Of Aquatic Organisms
and Their Uses

by Charles E. Stephen, Donald I. Mount, David J. Hansen, John R. Gentile, Gary A. Chapman, and William A. Brungs

Office of Research and Development
Environmental Research Laboratories
Duluth, Minnesota
Narragansett, Rhode Island
Corvallis, Oregon

TMDL endpoint: TDS = __

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Setting the TMDL Endpoint

Total Phosphorus and Sediment

Katie Shoemaker
Senior Engineer
Wetland Studies and Solutions, Inc.

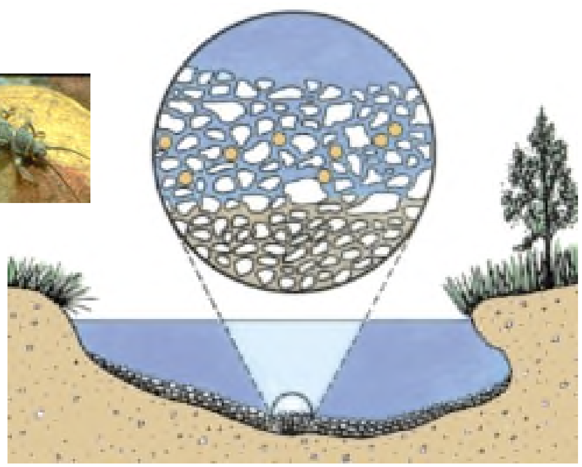
Sediment as a TMDL pollutant

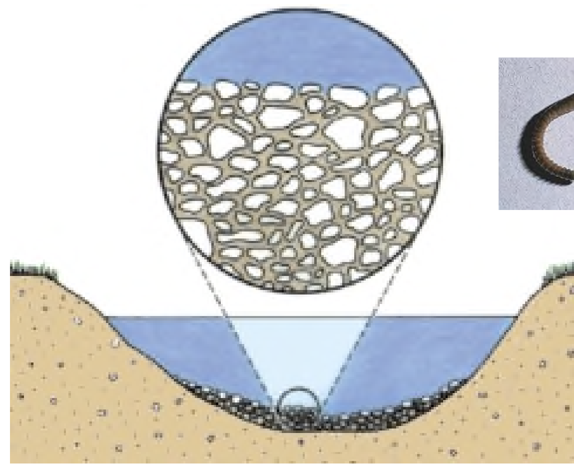
- A healthy aquatic community requires a clean stream bottom with lots of space between rocks and gravels (interstitial space)
- Excess sediment fills those spaces and eliminates habitat for some more sensitive organisms

Healthy Stream Bottom

Excess Sediment

Sediment sensitive stonefly

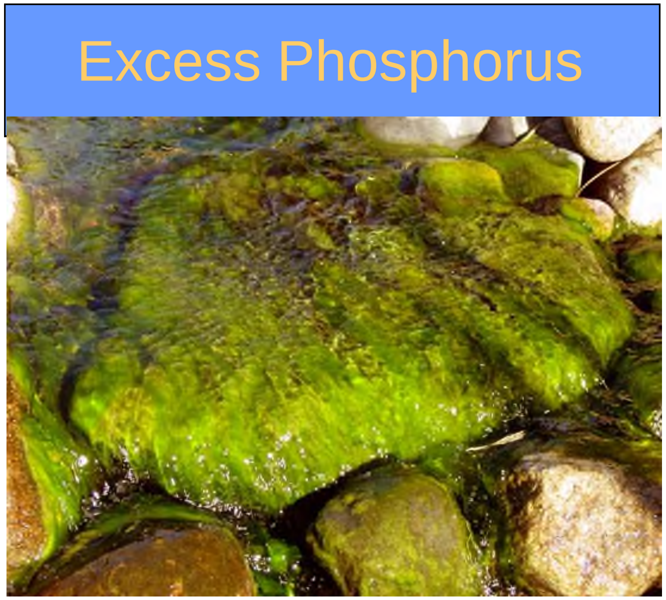




Sediment tolerant worm

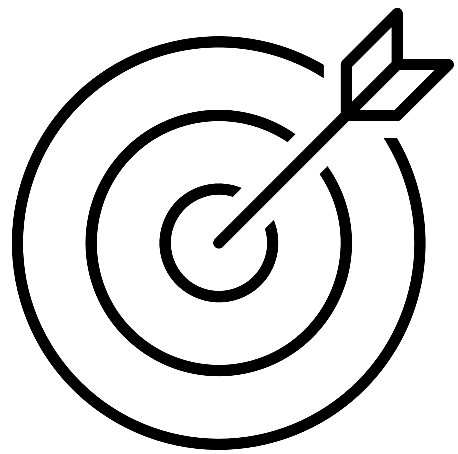
Total Phosphorus (TP) as a TMDL pollutant

- Nutrients, like phosphorus, increase algae growth
- Excess algae can change feeding niches and reduce dissolved oxygen levels



How Do You Develop a TMDL Endpoint Protective of Water Quality Standards?

- Water quality criteria are:
  - Numeric (e.g. E.coli), or
  - Narrative (e.g. total phosphorus and total suspended solids (TSS))
- Establishing a TMDL endpoint:
  - Numeric criteria = Endpoint
  - Narrative criteria requires development of a numeric endpoint



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How Do You Set a Protective TMDL Endpoint for Total Phosphorus (TP) and Sediment (TSS)?

Reference Watershed Approach

Uses pollutant loads present in one, nearby and similar unimpaired watershed

- ✓ Straightforward method
- ✗ Hard to find ideal reference watershed

VS.

All-Forested Load Multiplier (AllForX) Approach

Uses a regression developed from multiple comparison unimpaired/impaired watersheds

- ✓ Used in Virginia since 2014
- ✓ More rigorous result
- ✗ More effort and time

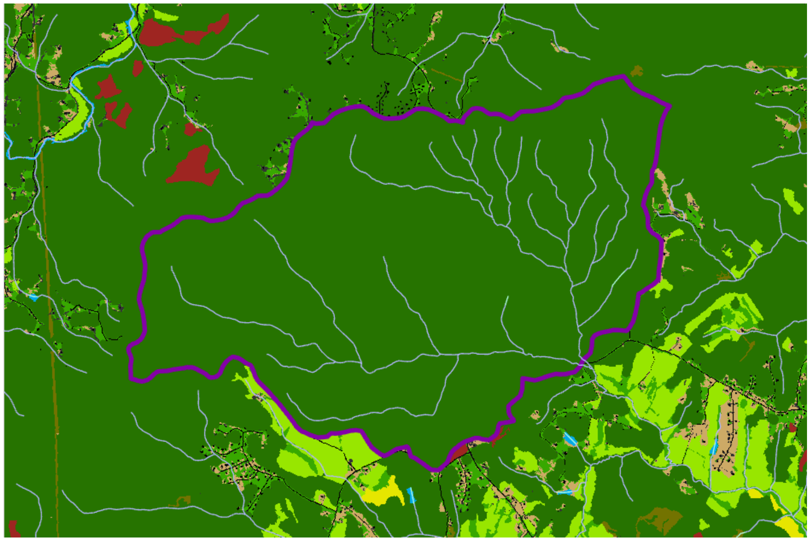
AllForX Method: Developing the Multiplier

Example:

Existing Sediment (TSS) Load: 500,000 lb/yr

vs.

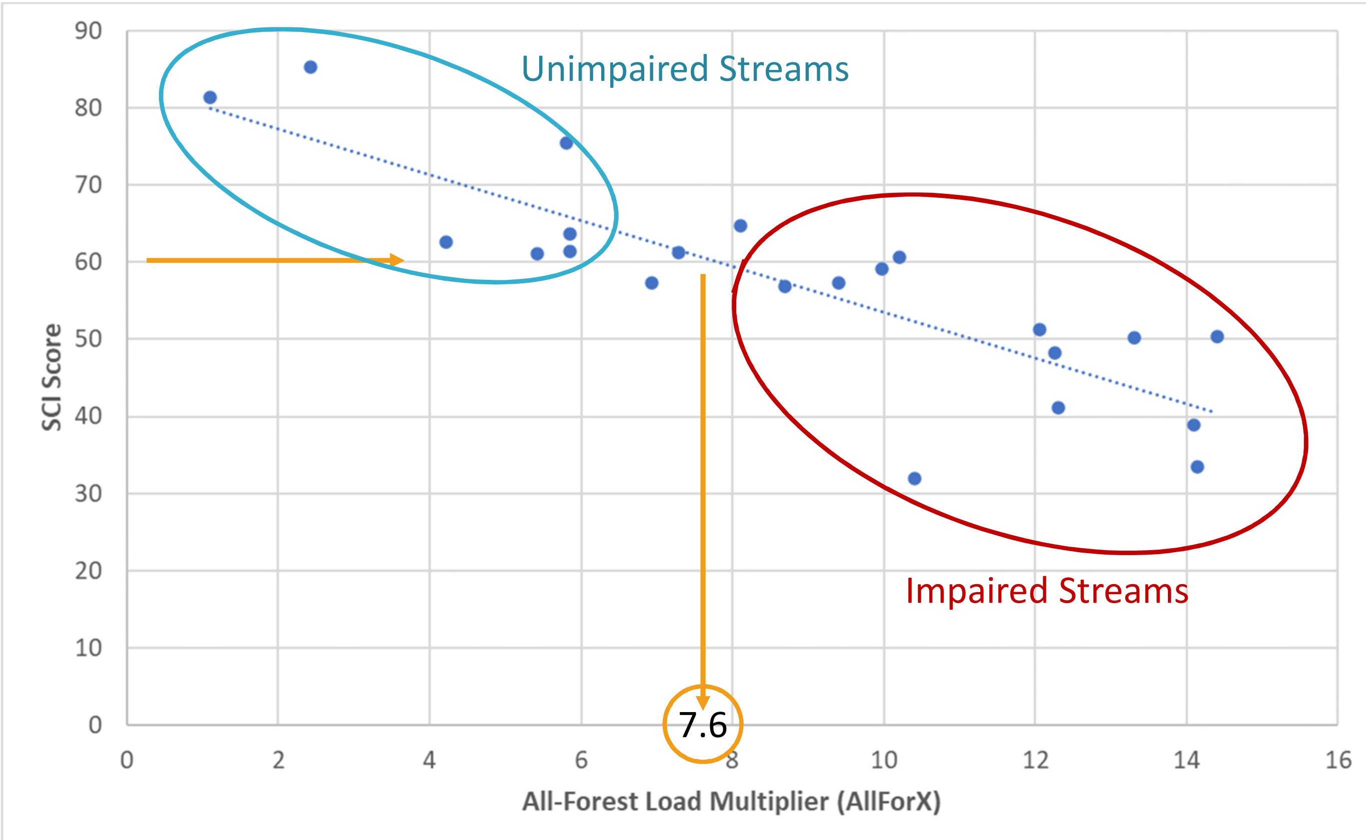
All Forested Sediment (TSS) Load: 50,000 lb/yr



All-Forest Multiplier (AllForX) 500,000 / 50,000 = **10**

AllForX multiplier identified for each comparison watershed, including the TMDL watershed

AllForX Method: Example Regression



AllForX Method: Example Calculations

Existing Sediment (TSS) Load: 500,000 lb/yr
All Forested Sediment (TSS) Load: 50,000 lb/yr
*All-Forest Multiplier (AllForX) 500,000 / 50,000 = **10***

Conducted for each comparison watershed, including the TMDL watershed

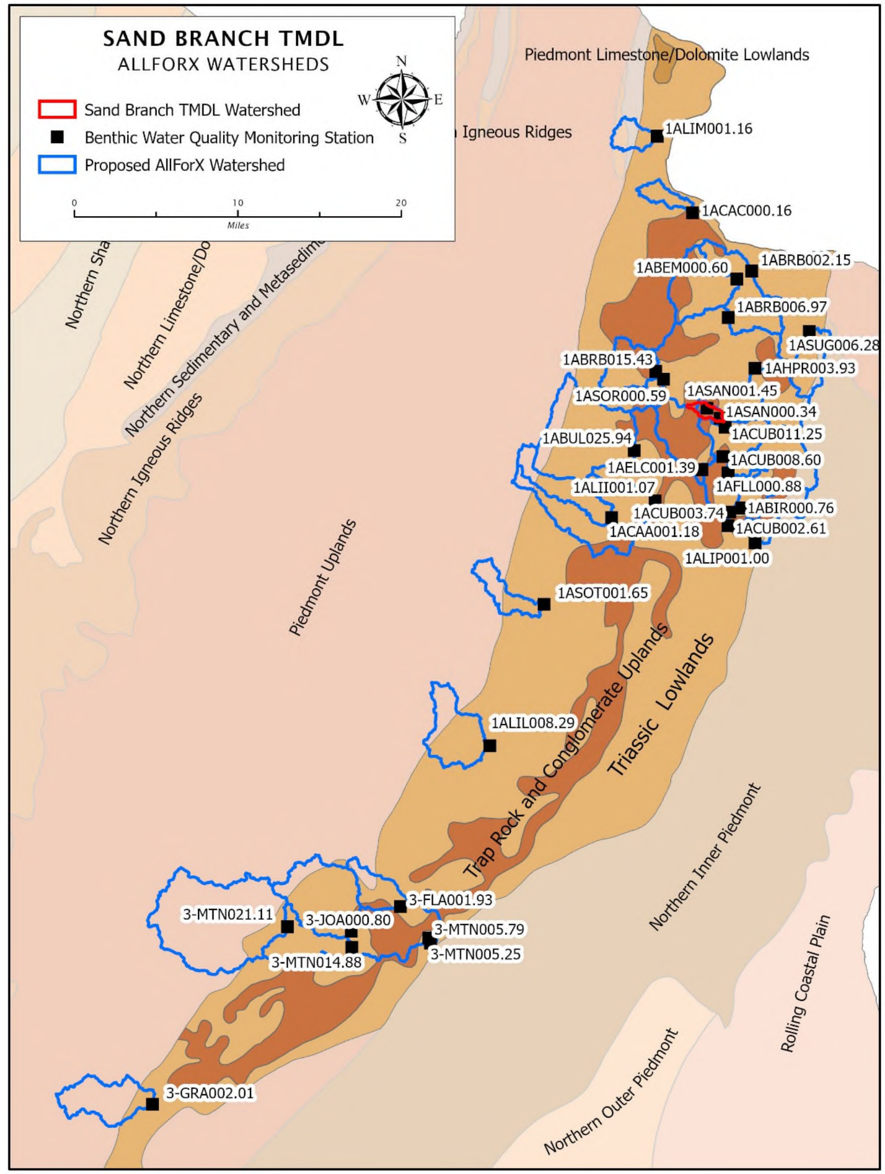
Regression Results: VSCI = 60 ➡ Threshold AllForX = **7.6**

To Obtain Target Loading (TMDL Endpoint):
(All Forested Sediment Load of TMDL watershed) x (Threshold AllForX)
50,000 lb/yr x 7.6 = 380,000 lb/yr

TMDL Sediment (TSS) Reductions:
(Existing Sediment Load of TMDL watershed) – (TMDL Endpoint)
500,000 – 380,000 = 120,000 lb/yr

AllForX Method: Selecting Comparison Watersheds

- Benthic Data
  - Abundant
  - Recent
- Location
  - Ecoregion
  - Close
- Size
  - Comparable



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Modeling the TMDLs

HSPF, Model Set-up and Source Assessment

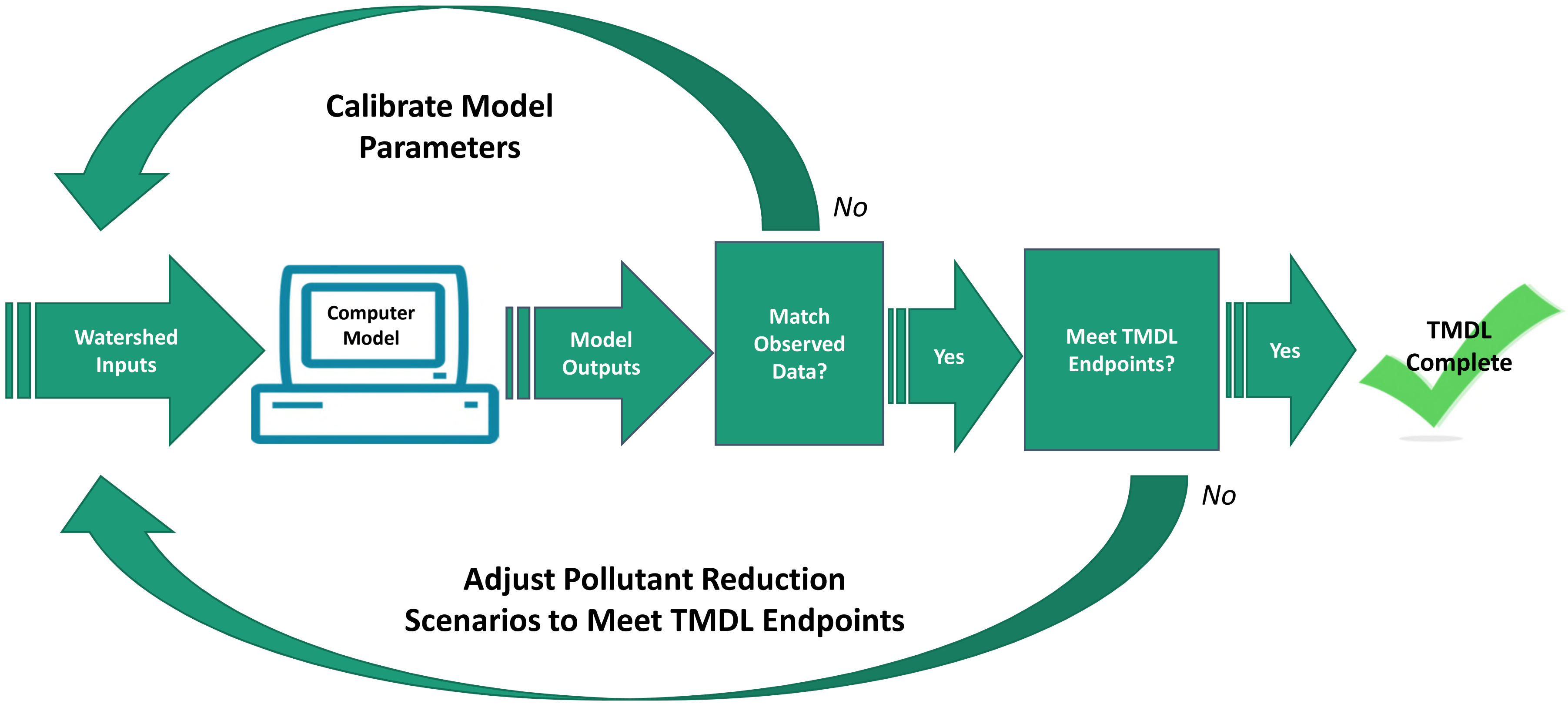
Katie Shoemaker
Senior Engineer
Wetland Studies and Solutions, Inc.

TMDL Development

1. Identify sources of the pollutant
2. Model their path to the stream
3. Determine reductions needed from each source to meet the TMDL endpoint

Diagram: Adapted from the Center for TMDL and Watershed Studies at Virginia Tech

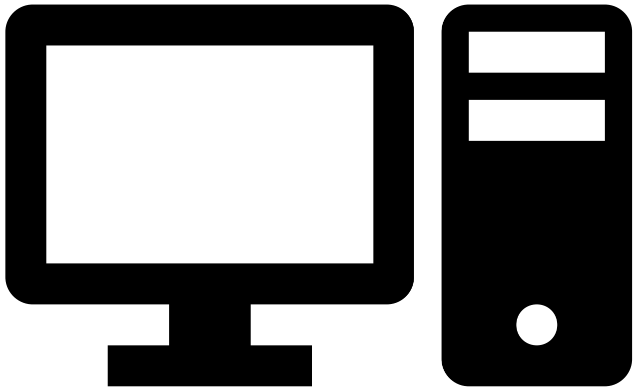
Model Watershed and Assign Reductions



Computer Watershed Model Selection

Computer model used to:

- Estimate existing baseline pollutant loads and projected pollutant loads that meets the TMDL endpoint
- Develop the TMDL endpoint
- Identify pollution reductions needed to meet the TMDL endpoint

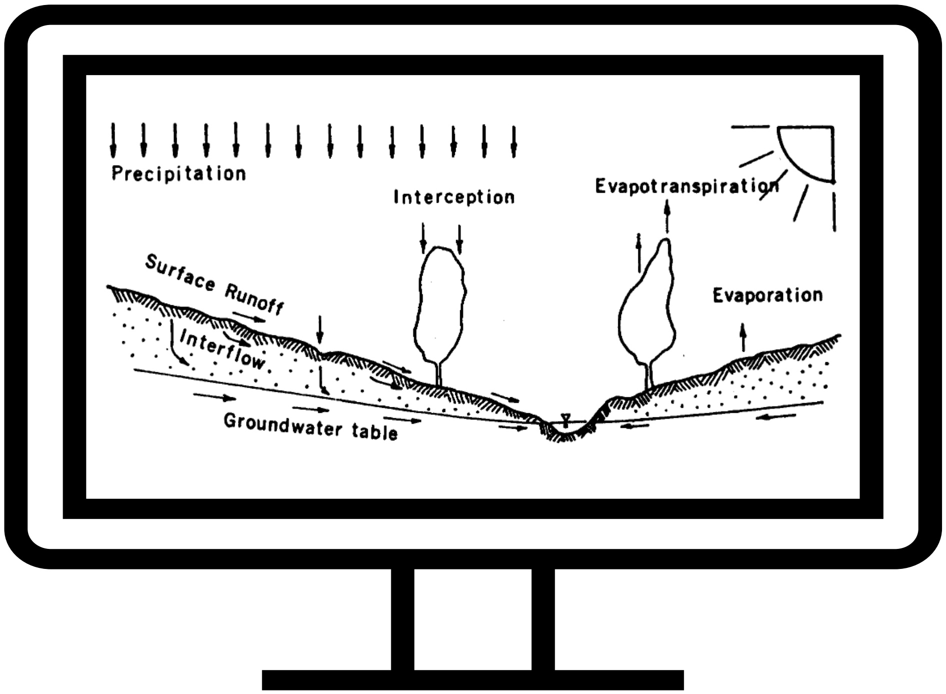


There are no perfect models!

Too little detail: hard to have confidence in results

Too much detail: may not have adequate return on investment

Watershed Computer Model Selection



HSPF (Hydrologic Simulation Program – FORTRAN)

- Continuous simulation
- Nonpoint and Point Sources
- Simulates stream network, including channel scour
- Can simulate TSS, TP, and TDS

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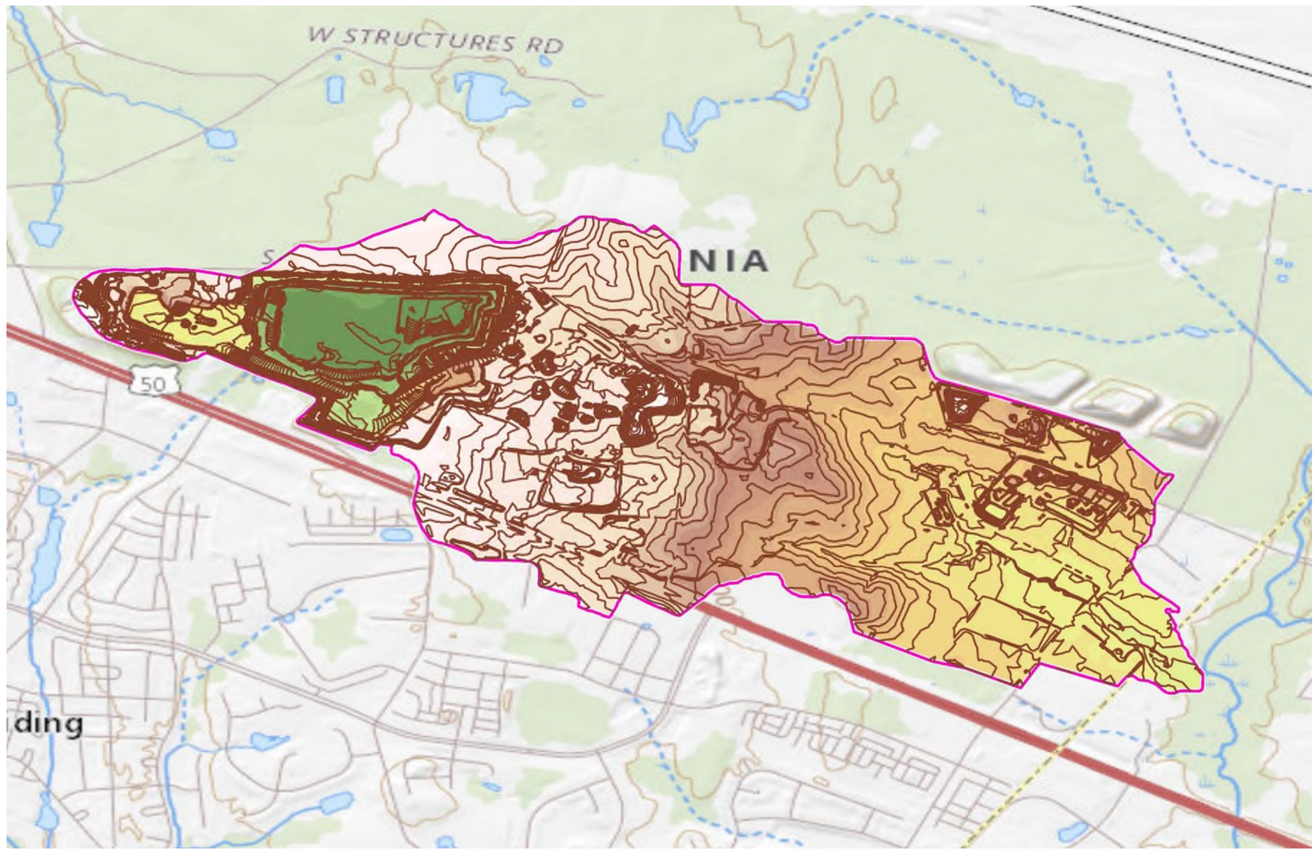
Model Setup

- Spatial Data
  - Land use
  - Soils Types
  - Topography
  - Stream network
- Meteorological Data
  - Precipitation
  - Temperature



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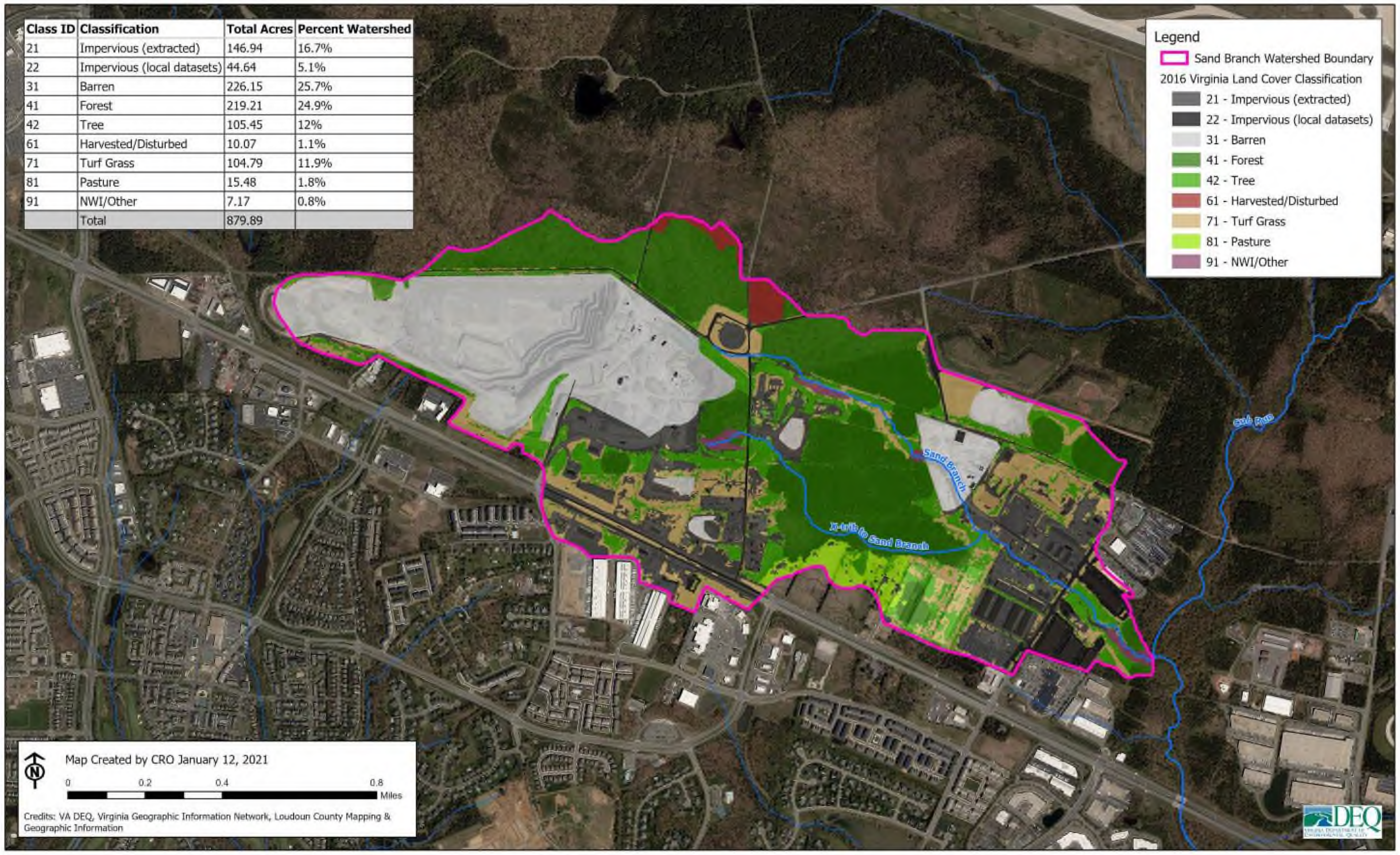
Identify Point Sources

Permit Type	Current Number
VPDES IP	1
Concrete Products GP	3
MS4	2
Stormwater Construction GP	1
Domestic Sewage GP	1
Nonmetallic Mineral Mining GP	1
Stormwater Industrial GP	1

- Identify baseline/existing loadings
- Consider existing permit requirements
- Develop wasteload allocation scenarios with TAC input

Identify Nonpoint Sources



Class ID	Classification	Total Acres	Percent Watershed
21	Impervious (extracted)	146.94	16.7%
22	Impervious (local datasets)	44.64	5.1%
31	Barren	226.15	25.7%
41	Forest	219.21	24.9%
42	Tree	105.45	12%
61	Harvested/Disturbed	10.07	1.1%
71	Turf Grass	104.79	11.9%
81	Pasture	15.48	1.8%
91	NWI/Other	7.17	0.8%
	Total	879.89	

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TMDL Equation

WLA + **LA** + **MOS** = **TMDL**

- WLA= Wasteload Allocation
  - Permitted/Point Source
  - Future Growth
- LA= Load Allocation
  - Nonpoint Source
- MOS= Margin of Safety
  - Accounts for inherent uncertainty

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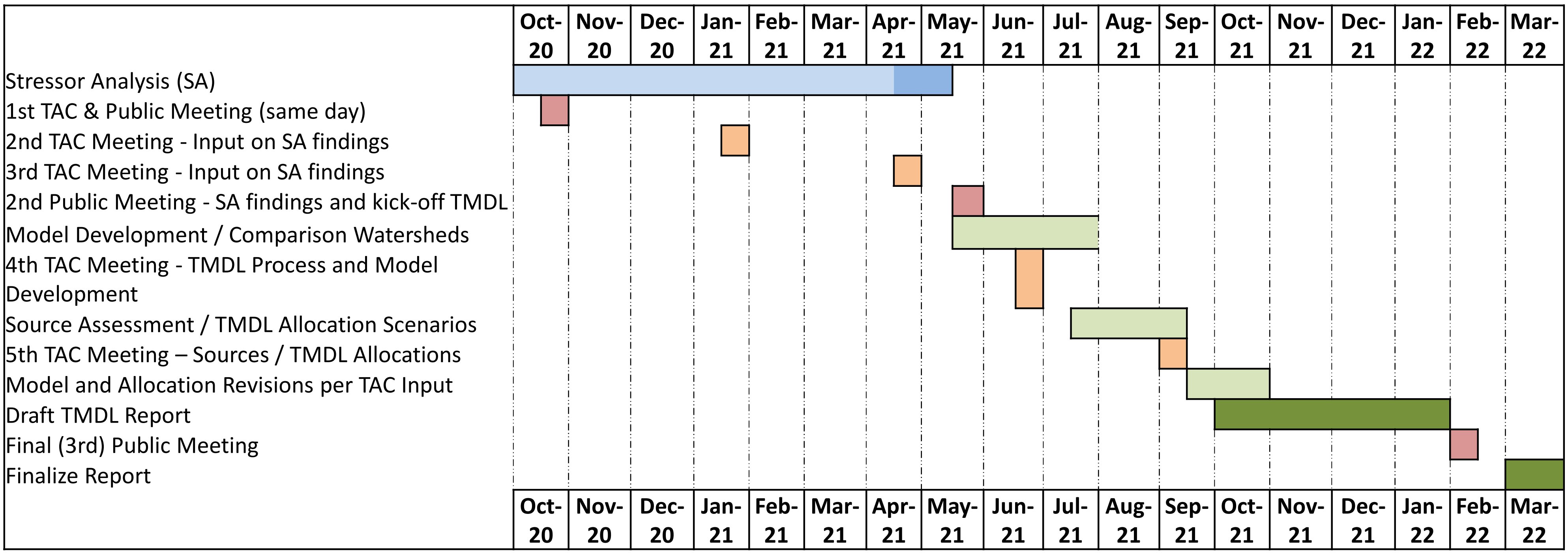
Meeting Wrap-up

Project Timeline and Next Steps

Sarah K. Sivers
Water Quality Planning Team Lead
Virginia Department of Environmental Quality

Project Timeline



Next Steps

- Complete model set-up for Sand Branch and comparison watersheds
- Conduct source assessment
- Develop TMDL endpoints
- Identify pollutant load reductions
- Develop TMDL allocation scenarios

Meeting Feedback

- Questions or Comments:
  - Sarah Sivers: (703) 583-3898 or Sarah.Sivers@deq.virginia.gov

- Meeting Feedback:
  - Virtual Meeting Public Comment Form (shared by email)
  - Submit to FOIA Board, external to DEQ