Integrating Nutrient Load Simulation into Basin-scale Watershed Models

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Outline

• Background
• Adaptive watershed approach
• Modeling scope
• Modeling challenges
• Conceptual approach
Minnesota
Modeling for 81 major watersheds
Minnesota’s nutrient issue

- Minnesota’s nutrient flux delivered to Gulf is about 2.9%
- Excess nutrients in Minnesota water are major concern - threaten aquatic life & recreation
- Many lakes/wetlands impaired
- More listings as monitoring ramps up and stream nutrient criteria approved
Clean Water Legacy Amendment

Legacy Amendment ~$150M FY10-11

Identify impaired waters and develop TMDL in 10 years – 10% per year
MPCA One-water Program

Adaptive Watershed approach

It’s a process!

- Integrates various water functions
- Includes intensive watershed monitoring
- Incorporates stressor identification
One-water program uses **BASINS*** modeling framework

*Better Assessment Science Integrating Point & Nonpoint Sources*
One-water modeling goals

- **Help** different aspects of water quality stressor identification process
- **Support** TMDL development activities and watershed restoration efforts
- **Highlight** priority response zones (hot spots) at a large scale
- **Run scenarios** to answer "what if" questions
- **Determine** type of landscape alterations that would help improve water quality
- **Prioritize** implementation resources
Modeling challenges

- What is the right scale and pace?
- What is the right approach?
- HSPF or SWAT, or both?
- How to go from model to implementation?

Models can be developed at any scale....
Not all models can be applied at every scale....
What is the right scale?

Subwatershed?

Watershed?

Basin?

Multi-basin?
Scale – Multi-basin

Lake Pepin

Turbidity impairment

Nutrient impairment
Loading sources represented in UMR-LP:

- **8 tributaries**
- **6 WWTPs**
HSPF modeling – large scale

- Lac qui Parle to Jordan
- 12,200 sq. miles
- 86% of area in cropland
- 260 miles of mainstem
- 9 linked models

Lower 27 miles of Minnesota River impaired by low DO
Scaling from basin to field
What is the right scale and pace?

Consider:
- Economy of scale
- Data needs
- Cost and time
- Goals

Modeling for 81 major watersheds
Current large-scale models: HSPF or SWAT

- Provide only a **spatially-lumped approximation** of field-scale practices
- Have an **incomplete representation** of temporal variability
- Can do a **good job** with $P$ but not for “N”

- Both models have strengths/weaknesses
  - HSPF – better fit to observed data
  - SWAT – may be more robust to changing conditions
Large basin models are essential – particularly for transport

But, intrinsic problems related to scale, temporal variability

This limits our ability to go from model to implementation
Potential solution strategies

1. Agronomic models
2. Comprehensive gridded models
3. Calibration to fine-scale models
4. Nesting of fine-scale models
1. Large-scale agronomic models

SWAT models – Soil Water Assessment Tool

• Potentially address changing conditions

• SWAT models have also been built for large basins – agronomic simulation, but still lumped, large-scale
2. Comprehensive gridded models

Why not simulate the whole basin at the field scale?

Newer grid-based models like GSSHA attempt to do this

- Still experimental
- Data intensive
- Long run times

Increased complexity does not always lead to better results!
3. Calibrate to **fine-scale** models

Develop models at the intensively studied **local watersheds** (e.g., **SWAT-DRAINMOD** combo)

**Strategy**: Constrain or “calibrate” the basin-scale models to reproduce fine-scale model results for intensive study areas

**MPCA is using this strategy to refine the Minnesota River model**
4. **Nesting** of fine-scale models

Potential refinement: **create “combo” models**

- *e.g.* Use SWAT-DRAINMOD to **create library** of unit area time series
- **Link** the time series as inputs to basin-scale model

**Drawbacks**

- Requires model recoding and complex data management
- Potentially longer model run times
Adequate data, time, and resources are required to construct a complex model commensurate with system complexity and management questions.

MPCA has developed a robust, scientifically credible modeling approach that can support decision-making for TMDLs and beyond.
Summary

MPCA is employing a strategy to combine the strengths of various models to meet the current goals of One Water Program.

The strategy
Constrain or calibrate the watershed scale models to reproduce fine scale model results for intensive study area.
Summary

Models can be developed at any scale, but not all can be applied at every scale,

To date better fit to observed data obtained with HSPF

Increased complexity does not always lead to better results!

Large scale models are essential!
More information

MPCA Web site
www.pca.state.mn.us

Phosphorus study
www.pca.state.mn.us/water/phosphorus.html#report

Nonpoint Source Management Program Plan
www.pca.state.mn.us/publications/wq-cwp8-08.pdf

eLINK
www.bwsr.state.mn.us/outreach/eLINK

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