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Print version

CEE 577: Surface Water Quality Modeling

Lecture #38

TMDLs

(including Slides from Dick Schwer & Michelle Thompson)

CHESAPEAKE

Ecoletter

SPRING 2000 ISSUE

WWOA

Too Many Damn Lawyers
Too Many Damn Laws
Trials in Managing Diverse Loads
Testing Man's Disciplinary Limits
Too Many Decisions Languishing
Trickles Make Dead Lakes

TMDL

TOTAL MAXIMUM DAILY LOAD

Trout May Die Laughing
Tax My Drain Later
Testing My Darn Limits
Totaling Mankind's Disagreeable Leftovers
Tough Mandatory Discharge Liability
Taxing Mankind's Disposable Lust
Transitory Management Documentation Link

But seriously, folks, see inside contents

A Publication of the Water and Waste Operators Association of Maryland, Delaware, and the District of Columbia, & the Chesapeake Water Environment Association

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What is a TMDL?

- Total Maximum Daily Load
- Term coined in 1972 Clean Water Act
- TMDL has different meanings
  - Technical: Pollutant mass balance
  - Regulatory: Water quality program

Slide courtesy of: Dick Schwer

Basis: State Water Quality Standards

- A water quality standard defines the water quality goals of a water body…. by designating the use or uses to be made of the water and setting criteria necessary to protect the uses. (40 CFR Part 131)
- Criteria established in standards
  - numerical (2 ug/L copper)
  - narrative (no toxics in toxic amounts)
    - Requires quantification with indicator

Slide courtesy of: Dick Schwer

Background: TMDL Basis

- Quantitative Expression for acceptable pollutant load in waterbody or stream segment:

$$\text{TMDL} \;\&\; \text{LC} \Rightarrow \text{WLAs} + \text{LAs} \; [+\text{MOS}]$$

- TMDL also referred to as assimilative capacity of the waterbody

Slide courtesy of: Dick Schwer

Background: TMDL Basis

- *Where:*

  LC = Loading Capacity of waterbody for pollutant
  usually determined by water quality modeling

  WLA (Waste Load Allocation) = portion of LC
  allocated to point source

  LA (Load Allocation) = portion of LC allocated
  to nonpoint source / natural background

  MOS = Margin of Safety for uncertainty
  - Explicitly as added load or
  - Implicitly as safety factors in modeling

Slide courtesy of: Dick Schwer

Background: TMDL Basis

- **Began as Quantitative Expression:**
  TMDL & LC ⇒ WLAs + LAs [+MOS]
- ***Where:***

LC = Loading Capacity of waterbody for pollutant
usually determined by water quality modeling
WLA (Waste Load Allocation) = portion of LC
allocated to permitted point source
LA (Load Allocation) = portion of LC allocated
to nonpoint source / natural background
MOS = Margin of Safety for uncertainty

- **Explicitly as added load or**
- **Implicitly as safety factors in modeling**

Slide courtesy of: Dick Schwer

Load Allocation Sources

- Agricultural Runoff
- Urban Runoff
- Non-permitted Storm Water
- Construction Site Runoff
- Atmospheric Deposition
- Ground Water Infiltration
- Contaminated Sediment

Slide courtesy of: Dick Schwer

TMDL Illustration: Pollutant "X" Loading Reduction

Source	PS_1 Lb/dy	PS_2 Lb/dy	NPS(s) Lb/dy	Bkgrd Lb/dy	MOS Lb/dy	Future Growth Lb/dy	TOTAL Lb/dy
Current Loading	20	10	50	20	----	----	100
TMDL Allocat'n	2 WLA_1	1 WLA_2	20 LA(s)	20	5	2	50
% Reduct'n	90%	90%	60%	----	----	----	50%

Slide courtesy of: Dick Schwer

TMDL Implementation Quandry

- For permitted point sources:

  TMDL → WLA_1 → permit limits

- For nonpoint sources

  TMDL → LA → best management practices (BMPs)

✓ Consequently, for point sources limits can be imposed <u>but</u> for nonpoint sources we rely on voluntary BMPs

Slide courtesy of: Dick Schwer

TMDL Program Requirements

- Authorized in 1972 Water Pollution Control Act by Section 303(d)
- States required to
  - List impaired waterbodies every 2 years
  - Develop TMDLs for listed waters
  - Implement control strategies to comply
- EPA oversight required to
  - Approve State 303(d) Lists and TMDLs
  - or Disapprove and issue Lists/TMDLs

Slide courtesy of: Dick Schwer

TMDL Program Reactivation

- EPA & States "ignored" for 20 years
- Environmental groups have filed ~45 lawsuits against EPA for lack of 303(d) enforcement of TMDL Program
- EPA response
  - Issued tighter guidance for 1998 lists
  - Set up TMDL Federal Advisory Group
    - Group issued June 1998 Report
    - Over 100 recommendations to improve TMDL program

Slide courtesy of: Dick Schwer

TMDL Rulemaking Saga

- August 1999: EPA proposed TMDL Rule
- Early 2000: Lobbying in Congress by nonpoint source interests against rule
- June 2000: House & Senate pass emergency appropriations bill
  - Rider to block implementing Final Rule
- July 2000: EPA signs Rule
  - But delays effective date of Rule to October 31, 2001 to avoid rider
- November 2000: EPA sued on delayed Rule

Slide courtesy of: Dick Schwer

Current Rulemaking Status

- October 2001: EPA further delayed Rule 18 months to April 2003
- Oct-Dec 2001: EPA held 5 "listening sessions"for public on possible changes
- November 2001: EPA issued guidance for State impaired waters listings due October 2002
- EPA currently completing draft of revised TMDL rule

Slide courtesy of: Dick Schwer

Rulemaking Process & Advocacy

- EPA meeting with interest groups & lawsuit litigants to discuss potential changes to rule
  - EPA will call this "Watershed Rule"
- Rule to Office of Management & Budget (OMB) by late May for review
- Proposal for public comment late June
- Rule expected to be promulgated early 2003

Slide courtesy of: Dick Schwer

Current TMDL Program

- Current regulations in effect
  - Code of Federal Regs Part 130.7 (1992)
- Program driven by enviro. groups suits
- States listing with poor quality data
- Troublesome listing issues:
  - threatened waters, air deposition, pollution
- Lack of specific guidance for TMDLs
- Emphasis on point sources and WLAs

Slide courtesy of: Dick Schwer

Typical Steps in Developing TMDL

- Criteria in water quality standard found to be exceeded and water body (or stream segment) listed as impaired
- Additional data collected on pollutant concentrations, sources and loadings
- Water quality modeling to determine reductions needed to meet criteria
- Sources assigned WLAs or LAs

Slide courtesy of: Dick Schwer

What's Missing?

- Implementation of the loadings from TMDL
- Not considered part of TMDL
  - Some groups (environmental) disagree
- Requires subsequent action by State and EPA
  - NPDES permit limits for point sources
  - Best management practices for nonpoint sources

Slide courtesy of: Dick Schwer

Impaired Waters Listing & TMDL Information

- 1998 & 2000 Lists →
  - 21,000 Impaired Waters &
  - 42,000 Impairments
  - Top Impairments
    - Sedimentation & Siltation - 5876
    - Pathogens - 5421
    - Metals - 4874
    - Nutrients - 4697
    - Organic enrichment/ Low DO - 4451

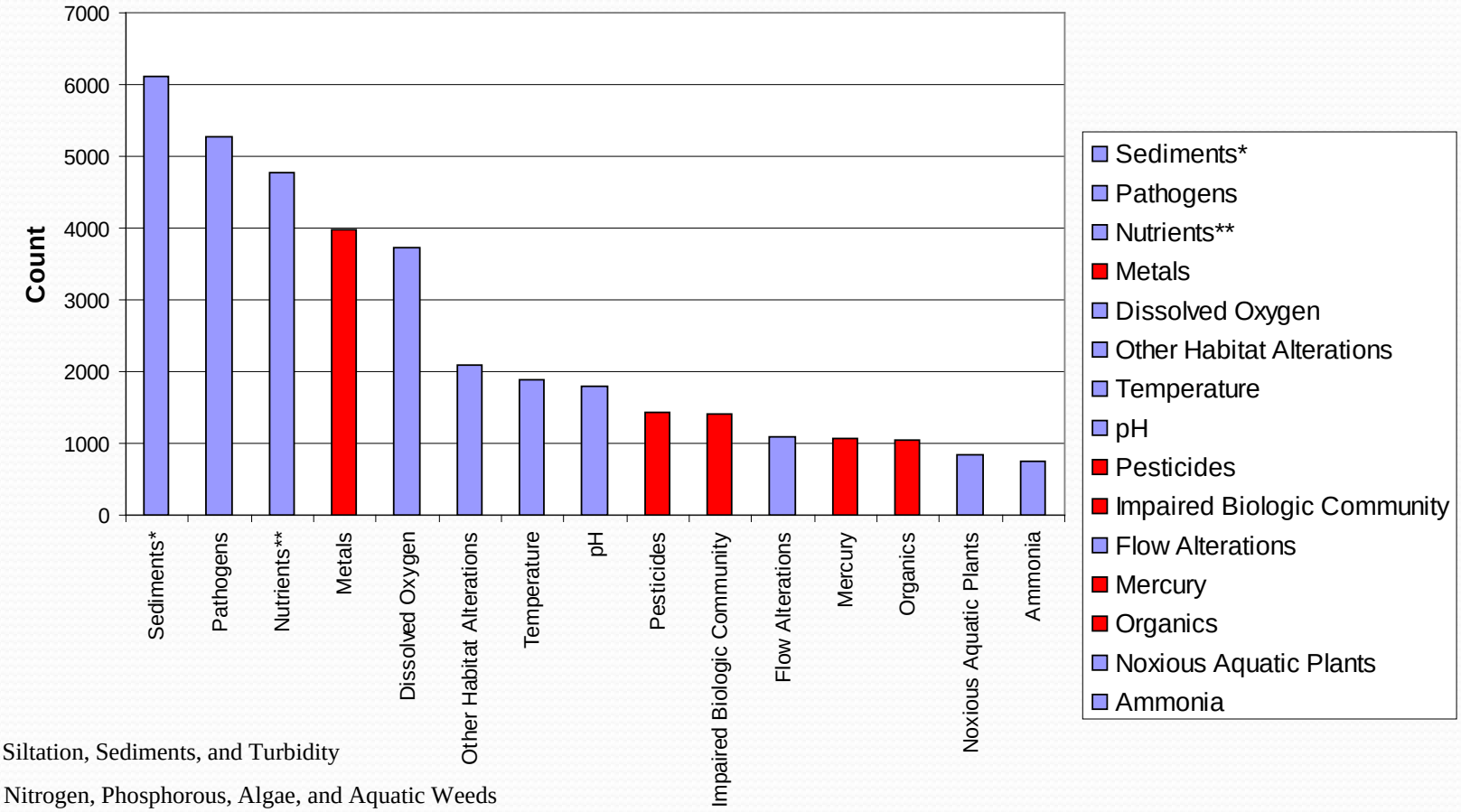
Slide courtesy of: Dick Schwer

Impaired Waters Listing & TMDL Information

- Approved TMDLs since 1996
  - Total - 4061
  - Pollutants
    - Metals - 1163
    - Nutrients - 666
    - Pathogens - 624
    - Sediment & Siltation - 429
    - Organic enrichment/ Low DO - 280
- EPA TMDL website URL
  - http://www.epa.gov/owow/tmdl/

Slide courtesy of: Dick Schwer

1998 303(d) listed impairments



* Sediments = Siltation, Sediments, and Turbidity

** Nutrients = Nitrogen, Phosphorous, Algae, and Aquatic Weeds

Impairments (91% of all impairments)

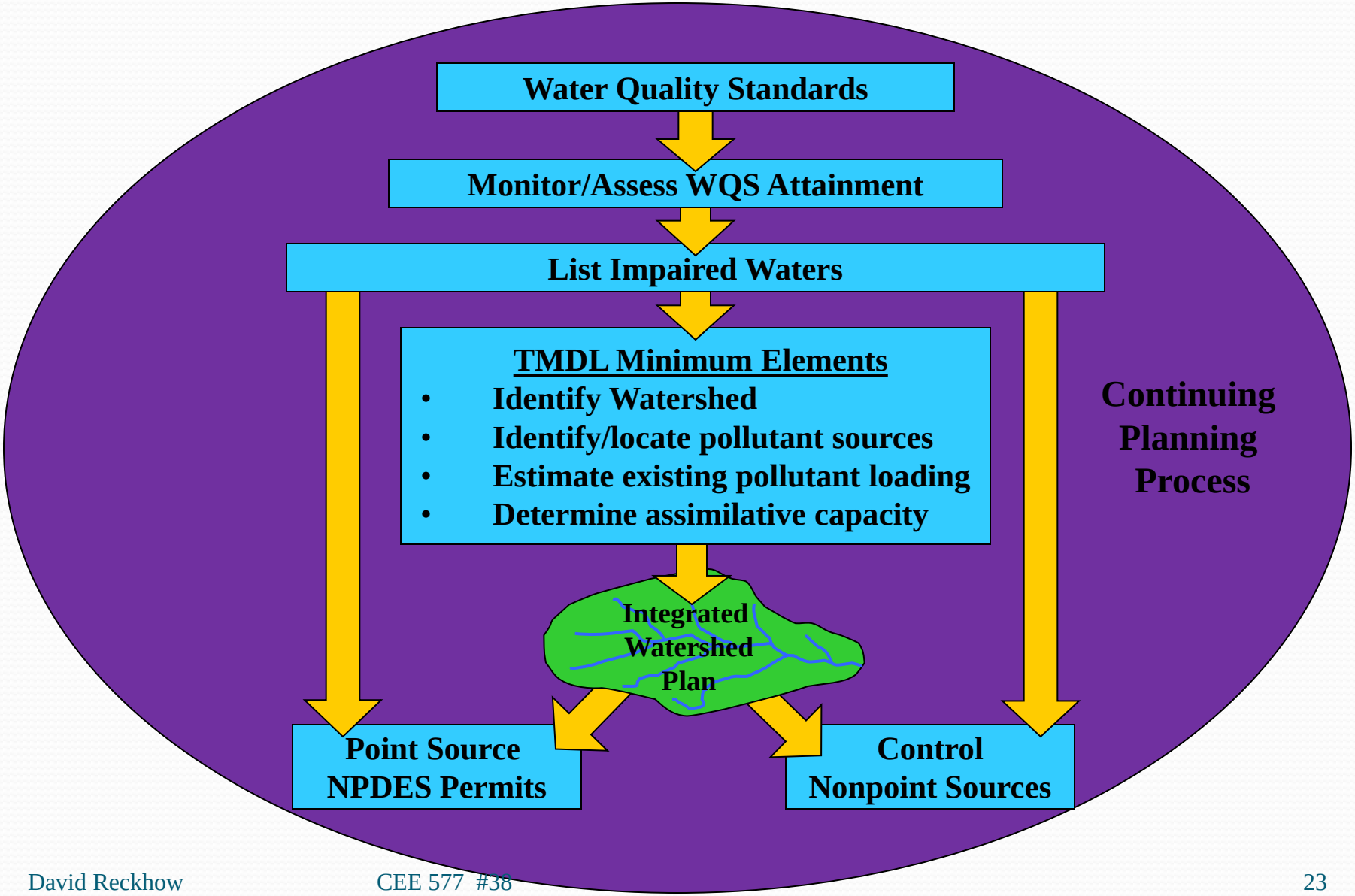
- **About 40,000 TMDLs are required for about 20,000 impaired waterbodies, based on the 1998 list of impaired waters.**

EPA Approach to New TMDL Rule

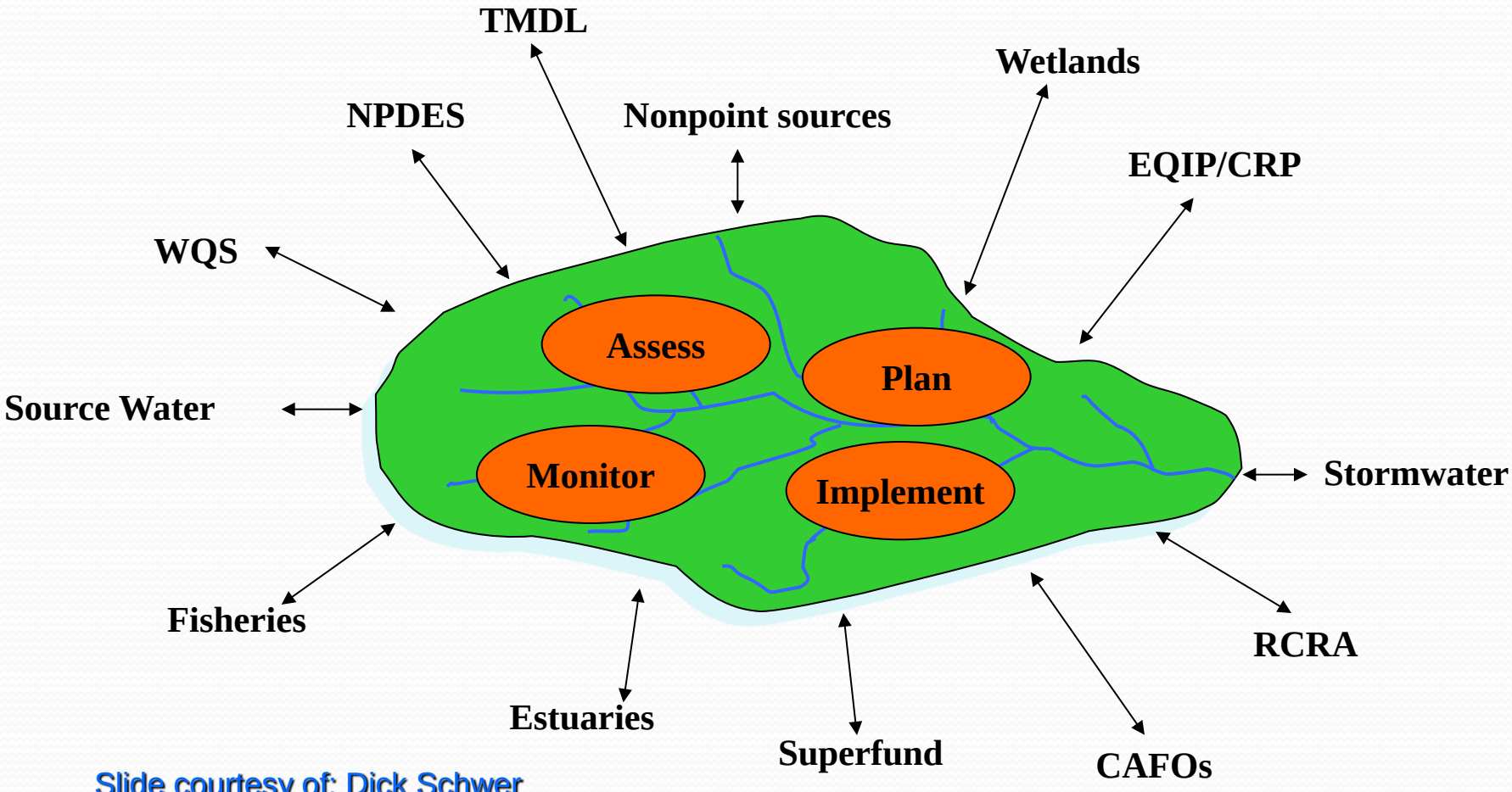
- Now called "Watershed Rule"
- Implementation will be addressed separately by each State under Continuing Planning Process (CPP)
- CPP to be "reinvigorated"
  - Stronger requirement to implement
  - Develop of Watershed Plans in 2 years
  - Cover range of issues from Water Quality Standards to Implementation Planning

Slide courtesy of: Dick Schwer

Clean Water Act Framework



Integrated Watershed Plan



Slide courtesy of: Dick Schwer

EPA Approach to New TMDL Rule

- Listing cycle increased to 4-5 years
- But no specific minimum quality data required to list
  - "All existing and readily available data and information must be considered"
- List waters in one of 5 categories
  - Basis: concerns for impairment and data
  - Only one category of impaired waters (5)
- Air deposition issue still not resolved

Slide courtesy of: Dick Schwer

EPA Approach to New TMDL Rule

- Pollutant minimization plans for insignificant sources, not "zero"
- Allocation basis
  - Specific allocations for each point source
  - Group allocations for nonpoint sources
- Should not inhibit pollutant trading between sources or source and NPS
- Address wet weather sources
- Watershed permitting

Slide courtesy of: Dick Schwer

Issues and Concerns about TMDL Program

- Criteria & uses that are appropriate
- Sufficient water quality data to determine if criterion is exceeded
- Sufficient data on pollutant loads and concentration to enable modeling
- Adequate water quality model to address fate and transport issues
- Accurate assessment of load reduction requirements

Slide courtesy of: Dick Schwer

Issues and Concerns about TMDL Program

- Sufficient and reasonable Margin of Safety assessment based on science
- Implementation that is effective and reasonable to meet criteria
- Adequate follow-up monitoring to determine when and if criteria met
- Has been a divisive program
- Should not be the only "game in town"
  - Other watershed approaches available

Slide courtesy of: Dick Schwer

What's Good About TMDL Program?

- Can serve as a catalyst for real water quality improvement
- Focus is achieving water quality standards (uses and criteria)
- Should enable improved water quality assessment and modeling tools
- Should put more emphasis on achieving nonpoint source reduction

Slide courtesy of: Dick Schwer

Analysis of MA TMDL studies

- 561 freshwater lakes fail to meet MA Surface WQ standards (303d list)
  - 527 due to nutrient related problem
    - 469 due to nuisance aquatic plants from nutrient enrichment
      - 90% are for macrophytes
        - rooted species are not expected to be affected by change in P loading
      - 10% are for algae
    - 58 due to other nutrient related problems
      - Low DO, turbidity from algae

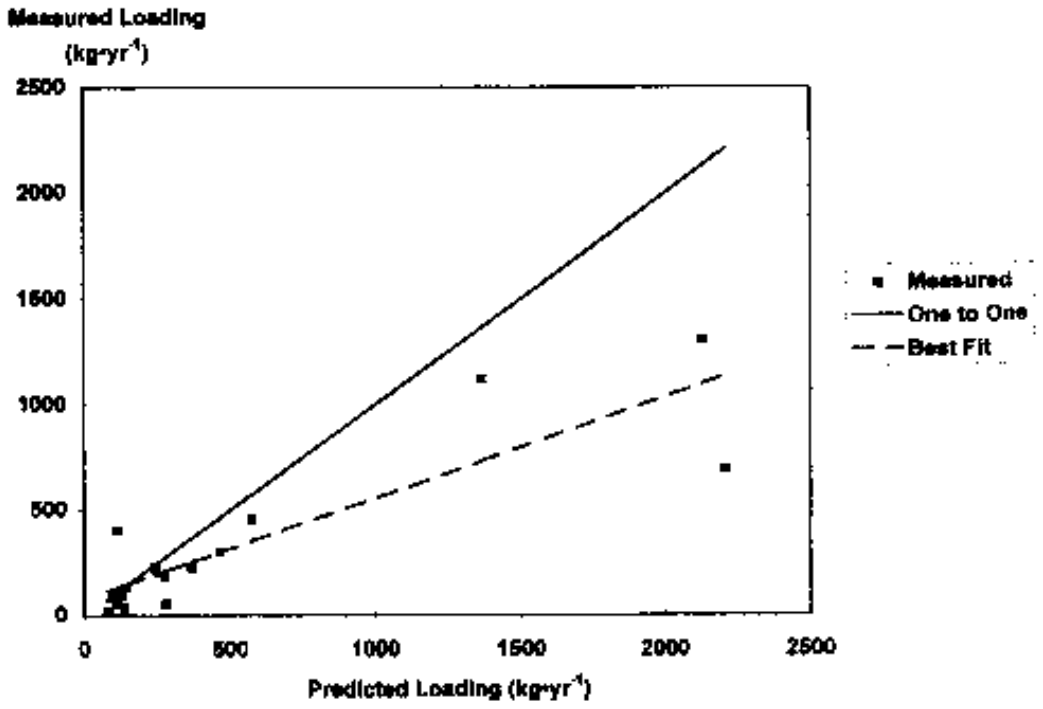
Mattson & Isaac, 1999; J. Lake & Res. Mgmt. 15:3:209

Analysis of MA Studies II

- 16 Diagnostic/Feasibility studies measured P loading and calculated it based on export coefficients

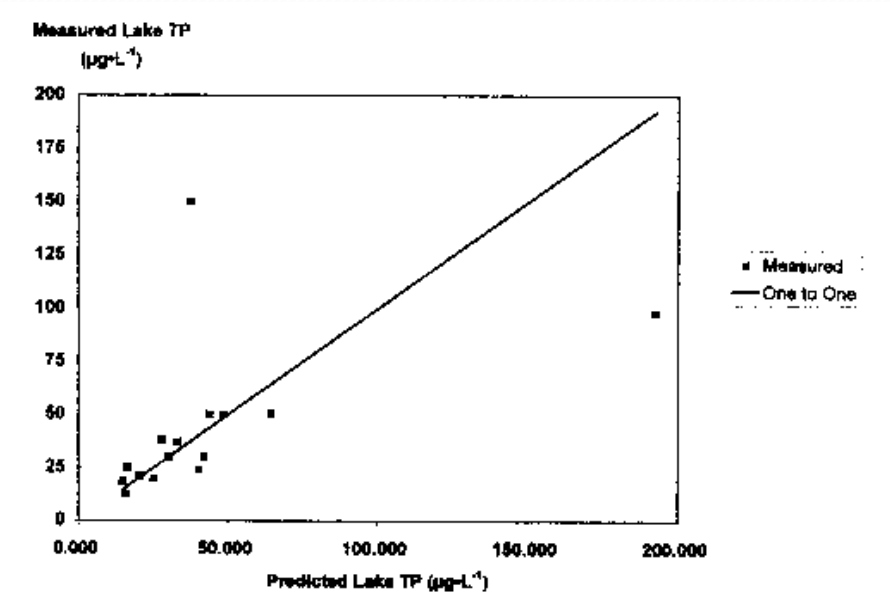
  - Analysis:
    - Chronic over prediction
  - Possible reasons
    - Under prediction of actual loading due to lack of storm event data
    - Biased land use data
    - Generally low P export in MA due to low P level in soils

Most likely



Mattson & Isaac, 1999; J. Lake & Res. Mgmt. 15:3:209

Analysis of MA Studies III



Analysis of MA Studies IV

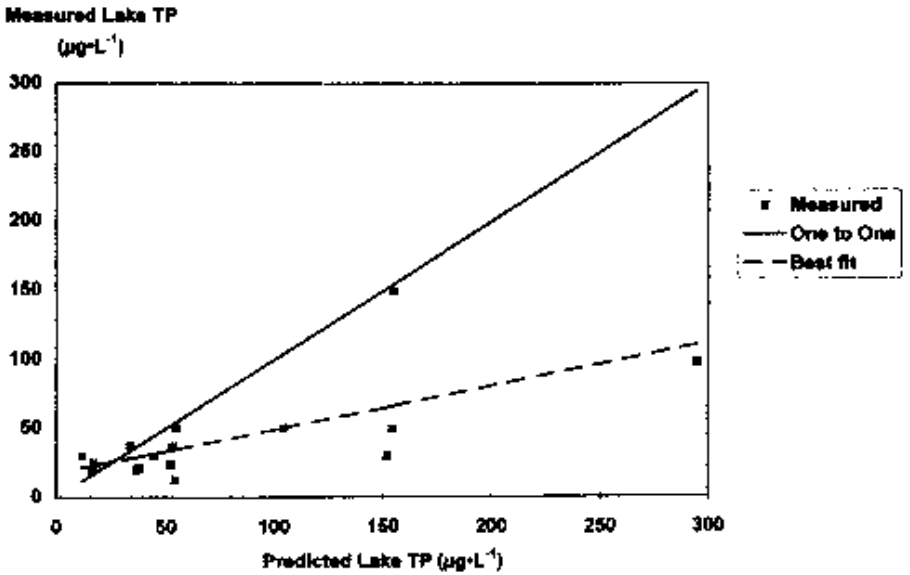
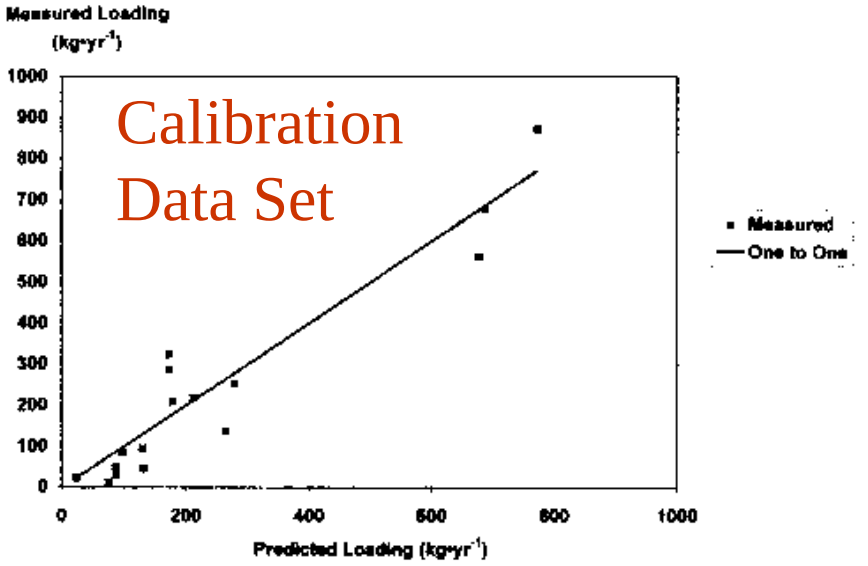
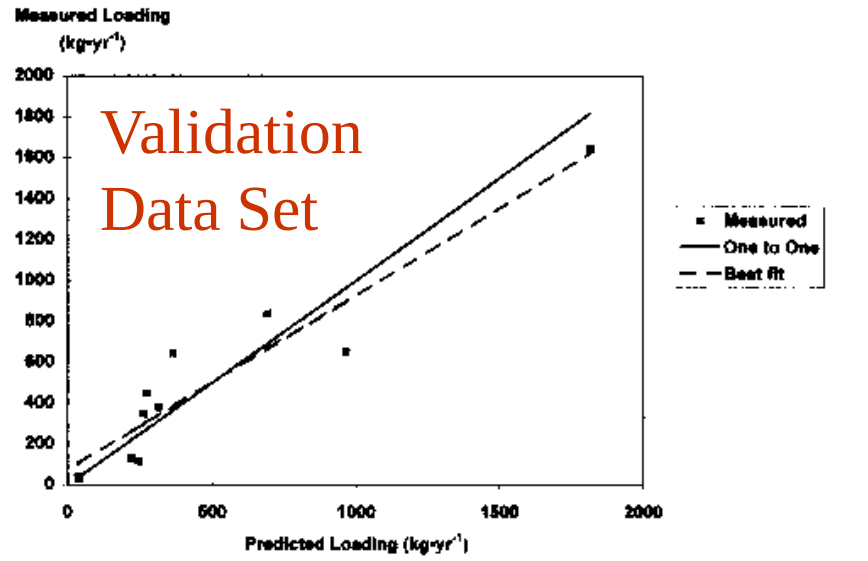


Figure 3. –Measured vs. predicted total phosphorus concentrations. Predictions based on land use phosphorus export coefficients used in 16 D/F studies and Reckhow's (1979) equation.

Analysis of MA Studies V

- New Model
  - Based on re-evaluation of actual P loadings and land use data
  - L_{ex} = 0.5(house septics) + 0.13(forest ha) + 0.3(rural ha) + 14(urban ha)$^{0.5}$

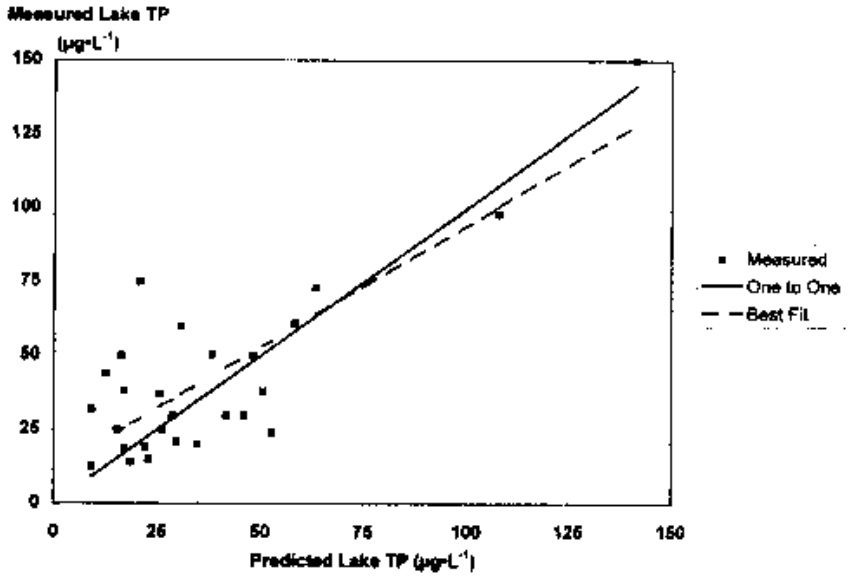




Analysis of MA Studies VI

- P predictions based on new model
- Uses
  - Carls
    - P is in ug/L
    - Oligotrophic: TSI<40
    - Mesotrophic: TSI=40-50
    - Eutrophic: TSI>50
  - Secchi Depth
    - Swimming standard of 4

$$TSI = 10\left(6 - \frac{\ln\left(48/TP\right)}{\ln(2)}\right)$$



$$Secchi(m) = e^{\left(\ln 2\left(6 - TSI/10\right)\right)}$$

Average Runoff =	61.0 cm·yr^{-1} (24.0 in·yr^{-1})
Lake area =	126.8 Ha. (313.1ac)
Homes with septic systems within 100m of lake.=	95.0
Other P inputs =	0.0 kg·yr^{-1}
Watershed information:	
Watershed Area (including lake and wetlands)=	971.7 Ha (3.8 mi^2)
Average Annual Water Load =	5923451.0 m^3·yr^{-1} (6.7 cfs)
Areal water loading to lake: q_s =	4.7 m·yr^{-1}.

Part B. Estimate of annual Nonpoint Source Pollution Loads by land use:

Land use	Area Ha (%)	P Load kg·yr^{-1} (%)	N Load kg·yr^{-1}	TSS Load kg·yr^{-1}
Forest category				
Forest:	524.1 (53.9)	68.1 (25.0)	1310.2	12577.4
Rural category				
Agriculture:	77.2 (7.9)	23.2 (8.5)	762.7	27821.2
Open land:	18.0 (1.8)	5.4 (2.0)	93.4	3985.2
Residential Low:	171.7 (17.7)	51.5 (18.9)	944.4	66623.1
Urban category				
Residential High:	27.7 (2.9)	70.2 (25.7)	152.4	12913.0
Comm - Ind:	2.8 (0.3)	7.1 (2.6)	28.0	108.7
Other Land uses				
Water:	130.6 (13.4)	0.0 (0.0)	0.0	0.0
Wetlands:	19.6 (2.0)	0.0 (0.0)	0.0	1038.7
Subtotal	971.7	225.5	3412.4	126680.7
Other P inputs:	NA	0.0 (0.0)		
95.0 Septics:	NA	47.5 (17.4)		
Total	971.7 (100.0)	273.0(100)	3412.4	126680.7

Part C. Summary of Lake Total Phosphorus Modeling Results

Areal P loading L= 0.2 g·m^{-2}·yr^{-1}.
Reckhow (1979) model predicts lake TP = L/(11.6+1.2q_s)·1000 = 12.5 µg·L^{-1}
Predicted transparency = 3.8 meters.
If all land were forested, P export would be 106.8 kg·yr^{-1}
And the forested condition lake TP would be 4.9 ppb.
Thus anthropogenic inputs increase lake TP by 155.7 percent.
The Trophic State Index has increased from 27.1 to 40.6
The Lake is predicted to be mesotrophic and culturally eutrophied.

s of MA

s VII

Bare Hill Pond Case Study

- Harvard, MA
- 44 ug/L measured P

- The End