North Dakota Nutrient Criteria

Establishing State-wide Nutrient Criteria for Lakes and Reservoirs Using a Stochastic Modeling Approach

Prepared in cooperation with:

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Background for Nutrient Criteria Development

- Prepared *Implementation Plan* (2007)
- Recommended:
  - First lentic (non-flowing), then lotic (flowing), systems; address wetlands separately
  - Stratify criteria by hydrologic planning regions before using ecoregions
- Lacking information for “reference” lakes
  - Existing data lacks in abundance and distribution
  - Consider regional modeling

Background for Nutrient Criteria Development

- Numeric Standards N.D. Century Code 33-16
- Total P limit = 100 ppb maximum
  - Restoration target = 20 ppb goal

State-wide Classification of Lentic Systems was Critical First Step

- Must determine which water bodies are lakes? reservoirs? or wetlands?
- Lake and reservoir classes must be further divided into sub-classes
  - Must reflect how system will respond to environmental conditions
    - Hydrologic and nutrient loading
- Considered 11 metrics

Metrics for Classifying Lakes and Reservoirs

- **Temperature / DO profiles (mixing)**
- **Morphoedaphic Index**
- **Metrics based on physical attributes:**
  - (surface area / drainage area) * volume = acre-feet
  - (drainage area * runoff depth) / (surface area * mean depth) = dimensionless ratio of volumes
  - (surface area) / (volume / fetch) = dimensionless ratio of surface area to receive solar radiation and energy required to mix
  - Hydraulic residence time (from outputs of a regional model)
  - TP mass residence time (from outputs of a regional model)
  - Inflow rate (Q_{in} as cubic feet per year)/ surface area = velocity (ft/year)
  - Overflow rate / evaporation rate (expressed in ft/year) = a water budget index
  - TP mass residence time in the water body / hydraulic residence time (from model) = dimensionless ratio of hydraulic and mass residence times
  - Surface area (from GIS)

Description of Physical Data for Classes

Assigned Class	Average Surface Area (acres)	Average Volume (ac-ft)	Average Drainage Area (sq.mi.)
LAKES			
I	74.1	575.9	13.8
II	156.8	1,770.8	12.9
III	364.3	4,444.3	16.6
IV	1,203.5	68,204.0	80.2
RESERVOIRS			
I	86.2	637.8	70.0
II	279.6	2,760.1	144.8
III	1,613.0	19,741.5	1,167.9
IV	1,542.7	28,570.0	472.2

General Approach to Setting Lentic Criteria

- Use a regional model to:
  - Establish “current” conditions based on land use
  - Adjust land use parameters to assess what a potential “reference” condition may demonstrate
- Chose **Upper Red River Basin** as pilot area for developing regional model

Modeling Considerations: Setting the Stage for Using a *Stochastic Approach*

- Challenges
  - Extensive modeling area with much geographic variability
  - Poor abundance and diversity of data
- Benefits
  - Based on chance and probabilities
  - Incorporates uncertainty of inputs
  - Provides results with estimates of uncertainty

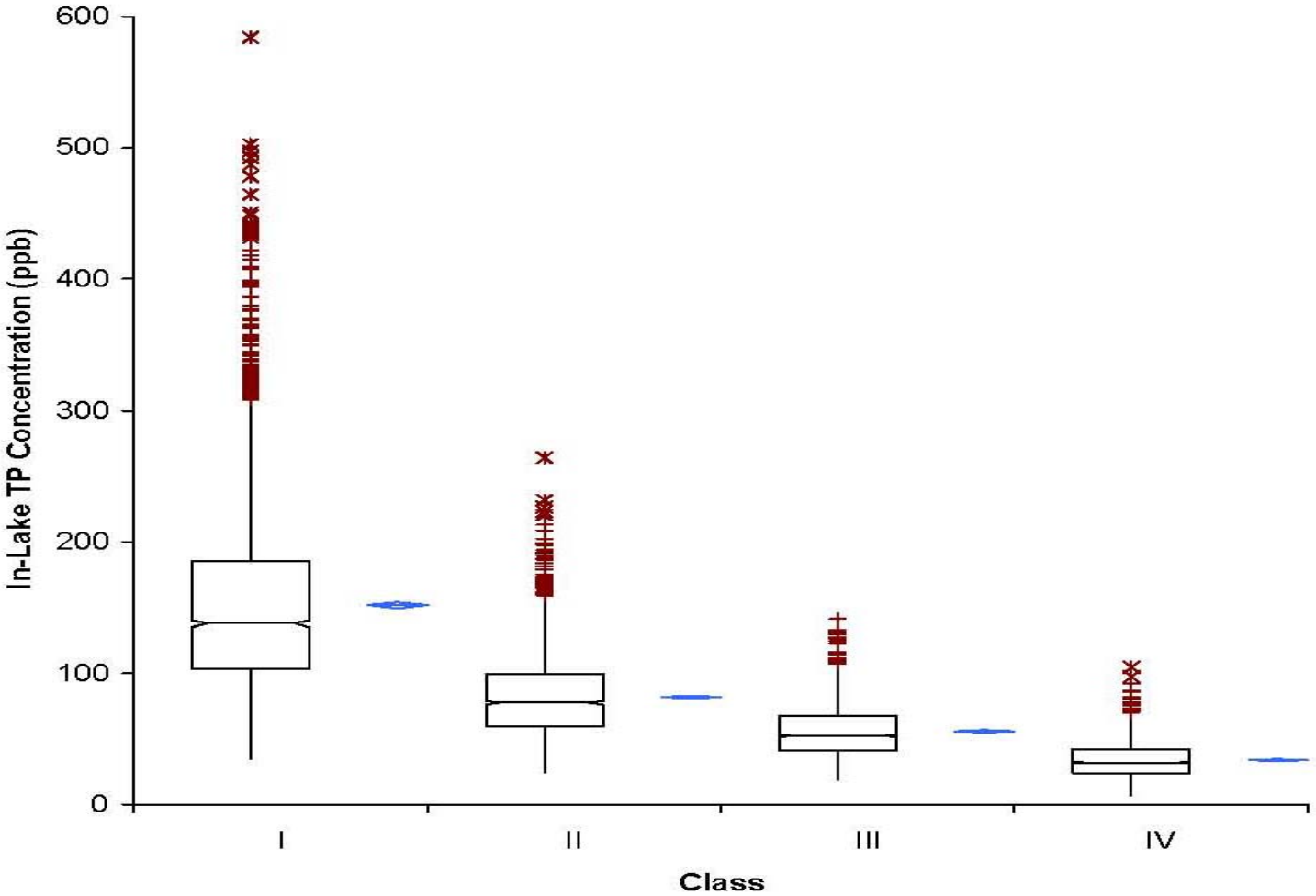
Implementation of the *Stochastic Modeling Approach*

- **Watershed Modeing Integrated with CNET model**
- **CNET Model (W.W. Walker)**
  - BATHTUB foundation
  - Spreadsheet based
  - Quickly evaluate multiple scenarios with same inputs across classes
  - Model inputs with probability distributions
- **Define model inputs with probability distributions**
  - Receiving water: Surface areas, drainage areas, volumes
  - Landscape: Curve numbers by land use, total phosphorus event mean concentrations, precipitation depths

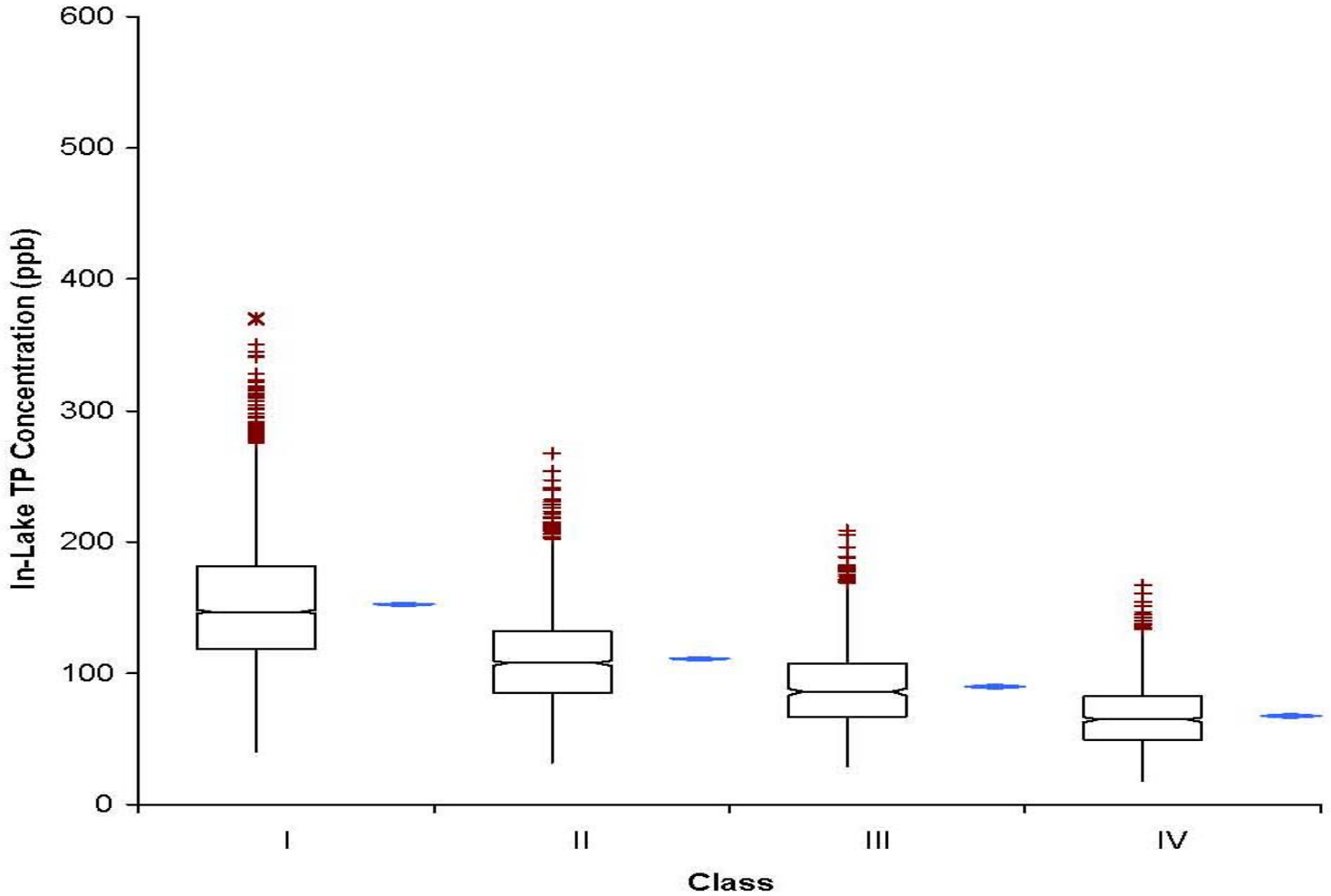
Stochastic Model Outputs

- Evaluated box plots for “Current” conditions
- Evaluated line charts with varying land use to examine potential “Reference” conditions

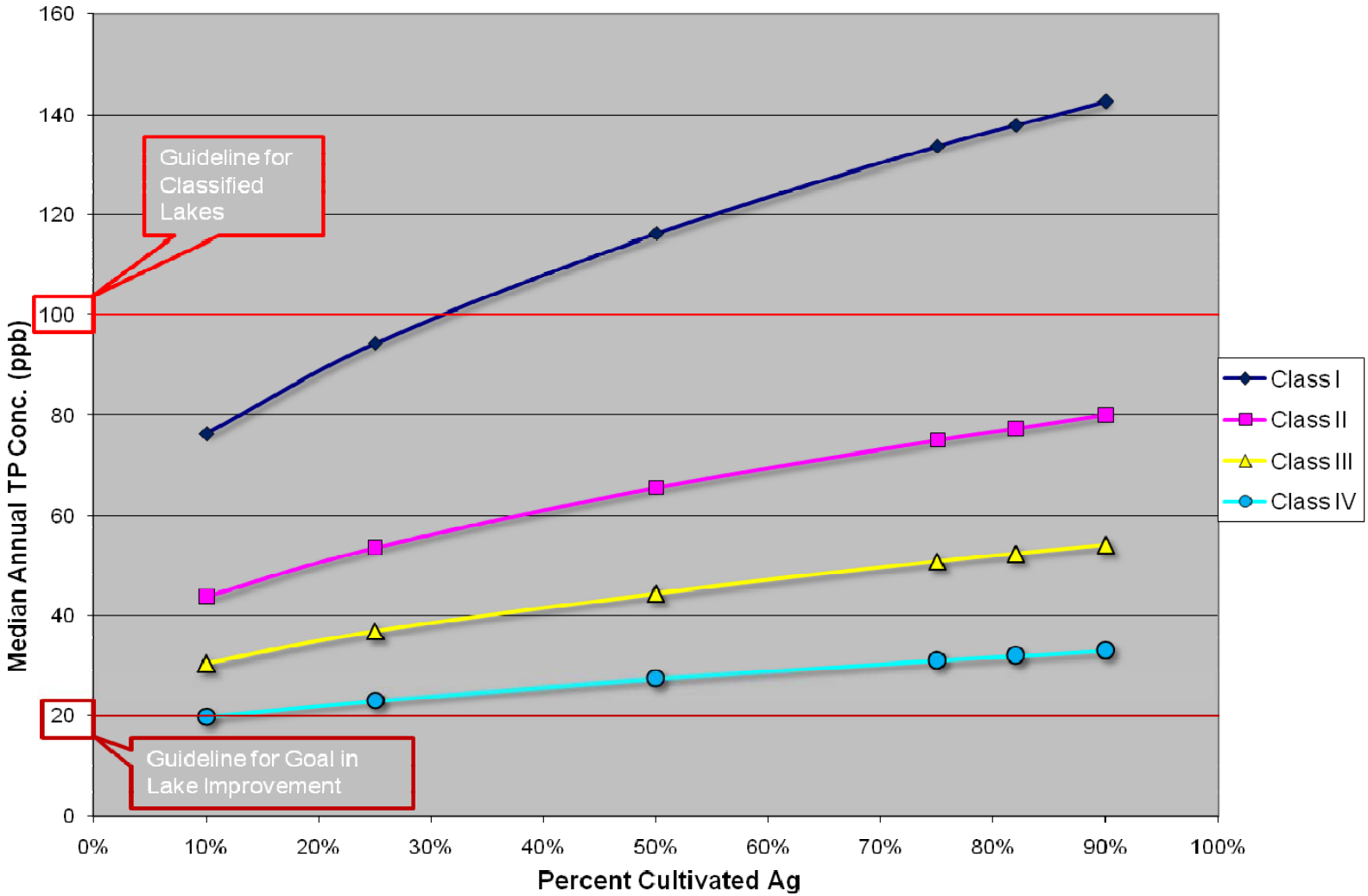
Current Condition TP Concentrations for Lakes



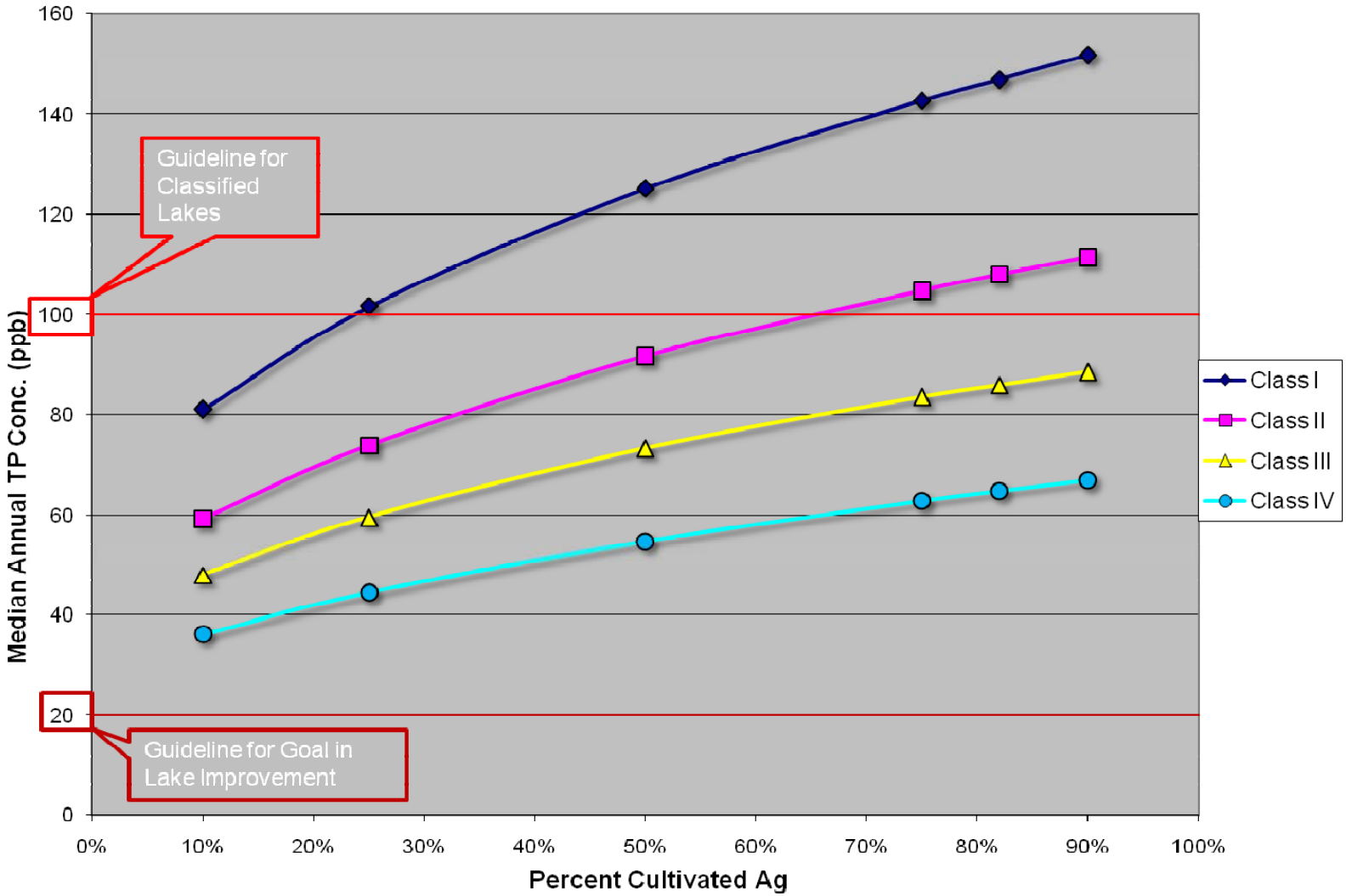
Current Condition TP Concentrations for Reservoirs.



Land Use Changes, Lakes



Land Use Changes, Reservoirs



Next Steps

- Additional data collection
  - Lake and Reservoir Morphometry
  - Chemistry
- Policy decisions to assess acceptable thresholds for eutrophication
- Model refinements and further progress beyond pilot area
  - Include Model outputs for chlorophyll –a and transparency
  - Regional application?