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Downstream Protection

Goal: Illustrate considerations and procedures associated with incorporating downstream protection into development of numeric nutrient criteria

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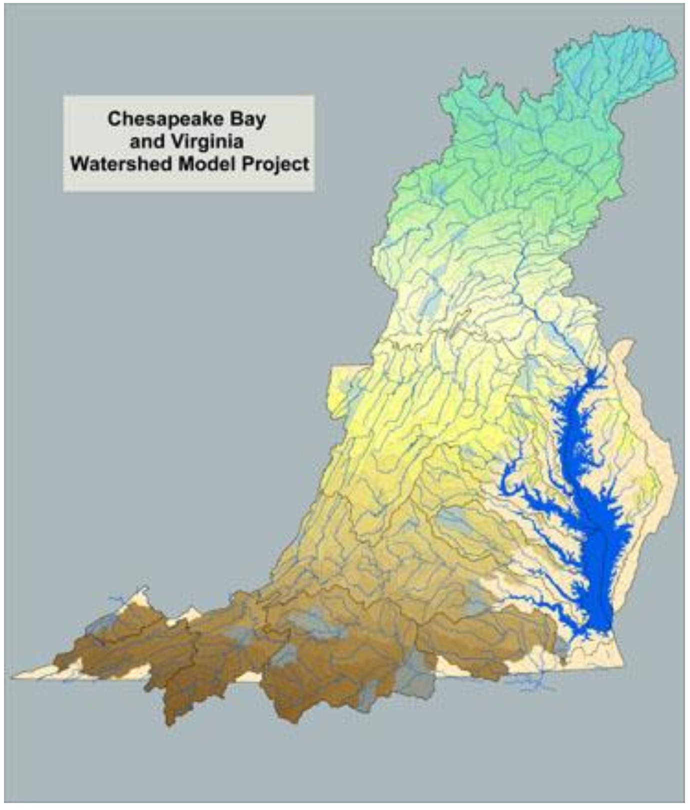
Outline

- Background
- Methods for setting criteria at the pour point:
  - Downstream criteria
  - Reference approach
  - Regression approach
  - Mechanistic modeling
- Methods for setting criteria farther upstream:
  - Fraction delivered
  - Mechanistic modeling
- Additional methods and considerations

Why is Downstream Protection Important?

Gravity...Because it all flows downstream...



- Adoption of criteria that address protection of downstream water quality standards is important in:
  - Helping avoid situations where downstream segments become impaired because of individual or multiple pollution sources in upstream segments
  - Providing clear water quality goals for trans-boundary waters
  - Determining if criteria protective of the downstream waters are more stringent than the levels needed to protect upstream waters

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Why is Downstream Protection Important?

- Demonstrating consistency with the existing regulatory requirement at 40 CFR §131.10(b)

  "In designating uses of a waterbody and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters."

- Other water quality programs that consider downstream protection include:
  - Permitting
  - Total maximum daily load
  - Assessment

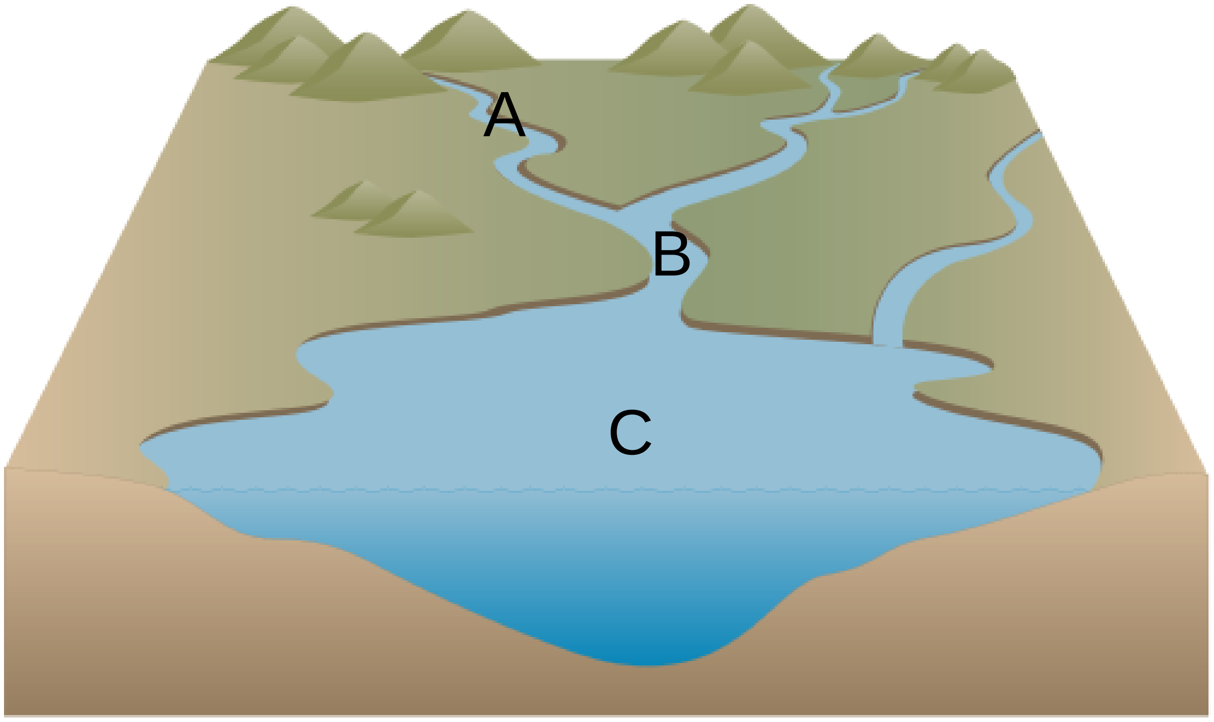
Additional Considerations for Nutrients

What we've learned and observed:

- Effects can be displaced in space and time
- The limiting nutrient varies spatially
- Numeric criteria clearly ensure downstream protection
- Impacts exist in lakes, reservoirs, and estuaries all across the United States

Where is Downstream?

The next segment down, as far as nutrient effects are observed

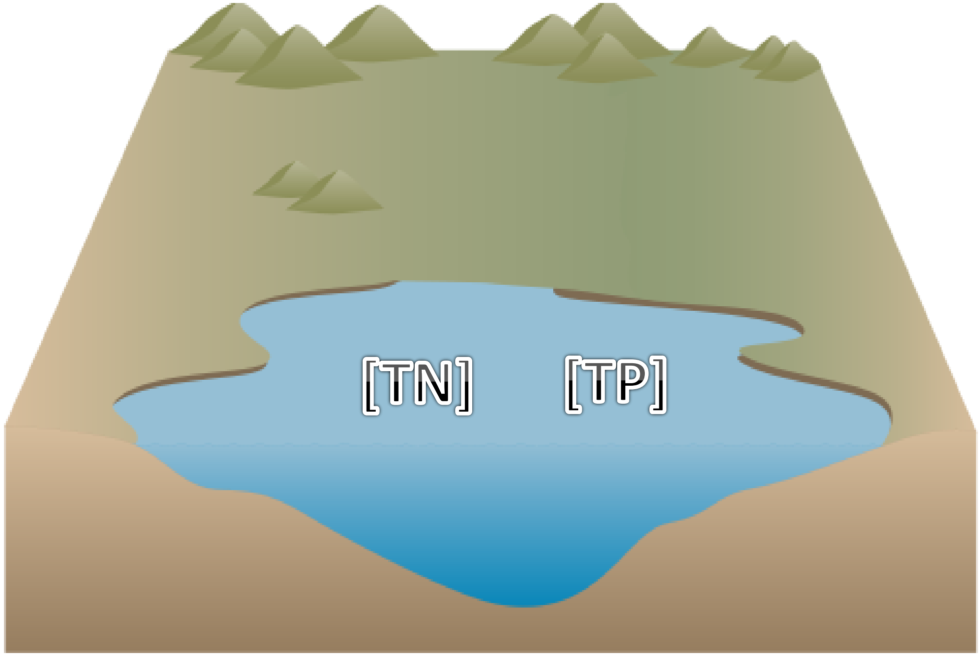


Development of Downstream Protection

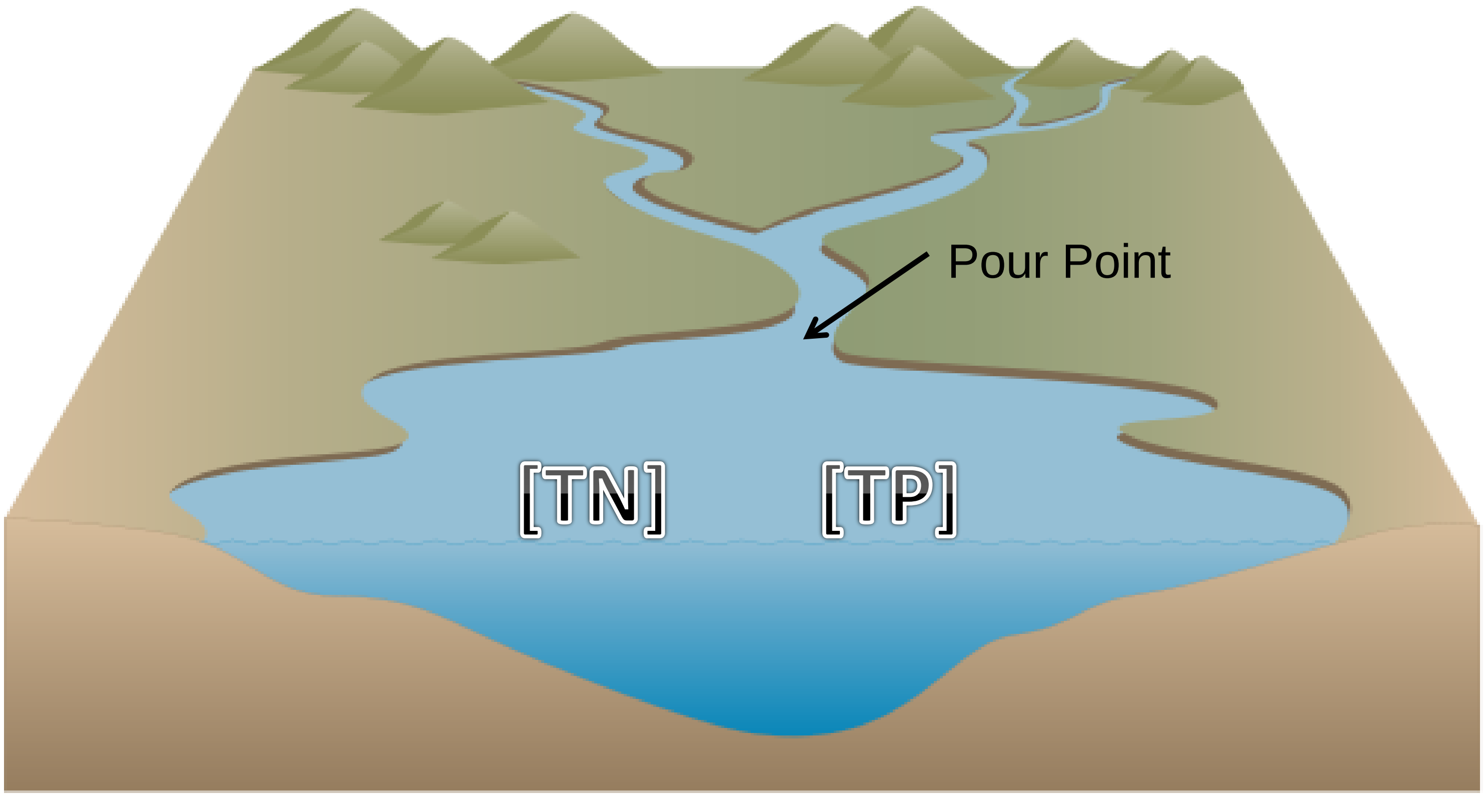
- Establish numeric criteria in the receiving waterbody and build upstream
- Methods for setting criteria at the pour point (segment immediately upstream of the receiving waterbody):
  1) Downstream criteria
  2) Reference approach
  3) Regression approach
  4) Mechanistic modeling
- Methods for setting criteria farther upstream:
  1) Fraction delivered
  2) Mechanistic modeling

Downstream Criteria

Determine protective limits for the receiving waterbody on which to base downstream protection



Set Criteria at Pour Point

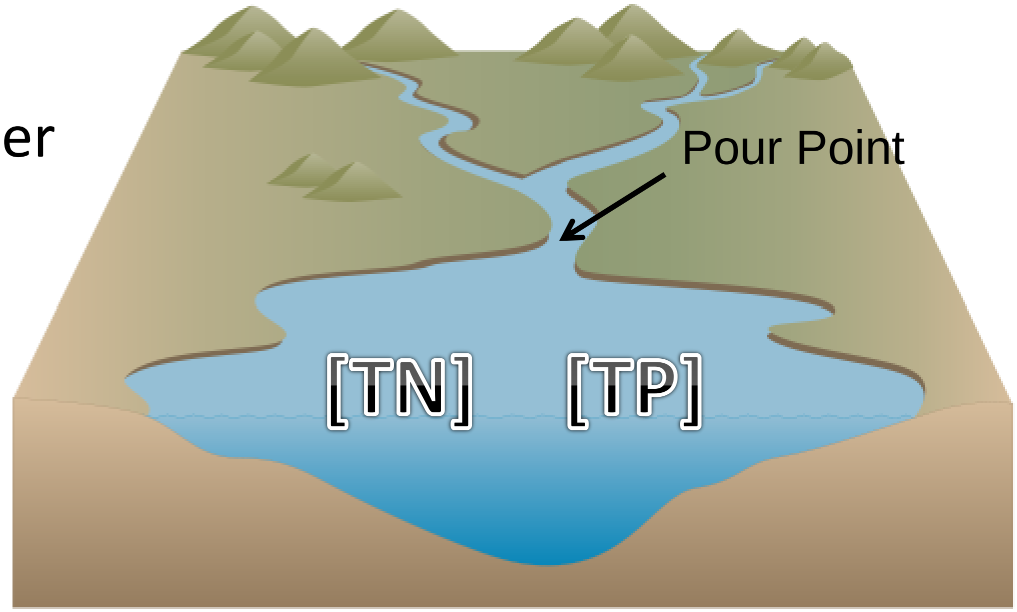


Set Criteria at Pour Point
1) Downstream Criteria

Apply downstream waterbody criteria at the pour point.

- Requires no additional data or analyses
- Conservative value

Criteria = downstream water [TN] and [TP]

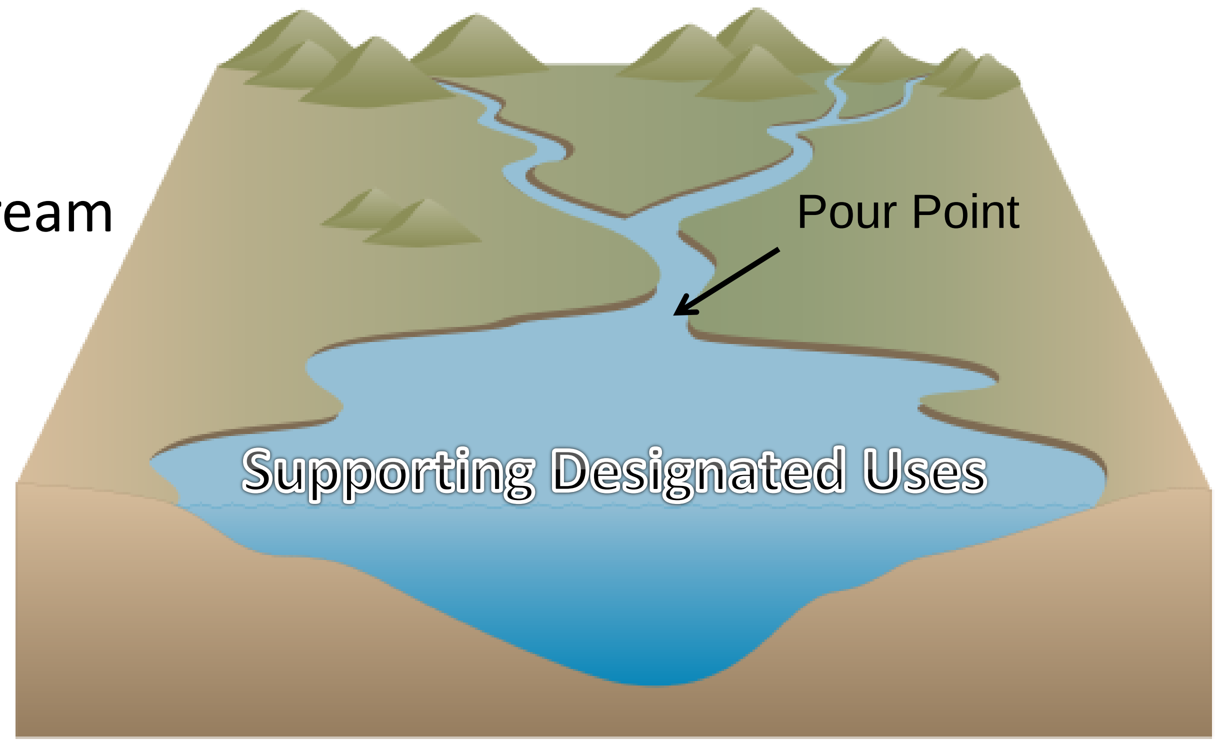


Set Criteria at Pour Point
2) Reference Approach

Reference Approach:

- When concentrations in the receiving water are supporting designated uses, maintaining the concentrations in the inflowing streams can be protective.

Criteria = existing instream [TN] and [TP]

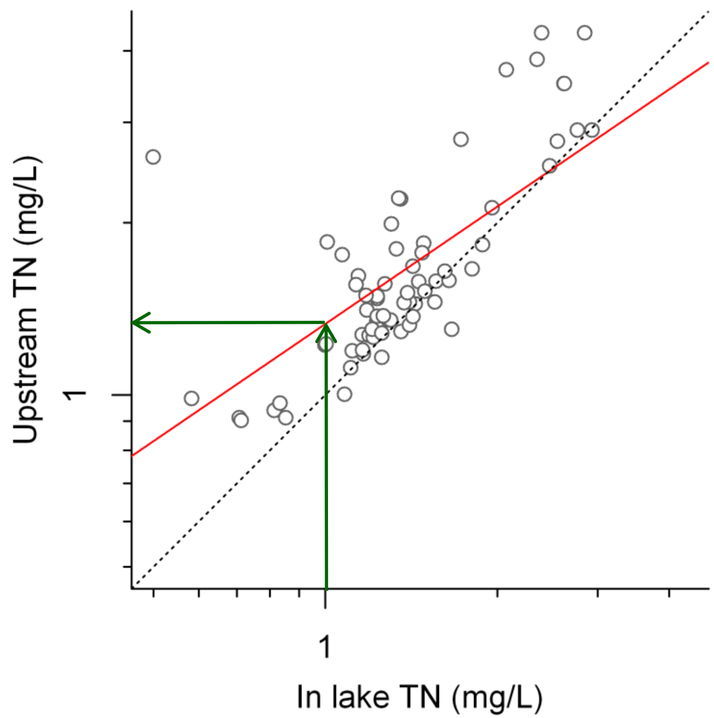


Set Criteria at Pour Point

3) Regression Approach

Regression approach:

- Derive pour point concentration from empirical relationship between lake and stream concentrations



Set Criteria at Pour Point

4) Mechanistic Modeling

Use models in a lake or estuary to ensure inflowing streams support lake or estuary criteria. Models include:

- BATHTUB in lakes
- Water Quality Analysis Simulation Program (WASP) in estuaries/lakes
- Other models include:
  - Soil & Water Assessment Tool (SWAT)
  - One Dimensional Riverine Hydrodynamic and Water Quality Model (EPD-RIV1)
  - River and Stream Water Quality Model (QUAL2K)
  - Hydrological Simulation Program – FORTRAN (HSPF)

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Set Criteria Upstream

1) Fraction Delivered

From any given upstream reach, calculate the criteria needed to support downstream waters using:

$$\bar{C}_i = \frac{\bar{C}_t}{\bar{F}_i}$$

Where:

C_i = Criterion for an upstream reach

C_t = Terminal reach protective concentration

F_i = Average fraction of total nitrogen or phosphorus transported out of the upstream reach that eventually enters the receiving waterbody

Set Criteria Upstream

1) Fraction Delivered

Before proceeding, scale needs to be considered; do criteria need to be set over long or short distances?

- Short:
  - Aquatic environments, and thus fraction delivered, are likely to be more similar
  - Potentially easier to directly measure nutrient retention/removal
- Long:
  - Multiple environments through a stream network can mean multiple processes may affect the fraction delivered

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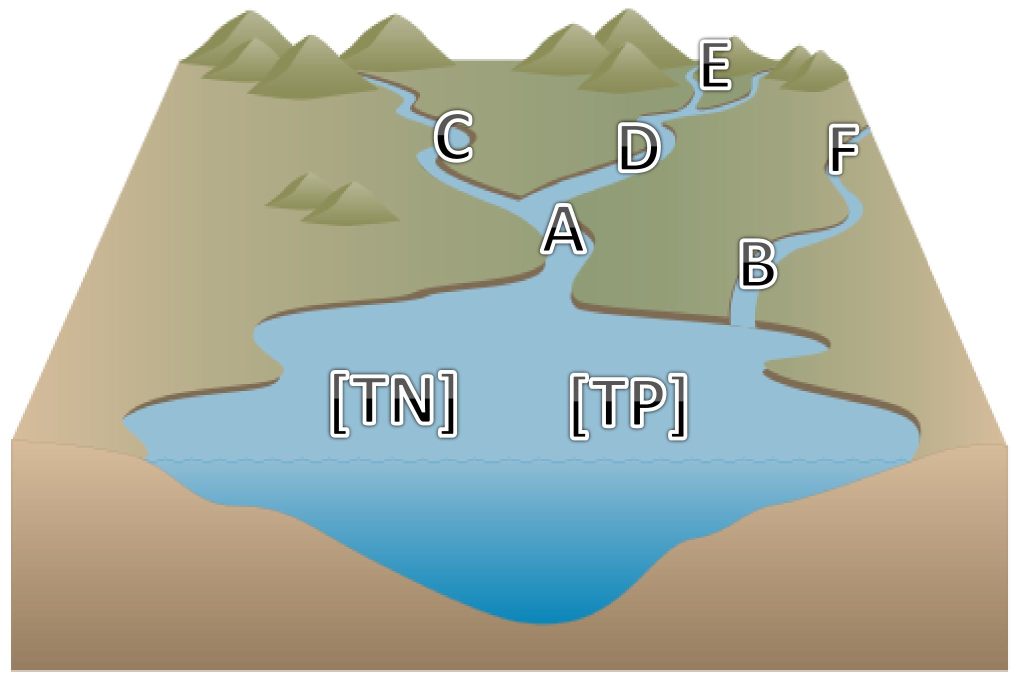
Set Criteria Upstream

2) Mechanistic Modeling

- Water quality models:
  - Calibrated scenario
  - Nutrient reduction scenario
    - Watershed anthropogenic nutrient loads are reduced from calibrated levels until the endpoints in the receiving waterbody are met.
- How to allocate the reduction to tributaries in watershed:
  - Spatial
    - Equal
    - Flow weighted
  - Temporal
    - Equal
    - Seasonal
    - Flows
  - Percent of anthropogenic reduction

Additional Considerations

- Use instream criterion or downstream criterion. The most stringent value applies to any one location.
  - Attainment
  - Exceedance at individual stations or throughout upstream network



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Additional Considerations

- Groundwater input
- Burial/removal (loss rates)
- Estimating load
  - Ungauged rivers
- Criteria as load or concentration
  - Streamflow can come from observations or watershed model

Methods: Other Approaches

Narrative:

- Narrative downstream protection should be specific. For example:
  - Use of tiered models
  - Pollutants to address
  - Conditions that should be examined (seasonal/annual criteria, hydrological conditions, ecological conditions)
  - How criteria apply to permits
  - Endpoints to use

- Should facilitate:
  - Establishment of effluent limitations
  - Assessment and listing of impaired waters
  - Development of total maximum daily loads
  - Application of antidegradation requirements

Lessons Learned

- Downstream criteria ensure that designated uses are met near- and far- field
- Many approaches to derive downstream criteria give states flexibility
- State regulators indicate that downstream criteria would simplify other aspects of water quality protection, including permitting and TMDLs