THE COSTS TO AGRICULTURE OF SAVING THE CHESAPEAKE BAY

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Chesapeake Bay Total Maximum Daily Load (TMDL)

- TMDLs are required under the Clean Water Act when waters do meet designated standards
- TMDLs set limits on pollution loads needed to meet standards
- There are 1000s of TMDLs across the US
- The 2011 Chesapeake Bay TMDL is historic because of the size of the water body and the number of states involved

Chesapeake Bay TMDL

- Specifies reductions of nitrogen, phosphorus, and sediment and pollution limits for Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia
- Requires pollution control measures to be in place by 2025, with at least 60 percent of the actions completed by 2017
- Jurisdictions are required to develop Watershed Implementation Plans (WIPs) describing how they would meet obligations

Chesapeake TMDL and Agriculture

- Agriculture's contributions
  - 44% percent of nitrogen phosphorus loads
  - 65% of the sediment loads
  - The largest economic source of nutrients and sediments
- TMDL agricultural N, P, S load reduction goals
  - 37%, 29%, and 28%, respectively, relative to 2009 baseline loads
  - 34%, 29%, and 22%, respectively, relative to 2011 baseline loads.
- The allocation of these reductions varies across political jurisdictions and major basins.

Questions

- What will with the WIPs cost in agriculture?
- Can the TMDL's agricultural load allocations be achieved at lower cost?
  - BMP selection
  - Spatial targeting
- Can water quality credit trading help reduce compliance costs?

Cost Concepts

- Social costs
  - The economic costs to society of actions to achieve the TMDL
  - The costs used for social BCA
- Private costs
  - The costs incurred by farmers, rate payers, etc.
  - The costs used to assess winners and losers, and that ultimately drive trading
- Government costs
  - Expenditures for planning, implementation, monitoring, enforcement, financial assistance
  - The costs used to assess governmental needs and impacts

WIP Costs

- Present value of installation, operation, and maintenance costs of BMPs in state WIPs (at 7% OMB discount rate)
- BMP definitions from USEPA CBP (conform to Bay watershed model)
- BMPs limited to well-established types included in the Bay model
  - interim or newly developed BMPs (e.g., various manure treatment technologies) were excluded

WIP Costs

- Two baseline years considered
  - 2009 (Consistent with USEPA CBP costs estimates)
  - 2011 (Based on with versus without principle of BCA)
- Only costs of new BMPs implementations included

WIP Costs

- Include installation, maintenance, and opportunity costs of land removed from crop production
- BMP installation costs primarily from NRCS payment schedules (collected by Abt Assoc. for USEPA CBP)
  - There is very limited data on actual BMP costs
- BMPs that research indicate to be economically beneficial (e.g., no-till, conservation till, dairy precision feeding, phytase) were assigned a zero cost even if eligible for positive payments.

Caveats/comments

- Data quality
  - Data generally at state or Bay watershed level rather than a smaller scales
  - Some BMPs very hard to cost without details (e.g. manure transport)
  - Multiple data sources and methods
- BMP mixtures
- Opportunity costs from changes in farm operations (partial budgeting vs whole farm estimates)

Caveats/comments

- Installation, operation, and maintenance costs likely overestimate social costs to agriculture
  - E.g., exclude private benefits of BMP adoption when present, ancillary environmental benefits of BMPs
- Assessments of private agricultural costs depend on the
  - Private benefits from BMPs
  - Public and private financial support for BMP implementation (e.g. EQIP, water quality trading)

Total WIP Implementation Costs

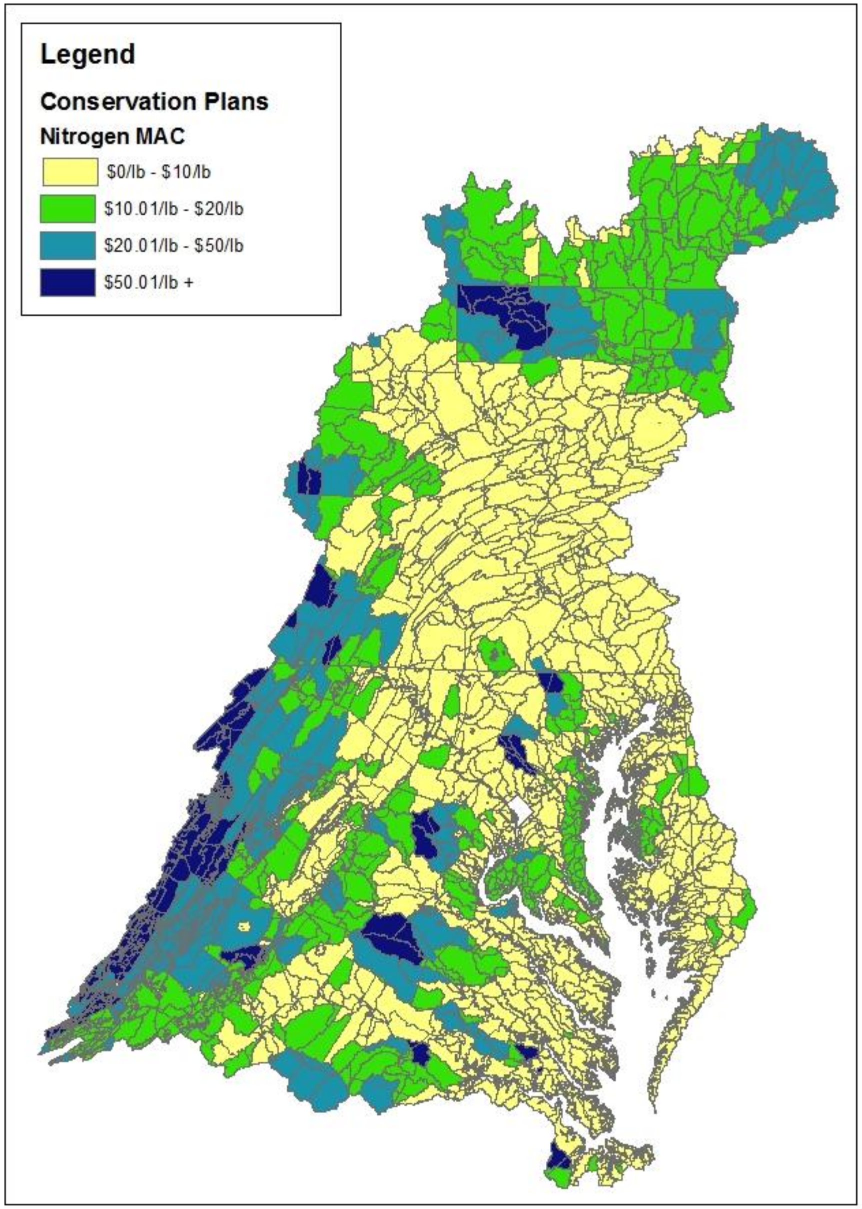
- Costs of getting WIP BMPs on the ground between baseline year and 2025
- 2011 Baseline: $3.6 Billion
- 2009 Baseline: $5.0 Billion
- 3 BMPs account for the majority of costs:
  - Alternative watering: 14.5% (2009) and 11.2% (2011)
  - Animal Waste Management Systems for Livestock: 20.7% (2009) and 26.2% (2011)
  - Stream Access Control w/ Fencing: 29.6% (2009) and 20.7% (2011)

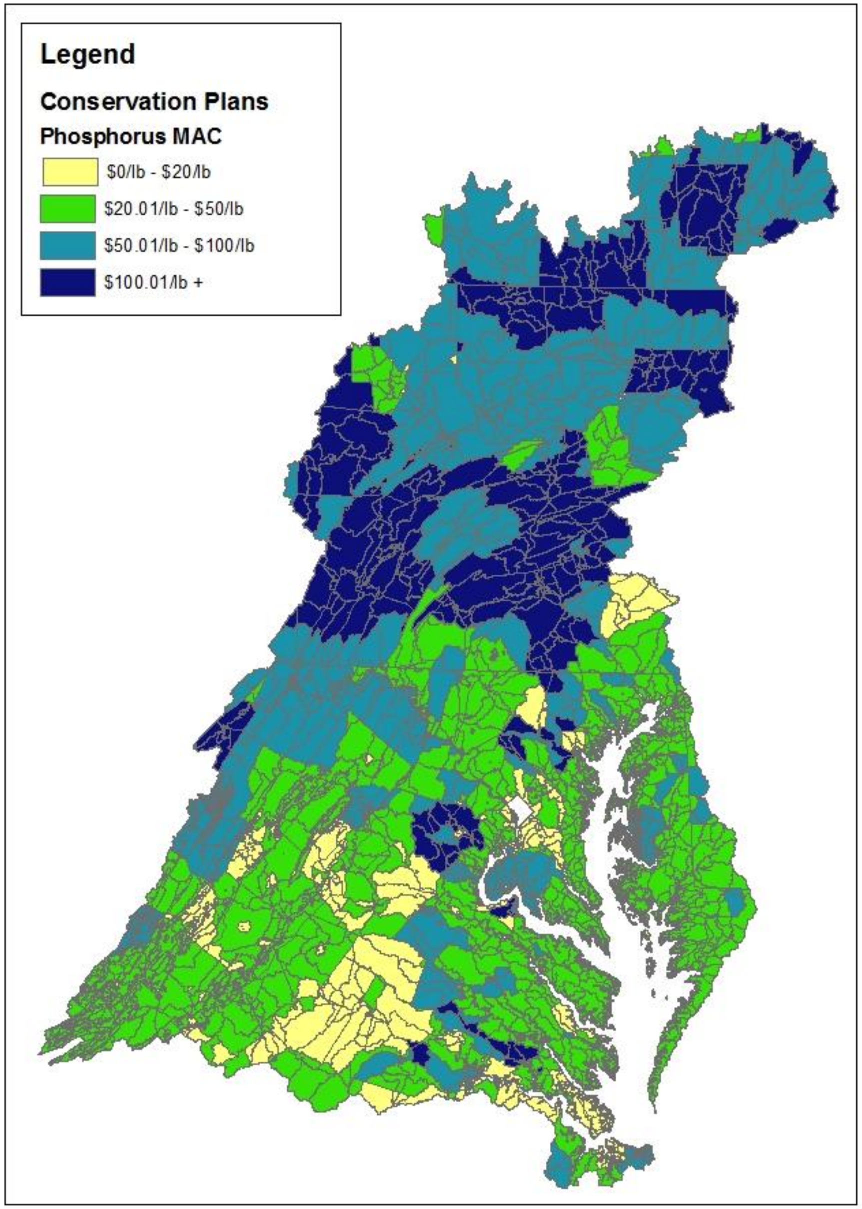
Annualized Full Implementation Costs

- 2011 Baseline: $902 million/year Bay-wide
  - DE: $19 million
  - MD: $83 million
  - NY: $71 million
  - PA: $378 million
  - VA: $307 million
  - WV: $44 million
- 3 BMPs account for the majority of costs:
  - Alternative Watering: 11.2%
  - Animal Waste Management Systems for Livestock: 26.2%
  - Stream Access Control w/ Fencing: 20.7%

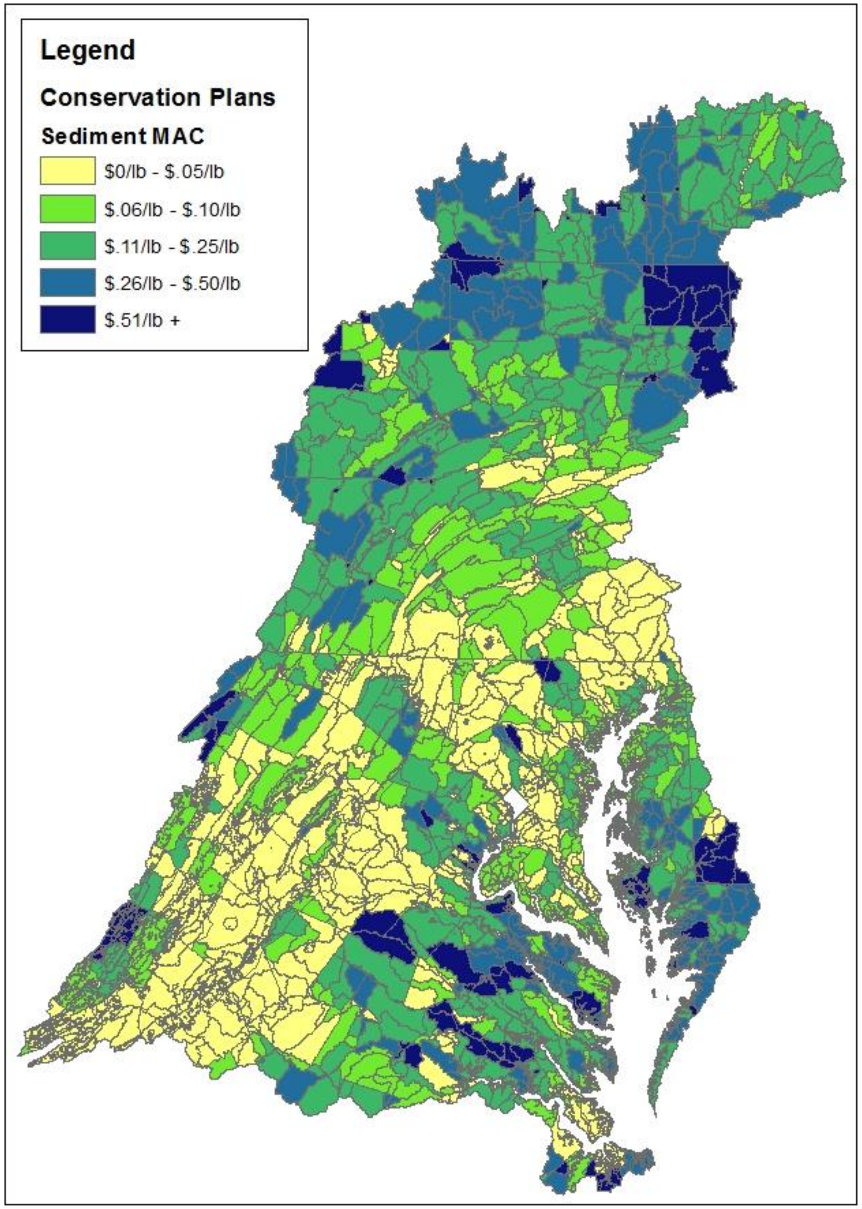
Can Ag Costs Be Reduced? Yes!!

- Spatial targeting
  - CBP distributed BMPs to ~2500 Bay model Land-River segments according to the proportional area of the applicable land use in each Land-River segment
  - BMP placement does not provide the biggest bang for the buck
- BMP selection
  - BMPs in the WIPs sometimes rank low in cost-effectiveness


Legend
Conservation Plans
Nitrogen MAC
$0/lb - $10/lb
$10.01/lb - $20/lb
$20.01/lb - $50/lb
$50.01/lb +



Legend
Conservation Plans
Phosphorus MAC
$0/lb - $20/lb
$20.01/lb - $50/lb
$50.01/lb - $100/lb
$100.01/lb +


Legend
Conservation Plans
Sediment MAC
$0/lb - $.05/lb
$.06/lb - $.10/lb
$.11/lb - $.25/lb
$.26/lb - $.50/lb
$.51/lb +

Examples

*This is a generalization across the Chesapeake Bay Watershed. Cost-effectiveness varies for each practice by pollutant and across LR segments. Thus, less cost-effective practices in general may be very cost-effective in certain LR segments and vice versa.

More Cost – Effective	Nitrogen Reduction Efficiency (%)	Phosphorus Reduction Efficiency (%)	Sediment Reduction Efficiency (%)
Barnyard Runoff	20	20	40
Capture & Reuse	75	75	N/A
Conservation Plan	3 - 8	5 - 15	8 - 25
Conservation Tillage	1.8 - 3.9	3.7 - 7.5	9.9 - 20.3
Continuous No-Till	10 - 15	20 - 40	70
Cropland Irrigation Management	4	N/A	N/A
Dairy Precision Feeding	25	25	N/A
Enhanced Nutrient Management	7	N/A	N/A
Nutrient Management	4.5 - 9.9	8.2 - 20.9	N/A
Poultry Phytase	N/A	32%	N/A
Swine Phytase	N/A	17% - 35%	N/A
Water Control Structures	33	N/A	N/A

Less Cost – Effective BMPs	Nitrogen Reduction Efficiency (%)	Phosphorus Reduction Efficiency (%)	Sediment Reduction Efficiency (%)
Ammonia Emissions Reduction	60	N/A*	N/A
AWMS – Livestock	75	75	N/A
AWMS – Poultry	75	75	N/A
Cover Crop – Early Drilled Rye	34	0 - 15	0 - 20
Prescribed Grazing	9 - 11	24	30
Stream Access Control w/ Fencing	26.1 - 53.8	25.6 - 52.3	9.2 - 63.4

Cost-Effective BMP Portfolios

- Cost-effective BMP Portfolios
  - A set of practices assigned to locations that minimizes the costs satisfying nitrogen, phosphorus, and sediment load allocation targets in each Chesapeake Bay jurisdiction
    - Portfolios I – load reductions from working lands only
    - Portfolios II – load reductions from working lands and land retirement
- Procedure
  - Calculate Marginal Abatement Cost (MAC) for each BMP and pollutant in each Bay model land-river segment = cost per pound of pollutant load reduction
  - Calculate using BMP costs + parameters from the Chesapeake Bay models needed to determine effectiveness
  - Implement practices in each jurisdiction from low MAC to high MAC until load allocation targets for all pollutants are satisfied

WIPs vs CEPs* (Working lands only)

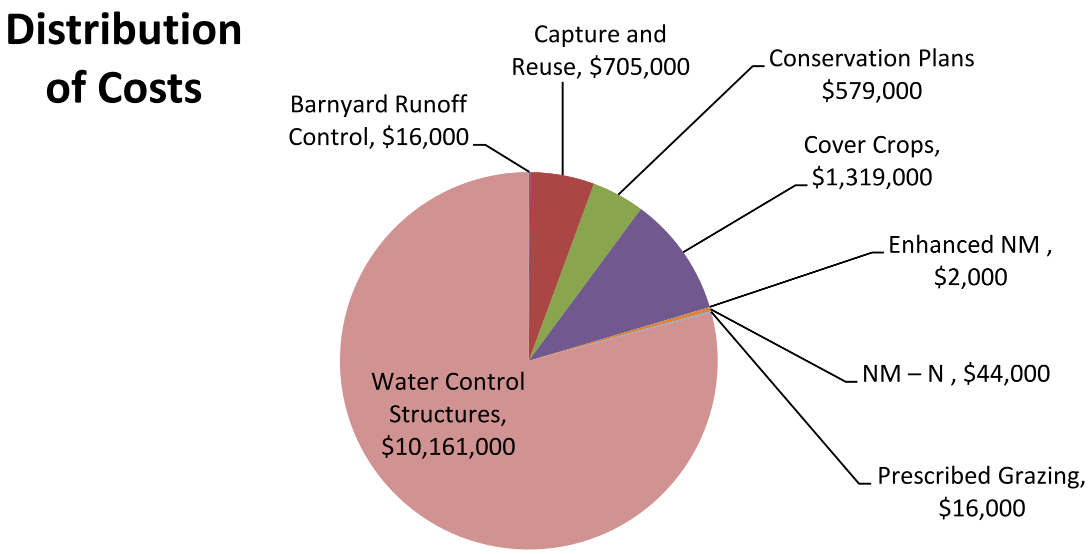
	WIP	CEP	Saving
Delaware	$19.4m	$4m	80%
Maryland	$83m	$12.8m	85%
New York	$71.2m	$51.8m	27%
Pennsylvania	$378.3m	$241.3m	36% **
Virginia	$307.4m	NF (P)	NF (P)
West Virginia	$44m	$16.8m	62%
Total	$903m	$634.1	30%

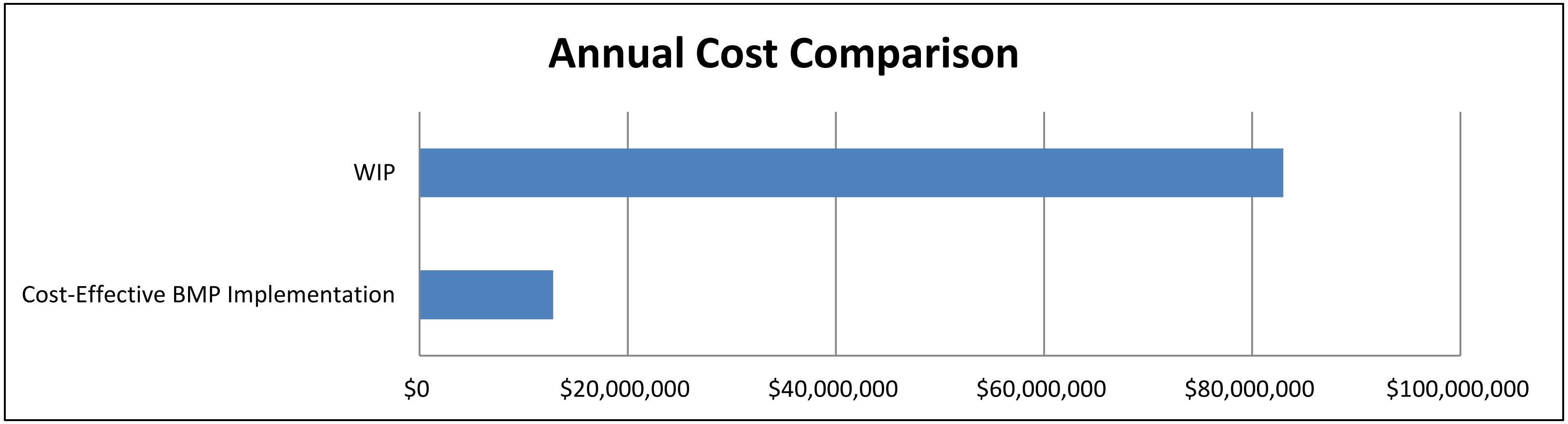
**Load reductions in PA were just under CBP TMDL load reduction targets, though they were met upon including land retirement

Cost-Effective BMP Portfolio: Maryland

BMPs included in lowest cost solution:

- Barnyard Runoff Control
- Capture and Reuse
- Conservation Plans
- Conservation Tillage
- Continuous No Till
- Cover Crops
- Cropland Irrigation Management
- Dairy Precision Feeding and Forage Management
- Enhanced Nutrient Management
- Nutrient Management – N
- Phytase - Poultry
- Phytase – Swine
- Prescribed Grazing
- Water Control Structures



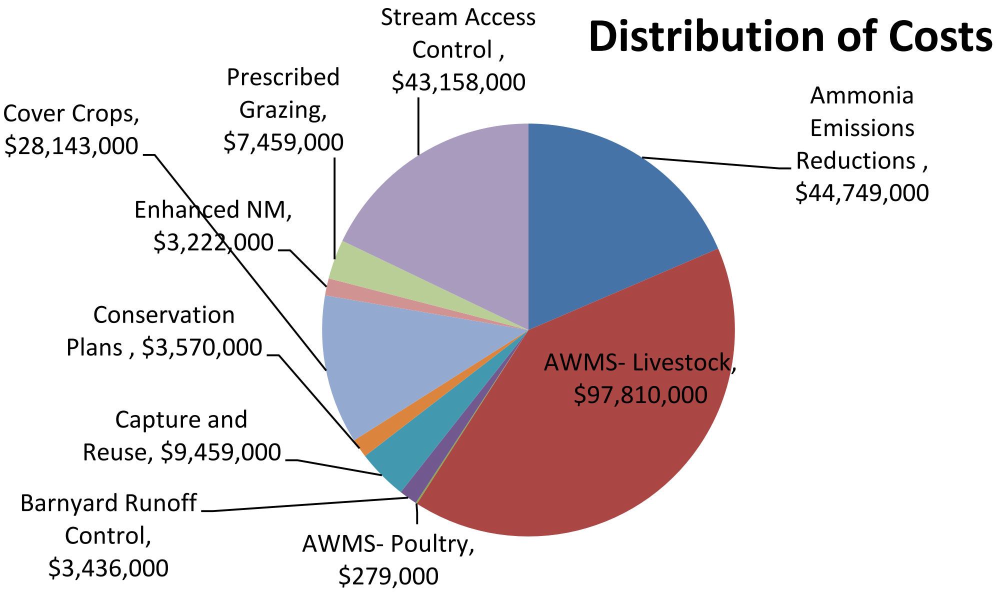


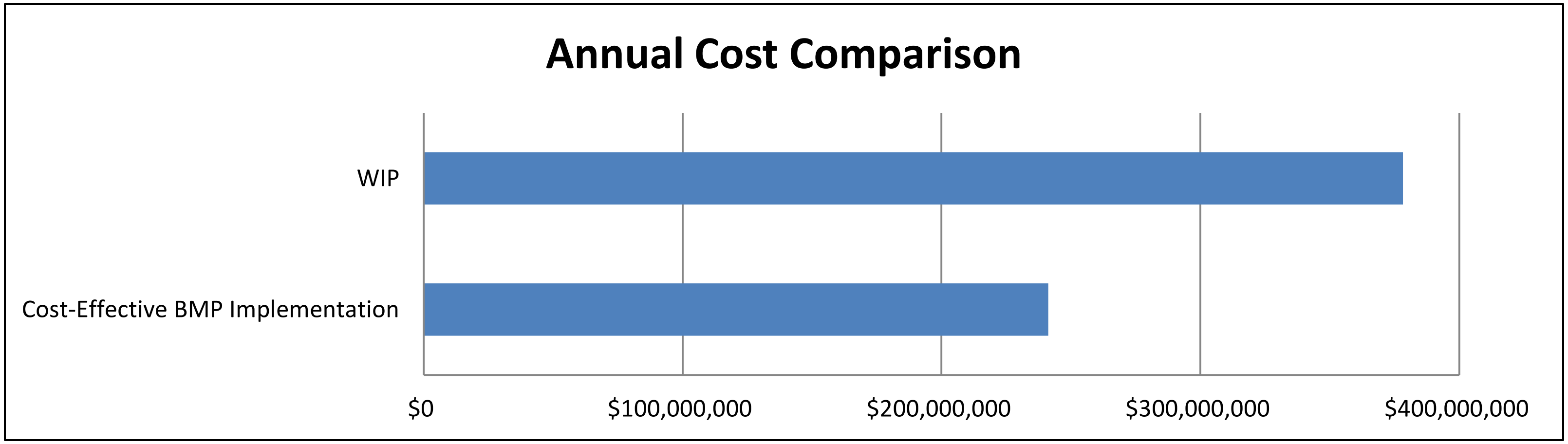
Cost-Effective BMP Portfolio: Pennsylvania*

*Using our portfolio of BMPs, PA reductions met about 98% of CBP Load Reduction Targets for P and TSS and 72% of N targets with all practices implemented

BMPs included in lowest cost solution:

- Ammonia Emissions Reductions
- Animal Waste Management Systems
- Barnyard Runoff Control
- Capture and Reuse
- Conservation Plans
- Conservation Tillage
- Continuous No Till
- Cover Crops
- Dairy Precision Feeding and Forage Management
- Enhanced Nutrient Management
- Nutrient Management
- Phytase - Poultry
- Phytase - Swine
- Prescribed Grazing
- Stream Access Control





Adding land retirement

Nitrogen	Average N MAC – Land Retirement	Average N MAC – All other BMPs
New York	$12.46	$52.11
Pennsylvania	$3.92	$14.04
Virginia	$10.32	$55.97
West Virginia	$13.83	$199.15

Phosphorus	Average P MAC – Land Retirement	Average P MAC – All other BMPs
New York	$170.61	$314.93
Pennsylvania	$134.12	$216.04
Virginia	$47.10	$260.91
West Virginia	$133.83	$754.14

Land Retirement Scenario

- Conversion of 25% of applicable acres in each Land-River segment to either hay without nutrients or forest
- BMPs applied to productive agricultural land reduced accordingly
- DE, MD, NY, and WV met all CBP load reduction targets without land retirement
- PA and VA required land retirement to meet CBP load reduction targets

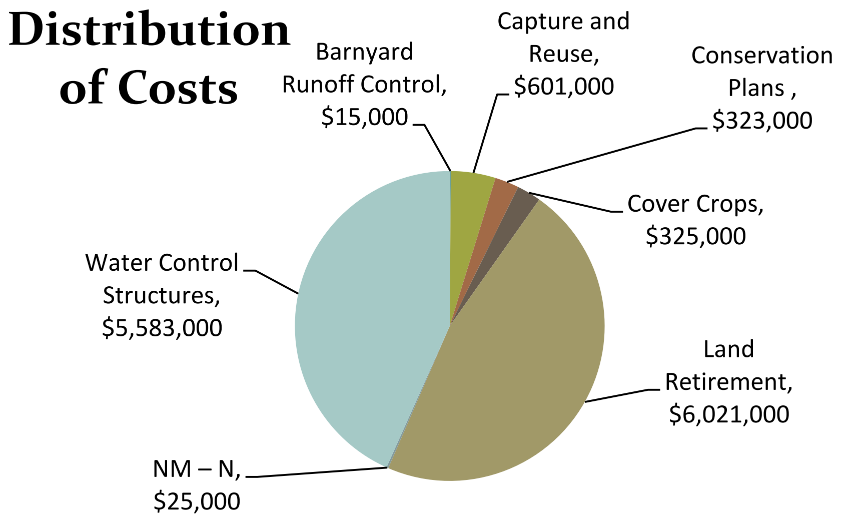
WIPs vs CEPs – Land Retirement Included

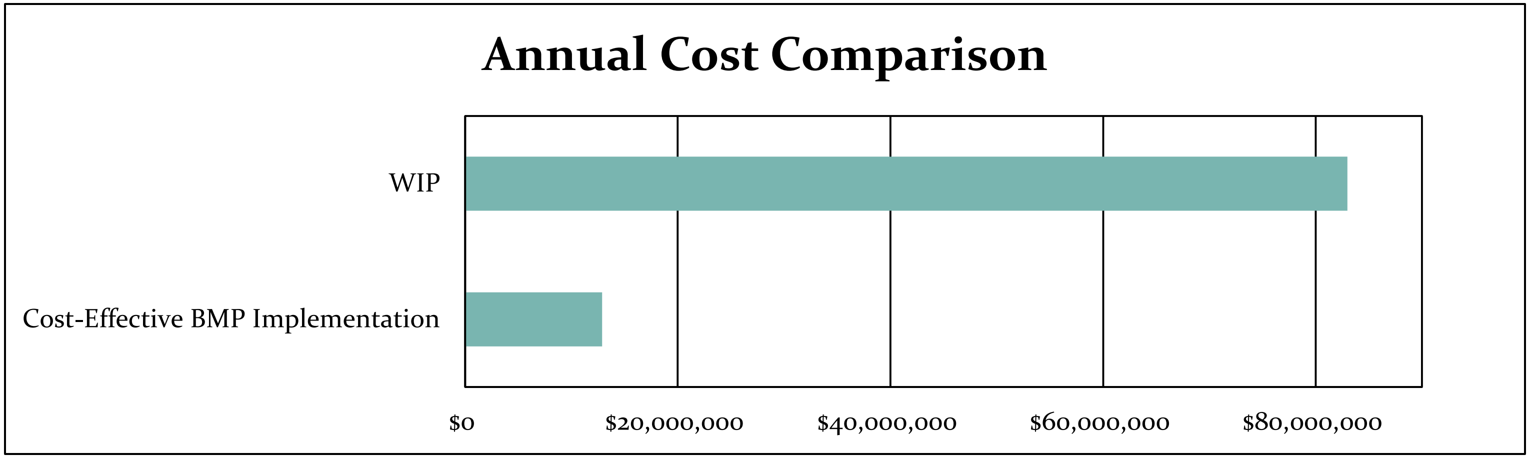
	WIP	CEP	Saving
Delaware	$19.4m	$3.5m	82%
Maryland	$83m	$12.9m	84%
New York	$71.2m	$10.1m	86%
Pennsylvania	$378.3m	$101.6m	73%
Virginia	$307.4m	$223.6m	27%
West Virginia	$44m	$6m	86%
Total	$903m	$357.7	60%

Cost-Effective BMP Portfolio including Land Retirement: Maryland

BMPs included in lowest cost solution:

- Barnyard Runoff Control
- Capture and Reuse
- Conservation Plans
- Conservation Tillage
- Continuous No Till
- Cover Crops
- Cropland Irrigation Management
- Dairy Precision Feeding and Forage Management
- Land Retirement
- Nutrient Management – N
- Phytase - Poultry
- Phytase – Swine
- Water Control Structures

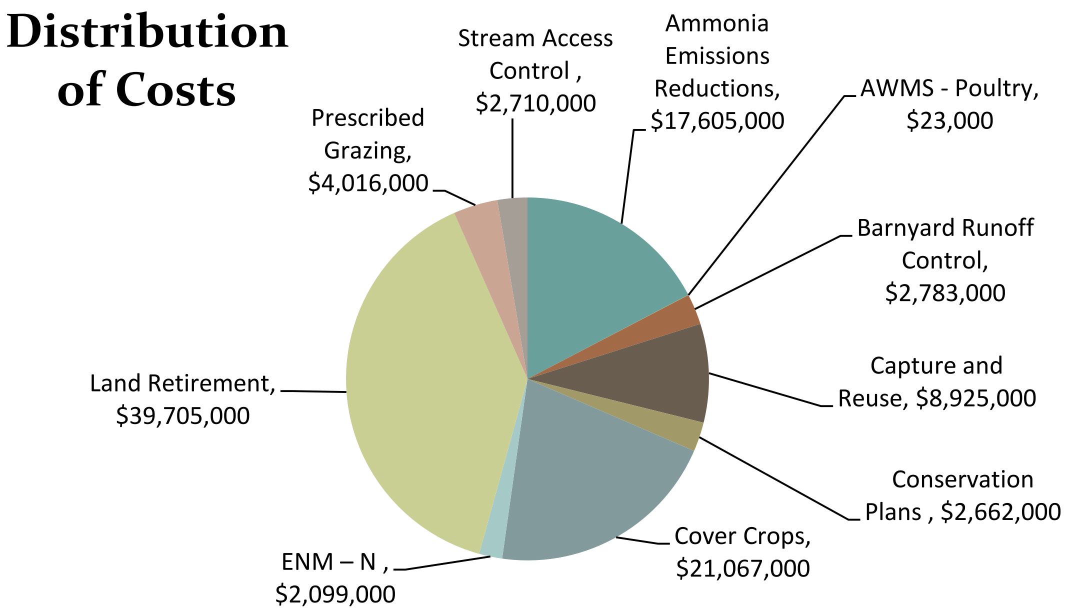


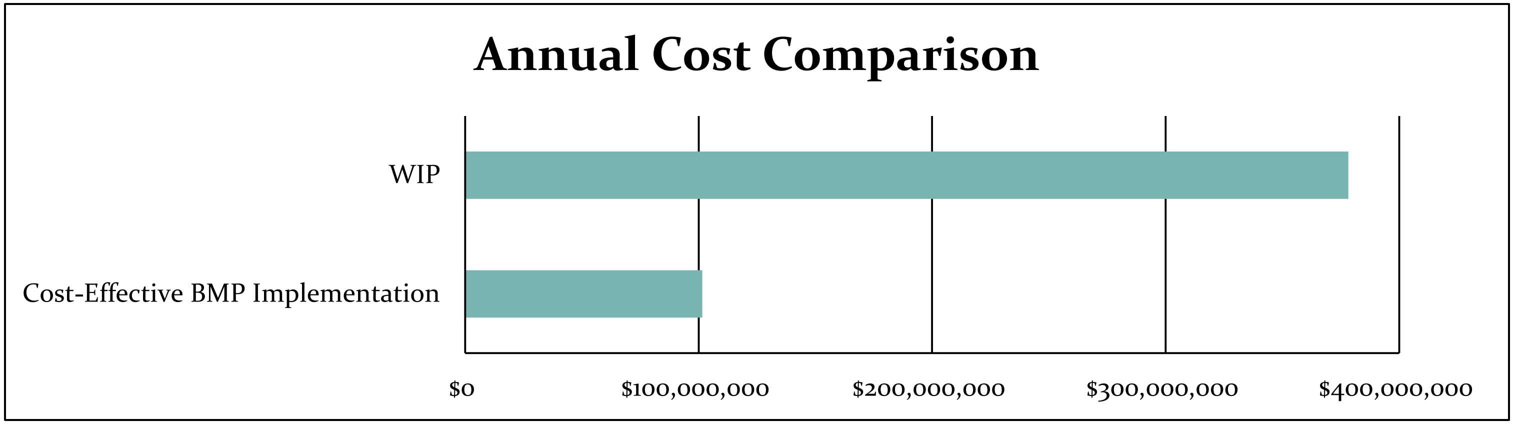


Cost-Effective BMP Portfolio including Land Retirement: Pennsylvania

BMPs included in lowest cost solution:

- Ammonia Emissions Reductions
- AWMS - Poultry
- Barnyard Runoff Control
- Capture and Reuse
- Conservation Plans
- Conservation Tillage
- Continuous No Till
- Cover Crops
- Dairy Precision Feeding
- Enhanced Nutrient Management
- Land Retirement
- Nutrient Management
- Phytase - Poultry
- Phytase - Swine
- Prescribed Grazing
- Stream Access Control





Water quality trading

- Trading is a mechanism for allocating pollution load reductions among alternative sources
  - Programs developed and "active" in PA and VA
  - Underdevelopment in MD, WVA and Bay-wide
- The case for trading: A well-designed and functioning market can:
  - Allocate load reductions to minimize pollution abatement costs while achieving WQ goals
  - Save costs compared to conventional regulatory approaches (e.g., WIPs)
- CEP cost savings compared to WIPs is an illustration of the potential of trading (in this case, gains from trading <u>within</u> agriculture <u>within</u> jurisdictions)!!

Implications for trading

- Larger gains possible from trading between point and agricultural sources
  - Under current regulations agriculture would be a supplier of credits rather than demander
- …and by trading across jurisdictions

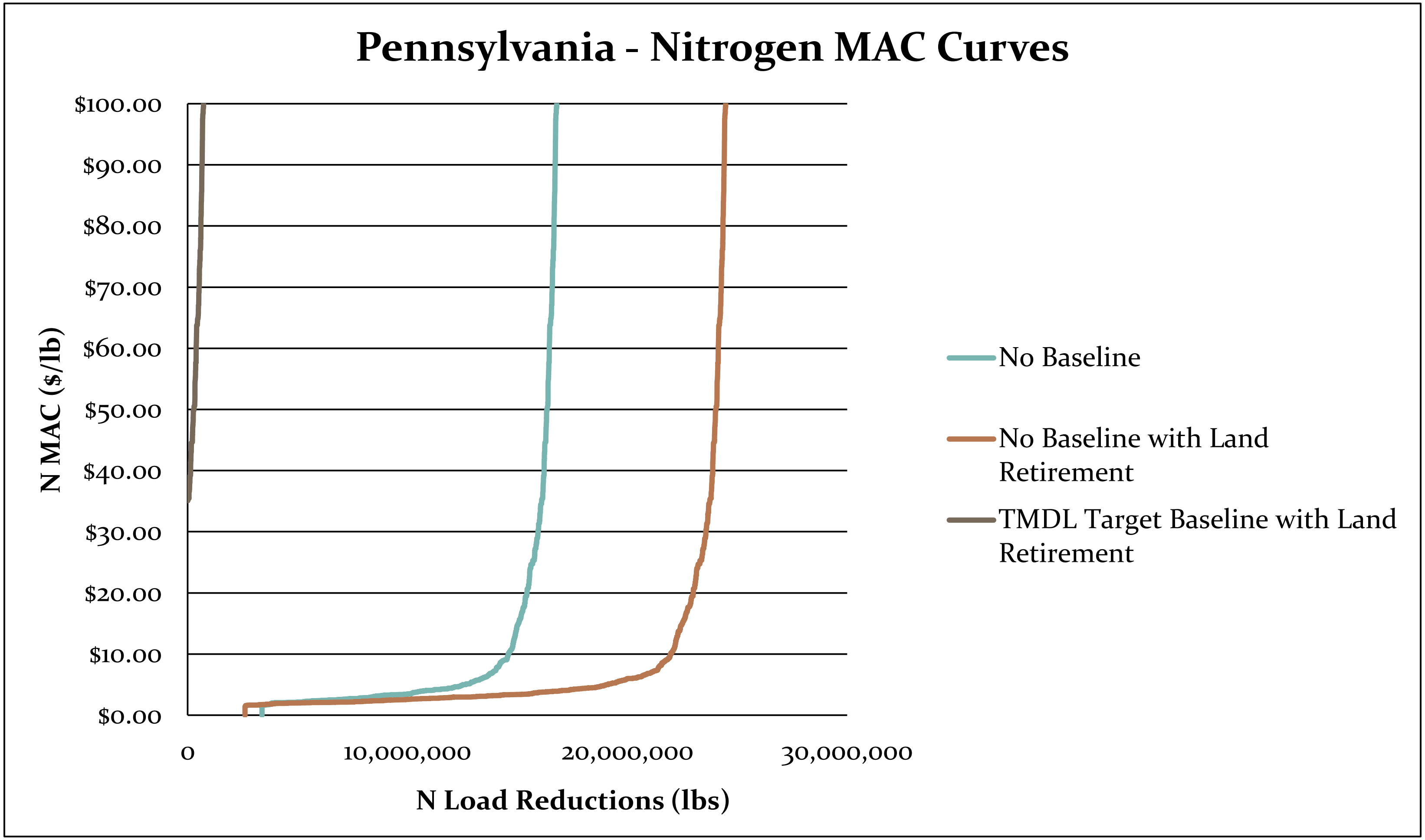
POTW N Credit Demand (Ribaudo 2013)

- About 9 million pounds of N credits would be demanded by POTWs at a price of about $9/lb.
- N credits demanded more than triples at a price of about $3/lb
- N credits demanded falls to about 3.3 million pounds at a price of $16.50/lb

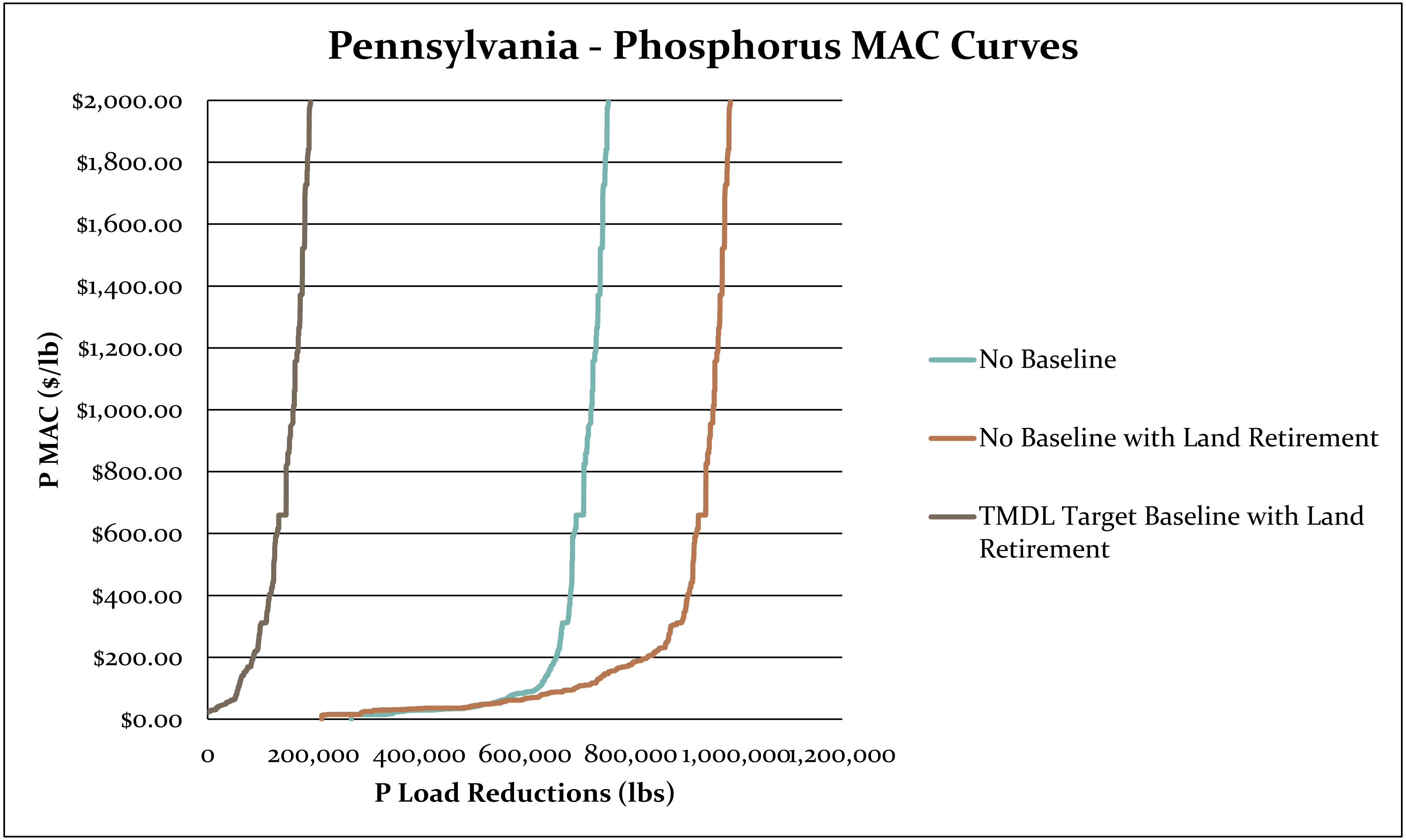
Credit Supply Curves

- By jurisdiction and pollutant type
- Depend on trading rules and other policies influencing BMP adoption
- Two simple cases
  - No financial support for BMPs
  - Case I - any new BMP generates credits
  - Case II – tradable credits can be generated within a state after the state's agricultural load allocation has been met

Nutrient Trading: Nitrogen MAC Curves with differing Baselines



Nutrient Trading: Phosphorus MAC Curves with differing Baselines



Key Messages

- Attention to BMP selection and spatial targeting can produced big cost savings!
- There are significant potential cost-savings from water quality trading
- Realizing gains is a function of market design and development
  - Overly restrictive rules can diminish eliminate gains
    - Baseline participation requirements
    - High trade ratios
  - Trading institutions are of <u>crucial</u> importance
    - Participation
    - Coordination

Questions