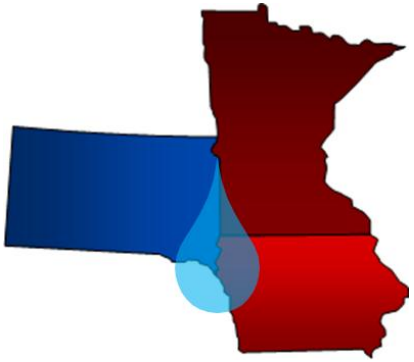
A Presentation of the 2012 Drainage Research Forum

November 20, 2012
Farmamerica, Waseca MN



IOWA STATE UNIVERSITY
University Extension

SDSU Extension

IOWA NUTRIENT REDUCTION STRATEGY

A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico

Dean W. Lemke, P.E.

November 20, 2012

All documents can be accessed and public comments submitted at:

www.nutrientstrategy.iastate.edu

Nutrient Reductions Needed to Meet Gulf Hypoxia Goal

Nutrient Reductions

- 45% reduction of nitrogen to Gulf
- 45% reduction of phosphorus to Gulf

Statewide strategy by 2013 for achieving reductions

Strategy Development

- Iowa Department of Agriculture and Land Stewardship – lead development of the nonpoint source strategy, Iowa's Hypoxia Task Force representative
- Iowa State University College of Agriculture and Life Sciences – co-lead for nonpoint source science assessment
- Iowa Department of Natural Resources – lead development of point source strategy

Science Assessment

For nonpoint source landscapes, to achieve 45% N & P reductions identify

- what practices needed
- what level of practice adoption
- what targeted locations for practices
- what estimated costs
- what resource assistance and programs are needed

Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen to the Mississippi River Basin

Nutrient Reduction Strategy Nitrogen Science Team

Nutrient Reduction Strategy – Science Team

- Matt Helmers – ISU – N Team Lead
- Tom Isenhart – ISU – P Team Lead
- John Lawrence – ISU
- John Sawyer – ISU
- Antonio Mallarino – ISU
- William Crumpton – ISU
- Rick Cruse – ISU
- Mike Duffy – ISU
- Reid Christianson – ISU
- Phil Gassman – ISU
- Dean Lemke – IDALS
- Shawn Richmond – IDALS
- Jim Baker – IDALS/ISU
- Keith Schilling – IDNR
- Calvin Wolter – IDNR
- Dan Jaynes – USDA-ARS
- Mark Tomer – USDA-ARS
- John Kovar – USDA-ARS
- David James – USDA-ARS
- Eric Hurley – USDA-NRCS
- *Mark David – Univ. of Illinois*
- *Gyles Randall – Univ. of Mn*
- *Katie Flahive - USEPA*

Approach

1. Establish baseline – existing conditions
   - Major Land Resource Areas used to aggregate conditions
2. Extensive literature review to assess potential performance of practices
   - Outside peer review of science team documents (practice performance and baseline conditions)
3. Estimate potential load reductions of implementing nutrient reduction practices (scenarios)
   - “Full implementation” and “Combined” scenarios
4. Estimate cost of implementation and cost per pound of nitrogen and phosphorus reduction

Practice Review Process

- Established an overall list of potential practices based on input of overall science team
- Shortened the list through detailed discussion of N team to those expected to have greatest potential for nutrient reduction and for which there was water quality data – reviewed by overall science team
- New and emerging practices could be added in future

Nitrogen or Phosphorus?

Nitrogen moves primarily as nitrate-N with water

Phosphorus moves primarily with eroded soil

Nitrogen Reduction Strategies Considered

- Row crop of choice (C/S vs CC)
- Nitrogen application rate
- Nitrogen source – manure or commercial
- Timing of nitrogen application
- Use of nitrogen stabilizers
- Cover crops (rye/oat)
- Living mulches (e.g. kura clover)
- Extended rotations
- Perennial cover/Perennial biomass crops/Grazed pastures
- Drainage water management
- Shallow drainage
- Wetlands Bioreactors
- Buffers

Nitrogen Reduction Strategies Not Considered – Lack of data or limited impact

- Green manure
- Continuous soybean
- Tillage and residue management
- Erosion control practices and structures
- Nitrogen source
- New nitrogen stabilizers (e.g., time release nitrogen)
- Placement of nitrogen
- Two-stage ditches
- Interaction of nutrient management practices
- Re-saturated buffers

Nitrogen Reduction Practices

	Practice
Nitrogen Management	Timing
	Source
	Nitrogen Application Rate
	Nitrification Inhibitor
	Cover Crops
Land Use	Perennial
	Living Mulches
	Extended Rotations
	Grazed Pastures
Edge-of-Field	Drainage Water Mgmt.
	Shallow Drainage
	Wetlands
	Bioreactors
	Buffers

Practice Review Process

- Extensive review of literature from Iowa and surrounding states
  - Used Iowa and surrounding states to try to have similar soils and climatic conditions
  - Reviewed and compiled impacts on nitrate-N concentrations and loads
  - Reviewed and compiled impacts on corn yield
- Summarized expected practice performance

Timing of Nitrogen Application

Practice	Comments	% Nitrate-N Reduction			% Corn Yield Change
		Min	Average (SD)	Max	Average (SD)
Timing of Nitrogen Application	Moving from Fall to Spring Pre-plant Application	-80	6 (25)	43	4 (16)
	Spring pre-plant/sidedress 40-60 split Compared to Fall Applied	-60	5 (28)	33	10 (7)
	Sidedress Compared to Pre-plant Application	-95	7 (37)	45	0 (3)
	Sidedress – Soil Test Based Compared to Pre-plant	-29	4 (20)	45	13 (22)

Different studies for different timing effects

Extended Rotations, Energy Crops, and Land Retirement

Practice	Comments	% Nitrate-N Reduction+			% Corn Yield Change
		Min	Average (SD)	Max	Average (SD)
Land Use	Energy Crops Compared to Spring- Applied Fertilizer	26	72 (23)	98	
	Land Retirement (CRP) Compared to Spring- Applied Fertilizer – Assume Grazed Pastures Similar	67	85 (9)	98	
	Extended rotations (At least 2 years of alfalfa in a 4 or 5 year rotation)	24	42 (12)	62	7 (7)

Targeted Wetland Restoration/Construction and Buffers

Practice	Comments	% Nitrate-N Reduction+			% Corn Yield Change
		Min	Average (SD)	Max	Average (SD)
Wetlands	Targeted Water Quality	11	52	92	
Buffers	Only for water that interacts with active root zone below buffer	33	91 (20)	99	

Summary

- Process has identified practices that have greatest potential for nitrate-N load reduction
- Process has estimated potential field-level costs associated with practice implementation
- To achieve goals will require a combination of practices
- N versus P requires different practices
- Multiple benefits of practices will need to be considered
- *Knowing the starting point is still a challenge and knowing what is being done on the land could (would) improve estimates of progress that can be made*

Iowa Science Assessment of Nonpoint Source Practices to Reduce Phosphorus to the Mississippi River Basin

Nutrient Reduction Strategy
Phosphorus Science Team

Practice Review Process

- Extensive review of literature from Iowa and surrounding states
  - Used Iowa and surrounding states to try to have similar soils and climatic conditions
  - Reviewed and compiled impacts phosphorus concentrations and loads
  - Reviewed and compiled impacts on corn yield
- Summarized expected practice performance

Approach

- Stream banks are known to be a potentially large source of suspended and bedded sediments.
- Estimated contributions ranging from 40 to 80% of annual sediment loads in Midwestern streams.
- Accurate accounting is difficult.

24%

76%

Isenhart et al.
Unpublished

Practice Review Process

P reduction practices fall into three main groups

1. P Management Practices
   - Application
   - Source (commercial fertilizer, manure)
   - Placement
   - Cover crops
   - Tillage
2. Land use change
   - Crop choice
   - Perennial vegetation
3. Erosion Control and Edge of Field Practices
   - Terraces
   - Wetlands
   - Buffers
   - Other erosion control

Phosphorus Management Practices

Placement of Phosphorus

- Subsurface banding of P or incorporation of surface-applied P fertilizer or manure on sloping ground reduces P loss significantly compared with surface application when runoff-producing precipitation occurs shortly after application
- Estimates in brackets are from a report by Dinnes (2004) and are the author's best professional judgment

Practice	Comments	% P Load Reduction		
		Min	Avg. (SD)	Max
Placement of Phosphorus	Broadcast incorporated within 1 week compared to no incorporation, same tillage	4	36 (27)	86
	With seed or knifed bands compared to surface application, no incorporation	-50 [-20]	24 (46) [35]	95 [70]

Phosphorus Management Practices

Cover Crops

- Cover crops reduce erosion by improving soil structure and providing ground cover as a physical barrier between raindrops and the soil surface

Practice	Comments	% P Load Reduction		
		Min	Avg. (SD)	Max
Cover Crops	Winter Rye	-39	29 (37)	68

Phosphorus Management Practices

Tillage

- Tillage practices affect soil erosion, the primary process for P delivery in IA
- Tillage effects on P loss are site specific, but less P loss generally occurs with minimum or no tillage compared with conventional tillage
- No-till can increase the proportion of total P lost as dissolved P, especially in tile-drained areas

Practice	Comments	% P Load Reduction		
		Min	Avg. (SD)	Max
Tillage	Conservation till – chisel compared to moldboard plowing	-47	33 (49)	100
	No-till compared to chisel plowing	27	90 (17)	100

Summary

- Process has identified practices that have greatest potential for nutrient load reduction
- Process has estimated potential field-level costs associated with practice implementation and is also considering larger-scale economic impacts of practice implementation
- To achieve goals will require a combination of practices
- N versus P requires different practices
- Multiple benefits of practices will need to be considered
- *Knowing the starting point is still a challenge and knowing what is being done on the land could (would) improve estimates of progress that can be made*

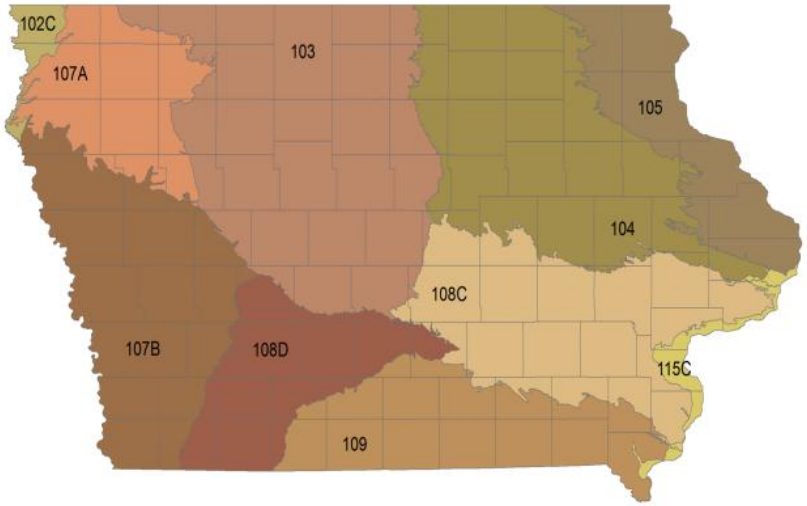
Nitrogen Practices – Potential Load Reduction

Target Load Reduction from NPS
for Hypoxia Goal ~41%

Load Estimation

- Nitrate-N concentration estimated from land use and nitrogen management
- Nitrate-N load for each MLRA a product of the nitrate-N concentration and water yield (estimated surface and subsurface flow)

MLRA	Water Yield
	in/yr
103	10.4
104	11.9
105	11.3
107A	7.1
107B	8.2
108C	11.2
108D	9.8
109	12.0



Combined Nitrogen Reduction Scenarios - EXAMPLES

	Scenario	Practice/Scenario	Nitrate-N Reduction	Phosphorus Reduction
			% (from baseline)	% (from baseline)
	BS	Baseline		
Combination Scenarios	NCS1	Combined Scenario (MRTN Rate, 60% Acreage with Cover Crop, 27% of ag land treated with wetland and 60% of drained land has bioreactor)	42	30
Combination Scenarios	NCS2	Combined Scenario (MRTN Rate, 100% Acreage with Cover Crop in all MLRAs but 103 and 104, 45% of ag land in MLRA 103 and 104 treated with wetland, and 100% of tile drained land in MLRA 103 and 104 treated with bioreactor)	39	40

Target Load Reduction from NPS for Hypoxia Goal ~41% for N and ~29% for P

Combined Nitrogen Reduction Scenarios - EXAMPLES

	Scenario	Practice/Scenario	Nitrate-N Reduction	Phosphorus Reduction
			% (from baseline)	% (from baseline)
	BS	Baseline		
Combination Scenarios	NCS3	Combined Scenario (MRTN Rate, 95% of acreage in all MLRAs with Cover Crops, 34% of ag land in MLRA 103 and 104 treated with wetland, and 5% land retirement in all MLRAs)	42	50
Combination Scenarios	NCS4	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 85% of all tile drained acres treated with bioreactor, 85% of all applicable land has controlled drainage, 38.25% of ag land treated with a wetland)	42	0

Target Load Reduction from NPS for Hypoxia Goal ~41% for N and ~29% for P

Combined Nitrogen Reduction Scenarios - EXAMPLES

	Scenario	Practice/Scenario	Nitrate-N Reduction	Phosphorus Reduction
			% (from baseline)	% (from baseline)
	BS	Baseline		
Combination Scenarios	NCS5	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 65% of all tile drained acres treated with bioreactor, 65% of all applicable land has controlled drainage, 29.25% of ag land treated with a wetland, and 15% of corn-soybean and continuous corn acres converted to perennial-based energy crop production)	41	11
Combination Scenarios	NCS6	Combined Scenario (MRTN Rate, 25% Acreage with Cover Crop, 25% of acreage with Extended Rotations, 27% of ag land treated with wetland, and 60% of drained land has bioreactor)	41	19

Target Load Reduction from NPS for Hypoxia Goal ~41% for N and ~29% for P

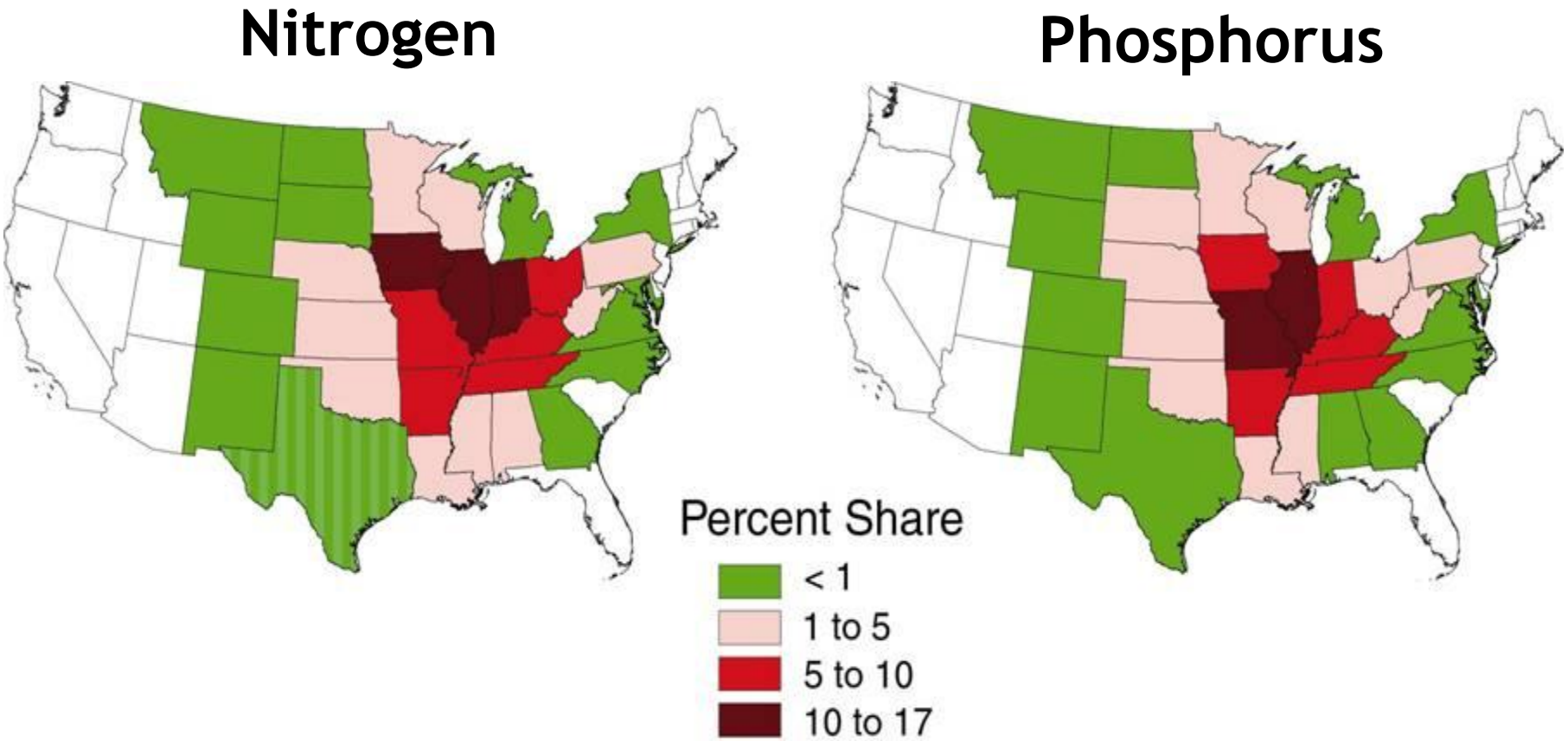
Combined Nitrogen Reduction Scenarios - EXAMPLES

	Scenario	Practice/Scenario	Nitrate-N Reduction	Phosphorus Reduction
			% (from baseline)	% (from baseline)
	BS	Baseline		
Combination Scenarios	NCS7	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with wetland, and 70% of all agricultural streams have a buffer)	42	20
	NCS8	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with a wetland, and 70% of all agricultural streams have a buffer) - Phosphorus reduction practices (phosphorus rate reduction on all ag land, Convert 90% of Conventional Tillage CS & CC acres to Conservation till and Convert 10% of Non-No-till CS & CC ground to No-Till)	42	29

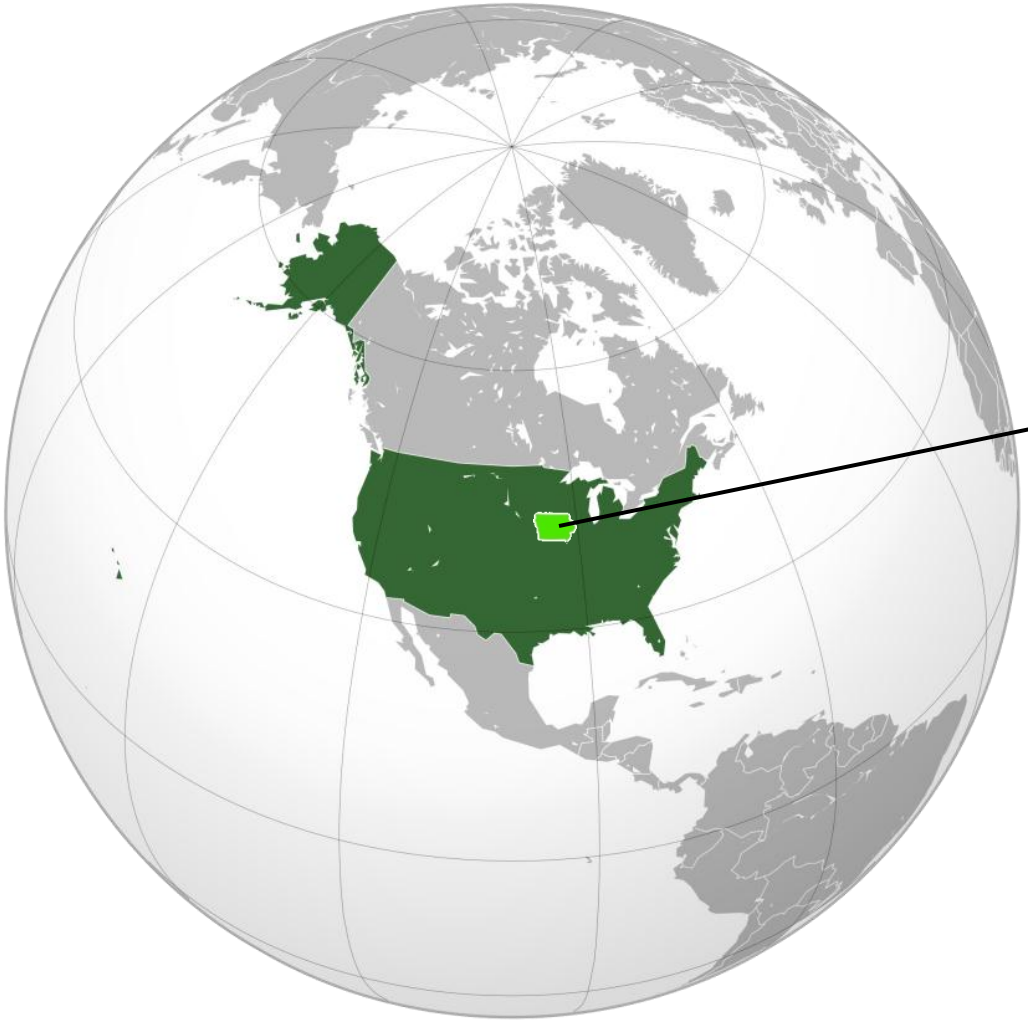
Target Load Reduction from NPS for Hypoxia Goal ~41% for N and ~29% for P

Policy Considerations and Strategy

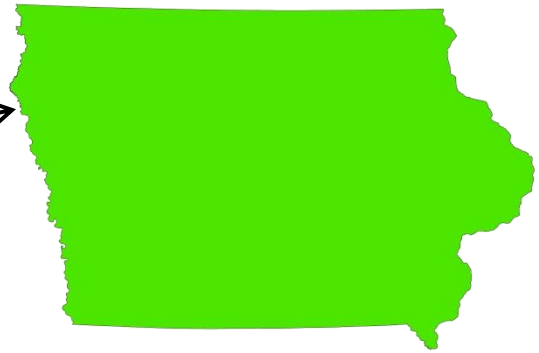
Nutrient delivery to the Gulf of Mexico
State shares of the total nutrient flux



Alexander et al,
Environ. Sci. Techn., in press



United States
4.5% of World Population



Iowa
0.04% of World Population

Total Grain Production (Metric Tons)
Iowa – 55 Million
Canada – 45 Million

Total Soybean Production (Metric Tons)
China – 15 Million
Iowa – 14 Million

Agricultural Nonpoint Sources

- *Nutrient impairment is not mainly due to mismanagement of fertilizers and manures, but more to historic changes in land use and hydrology*

Agricultural Nonpoint Sources

- *Nutrient impairment is not mainly due to mismanagement of fertilizers and manures, but more to historic changes in land use and hydrology*
- *It is unlikely that in-stream phosphorus loading WQ goals will be achieved from only in-field P loading reductions to streams, given in-channel bed and bank erosion and resulting P loads*

Iowa Strategy Actions

- Achieve nutrient load reductions through technology-based actions
- Continue to assess and evaluate nutrient water quality standards

Point Sources – Cities, Industries

- 102 major municipalities – 55-60% of Iowa's population, treat more than 80% of all city wastewater
- 28 major industrial facilities
- Permits require evaluation and implementation of additional wastewater treatment

Point Sources – Cities, Industries

- Install Biological Nutrient Reduction (BNR)
- Reduce by 67% of the N and 75% of the P currently discharged
- Reduce N 11,000 tons/yr, 4% reduction in N loads statewide
- Reduce P 2170 tons/yr, 16% reduction in P loads statewide

Nonpoint Sources

- Major municipal/industrial point source treatment will reduce N load 4%, P load 16%
- To achieve 45% Gulf reduction targets, nonpoint source targets are 41% reduction of statewide N load, 29% reduction of statewide P load

Science Assessment

- Combination of practices are needed to achieve target N & P load reductions
- 3 scenarios (not recommendations)
  - $756 million/yr, initial investment of $3.2 billion
  - $1.2 billion/yr, initial investment of $1.2 billion
  - $77 million/yr, initial investment of $4 billion

Goal – Iowa Leader

“As Iowa is a national and global leader in the production of food and renewable fuels, a goal of this strategy is to make Iowa an equal national and global leader in addressing the environmental and conservation needs associated with food and renewable fuels production.”

Strategy Approach

- The strategy sets forth concepts, from which operational plans will be developed in the future
- The strategy is a dynamic document that will change over time as new information, data and science is discovered and adopted

Watershed Prioritization

- Prioritization of watersheds – Water Resources Coordinating Council (WRCC)
  - HUC 8s
  - HUC 12s
- Determine watershed goals – WRCC

Setting Priorities

- Conservation programs – coordinate focus to targeting nutrient reduction to waters, increase program delivery in straight-forward, flexible manner
- Balance in-field and off-field practices – to optimize reductions of nutrients to waters
- Small watershed pilot projects
- Nutrient trading/innovative approaches

Research and Technology

- Policy framework that facilitates new technologies and creative solutions
- Enhanced and consistent funding to develop new technologies, private-sector entrepreneurial opportunity for new technologies, sustained public funding of research
- Support advancing the science of Gulf hypoxia

Strengthen Outreach, Education, Collaboration

- Enhanced public and private-sector roles – leadership, new technologies and services
- Enhanced role of CCAs – consulting, advisory services, accountability and certification
- Build broader awareness and information to farmers and landowners

Strengthen Outreach, Education, Collaboration

- Identify opportunities to achieve rapid adoption of nutrient reduction practices through market-driven solutions
- Collaborate with other Mississippi River states, share information, experiences, such as IA-Mississippi Farmer to Farmer Exchange

Increased Public Awareness and Recognition

- Watershed or farmer recognition program
- Iowa Farm Environmental Leader Award program – 2012
- Statewide marketing and public educational campaign – WRCC

Funding

- Effective use of funding resources, rely on existing or re-allocated funding sources initially
- WRCC make recommendations to executive and legislative branches on most effective use of limited resources

Accountability and Verification Measures

- Develop new and expanded frameworks to track progress, beyond water quality monitoring
- WRCC will collaborate with ISU nutrient science assessment team to support success measurement
- WRCC will establish public-private reporting system that documents nutrient and conservation practice adoption

Public Comment Period

- Through January 4, 2013
- Documents can be accessed and comments submitted at

www.nutrientstrategy.iastate.edu

ISU Extension Outreach/Education – 2012-13

- Integrated Crop Management Conference – 1000 CCA's
- Private & Commercial Pesticide Applicator Training
- Commercial Manure Applicator Training
- Crop Advantage Series meetings

Questions/Comments

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