GEORGE MORRIS CENTRE

Costs and Benefits of BMP's for Source Water Protection

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Agricultural Adaptation Council

Outline

- Purpose of the study
- What we did
- Approach
- Results
- Conclusions

Purpose

- Assess costs and benefits of BMP's in an existing source water protection context
- Objectives:
  - Select an appropriate case study
  - Understand existing knowledge
  - Determine existing N management practice
  - Evaluate effectiveness of candidate BMP
  - Determine costs and benefits of BMP implementation

Approach

- Consultations to establish case study
- Literature review
- Consultations to determine existing N management in cropping
- Identification and simulation of N transport, uptake, and leaching
- Quantification of economic costs of BMP's vs. what was actually implemented

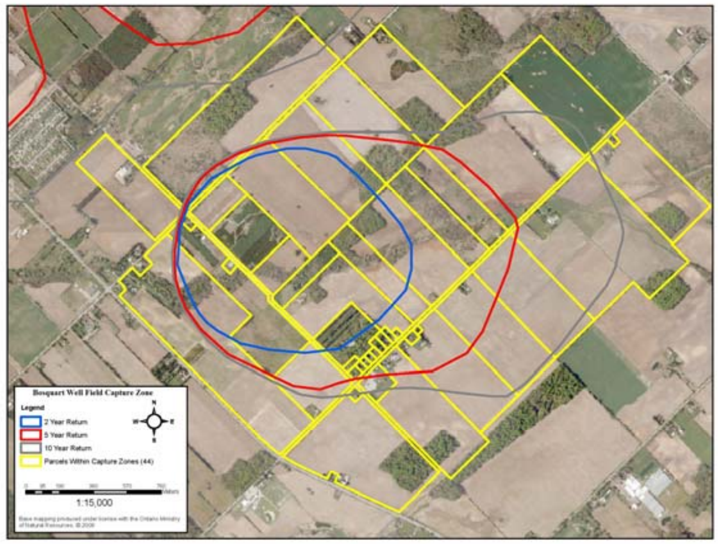
Case Region in ON

- Initial search of watersheds with water contamination from agricultural sources
- Stakeholder consultations
- 5 candidates:
  - South Nation
  - Woodstock/Oxford
  - Strathroy/Caradoc
  - Bay of Quinte
  - Waterloo
- Strathroy selected, based on:
  - Clear connection with N application from ag
  - Existing agronomic data/knowledge base
  - Known base for economic costs

Strathroy/Caradoc

- Caradoc aquifer- fine textured sand overlaid with clay, but some exposure
- Bosquart well field
  - 66 ha, 12 parcels in transient capture zone
  - 17 farms, 35 households, 469 acres in 10 yr capture zone
- Nitrate contamination issue, ↓ N loading recommended (2001), drinking water advisories
- N (and other) issues resolved via 26 km pipeline to access Lake Huron water

Bosquart Well Field



Transient State Capture Zone

Existing Knowledge

- Literature shows a range of BMP's for SWP have been investigated
- Literature also shows that BMP's can be effective
- BMP's that influence N contamination can have more general effect
- Basis to expect effectiveness of BMP's in Strathroy-Caradoc

Existing N Management

- Survey:
  - 14 of 17 farms
  - 11 of 35 single dwellings
- Findings: Agronomic practice
  - Corn:soybean rotation
  - 3 instances of kidney beans
  - No use of cover crops, biosolids, or manure
  - Minimum till broadly adopted
  - N application- band at planting and side dress
  - Soil testing (including N) in use
  - No use of crop consultant in N app or NM
- No apparent point source of N

BMP Alternatives

Based on

- survey results
- local conditions
- literature
- author experience
- N challenges in drinking water

Cases

1. "Rate Case"- consultation with a crop consultant to optimize timing and rate of N applications

2. "Rotation Case"- inclusion of winter wheat in rotation, underseeded to red clover cover crop

BMPs For Nutrient (i.e. nitrogen) Management	Case Studies		
	BASE	RATE	ROTN
Right Rate: Match Supply and Demand for Crop Nutrients			
Application calibration and upkeep	x p	x	x
Crop removal balance	x p	x	x
Crop scouting / assessment	x p	x	x
Nutrient management plans	x p	x	x
Plant tissue analysis		x	x
Record keeping	x p	x	x
Soil testing	x p	x	x
Variable rate fertilization			
Yield goal analysis		x	x
Right Time: On Time Delivery of Crop Nutrients			
Application timing	x	x	x
Enhanced efficiency fertilizers			

BMPs For Nutrient (i.e. nitrogen) Management	Case Studies		
	BASE	RATE	ROTN
Right Place: Appropriate Nutrient Placement			
Application method	x	x	x
Crop rotation			x
Buffer strips			
Reduced tillage	x	x	x
Cover crops			x
Incorporation of fertilizer	x	x	x
Right Advice: Appropriate Professional Advice and Analytical Information			
Advice from a professional agricultural consultant	x p	x	x
Results from a certified analytical laboratory	x p	x	x

Hydrogeologic Simulation

- N budget approach
- Endpoints measured:
- Long-term Potentially Leachable Nitrogen (LPLN)
- Simulate N mass load, N mass flux
- From crop land and septic systems
- Period 1994-2007
- Sensitivity analysis- porosity and dispersivity

N Source
Crop type
Crop ID#
Yield
Nmanure (prev fall)
Nmanure (spring)
Nfert (starter)
Nfert (broadcast)
Nfert (sidedress)
Napplied
Nminer (prev crop residues)
Nminer (prev manure)
Nminer (cover crop)
Natmdep (precip; dry)
Nseed
Nsymfix
Total N Inputs

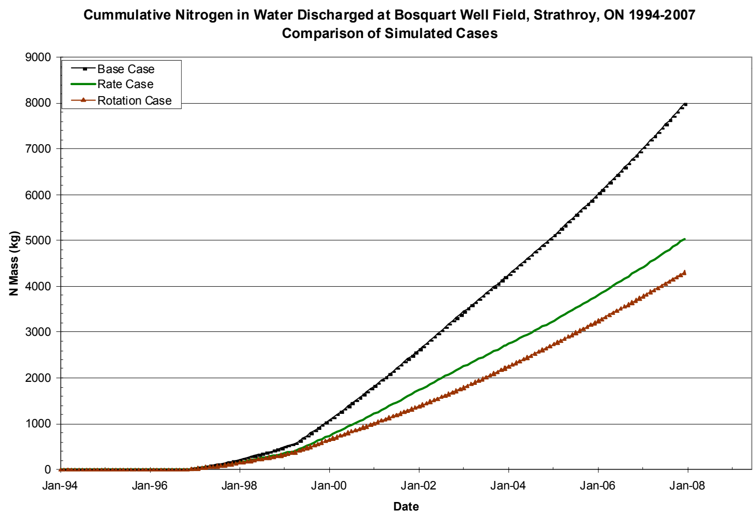
N Sink
Ngrain (harvest)
Nimmob (crop residue)
Nimmob (manure)
Nimmob (cover crop)
Nvol (fert)
Nvol (manure)
Nvol (senesc; misc)
Nerosion
Nrunoff
Ndenit
Total N Outputs
ΔNsi+ΔNso(OM)
Nleach (kg N/ha)
Nleach/TotalNip (%)

Simulation Results

- Simulated base compared with actual
- Compared with base case, both BMP's were successful in reducing LPLN over the time frame
- Both BMP's, implemented over the time frame, satisfy the N standard in drinking water
- Rotation case gave greater reduction in LPLN than Rate case
- Results robust to sensitivity analysis

Ppty ID#	Cropland in Transient Capture Zone (ha)	Relative Estimates of Mean Annual N Load From Cropland in Transient Capture Zone per Case Study (kg N / yr / ppty)		
		Base	Rate	Rotation
3	0.8	26.2	16.4	14.4
8	6.0	195.2	128.5	105.7
20	6.3	203.2	122.1	101.9
28	5.8	197.1	126.5	101.5
31	0.2	4.7	2.8	2.4
32	3.2	82.6	49.2	42.1
33	9.1	251.4	141.2	113.9
34	0.2	6.0	3.6	3.0
37	11.6	363.3	228.0	200.2
39	0.2	5.5	3.5	2.8
41	15.0	480.4	288.8	241.0
42	7.7	243.1	152.5	133.9
TOTAL	**66.1**	**2059**	**1263**	**1063**
Relative Estimate of Mean Annual Decrease in N Load From Cropland			**-39%**	**-48%**

Predicted N discharged in Well Field



Economic Analysis: Approach

- Cost-Benefit Analysis
  - Purpose: evaluation and comparison of public investment projects
    - Measure all benefits and costs, in time period incurred
    - Discount rate- reflect timing of costs and benefits, opportunity cost of capital
    - Sum discounted cash flows
- Here- unpriced, equivalent benefit (N-std)
- Costs of capital, operating costs, agronomic practices

Economic Analysis

- Pipeline vs. BMP's
- Retrospective analysis
- Reference year: 2005
- BMP#1 – "Rate Case"
- BMP#2 – " Rotation Case"
- Benefit: Nitrate level remains under the threshold of 10 mg/L

Economic Analysis

Option 1: Status Quo

Pipeline implementation

•Direct pipeline costs

•Indirect pipeline costs

Option 2:

BMP Implementation

•Costs of updating the well system

•Costs/benefits to farmers implementing the BMPs

Option 2A, BMP#1

"Rate Case"

Option 2B, BMP#2

"Rotation Case"

BMP costs

- Foregone profit per acre
- Model – yield given, varying N fertilizer
- Data: OMAFRA enterprise budgets, crop consultant
- Annual net costs/benefits
- Implementation costs

Budgeting model (section)

Field 8 Base Case

Item	Units	1999	1998	1997	1996	1995	1994
Crop type		soybeans	field corn	soybeans	field corn	soybeans	field corn
Yield	kg/ha	2688.00	8780.80	2688.00	8780.80	2688.00	8780.80
Applied N	kg N/ha	11.20	156.80	11.20	156.80	11.20	156.80
	kg N/acre	4.53	63.45	4.53	63.45	4.53	63.45
Cost w/o Fert.	$/acre	160.75	218.05	144.00	206.00	145.00	203.50
Fertilizer	$/acre	15.67	69.99	14.90	69.08	12.52	55.47
Total costs	$/acre	176.42	288.04	158.90	275.08	157.52	258.97
Yield	t/ha	2.69	8.78	2.69	8.78	2.69	8.78
Price	$/t	263.00	118.00	337.00	153.00	323.00	118.00
Revenue	$/ha	706.94	1036.13	905.86	1343.46	868.22	1036.13
	$/acre	286.09	419.31	366.59	543.68	351.36	419.31
Profit	**$/acre**	**109.67**	**131.27**	**207.69**	**268.60**	**193.84**	**160.34**

Economic Analysis

- Net present value
- Project length: 80 years
- Aggregate implementation cost/benefits to farmers 1994-2005
- Annual profit differences of BMP scenarios vs. the Base Case
- Water volume well *vs* pipeline

BMP costs/benefits

Table 1 Aggregate implementation cost/benefits to farmers 1994-2005

Field number	BMP Profit Difference to Base Case	
	BMP#1	BMP#2
Total (5%)	**-$15,291**	**-$148,147**

Table 2 BMP profit differences to base case

Field numbers	BMP Profit Difference to Base Case	
	BMP#1 **Rate Case**	**BMP#2** **Rotation**
8	-$93	-$63
28, 39	-$97	-$1,473
20, 34, 41	-$175	-$169
31, 32	-$157	-$323
33	-$538	-$769
3, 37, 42	-$239	-$3,082
Total	**-$1,300**	**-$5,879**

Costs

Option 1:

→Total cost of pipeline: $18,681,010

→ Allocated pipeline costs on equivalent volume to Bosquart well: $4,958,129

- Direct costs
- Decommissioning of wells
- Measures against basement flooding
- Plus water access costs

Option 2: Well upgrade costs: $ $2,482,100

- Update of well system
- Exceptionally expensive well to operate

Costs received from the Municipality of Strathroy-Caradoc

Economic Analysis

Present value of project costs (5%)

	Rate Case	Rotation Case	Pipeline
NPV of Project over 80 Years	-$8,034,090	-$8,123,837	-$8,430,142
Agronomic Implementation cost	-$15,291	-$148,147	
Project Total	**-$8,049,381**	**-$8,271,984**	**-$8,430,142**

Economic Analysis

- BMP's are the lower cost solution
- Case study approach
- Other drivers behind movement to alternative water supply

Conclusions

- Implemented with sufficient lead time, the BMP's could have been used effectively to address the N issue in drinking water
- Either BMP studied could have worked; hydrogeology and economic analyses produce different rankings
- Based on opportunity cost, results can provide a compensation value for mandated BMP's

Conclusions

- Study is somewhat unique, but should have broad applications
- Results offer perspective to municipalities confronting similar N issues
- Agronomic BMP's can be a low cost and effective N strategy in managing drinking water quality

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