

Can groundwater protection and agricultural production co-exist over vulnerable aquifers?

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Elevated levels of nitrates have been found in wells in most states, giving rise to health concerns (Power and Schepers, 1989)

Chemical and animal manure fertilizers associated with agriculture are the primary sources of nitrogen input to the environment (Puckett, 1994)

Nitrate is the most ubiquitous chemical contaminant in the world's aquifers and the levels of contamination are increasing (Spalding and Exner, 1993)

"Agriculture is the remaining, major unregulated source of environmental, primarily water, pollution... *and* presents a thorny problem for the design of public measures to protect groundwater pollution"

(Offutt, 1990 (Office of Management and Budget, Executive Office of the President))

**Response:**  
**Research and extension to support BEST MANAGEMENT PRACTICES**

## Evolution of the 'B' in BMP

BEST  
to  
BETTER  
to  
BENEFICIAL

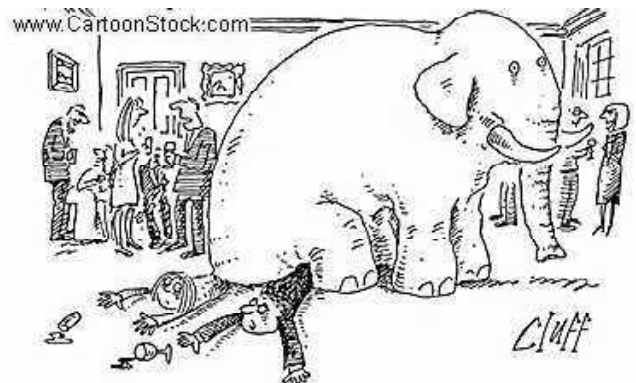
Comprehensive estimates of the costs of nutrient pollution are currently not available (Frisvold, 2004)

Since the 1970s, nitrate ( $\text{NO}_3$ ) contamination of groundwater has become a significant environmental problem, with many parts of the world now reporting groundwater nitrate pollution (Rivett et al., 2008)

Statistical tests of decadal-scale changes of nitrate concentrations in water from 495 wells [in the US] combined indicate there is a significant increase (Rupert, 2008)

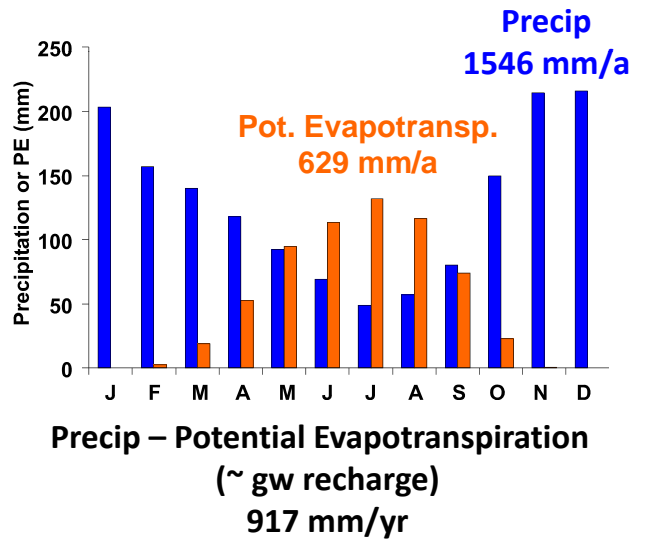
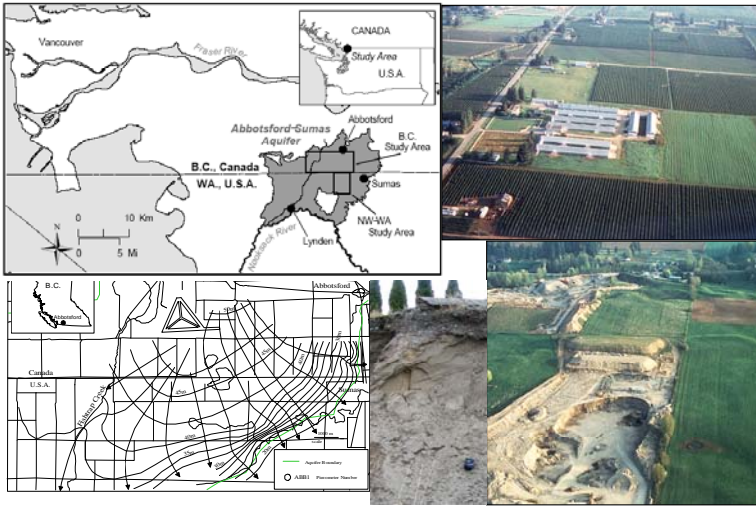
**Troubling lack of clear examples where improved management practices resolved groundwater nitrate contamination**

We've known about the 'problem' for 30 years....



"HAVE YOU NOTICED IT, TOO?"

# ABBOTSFORD/SUMAS AQUIFER



## Groundwater nitrate issue identified in 1970s

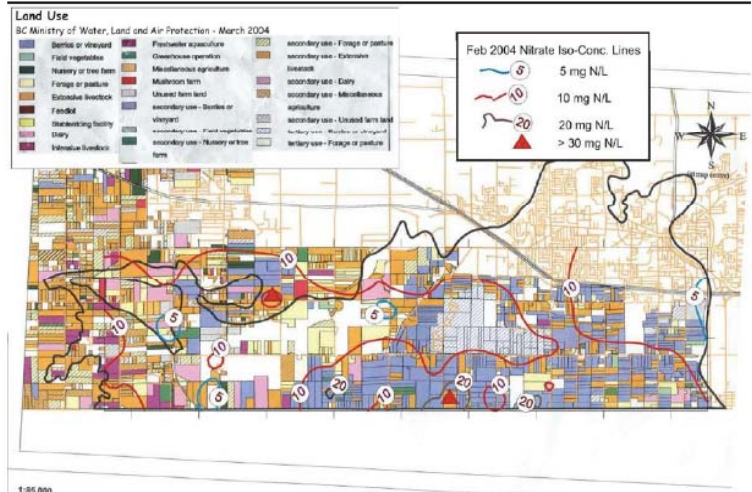
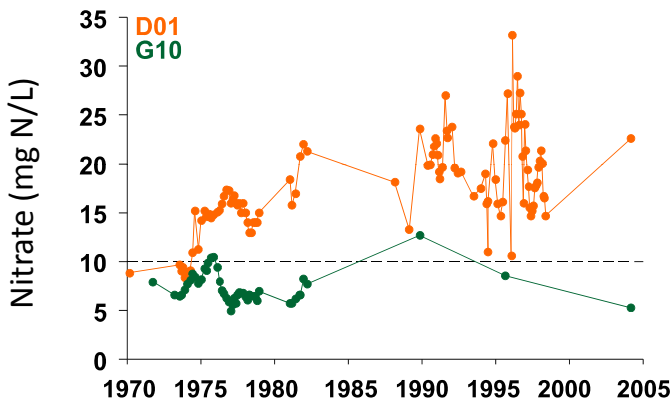
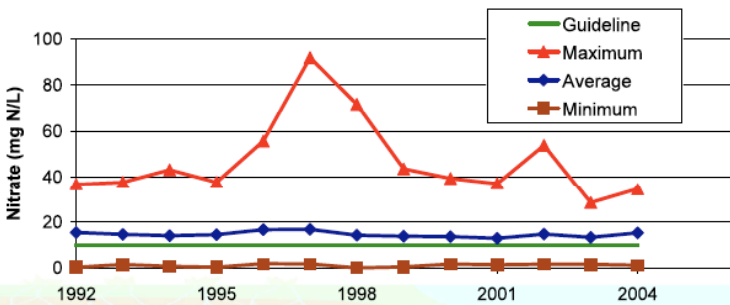


Figure 4. Nitrate iso-concentration lines (February 2004) in relation to land use in the Abbotsford Aquifer.

Graham, 2006



Environment Canada / Environnement Canada

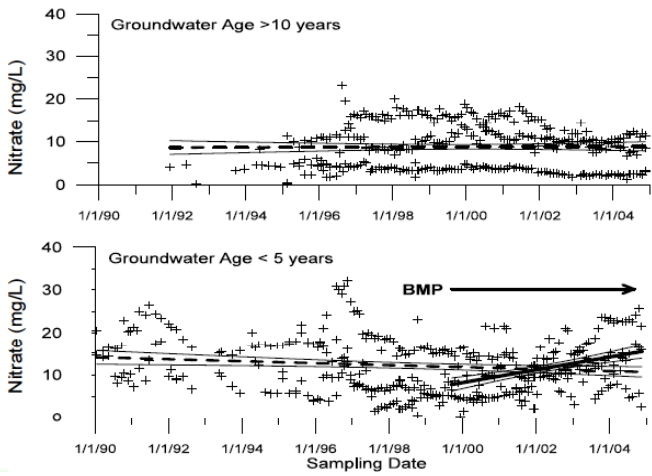
## The BMP response:

### Regulatory

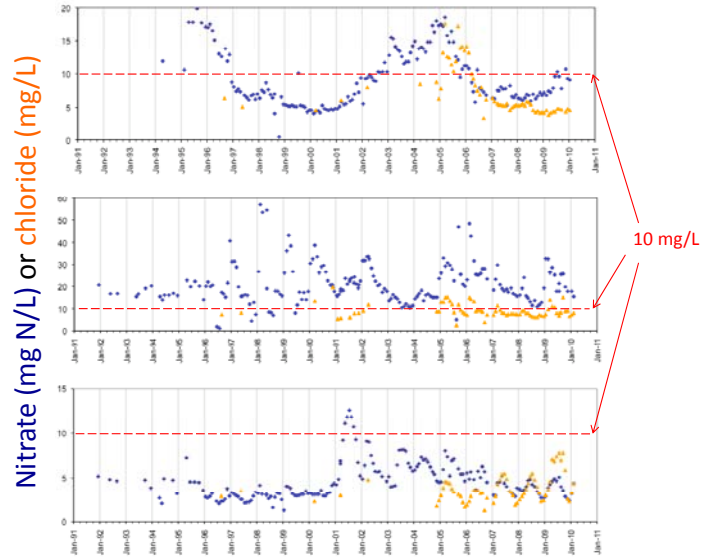
- Improved manure storage

### Voluntary

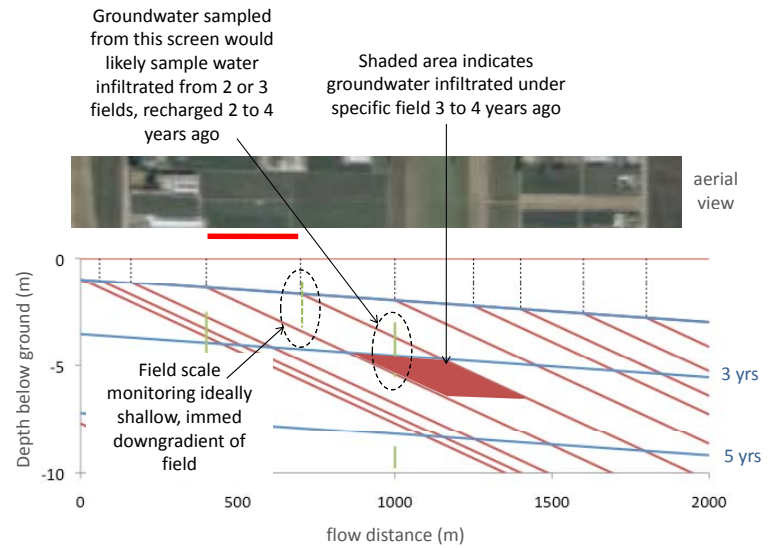
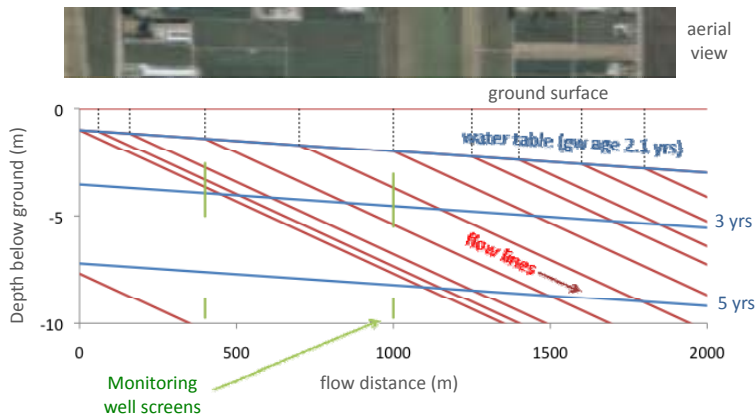
- N recommendation fact sheets
- post harvest N test
- Trucking manure off aquifer



Wassenaar et al., 2006



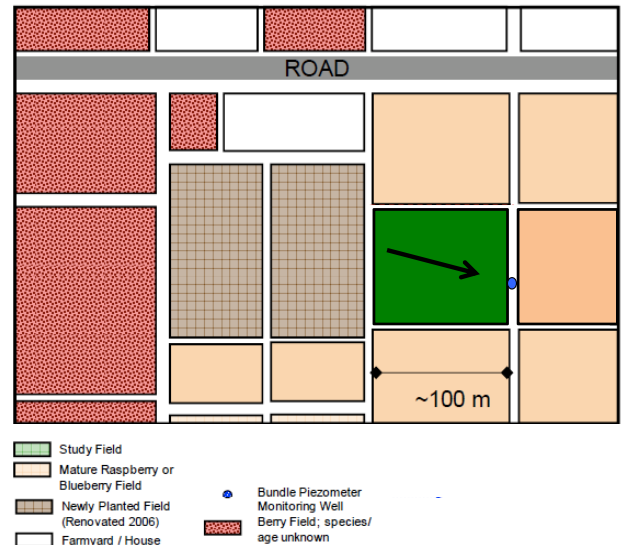
Conceptual cross section of flow illustrating conventional groundwater monitoring, complex groundwater NO<sub>3</sub> patterns (w/o considering aquifer heterogeneity, crop age, season!)



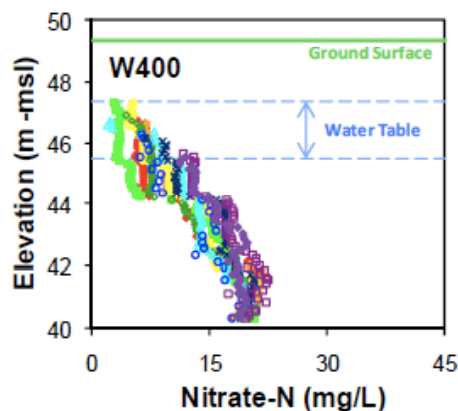
Question: Can intensive berry production on the Abbotsford Aquifer *without groundwater nitrate contamination* be accomplished?

GOALS:

- quantify nitrate loading to groundwater under specific commercial field with known management
- quantify soil N cycling and timing and rate of nitrate leaching from root zone
- link seasonal variations in soil zone leaching with loading to groundwater



## Groundwater nitrate monitoring



Kuipers, 2010

## NO<sub>3</sub> loading to the water table



Groundwater nitrate leached multiplied by estimated monthly recharge (total 1368 mm in 06-07) leads to an estimate of about 180 kg N/ha

Kuipers, 2010

## Soil N budget for a research field (kg N/ha)

Manure N (total)	287	Denitrification (8%*)	25
Fertilizer N	26	SOM change (20%*)	57
Irrigation	13	Volatilization (20%*)	57
<u>Atm deposition</u>	<u>40</u>	<u>Berry harvest</u>	<u>20</u>
<b>TOTAL</b>	<b>366</b>		<b>160</b>

\*Manure losses estimated from Zebarth, 1989; assumes system is in overall equilibrium and negligible mineralization or plant uptake

Soil budget estimated leaching losses = 206 kg N/ha

For 1368 mm recharged estimated that year ~ 15 mg N/L

For 917 mm average recharge ~ 19 to 22 mg N/L

Kuipers, 2010

Question: Can intensive berry production on the Abbotsford Aquifer *without groundwater nitrate contamination* be accomplished?

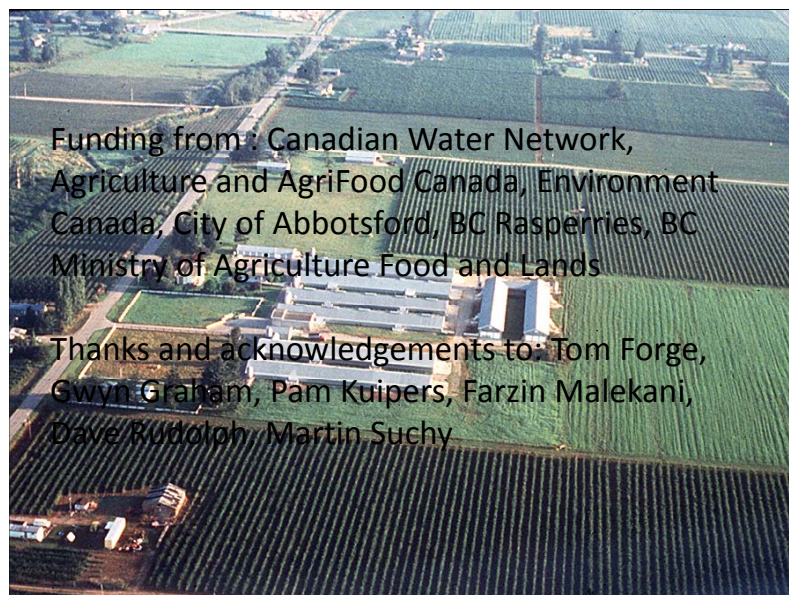
- average nitrate concentrations have remained stable over 30 to 40 years of monitoring
- no evidence that voluntary 'B'MP approach is working to date
- 'package' of BMPs could include N management, cover crop, irrigation management, etc.

**BUT**

Would there be any incentive for voluntary adoption??

## Key consequences for policy/decision makers

- Voluntary BMP approach was not effective
- careful hydrogeology in concert with soil zone N work is needed to LINK management DIRECTLY with groundwater quality for PRACTICAL farmers
- Even in the face of overwhelming scientific evidence, might not be reasonable to expect growers to 'do the right thing'



Funding from : Canadian Water Network, Agriculture and AgriFood Canada, Environment Canada, City of Abbotsford, BC Raspberries, BC Ministry of Agriculture Food and Lands

Thanks and acknowledgements to: Tom Forge, Gwyn Graham, Pam Kuipers, Farzin Malekani, Dave Rudolph, Martin Suchy