A Research Network Ensuring Safe Drinking Water for Canadian Small and Rural Communities

With a focus on

Source to tap characterization and modeling of water quality for small Canadian communities

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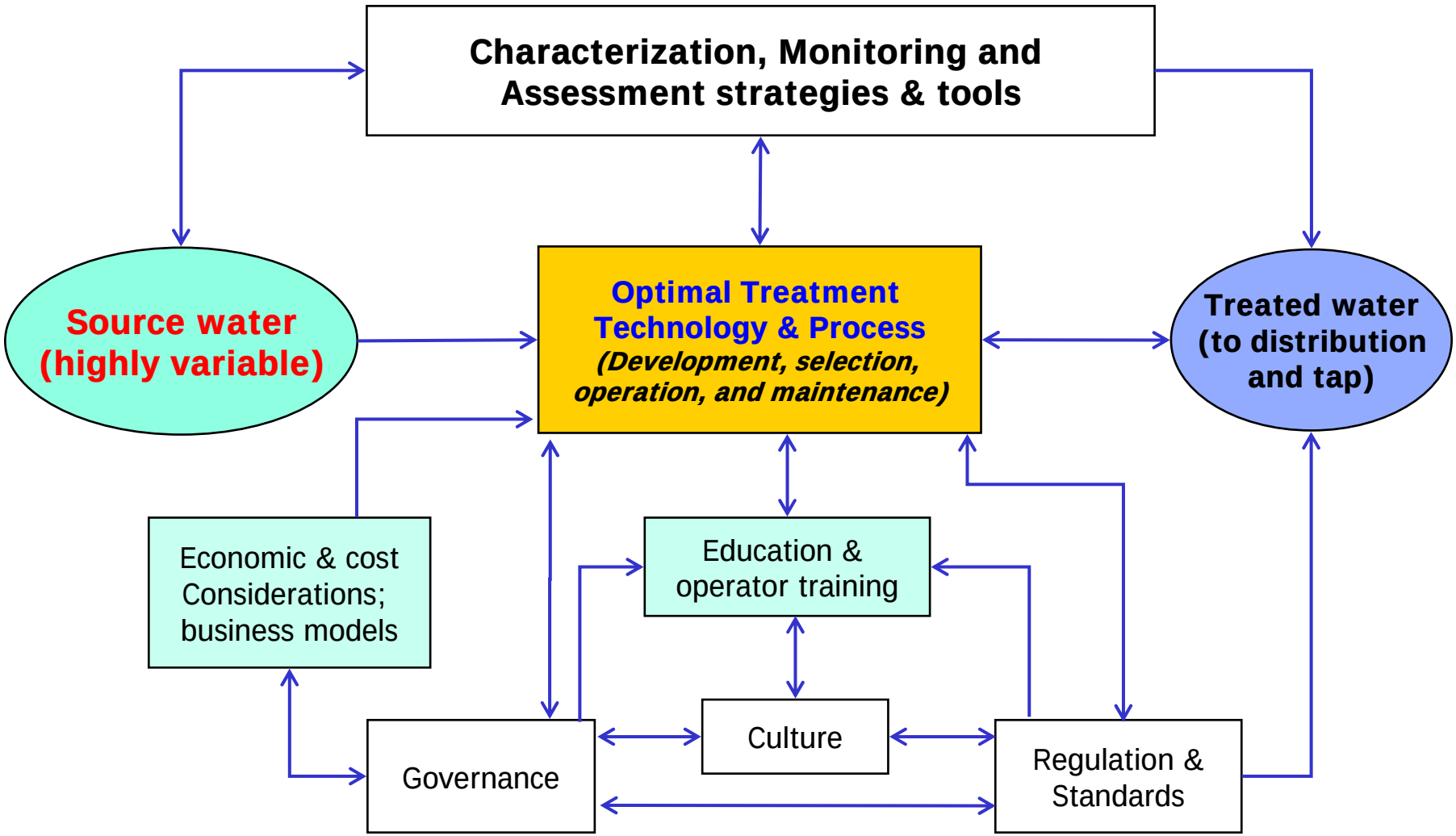
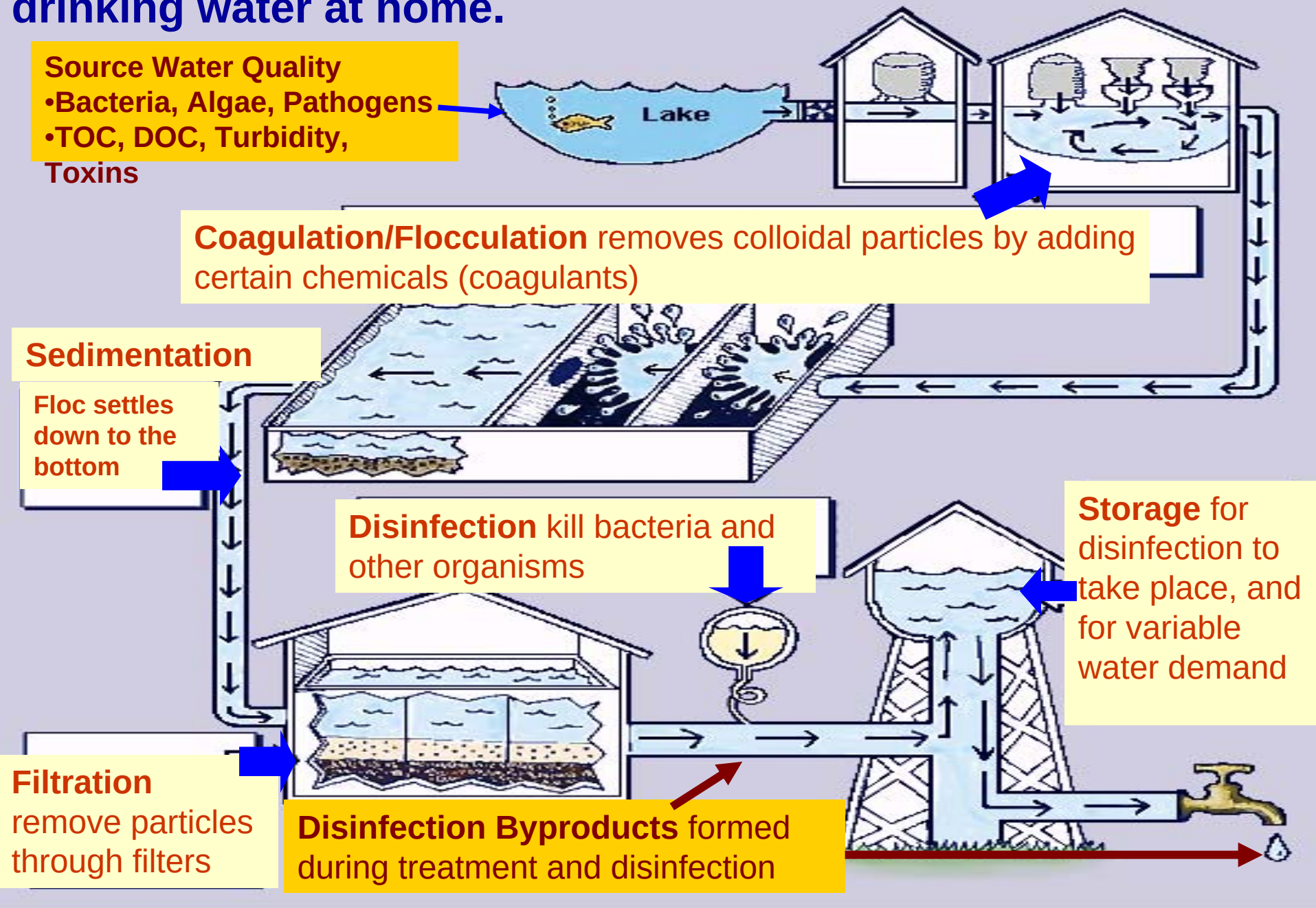
Structure of this Presentation

- Talk about the issues and challenges with source/tap water quality and some of the tools to characterize and track sources of problems;
- Introduce the newly funded research network on small water systems
- Develop partnerships with small and rural communities

One of the major challenges in developing robust, cost-effective and operator-friendly treatment technology for small/rural communities is the land-use and climate driven variability in source water quality the SRCs need to treat and disinfect across Canada.



Poor quality water at the source increases health risk of drinking water at home.



Challenges for Small / Rural Communities to sustain clean and healthy water under highly variable water quality, environment, resources and experience

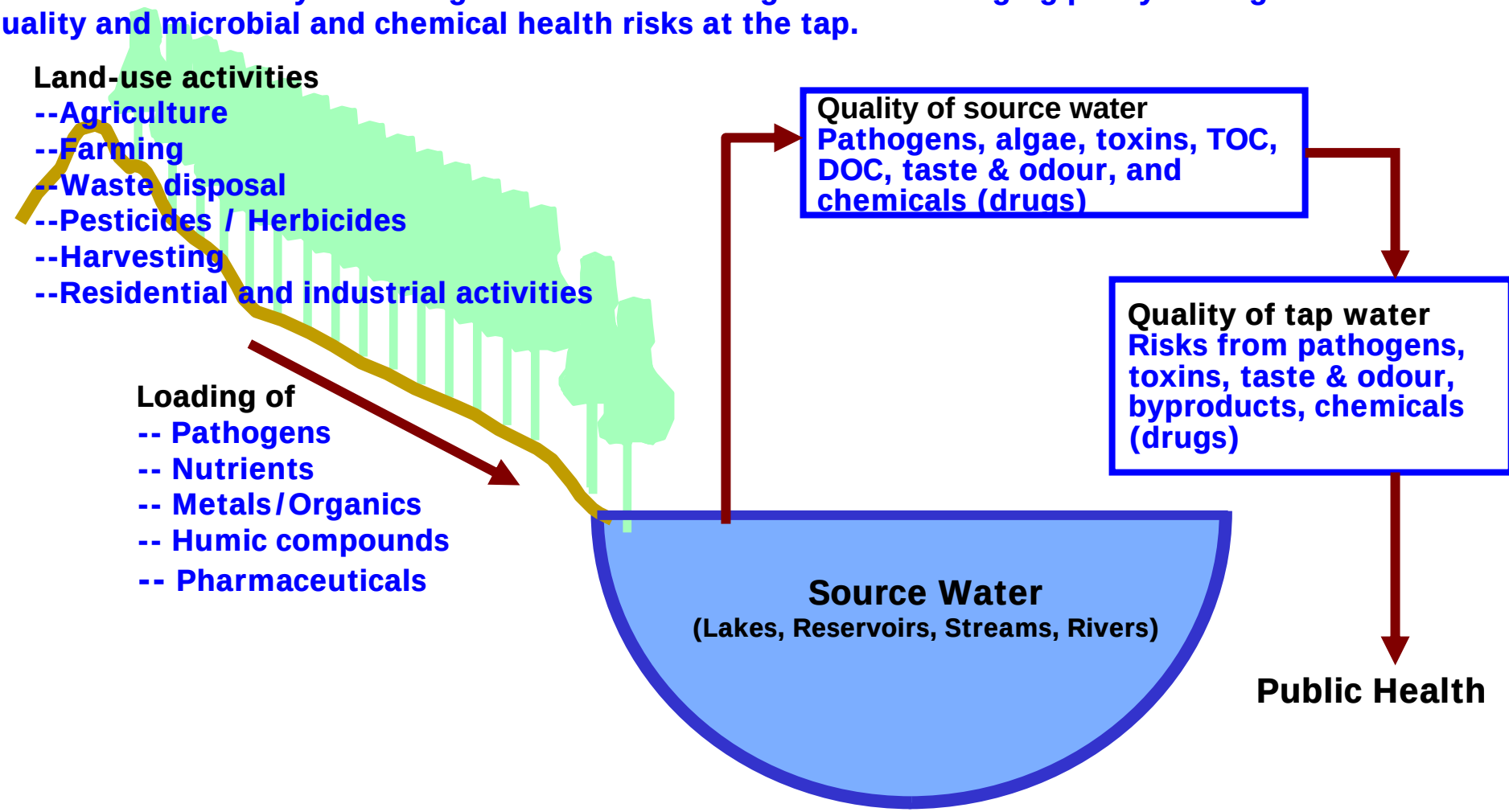
- **Large number of small communities in Canada**
  - ~ 1025 municipalities fall into the category of small water systems
  - Over 600 small water systems for First Nation Communities
  - Many private systems and recreational communities
- **Large regional, seasonal and long-term variability in source water across Canada**
  - Different types and intensities of landuse affect water quality very differently under variable geological and climatic conditions
  - Extreme climate variability produce highly variable and unpredictable changes in water quality
  - Seasonal and inter-annual characterization of source water quality thus become a major challenge
- **One treatment type does not fit the needs for all small systems under variable WQ.**
  - Our goal is to assess how source water quality dictates effectiveness of treatment and disinfection
  - Current approach does not include seasonal and inter-annual variability in source water quality for developing optimal treatment technologies

Sustaining clean and healthy water at the tap for SRCs in Canada is a major challenge because contamination of source water is not well regulated:

- For optimal and effective treatment technologies, need to know the WQ a treatment system may face seasonally with a year, and among years;

- Need to understand and evaluate the vulnerability of small systems to microbial and chemical contamination of source water, and implications for treatment efficiency and safety of tap water,

- Enhance community knowledge and understanding towards changing policy linking source water quality and microbial and chemical health risks at the tap.



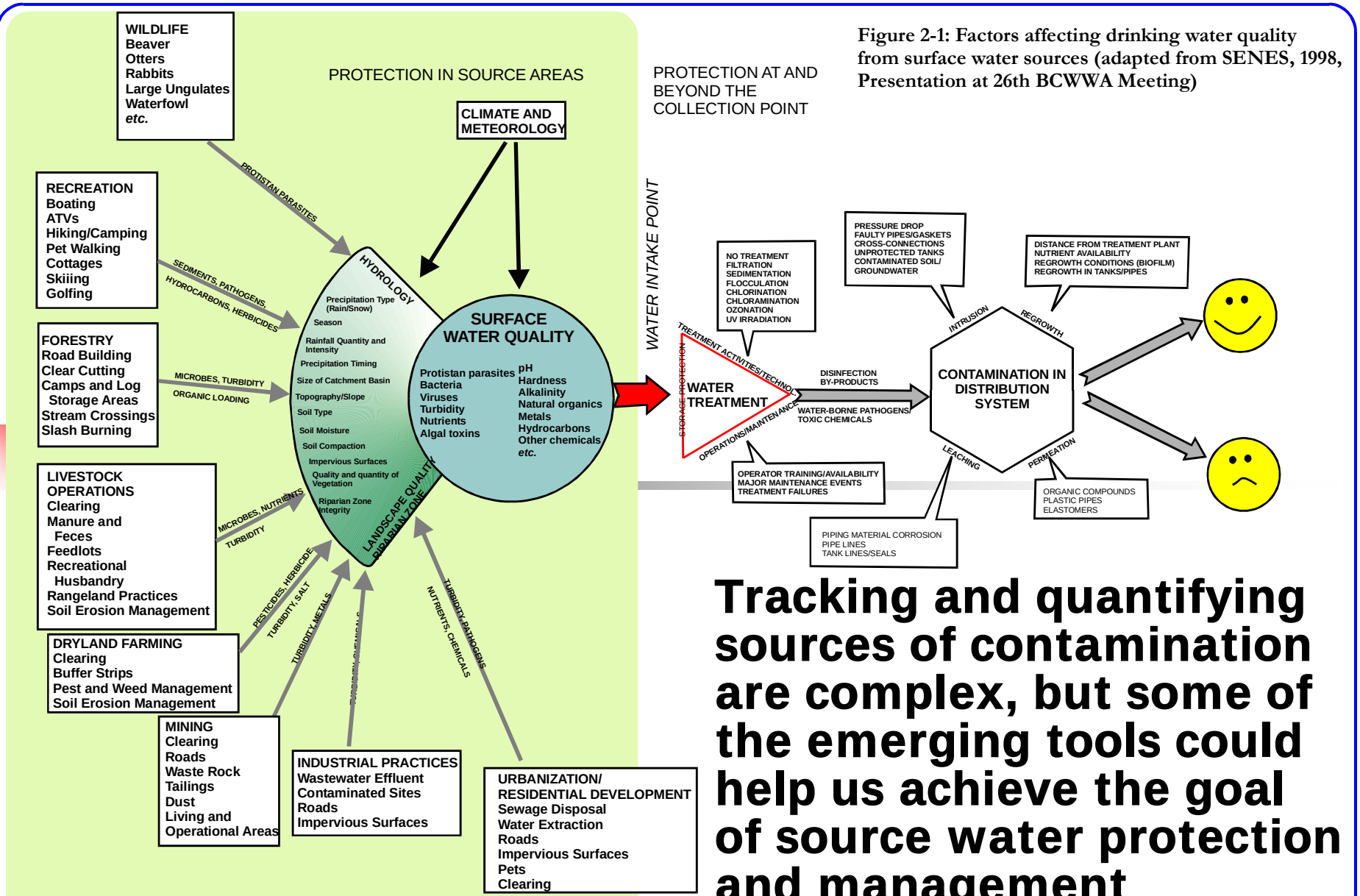


Figure 2-1: Factors affecting drinking water quality from surface water sources (adapted from SENES, 1998, Presentation at 26th BCWWA Meeting)

Tracking and quantifying sources of contamination are complex, but some of the emerging tools could help us achieve the goal of source water protection and management

BARRIER:
LAND USE RESTRICTIONS AND BEST MANAGEMENT PRACTICES

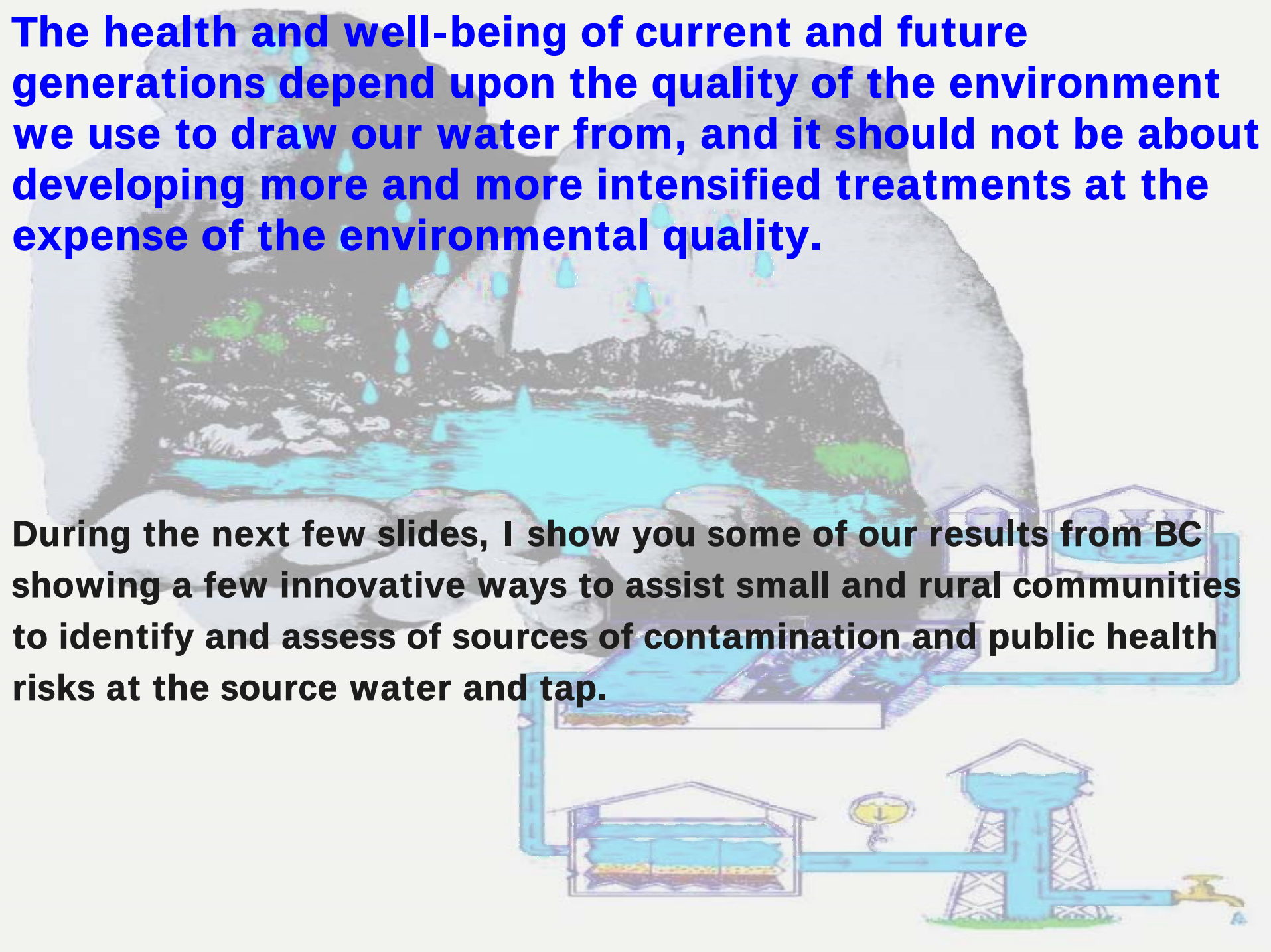
BARRIER:
PROTECTION OF LANDSCAPE AND RIPARIAN ZONE EFFECTIVENESS

BARRIER:
TREATMENT AND DISINFECTION

BARRIER:
CHLORINE RESIDUAL/ DISTN SYSTEM UPGRADES AND DISINFECTION

BARRIER:
ROUTINE TESTING, ADVISORIES

The health and well-being of current and future generations depend upon the quality of the environment we use to draw our water from, and it should not be about developing more and more intensified treatments at the expense of the environmental quality.



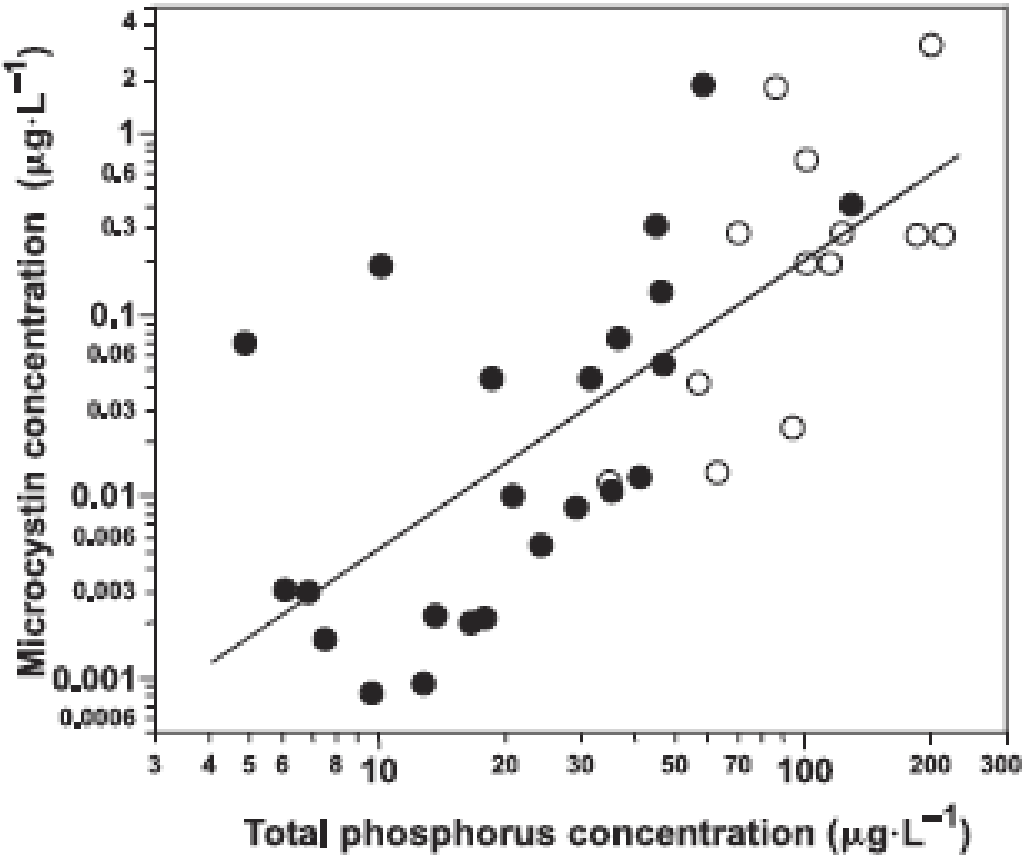
During the next few slides, I show you some of our results from BC showing a few innovative ways to assist small and rural communities to identify and assess of sources of contamination and public health risks at the source water and tap.




If we looked at many of the Canadian watersheds that provide drinking water to small and rural communities, we may see many of these activities, which can affect WQ at the source, and increase water quality and public health risks at the tap.

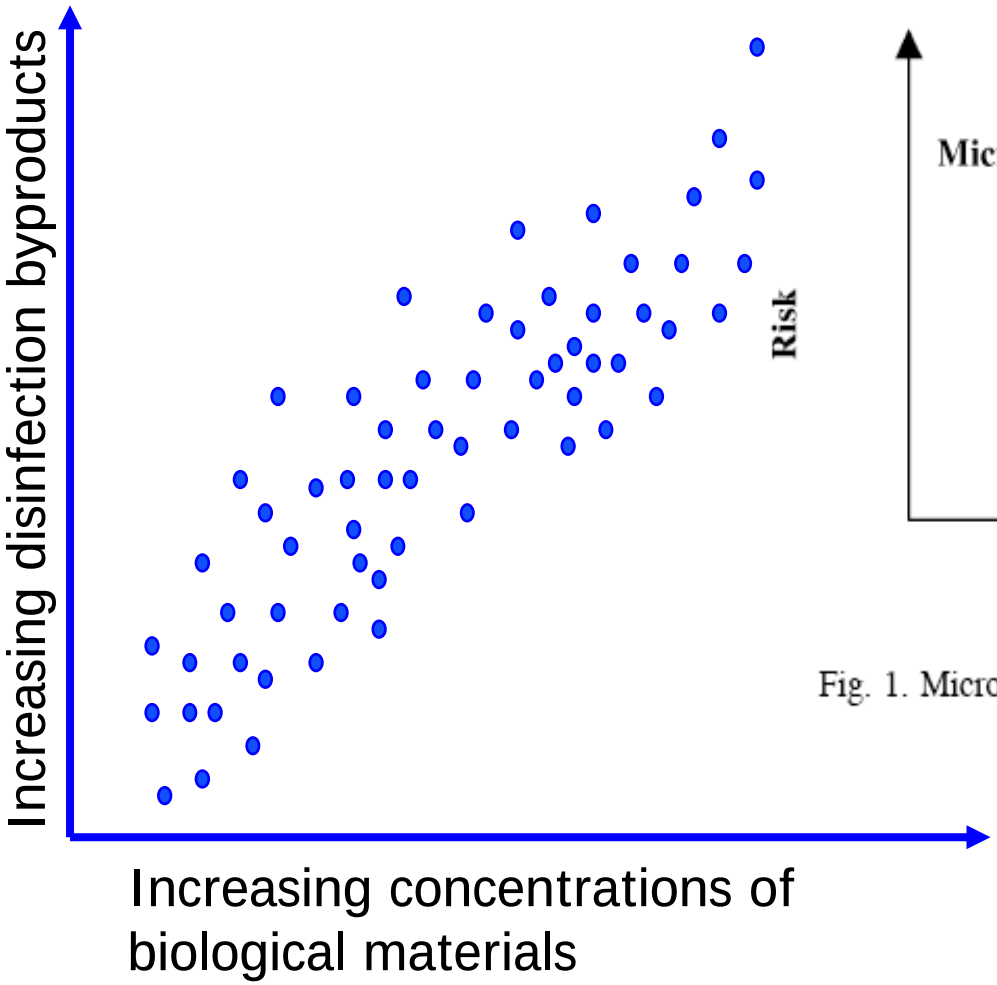
Phosphorus is the main nutrient linked to algal blooms and toxins in source water. Septic and sewage, storm water, fertilizers are the major sources of phosphorus.

Fig. 2. Positive relationship between log total phosphorus concentration and log microcystin concentration in southern Quebec (this study; ●) and the summer mean for eutrophic lakes in Alberta (Kotak et al. 2000; ○). Lakes in both regions follow the same trend.



Disinfection is critical to kill pathogens and provide safe (may not be healthy) drinking water. BUT

As biological materials are composed of 40-60% carbon, disinfection produces chlorinated hydrocarbons, harmful to humans at elevated concentrations.



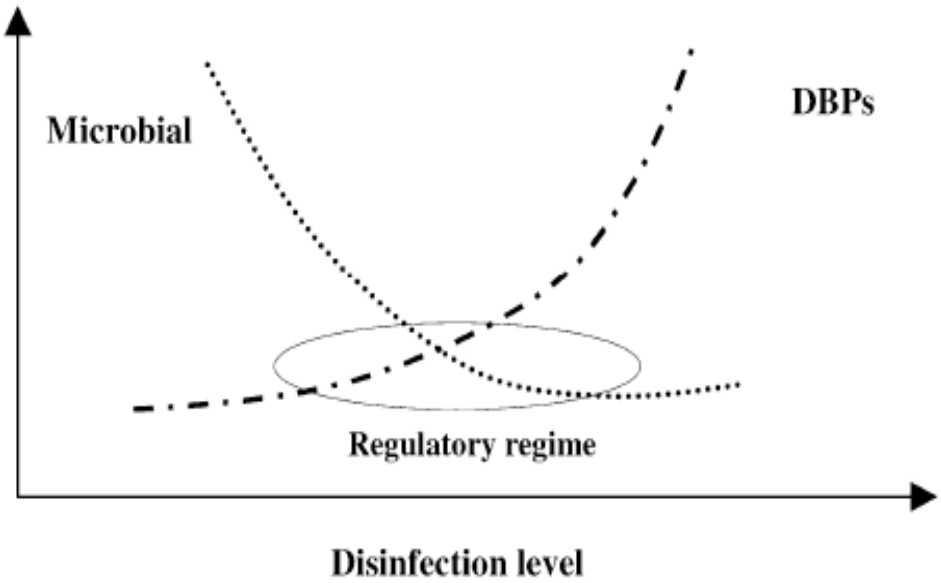


Fig. 1. Microbial and chemical risk trade-off analysis for disinfection.

Yinan Qi, Chii Shang*, Irene M.C. Lo

Water Research 38 (2004) 2375–2383

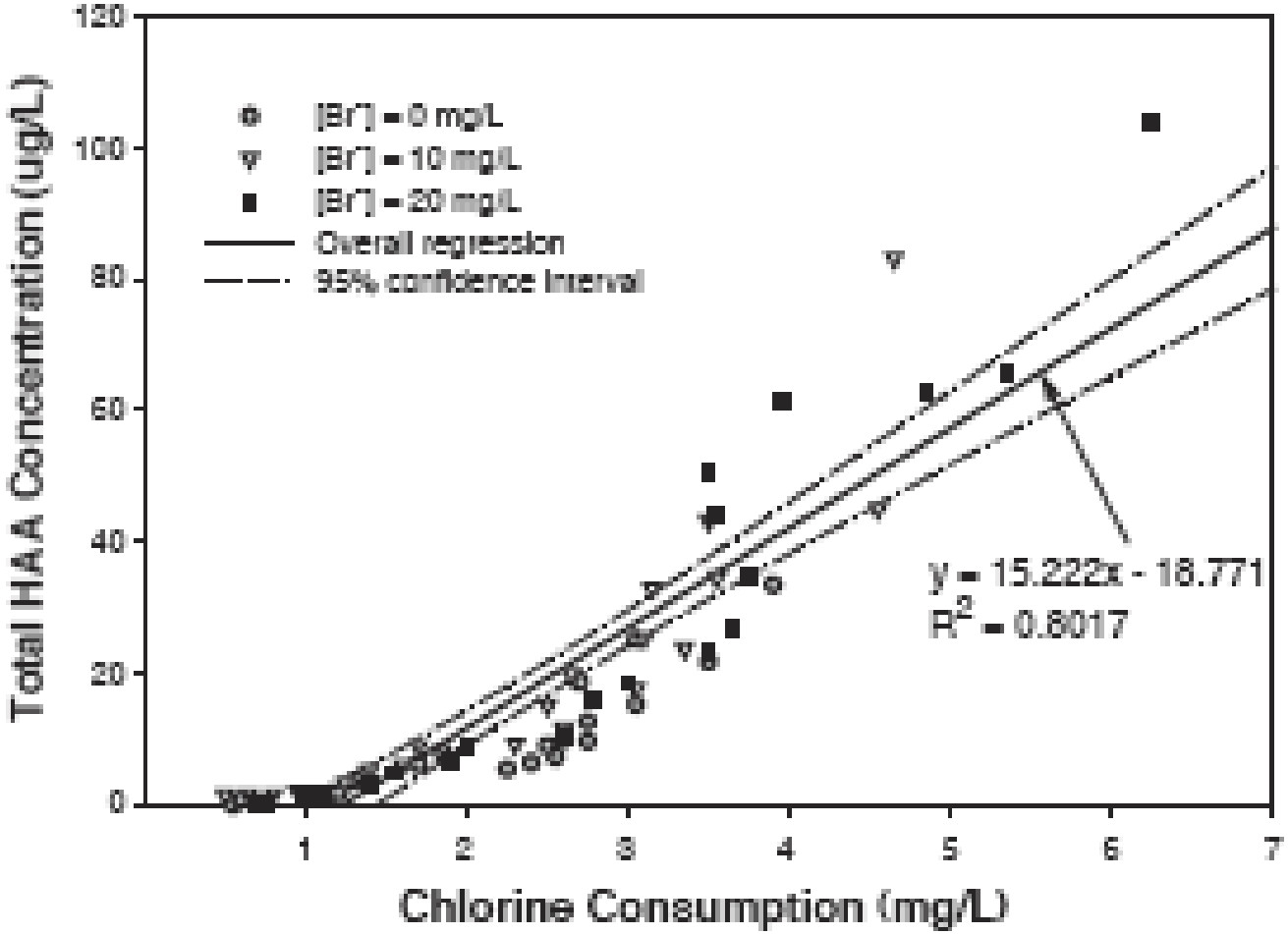
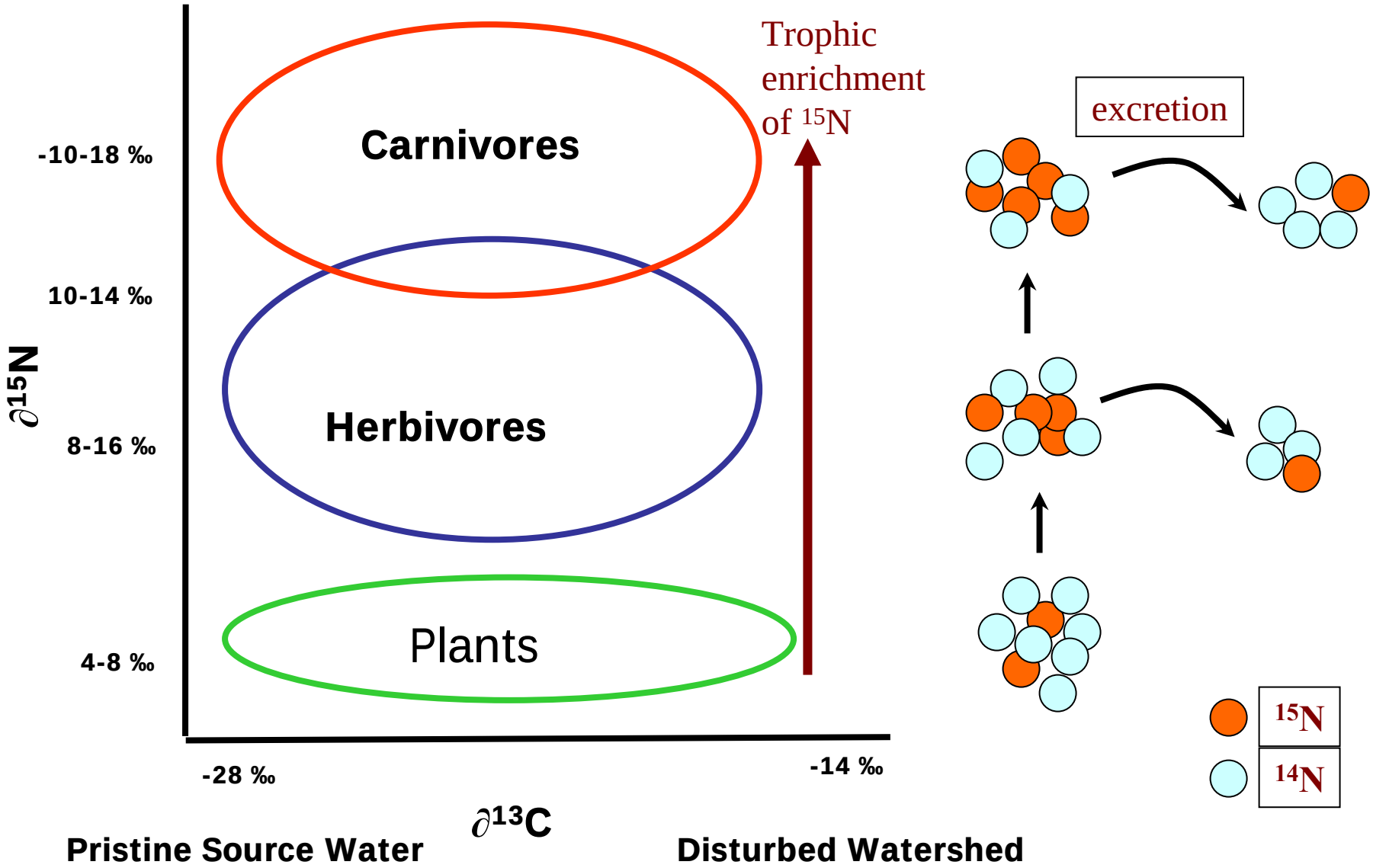


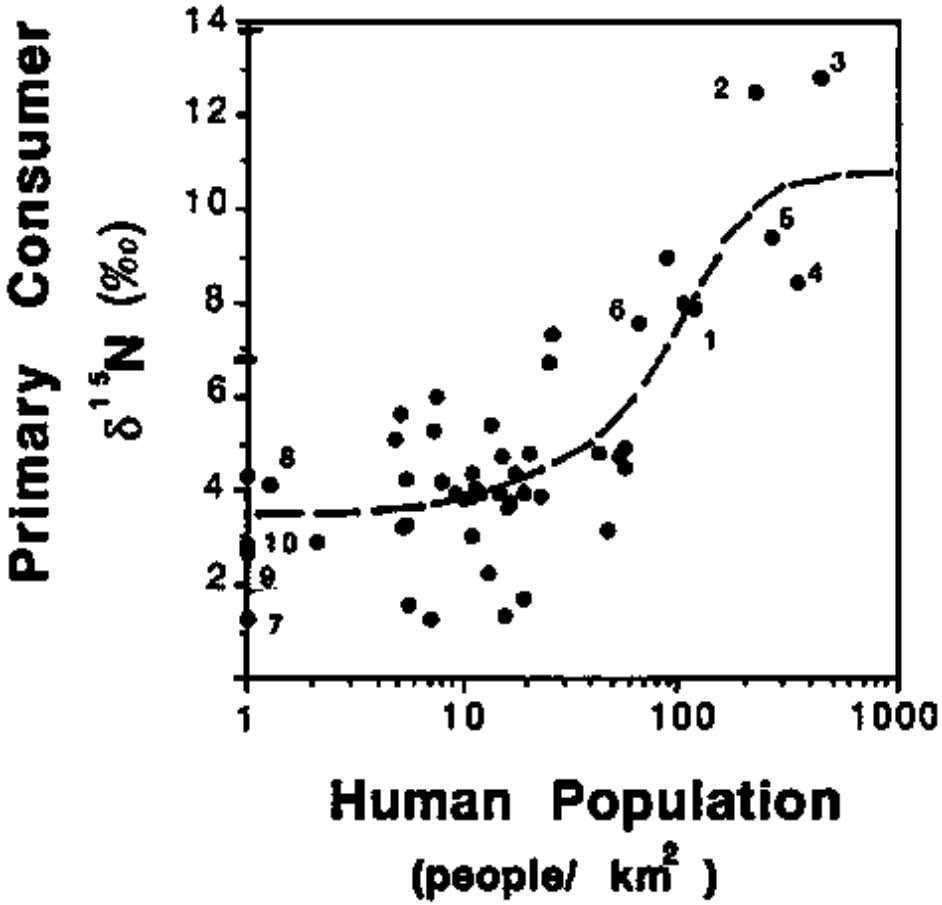
Fig. 5. Correlation of the formation of total HAAs versus chlorine consumption.

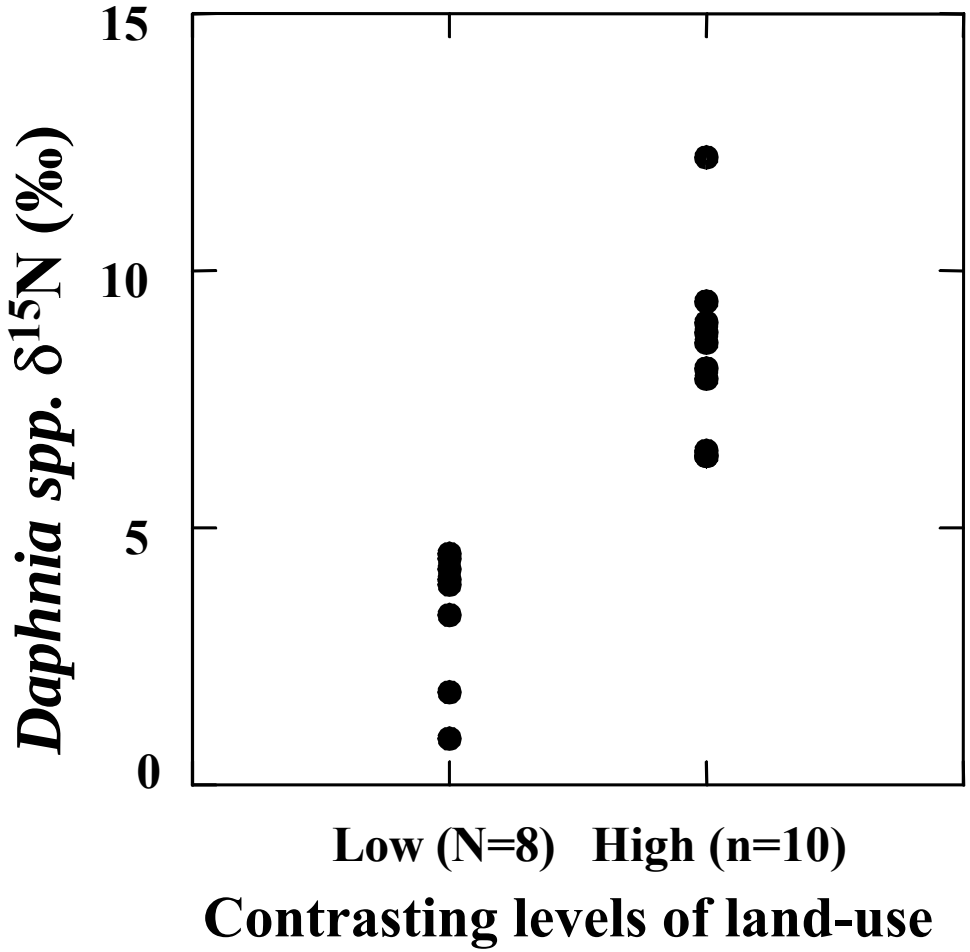
$\delta^{15}N$ as a tracer of sewage and septic loading to source water



Stable isotope of nitrogen can be used to detect septic and sewage input to source water

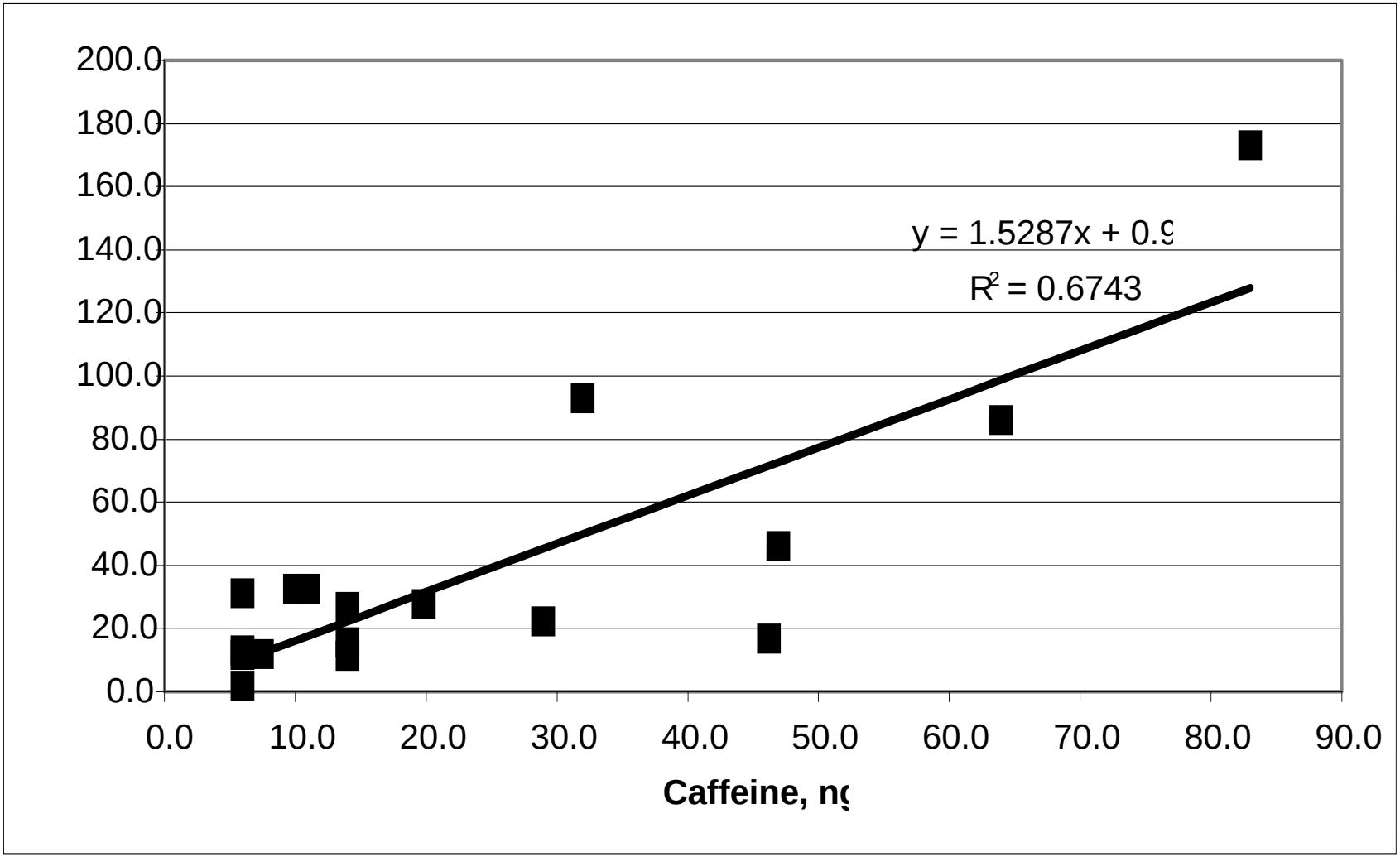
Proc. Natl. Acad. Sci. USA 93 (1996)



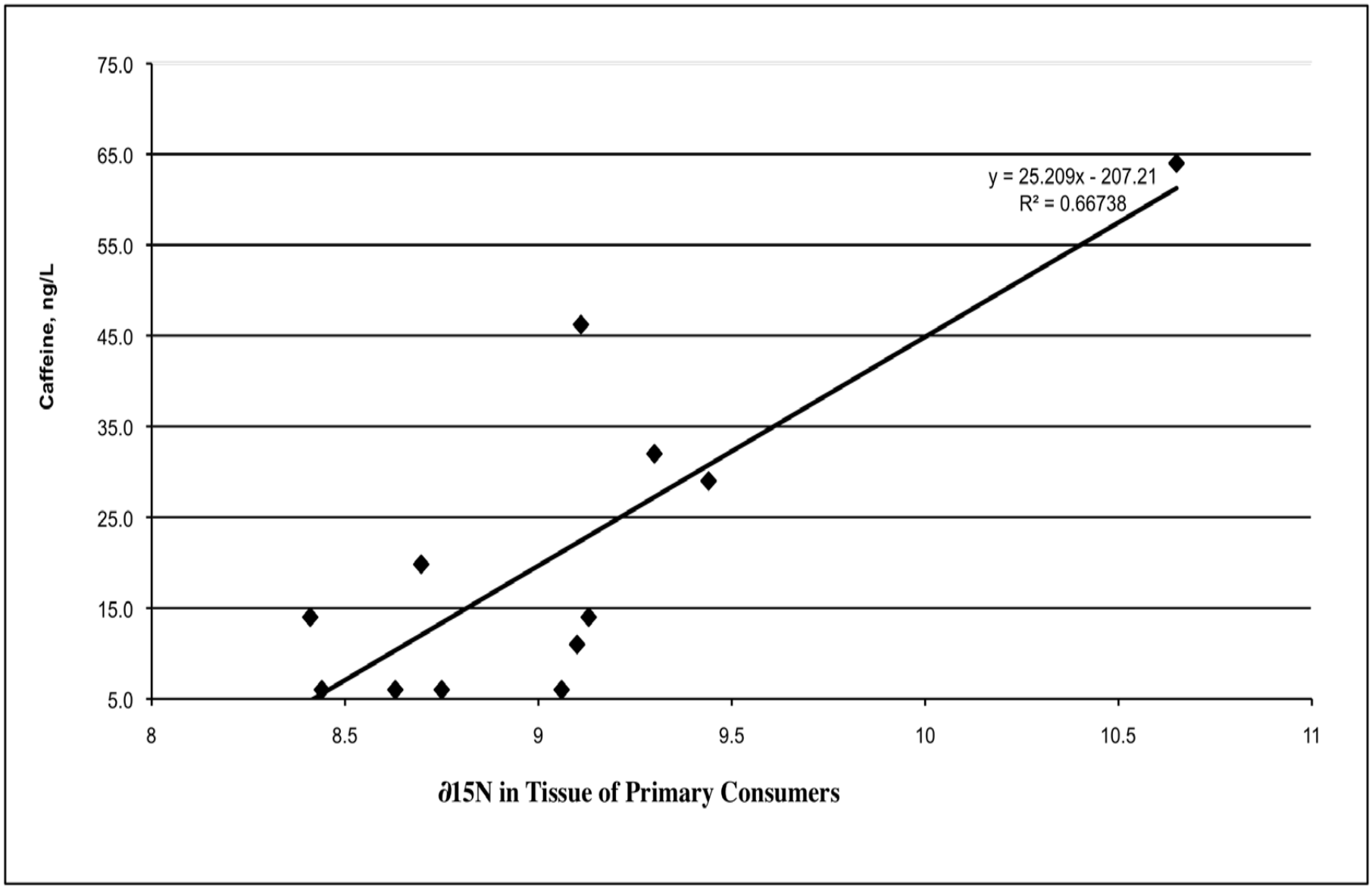


A quick and powerful tool to assess fecal contamination and decision making

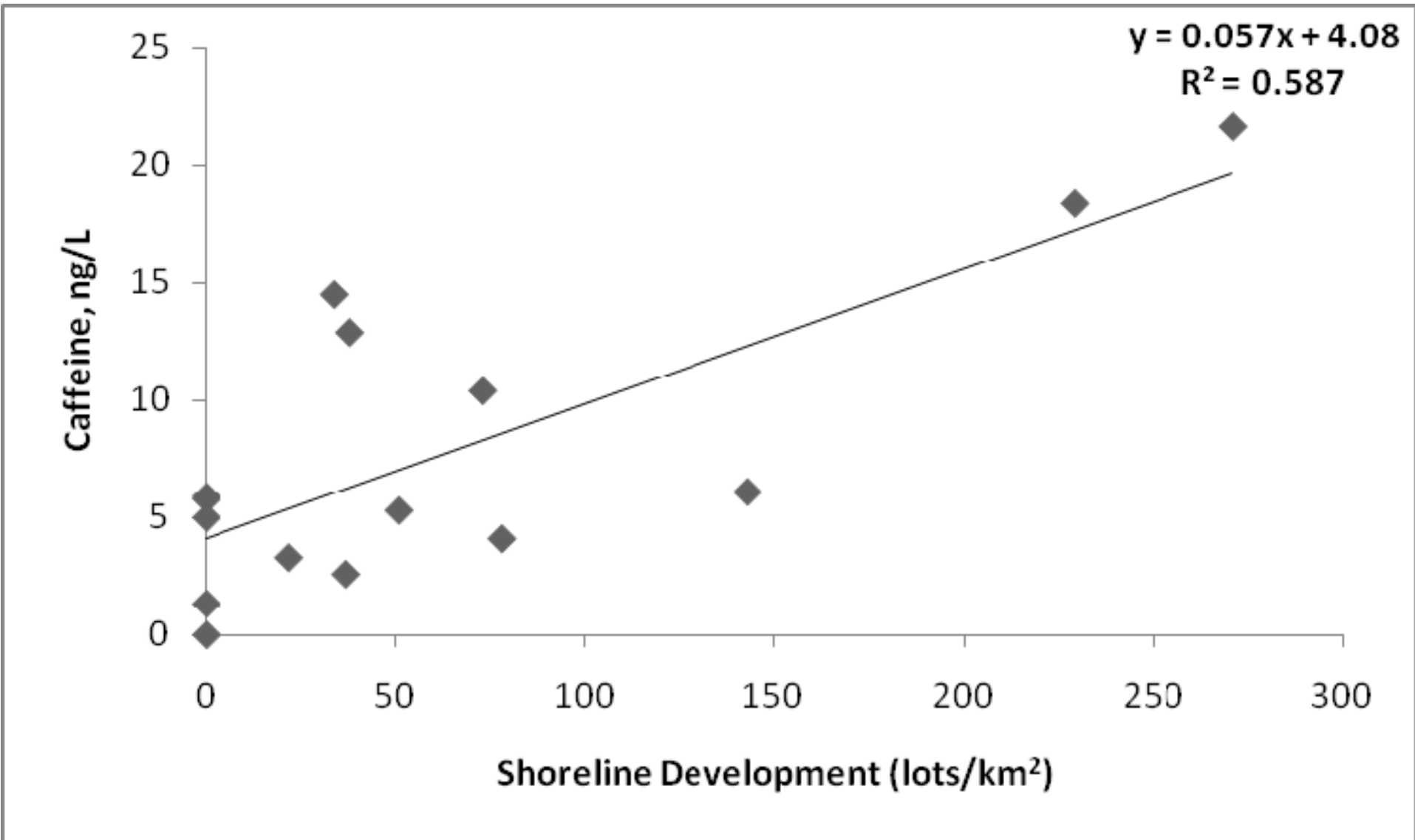
Caffeine is a good indicator of fecal contamination



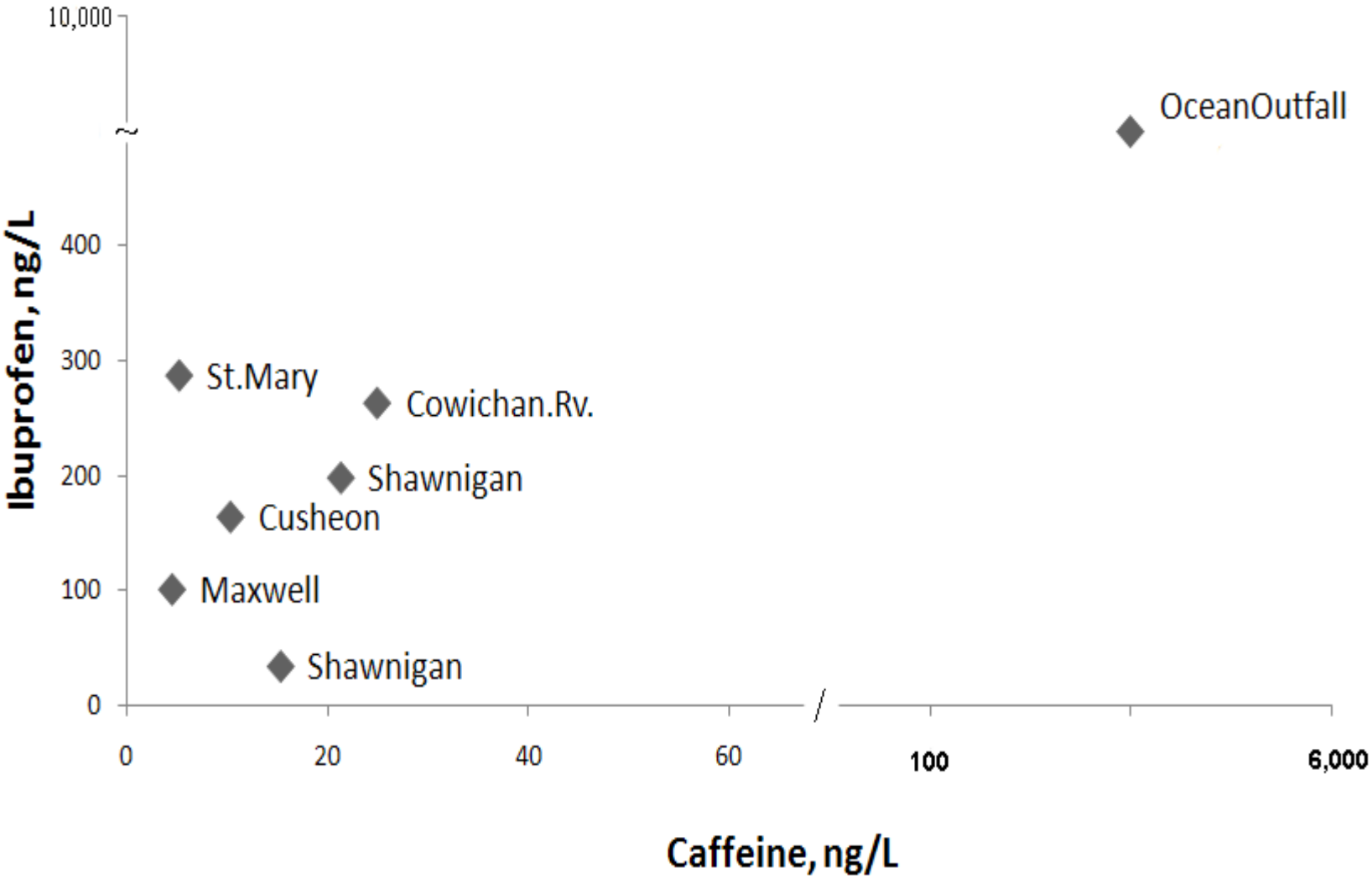
The relationship between Caffeine vs δ15N in mussel tissue also suggests Caffeine as a robust indicator of fecal contamination



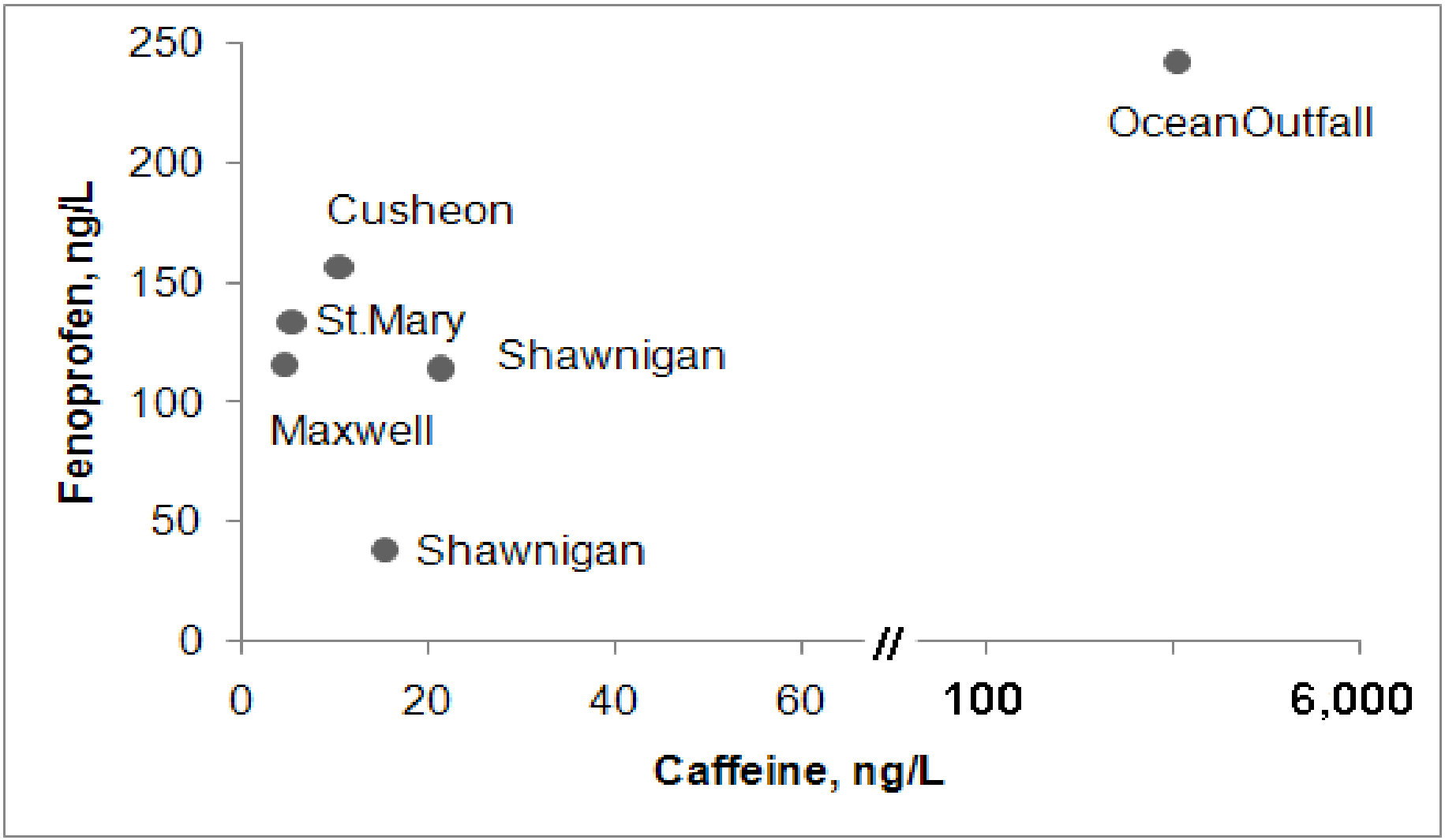
Relationship between Caffeine (ng/L) in source water and Residential Density (# of housing lots/km^2) on Vancouver Island



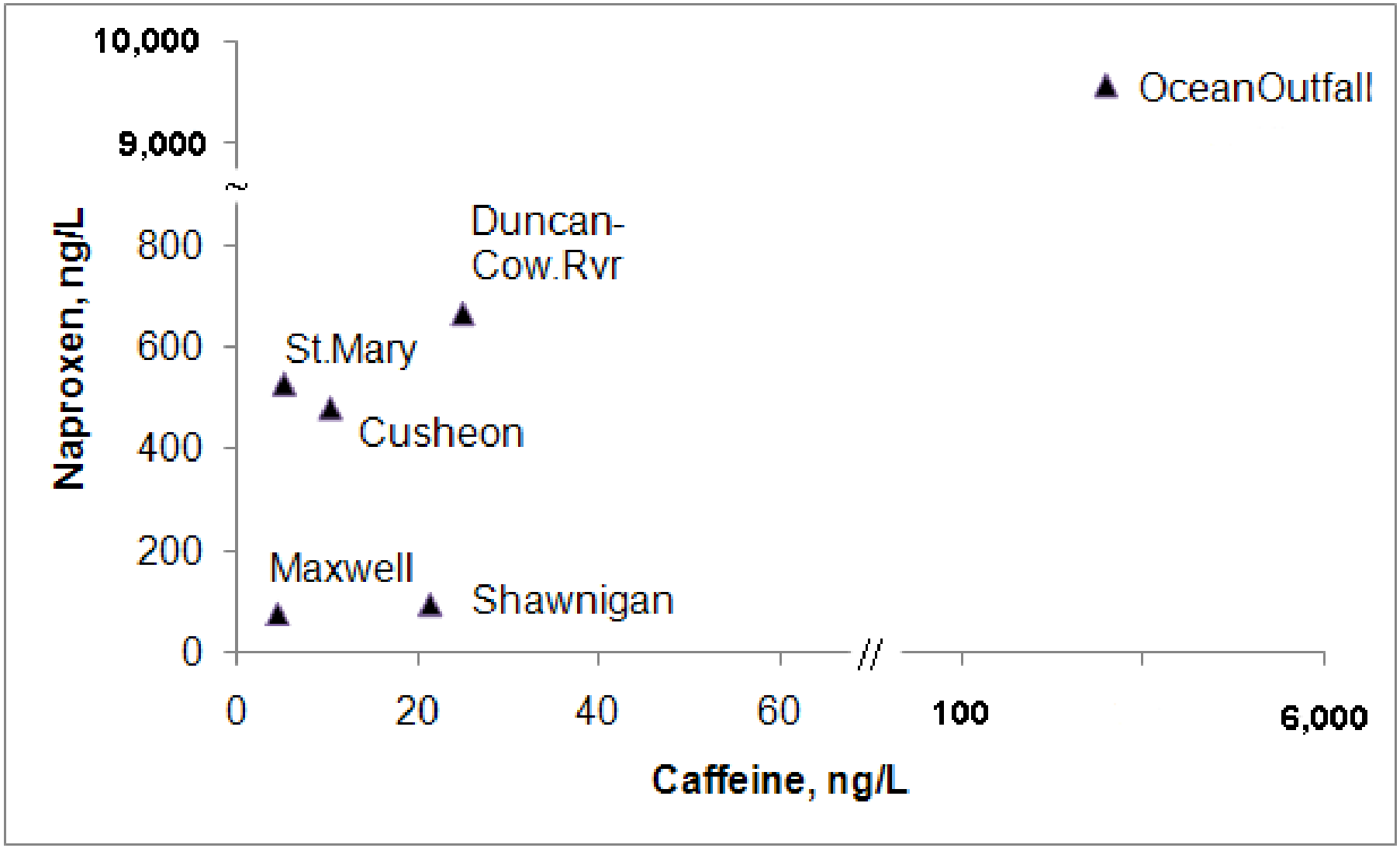
Ibuprofen (*analgesic & anti-inflammatory)* and Caffeine in Source Water several small water systems on Vancouver Island



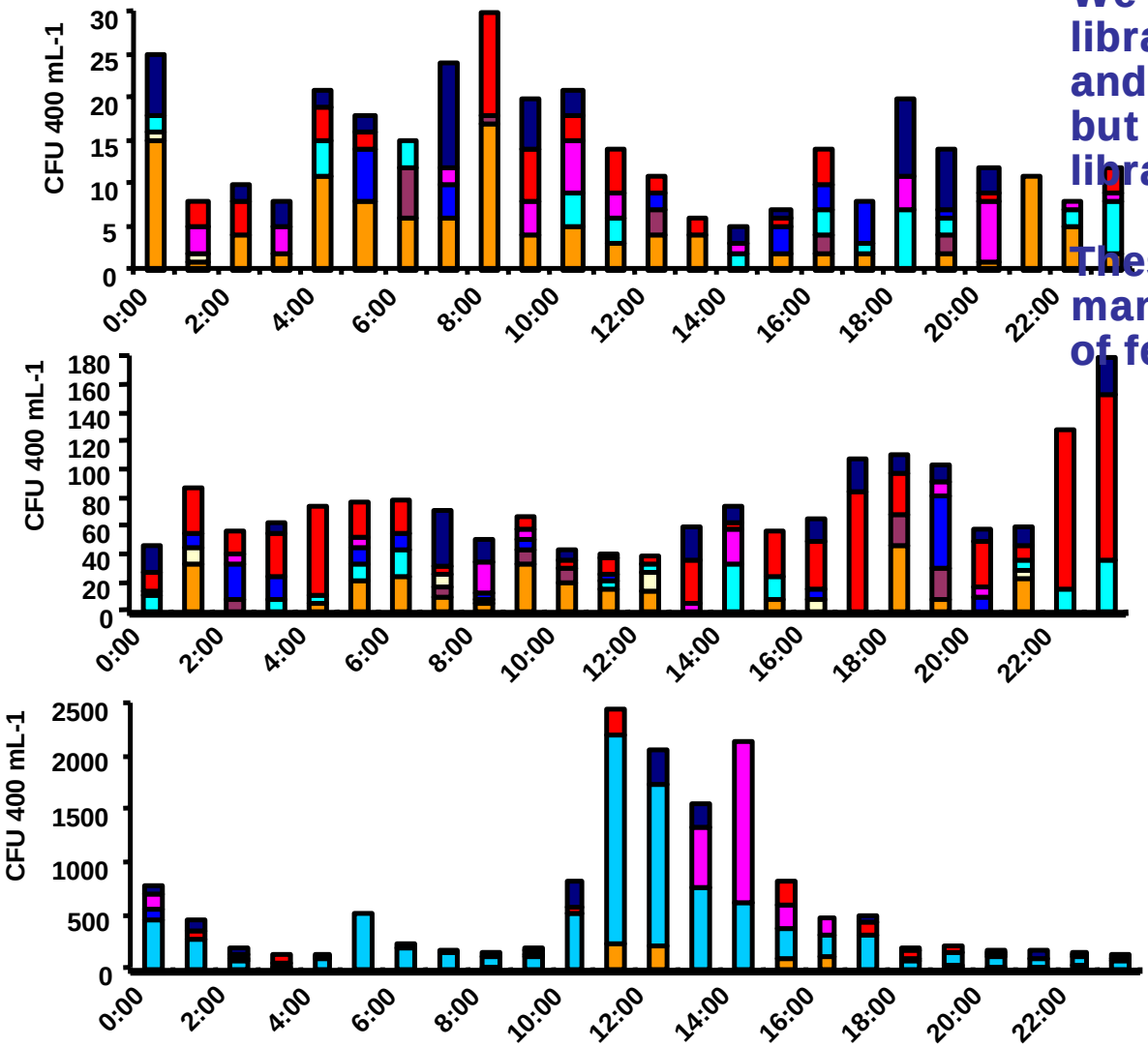
Fenoprofen (*analgesic & anti-inflammatory)* and Caffeine in Source Water several small water systems on Vancouver Island



Naproxen (*analgesic & anti-inflammatory)* and Caffeine in Source Water several small water systems on Vancouver Island



If you find fecal bacteria (*E. coli*) in your water, you could use genetic finger printing tools to detect sources of fecal contamination



We now have a molecular reference library covering all major domestic and wildlife fecal sources of *E. coli*, but need a much larger molecular library.

These are very powerful tools to manage risks from specific sources of fecal contamination.

Sources of fecal bacteria

- Unknown
- Rod/Beaver
- Raccoon
- Deer/Elk
- Canine
- Bovine
- Bear
- Avian

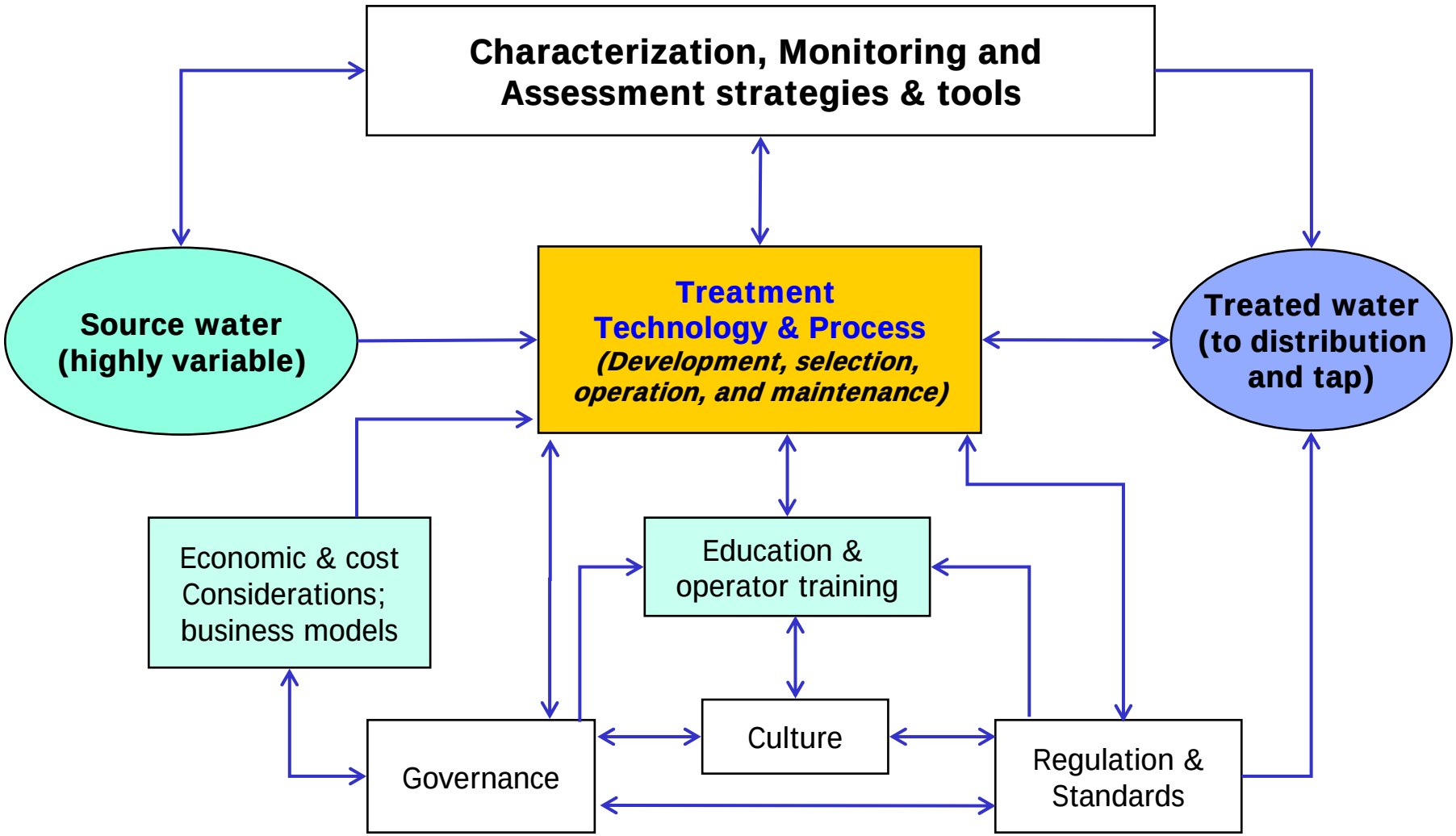
Three watersheds providing water to small communities: variable landuse show highly variable sources of fecal contamination of water

	Watershed		
Land use (ha)	Round Lake	Lakelse Lake	Cusheon Lake
Young forests (YF)	545	3200	619
Old growth forests (OGF)	18	22944	24
Recent logged forest (RLF)	92	7756	0
Selectively logged forest	57	40	0
Wetlands (WL)	0	1400	41
Agricultural crop (AG)	1807	0	73
Range land (RL)	28	0	4
Urban	0	1200	129
Recreation site (RS)	0	400	0
Burned area (BA)	0	40	0
Subalpine avalanche chutes (SAC)	0	1200	0
Alpine	0	320	0
Glaciers and snow (GS)	0	120	0
Water	190	1416	3
E. coli source (%)			
Avian	48.44	39.17	15.79
Bear	1.56	1.67	0
Beaver	0	0.83	0
Bovine	0	0.83	3.51
Canine	9.38	12.5	21.05
Deer	20.31	20	29.82
Dog	0	0	3.51
Elk/moose	7.81	3.33	0
Human	0	0	1.75
Horse	1.56	0	5.26
Moose	6.25	1.67	0
Llama/horse	1.56	0	3.51
Moose/deer	0	0.83	0
Raccoon	0	2.5	0
Rodent	3.13	15	14.04
Sewage	0	1.67	1.75

A Research Network Ensuring Safe Drinking Water for Canadian Small and Rural Communities

- Let me present you some details of this new network
- Discuss how we could partner with your province
- Develop partnership with small/rural communities from your province

Factors Influencing Delivery of Safe Drinking Water to SRCs



Mission of Réseau-Waternet

RES'EAU will develop, verify, and disseminate innovative technology platforms leading to adoption and implementation of *operator-friendly*, *cost-effective* processes that ensure clean and safe drinking water for small and rural communities

Specific Challenges to be addressed

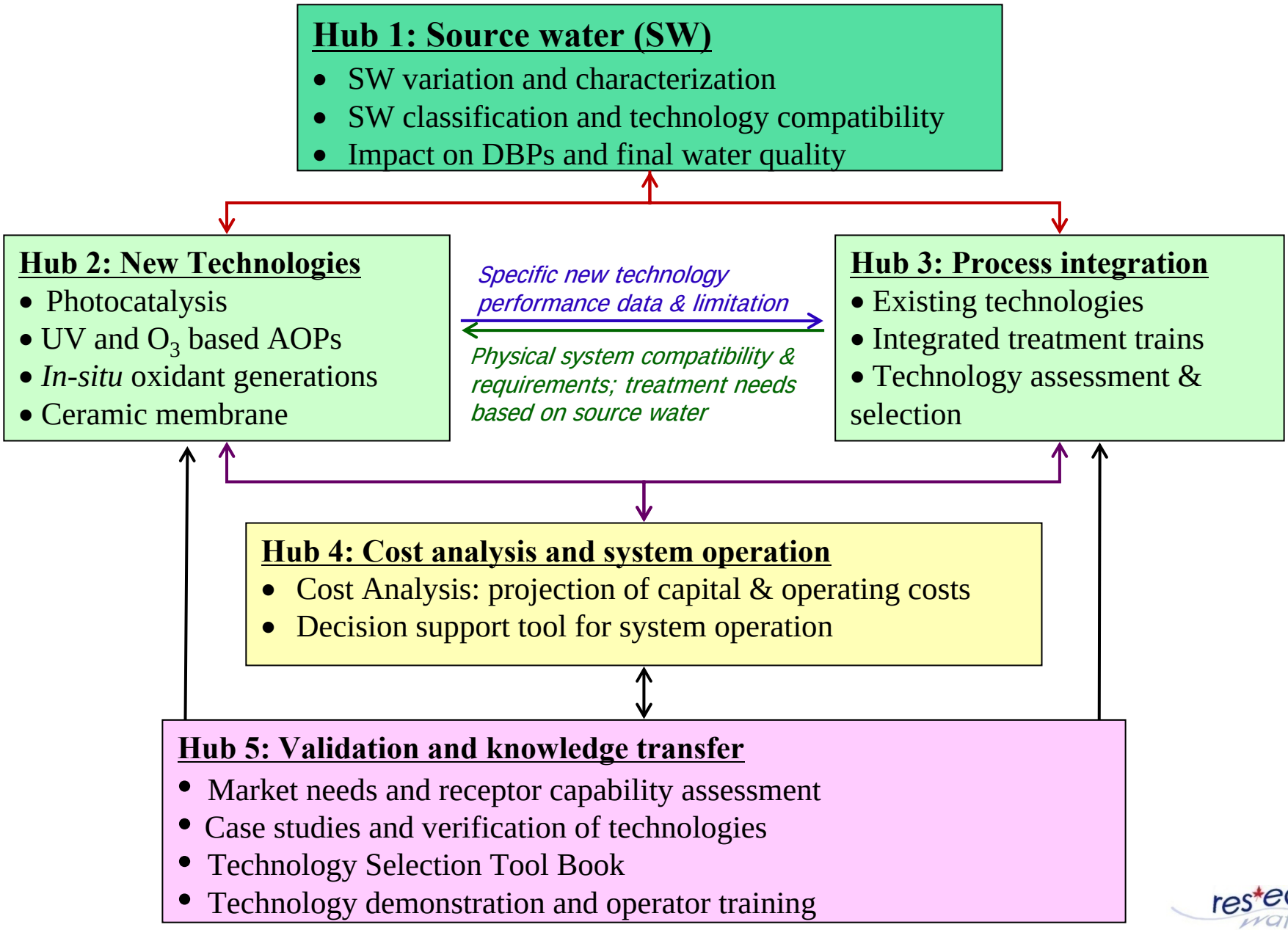
Technologies and processes must be:

1. Applicable to seasonally, annually and geographically variable of source water qualities
   - ***SRCs are widely distributed and each has its unique source water that varies seasonally and with climate***
2. Operator-friendly
3. Affordable and cost-effective to operate
4. Robust
5. Low in maintenance
6. Easily serviced with the assistance of remote expertise

Our Research and Knowledge Translation Network

- 18 research projects over 5 years
  - Grouped into 5 different *Hubs*
  - Significant interaction and networking among projects and *Hubs*

Network Structure



Our Network

- 14 university researchers and adjuncts
- 7 universities (in BC, AB, ON, and QC)
- 34 partners (in BC, AB, ON, QC and NL)
- 29 graduate students, 9 PDFs and many undergraduate students will receive training

Investigators

Gopal Achari	U of Calgary
Benoit Barbeau	Ecole Polytechnique
Pierre Berube	U of British Columbia
Mohammed Dore	Brock University
Elod Gyenge	U of British Columbia
Adam Holbrook	Simon Fraser University
Cooper Langford	U of Calgary
Asit Mazumder	U of Victoria
Madjid Mohseni	U of British Columbia
Manuel Rodriguez	Laval University
Rehan Sadiq	U of British Columbia (Okanagan)
David Wilkinson	U of British Columbia
Saad Jasim	Walkerton Clean Water Center
Troy Vassos	NovaTec

Our Partners

1. BC Water and Waste Association (BC WWA)
2. Canadian Water Network (CWN)
3. Canadian Water and Wastewater Association (CWWA)
4. **Department of Environment and Conservation (NL)**
5. Indian and Northern Affairs Canada (INAC)
6. Health Canada
7. Ministry of Community Services (BC)
8. Ministry of Environment (BC)
9. Ministry of Municipal and Community Affairs (NWT)
10. Ministry of Public Infrastructure and Renewal (ON)
11. Municipality of Brockton (ON)
12. Municipality of Bowen Island (BC)
13. National Water Research Institute (NWRI)
14. Ontario Centres of Excellence (OCE)
15. Ontario Centre for Environmental Technology Advancement (OCETA)
16. Ontario Clean Water Agency (OCWA)
17. Ontario First Nations Technical Services Corporation (OFNTSC)
18. Public Health Agency of Canada (PHAC)
19. Small Water Users Association of BC
20. Walkerton Clean Water Centre (WCWC)

1. BI Pure Water (Canada)
2. HF Research
3. Innovotech
4. Joule Microsystems
5. John Meunier
6. KWL Associates
7. Litebook Company
8. NovaTec Consultants
9. Simpson Environmental
10. Trojan UV
11. Veolia Water Canada
12. Zenon-GE
13. UltraFab Industries
14. Klaris Corp

reseau waterNET

Knowledge transfer

- Knowledge transfer and exchange is built-in within the ***RES'EAU*** network and its projects
  - There is a strong component of knowledge creation (i.e. technology development/evaluation)
  - Dissemination of knowledge and technology is considered key and most challenging
- Primary audience for knowledge transfer are:
  - Small utility managers and decision/policy makers
  - Small system operators
  - Technology developers and consulting engineering firms
- Knowledge exchange with regulators and policy makers will be a priority

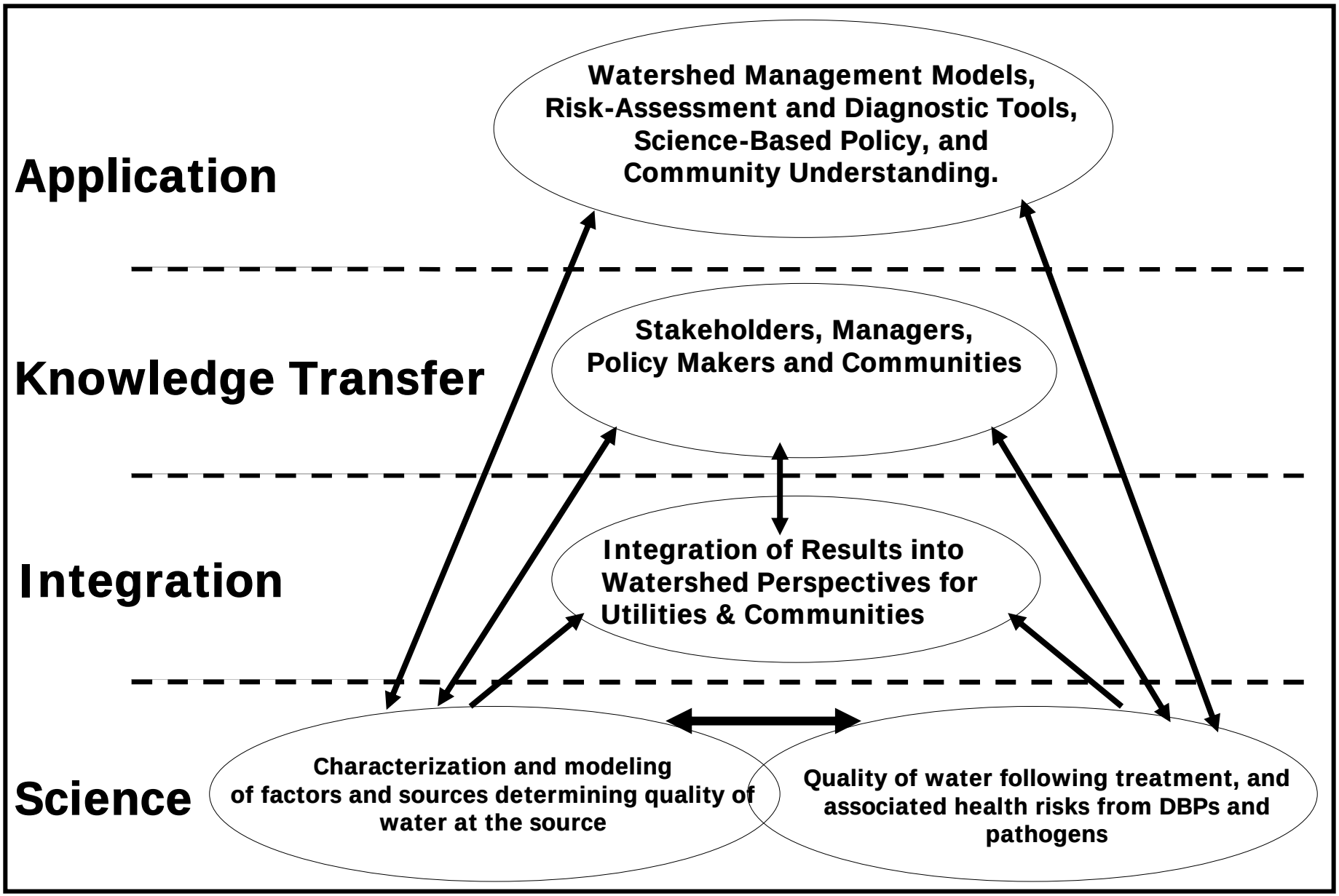
Proposed methods of knowledge transfer

- Direct contact and interaction with partners and stakeholders
- National workshops & annual meeting
  - Three workshops over 5 years
- Technology demonstration and operator training programs
  - In collaboration with key partners (e.g. WCWC, NovaTec)
- Technology Adoption Toolbook
  - Distributed among partners, small utilities, government agencies responsible for or connected to drinking water quality and management in small systems
- Provincial, territorial, and federal government information portals
- Professional organizations (CWWA, BC WWA, OFNTSC)

To address the issue of

Source to tap characterization and modeling of water quality for small Canadian communities:

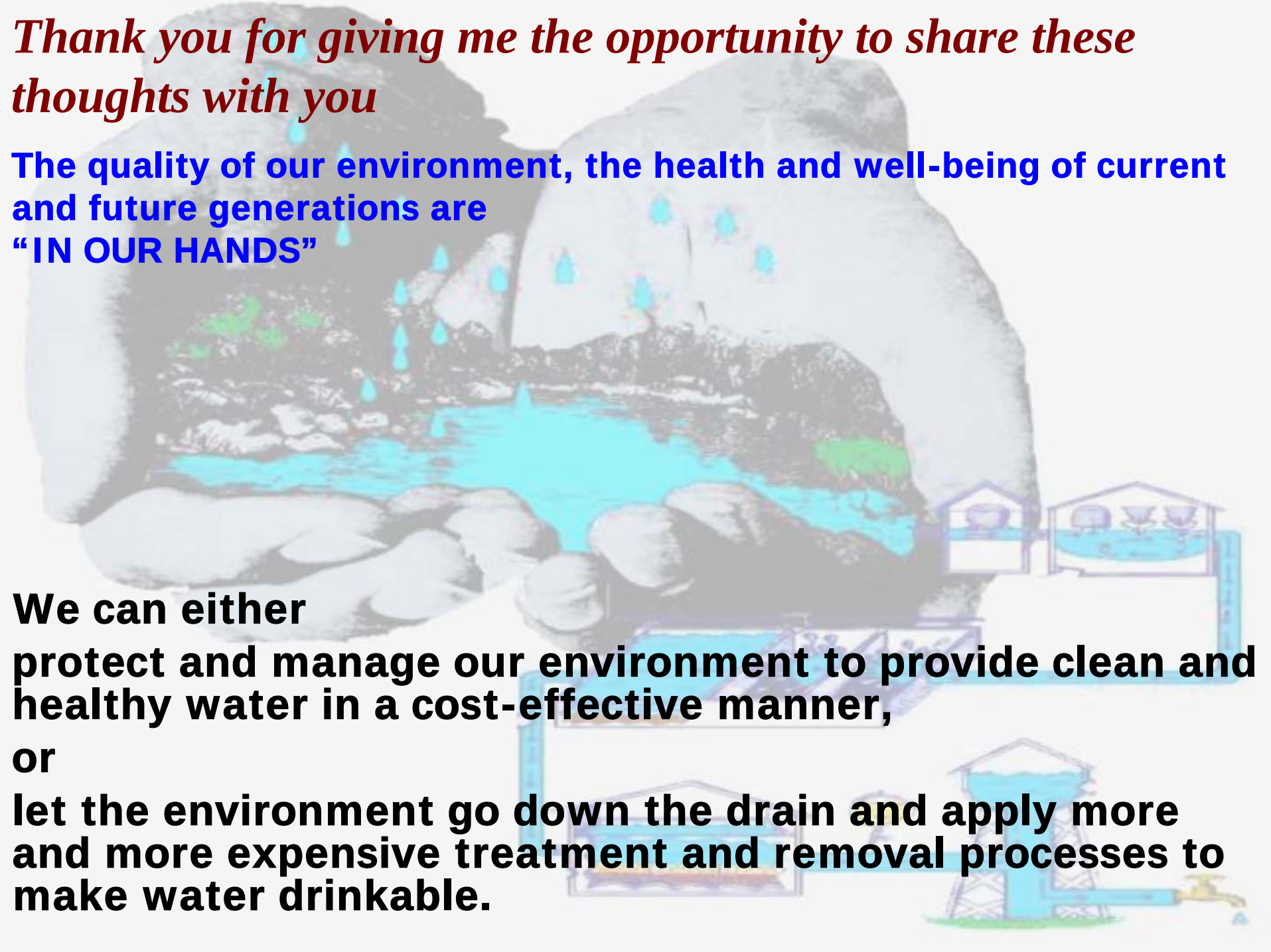
- **We have planned to include 60 small communities in the three provinces (NL, QC and BC) that use surface water as drinking water source;**
- **We are hoping that we (a few of us from Réseau-Waternet) could come back to meet some of the communities who would be interested in participating as community partners;**
- **Through this program, we will generate source- and tap-water quality data in relation to landuse and climate variability, and apply these results to assess community vulnerability and assist communities to develop optimal water treatment systems that accounts for variable water quality.**



The overall objectives and framework of our research program under Réseau-Waternet

Thank you for giving me the opportunity to share these thoughts with you

The quality of our environment, the health and well-being of current and future generations are
"IN OUR HANDS"



We can either

protect and manage our environment to provide clean and healthy water in a cost-effective manner,

or

let the environment go down the drain and apply more and more expensive treatment and removal processes to make water drinkable.