Approximating the Fate of Arsenic from Drinking Water Supplies in Maine

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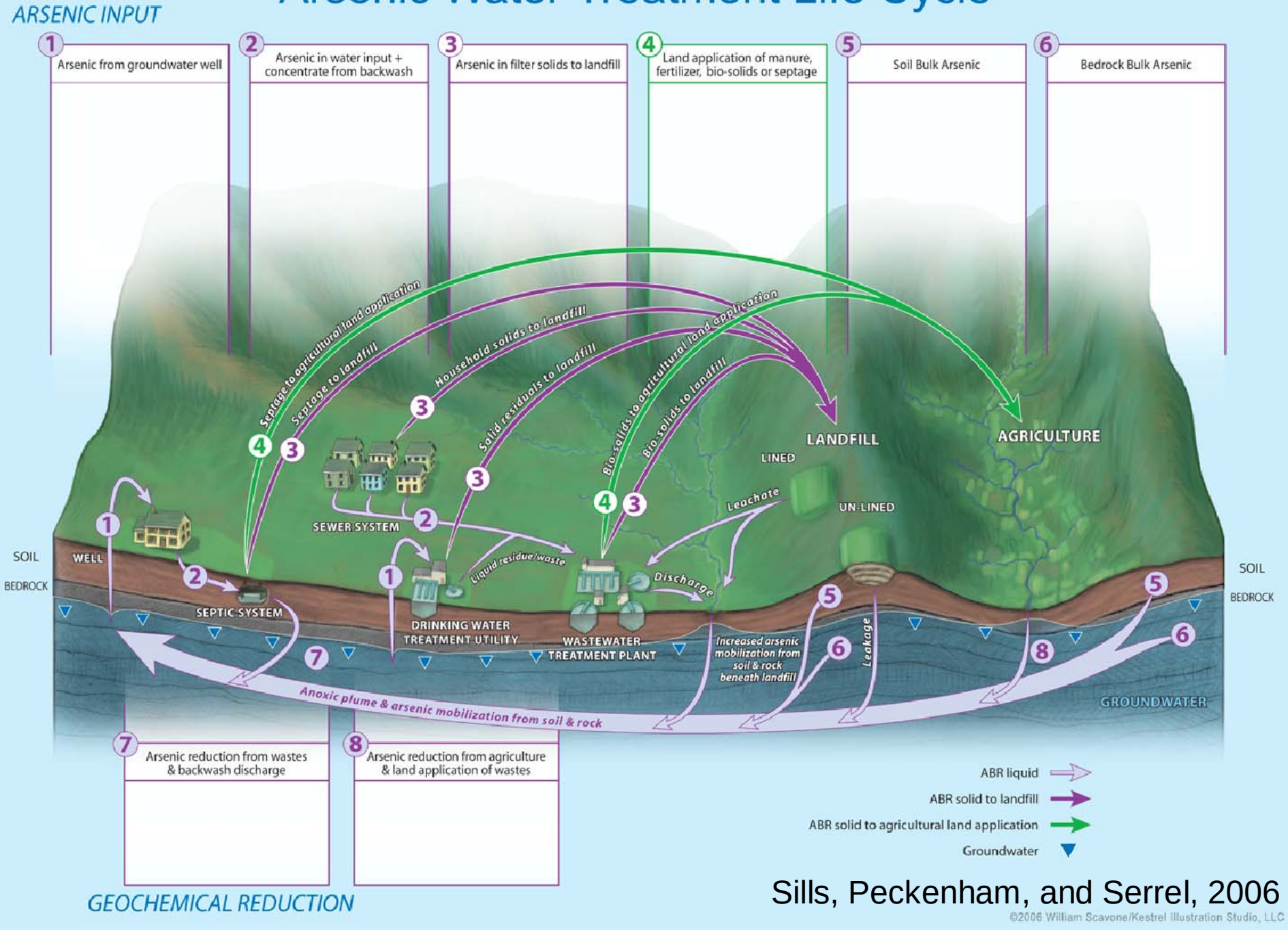
1865 THE UNIVERSITY OF MAINE

Senator George J. Mitchell Center
for Environmental and Watershed Research

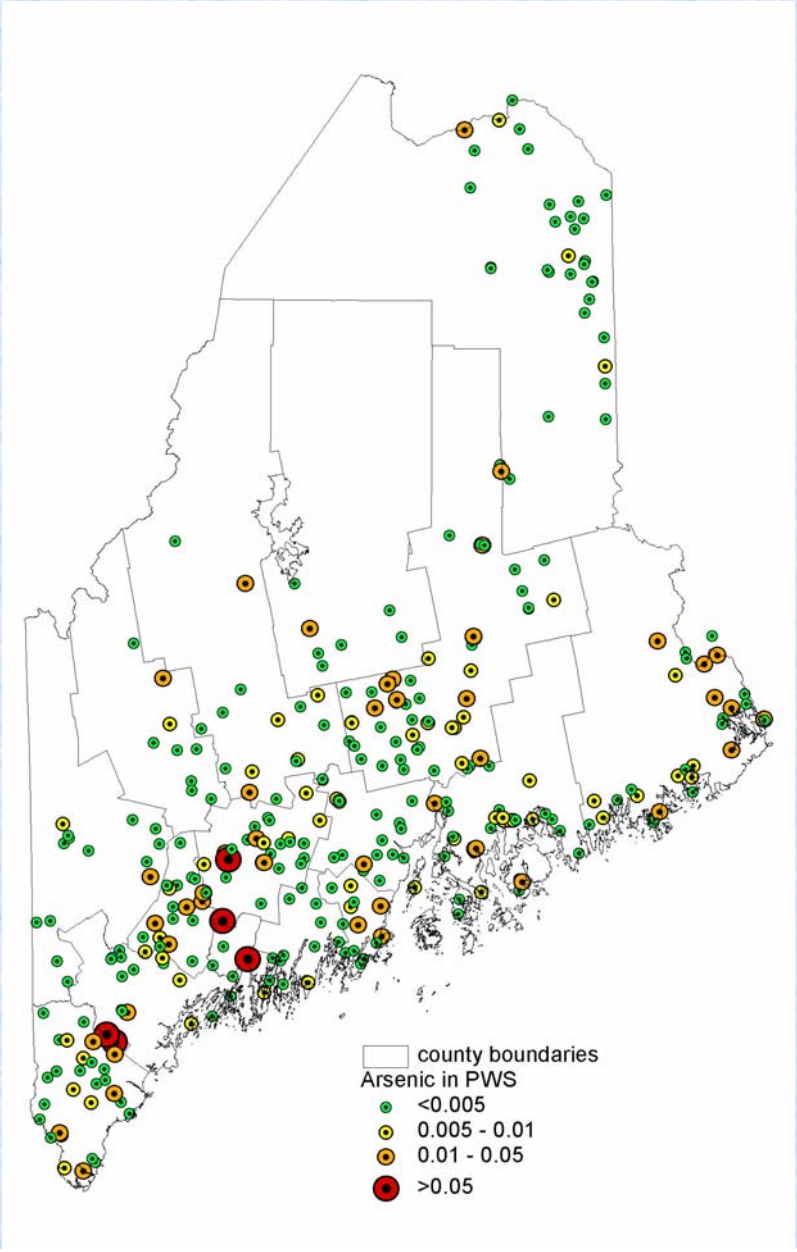
- Defining the problem.
- Drinking water treatment.
- Domestic arsenic transfers.
- Fate of arsenic-bearing residuals.

Arsenic Water Treatment Life Cycle



Sills, Peckenham, and Serrel, 2006

ARSENIC IN MAINE'S GROUND WATER



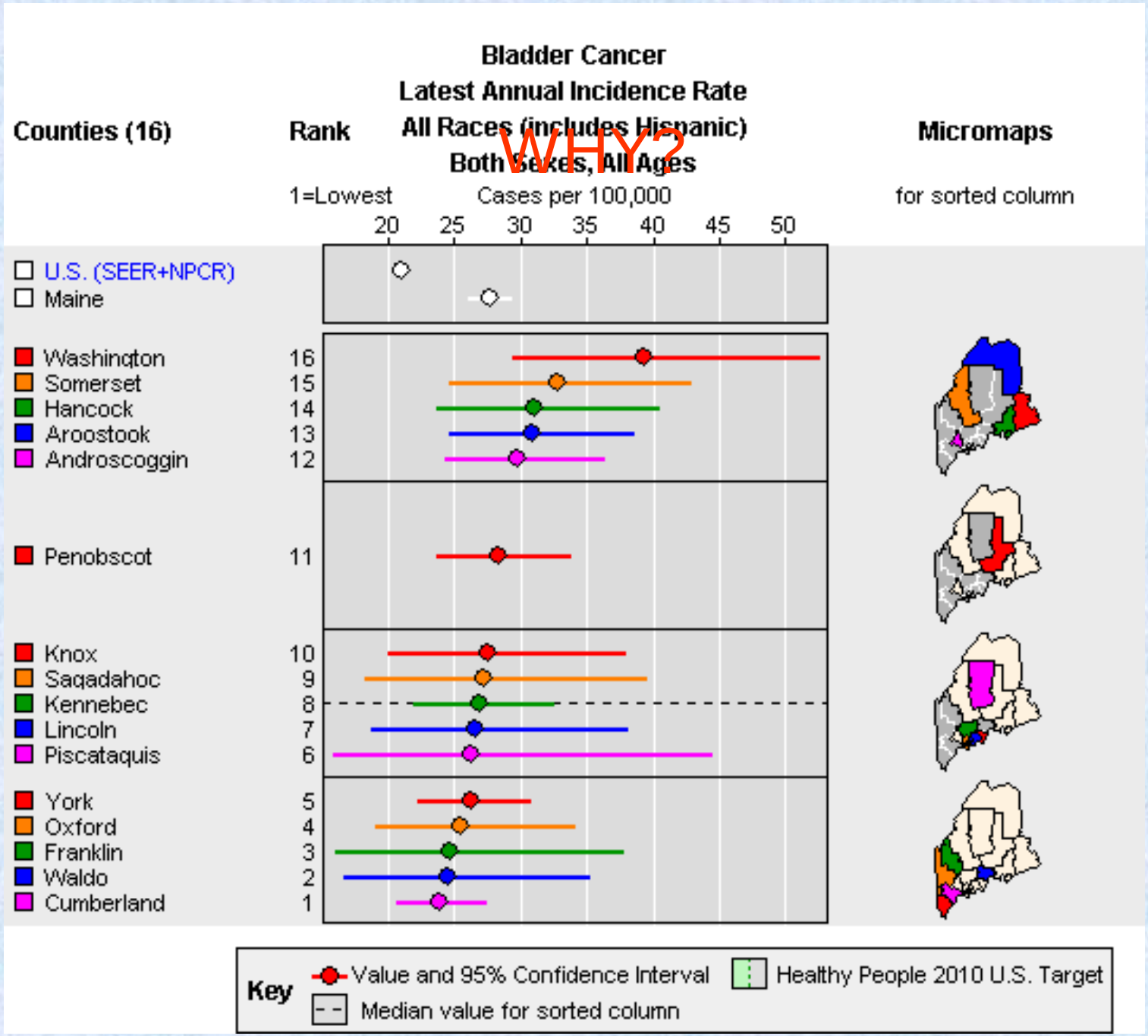
Review of Statewide

Public Well

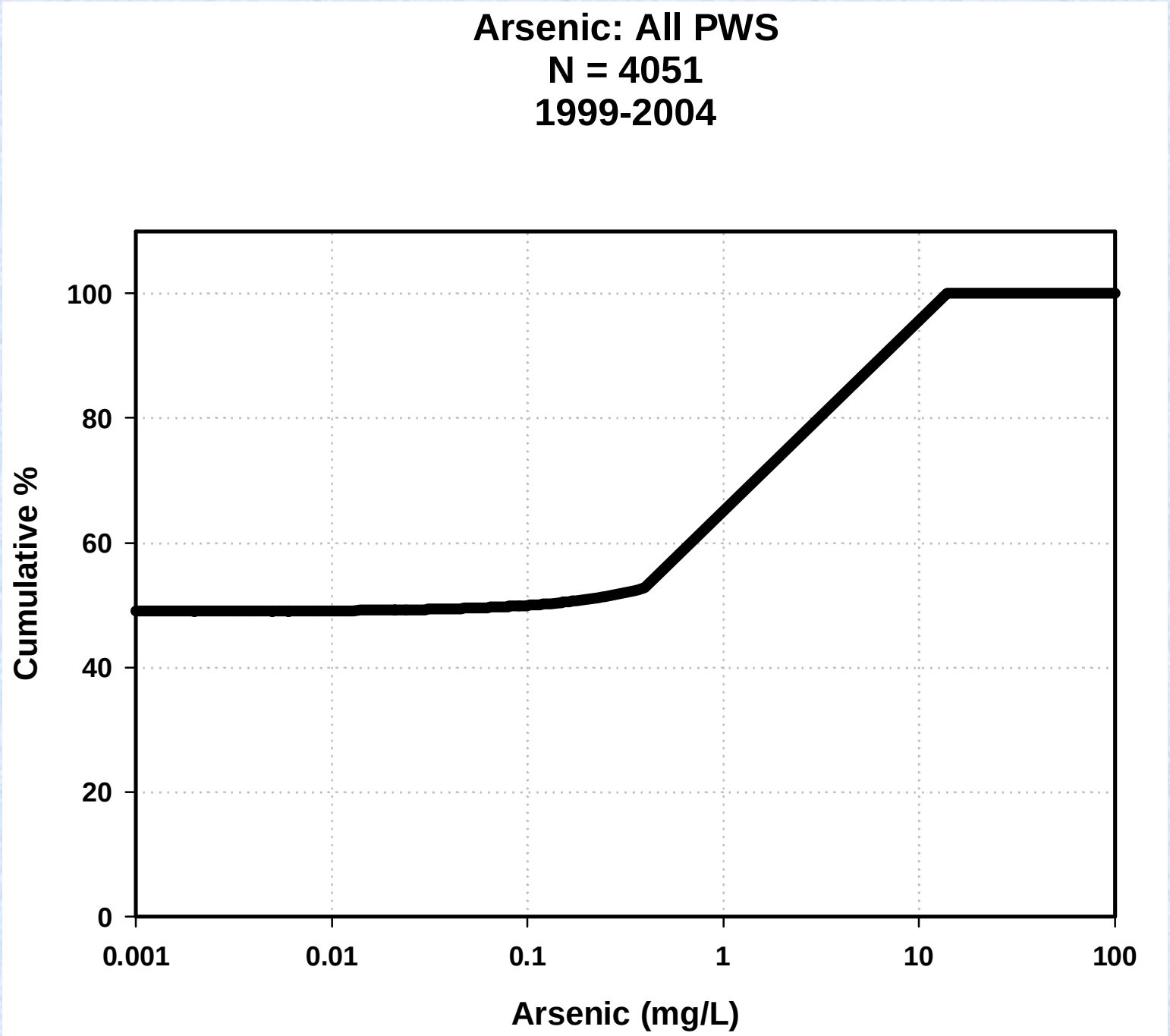
Test Data

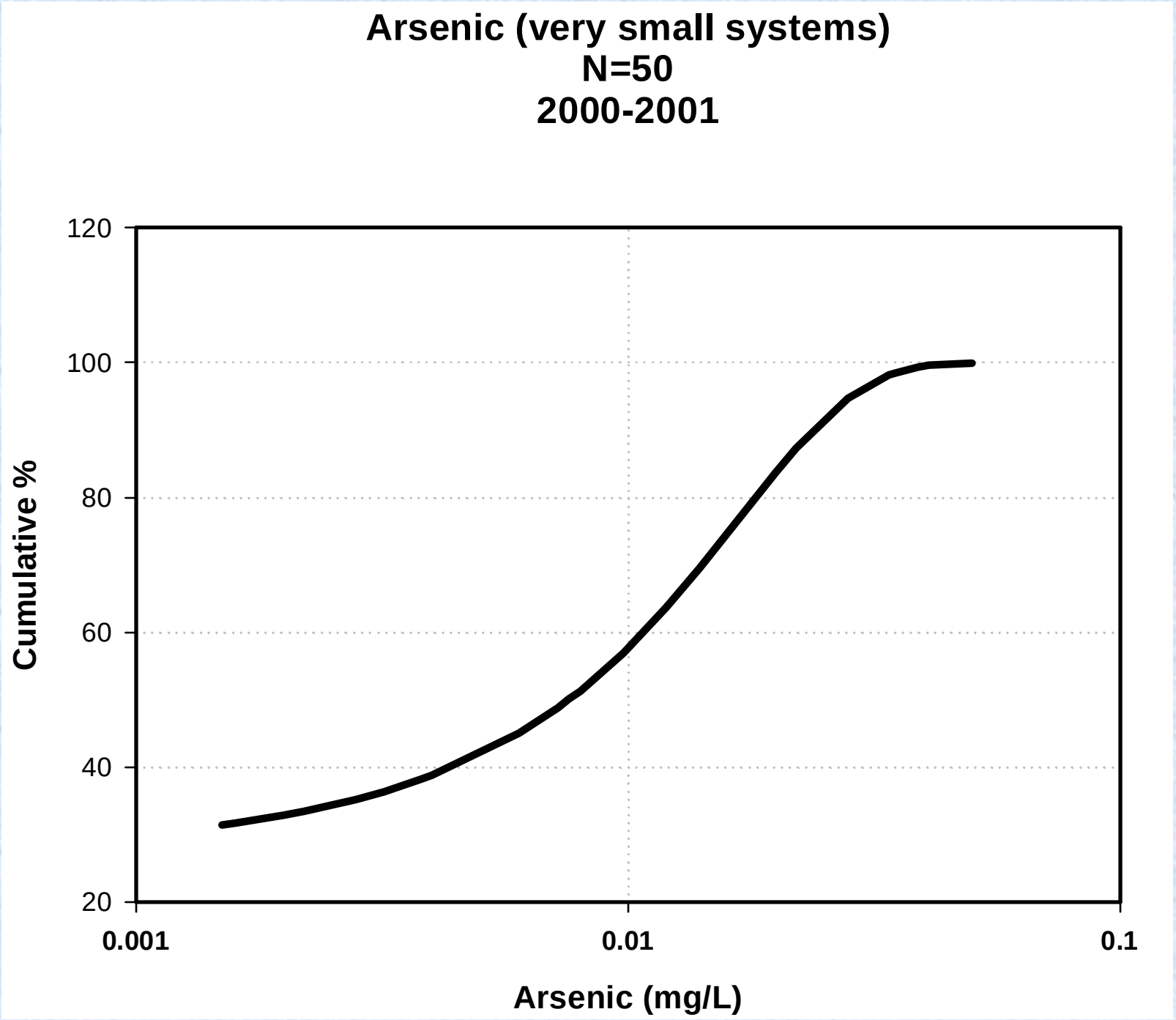
Source Water

- 2 % > 50 ppb
- 16 % > 10 ppb
- 36 % > 5 ppb



Map courtesy of SEER, 2006


Arsenic: All PWS
N = 4051
1999-2004
Cumulative %
100
80
60
40
20
0
0.001
0.01
0.1
1
10
100
Arsenic (mg/L)


Arsenic (very small systems)
N=50
2000-2001
120
100
80
60
40
20
Cumulative %
0.001
0.01
0.1
Arsenic (mg/L)

Maine 2005 Census Estimates

- Population: 1,320,505
- Households: 518,200

- PWS supply ~ 500,000 people
  - ~200,000 households

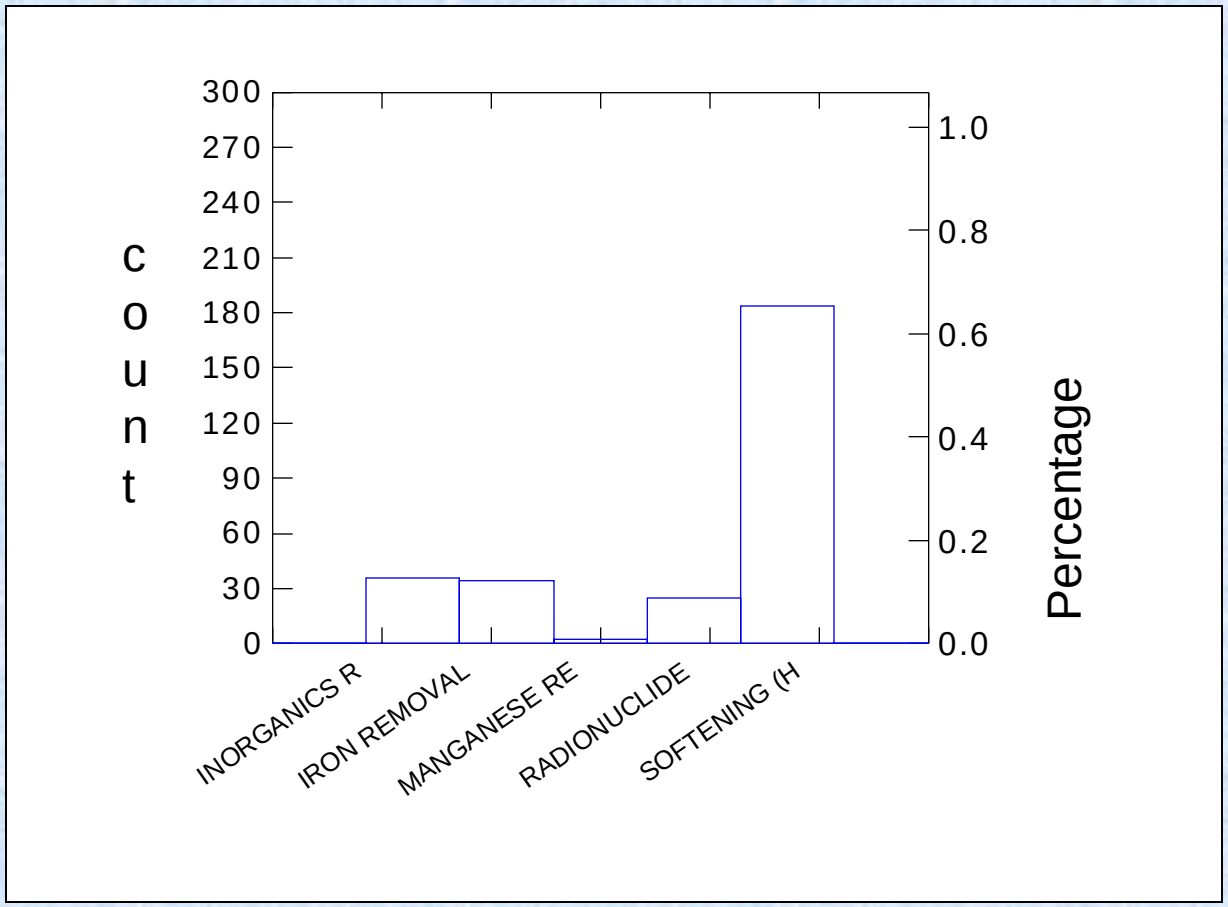
- Private Wells: ~300,000

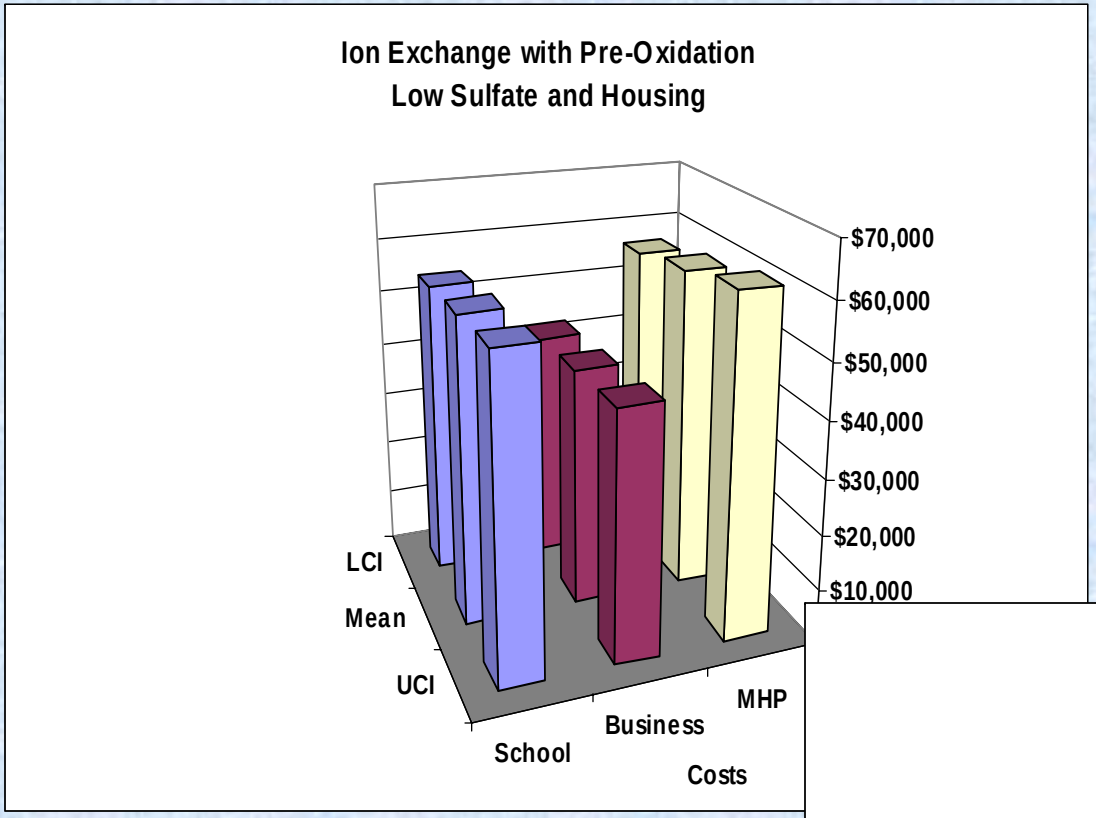
TECHNOLOGIES USED IN MAINE

Type	Location	Capital Cost	O/M Cost	Life Cycle (years)
Activated Alumina	POU	$600	$1,000	~
Reverse Osmosis	POU	$900	$150	3-5
Reverse Osmosis	POE	$9,000+	~	3-5
Iron Based Sorbent	POU	$450+	$100+/-	2-4
Iron Based Sorbent	POE	$1,750+	$100+/-	2-4

⇒Costs Drive Technology Selection

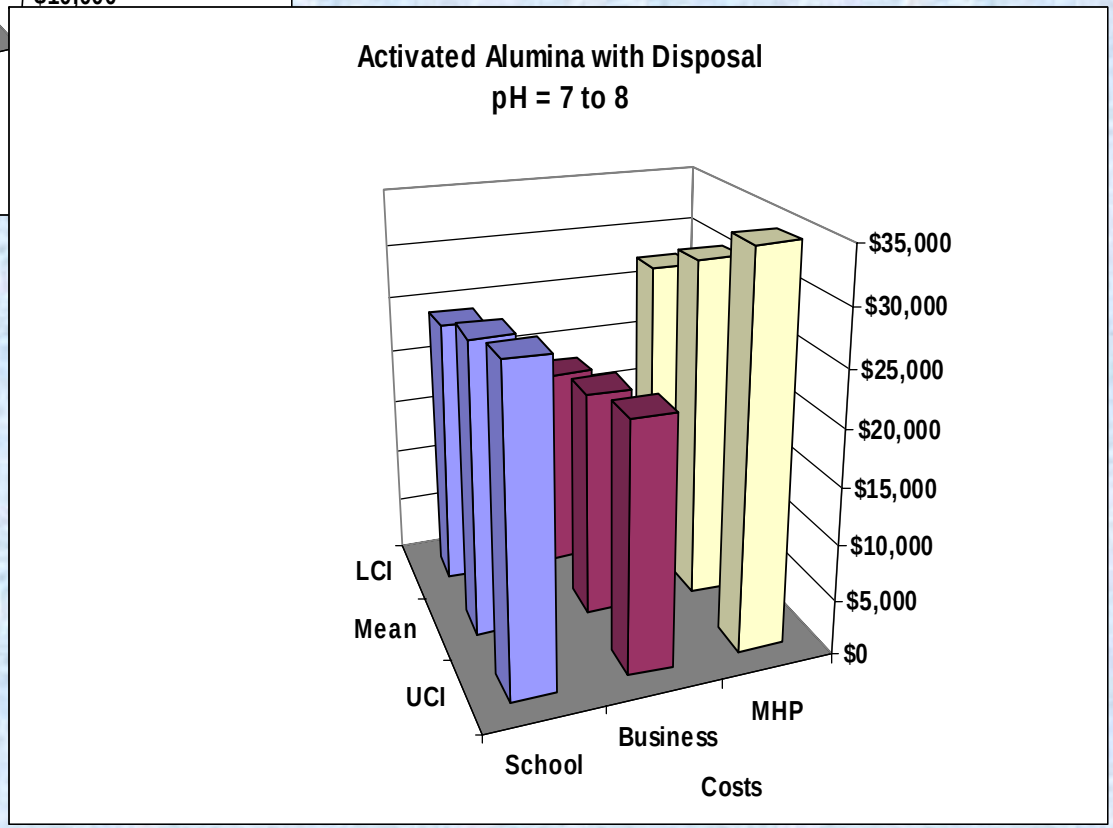
Removal Techniques in PWS (N = 281)





Arsenic Removal Costs for Small PWS

$20,000 to $60,000/year.



WATER USE

Schools = 20 gallons/person/day

Businesses = 15 gallons/person/day

Mobile Home Parks = 65 gallons/person/day

Based on USGS Estimates.

ABR 1st Approximation Private Wells

- 35% of wells >0.01 mg/L As
- 65 gpd/person = 163 gpd/household
- 300,000 households
- Range of Arsenic 0.01 to 0.05 mg/L

Low Estimate = **0.65** kg/day
High Estimate = **3.2** kg/day

ABR 1st Approximation
Small Public Supplies Using Wells

- 16% of wells >0.01 mg/L As

- N = 59 Community Supplies
- N = 72 Non-Community Supplies

- Mean Community Arsenic = 0.033 mg/L
- Mean Non-Community Arsenic = 0.023

Small Community Estimate = **1.5** kg/day
Non-Community Estimate = **0.027** kg/day

Sources & Sinks

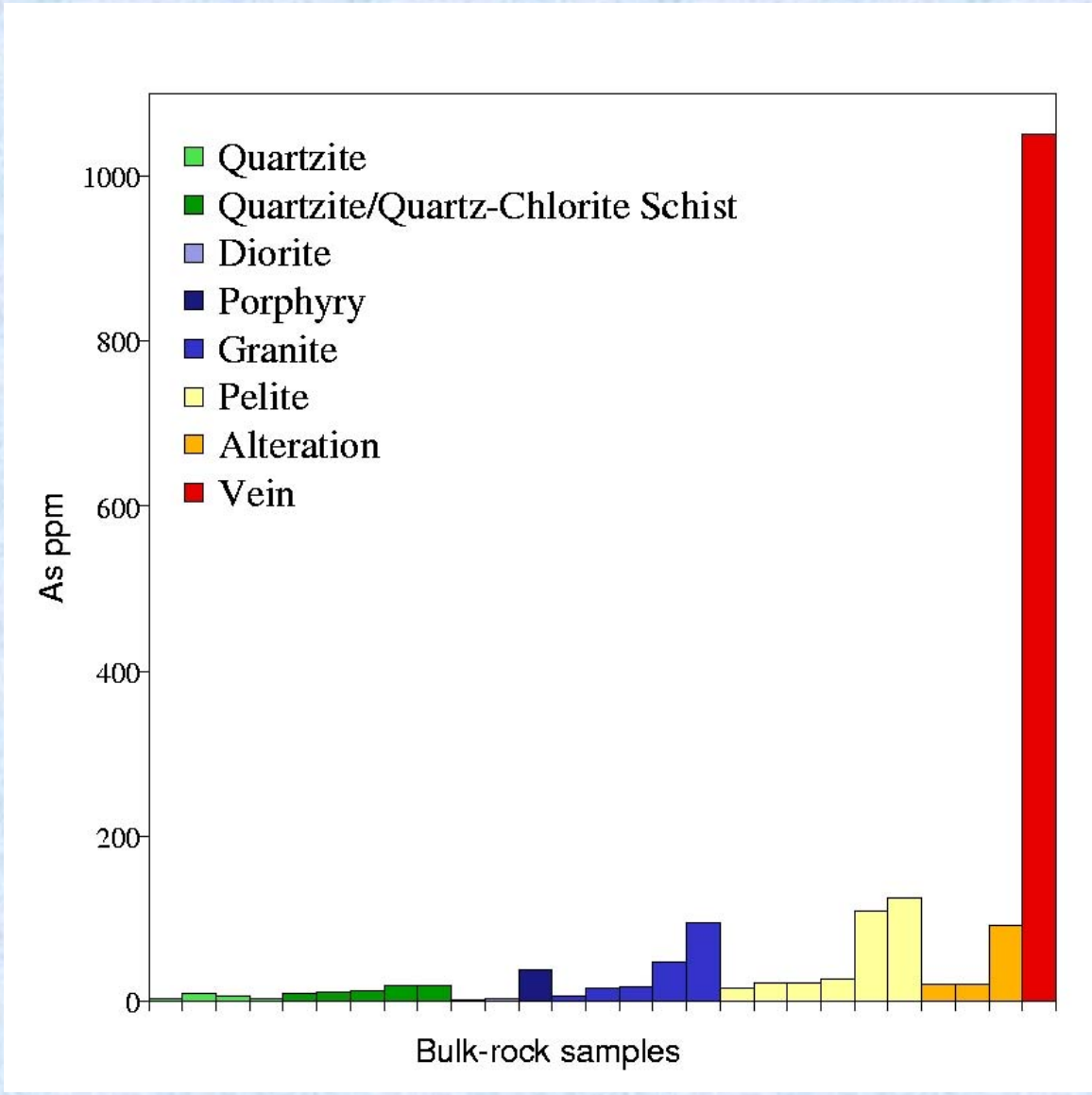
(research needed)

- Sources
  - Native Geology
  - Secondary Mobilization
    - Agriculture (former use of pesticides & biosolids)
    - Land Disposal of Arsenical Materials

Sinks

Septic Systems (20 to 100%)
WWTP (up to 100%)
Landfills (20 to 80% diverted from POU/POE)

Bulk-rock As concentrations (Northport, Maine)



Courtesy of Gail Lipfert, 2006

Septic tank processes affecting As

Average waste-water retention times = 3.1 days

Effluent

Expect:
- Reduction of As(V)
- As adsorbed to OM
- As complexed with OM
- Formation of organoarsenic acids

Solids

As removed from solution by adsorption onto OM.

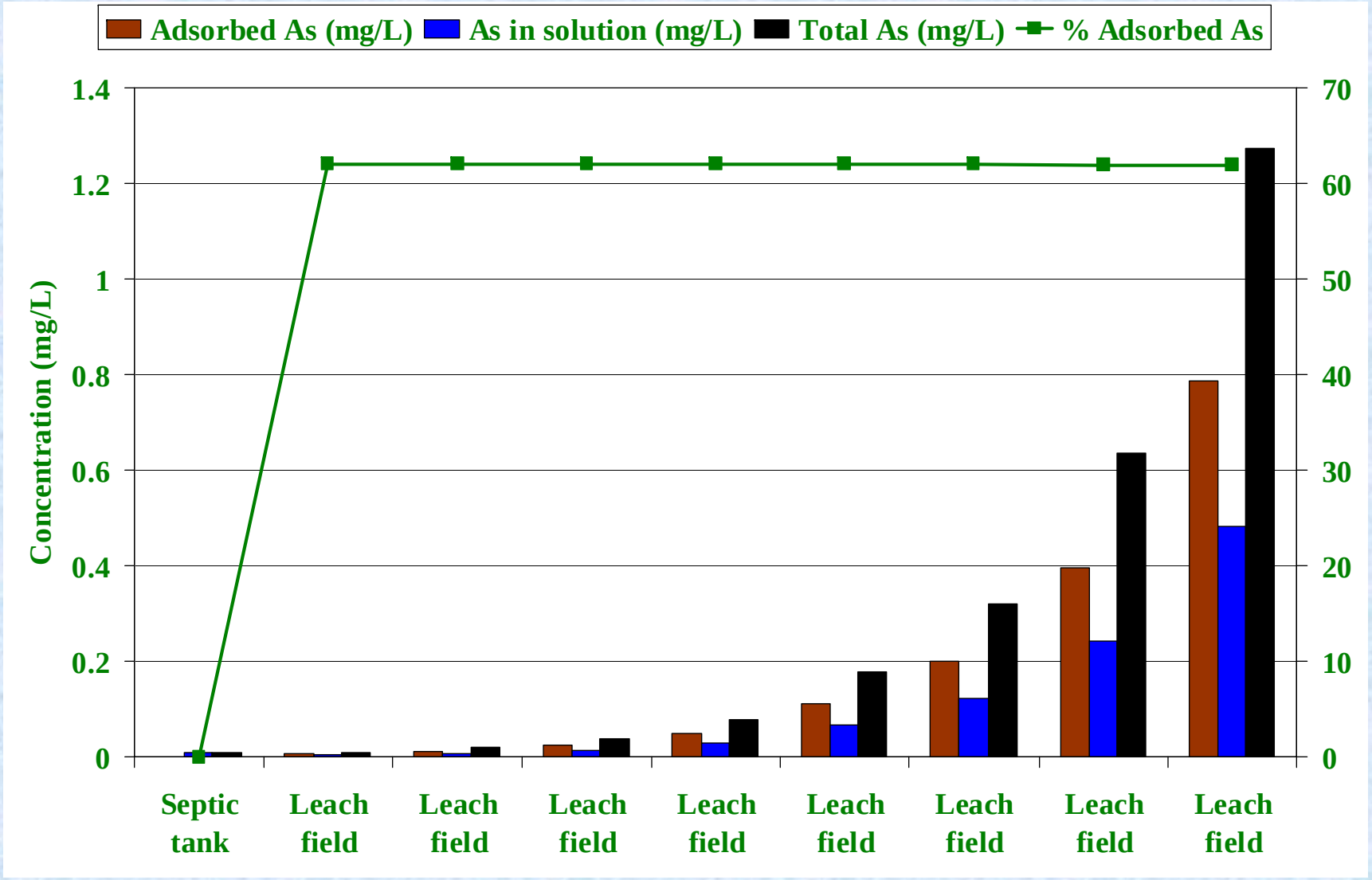
Microbes

As in septage: 6-9 ppm

Lipfert and Peckenham, 2007

Arsenic in the leach field

- PHREEQC batch model assumptions:
  - All OM is oxidized
  - Equilibrium with atmospheric O2
  - Same N, P, other cations and anions as septic effluent
  - (Based on Wilhelm et al., 1994, 1996)
  - Surface complexation model (Dzombak and Morel, 1990)
  - Surface sites: 0.1 mol/mol Fe (Stollenwerk and Colman, 2003)


Adsorbed As (mg/L)
As in solution (mg/L)
Total As (mg/L)
% Adsorbed As
Concentration (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
70
60
50
40
30
20
10
0
Septic tank
Leach field
Leach field
Leach field
Leach field
Leach field
Leach field
Leach field
Leach field

Closing Thoughts

- Total Daily Arsenic Passing Through Private Homes and Schools.

☹ 2.2 to 4.7 kg/day

Amount of Arsenic needed to affect

one household for 1 year ≅ 2.25 g.

Based Upon Mass Balance,

If ABR Recycles in the Environment

1,000 + Additional Households/Year Will Be Affected.

Plus: Fe, Mn, U, Ra,…

Information and Support Provided by:

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CONTRACTORS SUPPLYING INFORMATION

Advanced Quality Water Solutions

Air and Water Quality, Inc.

Aroostook Water Care, Inc.

Everett J. Prescott, Inc.

Haskell's Water Treatment

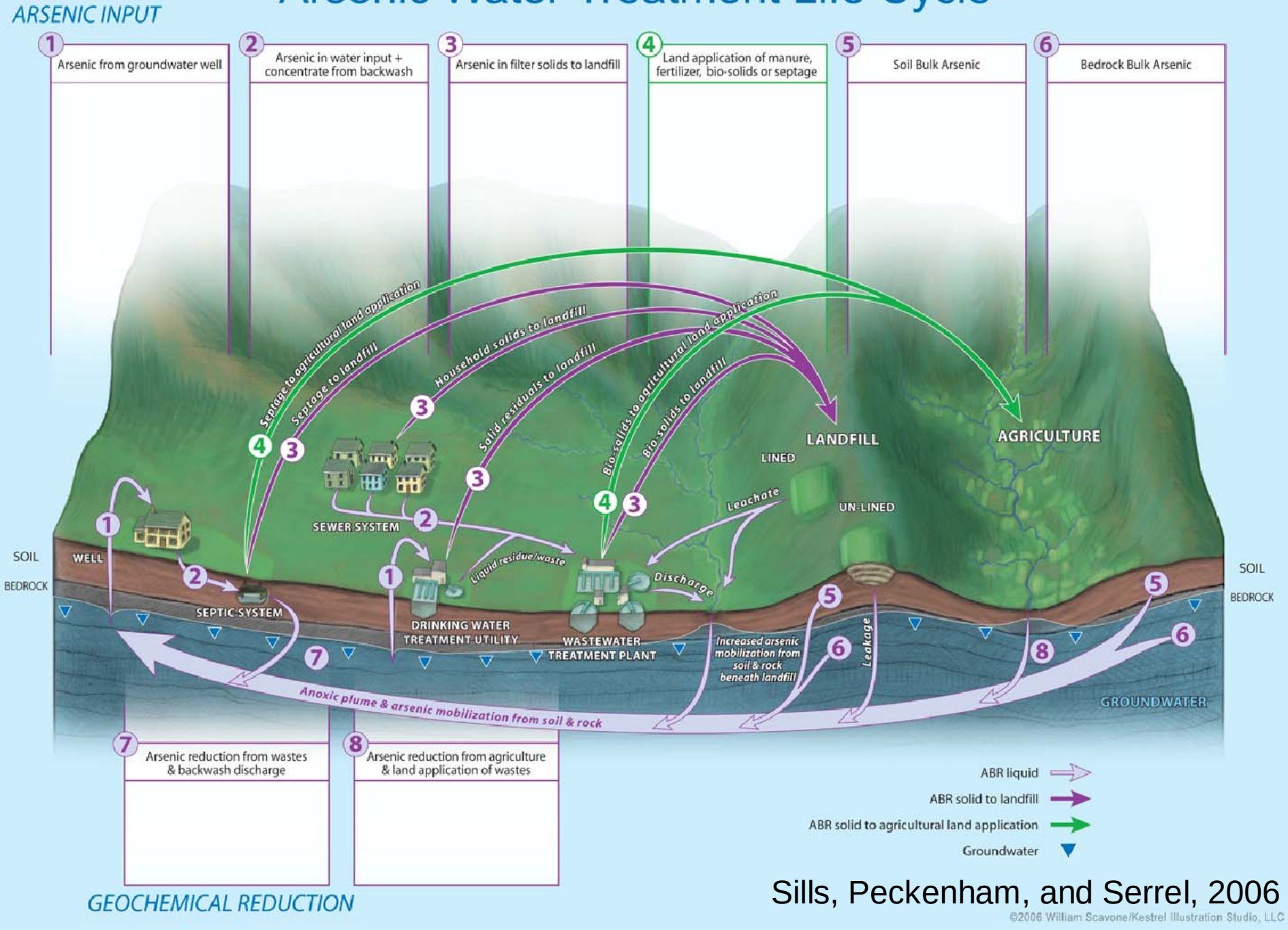
Lowry Aeration Systems

Main Source Water Treatment

Norlens Water Treatment


Quot Homines, Tot Sententiae
(Publius Terentius Afer).

Arsenic Water Treatment Life Cycle



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