Drinking Water Quality:

-Findings of the U.S. Geological Survey
-Challenges for Future Monitoring Activities
-Thoughts on NCS Collaborations

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U.S. Geological Survey

Mission: The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

<u>Water Discipline:</u>

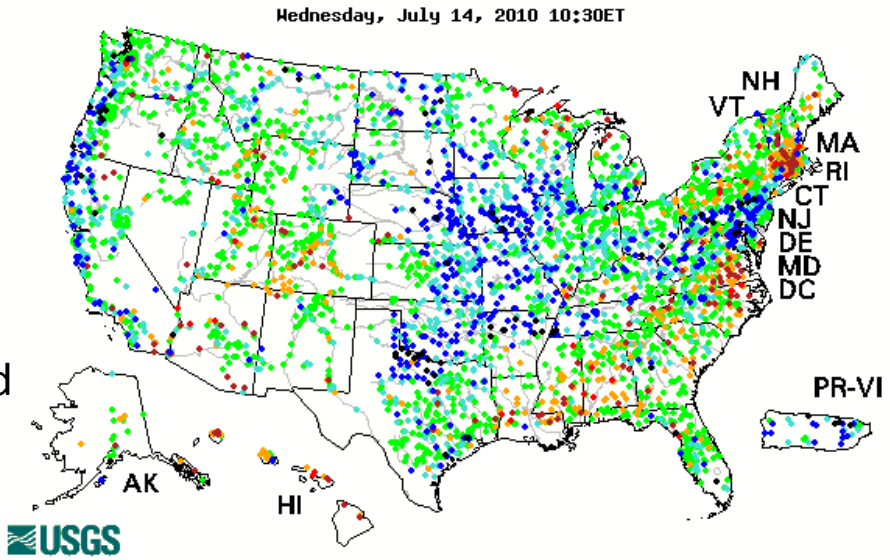
National Programs

- National Research Program
- National Water Quality Assessment Program
- Toxic Substances Hydrology Program

State Water Science Centers

National Water Information System – NWIS

- Nationally Consistent Database
- Collected With Common Field Protocols
- Analyzed by Common Laboratory Method
- Subject to Common Field and Lab QA/QC



Map of real-time streamflow compared to historical streamflow for the day of the year (United States)

The U.S. Geological Survey has monitored ambient, source, and drinking waters across the nation in various environmental settings for decades

General Findings

•thousands of sites across U.S.

•hundreds of analytes

•nationally consistent methods and protocols

-A range of anthropogenic and naturally occurring contaminants are present as mixtures in low levels (~parts per billion and lower) in ambient, untreated, and treated drinking waters from private as well as public supplies

-These contaminants are derived from many industrial, agricultural, municipal, domestic, and other sources.

-Naturally occurring inorganics (e.g. arsenic, radionuclides) are the most frequently detected above drinking water standards

-Some hydrogeologic settings are more vulnerable than others

-Some anthropogenic activities can increase the mobility of contaminants (i.e. factors other than source)

-Conventional treatment and source-water management can decrease vulnerability to some but not all contaminants

-Drinking water standards and(or) human-health benchmarks do not exist for many of the contaminants we detect

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Prioritizing Chemicals for Contaminant Research

1. Occurrence (predicted or known)
   - Production Volume
   - Prescriptions, other uses
   - Physical/Chemical Properties

2. Toxicity (predicted or known)
   - Conventional (e.g. carcinogenicity, etc.)
   - Emerging (e.g. endocrine disruption, etc.)

3. Stakeholder input and expert advice
   - U.S. EPA, FDA, etc.
   - Academicians and other researchers

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Monitoring Networks Are Designed to Test Hypotheses Related to Study Objectives

- Reconnaissance - *e.g*. "Are the contaminants present in selected drinking waters?"
- Targeted - *e.g*. "Is contaminant occurrence related to land use?"
- Probabilistic - *e.g*. "Are data representative of unmonitored sites?"
- Retrospective – *e.g.* "Are spatial or temporal patterns evident?"
  --Data Mining

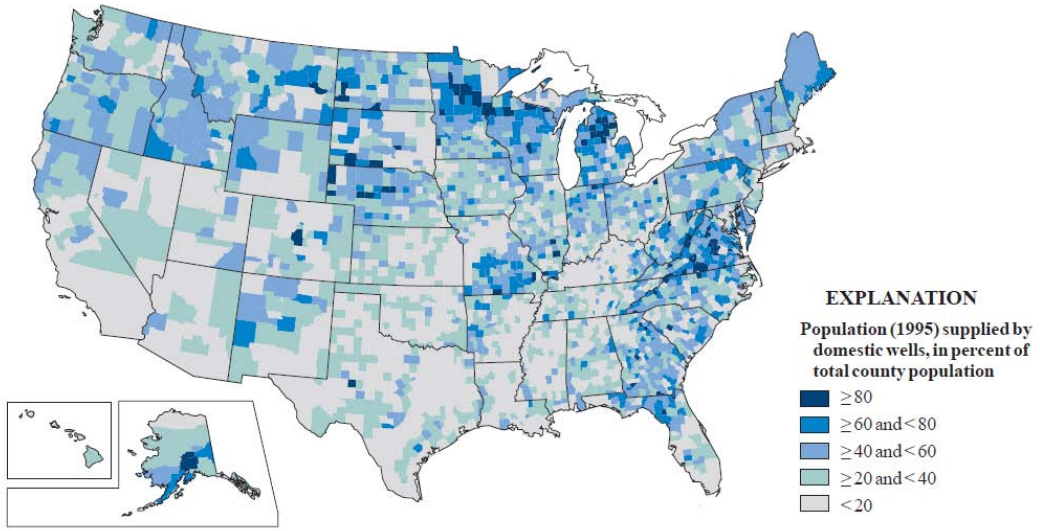

Figure 1. In many parts of the United States, domestic wells supply drinking water for large percentages of the population. Nationwide, more than 43 million people rely on domestic wells. Data shown are from Solley and others (1998).

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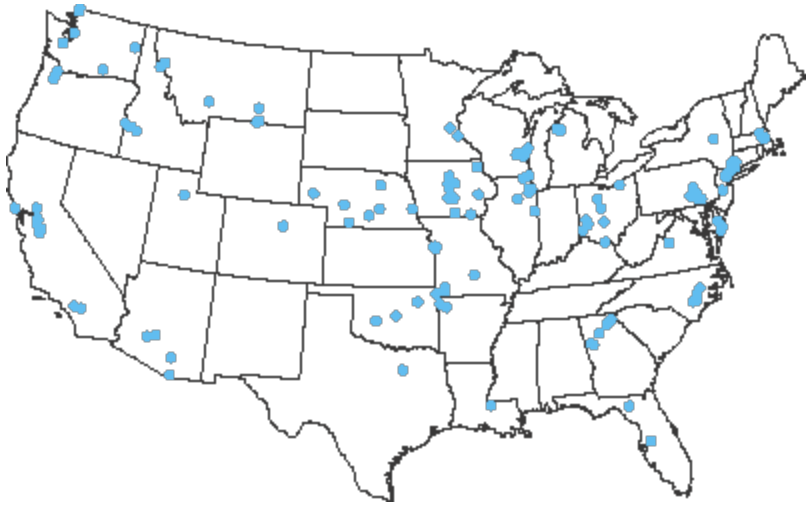
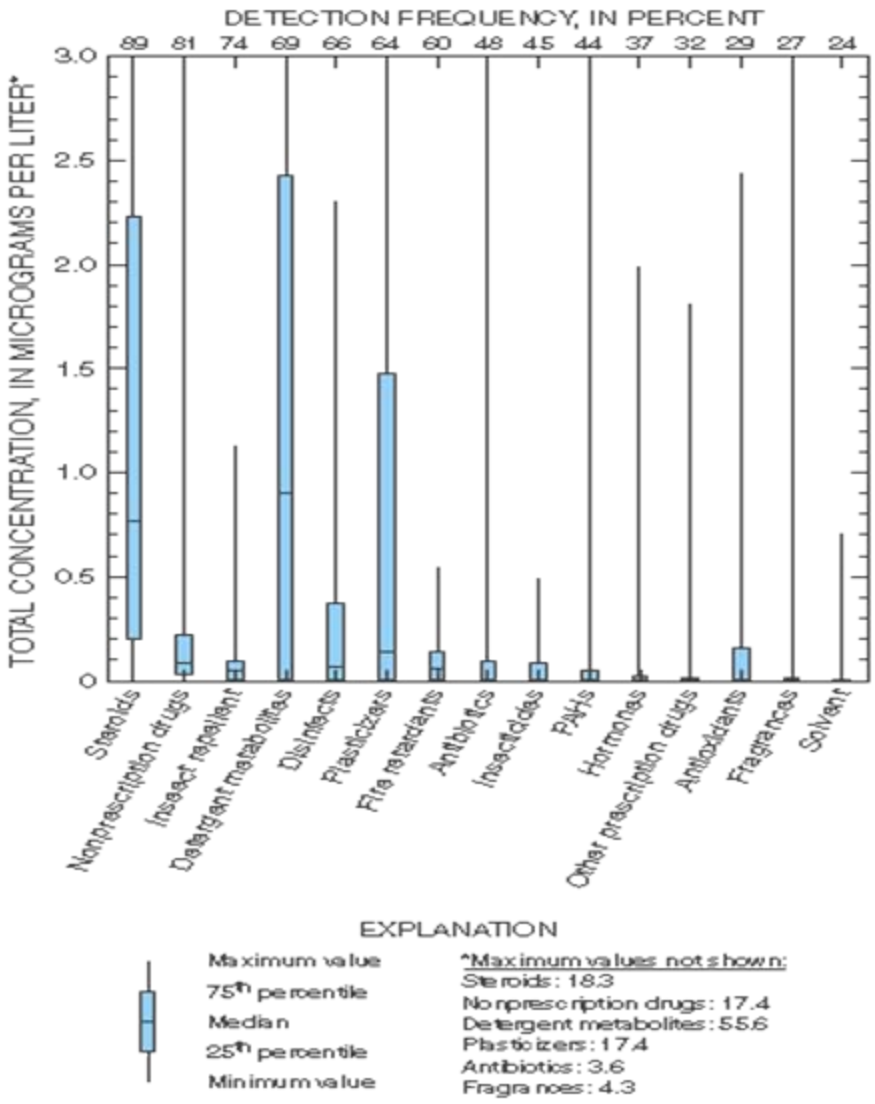
Reconnaissance Monitoring

Toxic Substances Hydrology Program



Pharmaceuticals, hormones, and other organic wastewater compounds in U.S. Streams



Kolpin et al., 2002

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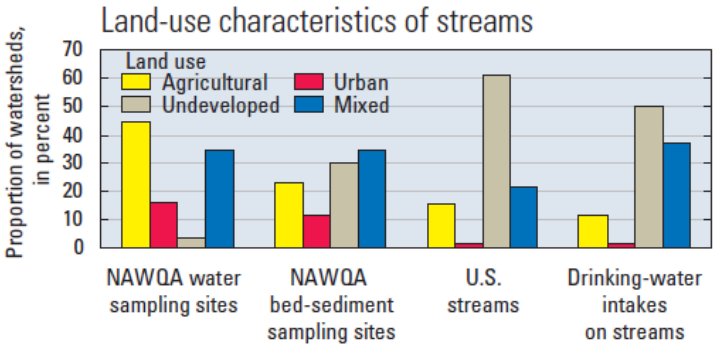
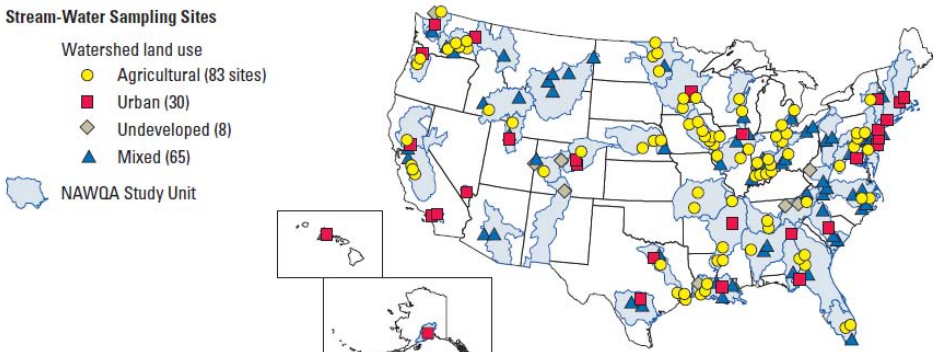
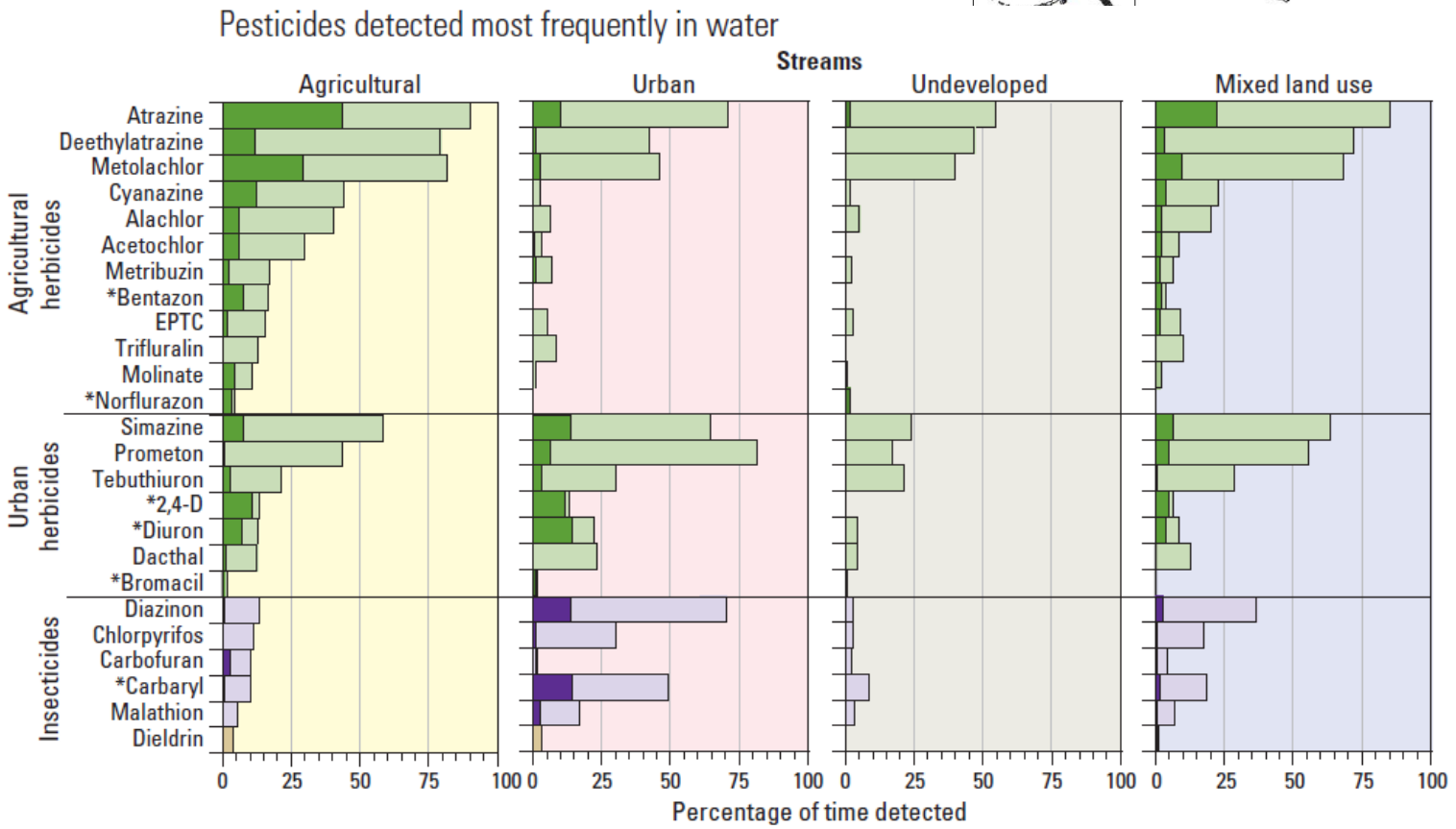
Targeted Monitoring Design (national assessment):

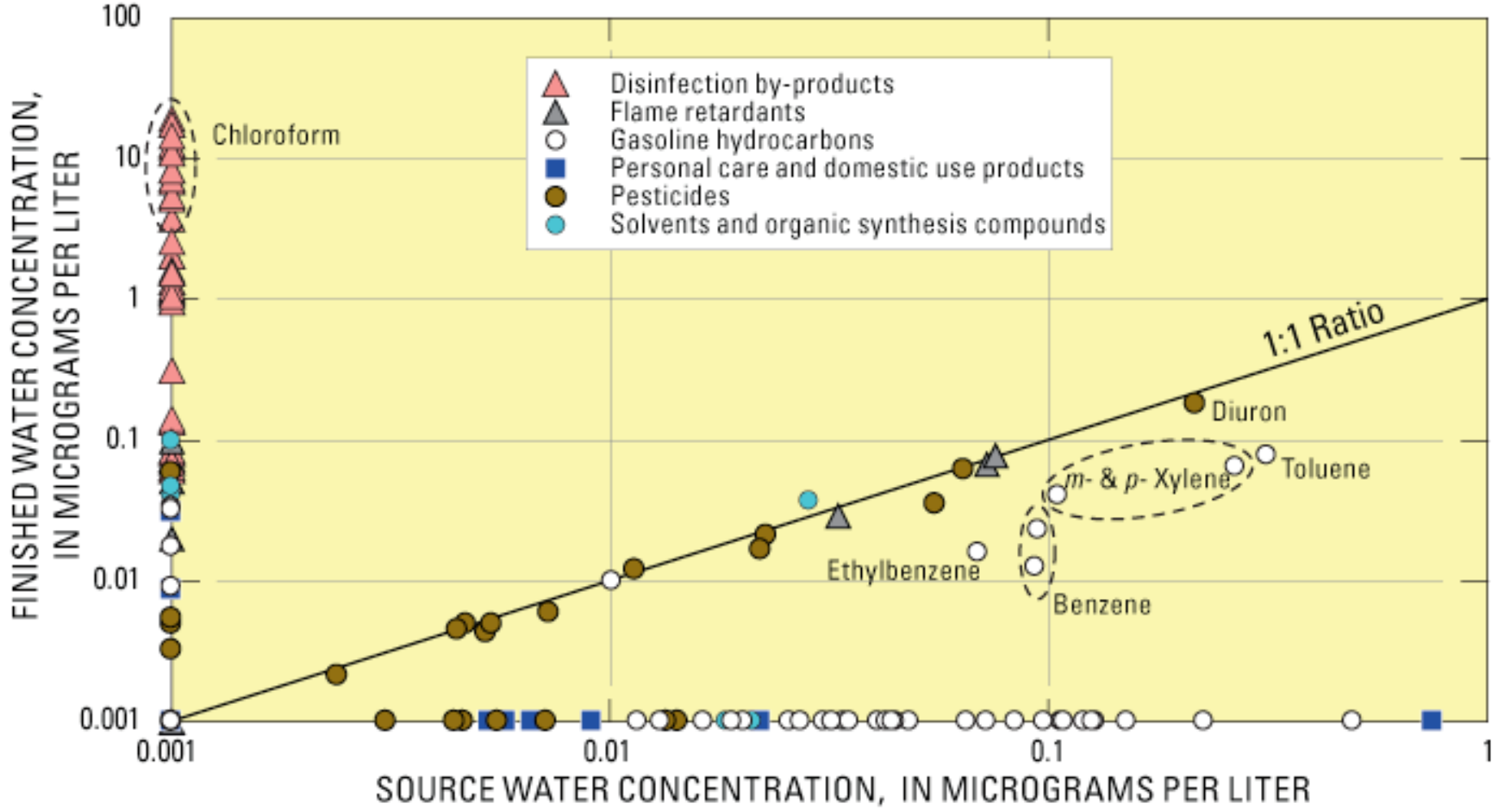
National Water Quality Assessment Program: Pesticides







Targeted Monitoring Design (local process):



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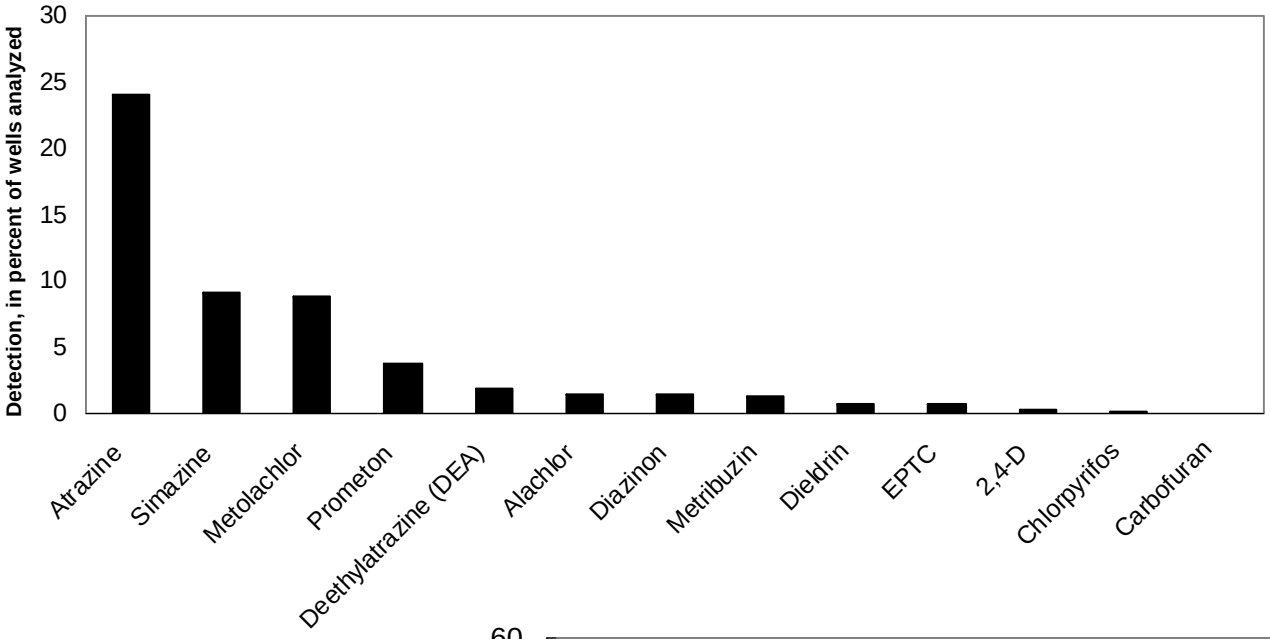
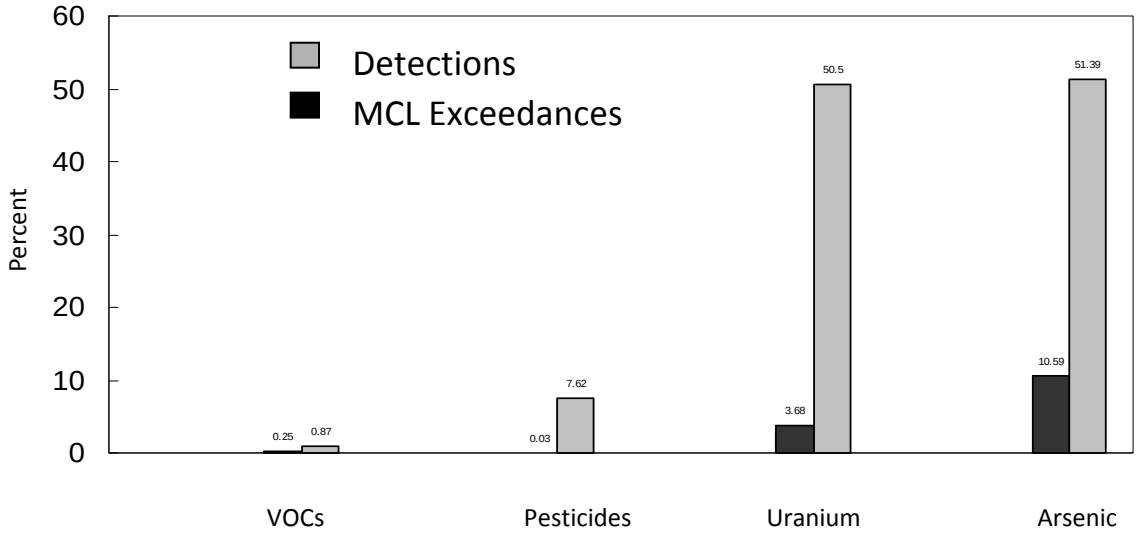
Carpenter and McGhee, 2003

Retrospective Data Analysis (National-Scale Data Mining)



Data mined from NWIS: Thousands of privately owned wells. Pre-treatment. Nationally consistent methods. Various local objectives and study designs. Low laboratory reporting levels (≤ppb)



Focazio et al, 2006

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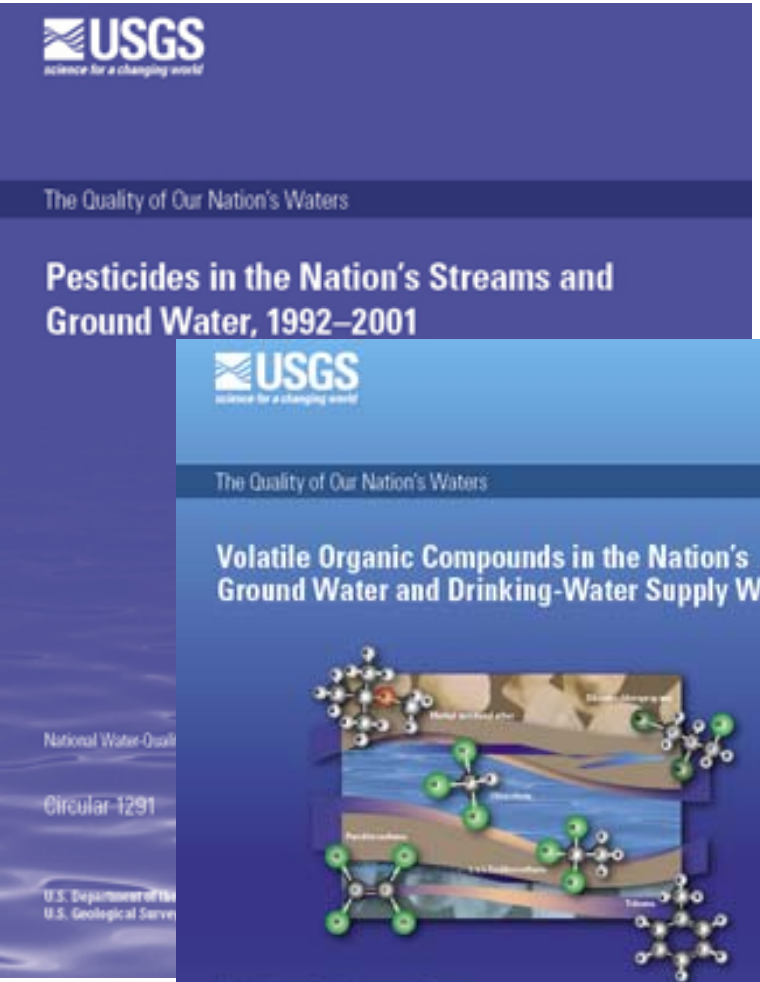
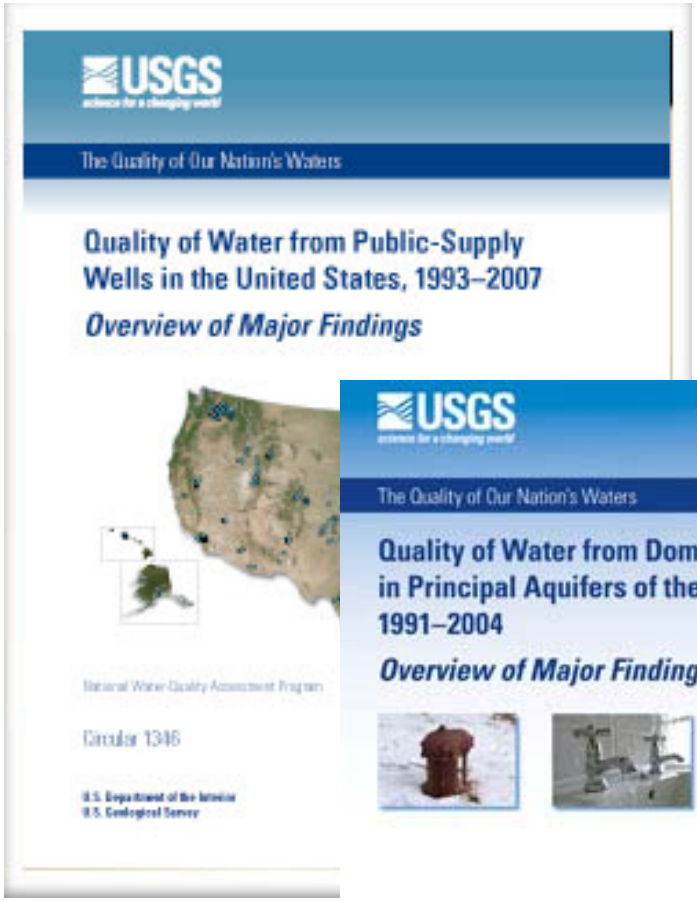
Recent Publications of Interest Cited in this Presentation





Challenges: Linking Contaminant Occurrence in Drinking Water to Human-Health Risk in the National Children's Study

Requires Collaboration with Human-Health Experts

-National Consistency
- --Public vs private water supplies
- --Explanatory variables
- --Methods

-Targeting the "right" contaminants
- --Physical/chemical properties (K_{ow}, etc.)
- --Conventional vs emerging Toxicology
  - What are the critical endpoints, MOAs etc.?

-Developing the "right" laboratory analytical methods and occurrence models
- --Technological capabilities (GC/MS, LC/MS, etc.)
- --Data Quality Objectives (Laboratory Reporting Levels, etc.)
- --Using explanatory variables to develop predictive models

-Asking the "right" questions
- --Exposure assessments and further
- --Model and(or) Monitor?

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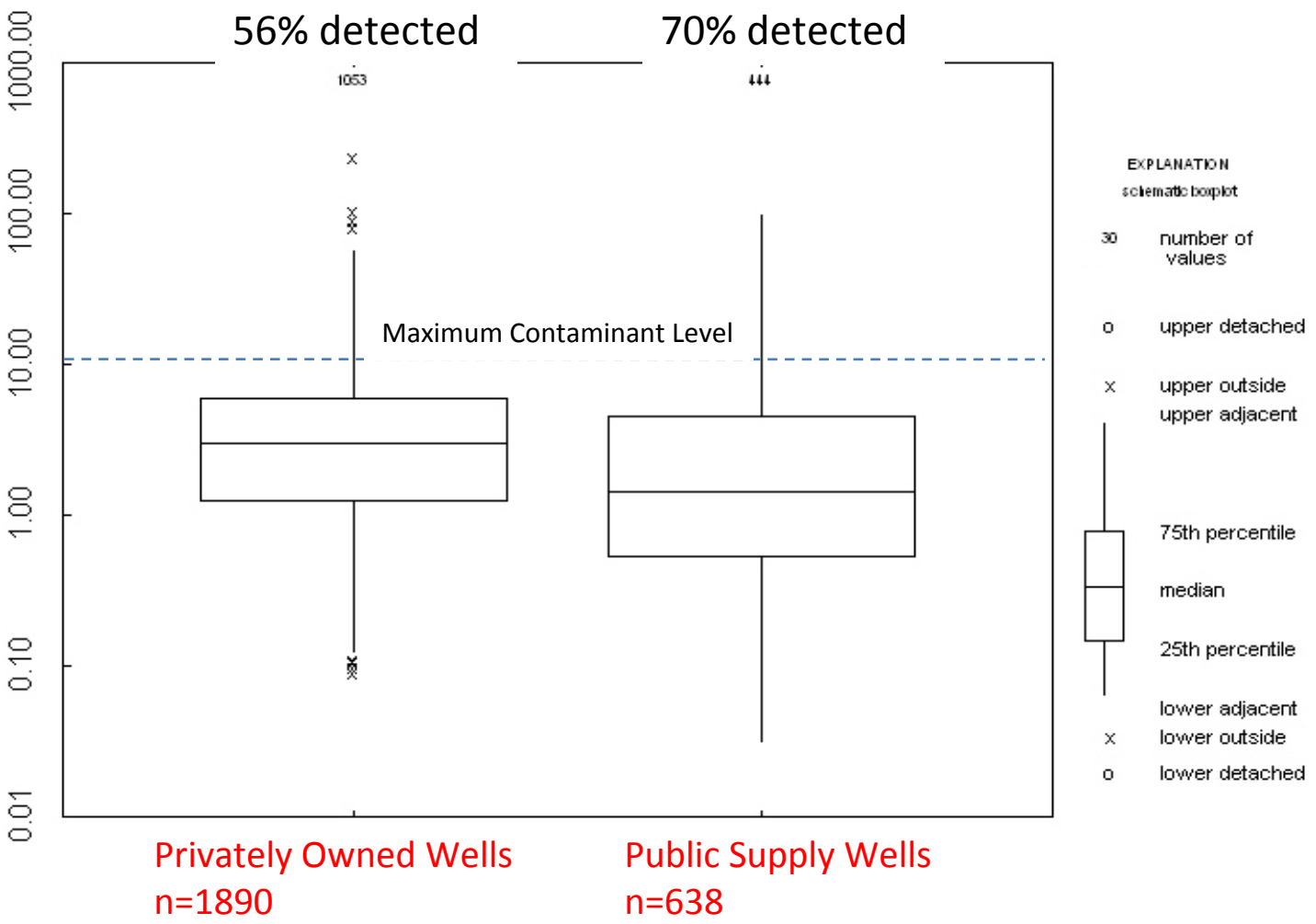
National Consistency: Challenges in monitoring various sources of drinking water

Data mined from NWIS: Thousands of privately owned wells. Pre-treatment

Unpublished Data:
Do Not Cite or Distribute



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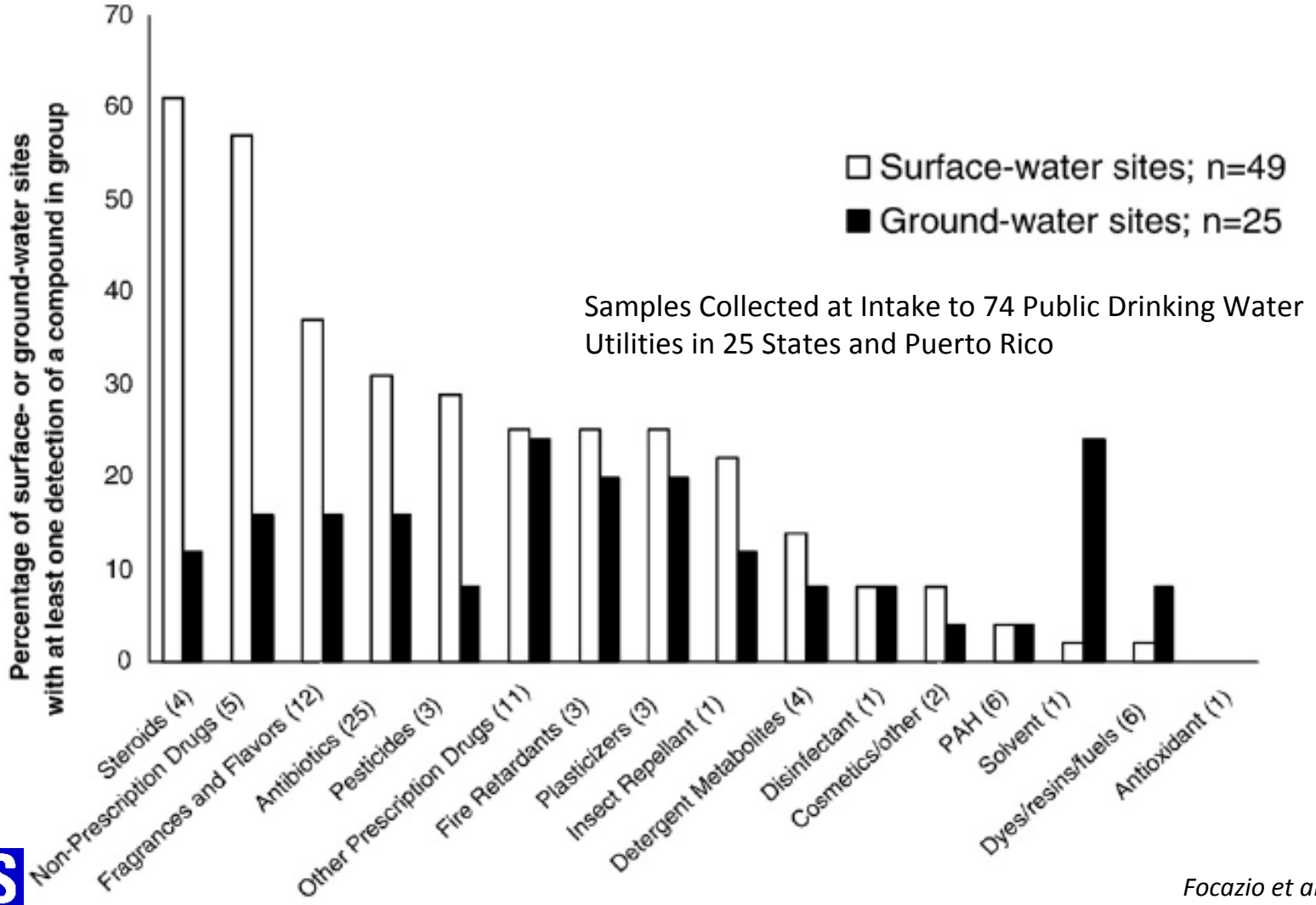
What are the “right” contaminants to look for? When, and how often?



Focazio et al., 2008

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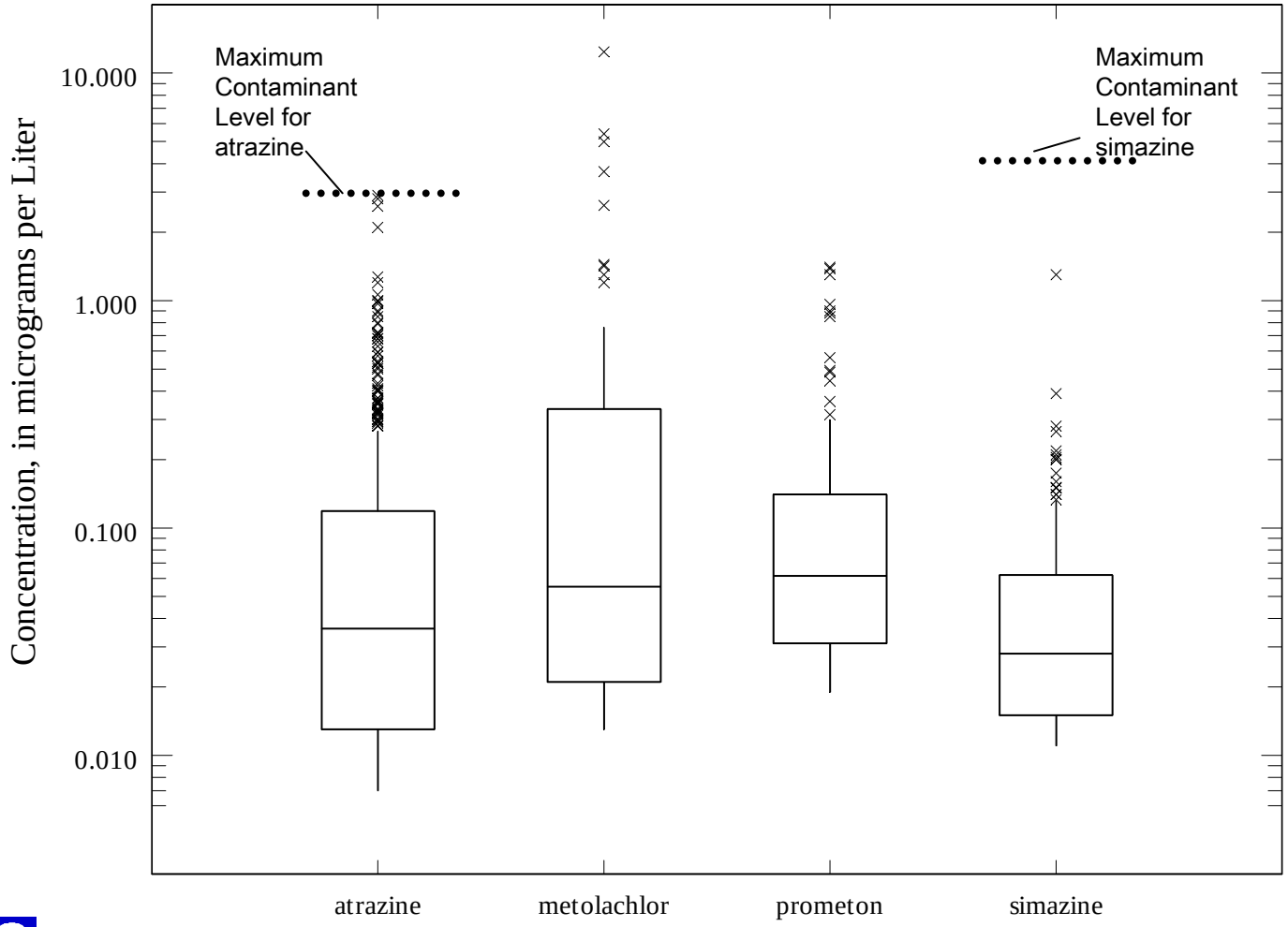
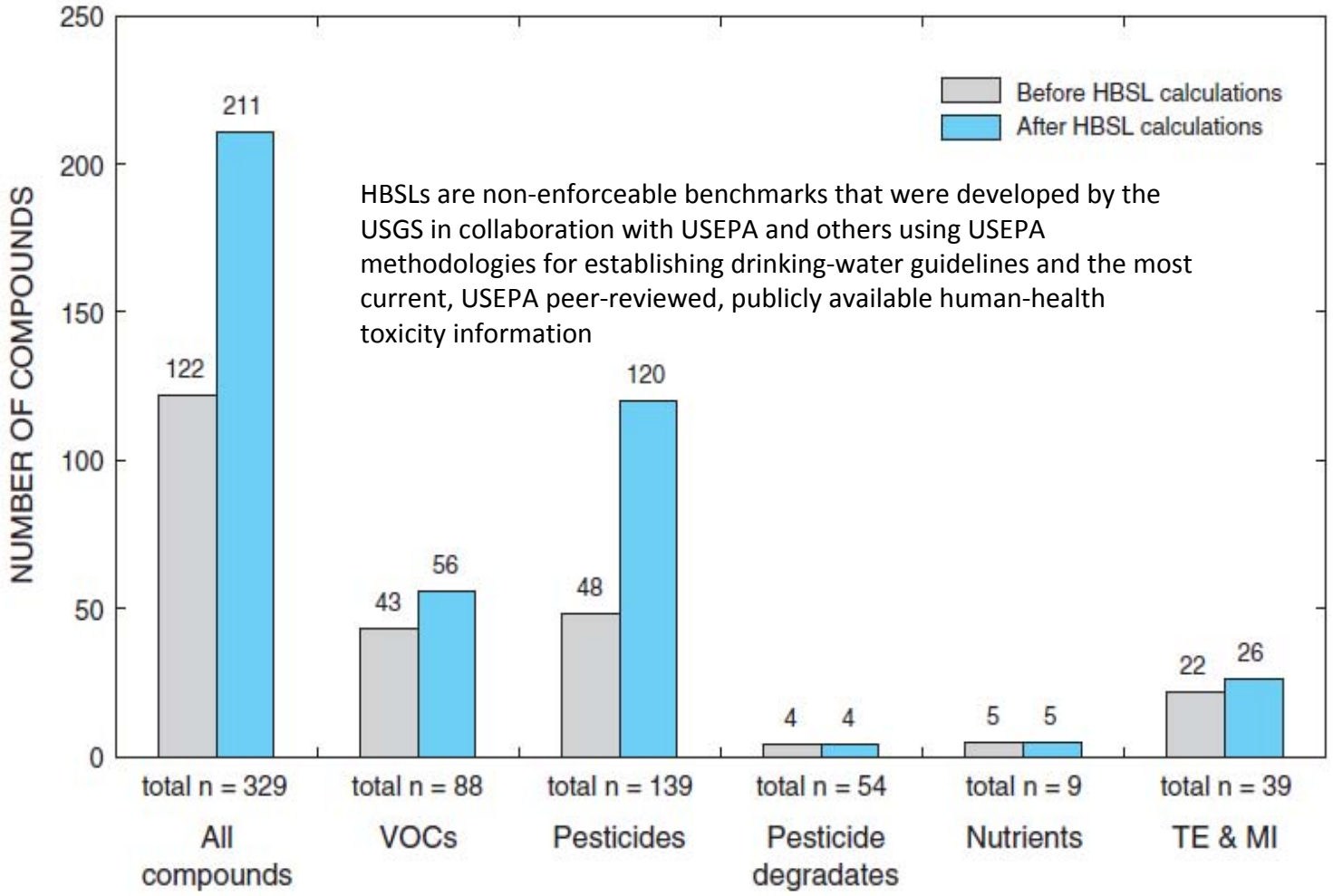
What are the right contaminants?

What is the relevance of contaminants we detect when there is no drinking water standard for comparison?



Focazio et al, 2006

USGS Health-Based Screening Levels (HBSLs) were designed to provide a nationally consistent metric to help in interpreting our water data within a human-health context.



[NAWQA, National Water-Quality Assessment Program; VOCs, volatile organic compounds; HBSL, health-based screening level; MCL, maximum contaminant level; Lifetime HA, Lifetime Health Advisory; RSD, Risk-Specific Dose; ACT, action level; TE & MI, trace elements & major ions; n, number of compounds]

Toccalino and others, 2003, 2006

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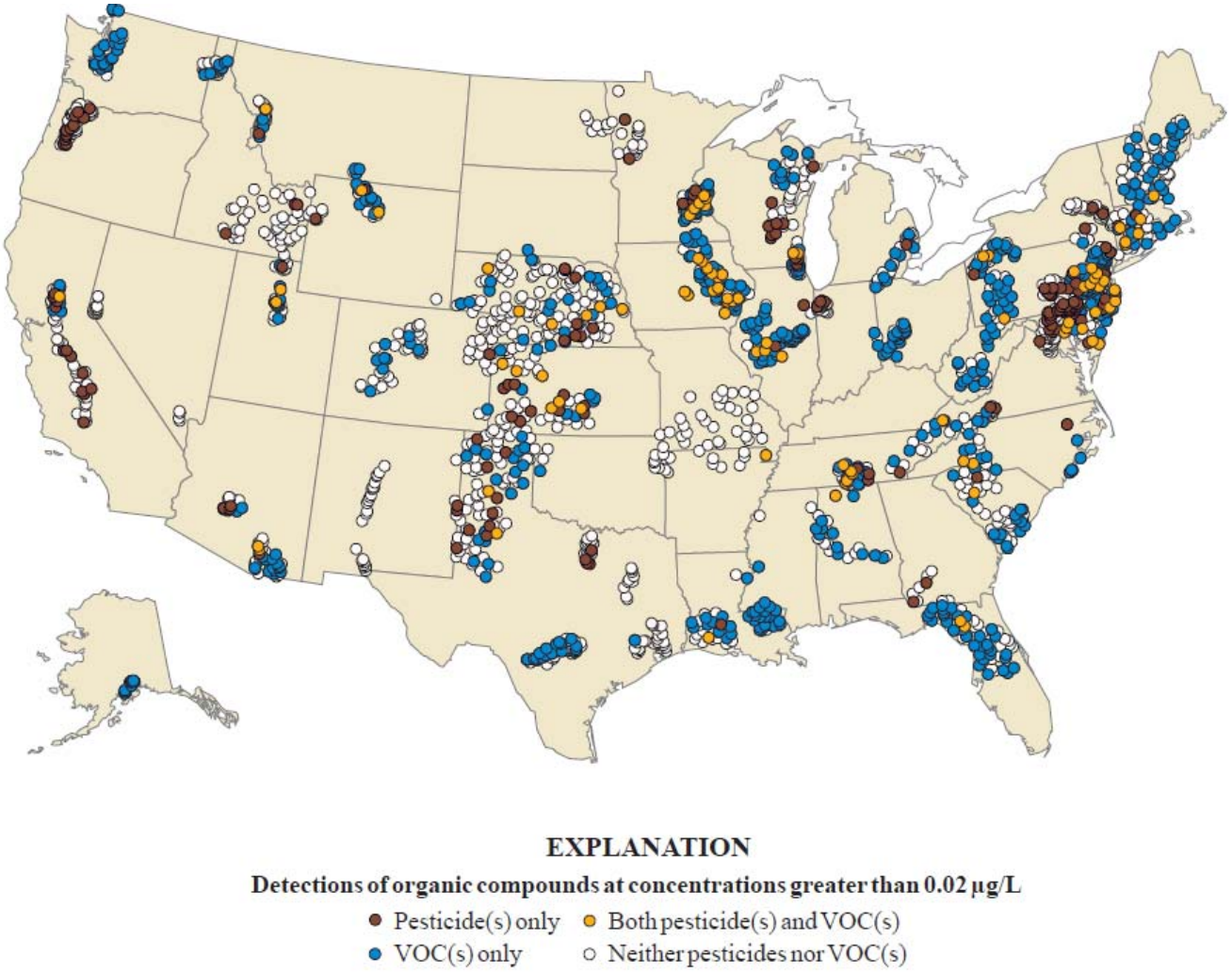
What are the right questions to ask?

Screening Levels Provide Improved Perspective But Remain Limited in Application



Concentrations above USGS Health-Based Screening Levels or MCLs in Private Wells

DeSimone et al, 2008

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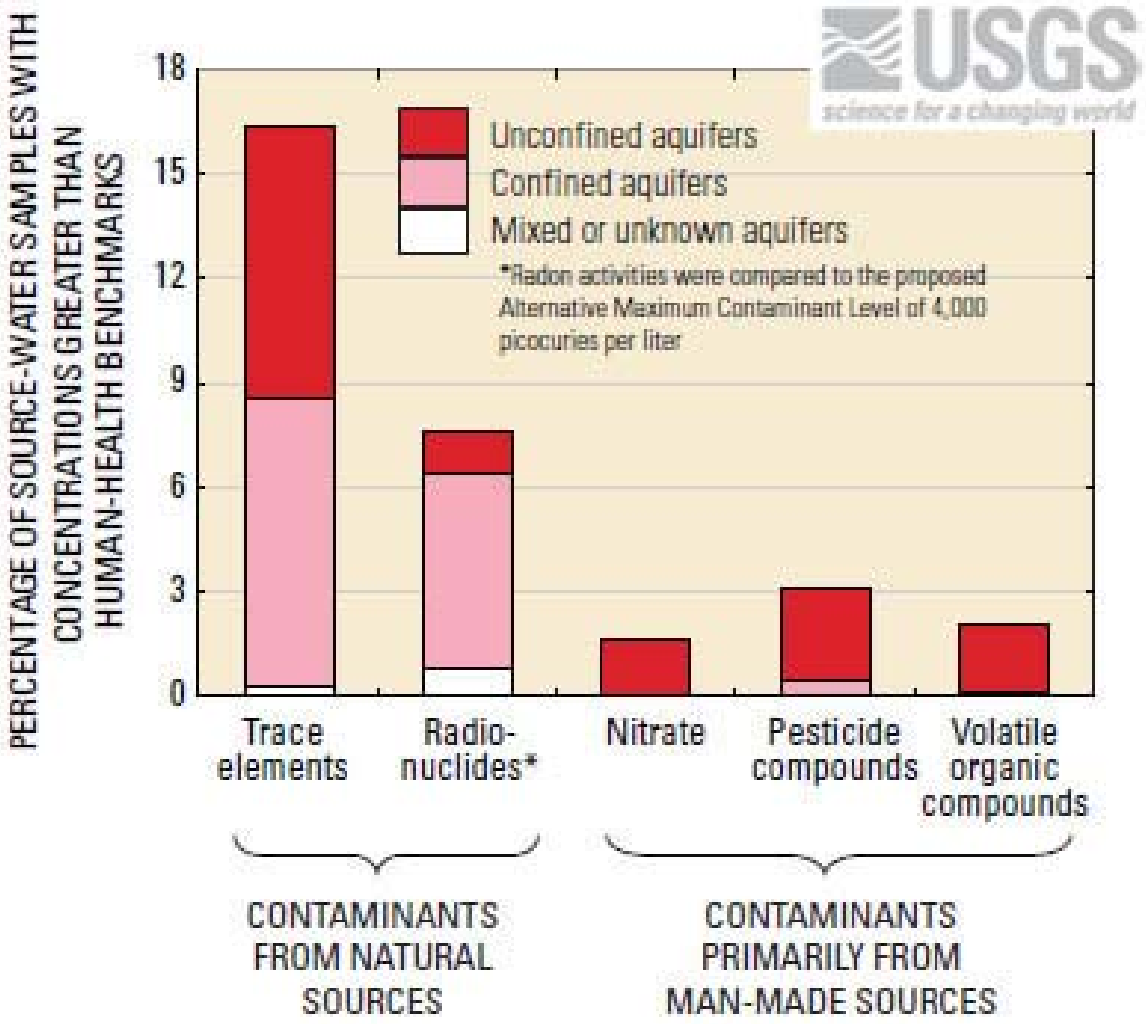
What are the right questions to ask?

Are explanatory variables identifiable and quantifiable?



Toccalino and Hopple, 2010

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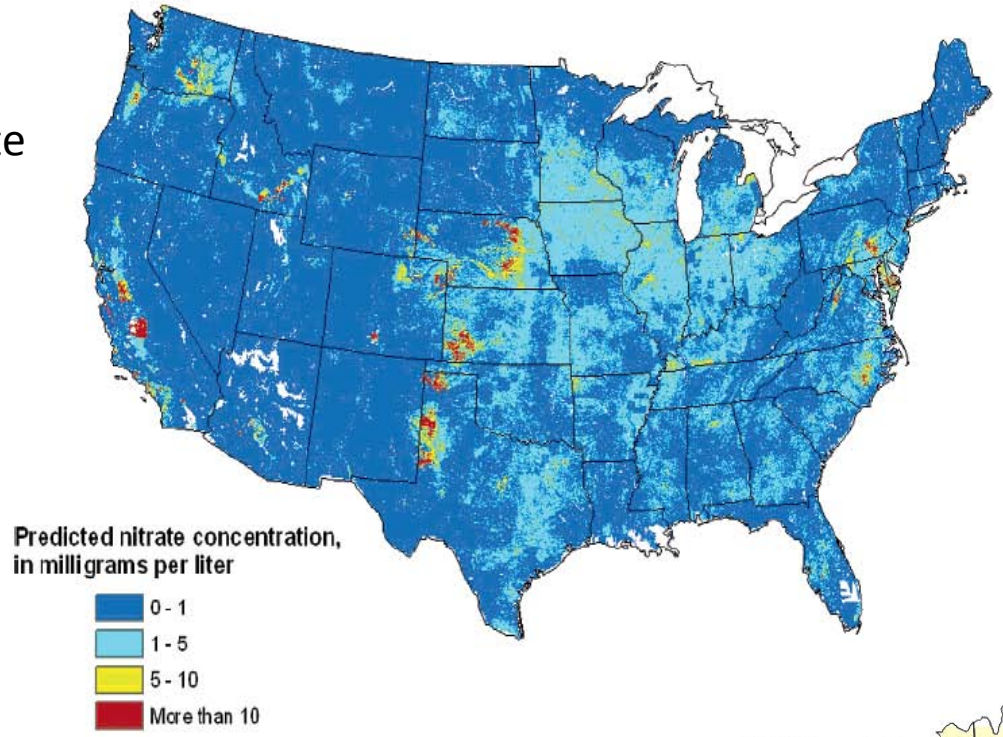
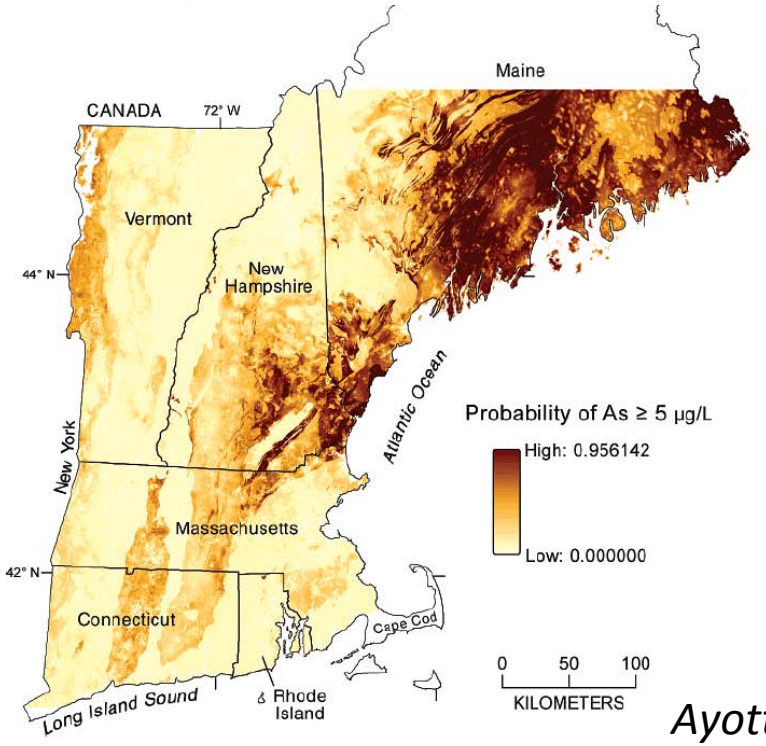
Nitrate



Nolan and Hitt (2006)

Logistic Regression Models of Anthropogenic and Natural Contaminants

Arsenic



National/Regional Patterns, Local Controls

Ayotte et al, 2006

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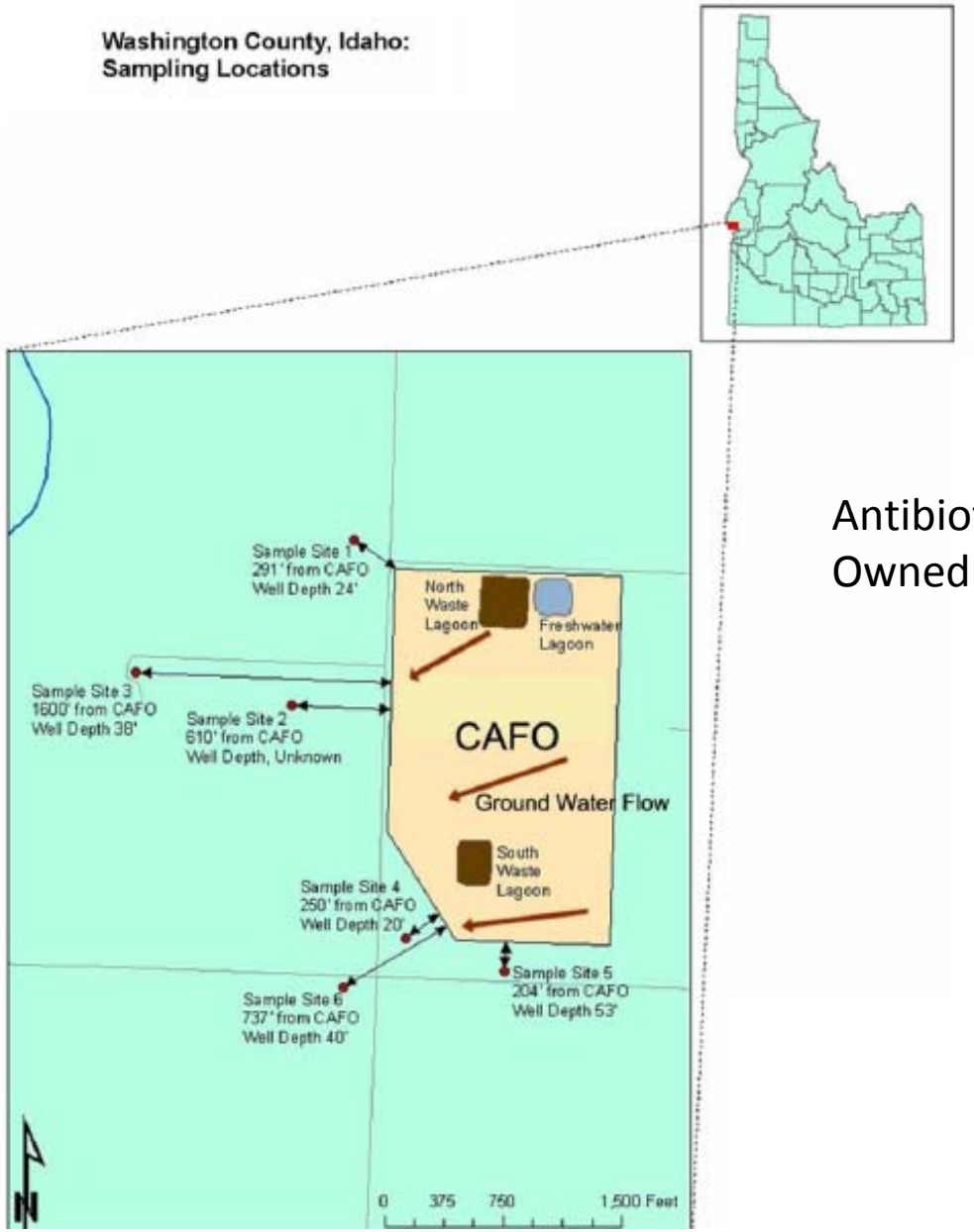
Local Heterogeneities Obfuscate Interpretations of Regional and National Models



Antibiotics in Privately Owned Domestic Wells

Batt et al., 2006

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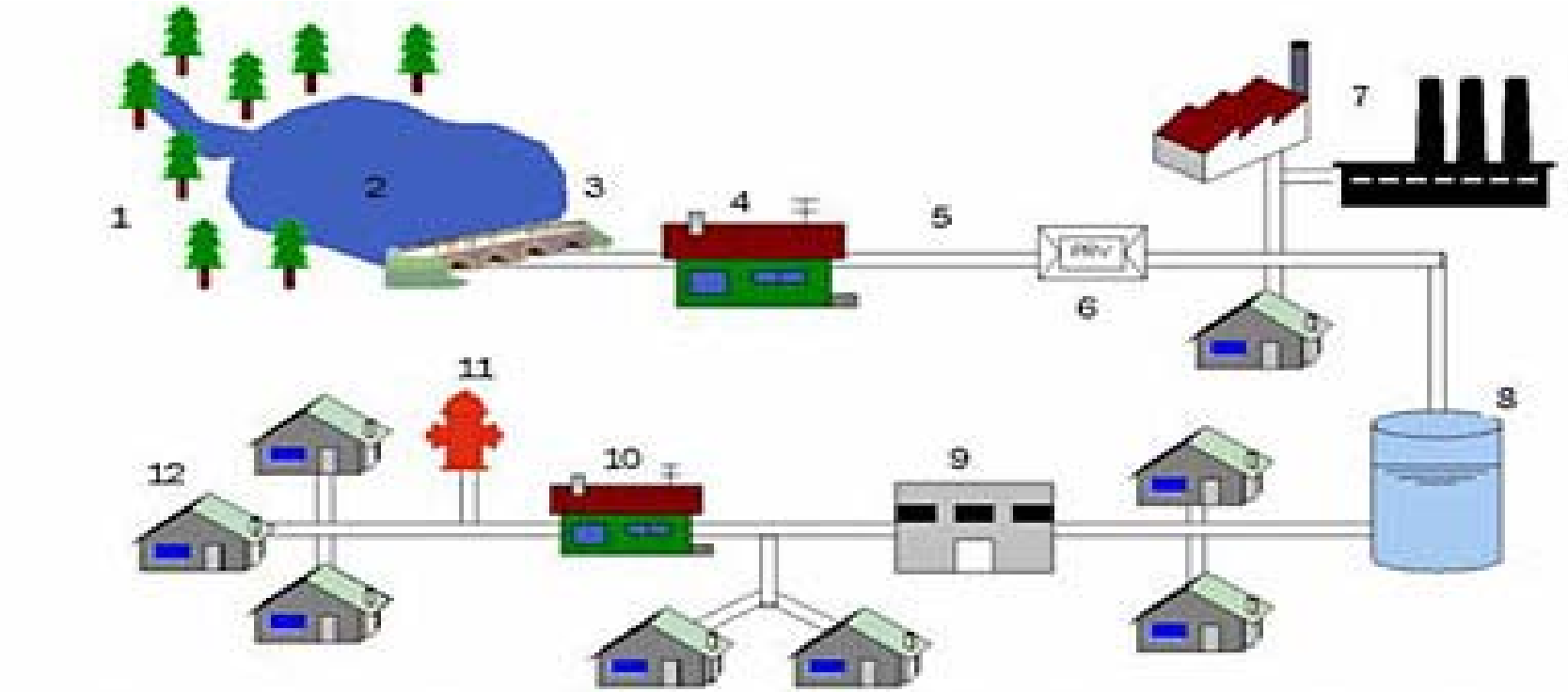
Exposure?



1. Watershed Management
2. Raw Water Quality Monitoring
3. BC Hydro Penstocks
4. Disinfection Station
5. Treated Water Quality Monitoring
6. Pressure Reducing Valves
7. Industrial Park
8. Reservoirs
9. Pump Stations
10. Re-chlorination Station
11. Fire Hydrants
12. Your Home

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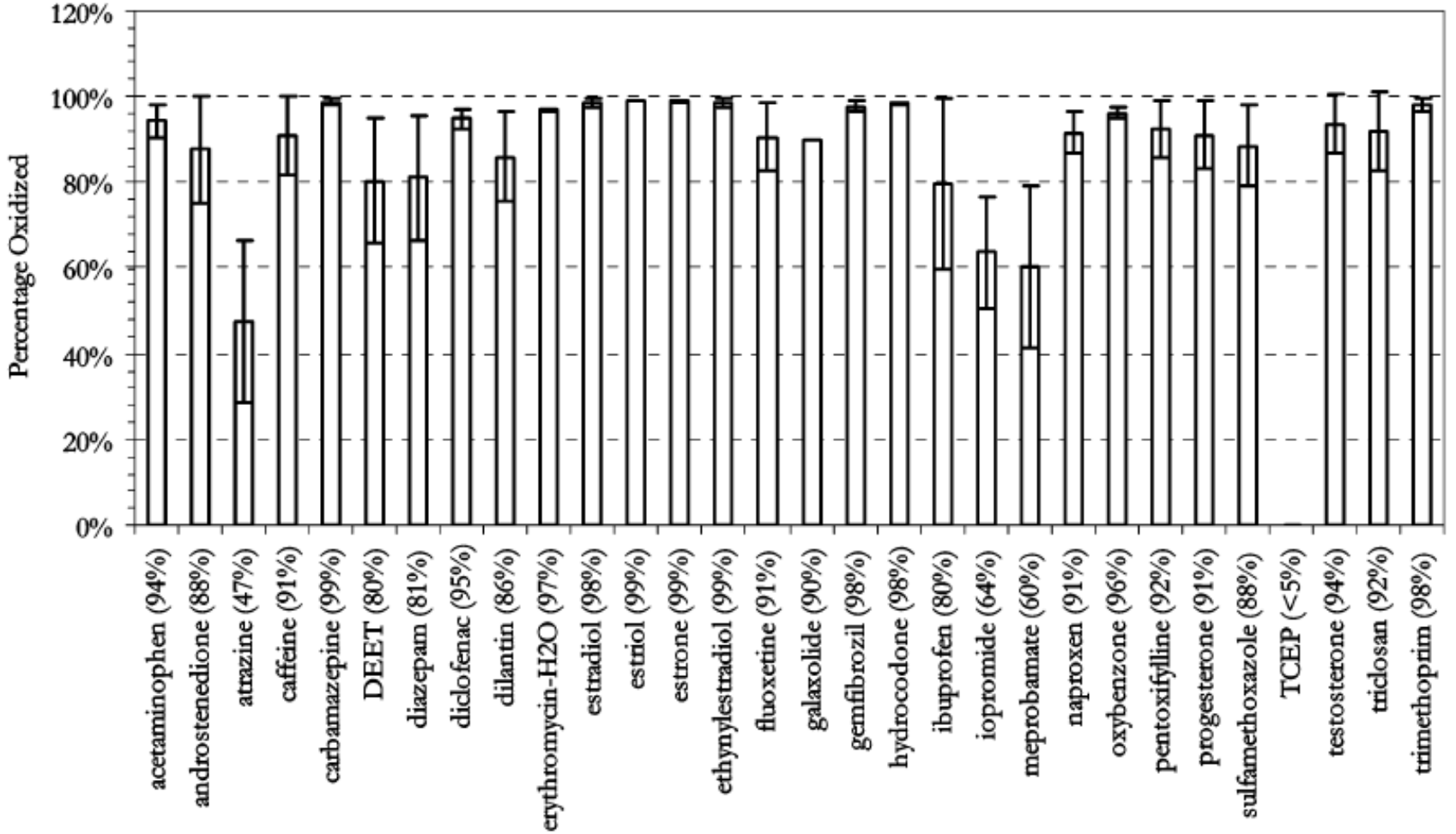
Are Raw Water Concentrations Representative of Tap Water?

Advanced Oxidation Processes

Effective in Oxidizing Many, But Not All, EDCs and PPCPs

Effective in Reducing Some Estrogenicity

Produce Disinfection/Oxidation By Products



Westerhoff et al., 2007

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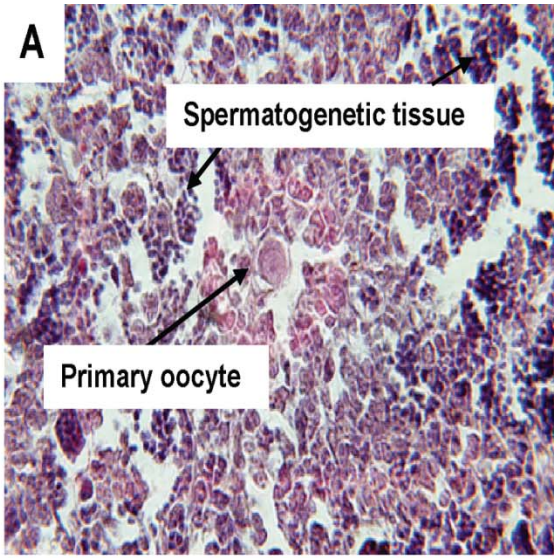
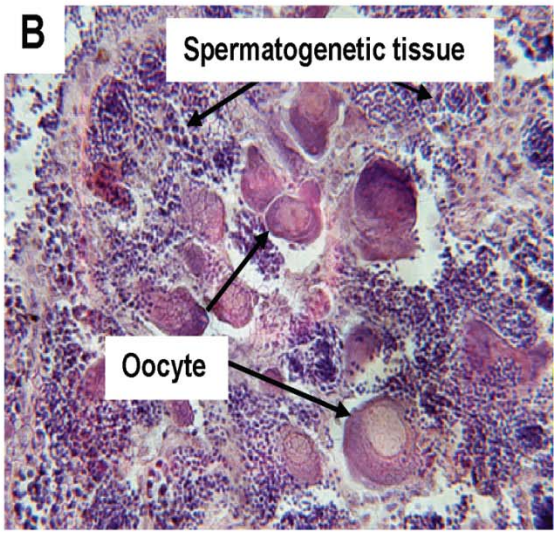
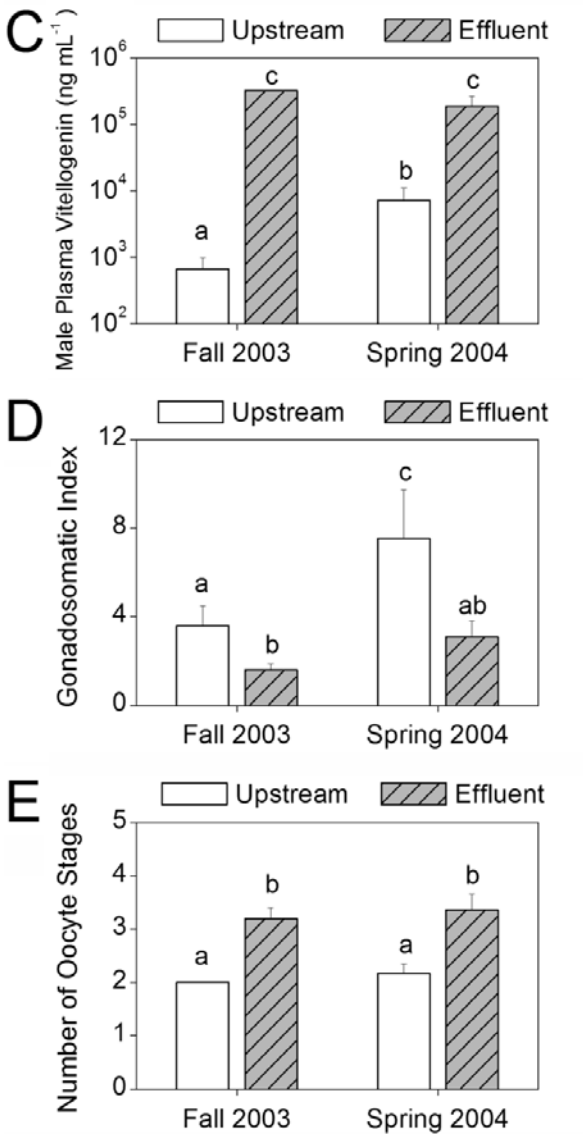
Can Evidence of Aquatic Ecological Impacts Inform Human-Health Related Research Designs?

Reproductive Endocrine Disruption in Fish





Estrogenic Wastewater Effluent and Fish Intersex at Boulder Creek



Vajda et al., 2008

Linking *Contaminants* in Drinking Water to Human-Health

-Thoughts on NCS and USGS Collaborative Efforts

-National Consistency

-Targeting the "right" contaminants

-Developing the "right" laboratory analytical methods

-Asking the "right" questions

One Example:
Endocrine Active Compounds Have Been Detected in Untreated and Treated Drinking Waters.
Ecological Impacts Are Being Documented in Ambient Waters.

Biogenic Hormones
Synthetic Hormones
Pesticides
Plastic Manufacturing Ingredients
Flame Retardants
Fragrances
Metals and metalloids
Disinfection By-Products
Etc.

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water.usgs.gov

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Thank you

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