Monitoring Water for Gas Well Impacts

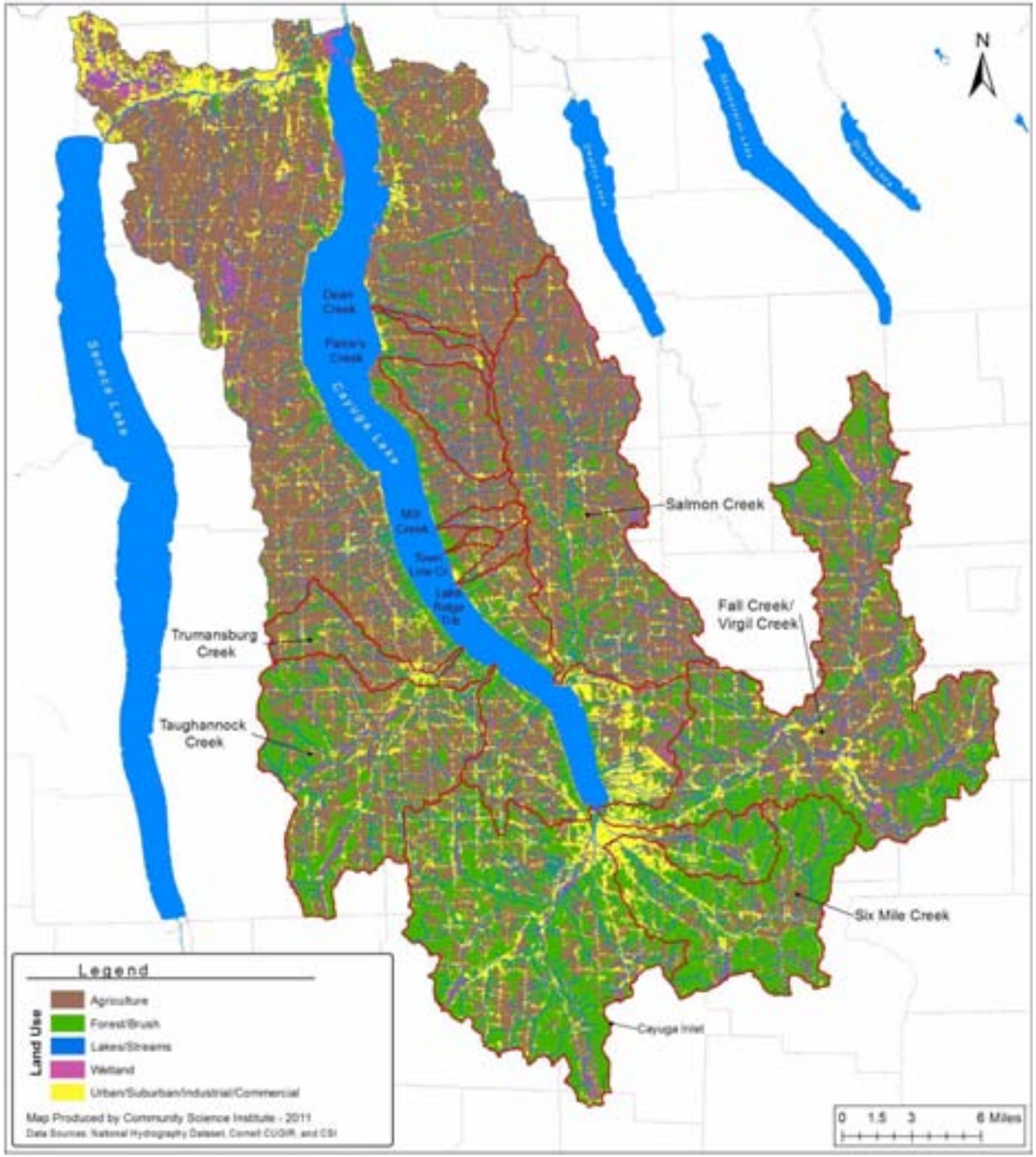
The use of "signature chemicals" to assess exposure to waste from the shale gas industry

Community Science Institute
Background in Brief

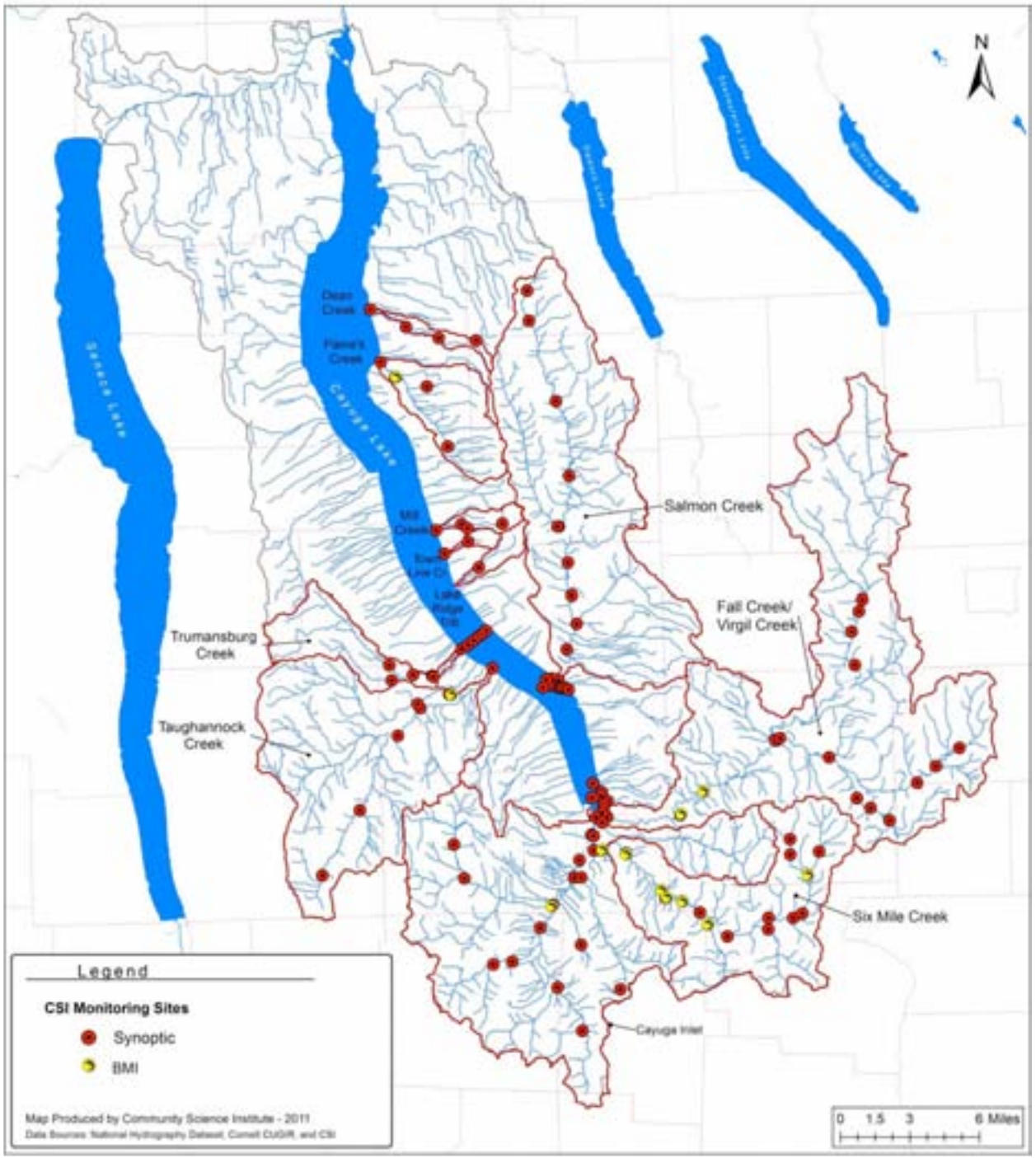
- **Community Science Institute** is a not-for-profit 501©3 tax-exempt organization, founded 2000
- **Mission**: Empower citizens to become stewards of their local environment by participating in monitoring programs
- **Certified laboratory**: NYSDOH-ELAP #11790, potable and non-potable water, 35 matrix-analyte combinations
- **Mapping capability**: ArcGIS software, version 10
- **Staff**: 2 full-time, 4 part-time, 1 student intern
- **Sources of support**: Local governments, local foundations, fee-for-service testing, Cornell University, individual donors
- **Budget**: $180,000 in 2010

CSI Monitors Water Quality in the Cayuga Lake Watershed

- Partnerships with 7 autonomous groups of volunteers covering >100 sampling locations
- Each group is responsible for sampling a set of fixed locations, e.g., a stream, up to 5 times/year
- Synoptic; base flow and stormwater conditions
- Volunteers transport samples to CSI's certified lab
- Analyses focus on agricultural/urban/suburban impacts: Bacteria, sediment, nutrients, salt
- Certified data items in open online database at www.communityscience.org/database, ~20,000 data items total, ~5,000 new data items per year



Cayuga Lake Watershed: Land Use and CSI Monitoring Sets

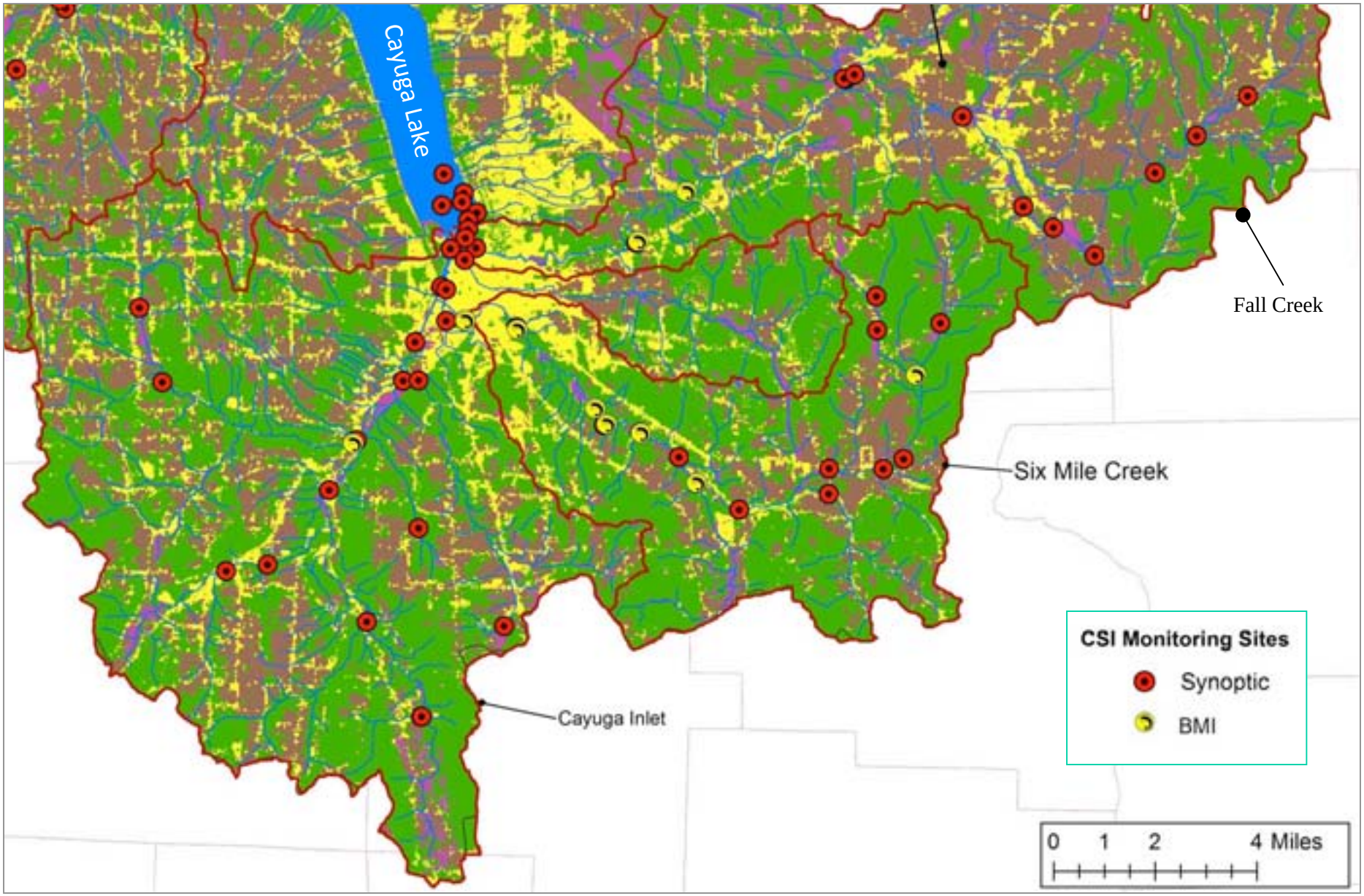


Cayuga Lake Watershed: CSI Monitoring Sites

CSI Monitoring Sites

- Synoptic
- BMI

CSI Monitoring Sites: Detail



Risks to Water and Health from "Hydrofracking" of Shale Gas Wells

- Shale gas industry, particularly its waste products, poses risks to water that are serious yet poorly defined
- What **is** known about flowback and drilling waste:

  - Scores of **toxic and radioactive chemicals** in waste

  - Waste qualifies as **hazardous waste** yet is specifically **exempted** under state and federal law

What is **not** known about gas well waste:

- The **specific chemicals** in waste from **each** gas well
- The **actual toxicity** of waste from **each** gas well
- The **probability, or risk,** of contaminating water

We Know How To Assess Risk

- **A process for assessing risk** from hazardous chemicals was created by EPA 20 years ago
- EPA framework focuses on **ecological** risk
- EPA conceptual framework can also be applied to **human health** risk assessment

<u>Risk</u> assessment begins with <u>exposure</u> assessment

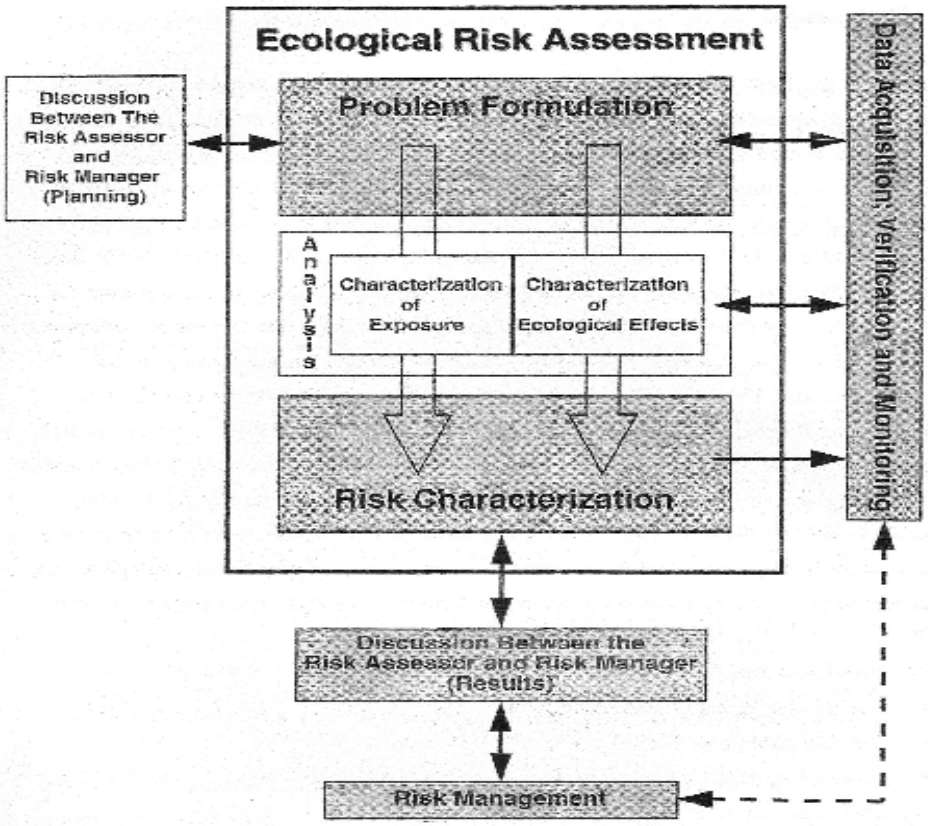


Figure 1. The Conceptual Framework for Ecological Risk Assessment (adapted from EPA, 1992a)

Risk ~ Exposure x Toxicity

Risk to human health and the environment from toxic chemicals is a composite function of **exposure and toxicity**

Any toxic chemical poses a risk **if it gets into the environment --** water, soil or air, such that humans and other species come in contact with it.

By conventional definition, even a highly toxic chemical poses no risk if there is no exposure to it.

Potential Pathways of **Surface Water** Exposure to Hazardous Shale Gas Waste

1. *Transport of fracking chemicals and storage on the drill pad*: **Truck accidents, leaks from storage containers**
2. *Mixing and high pressure underground injection of millions of gallons of fracking fluid*: S**pills on drill pad, leaks from valves**
3. *Storage of flowback in open pits*: **Off-gases (radon, VOCs), leaks through tears in plastic liner, breach of pit walls, overflow from rain**

Potential Pathways of **Surface Water** Exposure (cont'd)

4. *Transport of flowback to disposal site*: **Truck accidents, leaks from pipes and valves**
5. *Disposal of flowback by POTWs (sewage plants)*: **Inadequate screening based on outdated Priority Pollutant List (PPL), toxic and radioactive chemicals are discharged to streams and lakes undetected**
6. *Food web:* **Some radioactive and toxic chemicals may undergo bioaccumulation and biomagnification, enhancing exposure at higher levels of an ecosystem's food chains**

Shale Gas Industry: Potential Pathways of **Groundwater** Exposure

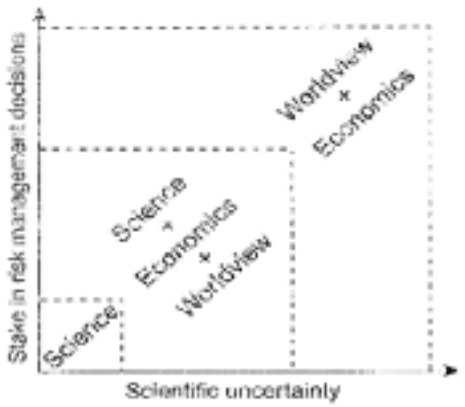
Millions of gallons of fracking fluid injected underground: **Faulty cement casing around well hole; unanticipated fracture patterns; abandoned gas wells not detected or plugged; earthquakes**

Surface water may be at equal or greater risk of contamination than groundwater

No Exposure Assessment for "Hydrofracking" To Date

- Reports of accidents in Pennsylvania and other states strongly suggest **exposure of water** to hazardous shale gas waste **can and does** occur by **multiple** pathways
- Knowing the **probability of exposure** is the first step in **managing risk** from shale gas waste
- Without exposure assessment, there is huge **scientific uncertainty** about risk
- The greater the scientific uncertainty, the more r**isk management** decisions are dominated by **economic and world view** issues

Figure I-2. Risk management decisions are based on a risk-specific mix of science, economic factors and worldview considerations



How Might Exposure Be Assessed?

Two approaches for assessing exposure of surface water and groundwater to shale gas waste:

- Gas companies could add **tracer dyes** to fracking fluid, e.g., rhodamine
- Citizens monitor “signature chemicals” associated with shale gas waste, plus biological indicators of stream health

Feasibility of Two Exposure Assessment Strategies

1. Tracer dyes: Potentially effective in theory, however, gas companies would need to agree to add tracer dyes voluntarily. Alternatively, New York State would need to mandate addition of tracer dyes to fracking fluids.
2. Water quality monitoring by citizens:

   a) Shale gas waste has a distinctive "chemical signature," detectable at up to ~ 1,000x dilution;

   b) Aquatic organisms may be harmed by very low levels of toxic chemicals in shale gas waste

Shale Gas Waste is characterized by a broad "*Chemical Signature*"

1. *Brine*: Conductivity, total dissolved solids, chloride
2. *Acid*: pH, acidity, alkalinity
3. *Metals*: Total hardness, calcium, strontium, barium; sometimes arsenic, manganese, iron and others
4. *Detergents*: Methylene Blue Active Substances
5. *Bulk organic chemicals*: Chemical oxygen demand, dissolved oxygen; possibly uv absorbance, color
6. *Individual organic compounds*: Total of 52 VOCs analyzed in standard test, including BTEX chemicals
7. *Natural gas*: Methane
8. *Naturally occurring radioactive materials (NORM)*: Gross alpha and gross beta radioactivity

Use "*Chemical Signature*" to Assess Exposure of Private Wells (Groundwater)

- **Perform pre-drilling baseline**: Contract with a certified lab to test for broad "chemical signature" pre-drilling
- **Window for baseline ~5 years** prior to drilling (consistent with state monitoring programs under Clean Water Act)
- **Repeat broad "chemical signature" within 6 months after gas well completion**, then biannually or each time gas well is re-fracked
- If contamination is suspected, seek expert corroboration
- Pursue testing for all contaminants plus a comprehensive health risk assessment from government, gas company
- Seek legal advice, as appropriate

Use of "*Chemical Signature*" to Assess Exposure of Streams and Lakes

Monitoring streams presents a different set of challenges than monitoring private wells

- ✓ Most streams and lakes are part of the environmental commons, not private property
- ✓ Streams and lakes are ecosystems that are affected by activities throughout their watershed
- ✓ Flowing water connects the different parts of a watershed such that pollution upstream can result in pollution downstream
- ✓ Monitoring needs to occur at multiple locations and encompass each watershed as whole

CSI's Approach to Monitoring Streams: Volunteers Perform Field Tests with Certified Lab Support

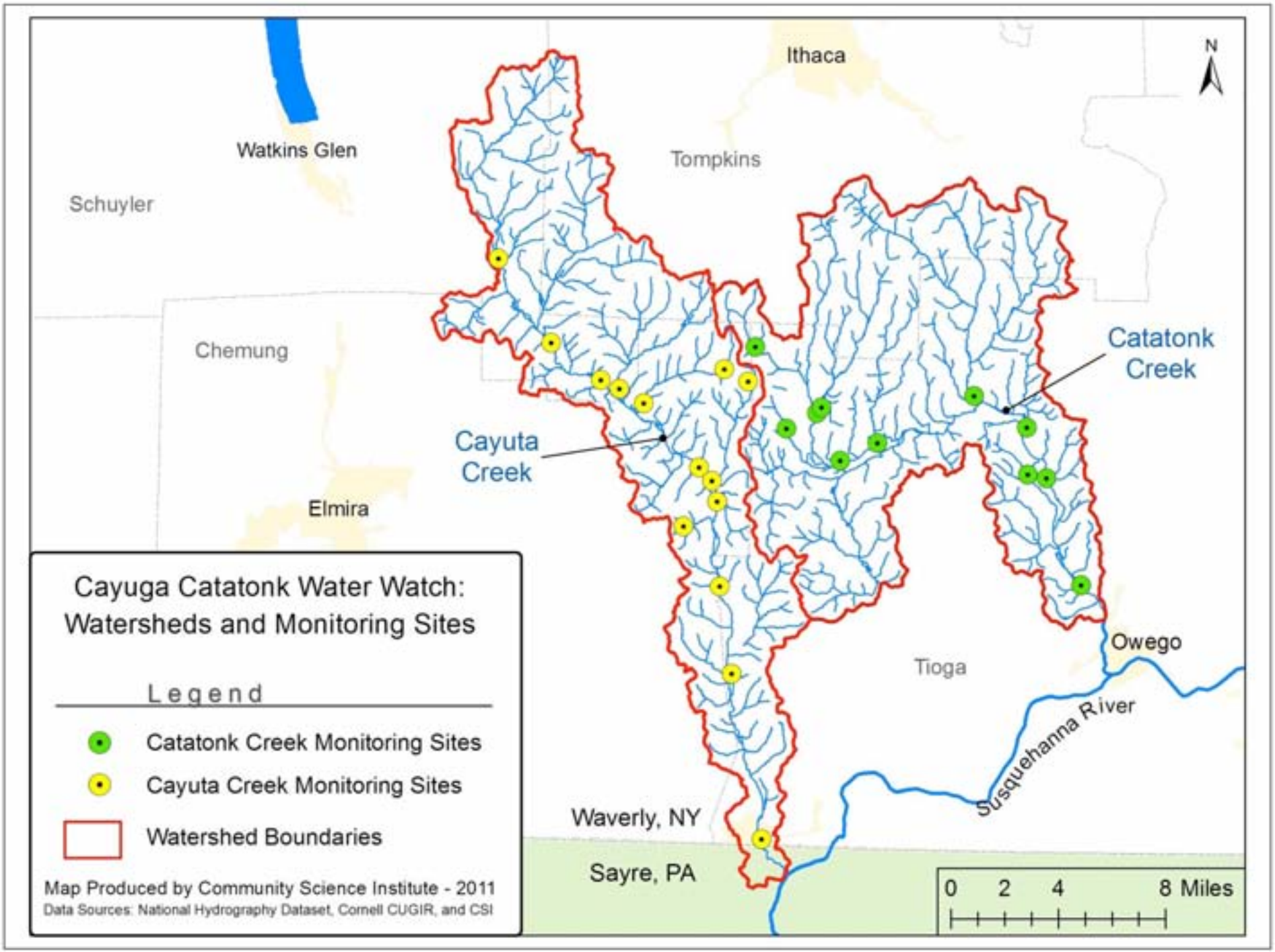
- **A local group of trained volunteers** monitors multiple stream locations, each draining ~5 sq. mi. or less
- **Volunteer teams perform "red flag" field tests monthly**: Temperature, pH, DO, conductivity, total hardness
- **Volunteers are supported by CSI's certified lab** with calibration standards, split samples, and data review
- **Volunteer teams perform aquatic insect (biological) monitoring annually** at selected locations
- **Volunteer field data are posted online** in CSI's public data archive if data meet quality control criteria

Annual comprehensive "*Chemical Signature*" Tests at Strategic Subset of "Red Flag" Monitoring Sites

- Comprehensive "chemical signature" tests are required to document contamination of stream water conclusively
- Volunteers collect samples from a strategic subset of stream locations at least once a year, e.g., 10 of 25 sites
- Certified lab performs many -- but not all – of the same "chemical signature" tests as for groundwater
- Save scarce funds by eliminating some certified "chemical signature" tests (reason for eliminating test)
  - -- "Red flag" field tests by volunteers (redundant)
  - -- Arsenic, manganese, iron, detergents (probability of detection judged to be relatively low)
  - -- VOCs, methane (these are gases that escape rapidly from flowing stream water)

Biological Indicators of Stream Health

- Communities of aquatic insects called benthic macroinvertebrates, or BMI, live in stream riffles
- BMI community structure, i.e., the relative abundance of various aquatic insect families, is sensitive to pollution
- Changes in BMI community structure can reveal long-term, low-level contamination before chemical changes are detected
- NYSDEC uses BMI analysis to monitor stream health


Ithaca
N
Watkins Glen
Tompkins
Schuyler
Chemung
Catatonk Creek
Cayuta Creek
Elmira
Owego
Tioga
Susquehanna River
Waverly, NY
Sayre, PA
0 2 4 8 Miles
Cayuga Catatonk Water Watch: Watersheds and Monitoring Sites
Legend
Catatonk Creek Monitoring Sites
Cayuta Creek Monitoring Sites
Watershed Boundaries
Map Produced by Community Science Institute - 2011
Data Sources: National Hydrography Dataset, Cornell CUGIR, and CSI

Transparent Baseline Monitoring in New York's Southern Tier

- It is essential to have public baseline chemical and biological "signatures" for streams and groundwater prior to the advent of hydrofracking
- In addition to the Cayuga Lake watershed and the Cayuta-Catatonk Water Watch, CSI plans to organize baseline stream monitoring partnerships with volunteer groups in Chenango, Broome and Chemung Counties
- CSI hopes private homeowners will share their groundwater data, but always in formats that guard their privacy