Cornell University

NEW YORK STATE WATER RESOURCES INSTITUTE

Monitoring for Water Resource Impacts: Risks & Science

November 17, 2010

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Outline

1. Discussion of water resource events & risks

2. Use of a framework for organizing events & risks (with discussion of implications for planning; prevention; detection; mitigation)

3. Monitoring and what it can and cannot do

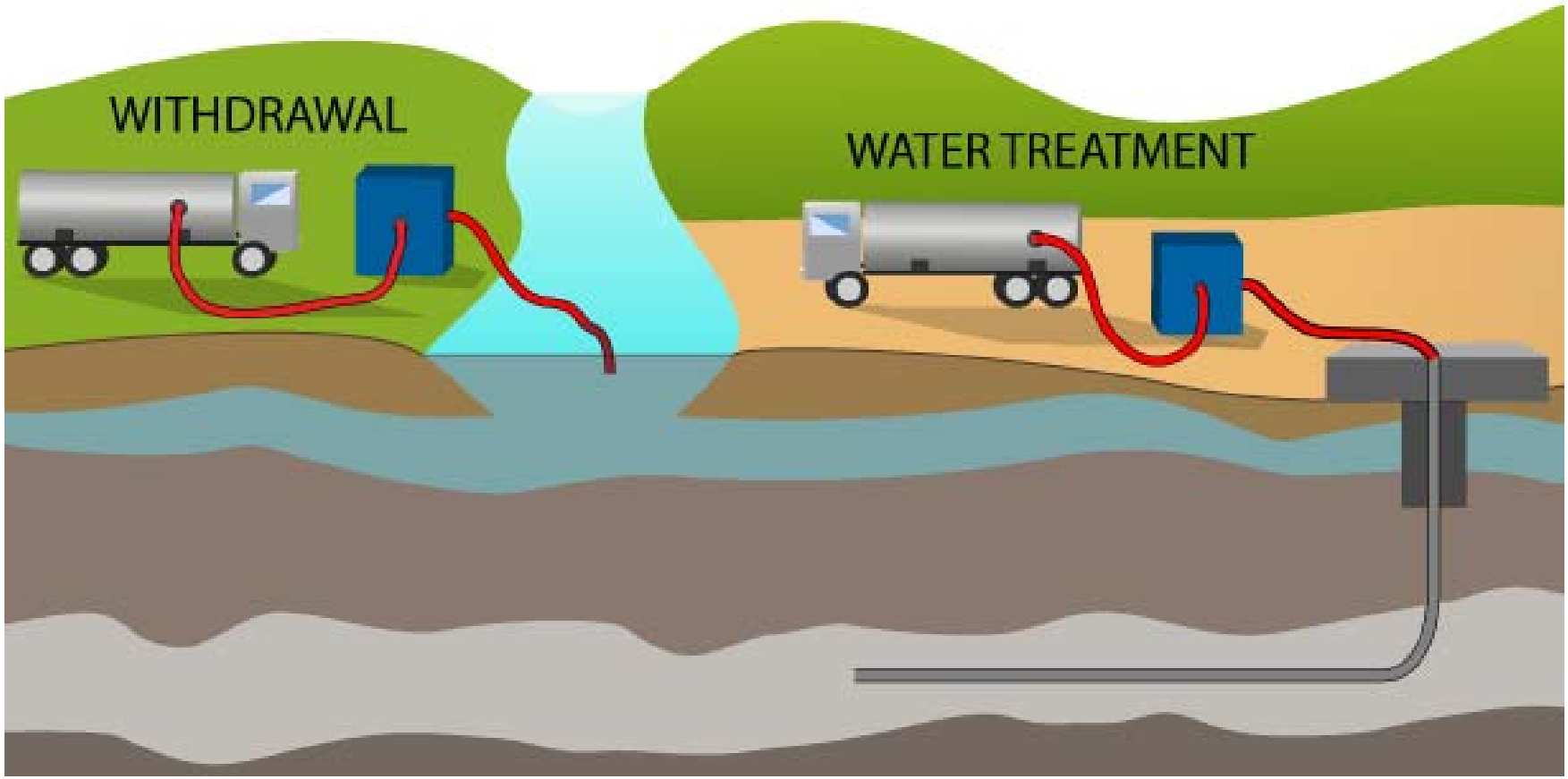
Monitoring

"Observe and check the progress or quality of (something) over a period of time"

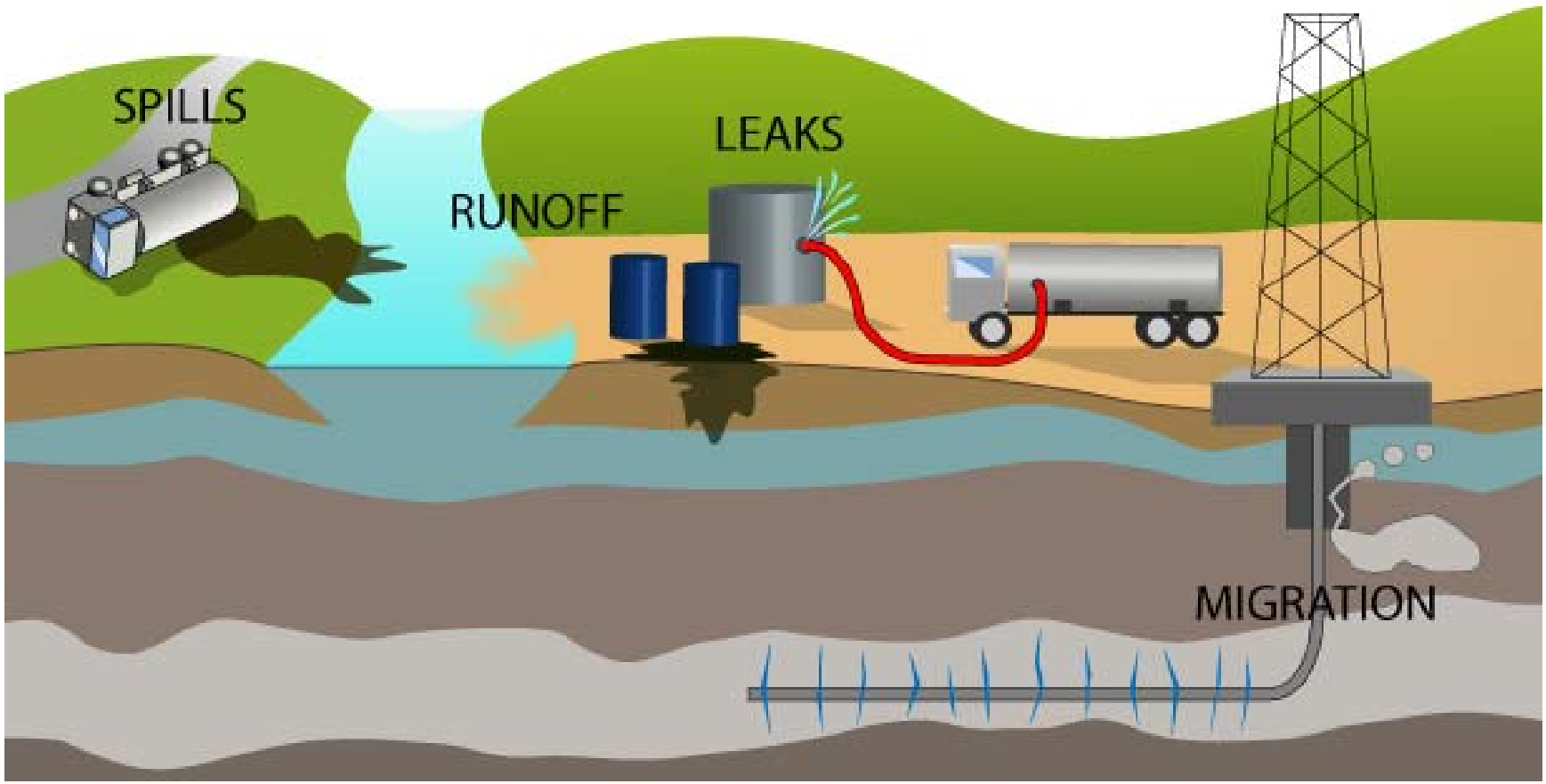
Monitoring

- What to monitor for?
- Where to monitor?
- How often?
- Who monitors?
- How is the data managed?
- How is monitoring connected with quality?

Deterministic events



Probabilistic events



Organizing a Framework

	Deterministic	Probabilistic
Surface	* Withdrawals * Wastewater	* Spills * Runoff
Subsurface		* Migration of gas and liquid due to cement failure or hydraulic fracturing

Certain:
Can be planned for

Uncertain:
Risk assessment

Can monitoring address these events & risks?

<u>Maybe</u>, if we can detect and measure the right things?

Detection & measurement issues

1. Scale and characteristic times

From NYSDEC

Scale and characteristic times

Scale

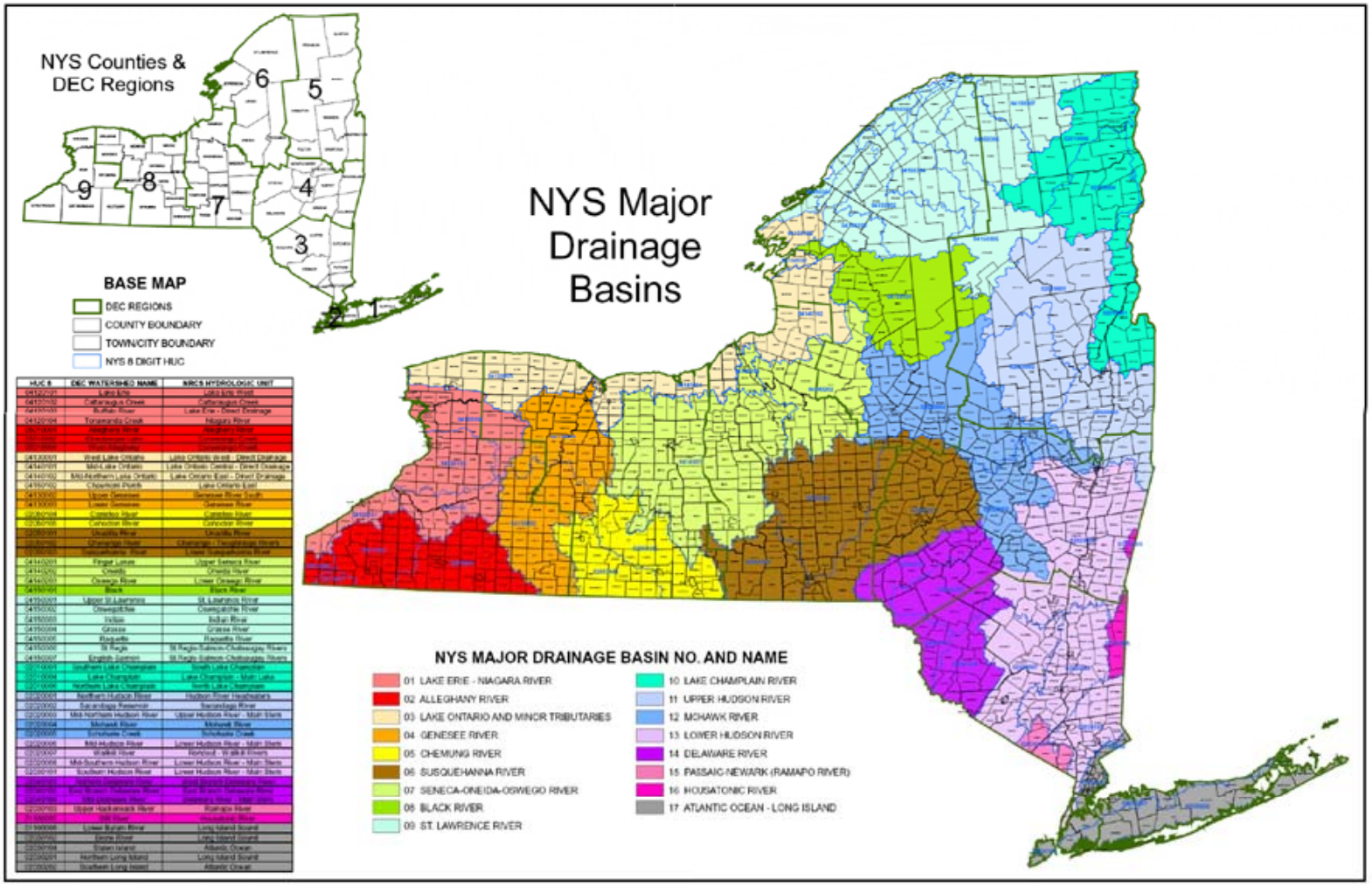
- Individual consumption ~ 1 gal/day
- Private water well ~ 10,000 gal/day
- Fall Creek ~ 100,000,000 gal/day
- Susquehanna River ~ 10,000,000,000 gal/day

Characteristic times

- Spill or leak ~ 1 day
- Drilling activity ~ 10 – 100 days
- Groundwater (1000 ft) ~ 10 – 1000 days

What are the implications for monitoring?

Scale and characteristic times

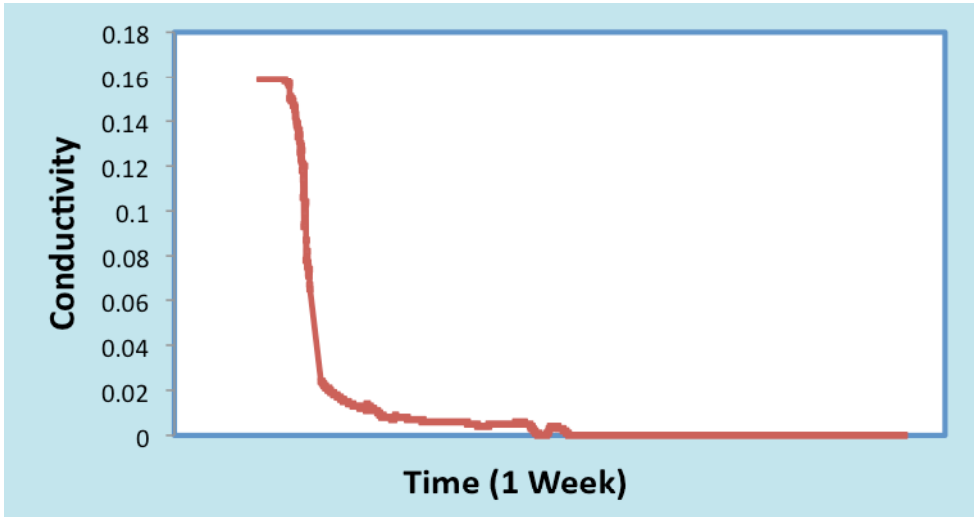


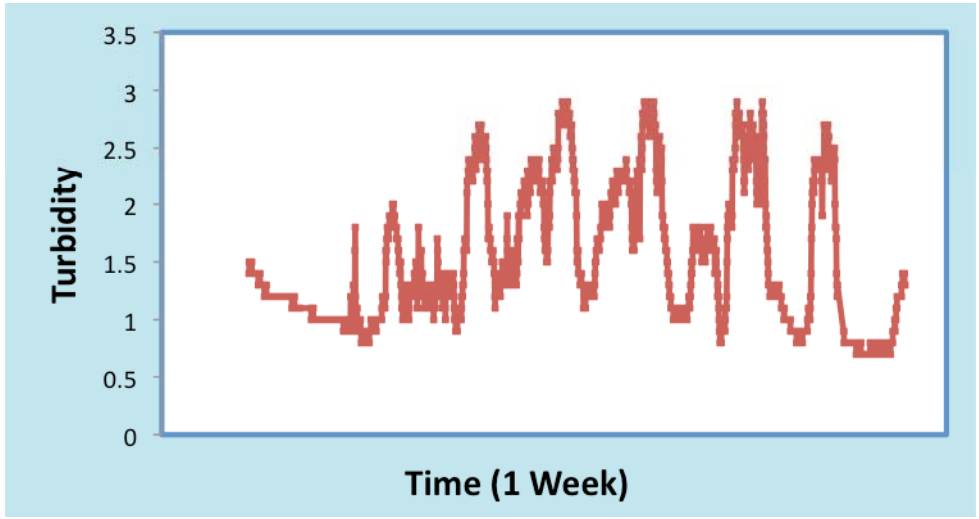
From NYSDEC

Detection & measurement issues

1. Scale and characteristic times
2. **Variability, significance and uncertainty**

Variability, significance and uncertainty





Data for Tomjack Creek near Burlington, PA
(provided by SRBC)

EPA's stance on hydraulic fracturing

"However, the threat posed to USDWs by the introduction of some fracturing fluid constituents is reduced significantly by the removal of large quantities of groundwater (and injected fracturing fluids) soon after a well has been hydraulically fractured. In fact, CBM production is dependent on the removal of large quantities of groundwater. EPA believes that this groundwater production, combined with the mitigating effects of dilution and dispersion, adsorption, and potentially biodegradation, minimize the possibility that chemicals included in the fracturing fluids would adversely affect USDWs."

Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs - EPA June 2004

Detection & measurement issues

1. Scale and characteristic times
2. Variability, significance and uncertainty
3. **Dilution**

Dilution

$C = (C_1Q_1 + C_2Q_2)/(Q_1 + Q_2)$

Assume:

- 1 Truck spill <u>everyday</u>
- Wastewater TDS = 200,000 ppm
- Volume per truck = 30,000 L

- Fall Creek TDS = 20 ppm* 36 ppm
- Sus River TDS = 50 ppm* 52 ppm

* Values reflect Cl- only

- Can mitigate some impacts
- Can make monitoring a challenge
- Characteristics of water body/aquifer are important
- Contaminant type matters

Detection & measurement issues

1. Scale and characteristic times
2. Variability, significance and uncertainty
3. Dilution
4. **Dispersion**

Dispersion

- Can mitigate some impacts
- Can make monitoring a challenge
- Characteristics of water body/aquifer are important
- Contaminant type matters

Image from NASA

Detection & measurement issues

1. Scale and characteristic times
2. Variability, significance and uncertainty
3. Dilution
4. Dispersion
5. **Adsorption**

Adsorption

- Can mitigate some impacts
- Can make monitoring a challenge
- Characteristics of water body/aquifer are important
- Contaminant type matters

Image from instructables.com

Detection & measurement issues

1. Scale and characteristic times
2. Variability, significance and uncertainty
3. Dilution
4. Dispersion
5. Adsorption
6. **Biodegradation**

Biodegradation

- Can mitigate some impacts
- Can make monitoring a challenge
- Characteristics of water body/aquifer are important
- Contaminant type matters

Image from Alaska-in-Pictures.com

Monitoring

- What to monitor for?
- Where to monitor?
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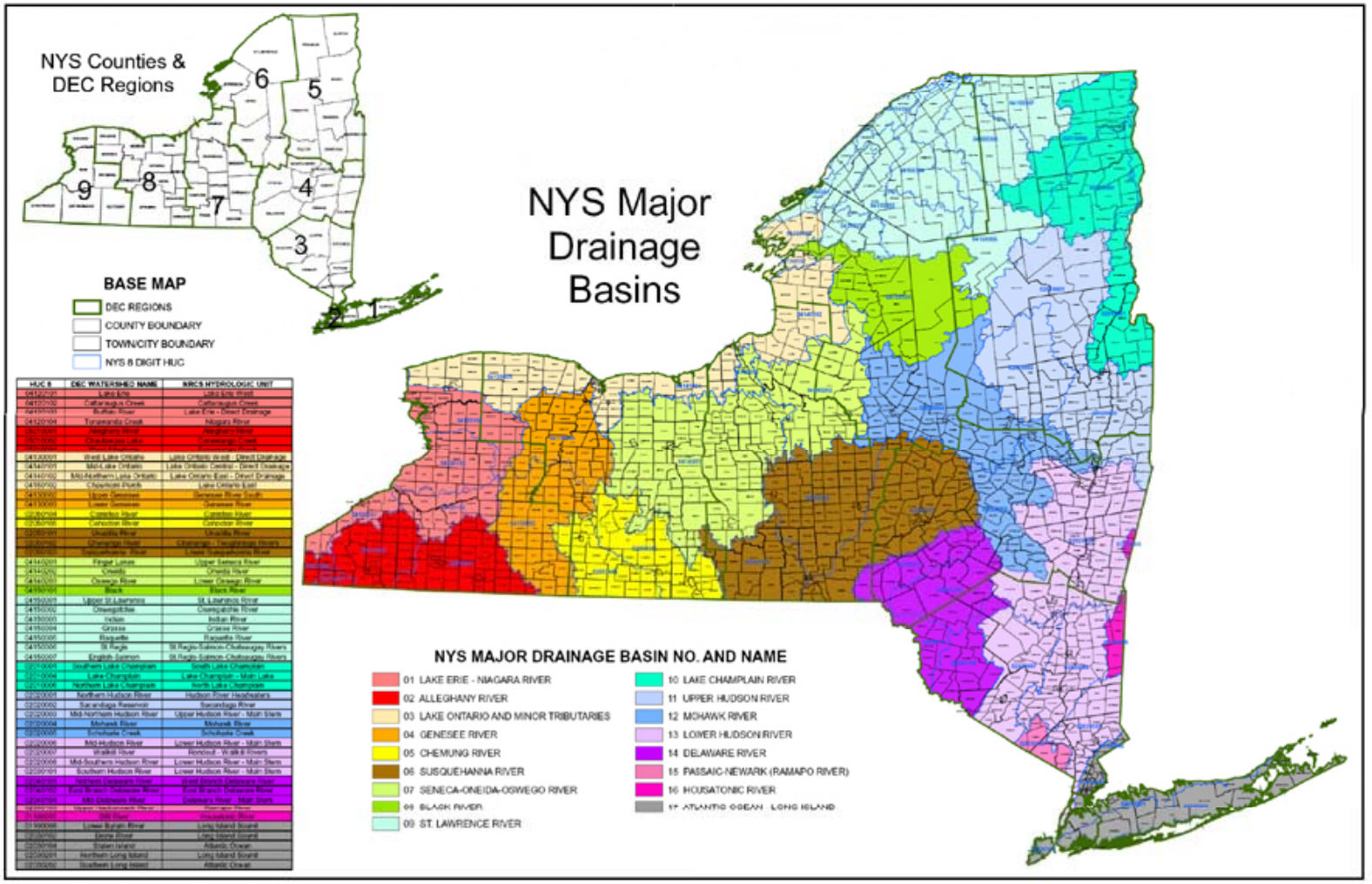
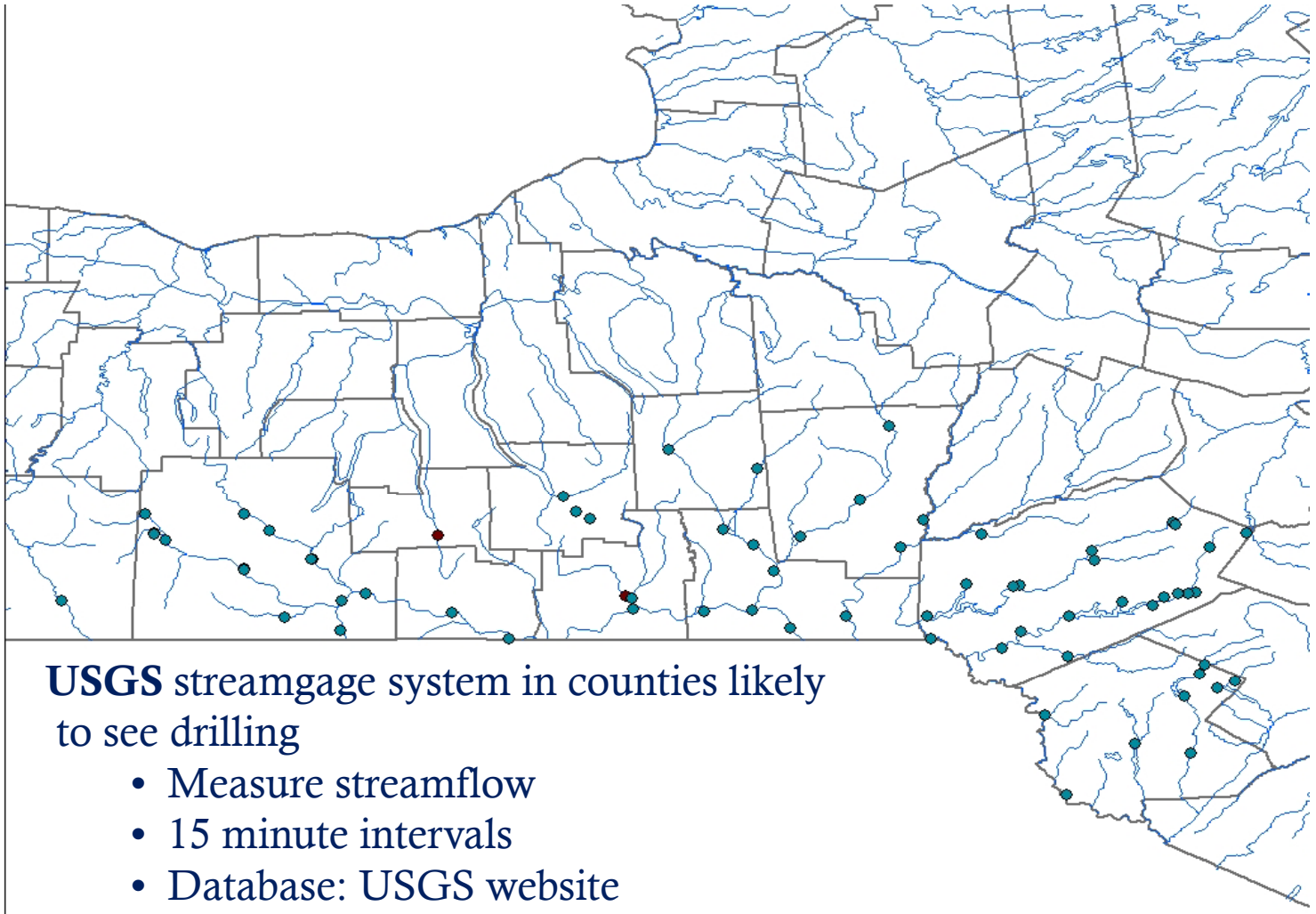
Basin-scale monitoring



From NYSDEC

Basin-scale monitoring



USGS streamgage system in counties likely to see drilling

- Measure streamflow
- 15 minute intervals
- Database: USGS website

Basin-scale monitoring

SRBC remote water quality monitoring system

- Only 1 currently in NY, with 9 more planned
- Measure
  - Conductivity; DO; turbidity; pH; temp.
  - 5 minute intervals
- Measure
  - Additional parameters
  - ~ 5 times/year
- Database: SRBC website

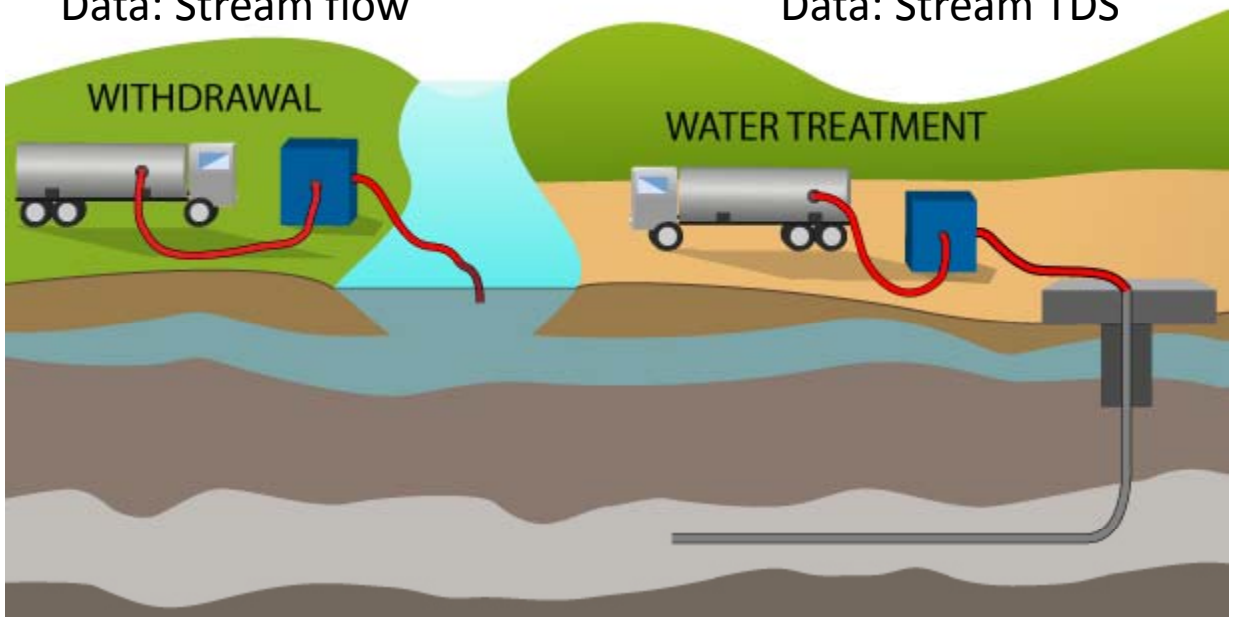
- Regulatory authority over water withdrawals and consumptive water use in the Susquehanna River Basin

From SRBC

Deterministic events & basin-scale monitoring

Data: Stream flow

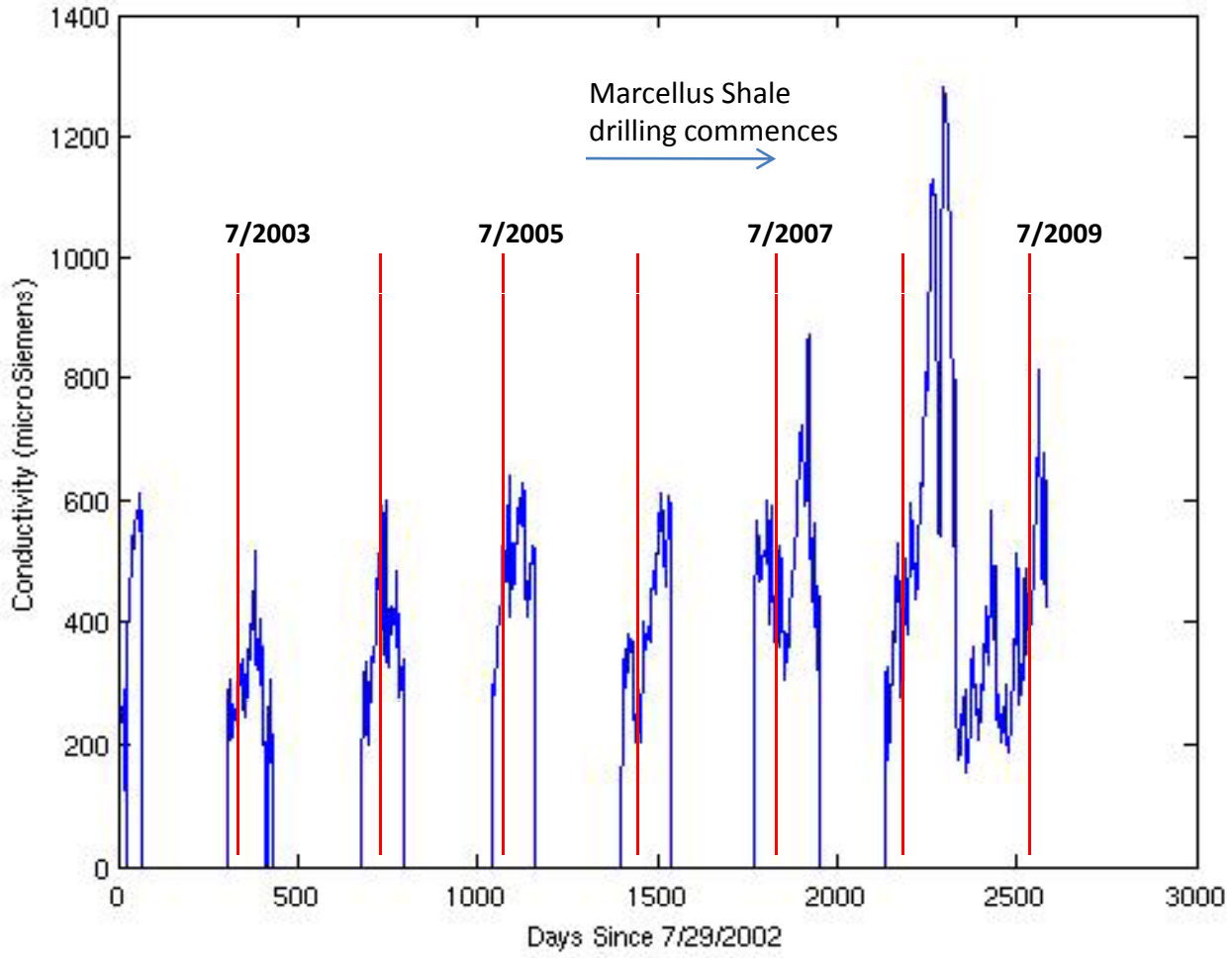
Data: Stream TDS



Monitoring benefit:
Planning & permitting

Monitoring benefit:
Limited; some long-term & cumulative regional water quality (TDS)

Monongahela River at Elizabeth, PA (2002-2009) - Specific Conductivity



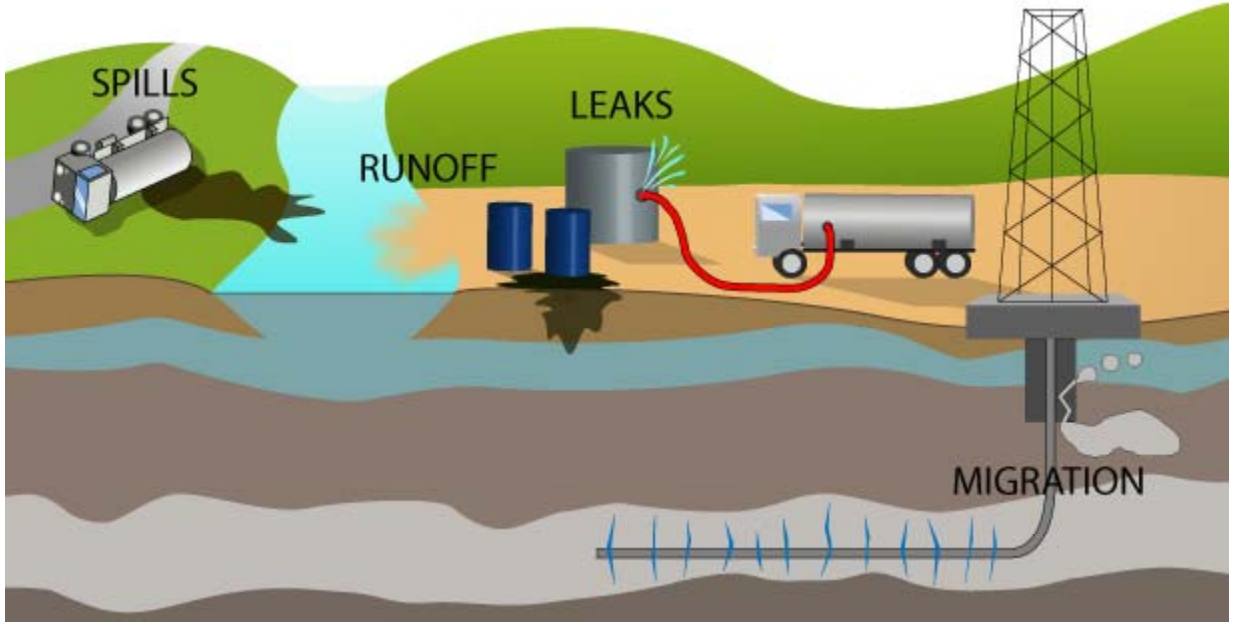
Basin-scale monitoring

- Some systems in place with database access and limited regulatory authority
- Good for planning with respect to water withdrawals
- May help reveal long-term and cumulative impacts (using limited measures of water quality)
- Poor for detecting impacts on small scales and timeframes, or as a result of specific contaminants

Probabilistic events & local-scale monitoring

Prevention and containment are key, since events are uncertain in time and space

Data: ?



Monitoring benefit:
Private water well testing before & after drilling activity may detect negative impacts

Local-scale monitoring

Typical concentrations of flowback constituents based on limited samples from PA and WV, and regulated in NY[1]

CAS #	Parameter Name	Total Number of Samples	Number of Detects	Min	Median	Max	Units
	1,4-Dichlorobutane	1	1	198	198	198	%REC
	2,4,6-Tribromophenol[1]	1	1	101	101	101	%REC
	2-Fluorobiphenyl[2]	1	1	71	71	71	%REC
	2-Fluorophenol[3]	1	1	72.3	72.3	72.3	%REC
00056-57-5	4-Nitroquinoline-1 -oxide	24	24	1422	13908	48336	mg/L
	4-Terphenyl-d14 [4]	1	1	44.8	44.8	44.8	%REC
00067-64-1	Acetone	3	1	681	681	681	µg/L
	Alkalinity, Carbonate, as CaCO3	31	9	4.9	91	117	mg/L
	Alpha, Radiation	25	6	22.41	1414.5	18950	pCi/L
07439-90-5	Aluminum	29	3	0.08	0.09	1.2	mg/L
07440-36-0	Antimony	29	1	0.26	0.26	0.26	mg/L
07664-41-7	Aqueous ammonia	28	25	12.4	58.1	382	mg/L
07440-38-2	Arsenic	29	2	0.09	0.1065	0.123	mg/L
07440-39-3	Barium	34	34	0.553	661.5	15700	mg/L
00071-43-2	Benzene	29	14	15.7	479.5	1950	µg/L

What do you test for?

From NYSDEC dSGEIS – Table 5.9

Local-scale monitoring

Private water well testing

- General testing always good idea
- More specific testing for parameters associated with drilling

- Measure
  - Range of parameters
  - Test before (baseline), during, and after drilling activity – *keep characteristic times in mind!*
- State certified lab
- Paid for by drilling company?
- No database

- Before/after testing by certified lab can be used to legally prove contamination in some cases

	Resource			
Parameter	**WRI**	**NY DEC**	**PSU**	**CSI**
Total Dissolved Solids (TDS)	1	1	1	1
pH	1	1	1	1
Barium	1	1	1	2
Methane	2	3	1	2
Hardness	2	2	2	1
Surfactants	2	2	2	2
Total Suspended Solids (TSS)	2	2	2	2
Strontium	2	2	2	
Alkalinity	2	3 *	2	2
Gross alpha	2	3 **	3	2

Partial table taken from the WRI website

Local-scale monitoring

- No system in place for organizing and managing information
- Local monitoring may detect local, site-specific events
  - Private water well testing must be done carefully (certified lab) and at the right times in order to result in regulatory action (NYSDEC)
- Effects of any single event too dilute or uncertain for basin-scale monitoring
- May not be helpful in determining overall environmental impacts on region

Organizing a Framework

	Deterministic	Probabilistic
Surface	* Withdrawals * Wastewater	* Spills * Runoff
Subsurface		* Migration of gas and liquid due to cement failure or hydraulic fracturing
Monitoring	Basin-scale	Local-scale
	Need: Planning & regulatory capacity outside of S/DRBC	Need: Focus on prevention & containment; Database management for water well info

Questions?

	Deterministic	Probabilistic
Surface	* Withdrawals * Wastewater	* Spills * Runoff
Subsurface		* Migration of gas and liquid due to cement failure or hydraulic fracturing
Monitoring	Basin-scale	Local-scale

Additional resources

NYS Water Resources Institute
http://wri.eas.cornell.edu/

New York State Department of Environmental Conservation
http://www.dec.ny.gov/energy/205.html

Pennsylvania Department of Environmental Protection
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/reports.htm

US Geological Survey waterwatch
http://waterwatch.usgs.gov/?m=real&r=ny&w=map

Susquehanna River Basin Commission
http://www.srbc.net/wrp/

Delaware River Basin Commission
http://www.state.nj.us/drbc/

Penn State University Extension webinar on private well testing
http://extension.psu.edu/water/webinar-series/past-webinars

Alliance for Aquatic Resource Monitoring (ALLARM)
http://www.dickinson.edu/ALLARM