

# TRENDS IN METHYL *TERT*-BUTYL ETHER CONCENTRATIONS IN PRIVATE WELLS IN SOUTHEAST NEW HAMPSHIRE: 2005 TO 2015

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With acknowledgment to:

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NH Dept. of Environmental Services

**Lucio Barinelli**

NH Dept. of Health and Human Services

# IN THE HEADLINES

## ExxonMobil Found Liable In N.H. Pollution Trial

By SAM EVANS-BROWN • APR 9, 2013

A jury in New Hampshire has ruled that Exxon-Mobile must pay the state \$236 million dollars to help clean groundwater contaminated with a gasoline additive known as MTBE. But the monetary award is by no means a done deal.

In a little state like New Hampshire, \$236 million is nothing to sneeze at.

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REUTERS

Business Markets World Politics Tech Commentary Breakingviews Money Life Pictures

INTERNAL REUTERS NEWS ROOM EXCLUSIVES AND WINS MOL | Fri Oct 2, 2015 | 4:42pm EDT

### New Hampshire court upholds \$236 million water pollution judgment against Exxon

## MtBE to be banned by 2007

By COLIN MANNING N.H. Statehouse Writer

CONCORD -- Gov. John Lynch signed legislation Tuesday eliminating the use of the dangerous gasoline additive MtBE in New Hampshire by 2007. But is there a chance getting rid of the additive that has plagued drinking water supplies in Strafford and Rockingham counties could mean even higher gas prices at the pumps?

MtBE is intended to reduce air pollution by allowing cars to burn cleaner and more efficiently. By banning the substance from gasoline supplies, the state will instead opt for adding ethanol to gas,



The U.S. Supreme Court building in Washington is shown on Monday (REUTERS/Kevin Lamarque)

### U.S. Supreme Court refuses to hear ExxonMobil MTBE appeal

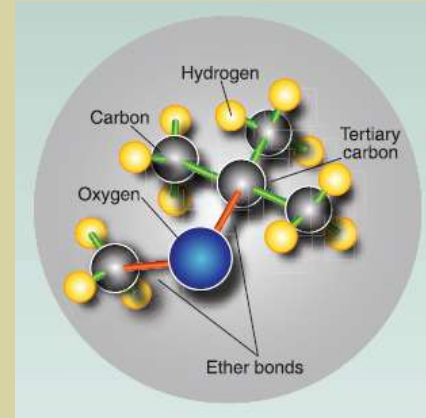
By DAVE SOLOMON

New Hampshire Union Leader

ExxonMobil has run out of options, and will soon have to pay New Hampshire

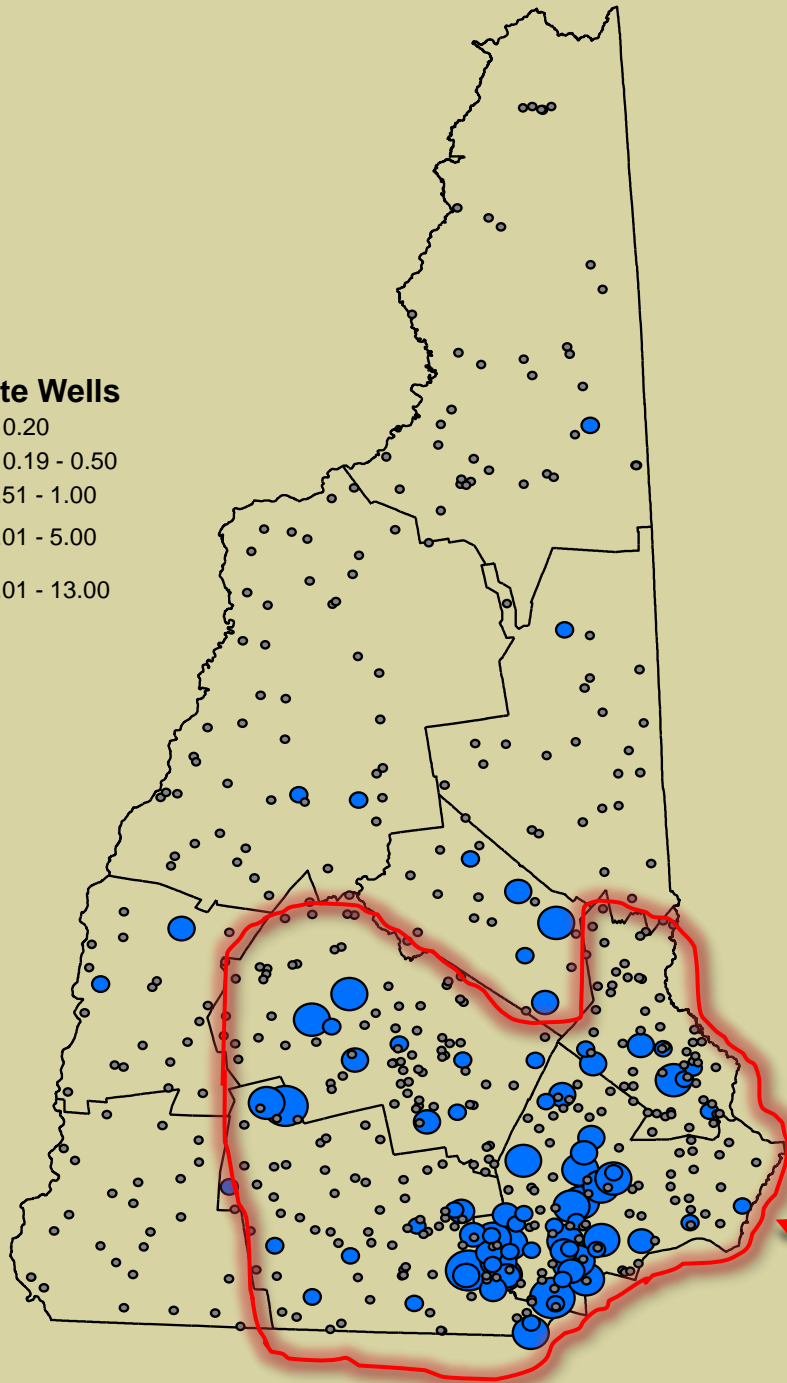
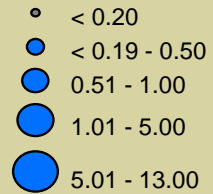
# OBJECTIVE

1. Significant factors in 2005 study
2. Approach for 2015 study
3. In Confidence
4. Major Findings
5. Conceptual Model
6. New England Perspective



# SIGNIFICANT FACTORS IN 2005 STUDY

## Private Wells



MtBE strongly correlated with:

## 1. RFG counties

## 2. Population Density

- housing density
- road density
- distance to roads

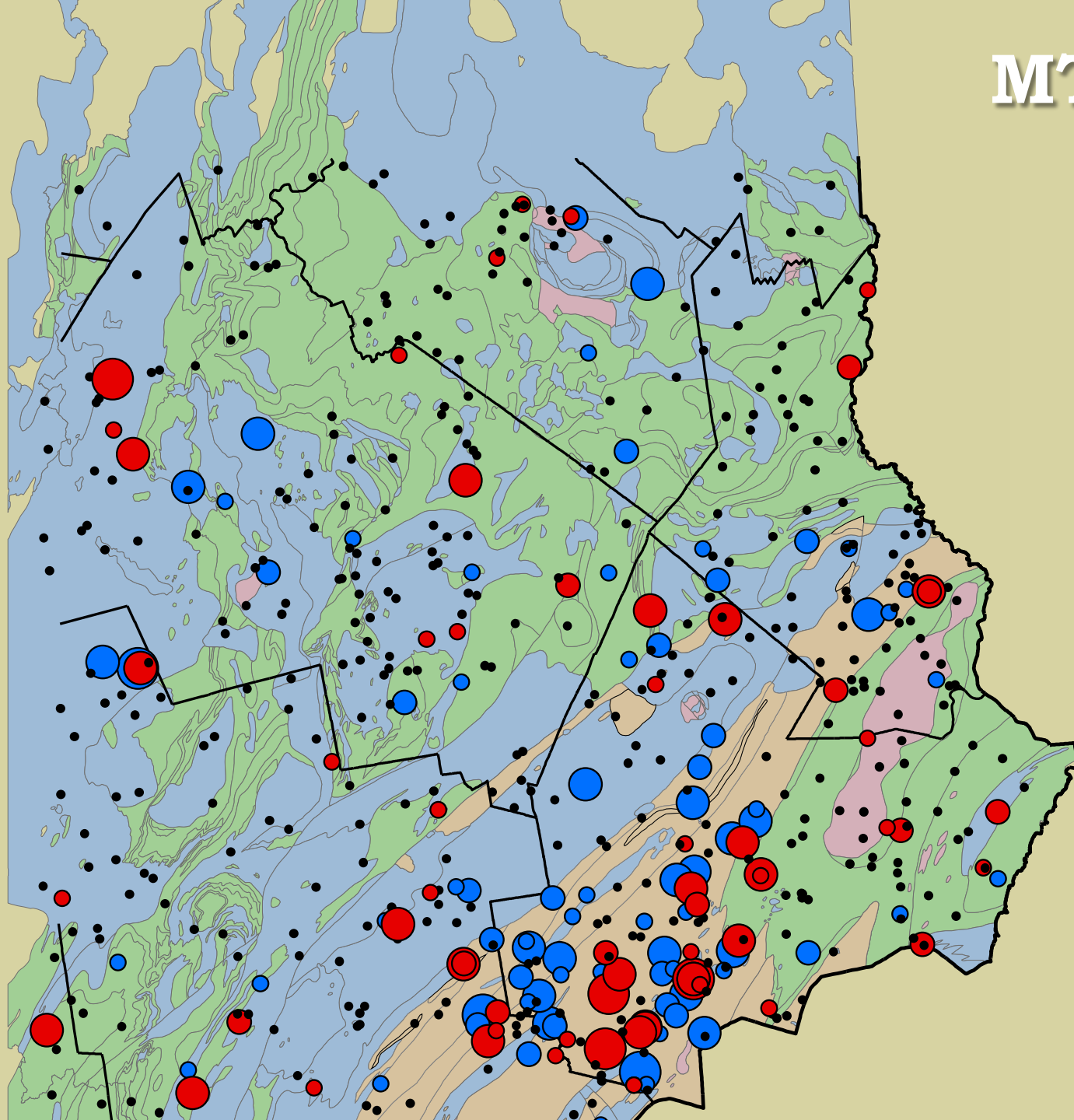
## 3. Geology

- Berwick Formation

RFG counties

Ayotte and others, 2008

# MTBE DISTRIBUTION IN RFG COUNTIES 2005 STUDY



Metasedimentary rocks of the  
Berwick Formation



SOB, SOBc, SOBg

Other metasedimentary  
rocks and granites



Metamorphic



Granite

MTBE in wells in 2005



Public wells



Private wells

# APPROACH FOR 2015 STUDY

**OBJECTIVE:** Time-step analysis of MtBE in domestic (household) wells from 2005 to 2015 to determine changes in MtBE concentrations and detection frequencies in southeast NH

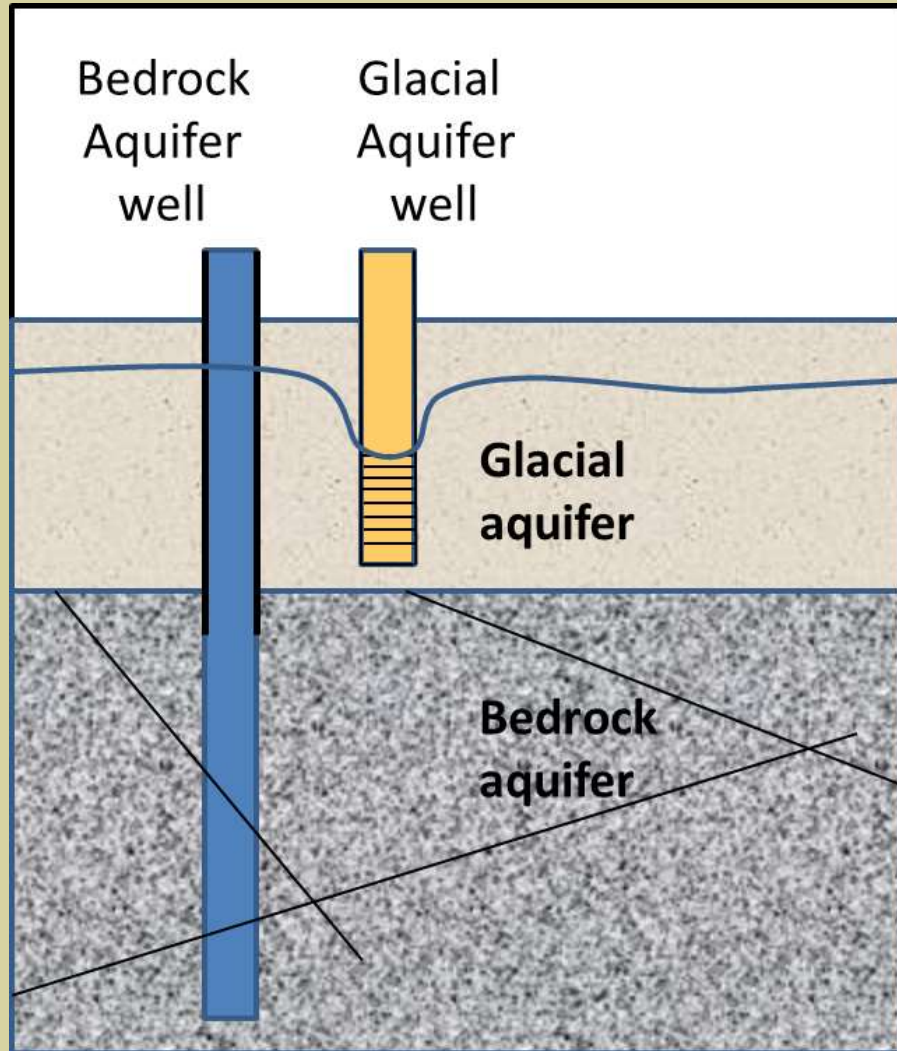
## CHALLENGES:

- We assumed a large percentage of non-detections.
- We assumed a majority of MtBE concentrations in 2015 < 1.0 µg/L.

## APPROACH:

1. Resample ~200 domestic wells from 2005 study in RFG counties only.
2. Use the same laboratory, analytical method, and LRL (0.2 µg/L) as previous study.
3. Integrate extensive QA/QC (blanks, replicates, spikes & spike replicates.)
4. Develop confidence intervals to assess comparability.
5. Determine changes from 2005 (overall and by subgroups).

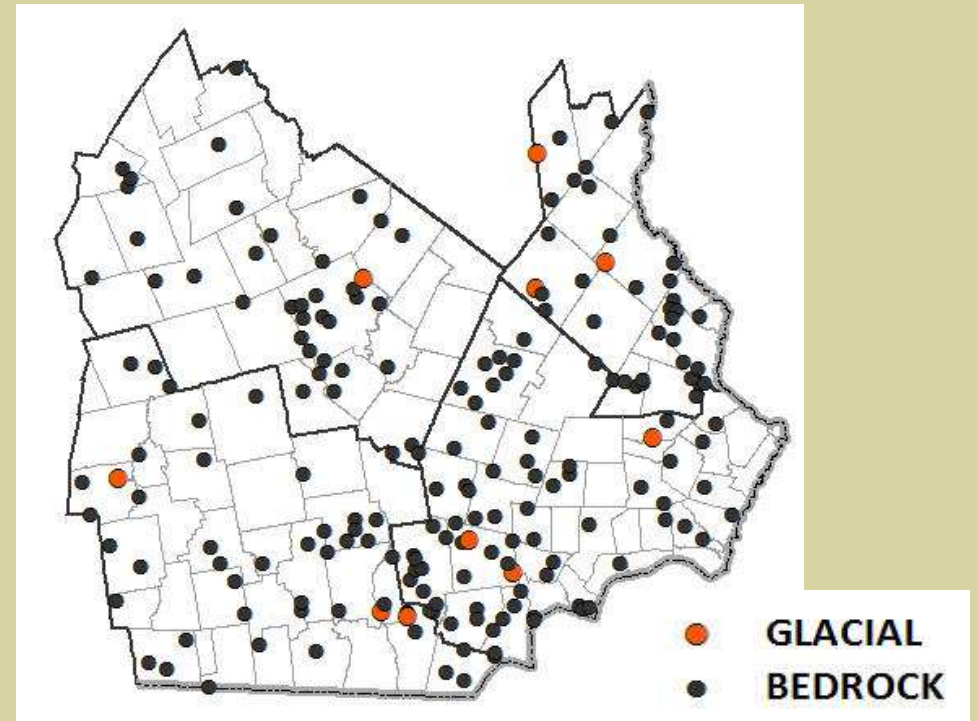
# STUDIED WELLS



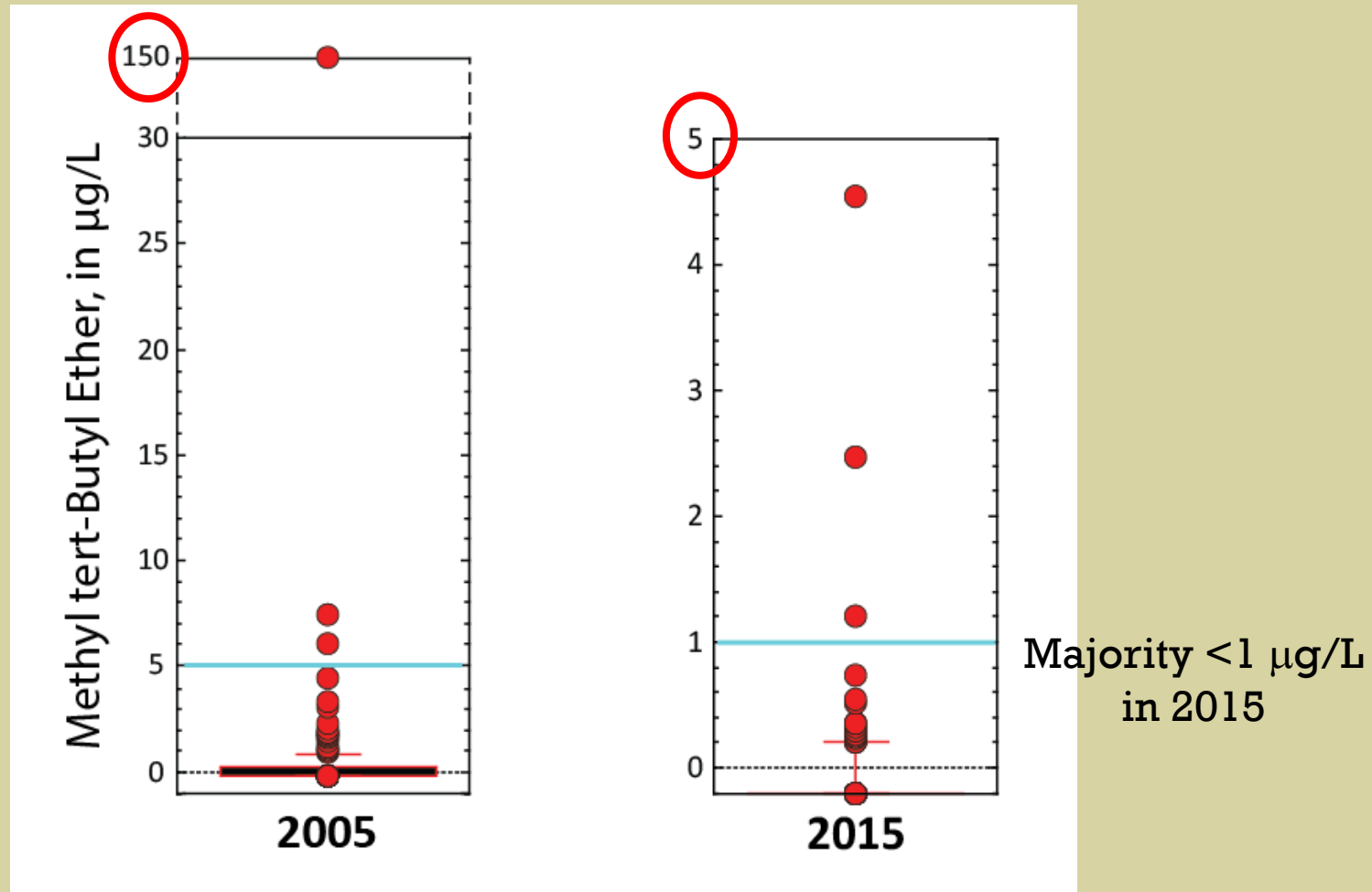
Randomly selected....

**185** fractured-crystalline bedrock wells

**10** shallow, glacial (dug) wells



# DISTRIBUTION OF MTBE CONCENTRATIONS



There were also 140 (72 %) non-detected ( $< 0.2 \mu\text{g/L}$ ) sample pairs



# USE OF CONFIDENCE INTERVALS TO DETERMINE CHANGES IN CONCENTRATIONS

$$[C_L, C_U] = C \pm 1.96 \times \sigma$$

**C** = concentration, as reported by the laboratory  
 $\sigma$  = sampling variability of measured concentration

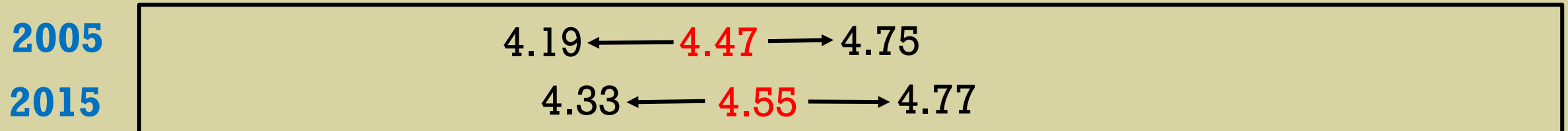
Sampling Event	Number and TYPE of MEASURABLE replicate sample pairs	Mean RSD
2005 study	13 ENVIRONMENTAL	2.42 %
2015 study	16 ENVIRONMENTAL & 33 SPIKE	3.15 %

In 2015, we targeted replicate pairs at sites with 2005 detections  
All field and lab spike samples were replicated too.

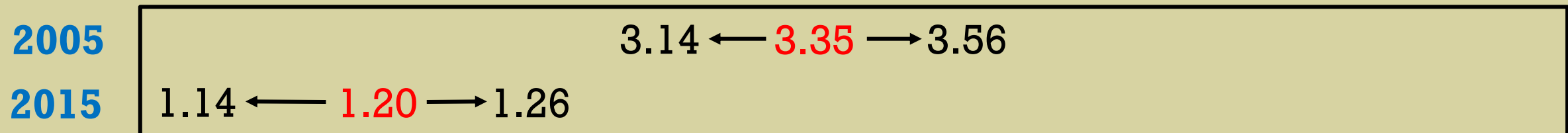
Resulting in ~ 60% QAQC samples.

# APPLYING CONFIDENCE INTERVALS TO THE DATA

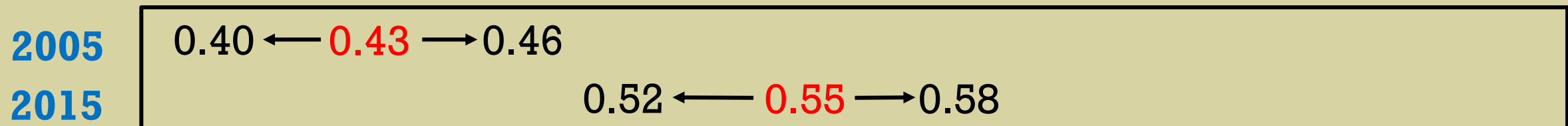
## No Change



## Decrease



## Increase

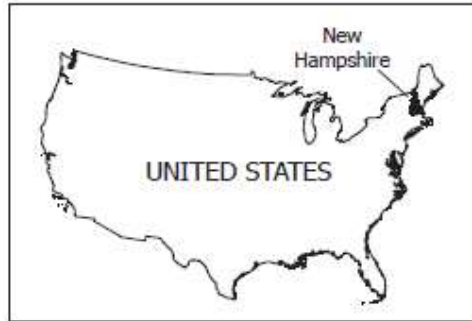


# SUMMARY OF MTBE CHANGES IN 51 WELLS, 2005 TO 2015

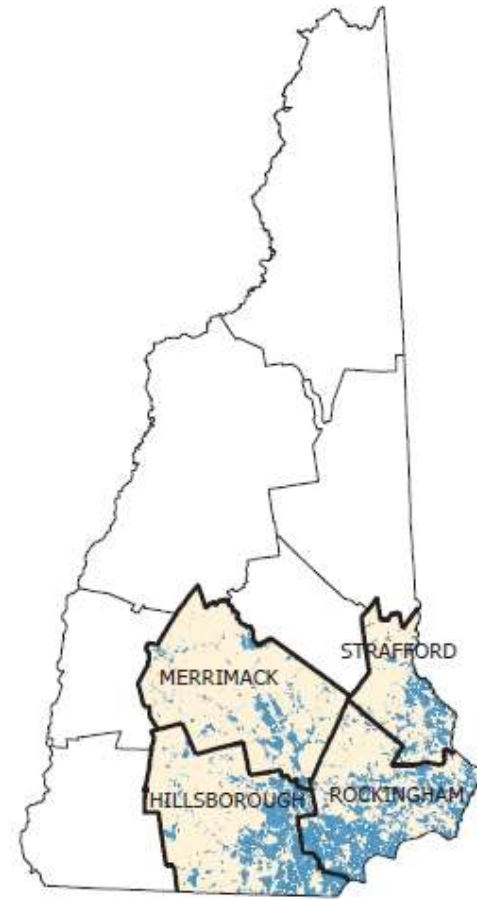
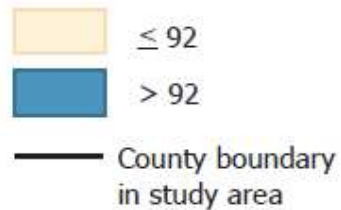
MtBE Concentrations...	N	MINIMUM	MEDIAN	MAXIMUM
		(Change in concentrations, in percent)		
INCREASED	4	0.01 µg/L (5%)	<b>0.07</b> µg/L (17%)	2.26 µg/L (1,074%)
DECREASED	47	0.01 µg/L (5%)	<b>0.41</b> µg/L (66%)	150.8 µg/L (99%)

**NOTE: NO MtBE detections in 140 wells in 2005 and 2015; No changes in MtBE concentrations in 4 wells.**

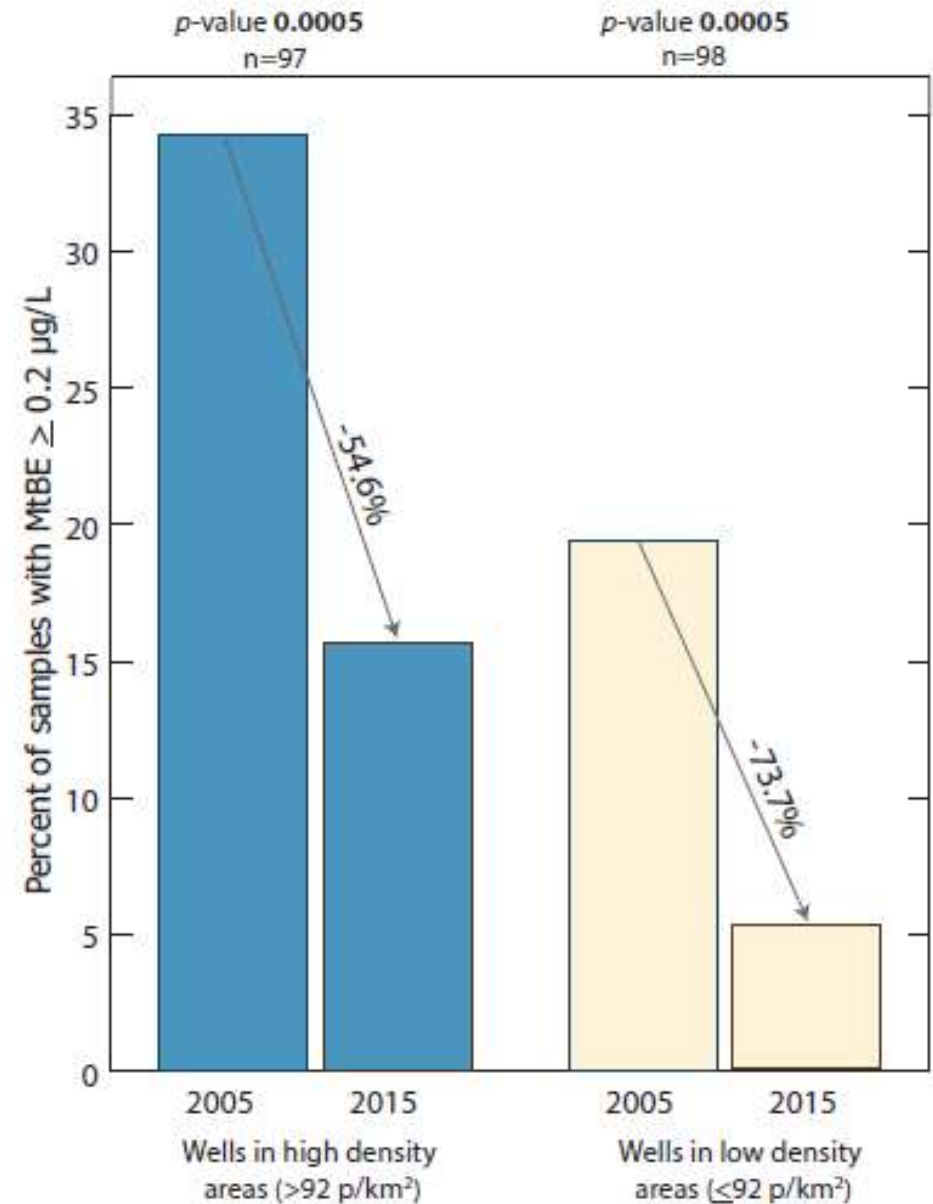
# POPULATION DENSITY



2010 Population Density, in persons per square kilometer

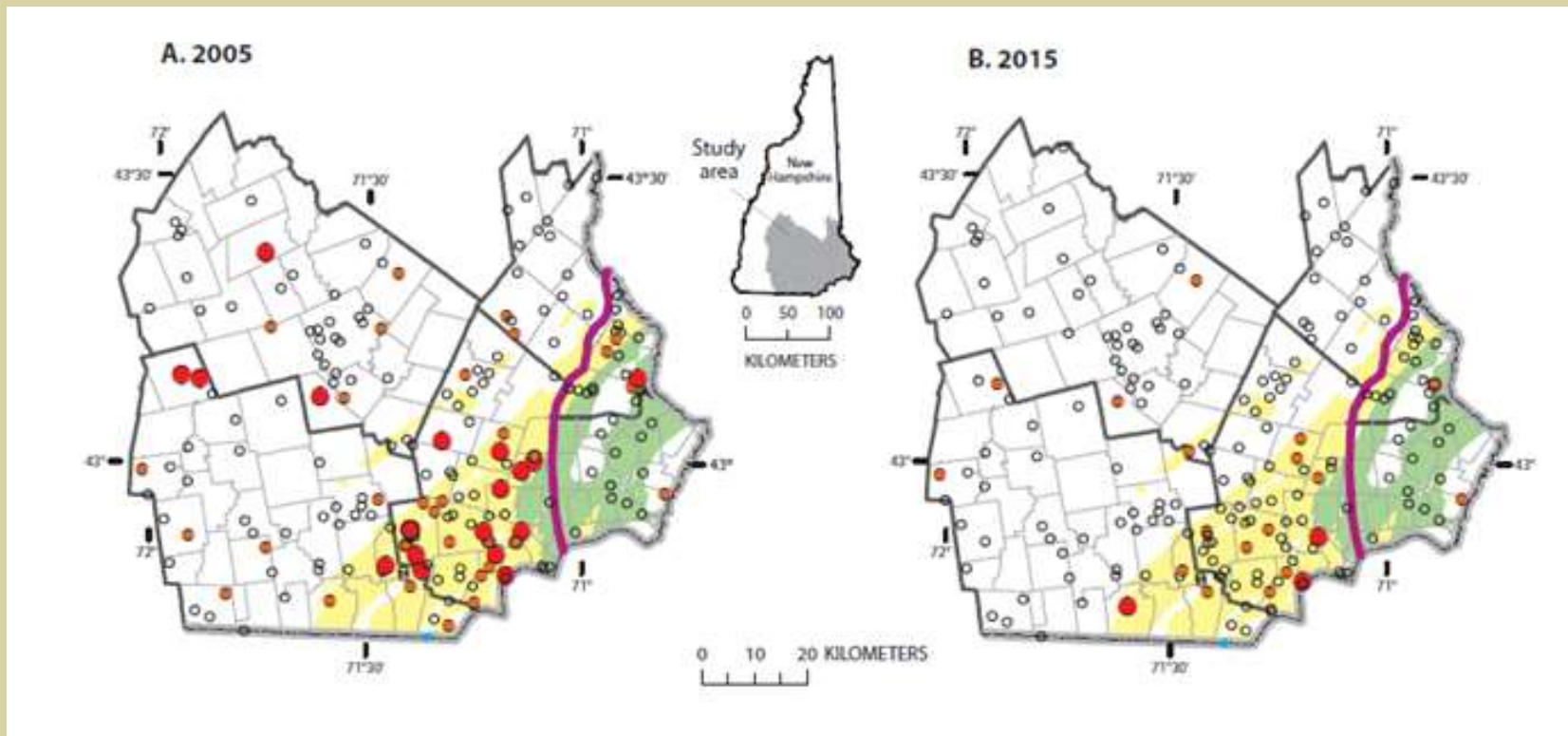


0 25 50 KILOMETERS



# MAJOR FINDINGS

- Of the 195 wells resampled in 2015, 10.3% had MtBE detections ( $\geq 0.2 \mu\text{g/L}$ ) compared to 26.7% in 2005—representing a 62% decrease overall for the study area.
- On average, MtBE concentrations decreased 66% among 47 wells, whereas MtBE concentrations increased 17% among 4 wells.
- The decontamination rate (percent change in detection frequency) was lowest (-45.5%) in high density areas and in wells completed in the Berwick Formation.
- The decontamination rate was highest (-78.6%) in low density areas and in wells completed in granite, mafic, and metamorphic rocks.
- Wells completed in the Kittery and Eliot Formations had no MtBE detections in 2005 or 2015, even though 46% of the wells are in high density areas.



<b>All Wells</b>		<b>Berwick</b>	<b>Eliot &amp; Kittery</b>	<b>Other bedrock</b>	<b>Dug wells</b>
10.3 %	Detection Frequency in 2015	24.6%	0 %	5.5 %	0 %
-62 %	Decontamination rate: 2005 to 2015	-46 %	0 %	-74 %	-100 %

# CONCEPTUAL MODEL

## Shallow Depths to Bedrock:

Vulnerable to surface loaded contaminants.

## Impermeable glacio-marine silt-clay deposits:

May impede the downward movement of contaminants

## Deep Wells with low yield:

Need large contributing areas

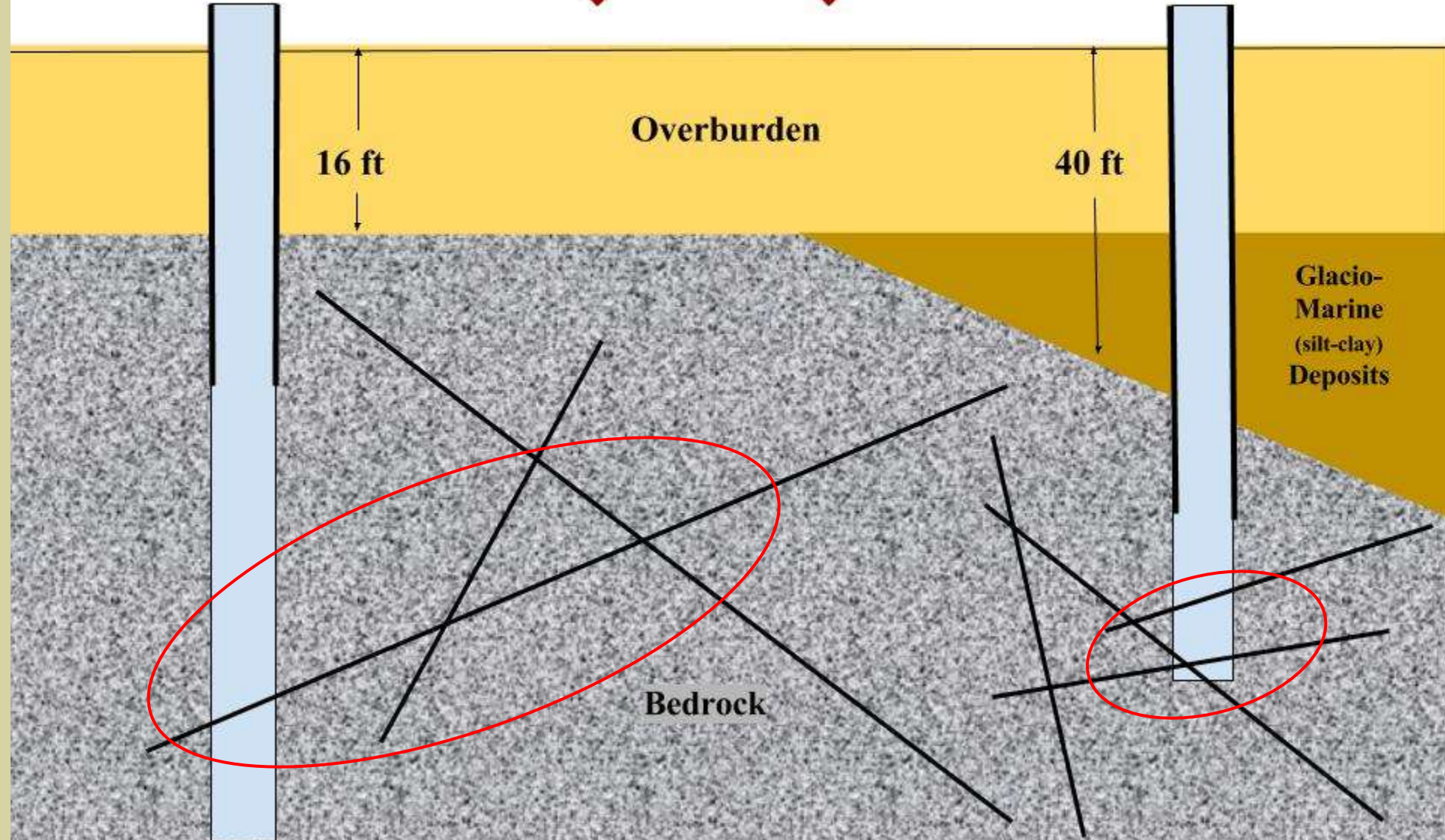
## Berwick Formation

Ave Yield = 8 gpm  
Ave Depth = 300 ft

## Eliot/Kittery Formations

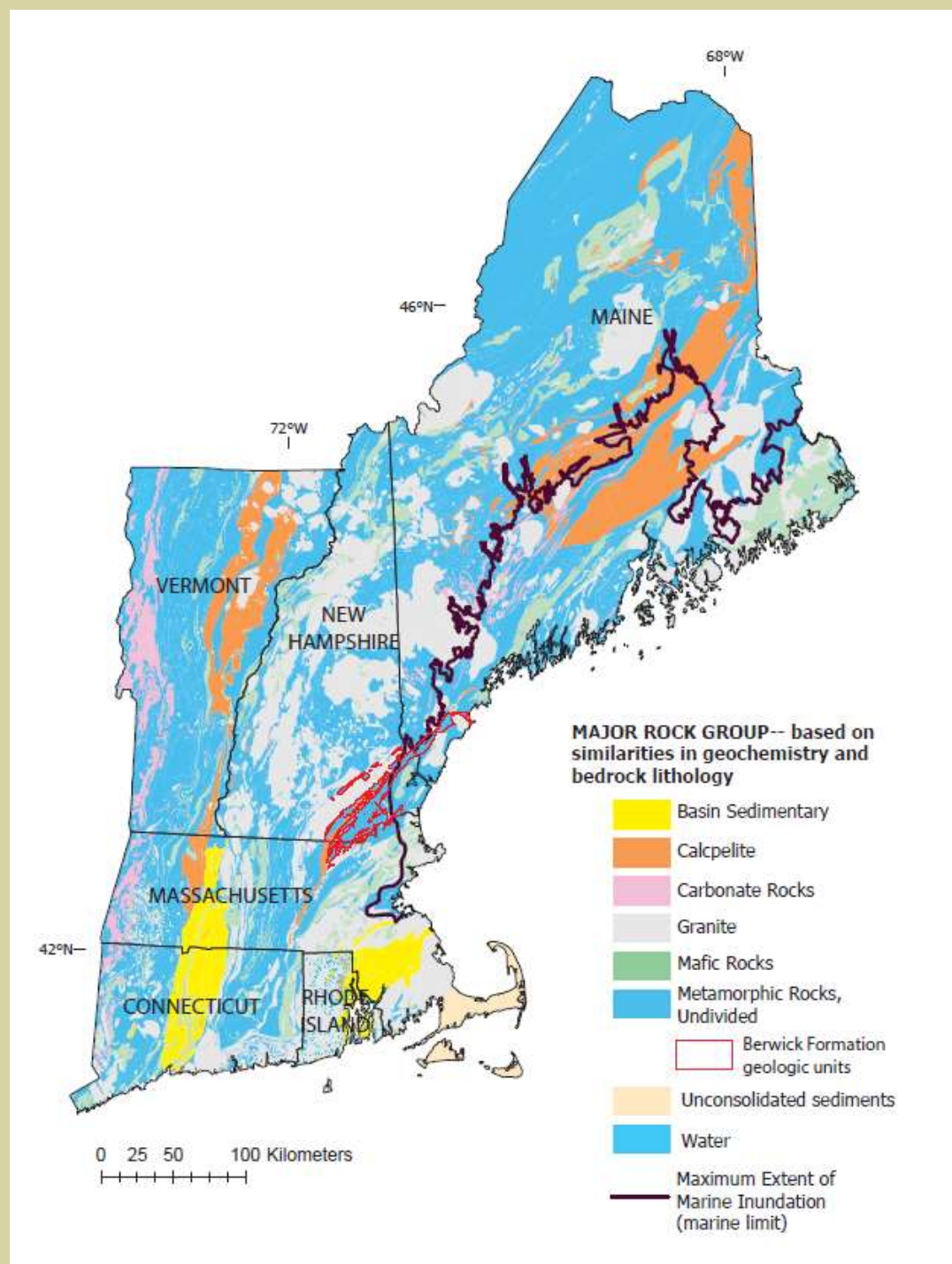
Ave Yield = 14 gpm  
Ave Depth = 233 ft

MTBE



# NEW ENGLAND PERSPECTIVE

- MtBE persistent and pervasive at low levels
- Heterogeneous decontamination in bedrock
- Geologic formations cross state boundaries
- Local issues likely exist regionally
- Marine inundation significant in Maine – Is MtBE less prevalent here?






# OTHER CONTAMINANTS OF CONCERN

<b>Contaminant of Concern</b>	<b>Solubility in Water (mg/L)</b>
Sodium chloride	359,000
MtBE	36,200
Benzene	1,780
Perfluorooctanoic acid (PFOA)	3,400
Perfluorooctane sulfonate (PFOS)	570

# THIS STUDY WAS PUBLISHED IN ***ENVIRONMENTAL SCIENCE AND TECHNOLOGY*** IN JANUARY 2017

## Trends in Methyl *tert*-Butyl Ether Concentrations in Private Wells in Southeast New Hampshire: 2005 to 2015

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New England Water Science Center, U.S. Geological Survey, 331 Commerce Way, Pembroke, New Hampshire 03275, United States

### [Supporting Information](#)

**ABSTRACT:** In southeast New Hampshire, where reformulated gasoline was used from the 1990s to 2007, methyl *tert*-butyl ether (MtBE) concentrations  $\geq 0.2 \mu\text{g/L}$  were found in water from 26.7% of 195 domestic wells sampled in 2005. Ten years later in 2015, and eight years after MtBE was banned, 10.3% continue to have MtBE. Most wells (140 of 195) had no MtBE detections (concentrations  $< 0.2 \mu\text{g/L}$ ) in 2005 and 2015. Of the remaining wells, MtBE concentrations increased in 4 wells, decreased in 47 wells, and did not change in 4 wells. On average, MtBE concentrations decreased 65% among 47 wells whereas MtBE concentrations increased 17% among 4 wells between 2005 and 2015. The percent change in detection frequency from 2005 to 2015 (the decontamination rate) was lowest (45.5%) in high-population-density areas and in wells completed in the Berwick Formation geologic units. The decontamination rate was the highest (78.6%) where population densities were low and wells were completed in bedrock composed of granite, metamorphic, and mafic rocks. Wells in the Berwick Formation are characteristically deeper and have lower yields than wells in other rock types and have shallower overburden cover, which may allow for more rapid transport of MtBE from land-surface releases. Low-yielding, deep bedrock wells may require large contributing areas to achieve adequate well yield, and thus have a greater chance of intercepting MtBE, in addition to diluting contaminants at a slower rate and thus requiring more time to decontaminate.

