



# Energy and Environmental Risk

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*Earth and Environmental Sciences*

# What is our Theme?



- ◆ ALL FORMS OF ENERGY CARRY RISKS
  - ➔ Quantifying risks must be based on science, measurements, risk analysis...
  - ➔ Then, policy recommendations can ensue...
  - ➔ And appropriate political/economic decisions arrived at...
- ◆ WHAT TYPE OF ENERGY FUTURE DO YOU WANT?
- ◆ WHAT RISKS ARE ACCEPTABLE?
- ◆ Continued discussion is part of our lives...

It's great!



It's evil!



(...it's probably neither...)

# Energy and Environmental Risk...



**Energy & environmental risks are often...**

- ...misunderstood
- ...missetimated
- ...misrepresented



# Transportation & Storage Risks...



- ◆ Aleyska pipeline risk reduction...

**Thermosiphon-stabilized piles greatly reduced permafrost degradation risk**

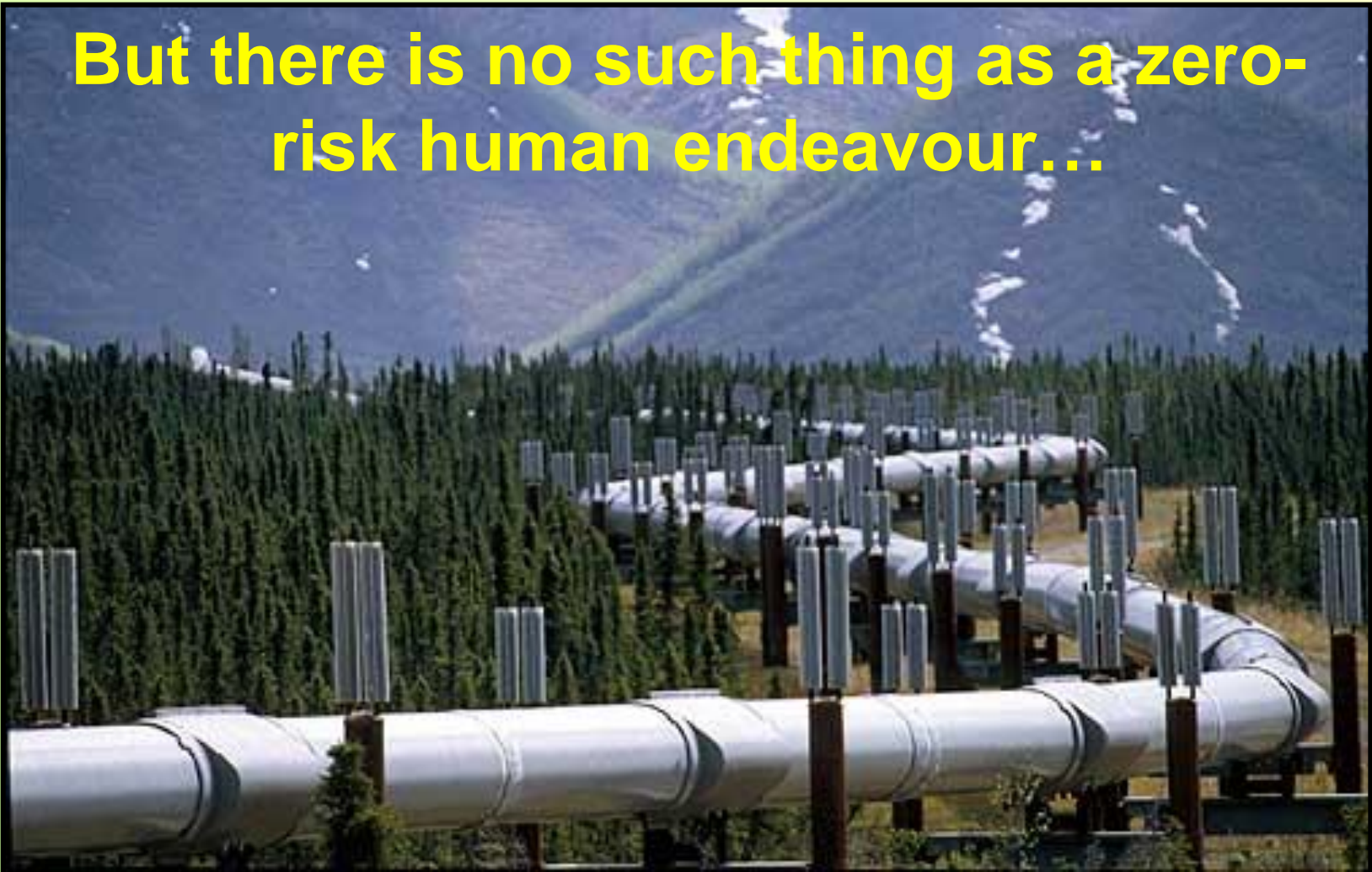


# Transportation & Storage Risks...



- ◆ Aleyska pipeline risk reduction...

**But there is no such thing as a zero-risk human endeavour...**



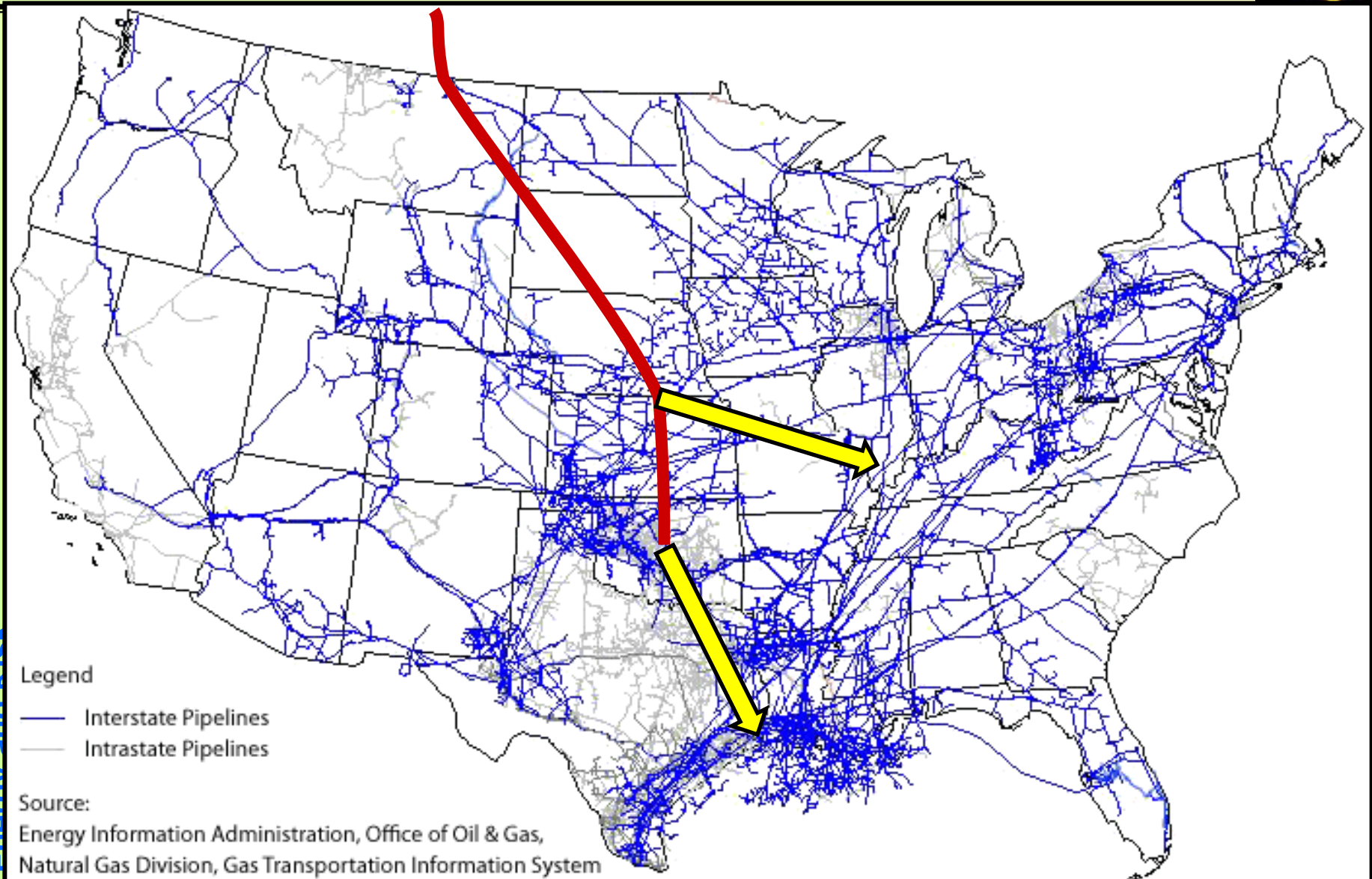




# Oil and Gas Pipeline and Storage Risks



# Keystone Pipeline Risks



## Legend

- Interstate Pipelines
- Intrastate Pipelines

## Source:

Energy Information Administration, Office of Oil & Gas,  
Natural Gas Division, Gas Transportation Information System

# Ogallala Aquifer



# Is Aquifer Contamination a Risk?



- ◆ Yes, but an extremely small one (volumes)
- ◆ First, leak detection technology is quite good, and as soon as a leak is detected – shut down
- ◆ Second, oil & water are immiscible, oil gets “trapped” on top of water, & can be removed
- ◆ Third, clean-up requirements are very stringent
- ◆ Fourth, aquifer recharge is a dilution process
- ◆ Fifth, contaminants are not toxic (smelly, yes)
- ◆ **NEVERTHELESS, there are RISKS**



# What are the Issues? The Risks?





# Northern Gateway Risks - Enbridge



- ◆ Pipeline – river crossings, steep terrain...
- ◆ Seaport and ships – narrow channel, storms





Helpful? Informative? I don't think so.

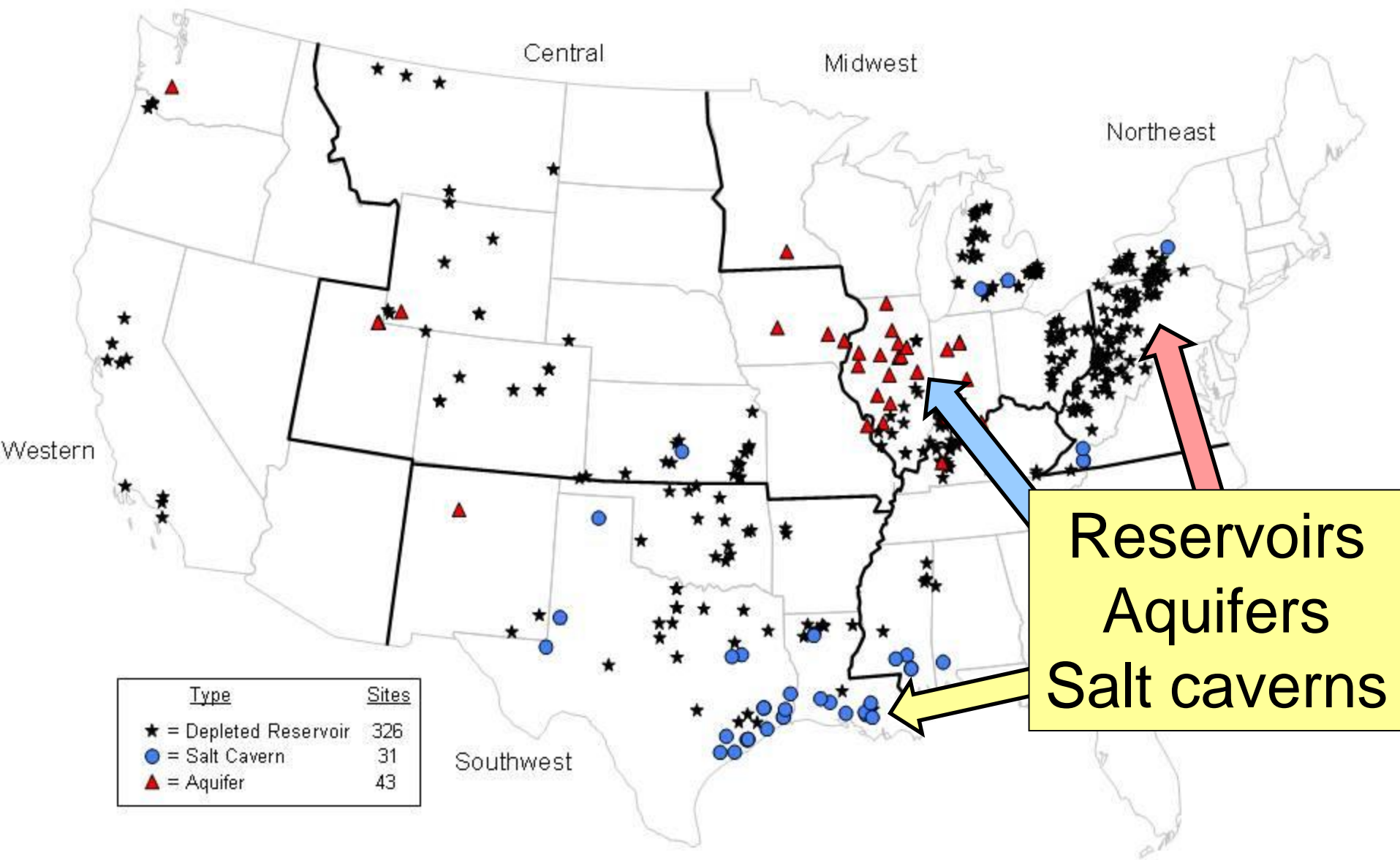


# Natural Gas Transport & Storage



- ◆ Transport – natural gas pipelines...
- ◆ Storage – old gas reservoirs, salt caverns...



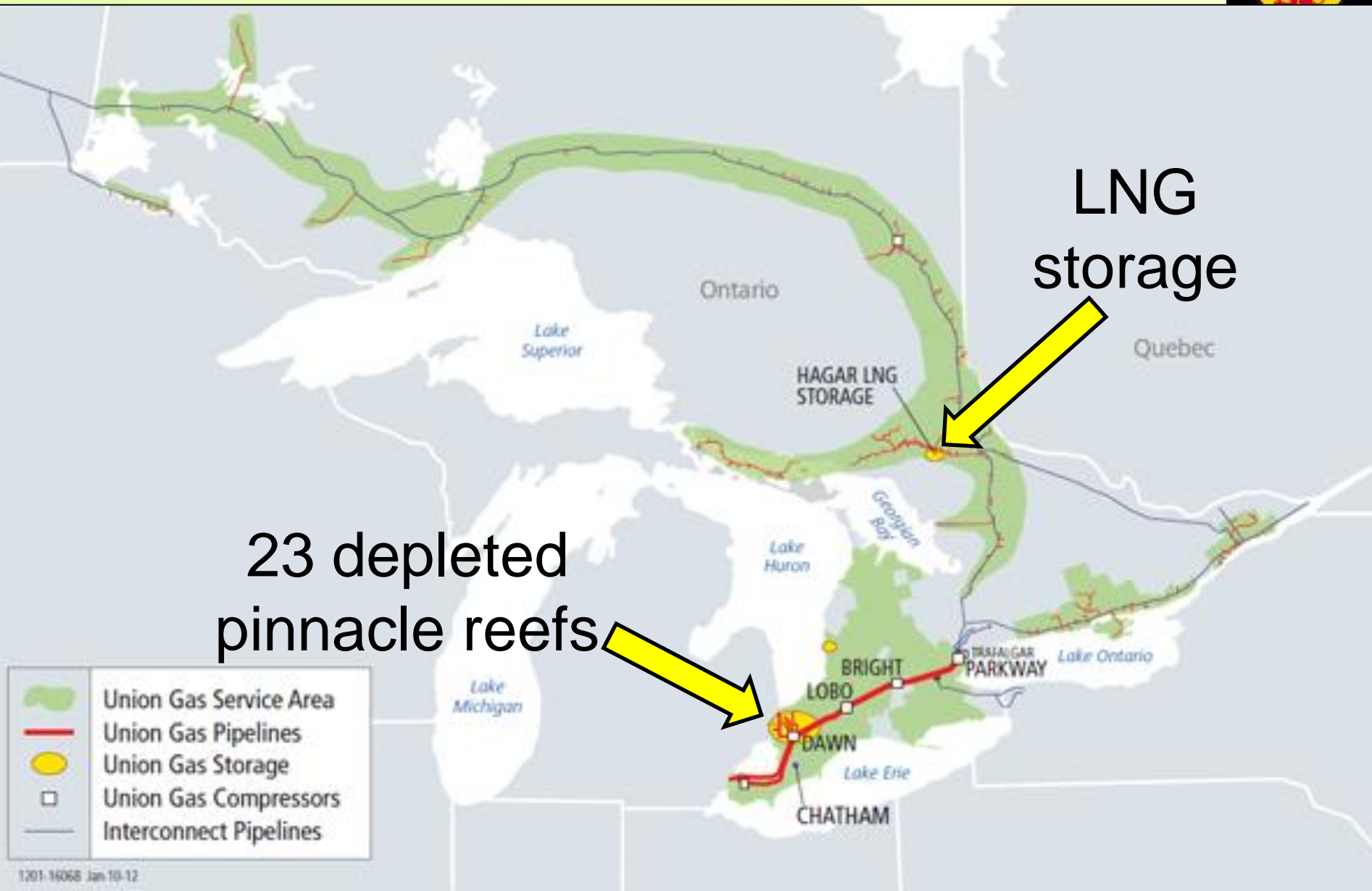


Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division Gas, Gas Transportation Information System, December 200

## Underground CH<sub>4</sub> storage facilities - USA



# Storage in Ontario...



# Gas Pipelines and Storage



- ◆ A clear regulatory framework exists
- ◆ The demands and safety standards are strong
  - Very few serious accidents have happened
  - CH<sub>4</sub> is far less dangerous than supposed
  - Underground storage is safe and economical
- ◆ But...
  - Regulatory bodies must monitor and enforce
  - Cutting corners, under-reporting incidents are risks
  - Adequate monitoring of lines and facilities





## Gas fracking will revolutionise the US economy

Headline from...

**The Telegraph**

March 26 2012 (yesterday)

<http://www.telegraph.co.uk/finance/commodities/9165898/Gas-fracking-will-revolutionise-the-US-economy.html>

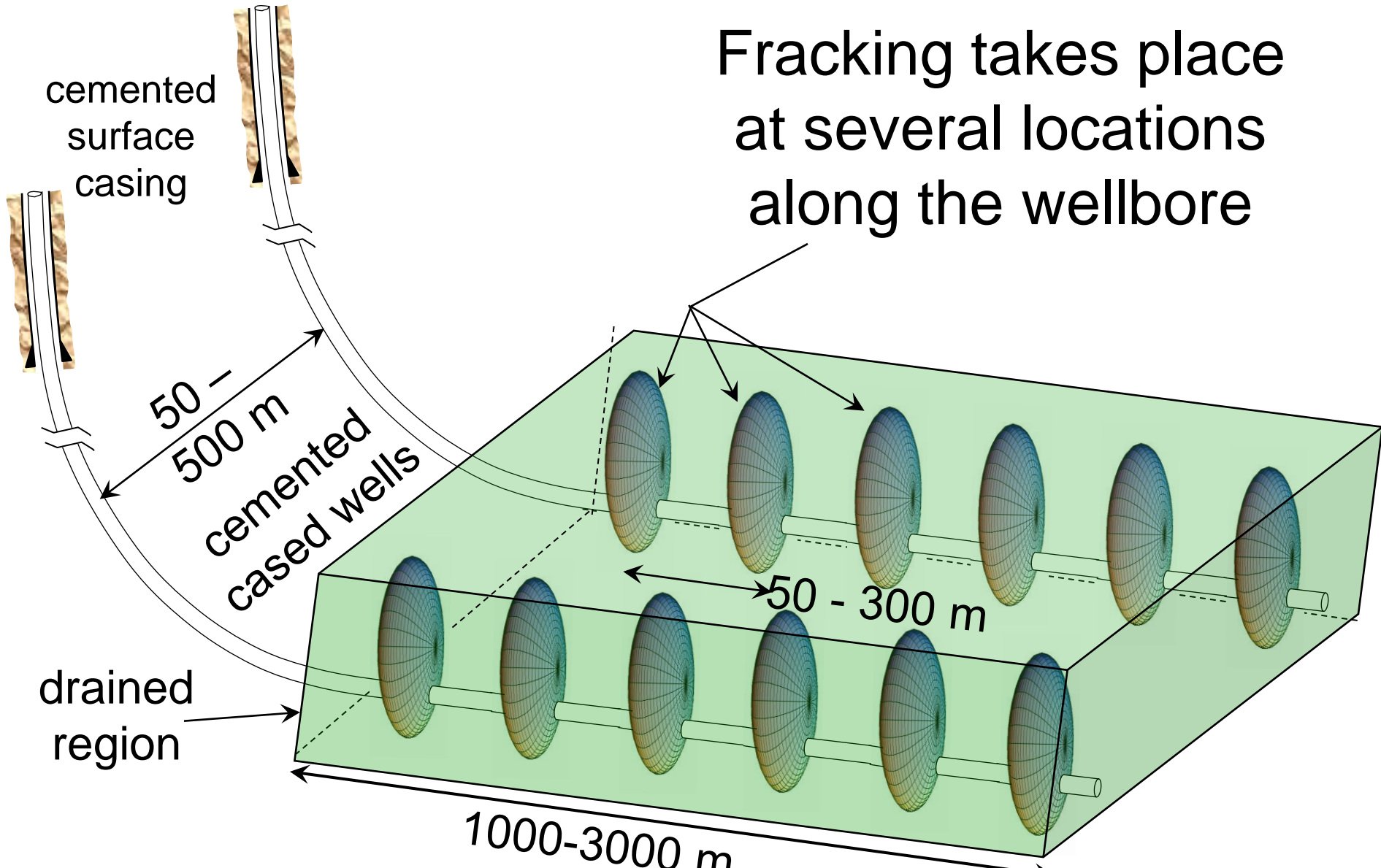


# What is Fracking?



- ◆ Shale gas formations have low permeability
- ◆ To access the  $\text{CH}_4$  economically, we have to increase both drainage area and drainage rate
- ◆ A section of the well at depth is isolated
- ◆ Water + some additives + sand are mixed and injected at very high rates and pressures to...
- ◆ Fracture the reservoir so that the gas can flow more easily to the horizontal wellbore

# Fracking a Horizontal Well

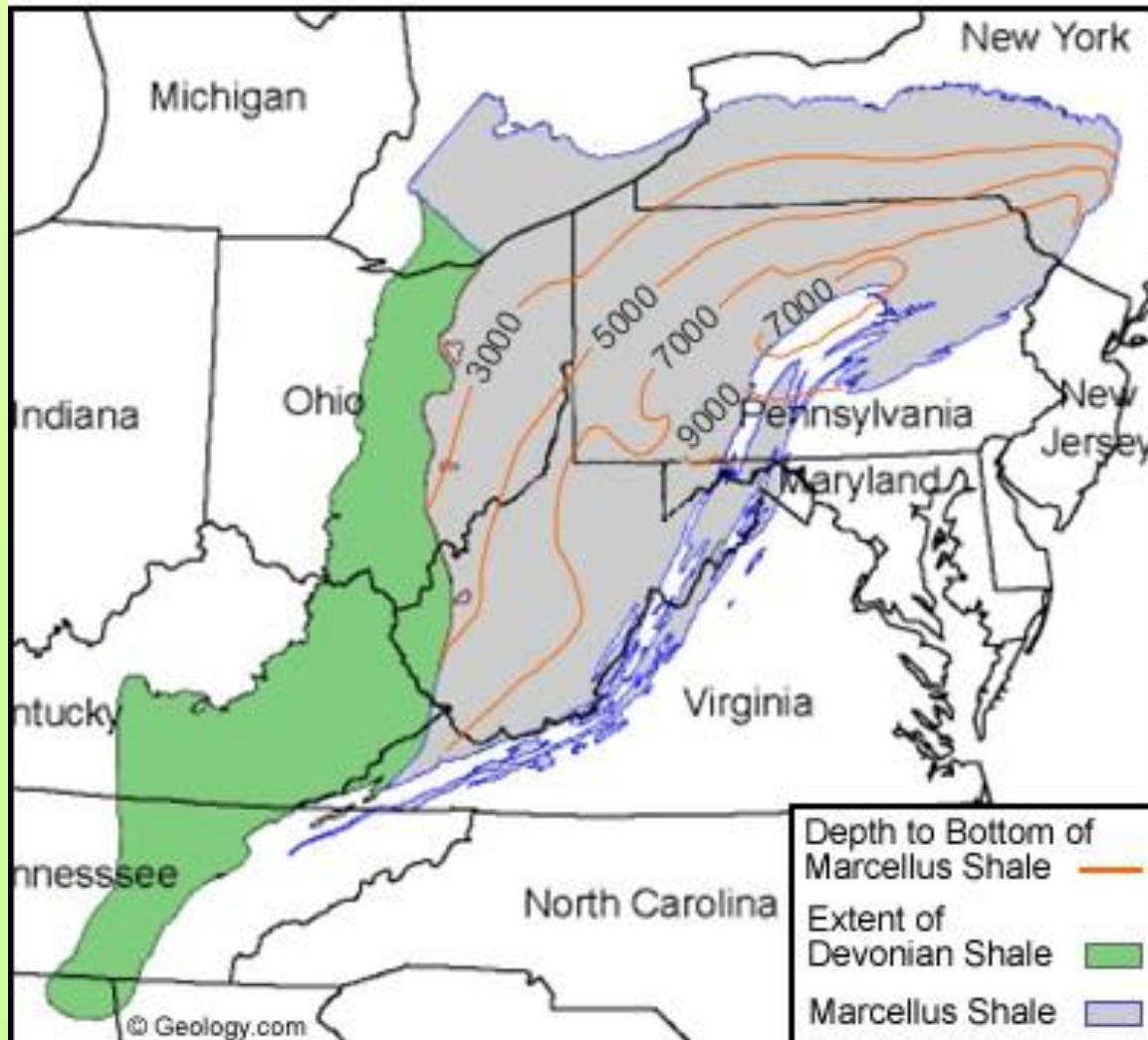


# Fracturing the Marcellus Shale

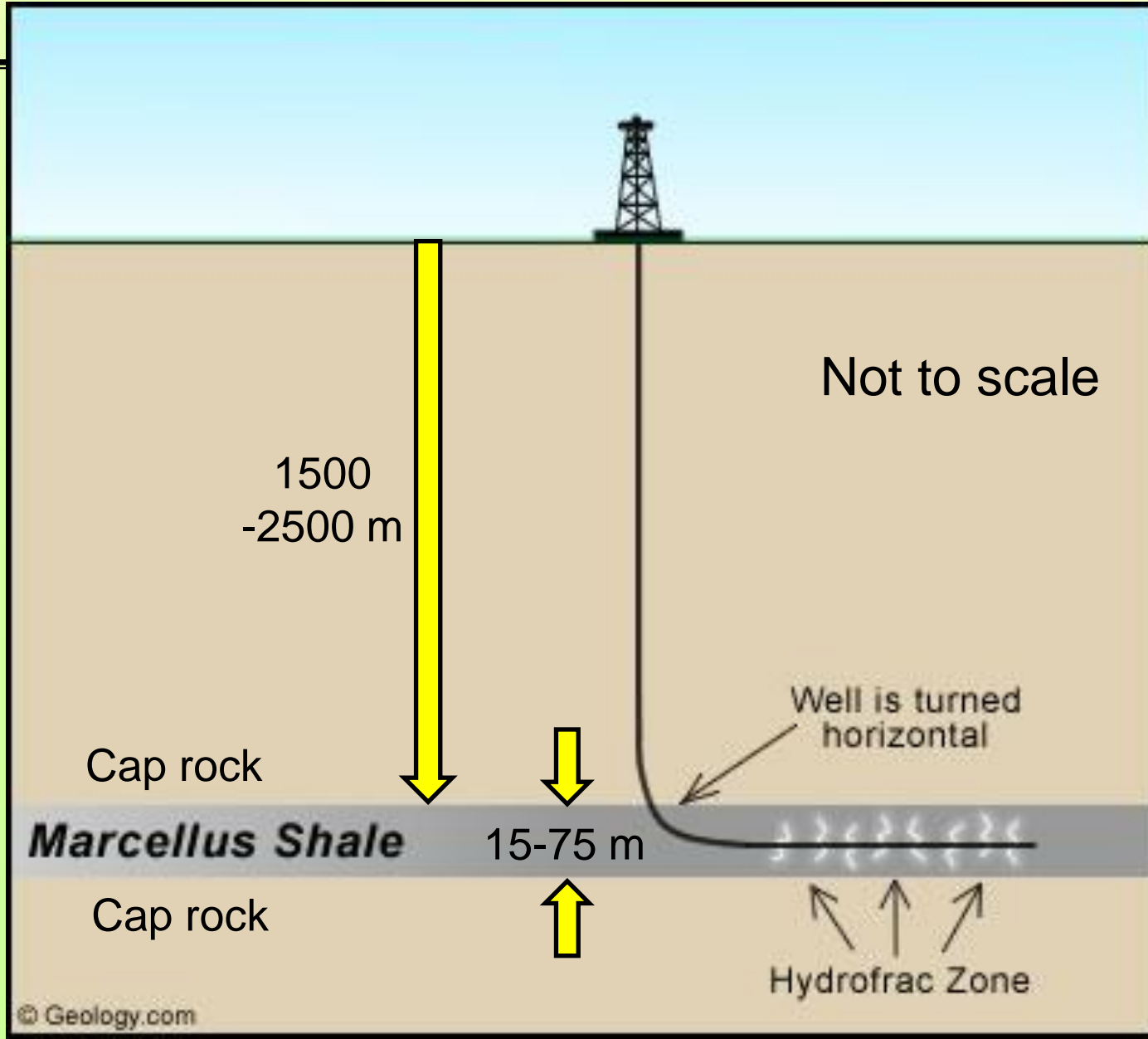


## The Marcellus Shale Formation

- Large Area
- Modest Depth
- Lots of Gas



# Typical Marcellus Shale Conditions

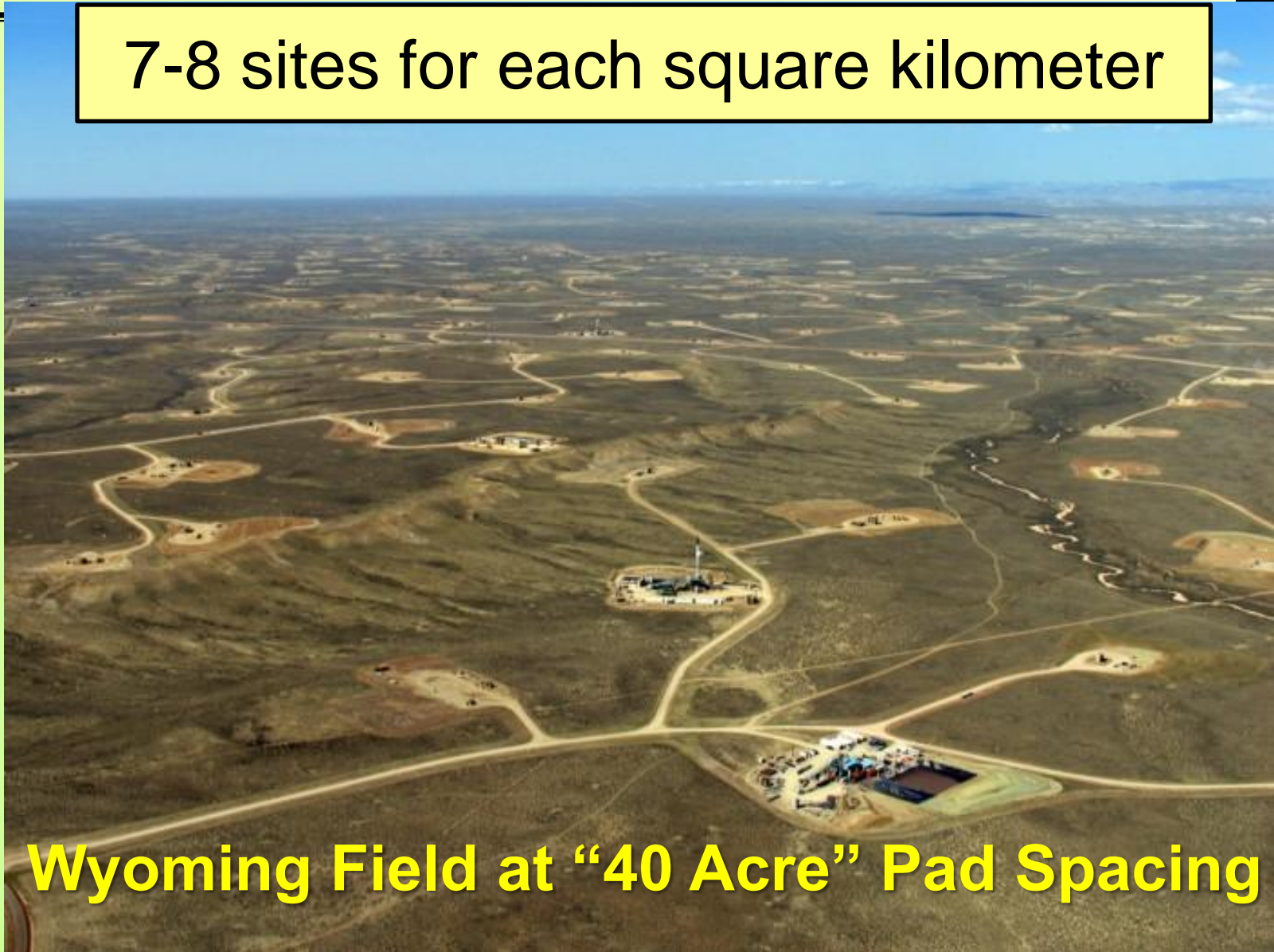




# The “Old Way”



7-8 sites for each square kilometer

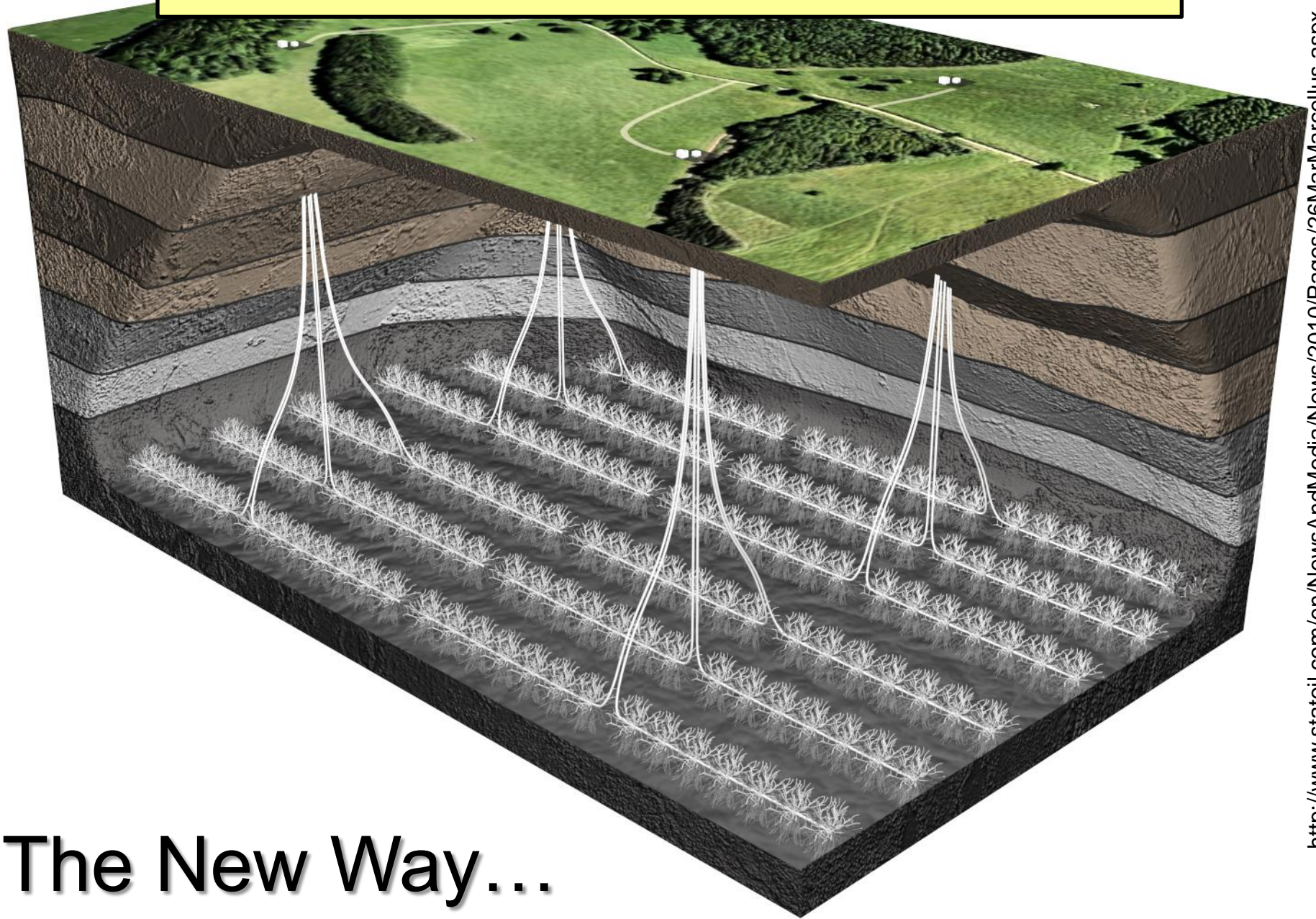


<http://www.skytruth.org/>

**Wyoming Field at “40 Acre” Pad Spacing**



One site for each 2-4 square kms.!



The New Way...



# Drilling and Fracking Operations



To get good definitions, go to <http://www.glossary.oilfield.slb.com/>

# Marcellus Shale Gas Drilling – PA, USA





# Massive Staged Hydraulic Fracture



marcellus-shale.us

[http://www.marcellus-shale.us/Marcellus\\_FRAC.htm](http://www.marcellus-shale.us/Marcellus_FRAC.htm)

Shale gas development, Pennsylvania USA



# What are the Real Risks?



- ◆ Will the fractures rise from 1500 m up to the surface and contaminate the groundwater? No
- ◆ Are all fracturing chemicals toxic? No, and safer alternatives are being developed.
- ◆ Does groundwater contamination happen? Yes, from truck accidents, pond leakage, burst valves, stupidity, but not from deep fracturing.
- ◆ Are these incidents common? No, the vast majority of claims have been shown to be unfounded (gas aquifers, metals in GW...)

# World's Largest Frac Job - 2009 - BC



Risks in BC are very different than in Pennsylvania



# The Reality...



- ◆ Deep fracturing does not interact with the surface, only if the wellbore is defective
- ◆ Worries about earthquake triggering are unfounded
- ◆ GW issues are from “standard” industrial accidents (truck accidents, leaky ponds...)
- ◆ Companies are now pursuing full disclosure of all chemicals used
- ◆ Regulatory agencies are tightening up the implementation of hydraulic fracturing



# Shale Gas Value...



CH<sub>4</sub> is a clean fuel, it can displace coal for electricity. Fracturing is an extremely safe technology. Regulatory policy must be improved & enforced.



Source: ALL Consulting, 2008

# CAPP Policy Statement (Jan 2012)



- ◆ We will safeguard the quality and quantity of regional surface and groundwater resources, through sound well placement, construction practices, sourcing fresh water where alternatives where appropriate, and recycling water for reuse as much as practical.
- ◆ We will measure and disclose water usage with the goal of continuing to reduce our effect on the environment.
- ◆ We will support the development of fracturing fluid additives with the least environmental risks.
- ◆ We will support disclosure of fracturing fluid additives.
- ◆ We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing.

Good intentions are cheap. Regulatory enforcement less so.







# Oil Sands Environmental Risks

## Different Views



Oilsands development has been painted in extremely polarized views:

*Oilsands are vital to Canada's economy and environmental issues are well managed...*

or

*Oilsands development is a vast ecological and human disaster; it must be stopped.*

# The Size of the Resource...



ALBERTA, CANADA

TAR SANDS

175-400

BILLION

BARRELS OF OIL



CLICK HERE  
TO GET MORE  
**INFO**

# The Visual Impact of Oilsands Development...

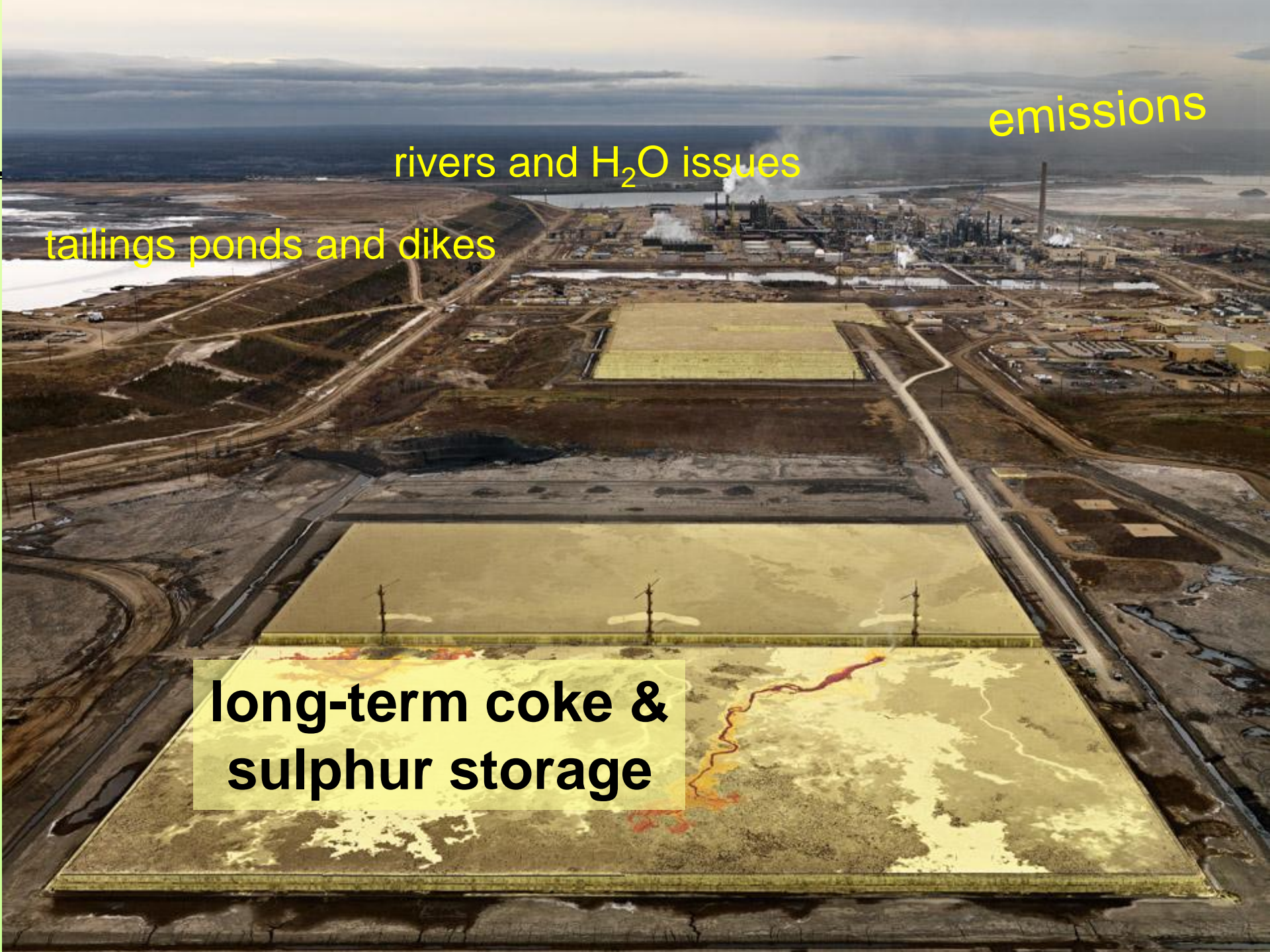




# Injecting Some Realism



- ◆ Economic importance is indeed large, but...
  - There are emissions issues (particulates, NOX...)
  - There are water issues (regional water quality)
  - There are reclamation issues (mature sludges)
  - There are economic issues (Dutch disease)
- ◆ ...and, oilsand development is not a disaster...
  - Area for mining is quite small
  - Reclamation is starting and will be enforced
  - Emissions, water, tailings pond management are improving (albeit slowly)...



emissions

rivers and H<sub>2</sub>O issues

tailings ponds and dikes

**long-term coke &  
sulphur storage**



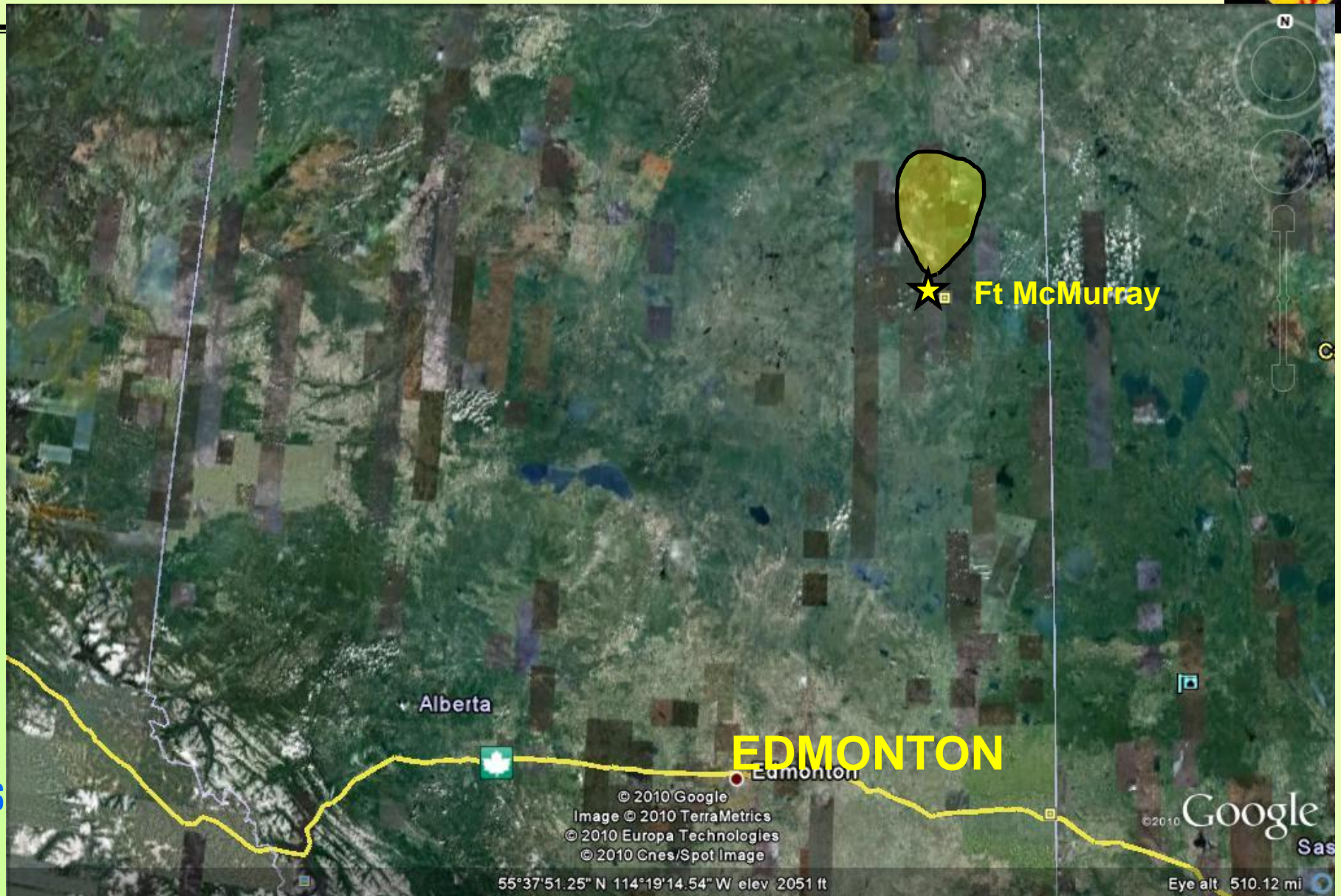
# How Big is the Eventual Mining area?



- ◆ ~2600 km<sup>2</sup> may be mined in total
- ◆ How does this compare with the Los Angeles Urban Area?
- ◆ How big is this in the context of the boreal forest area of Canada?
- ◆ How big is this compared to the history of coal strip mining in Germany (Ruhr Valley)?
- ◆ Reclamation is beginning, and the reclaimed land will likely be 3-4 times more productive in terms of biomass that currently.



# Alberta's Oil Sand Mining Area





# Los Angeles...

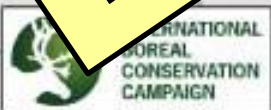
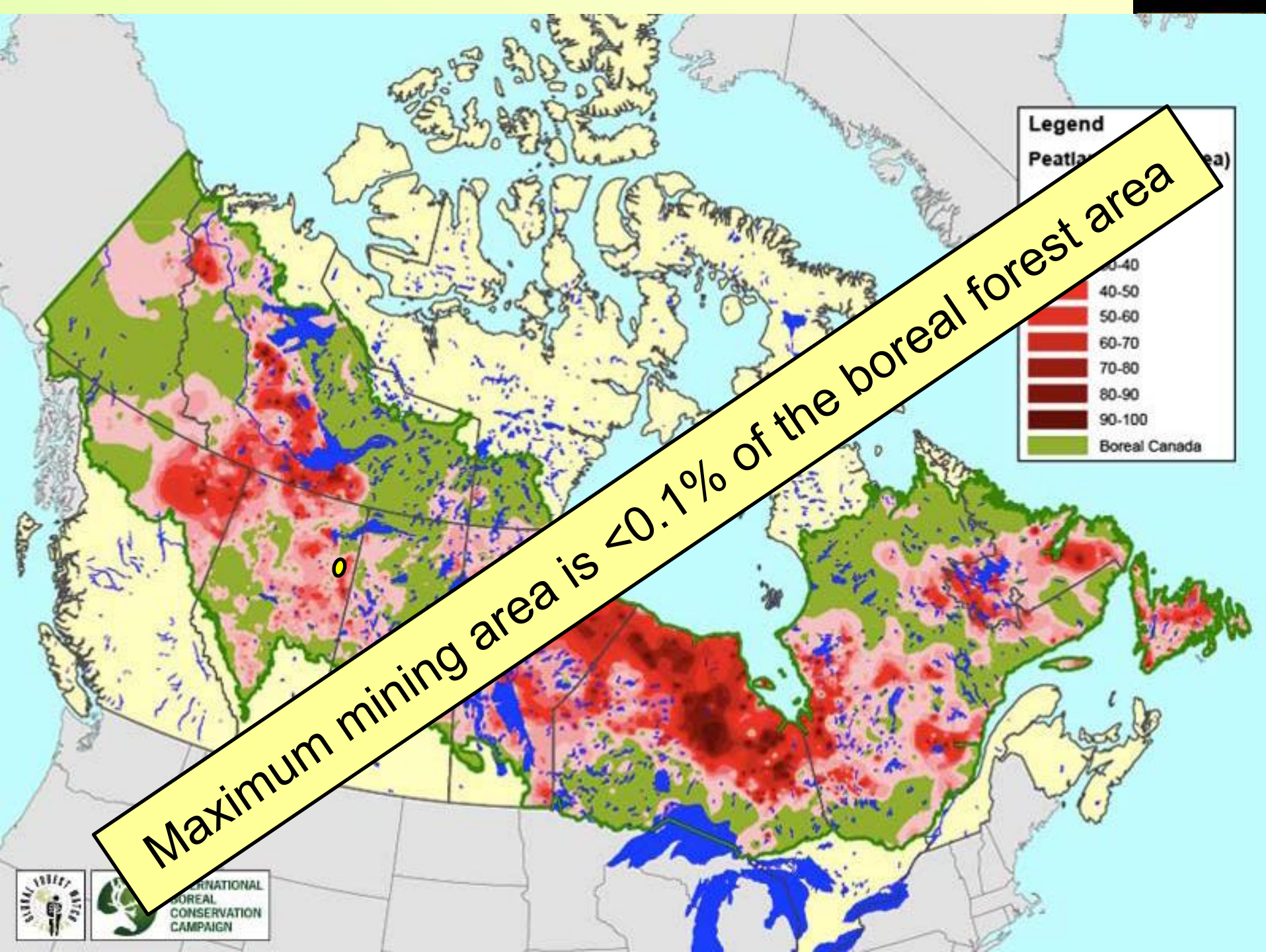


## Los Angeles Urban Area

Maximum oilsands mining area <50% of Los Angeles'

5812 km<sup>2</sup>







Well-drained boreal terrain is far more productive than black spruce swamp



Clearwater River

# Which Risks are Real?



- ◆ Clearly, the boreal forest is not at risk
- ◆ The ultimately reclaimed land will be much more productive than the blackfoot and muskeg
- ◆ Some genuine risks...
  - Tailings dyke rupture
  - Excessive run-off seepage into the river, increasing levels of contaminants above limits
  - Too many particulates, NOX & SOX from refineries, upgraders...
  - Inadequate reclamation

Each of these is a regulatory policy and enforcement issue



# Environmental Track Record...



- ◆ Companies' track record is not great
- ◆ These are mostly regulatory-based issues
- ◆ Yes, we can do better
- ◆ But, we need...
  - Science
  - Clarity
  - Consistency
  - Enforcement



~11.3°API



# Misunderstood Hazards and Risks



- ◆ Tsunami risk
- ◆ Size of the oilsands mining area
  - The eventual oil sands mining area (2600 km<sup>2</sup>) is **less than half** the area of the GTA (5904 km<sup>2</sup>)
  - It will eventually be reclaimed to a much higher eco-productivity level than the original land

# Poorly Estimated Risks



- ◆ Risks of natural gas pipeline breaching
  - Greatly overestimated by almost everyone
  - Far from urban areas,  $\text{CH}_4$  is buoyant, explosion risks are low (no oxygen)
  - $\text{CH}_4$  pipelines are remarkably safe...
- ◆ Shore line terminal facilities risks
  - Norway – rock slides in the fjords
  - Refineries on the Mediterranean coast
  - Production and refining facilities in the Gulf of Mexico

# Deliberately Misrepresented Risks



- ◆ Fracking of deep shales for CH<sub>4</sub> production
  - Deep fracturing itself has never caused groundwater contamination
  - Surface spills (trucks), leaking ponds, open valves, carelessness, mistakes... cause contamination
- ◆ Earthquake hazard and nuclear power



# Framing the Energy Debate...



- ◆ Ideological stances are counterproductive
- ◆ Energy has risks; let's manage them properly

