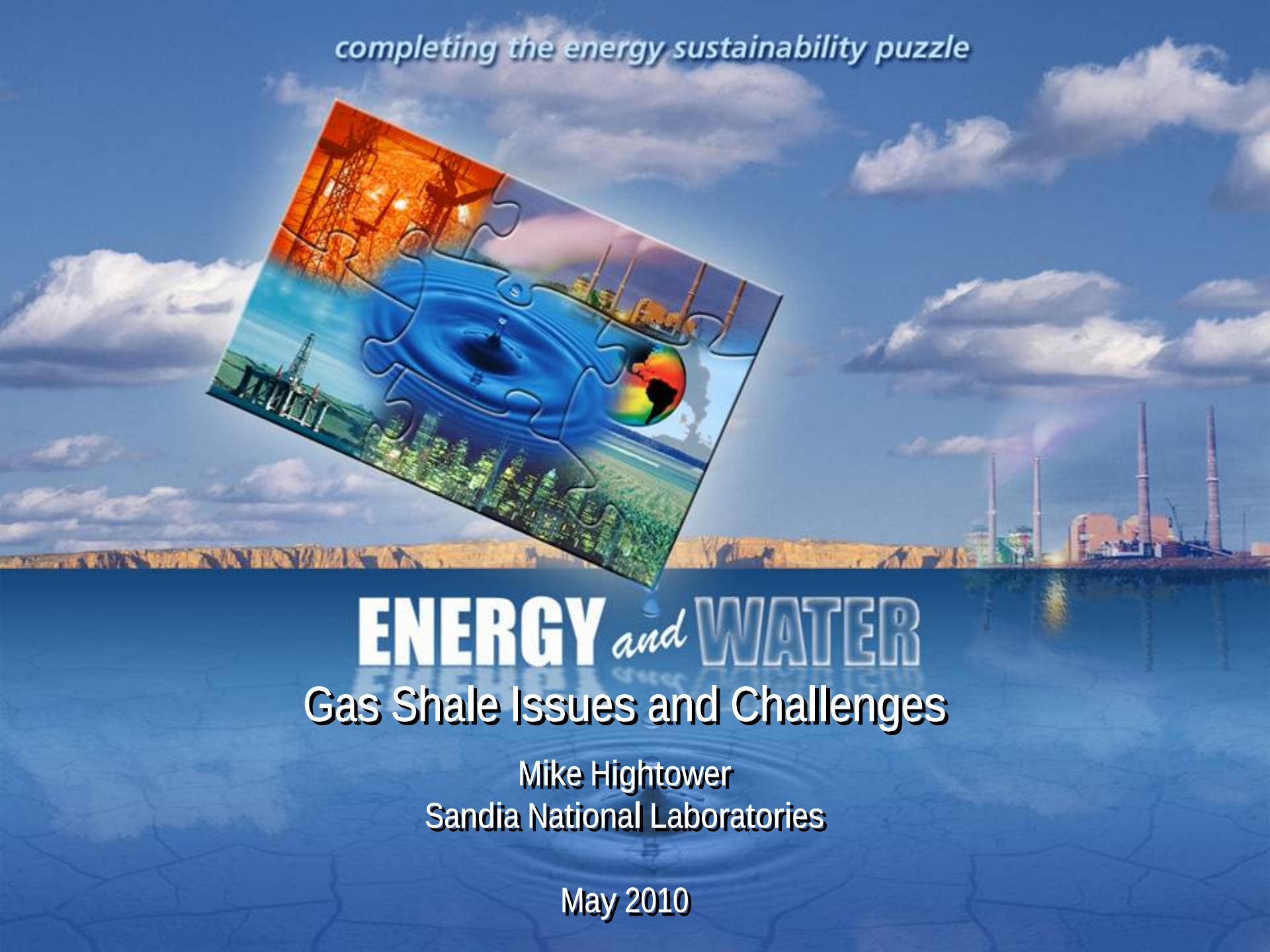
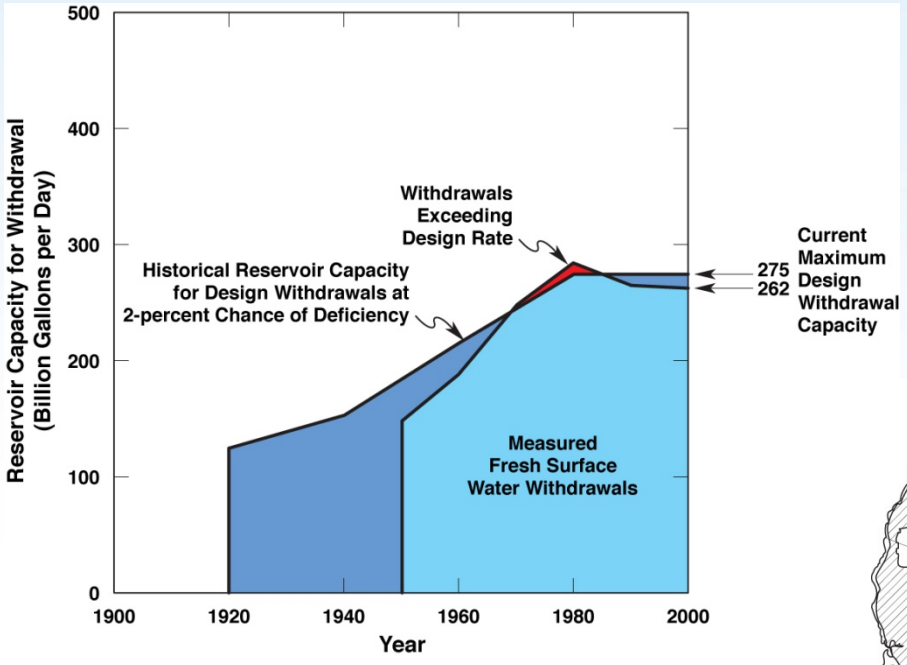


Gas Shale Issues and Challenges

Mike Hightower
Sandia National Laboratories

May 2010

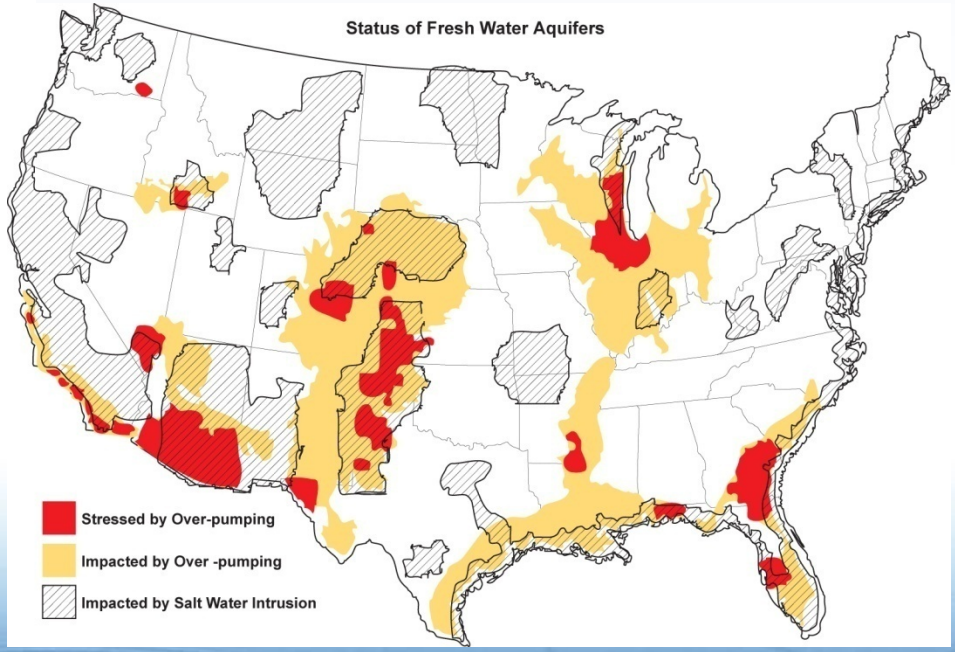
Growing Limitations on Fresh Surface and Ground Water Availability



(Based on USGS WSP-2250 1984 and Alley 2007)

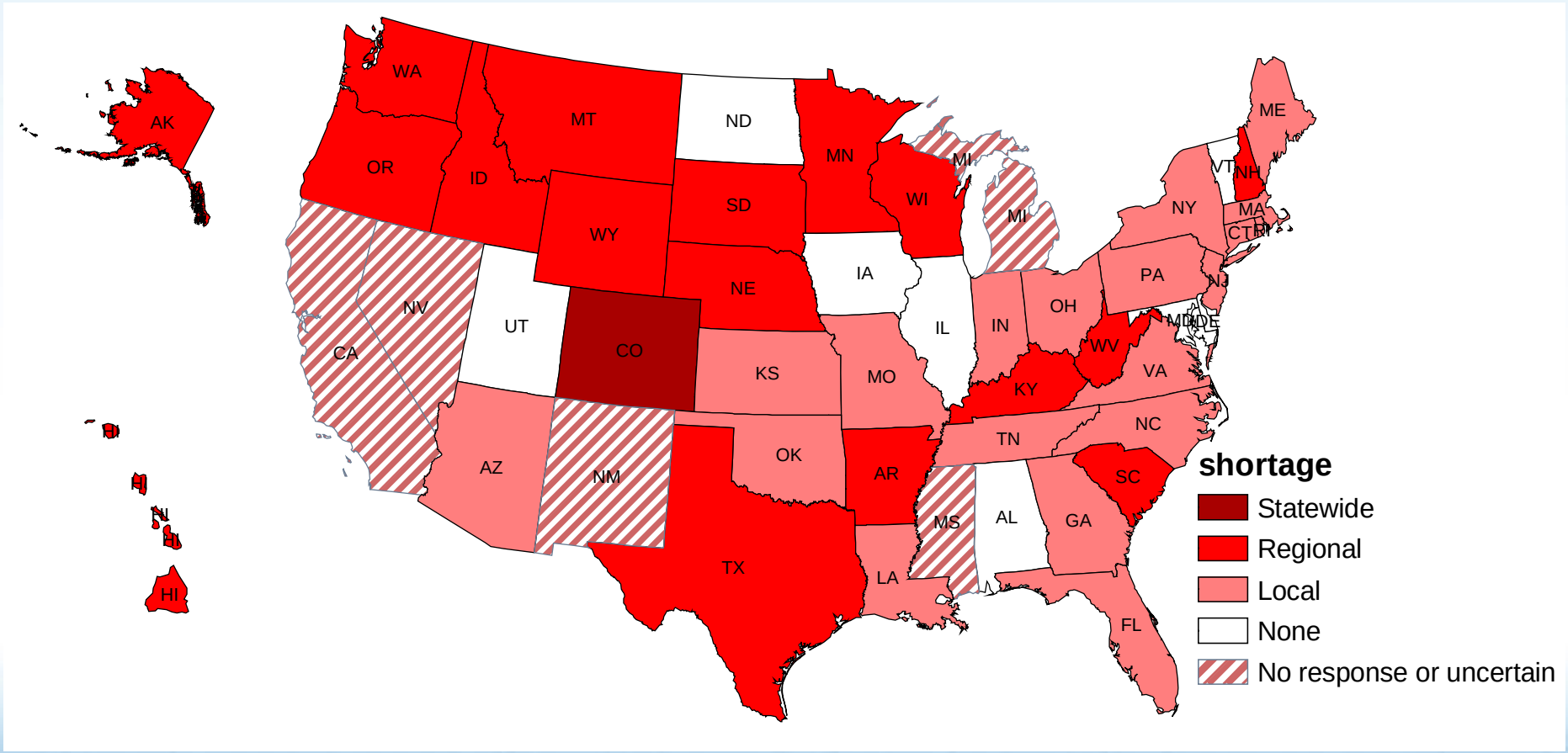
- Little increase in surface water storage capacity since 1980
- Concerns over climate impacts on surface water supplies

- Many major ground water aquifers seeing reductions in water quality and yield



(Shannon 2007)

Most State Water Managers Expect Shortages Over The Next Decade Under Average Conditions

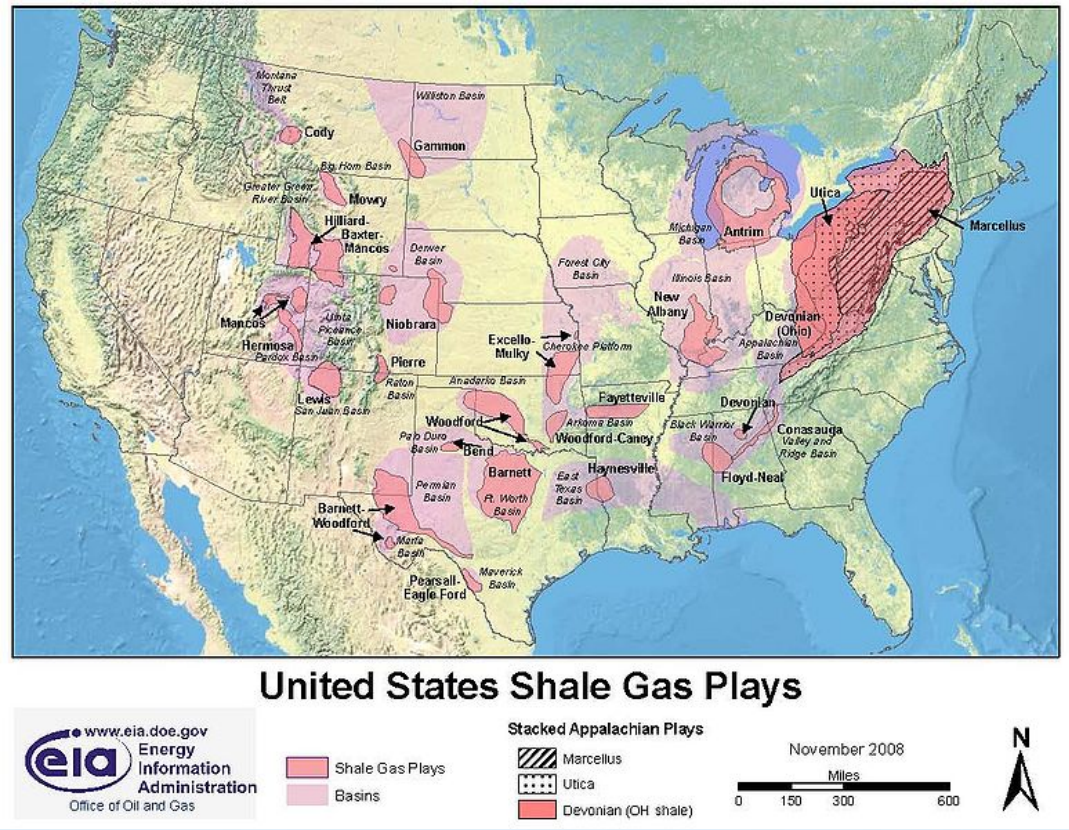


Source: GAO 2003

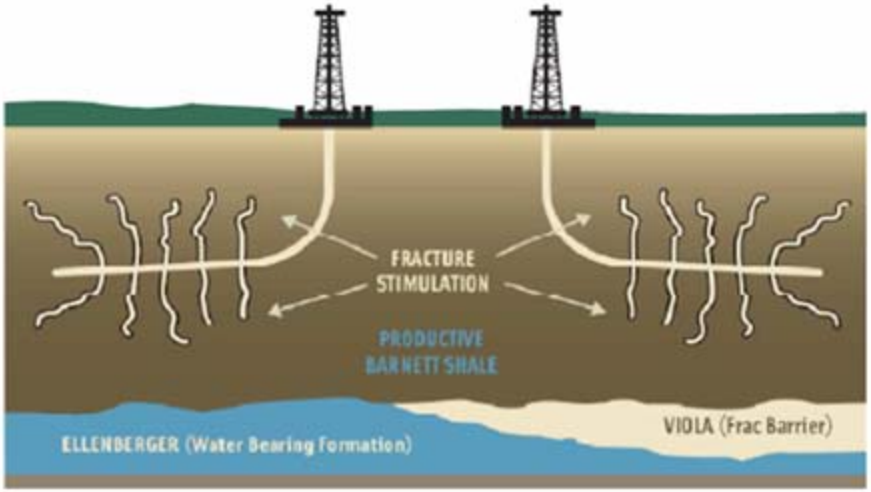
ENERGY and WATER

Gas Shale development could be extensive and impact water availability and quality

- Water is used in drilling, completion, and fracturing
- Up to 3 million gallons of water is needed per well
- Water recovery can be 20% to 70%
- Recovered water quality varies – from 10,000 ppm TDS to 100,000 ppm TDS
- Recovered water is commonly injected into deep wells, but not appropriate for all areas



Gas Shale Site Development
Common Approach and Practices



Hydraulic fracturing

Typical drilling site

Reference: Modern Shale Gas, Development in the United States: A Primer Groundwater Protection Council, ALL Consulting, National Energy Technology Laboratory, U.S. Department of Energy, April 2009

Relative Water Use of Gas Shale Development

Water Use per Unit Energy (gallons/MMbtu)	
Natural Gas Extraction	1-2
Coal Gasification	50-100
Coal Liquefaction	20-50
Insitu Oil Shale	2-10

Average shale gas well yield – 2-6 BCF

Major Gas Shale Water-Related Development Issues

- Storm water runoff from drilling pad
  - Local issue
- Drinking water impacts
  - Few identified complaints, likely surface casing issue
- Finding adequate water supplies
  - Example: Permitting of 200 wells/year increasing to 1000 wells/year
  - Will limit speed of gas shale development in some areas
- Disposal of flow back
  - Local limitations for deep well injection
  - Environmental and cost issues of trucking
  - Limitations on ability to discharge to POTW - salt and chemical issues
  - Will limit speed of gas shale development in some areas