

THE WATER ENERGY NEXUS

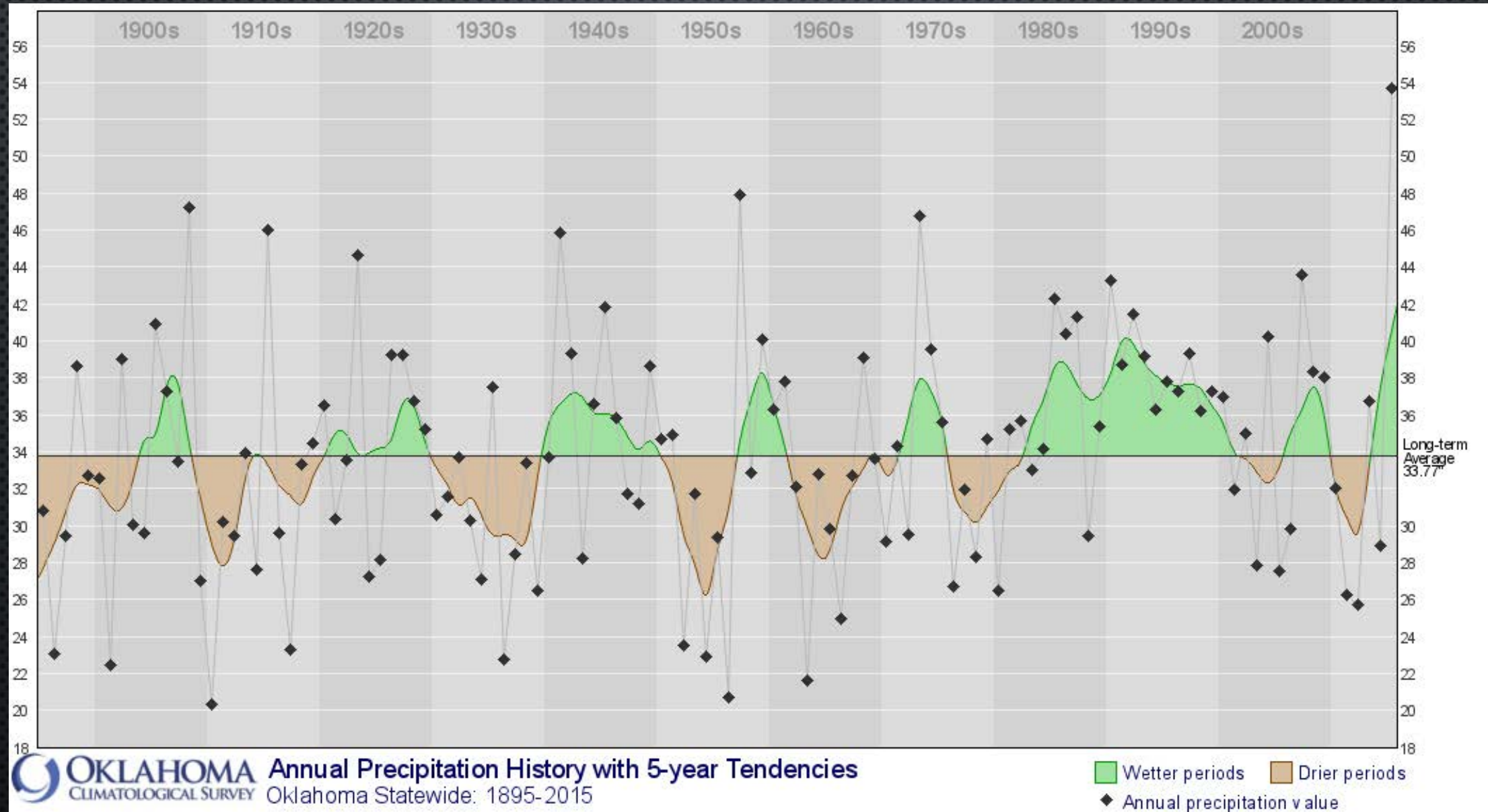
UNDERSTANDING THE WATER ENERGY NEXUS AND ITS
IMPACT ON WATER AVAILABILITY IN OKLAHOMA

MICHAEL MORFORD

JANUARY 2017

SECTION I: INTRODUCTION

RAINFALL MAKES MEMORIES FADE FAST

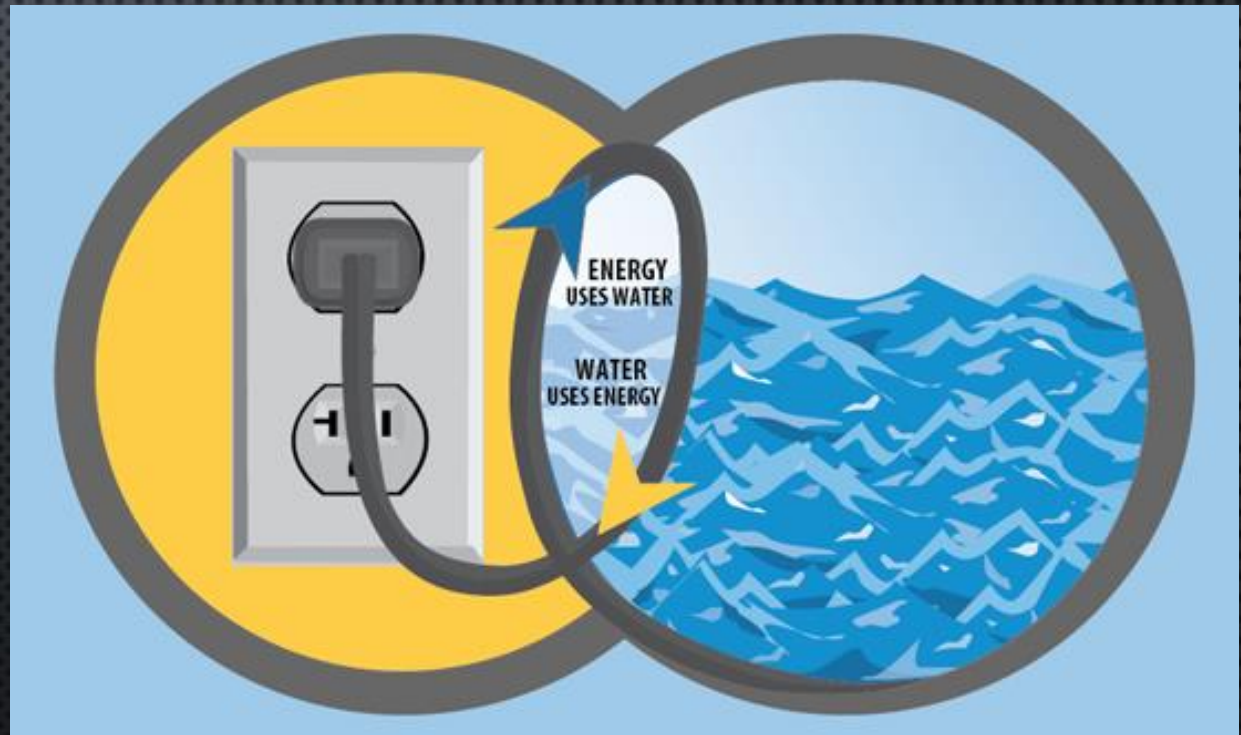
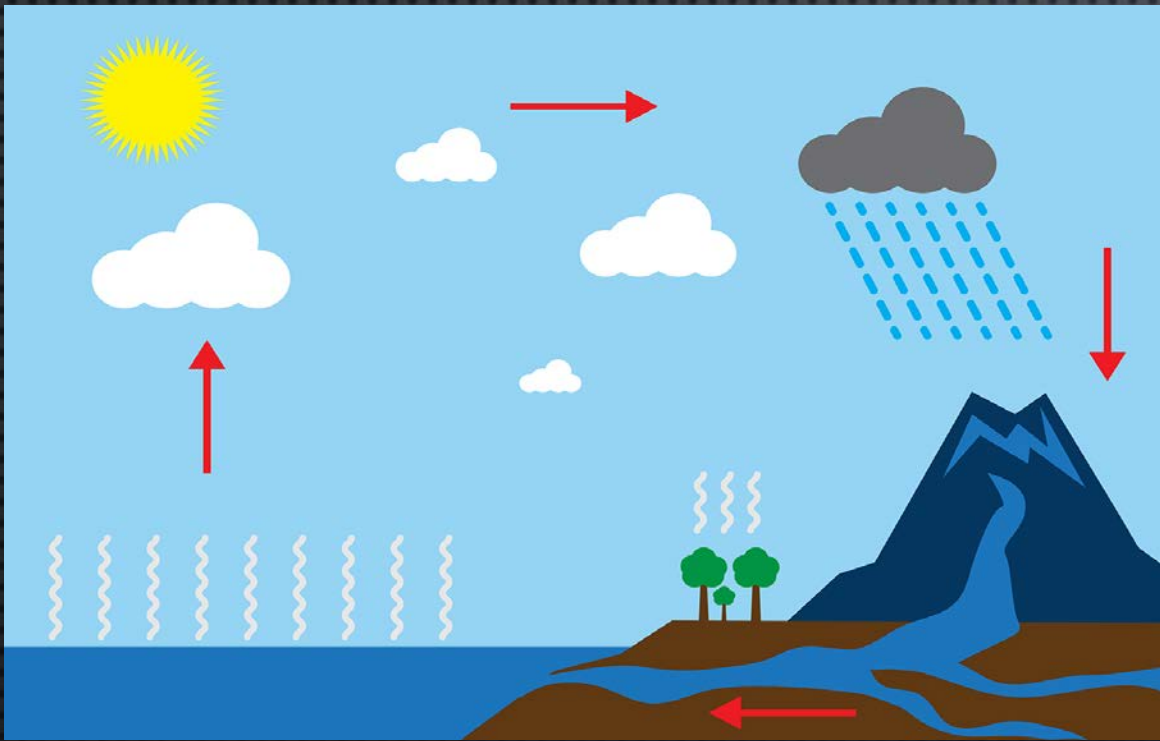


WATER AVAILABILITY IS MORE THAN THE WATER CYCLE

TRADITIONAL VIEW

VS

MODERN VIEW



SECTION II:
DEFINING THE WATER
ENERGY NEXUS

thirsty energy

energy
and water's
interdependence

energy needs water

Energy production
processes require
water

- hydropower
- thermoelectric cooling
- power plant operations
- fuel extraction and refining
- fuel production

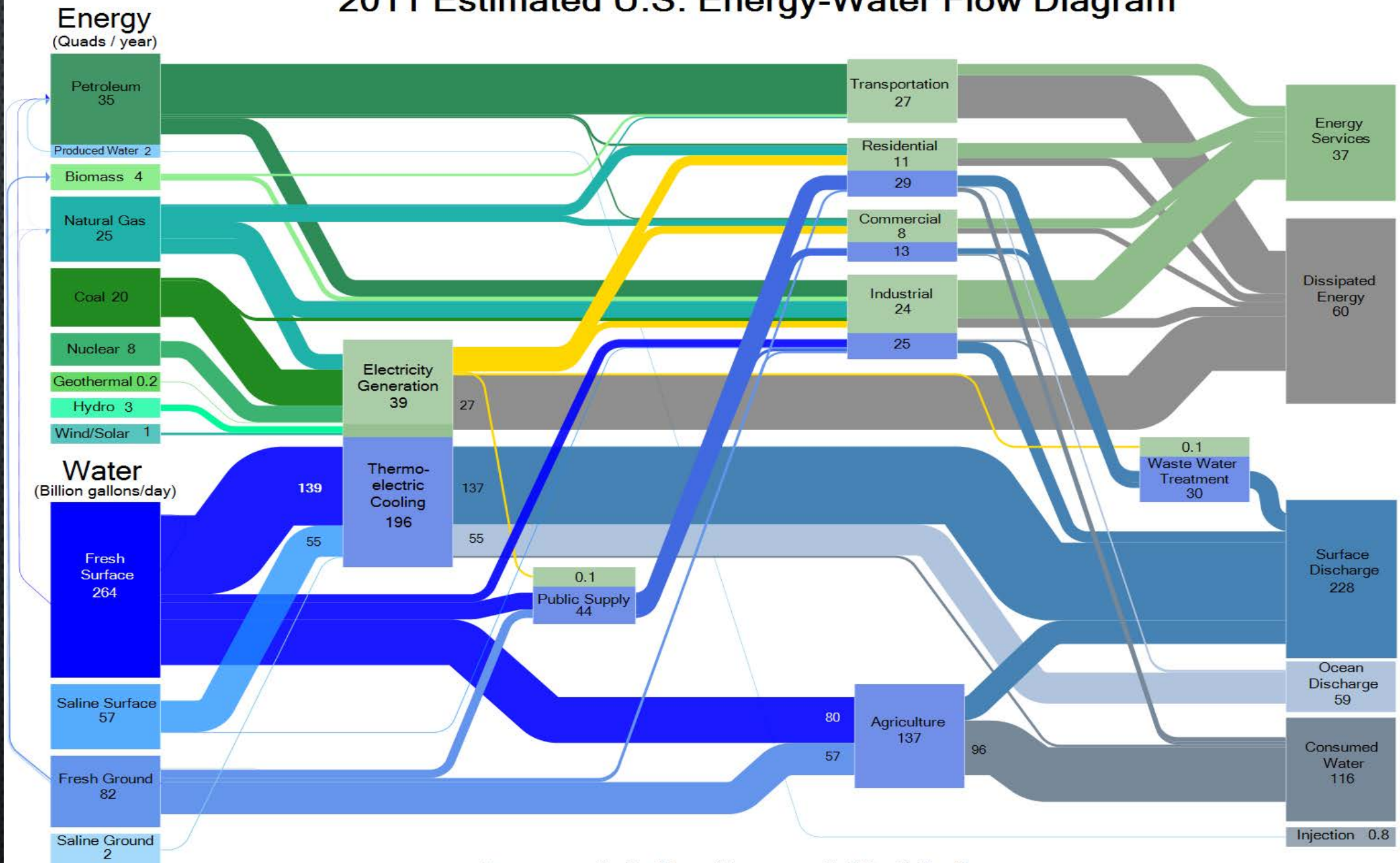
water needs energy

Water production, processing,
distribution, and end-use require
energy

- extraction
- treatment
- transportation



2011 Estimated U.S. Energy-Water Flow Diagram

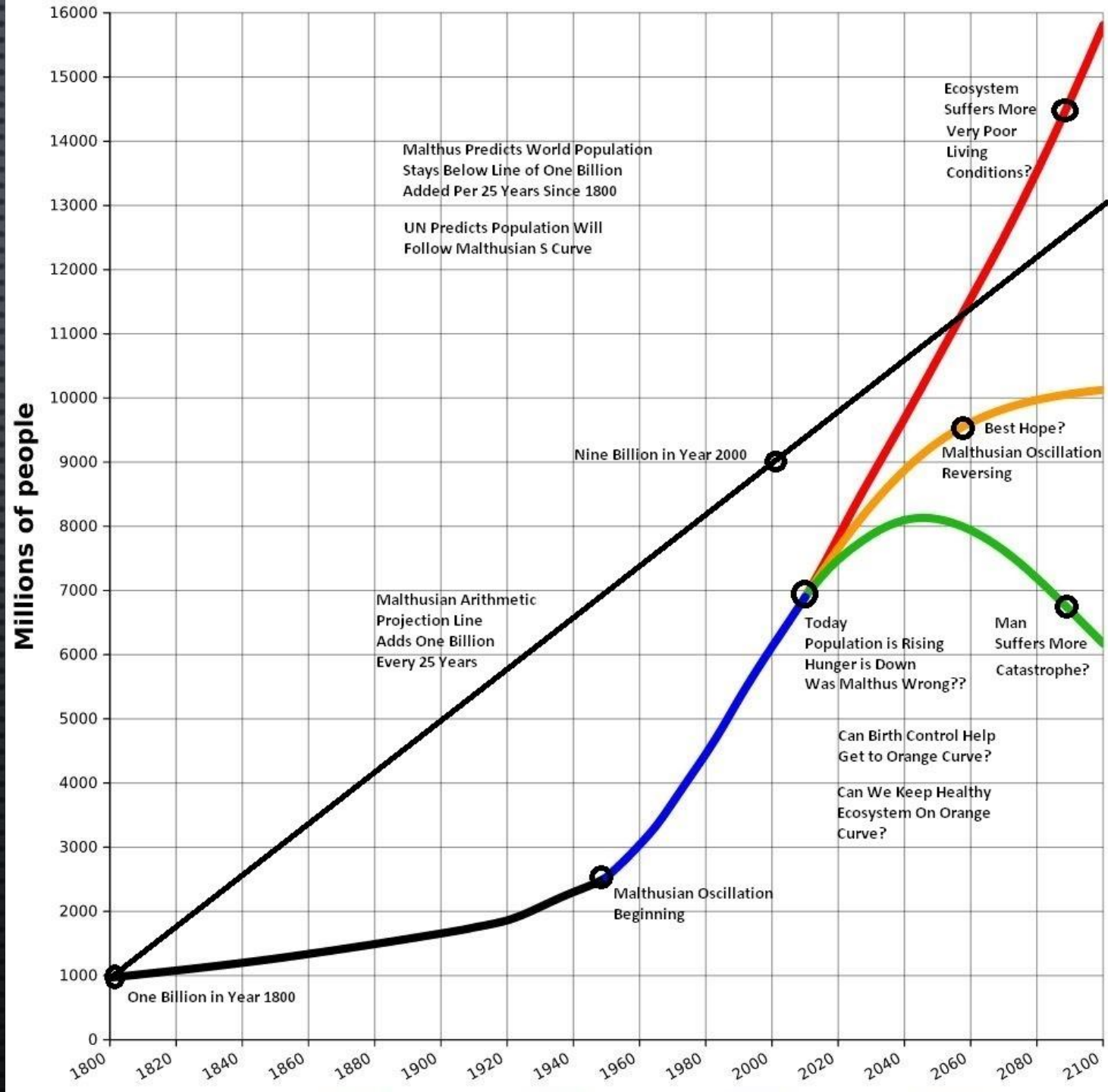
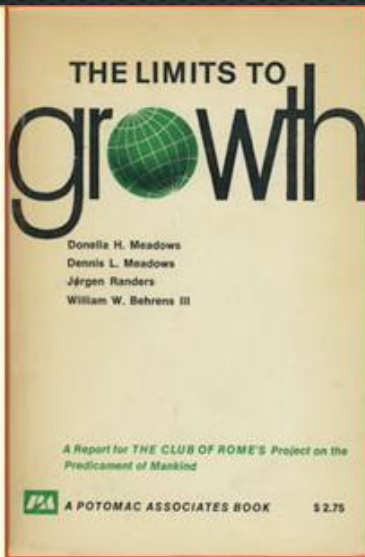
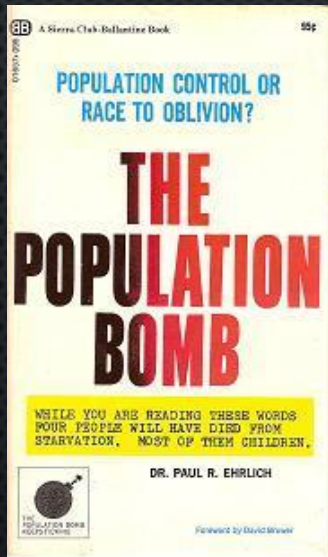


Energy reported in Quads/year. Water reported in Billion Gallons/Day.

TERM ETYMOLOGY

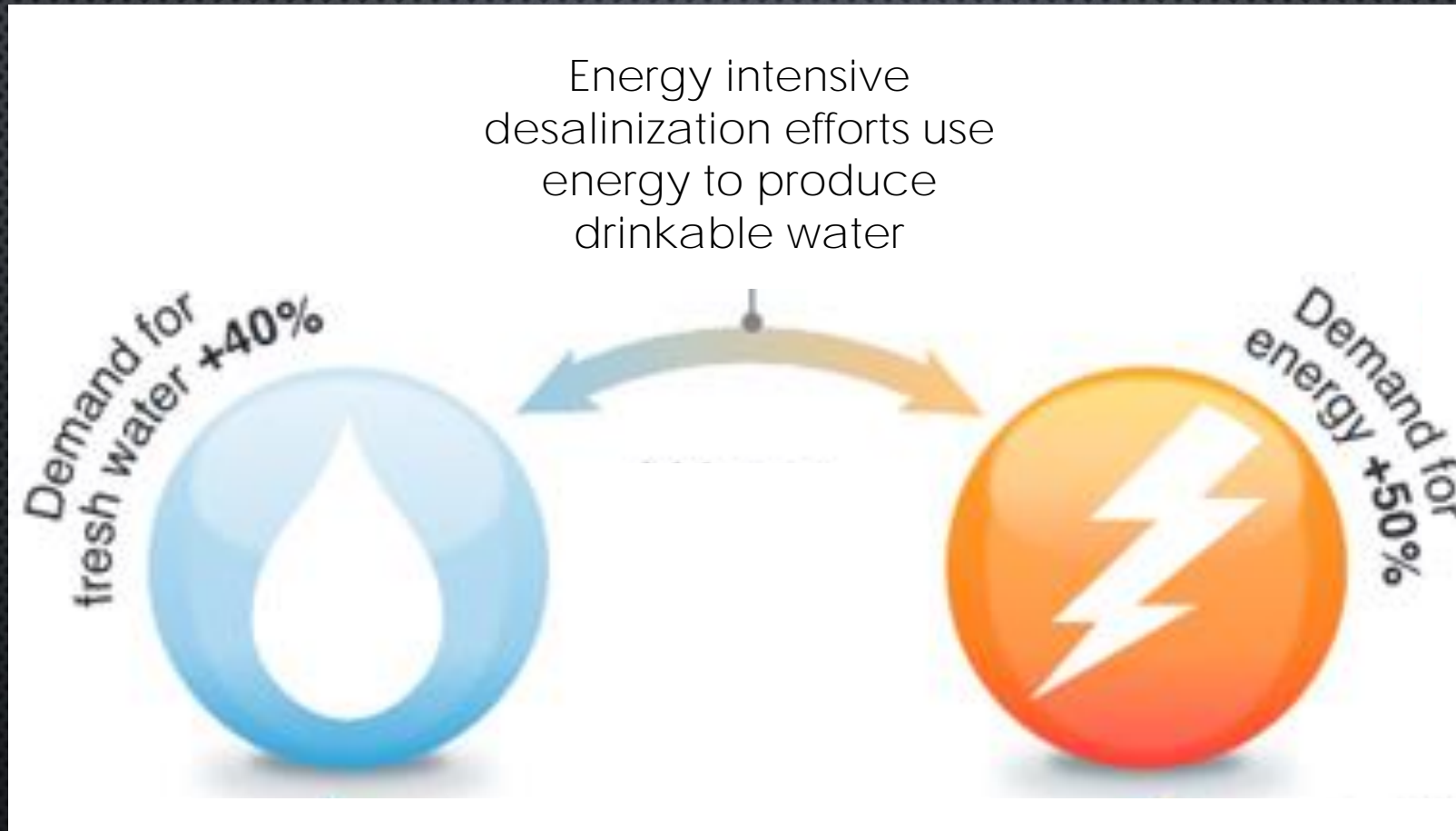


Reverend
Thomas
Robert
Malthus
c. 1798

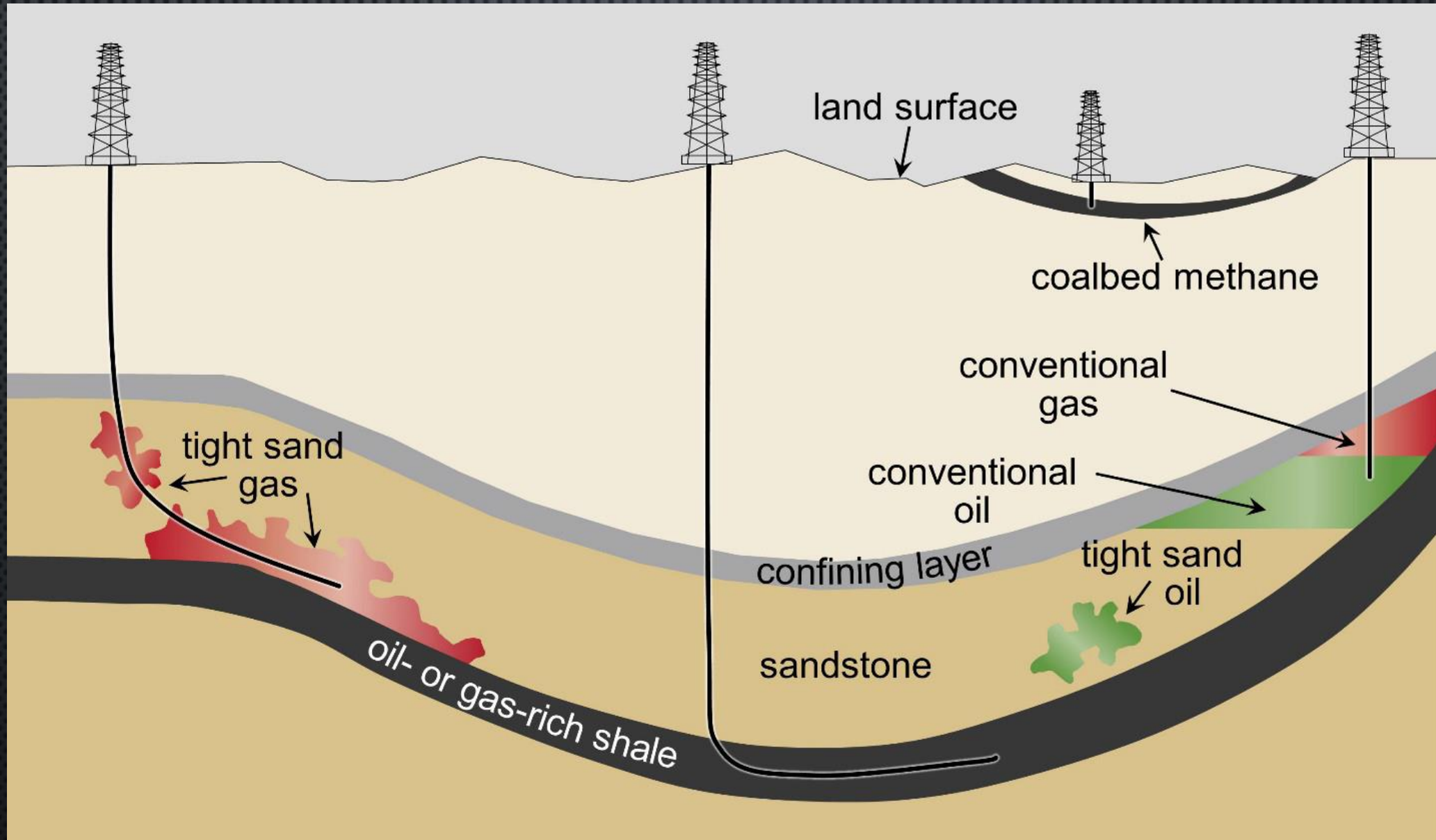


SECTION III:
THE IMPORTANCE OF
UNDERSTANDING THE NEXUS

THE WATER ENERGY NEXUS IS STRESSED TO A BREAK POINT



SHALE RESOURCE EXTRACTION CHANGED THE GAME



CLEAN ENERGY HAS ARRIVED FOR GOOD

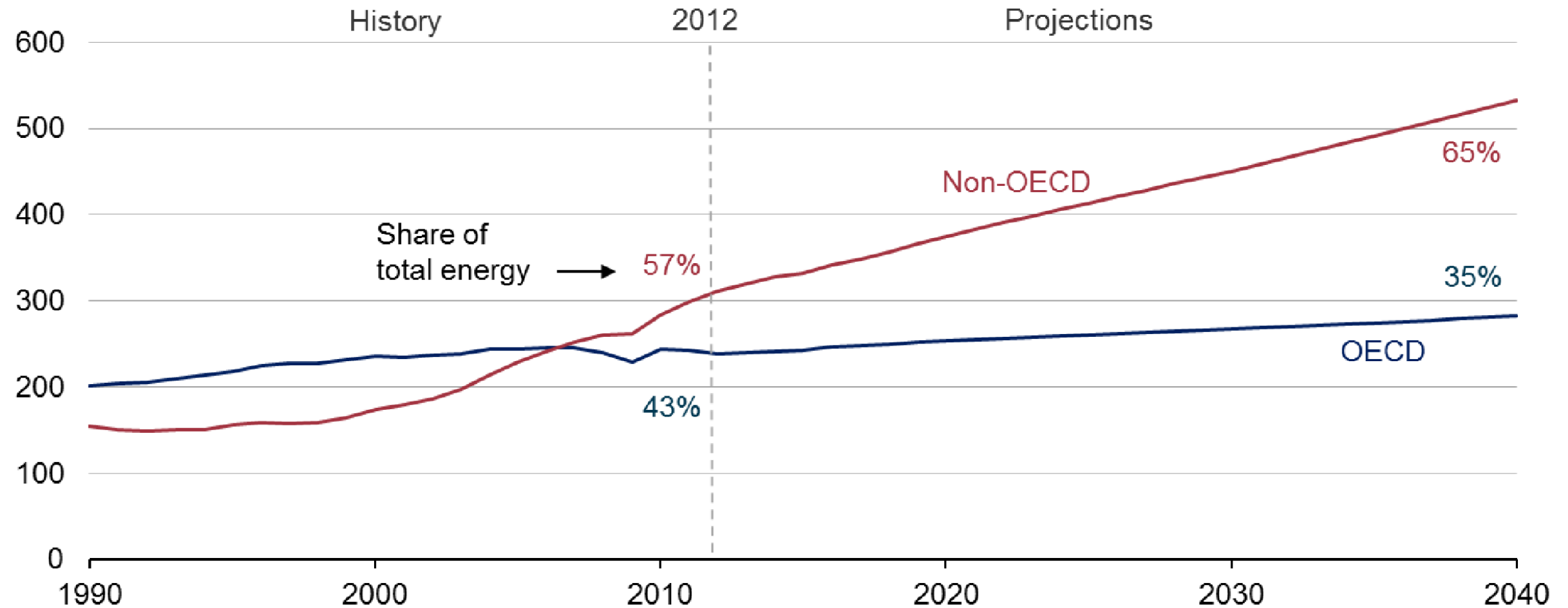


GLOBAL ENERGY SECURITY IS MERELY PERCEPTION

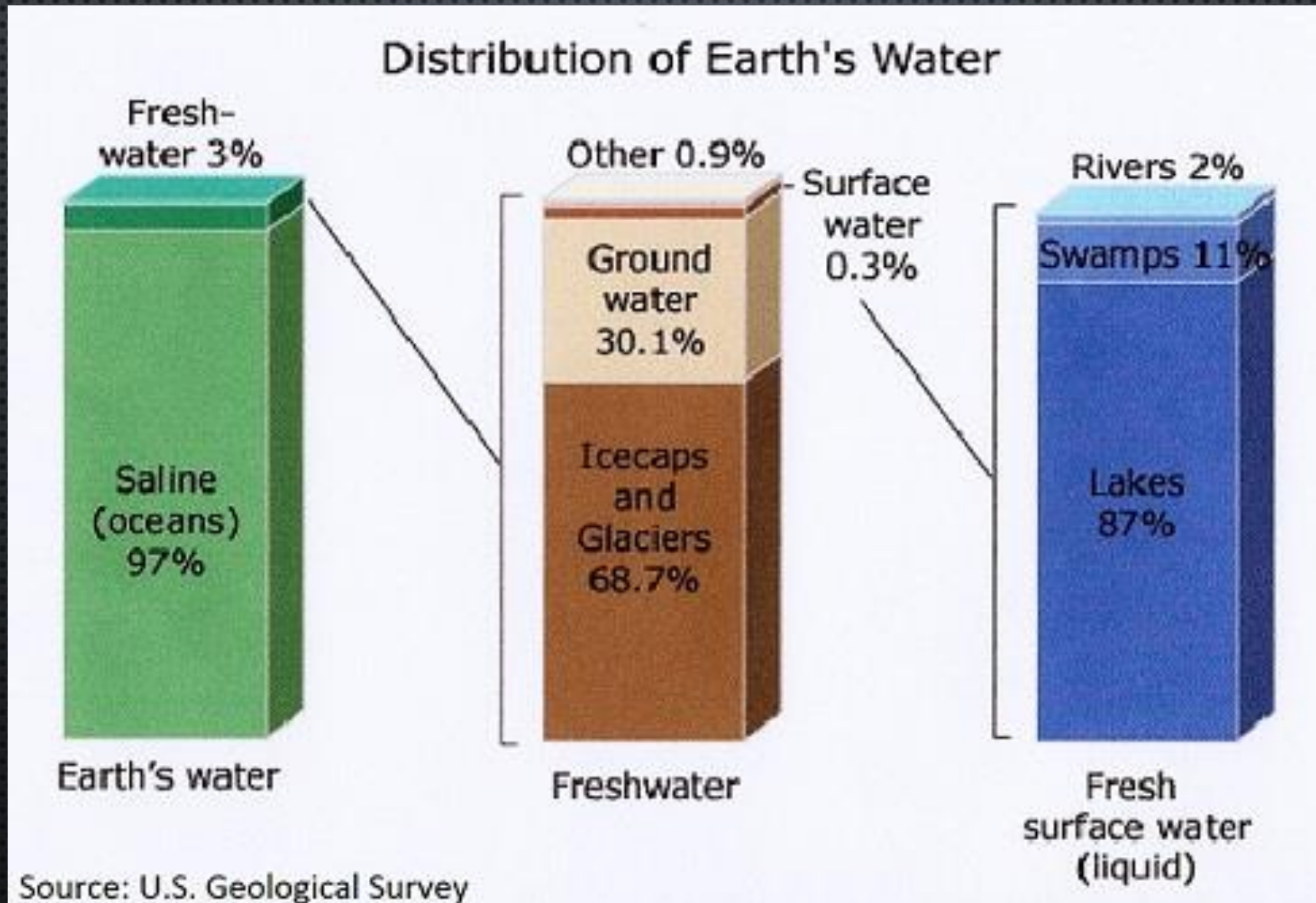
Non-OECD nations drive the increase in total energy use

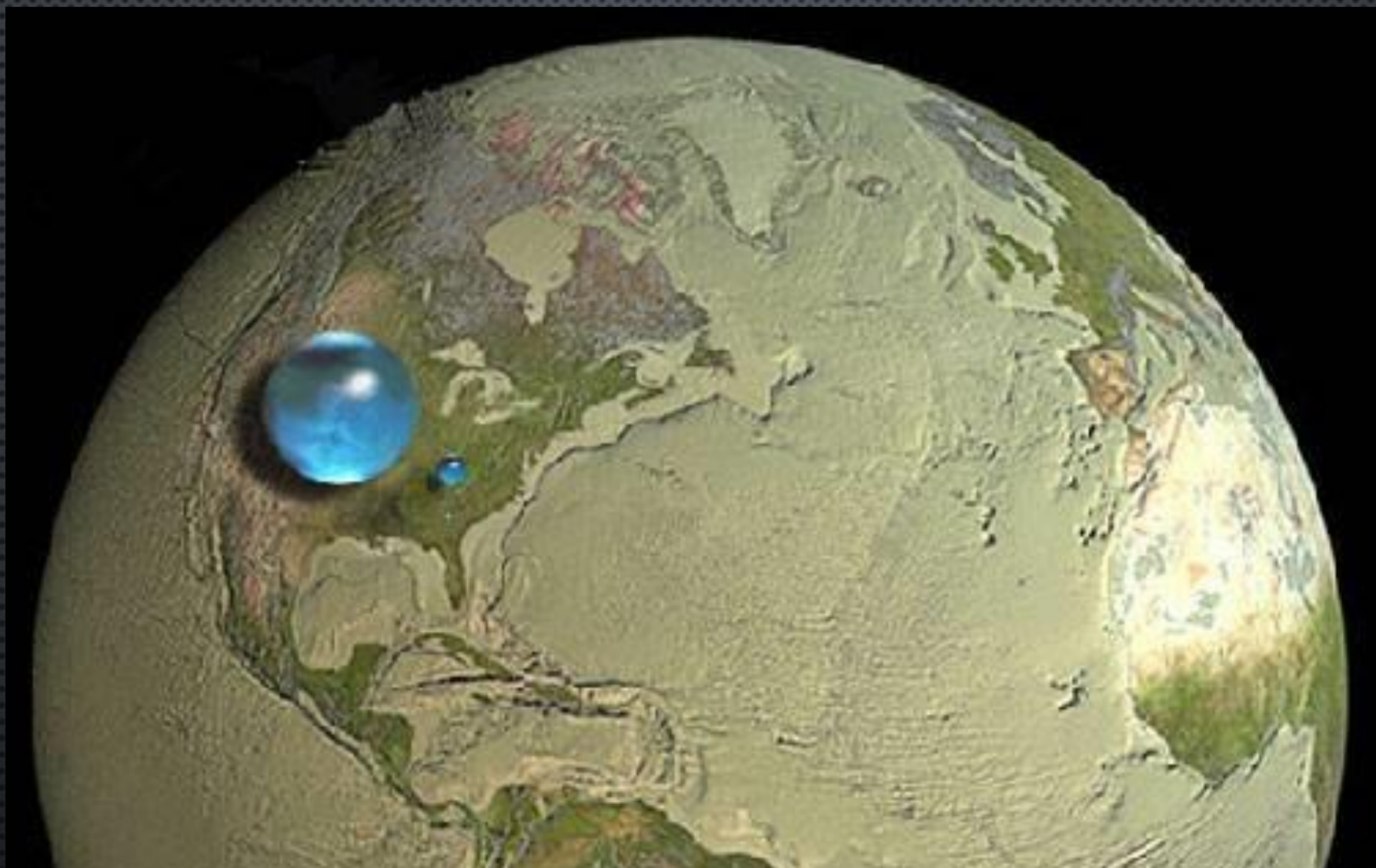
Source EIA

world energy consumption
quadrillion Btu



THERE'S LESS FRESH WATER THAN YOU THINK





Water in, on, and above the Earth



- Liquid fresh water
- Freshwater lakes and rivers

Howard Perlman, USGS
Jack Cook, Adam Nieman
Data: Igor Shiklomanov, 1993

WATER SCARCITY IS HERE MORE THAN WE REALIZE

it's already happening

The Americas

U.S.

Power plants shutting down or reducing power generation

due to low water flows or high water temperatures, resulting in financial losses

Companies that extract natural gas and oil via hydraulic fracturing faced higher water costs or were denied access to water

due to one of the worst droughts in American history

Source: U.S. Department of Energy, 2010

California's hydroelectric power generation was 38% lower than the prior summer

due to reduced snowpack and low precipitation in the summer of 2012

impact hotspots



UNITED STATES

VENEZUELA

Record lack of rainfall resulted in low water flows and several power interruptions

Source: NYTimes, 2010

BRAZIL

Dams in the southeast and central west of Brazil were at 28% of their water capacity in 2012

due to the worst drought in 50 years. This number is below the mark considered sufficient to guarantee electricity supply

Source: Reuters, 2010

A drought in the north-east of Brazil led to eight months of power rationing

resulting in R\$54 billion (\$26bn) of financial losses for the industry and impacting economic growth in 2001

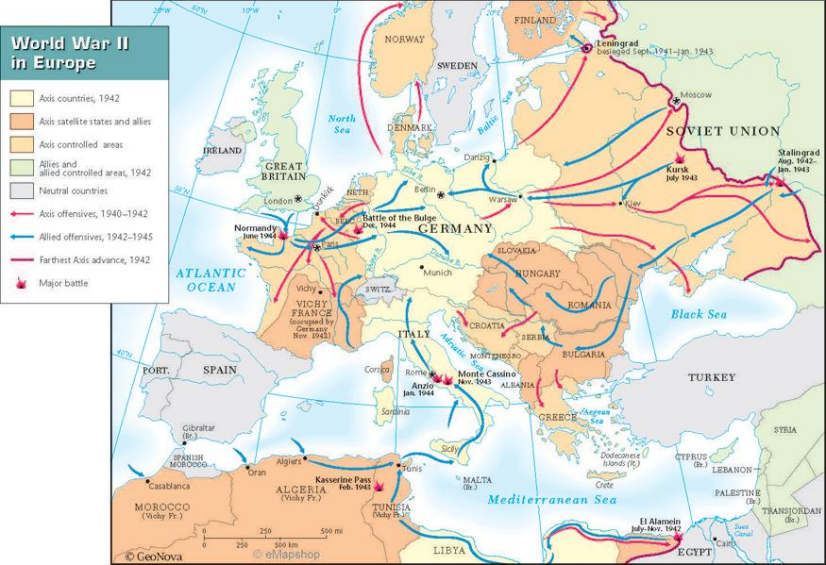
Source: BBC, 2010

VENEZUELA

BRAZIL

SECTION IV:
THE RAMIFICATIONS OF
A BREAKING NEXUS

CONFLICTS FROM ENERGY



CONFLICTS FROM WATER



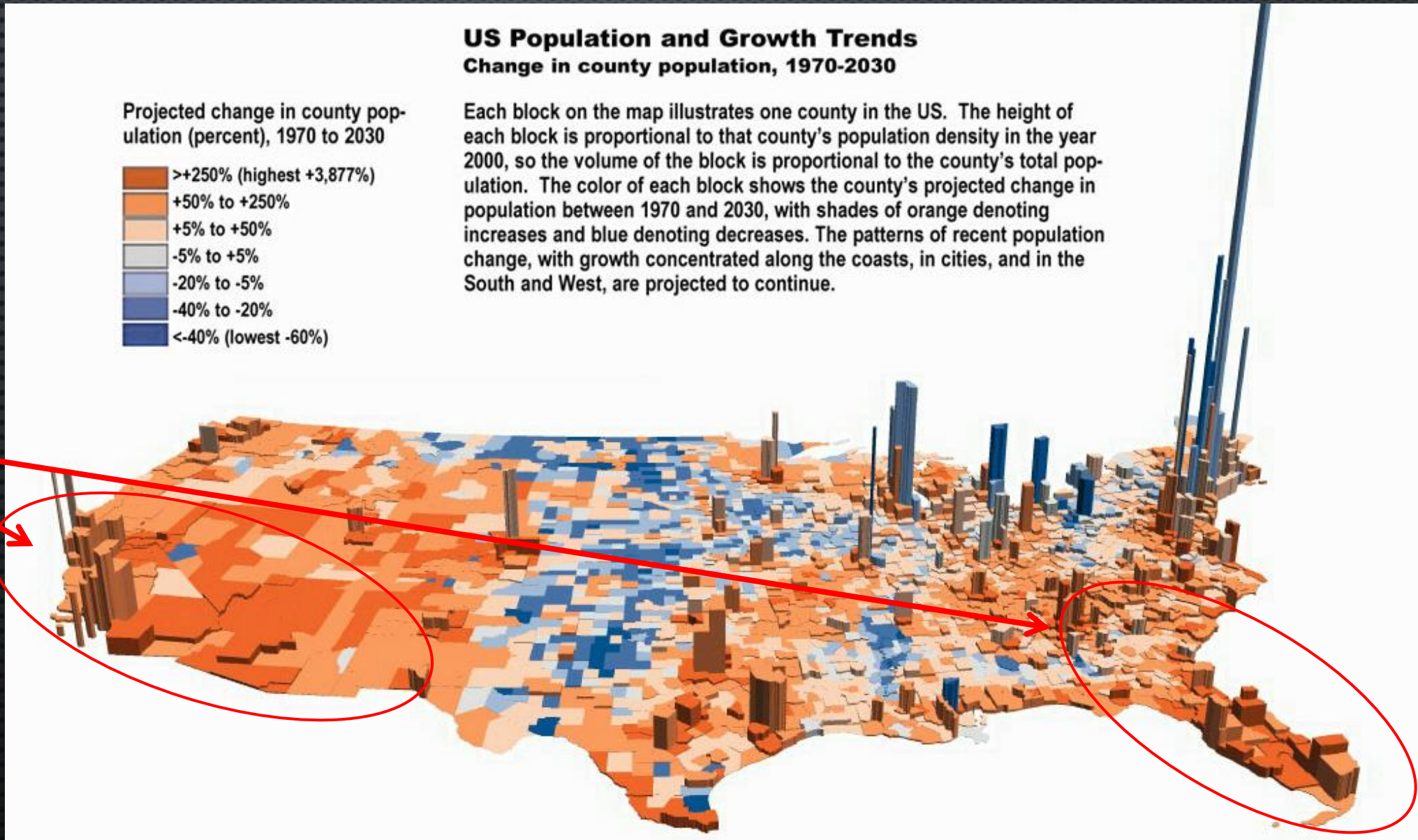
SECTION V:
THE WATER ENERGY
NEXUS IN THE U.S.

DOMESTIC FORMS OF STRESS

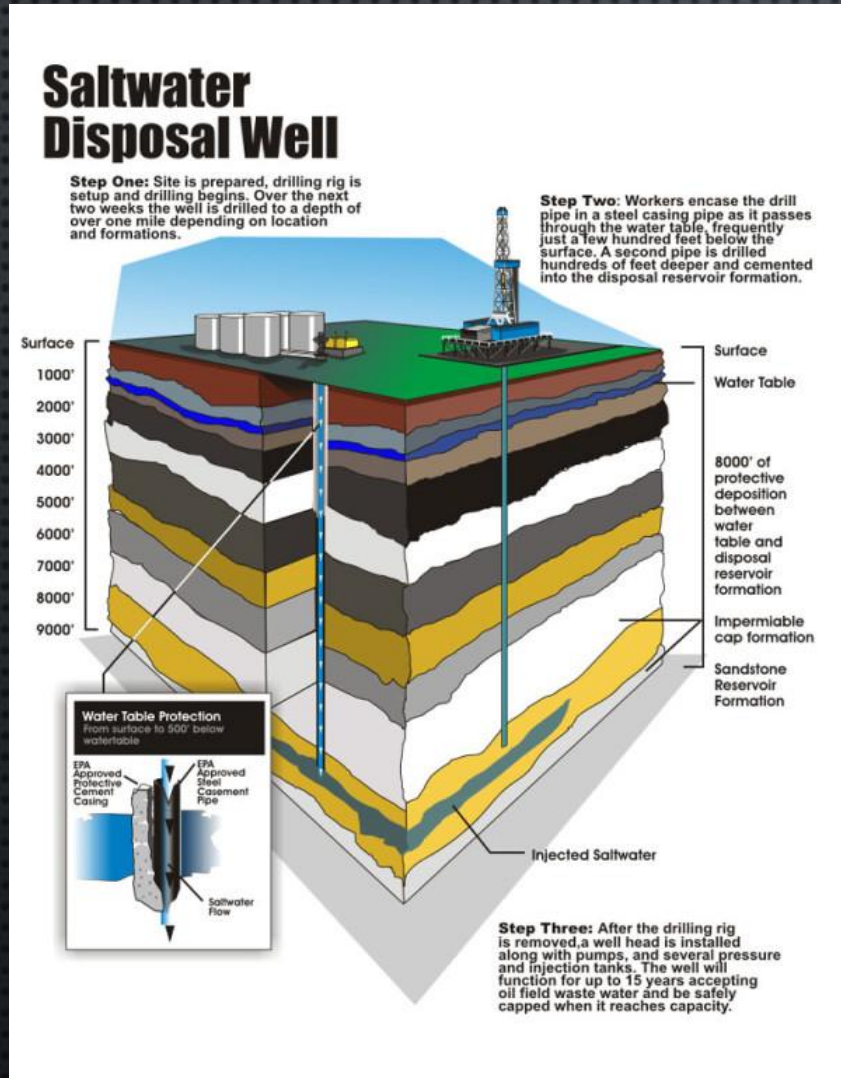
- 4 PRIMARY CATEGORIES OF STRESS ON THE WATER ENERGY NEXUS IN THE U.S.
 1. WATER MOVEMENT
 - a) THINK FLINT, MICHIGAN – OVER 3,000 OTHER COMMUNITIES HAVE IT WORSE
 - b) THE AGING WATER INFRASTRUCTURE – A \$1 TRILLION PROBLEM
 2. SECURE ACCESS TO ENERGY & WATER
 - a) THING STANDING ROCK PROTESTS
 - b) SARDIS LAKE HERE IN OKLAHOMA
 3. WATER AVAILABILITY
 4. TREATMENT & DISPOSAL OF WASTE WATERS FROM ENERGY PRODUCTION

WATER AVAILABILITY IN THE U.S.

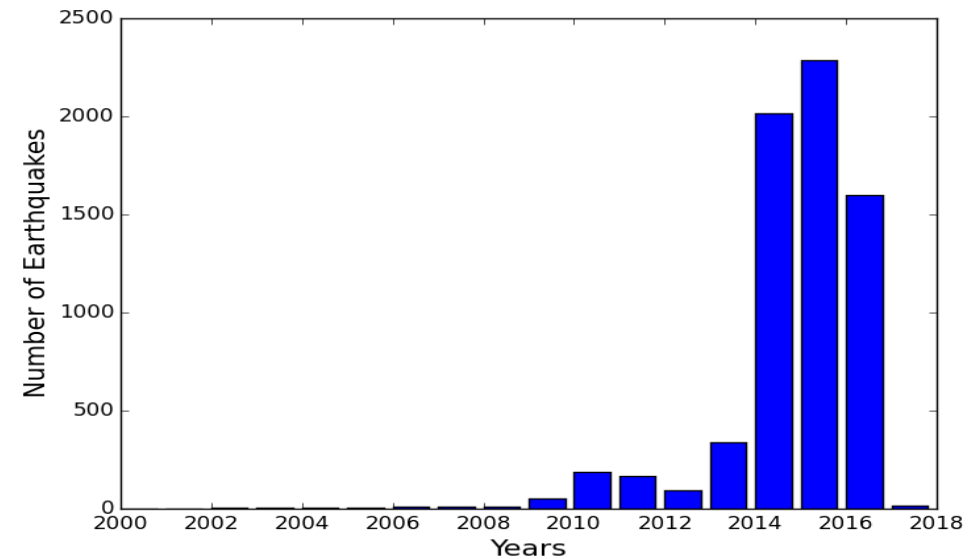
Areas of highest population growth are also the hottest, require the most electricity, and have the poorest sources of fresh water



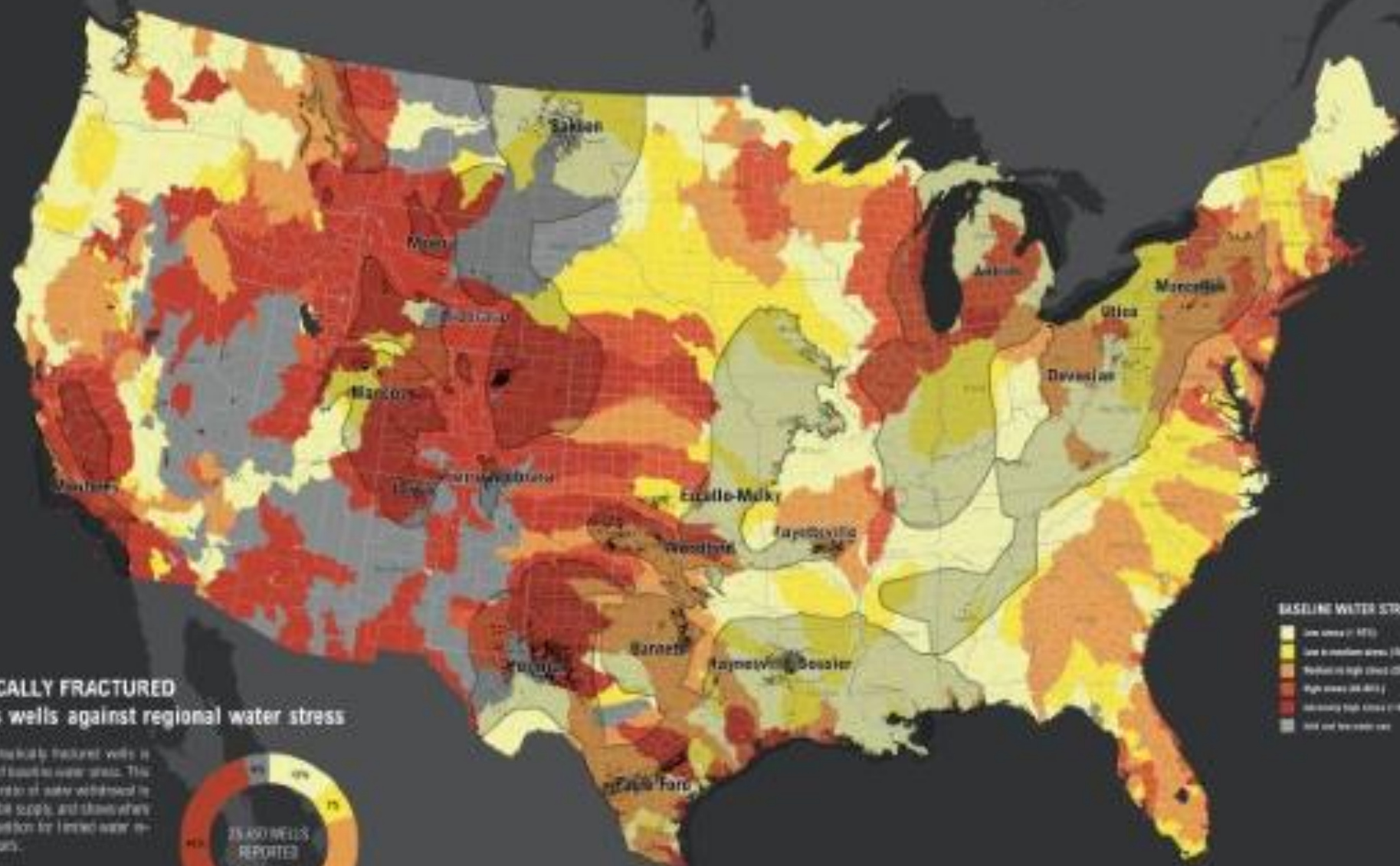
WASTE WATER DISPOSAL



Oklahoma Earthquakes Per Year



SECTION VI:
THE NEXUS' IMPACT
ON OKLAHOMA


BASELINE WATER STRESS


HYDRAULICALLY FRACTURED oil and gas wells against regional water stress

A cluster of hydraulically fractured wells is located in an area of low to water stress. This map measures the ratio of water withdrawn to near-surface available supply, and shows where there is high competition for limited water resources among users.

Red areas on the baseline water stress map are places where a large portion of available water supply is already being used. The regions are dry and undeveloped.

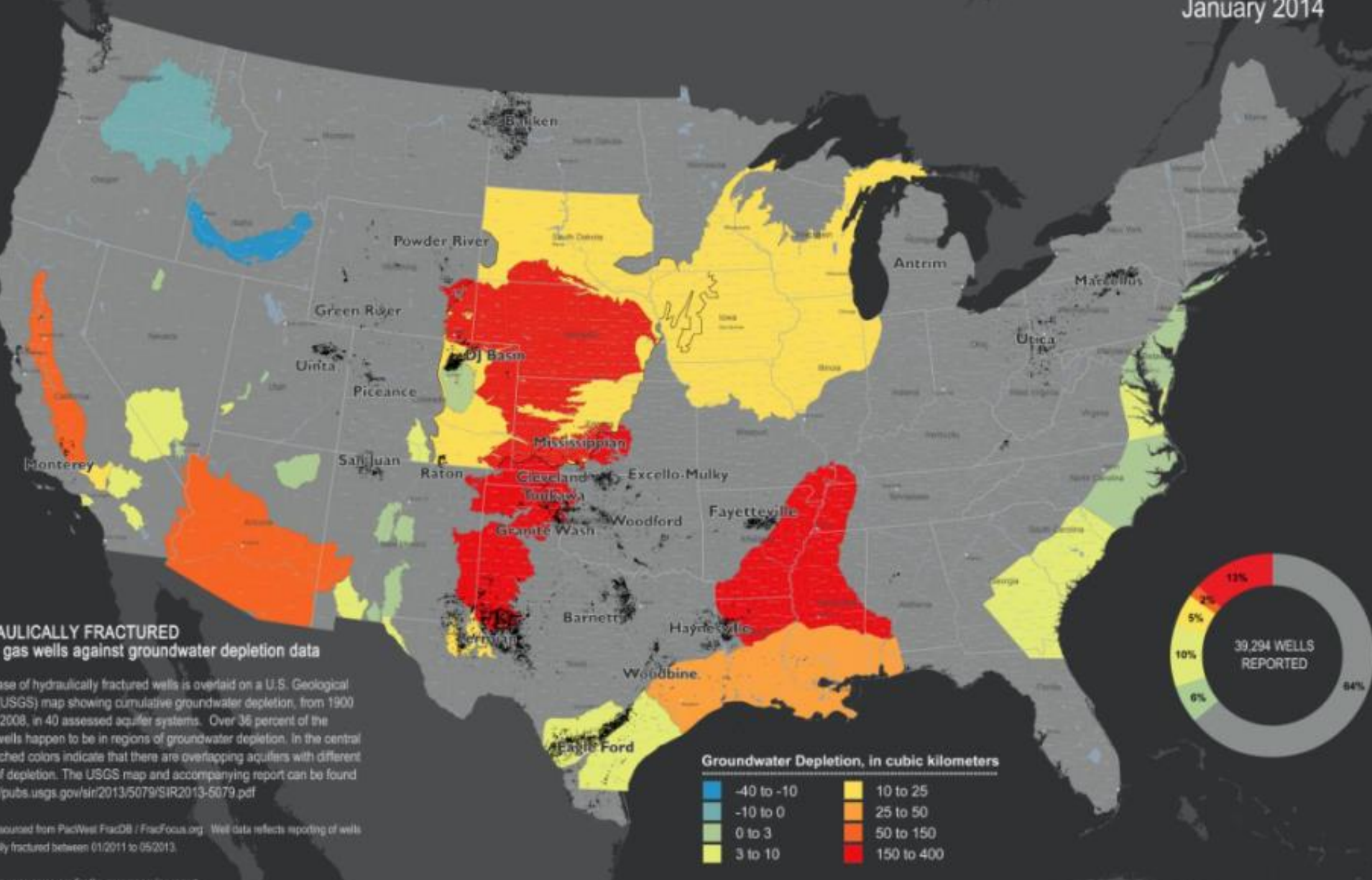


HYDRAULICALLY FRACTURED oil and gas wells against groundwater depletion data

A database of hydraulically fractured wells is overlaid on a U.S. Geological Survey (USGS) map showing cumulative groundwater depletion, from 1900 through 2008, in 40 assessed aquifer systems. Over 36 percent of the 39,294 wells happen to be in regions of groundwater depletion. In the central U.S. hatched colors indicate that there are overlapping aquifers with different values of depletion. The USGS map and accompanying report can be found at <http://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf>

Well data sourced from PacWest FracDB / FracFocus.org. Well data reflects reporting of wells hydraulically fractured between 01/2011 to 05/2013.

Please see www.ceres.org for the accompanying report.



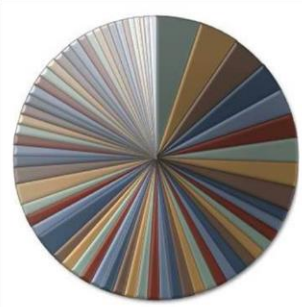
Groundwater Depletion, in cubic kilometers

Blue	-40 to -10	Yellow	10 to 25
Cyan	-10 to 0	Red-Orange	25 to 50
Light Green	0 to 3	Red	150 to 400
Yellow	3 to 10		



THESE AREN'T YOUR FATHER'S FRACK JOBS

4.75 million
gallons
(standard frac job in
Oklahoma)



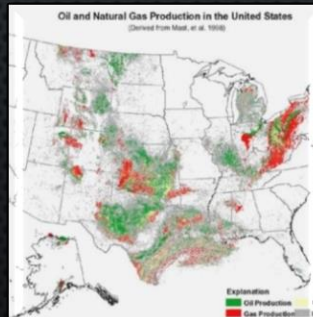
1%
(Estimate of oil-related
wastewater recycled in
Oklahoma)



2% vs. 30%
(Statewide vs. local demand
of freshwater from fracking)



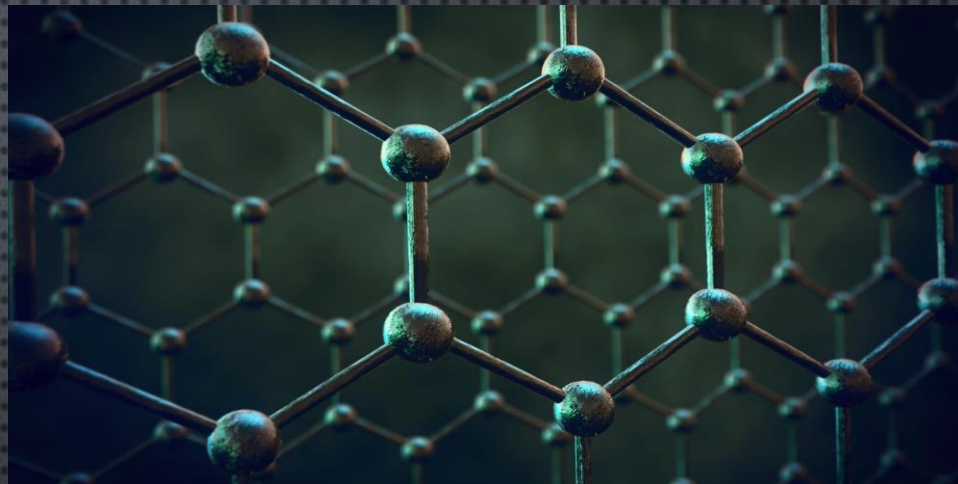
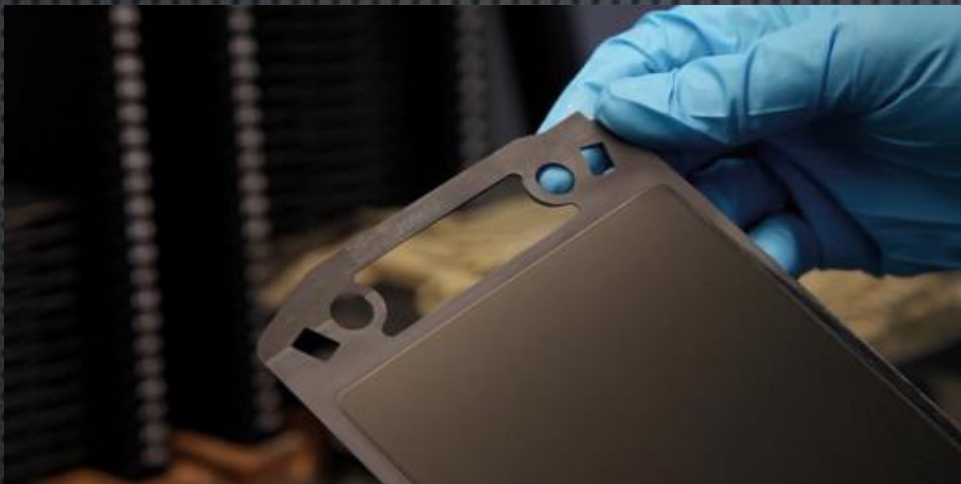
70%
(amount of water in frac job
lost downhole)



128%
(increase in freshwater
demand since 2008)

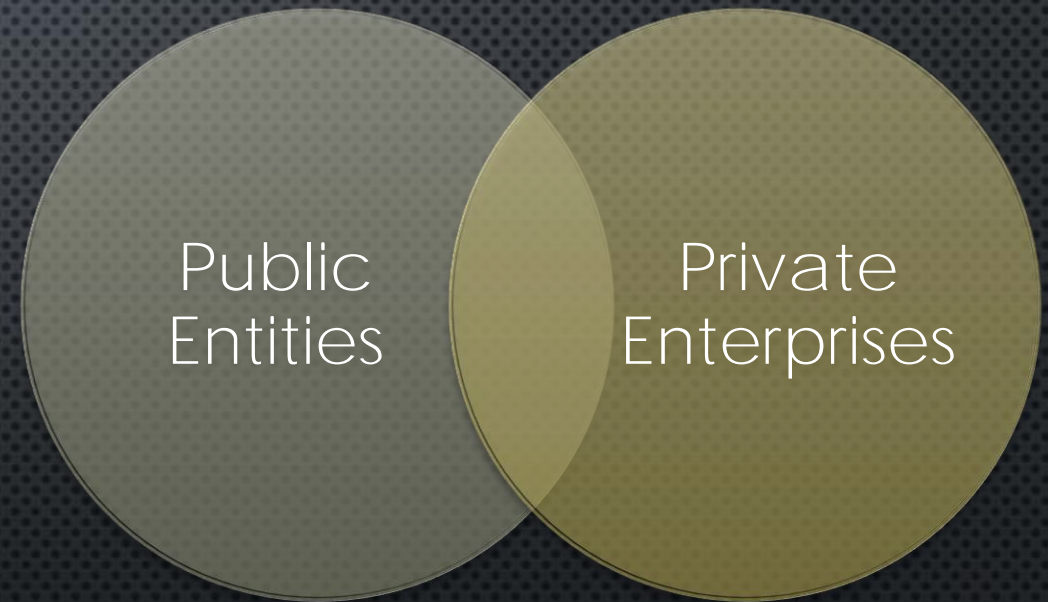
SECTION VII: SOLUTIONS

THERE ARE PROMISING TECHNOLOGY IS ON THE HORIZON



ONLY COLLABORATION WILL PROVIDE THE LONG-TERM SOLUTION

- PUBLIC-PRIVATE PARTNERSHIPS
- INCREASES IN STATE- AND FEDERAL-GRANTS
- REGULATORY CHANGES TO ACCELERATE TECHNOLOGY ADOPTION
- POLICY INITIATIVES THAT MOTIVATE CHANGES IN BEHAVIOR
- BETTER PUBLIC AWARENESS



SUMMARY

- UNDERSTANDING THE WATER-ENERGY NEXUS IS VITAL
- IDENTIFYING THE KEY STRESS POINTS FRAMES THE PUBLIC DEBATE
- ADDRESSING THE UNDERLYING ISSUES CAUSING THE STRESS POINTS IS A MUST FOR POLICY MAKERS
- UNDER CURRENT DYNAMICS, THE WATER-ENERGY NEXUS WILL FRACTURE
- WHILE SOLUTIONS SHOULD BE MARKET-BASED, ANY COURSE MUST PUT WATER FIRST
- FORTUNATELY, WE HAVE ANSWERS

QUESTIONS?

FOR A TRANSCRIPT OF THE SPEECH OR A COPY OF THE SLIDES:

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