River Network
Connecting People, Saving Rivers

The Carbon Footprint of Water

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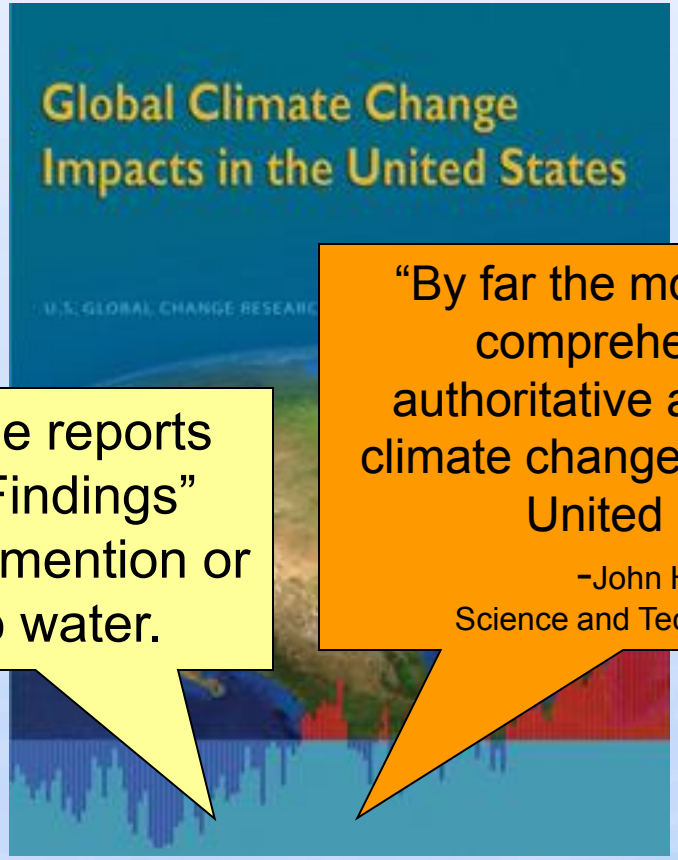
U.S. Global Change Research Program

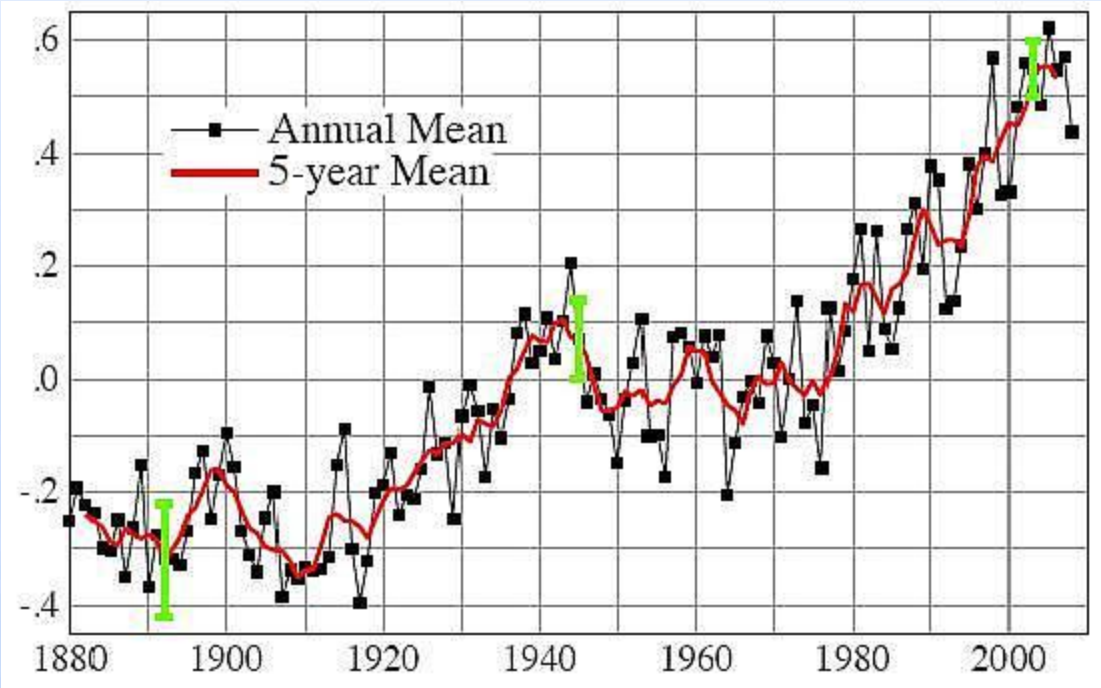


Eight of the reports "10 Key Findings" specifically mention or relate to water.

"By far the most up to date, comprehensive and authoritative assessment of climate change impacts on the United States."

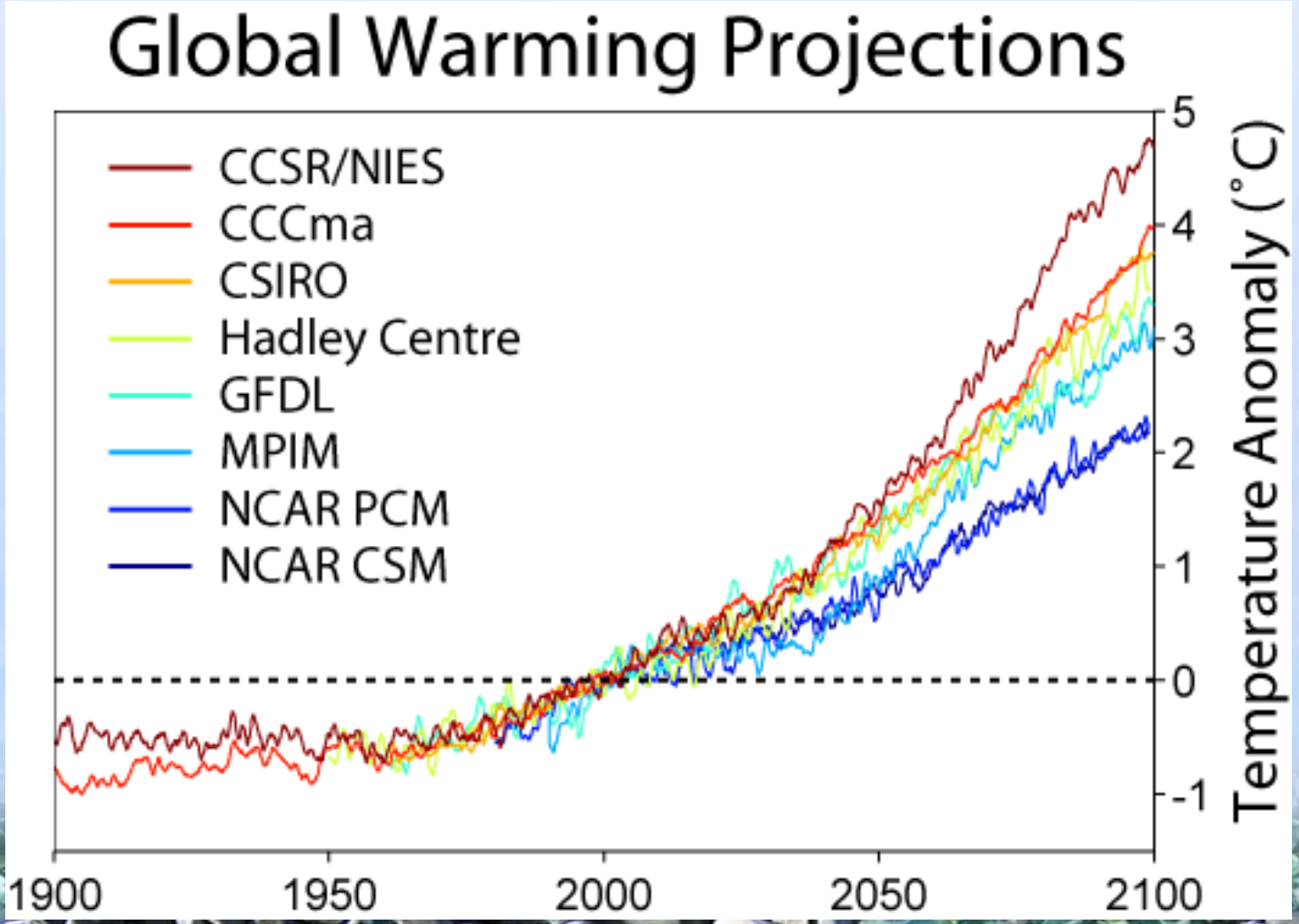
-John Holdren,
Science and Technology Advisor

Long Term Temperature Trends



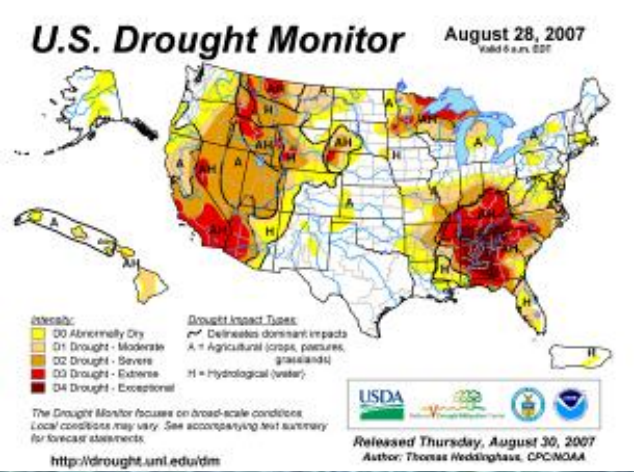
NASA Goddard Institute for Space Studies

What will this mean?



Water Change

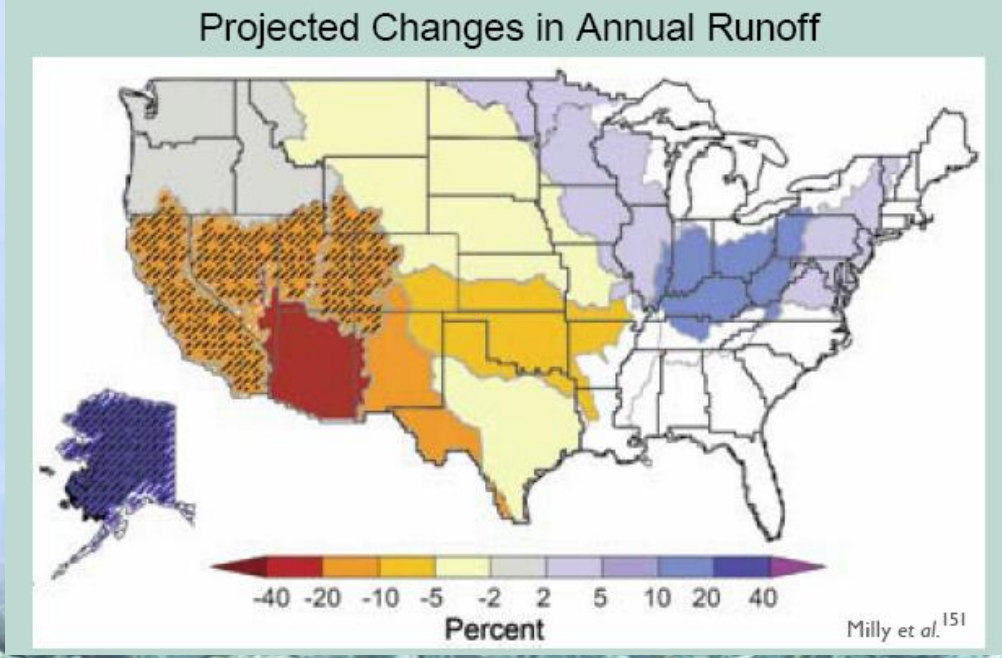
- Higher Temperatures and Increased Drought
  - Increased water demand for irrigation
    - Some research estimates an over 40 percent increase in land needing irrigation by 2080.
  - Billions of thirstier farm animals
  - More water needed for industrial cooling



Adapted from Pacific Institute's, "Climate Change and Global Water Crisis: What Businesses Need to Know and Do" <http://www.pacinst.org/reports/ungc_climate_water/report.pdf>

Storming the Future

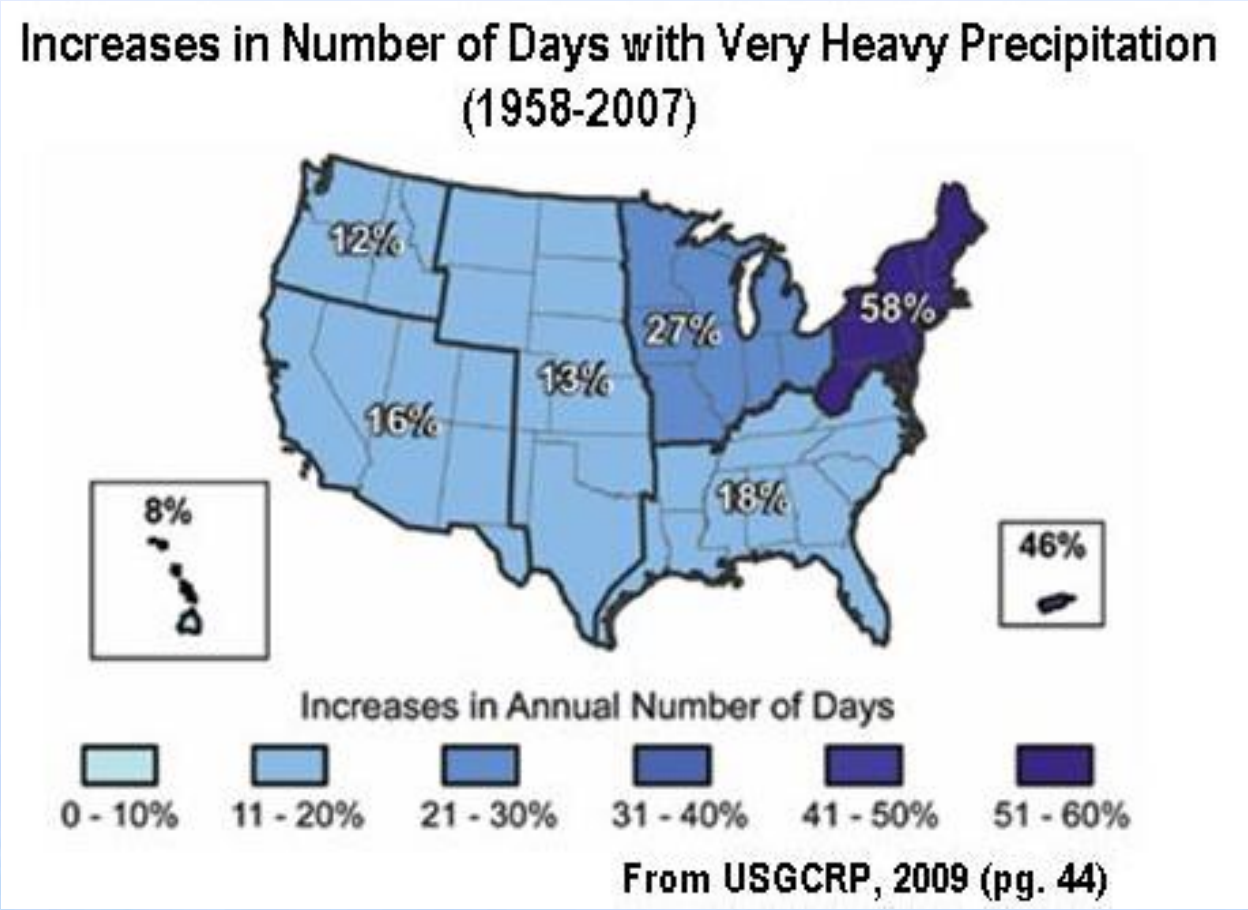
- In the past century, total precipitation in U.S. has increased by about 7%
- For every 1° F rise in temperature, water holding capacity increases by 4%



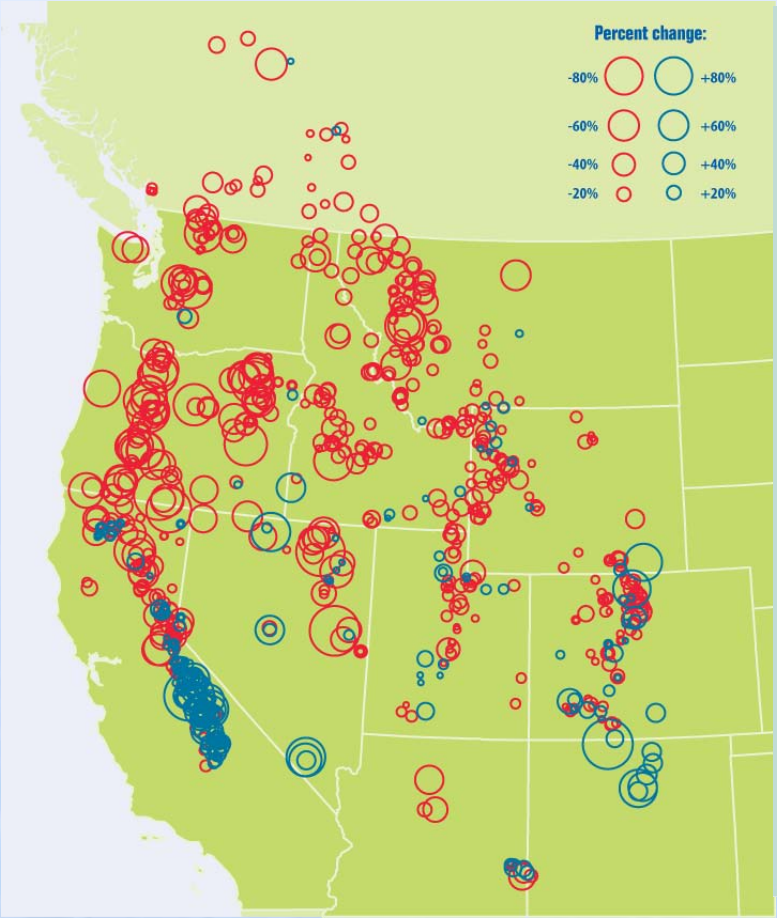
Source: USGCRP, 2009

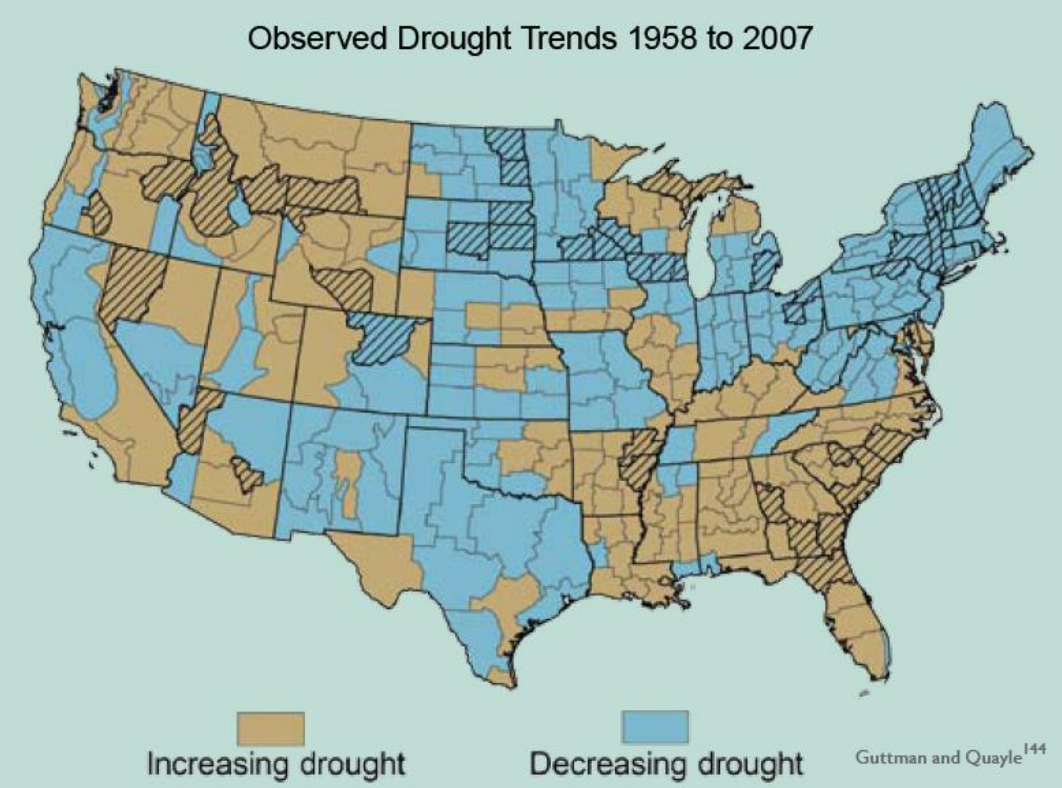
Extreme Precipitation

Top 1% of events:



Regional Differences

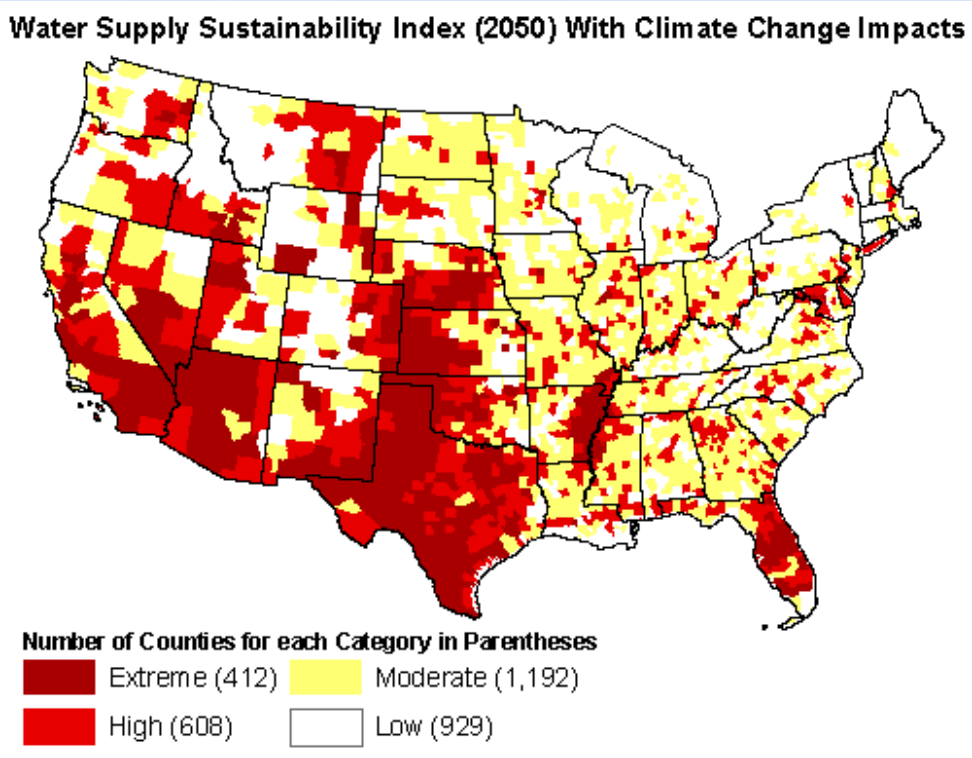




Trends in end-of-summer drought as measured by the Palmer Drought Severity Index from 1958 to 2007 in each of 344 U.S. climate divisions.[144] Hatching indicates significant trends.

Water Insecurity

- More than 1,100 counties now face higher risk of water shortages by 2050 due to climate change
  - A full one-third of continental U.S.
  - Fourteen states face extremely high risk
    - 400 counties
    - 14-time increase from previous estimates



NRDC and Tetra Tech: http://www.nrdc.org/globalWarming/watersustainability/

Targeting Local Action

Table One: Potential Environmental Results of Water and Energy Initiatives

Sector	Water	Energy	GHG
Targeted Water Use Sector	***Potential for water savings***	***Potential for energy savings***	***Potential GHG reduction***
Land Use LID	Medium	High	High
Energy Sector	High	Low	High
Residential Hot water	Low	High	High
Water Supply Utilities	Medium	High	Medium
Waste Water Utilities*	Low	Medium	High
Commercial/ Industrial Processes	Medium	Medium	Medium
Residential Cold water	Medium	Medium	Medium
Storm water Management	Low	Medium	High
Agricultural Sector**	High	Low	Low

* estimate for direct use at waste water facilities, not consumer use

**estimate does not include reforming livestock related water uses

Energy Sector v. Public Supplies

- 25% of all non-agricultural fresh water *consumption* in U.S. is used for thermoelectric power generation.
- 53% fresh, surface water *withdrawals*
- On average, 2 gallons of water consumed per kWh

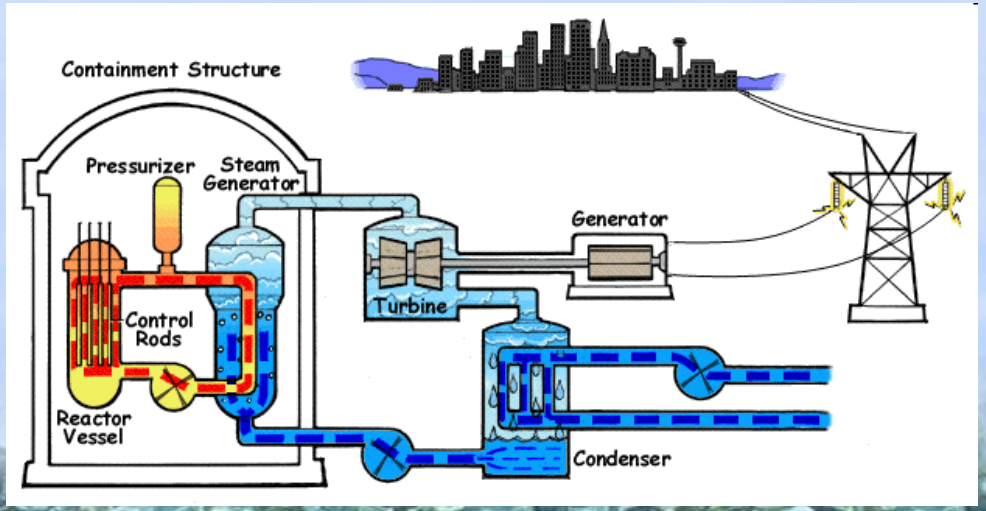
"Consumptive Water Use for U.S. Power Production" >http://www.nrel.gov/docs/fy04osti/33905.pdf>, USGS and Michael Hightower, Sandia National

Burning our Rivers

- Thermoelectric power accounts 90% of all electricity
  - Coal (49%)
  - Natural Gas (20%)
  - Nuclear (19%)
  - Petroleum (2%)

<u>Thermoelectric Power:</u> ***Electrical power generated from a heat source, such as burning coal or nuclear fission, indirectly through devices like steam turbines.***

Typical coal plant use 12-20 million gallons of water per hour!



EIA <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html>, diagram from <http://www.nrc.gov/images/reading-rm/basic-

Reduce Water in Energy: Promote Renewables

Source	Gallons Per kWh
Wind	**0.001**
PV Solar	**0.030**
Nuclear	0.62
Hydro	18.27

In Oregon, an average of 3.7 gallons of water *consumed per kWh electricity*

Gipe, Paul. "Wind Energy Comes of Age," 1995 <http://www.awea.org/faq/water.html>

More Wind Less Water

Figure A-19. Annual water consumption savings due to deployment of wind energy

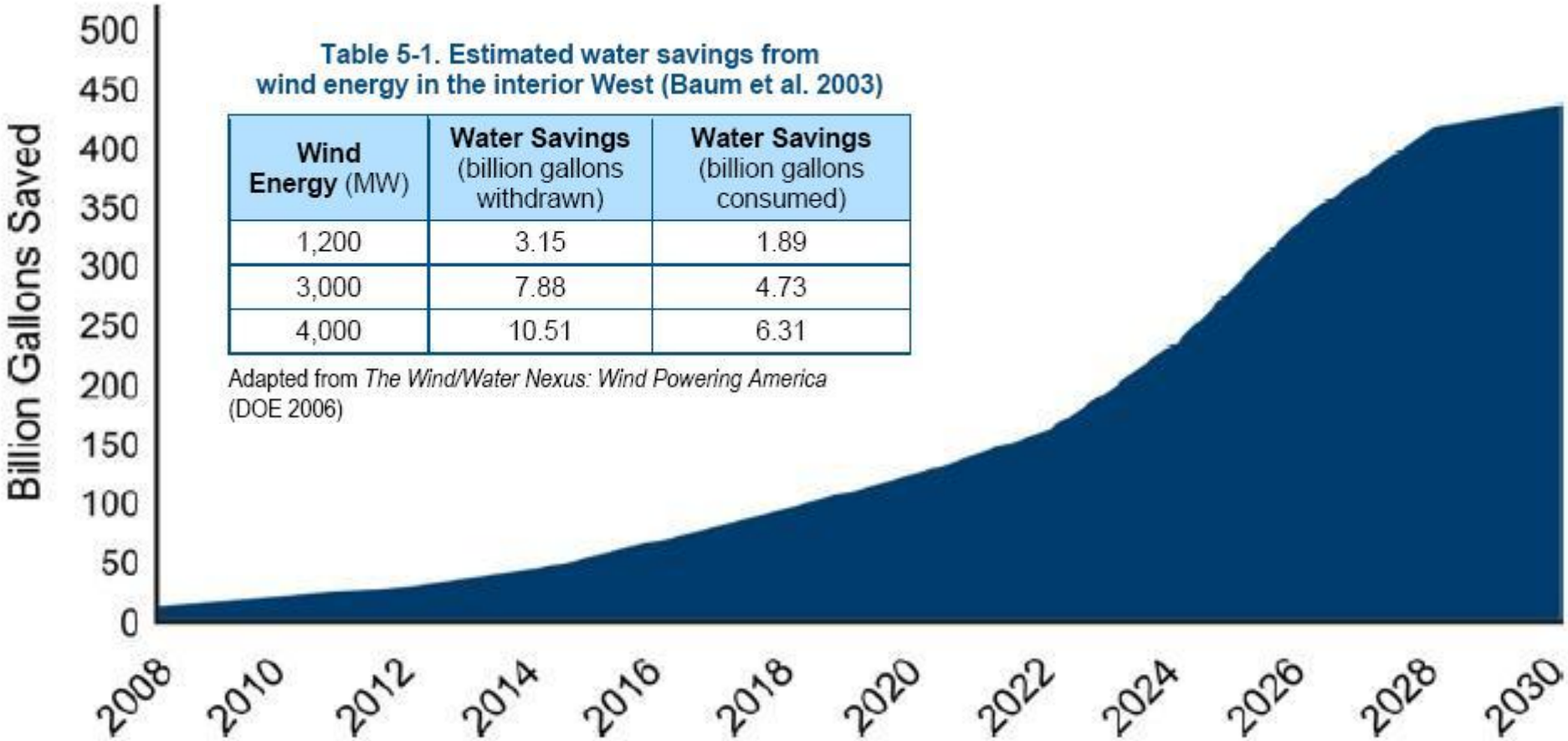


Table 5-1. Estimated water savings from wind energy in the interior West (Baum et al. 2003)

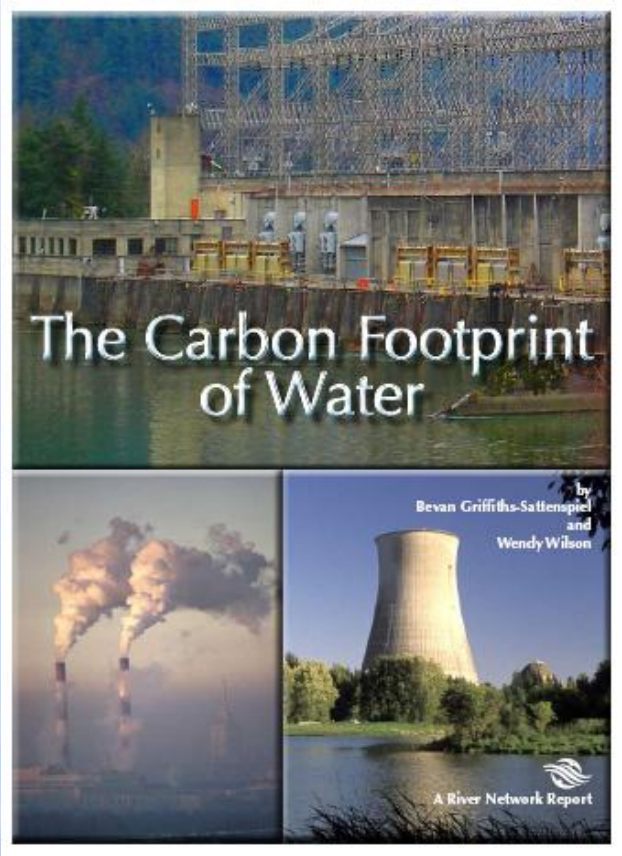
Wind Energy (MW)	**Water Savings** (billion gallons withdrawn)	**Water Savings** (billion gallons consumed)
1,200	3.15	1.89
3,000	7.88	4.73
4,000	10.51	6.31

Adapted from *The Wind/Water Nexus: Wind Powering America* (DOE 2006)

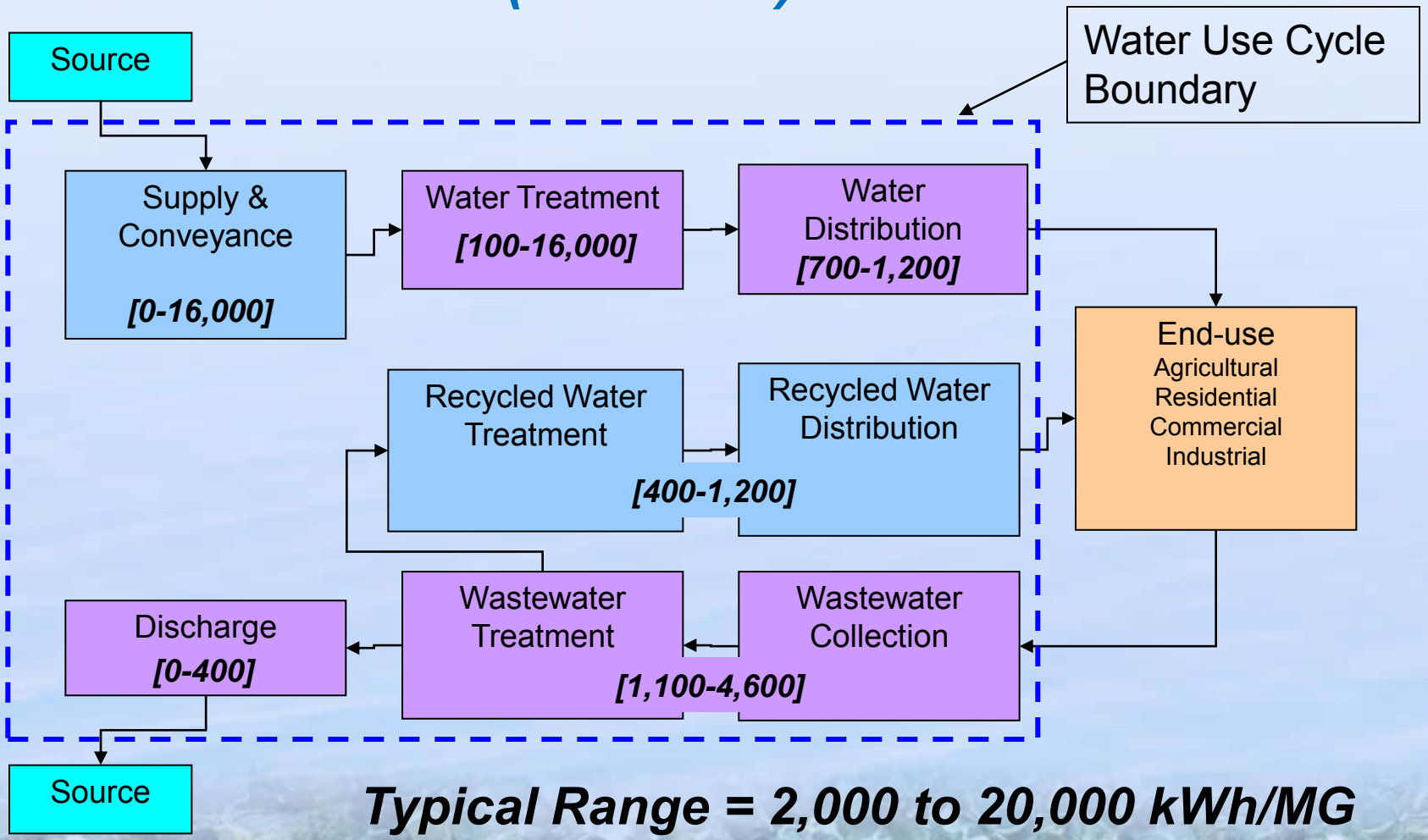
Source: U.S. Department of Energy, 20% Wind Energy by 2030 <http://www.20percentwind.org/20p.aspx?page=Report>

The Carbon Footprint of Water

- Water-related energy use is equivalent to *at least* 520 billion kWh (water heating only)
  - Electricity output of 150 thermoelectric or coal-fired power plants
  - Equivalent to 13% U.S. electricity use
- Resulting in 290 million metric tons of CO_2 emissions
  - Annual greenhouse gas emissions of over 50 million cars



Water Use Cycle Energy Intensities (kWh/MG)



Typical Range = 2,000 to 20,000 kWh/MG

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Municipal water/sewer plant energy use

- U.S. annual total* = 75 billion kilowatt hours per year
- 3% of total U.S. consumption of electricity
- Equal to entire residential electricity demand of California
- More than entire energy-intensive pulp/paper and petroleum sectors *combined*
- Public bill = Already $4B/yr. Increasing.

* 60,000 drinking water treatment plants + 15,000 sewage treatment plants

Sources: Pacific Institute & NRDC

Key Energy-Intensity Factors

- Groundwater 30% more energy intensive than surface
- Desalination 7x more energy intensive than groundwater
- Distribution leakage can result in significantly greater energy intensity

Generic Energy Intensity of Water Supply Types

Source Types	Energy Intensity (kWh/MG)
Surface Water (Gravity Fed)	0
Groundwater	2000
Brackish Groundwater	3200
Desalinated Seawater	13800
Recycled Water	1100

Range of Energy Intensities for Water Use Cycle Segments

Water Use Cycle Segments	Range of Energy Intensity (kWh/MG)	
	Low	High
Water Supply and Conveyance	0	14,000
Water Treatment	100	16,000
Water Distribution	250	1,200
Wastewater Collection and Treatment	700	4,600
Wastewater Discharge	0	400
Total:	**1,050**	**36,200**

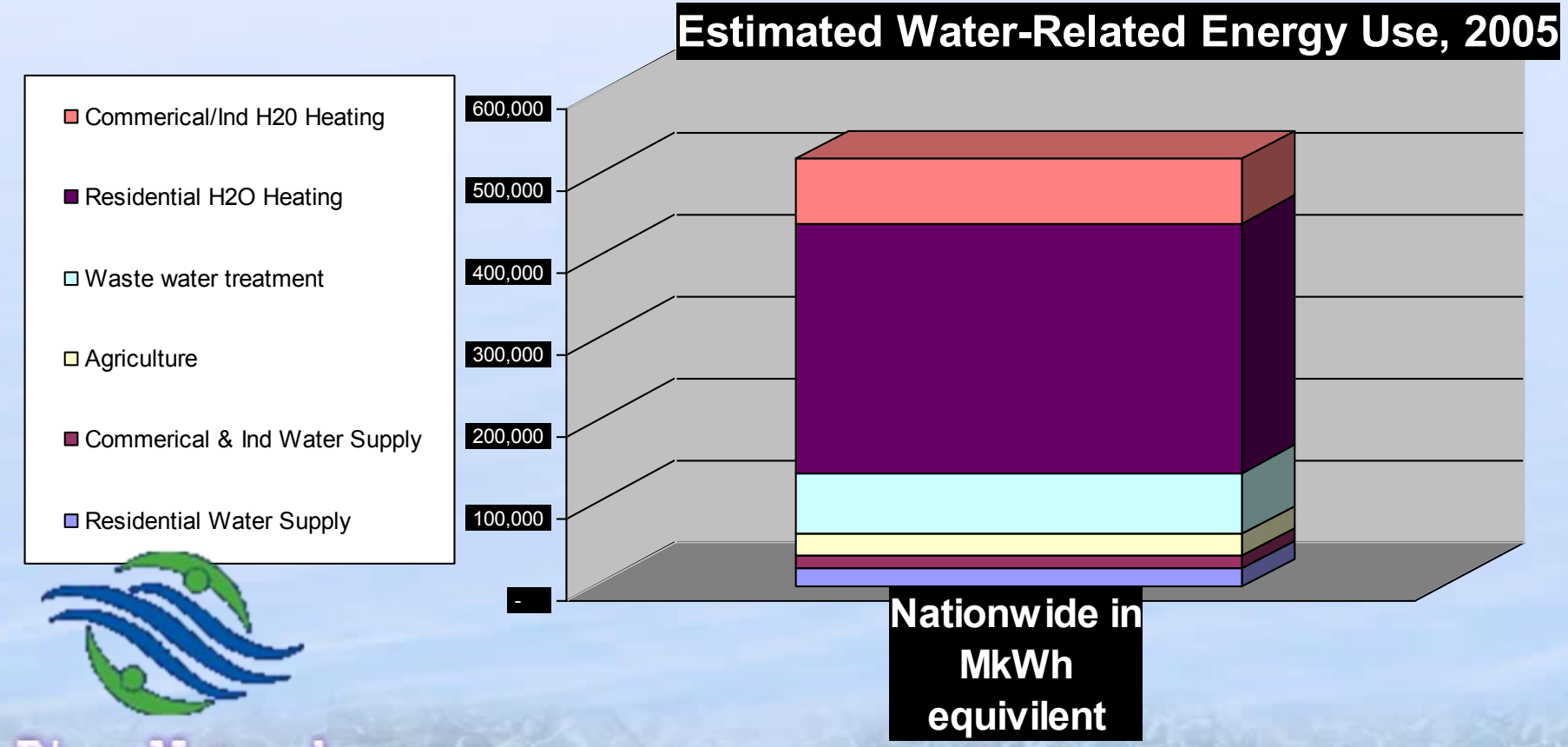
Lessons Learned:

- Intensity can vary within a specific system
  - Location of end-user
  - Time of year
- Portland, OR
  - Bull Run: 570 kWh/MG
  - Groundwater: 3,700 kWh/MG
  - Backup supply 6.5x more energy intensive
  - In 2006, groundwater accounted for 43% of electricity demand despite providing just 14% of water supply

Total Water-Related Energy Use:

System inputs: Groundwater pumping, inter-basin transfers, pumping to drinking treatment plants and to homes, sewage treatment plants and discharge. (Typical range: 1,250 – 6,500kWh/MG)	**137,864 MkWh**
End use residential: Water heating	**304,200 MkWh**
End use commercial: Businesses and institution water heating, (no data on industrial heating & cooling)	**79,100 MkWh**
Indirect inputs: Concrete production, new pipelines, etc.	**0**
Total:	**521,164 MkWh**

Nationwide Water-related Energy



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We estimate total current U.S. water-related energy use to be *at least* 521 billion kWh per year.*

* Includes water-related energy other than electricity (i.e., natural gas) in kWh equivalent.

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Equivalent to 13% of U.S. electrical production.

(Total production 3.92 Trillion kWh)

…with a carbon footprint of *290 million metric tons of CO2*

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Carbon Footprint of Water

- After space heating and cooling, water heating is typically the largest energy user in the home.
- In five minutes, a hot water faucet uses as much energy as a 60-watt bulb uses in 14 hours.

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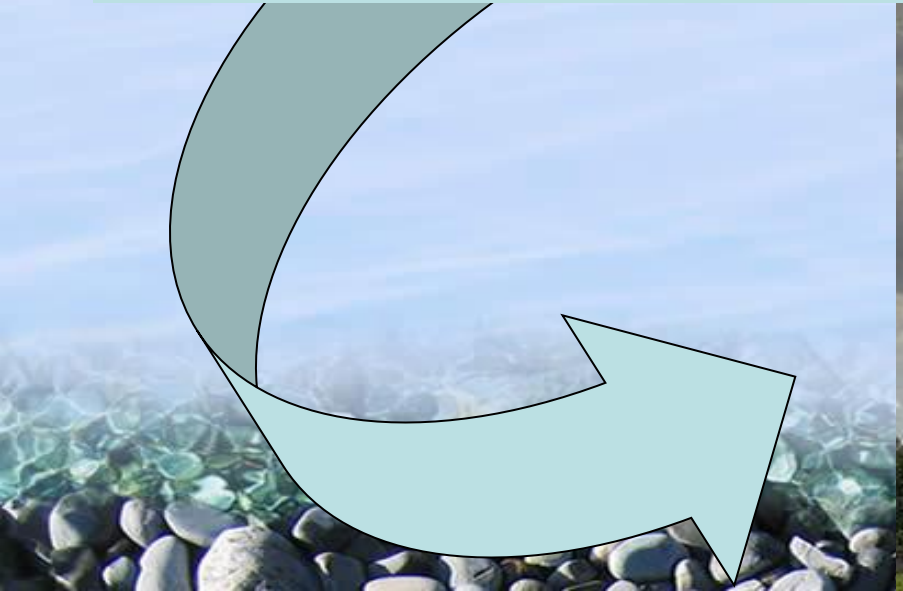
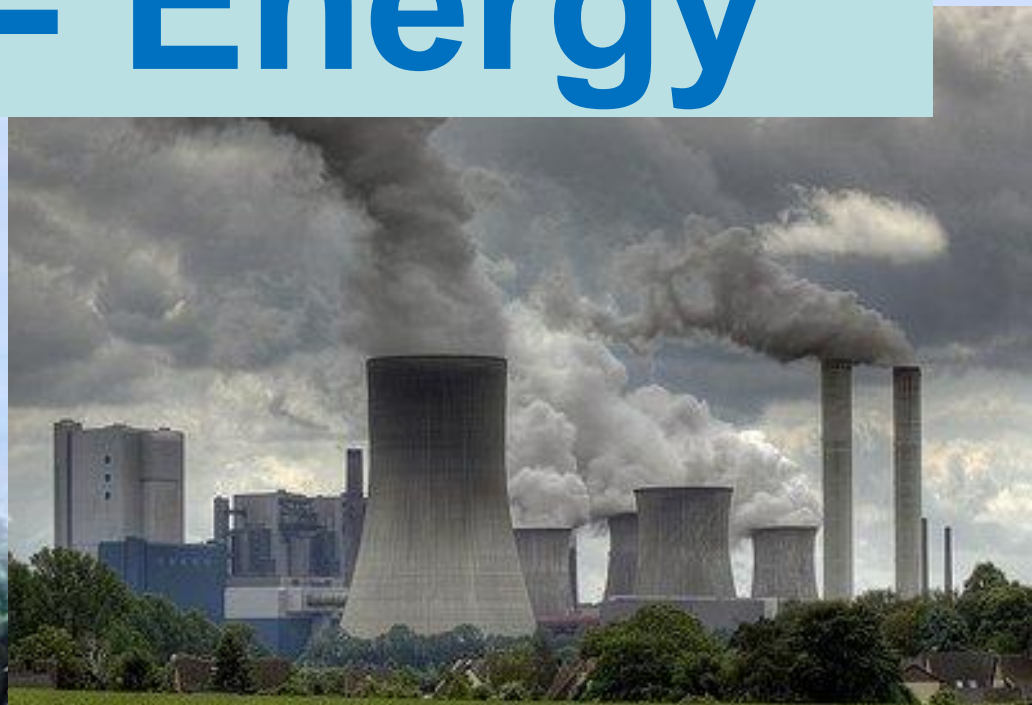
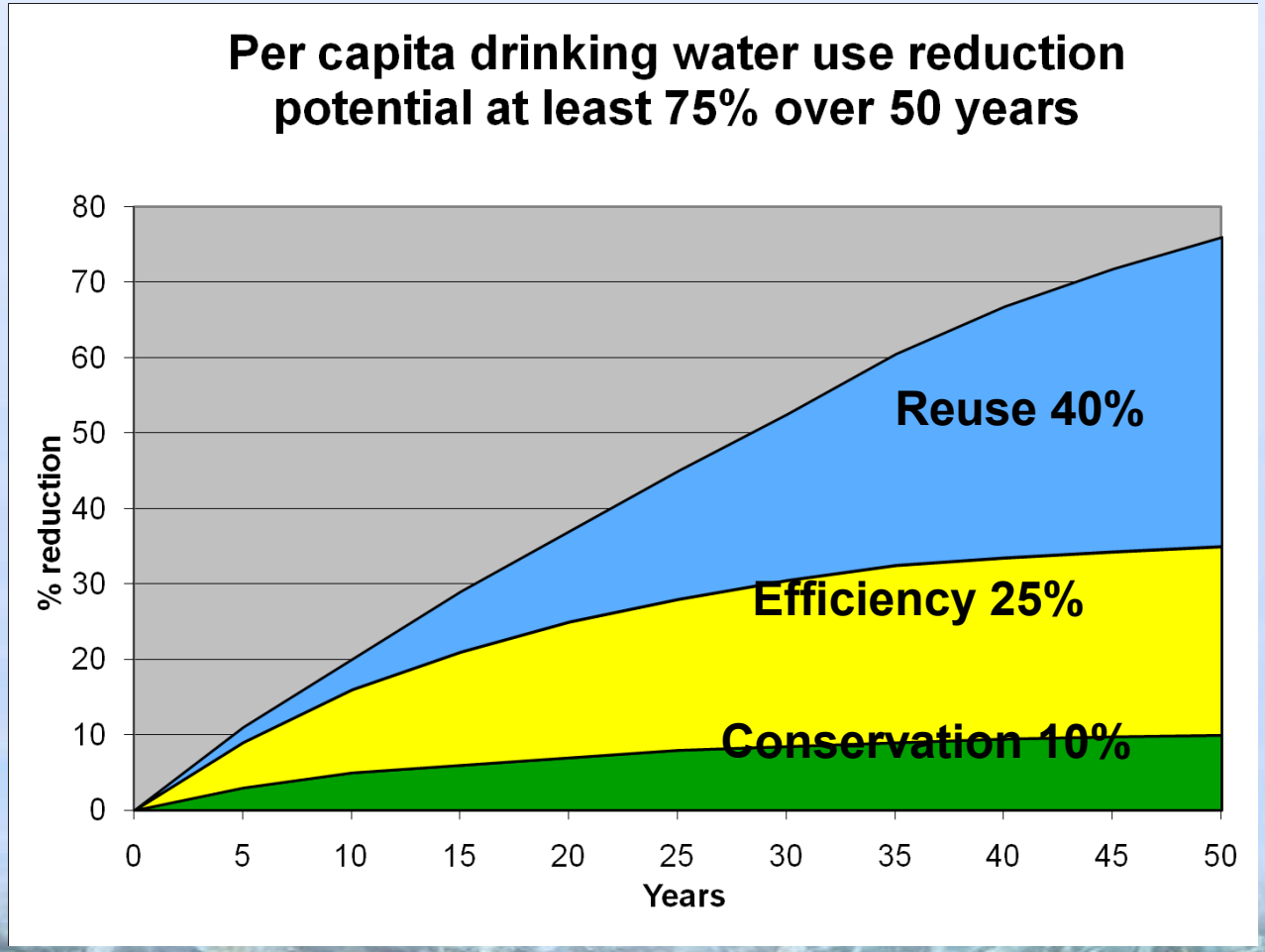
Source: US EPA & ACEEE

Water = Energy





Needed: A "Blue Wedge" Against Climate Change



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Needed: Watershed Level, State & Community Solutions

Encourage and reward stewardship

Penalize or prohibit profligate waste

1. Fix System Leaks

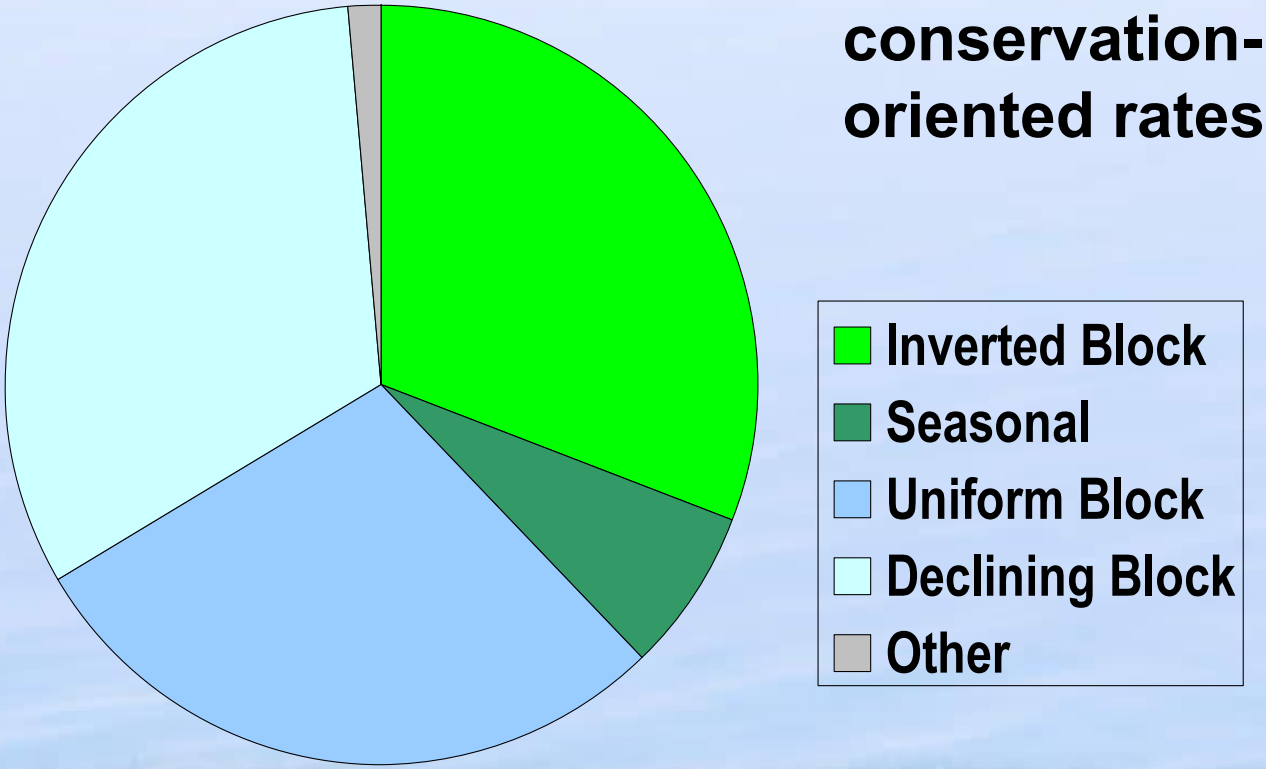
- The USGS estimates water losses of 6 billion gallons per day
  - **Enough to supply the 10 largest cities in the US**
  - **Results in:**
    - **About 1.5 billion kWh of wasted energy**
    - **1.1 million metric tons CO_2 emissions**

-George Kunkel Jr P.E.From "Water Efficiency and Accountability" pg. 65 of the March 2008 issue of Water Efficiency; Assumes 1,500 kWh/MG and 1.34 lbs. CO_2 per kWh

2. Restructure water prices

Nationwide survey of water utilities

38% have conservation-oriented rates



Source: Adapted from the 2002 RFC Water and Wastewater Rate Survey; 148 systems surveyed

3. Reduce Outdoor Use

"Of the 7 billion gallons of water used outdoors on the average day, as much as 50% is wasted due to wind, evaporation, improper system design, installation or maintenance."

– US EPA

- **About 10.5 million kWh per day**
- **Over 3.8 billion kWh per year**
- **About 5.1 billion lbs. of CO_2**
- **Outdoor demand often drives need for energy-intensive marginal sources**

Assumes 1,500 kWh/MG and 1.34 lbs. CO_2 per kWh

4. Reduce High-Carbon End Uses:

- Faucets
- Showerheads
- Washing machines
- Dishwashers
- Hot water heaters*

* Tankless models save little water, but a lot of energy

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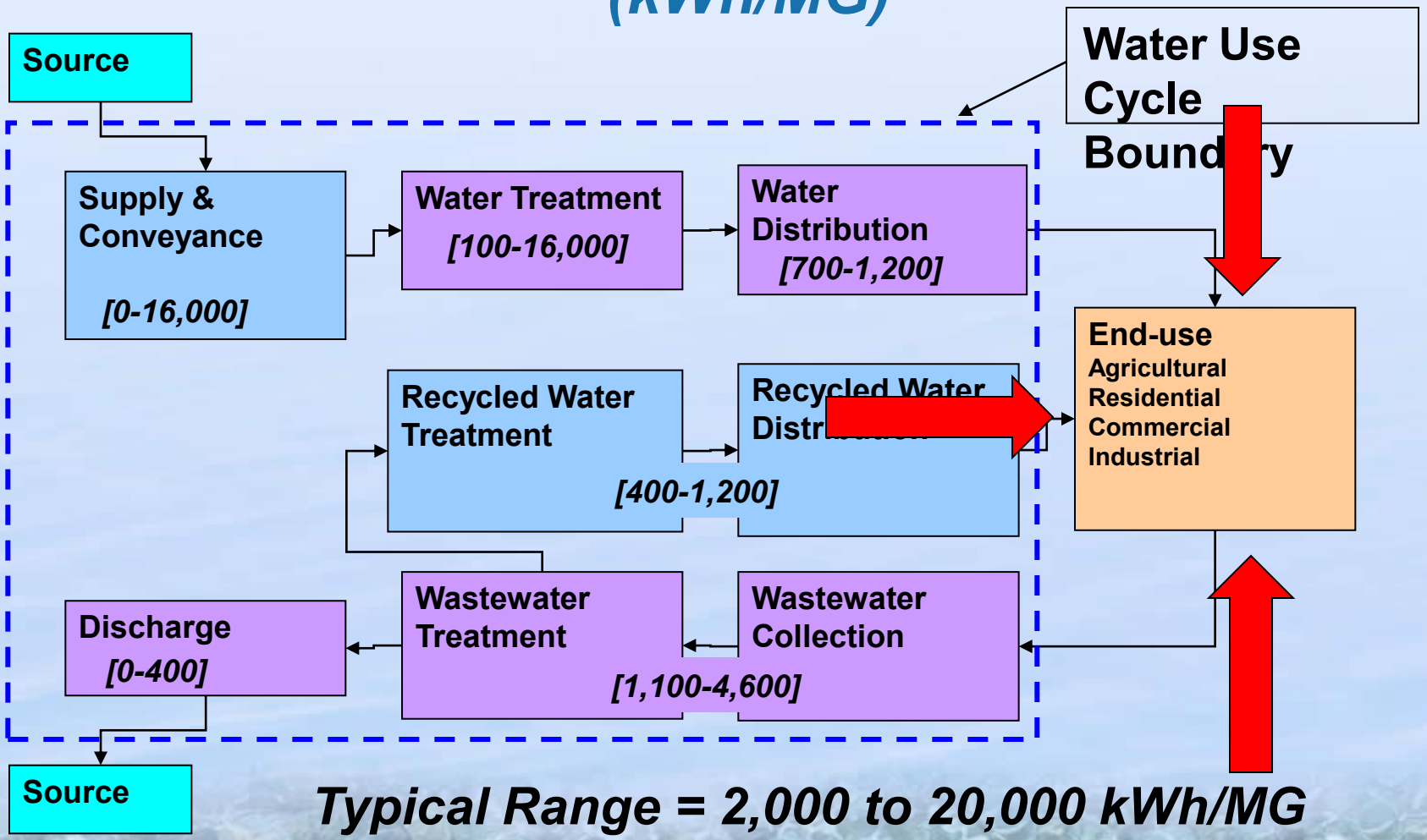
Water Use Cycle Energy Intensities

(kWh/MG)



Typical Range = 2,000 to 20,000 kWh/MG

Source: California Energy Commission, 2005 Integrated Energy Policy

Showerheads

- A family of four switching from a standard 2.5 gpm to an efficient 1.5 gpm showerhead can save:
  - 8,320 gallons of water
  - 1,240 kWh of electricity
    (more than a clothes washer)
  - 1,660 lbs of CO_2
  - $175 off utility bills

Assumes 5 showers per week at 8 minutes each. Electric water heater, $0.102 per kWh, .2036 kWh/gallon hot water, 73.1% hot water.

Pre-Rinse Spray Valves

- California Urban Water Conservation Council found:
  - **Annual water savings were approximately 50,000 gallons per valve**
  - **Annual energy savings totaled more than 7,600 kilowatt-hours**
    - **5.5 Metric ton CO2 reduction**
    - **Taking 1 car off the road**
  - **Investment of $25 and $50 could save up to $800 annually on bills.**

Hidden Oasis: Water Conservation and Efficiency in Las Vegas. Pacific Institute,

4. Indoors Cold Water: Switch Toilets

- If just 1% of American homes replaced an older toilet with a WaterSense labeled toilet:
  - **20% more efficient than the current federal standard**
  - **Save more than 38 million kWh of electricity annually**
  - **Enough electricity to supply more than 43,000 households for one month.**

Fixing Leaks At Home

- Approximately 5 to 10 percent of American homes have water leaks that drip away 90 gallons a day or more.
  - Could be reduced by 30,000 gallons/year if new, efficient fixtures were installed
- An estimated 27% of water lost to leaks has already been heated.
- Retrofitting the 5 percent of American homes that leak the most would annually save:
  - More than 177 billion gallons of water
  - Approximately 34 Billion kWh
  - 24 .4 MMT of CO_2
    - Equivalent to 5.3 coal power plants

Sources: U.S. EPA
http://www.epa.gov/watersense/news/facts.htm

5. Protect Groundwater

Watershed Degradation + Climate Change = Loss of groundwater recharge and less reliable water supplies.

Emphasizing Natural Hydrology

If loss of recharge caused a10 foot drop in groundwater nationwide we would use:

- More energy use to pump groundwater by over 1.5 billion kWh per year
- Costs increase by $150 million for pumping-related energy
- Emissions increase of 2 billion pounds of CO_2

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Assuming 60% pump efficiency, 1.34 lbs CO_2 per kWh, and $0.10 per kWh

Low Impact Development (LID)

- Implementing LID in California by 2030:
  - **Save up to 362 MGD**
    - Enough water for 800,000 households
  - **Save up to 1.2 billion kWh Annually**
    - Power 102,000 homes
  - **Save over 535,000 metric tons of CO2**
    - Take nearly 100,000 cars off the road

6. Provide Low-carbon Sources: Reused water

- Rainwater “harvested” on site
- Stormwater detained near site
- Graywater from dishes, washing machines, etc.
- Wastewater treated to levels adequate for re-use

Saving Water Saves Energy

Traditional Programs vs. Water Efficiency

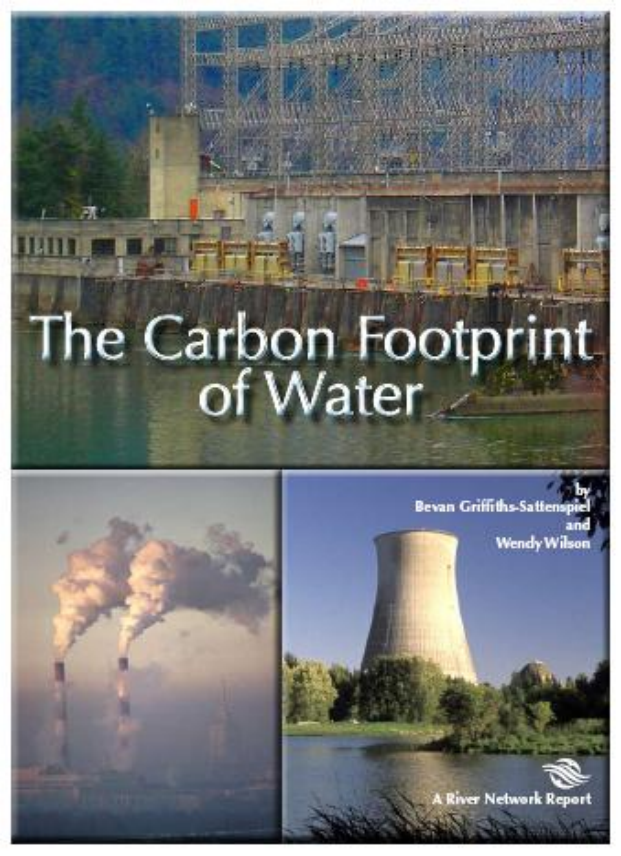
California:	Energy Efficiency Programs		
	2004-2005	2006-2008	WUE
GWh (Annualized)	2,745	6,812	6,500
MW	690	1,417	850
Funding ($ million)	$762	$1,500	$826
$/Annual kWh	$0.28	$0.22	$0.13
WUE Relative Cost	46%	58%	

CEC, 2005

That means water efficiency can save over 95% of the energy at 58% of the cost of planned energy conservation programs

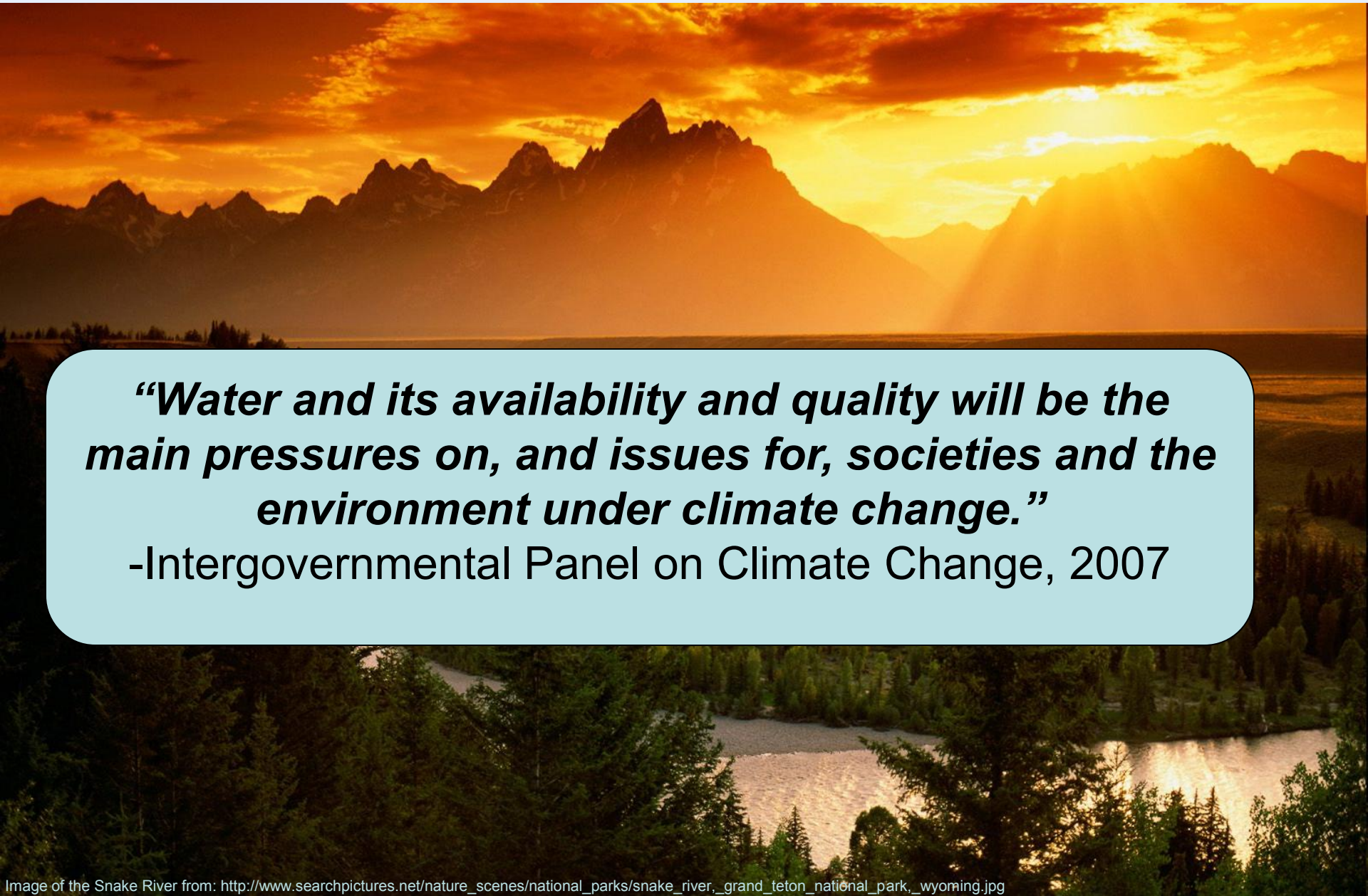
Break Trends!

- Energy for water supply already 20-60% of operating costs for many municipalities.
- Increasing energy demand
  - *by 2030 50% increase public and commercial water?*
  - *3x greater for industrial and irrigation use?*
- Greater use of marginal, more energy intensive water supplies?
- Higher treatment needs?



Original Source: EPRI, 2002

Climate Change and Water



"Water and its availability and quality will be the main pressures on, and issues for, societies and the environment under climate change."

-Intergovernmental Panel on Climate Change, 2007

Image of the Snake River from: http://www.searchpictures.net/nature_scenes/national_parks/snake_river,_grand_teton_national_park,_wyoming.jpg

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Questions?

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