WATER NEXUS 2012

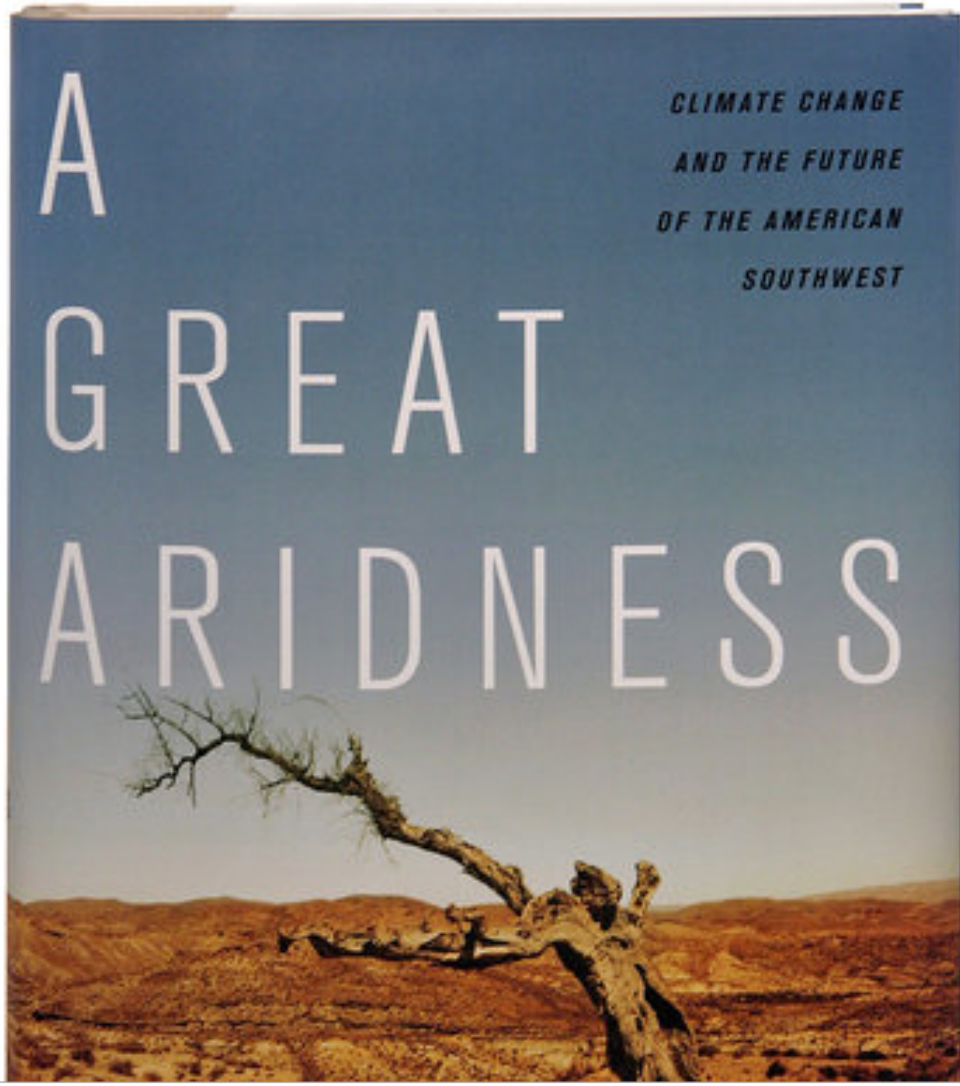
Connecting the Dots: The water, food, energy, and climate nexus

Water in the West: Groundwater, Energy, Ecosystems, and Infrastructure

Moderator: Dick Luthy

Panelists: Craig Criddle, Andrew Fahlund, David Freyberg, and Buzz Thompson

Monday, April 16, 2012 | Frances C. Arrillaga Alumni Center | 326 Galvez Street | Stanford University

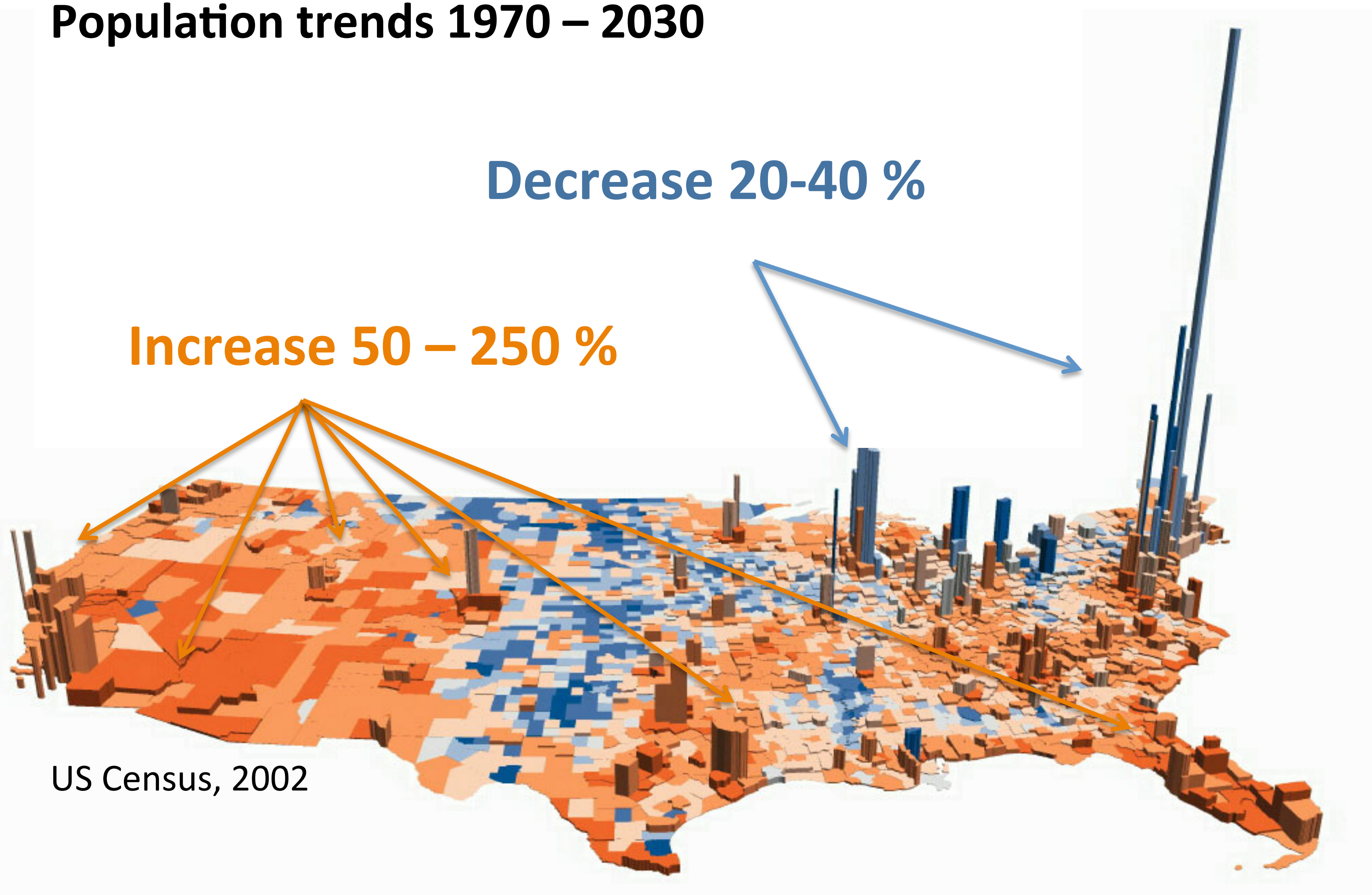


Macro-level factors:

- Aridity
- Population
- Climate
- Ecosystems
- Living sustainably

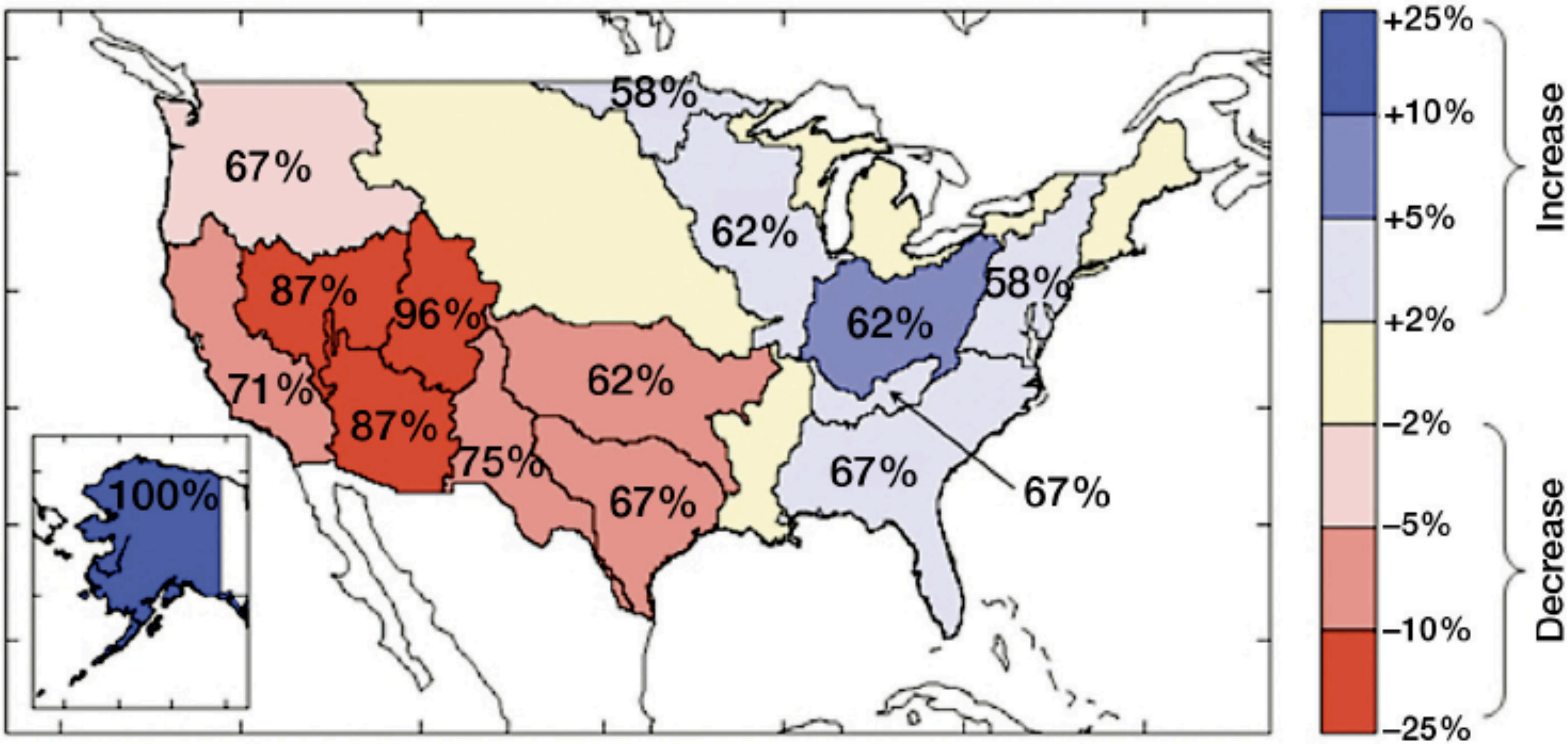
Macro-level factors: population

Population trends 1970 – 2030



US Census, 2002

Macro-level factors: climate change



Less runoff in 2041-2060 relative to 1901-1970

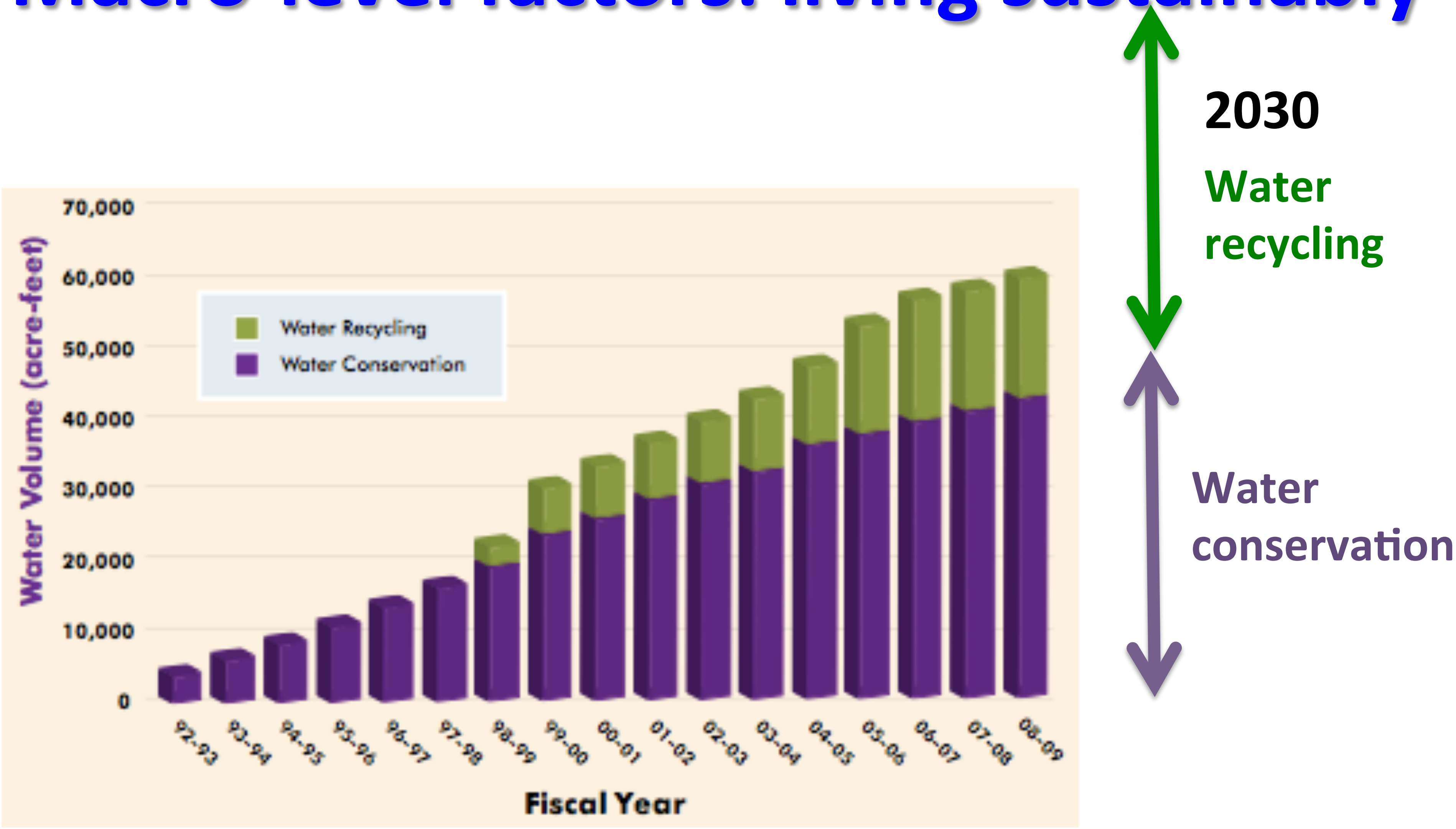
P.C.D. Milly, USGS, 2005

Macro-level factors: ecosystems

Kern River
New York Times
June 5, 2008

Calera Creek
Pacifica, CA
Restored ecosystem
with recycled water

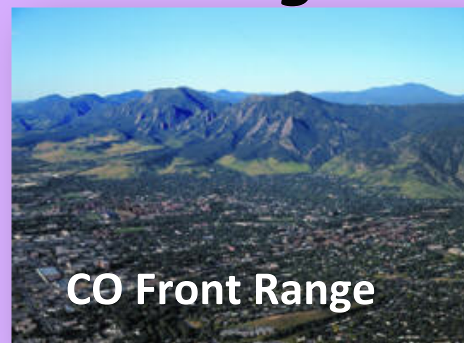
Macro-level factors: living sustainably



By 2030 the saved water will be about 98,000 ac-ft/y & about half from water recycling.
From Watts to Water, Santa Clara Valley Water District, 2011

Re-inventing the Nation's Urban Water Infrastructure [ReNUWIt]

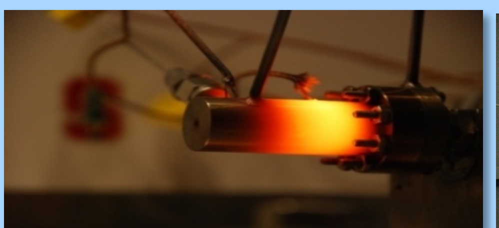
Urban Systems Integration & Institutions



AURORA

CITY OF PALO ALTO
INCORPORATED
APRIL 16 1894
CALIFORNIA

Efficient Engineered Systems



Natural Water Infrastructure Systems

Water in the West

Groundwater, Energy, Ecosystems & Infrastructure

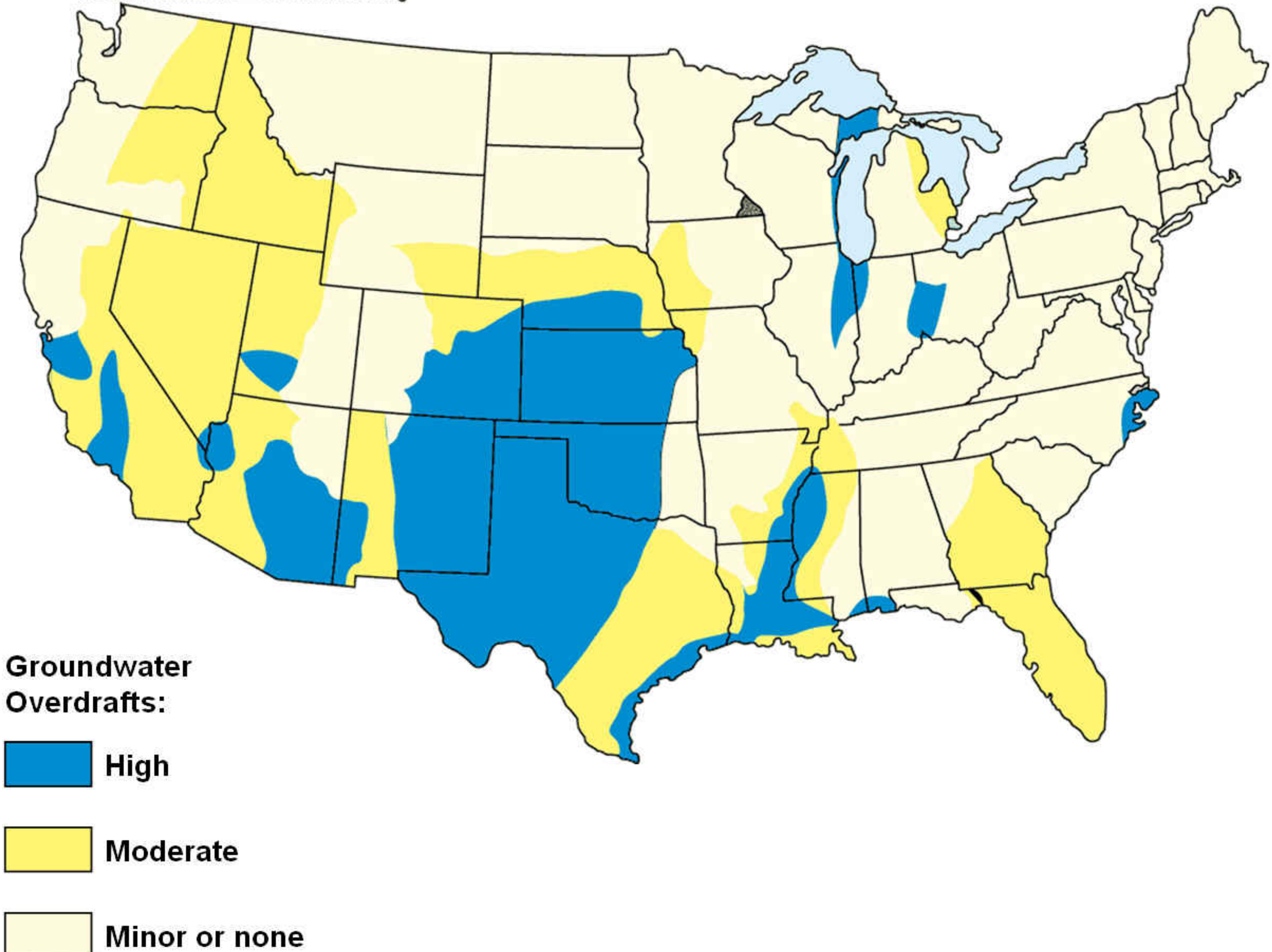
Richard G. Luthy – Moderator

Buzz Thompson

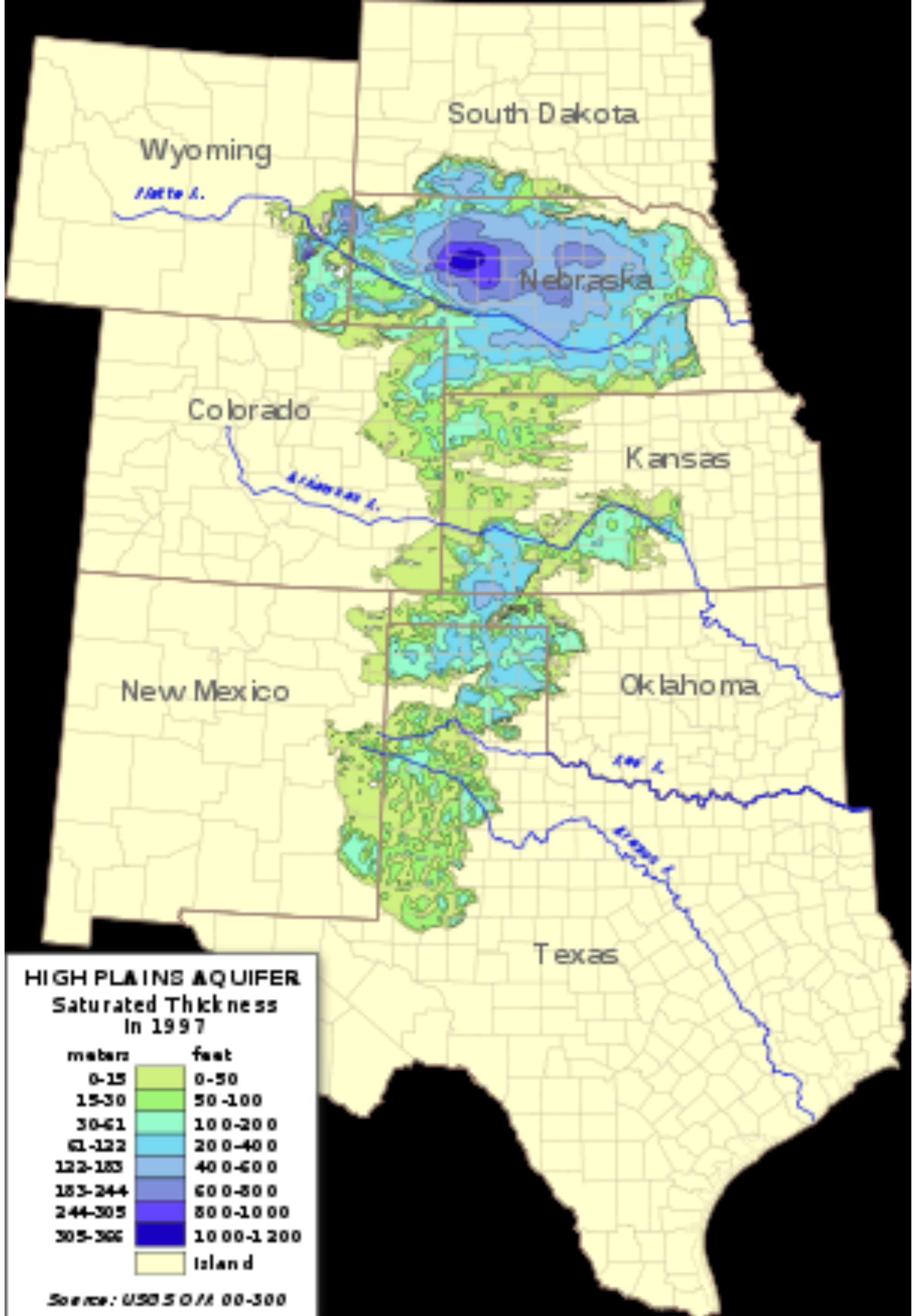
Craig Criddle

David Freyberg

Andrew Fahlund



Groundwater Overdrafts:
High
Moderate
Minor or none



South Dakota
Wyoming
Nebraska
Colorado
Kansas
New Mexico
Oklahoma
Texas
HIGH PLAINS AQUIFER
Saturated Thickness
in 1997
meters
feet
0-15
0-50
15-30
50-100
30-61
100-200
61-122
200-400
122-183
400-600
183-244
600-800
244-305
800-1000
305-366
1000-1200
Island

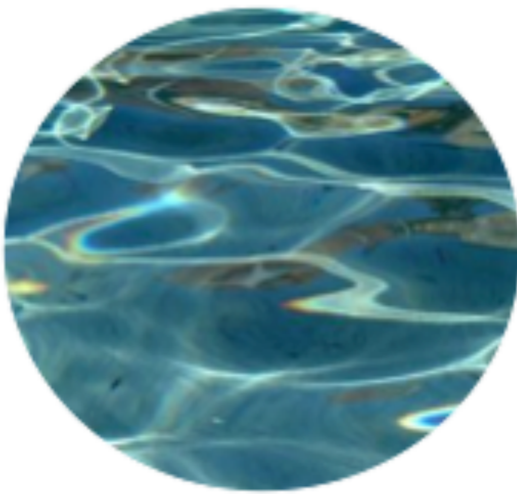

WELCOME
TO
HAPPY
"The Town Without A Frown."


SALE

Corralitos
La Selva Beach
Freedom
Watsonville
Pajaro
Aromas
Las Lomas
Moss Landing


1925
1955
SAN JOAQUIN VALLEY
CALIFORNIA
SUBSIDENCE 9M
1925-1977
1977

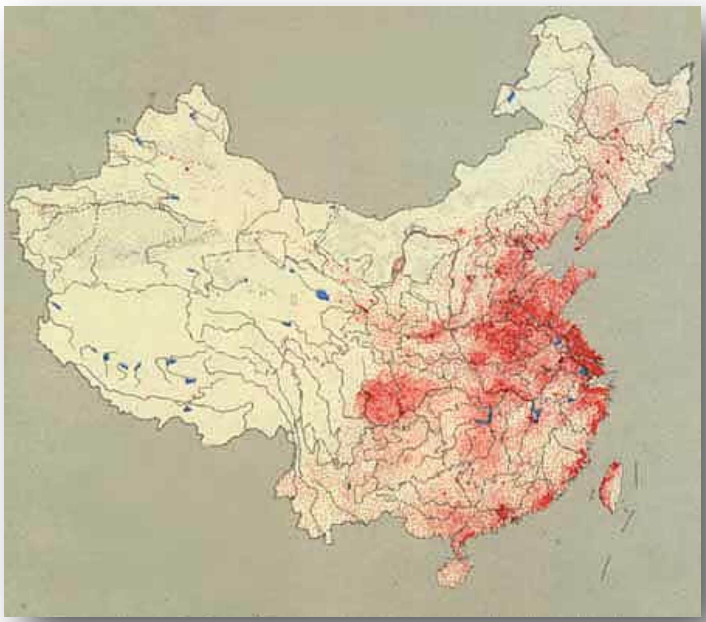
From Energy-for-Water to Energy-from-Water



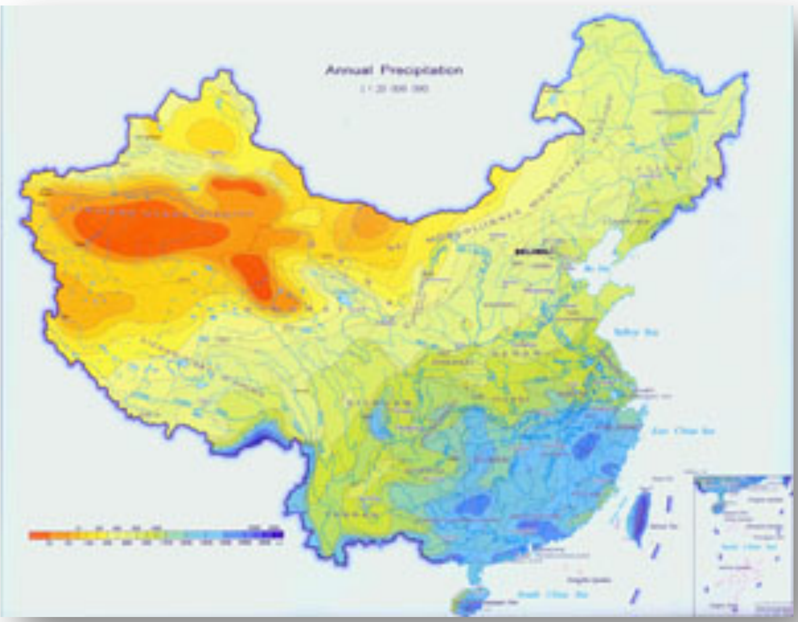
Connecting the Dots
April 16, 2012

Craig Criddle, ReNUWIt NSF Engineering Research Center, Woods Institute for the Environment, Civil and Environmental Engineering, Stanford University

Many people live where there is little freshwater.

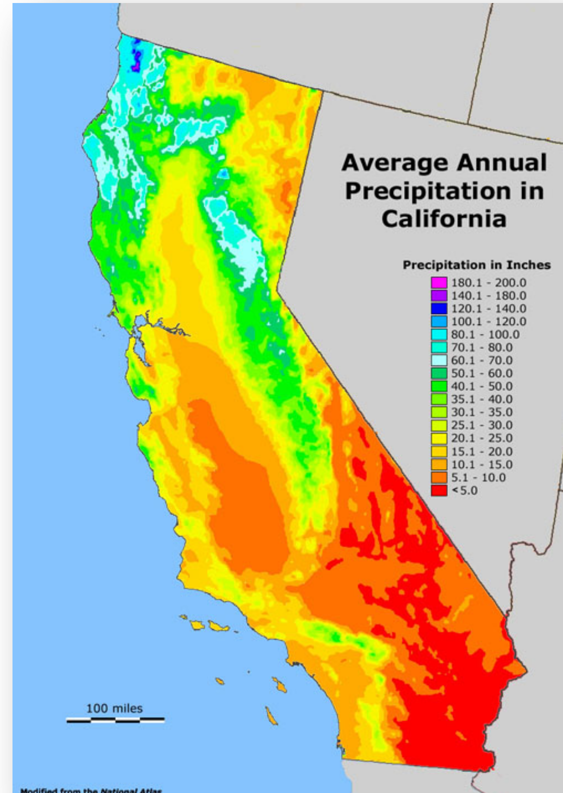


Population Density



Annual Precipitation

Population Density



Annual Precipitation

The Past: move the water to where it is needed, often at high energy cost

From Northern California to Southern California

>2 kWh/m^3

12 billion m^3/year

From Southern China to Northern China

45 billion m^3/year

Can we do better?

Local generation of clean water

- *Freshwater from seawater*
- *Freshwater from wastewater*

Wastewater has significant advantages.

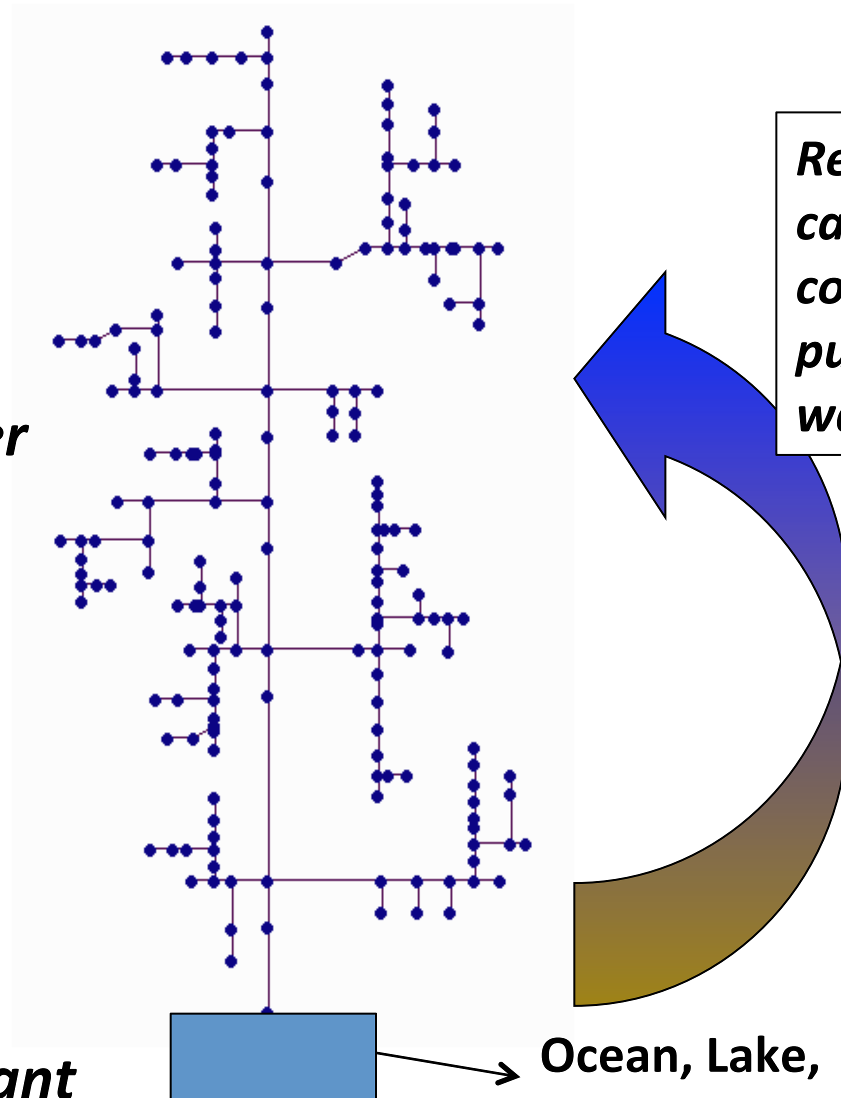
Seawater desalination has high energy requirement: similar to transporting water from Northern California to Southern Caifornia, >2 kW-h/m^3

Treated wastewater is almost fresh.

Many uses of treated wastewater do not require desalination. It is often enough to remove organics and pathogens. Its further desalination requires ~0.4 kW-h/m³

A challenge of treated wastewater is delivery to customers.

Wastewater collection system

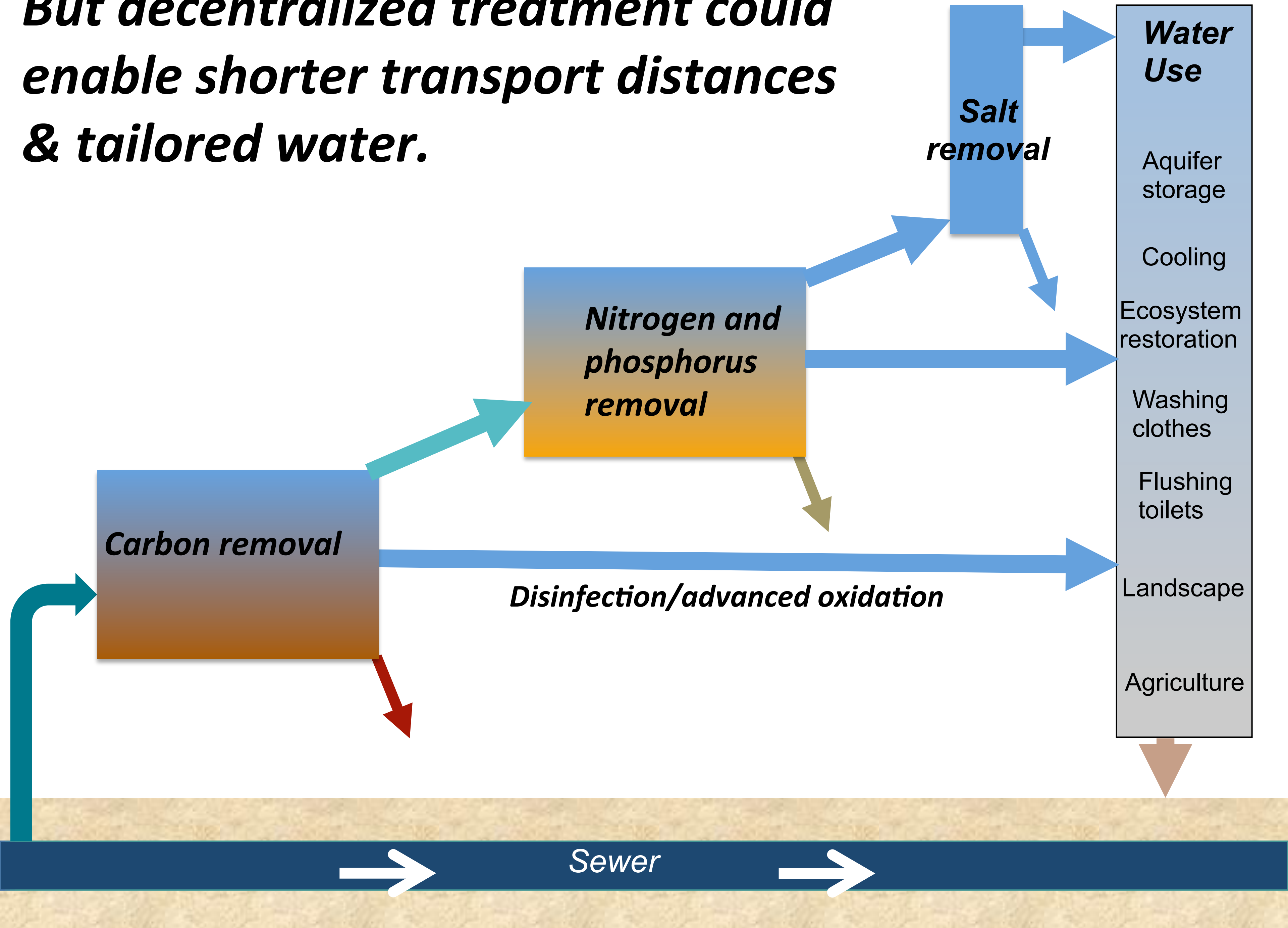


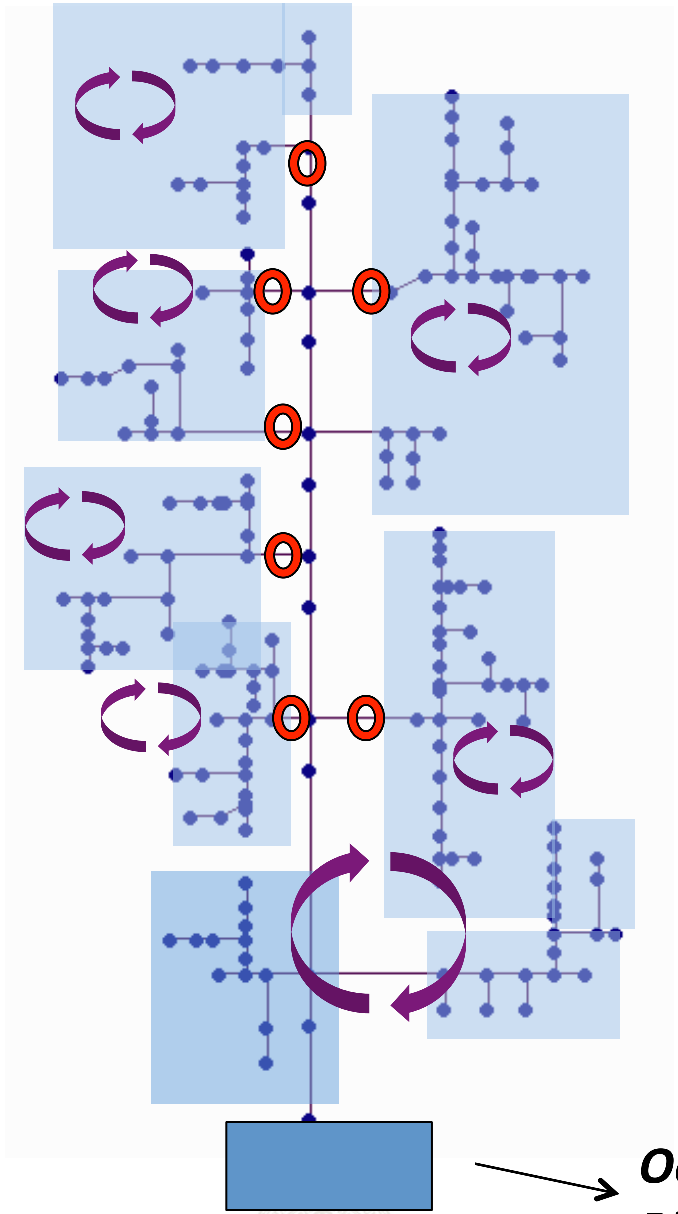
Centralized treatment plant

Ocean, Lake, River

Recycle distances can be long so costs for pipe and pumping of reused water can be high

But decentralized treatment could enable shorter transport distances & tailored water.



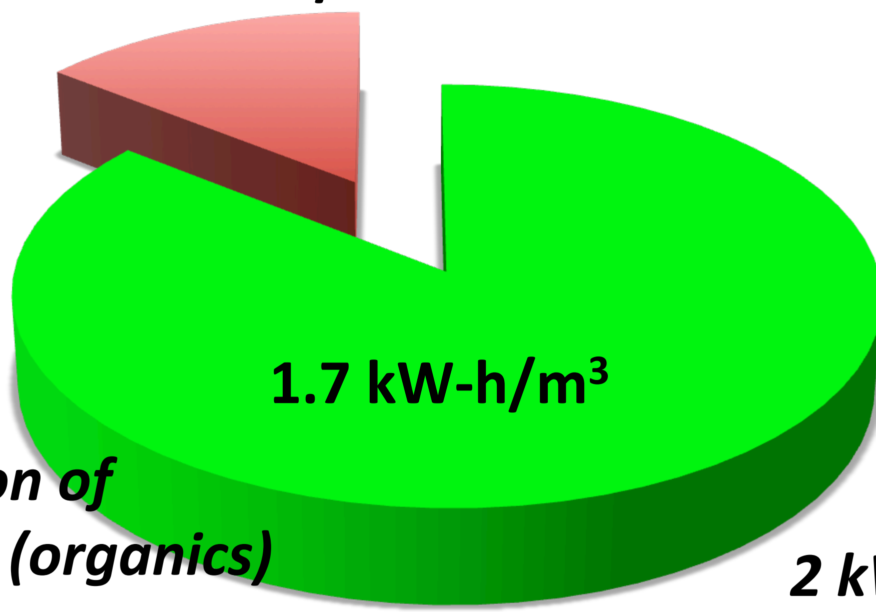


Decentralized treatment systems

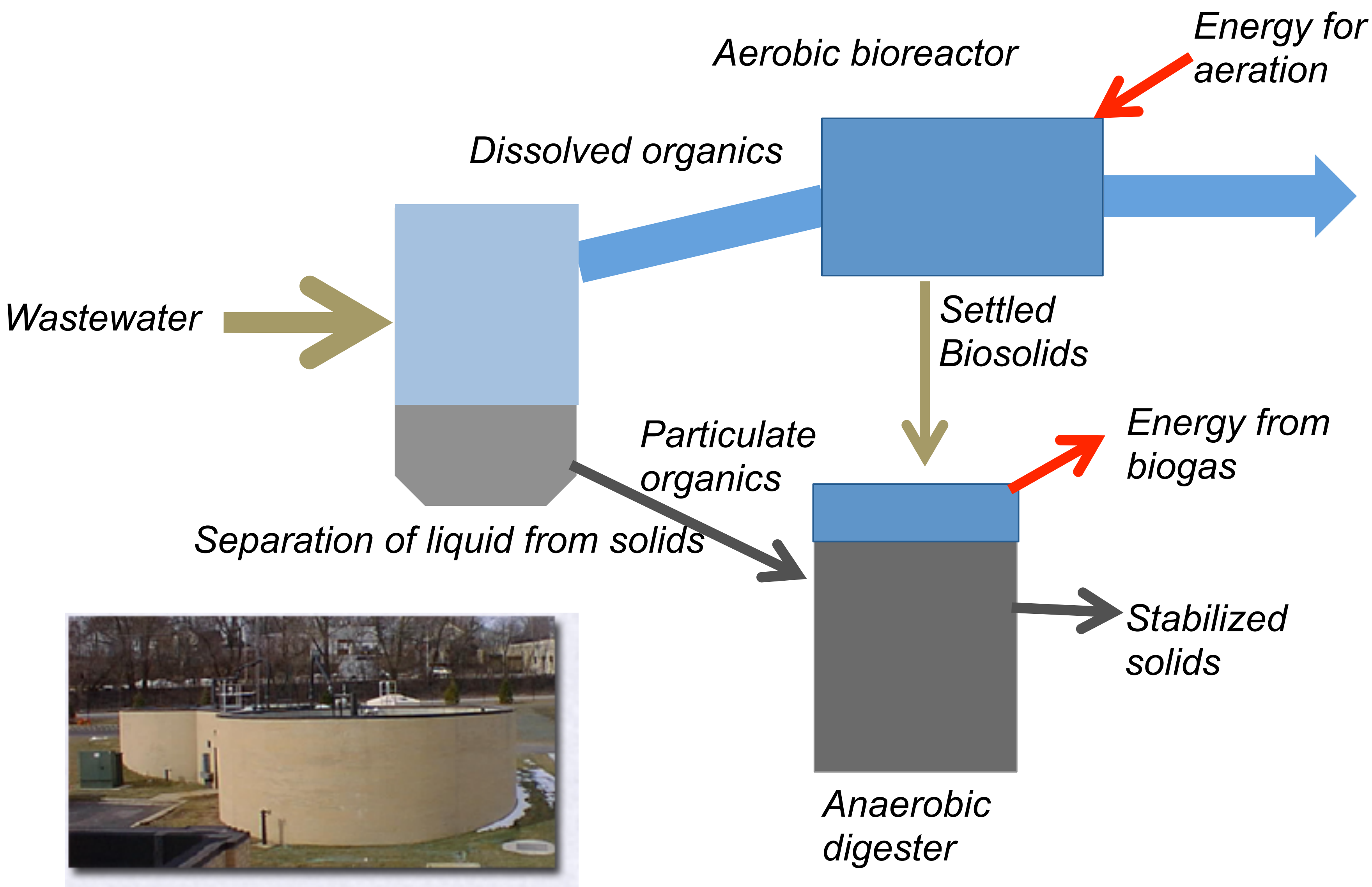
Centralized treatment plant

Ocean, Lake, River

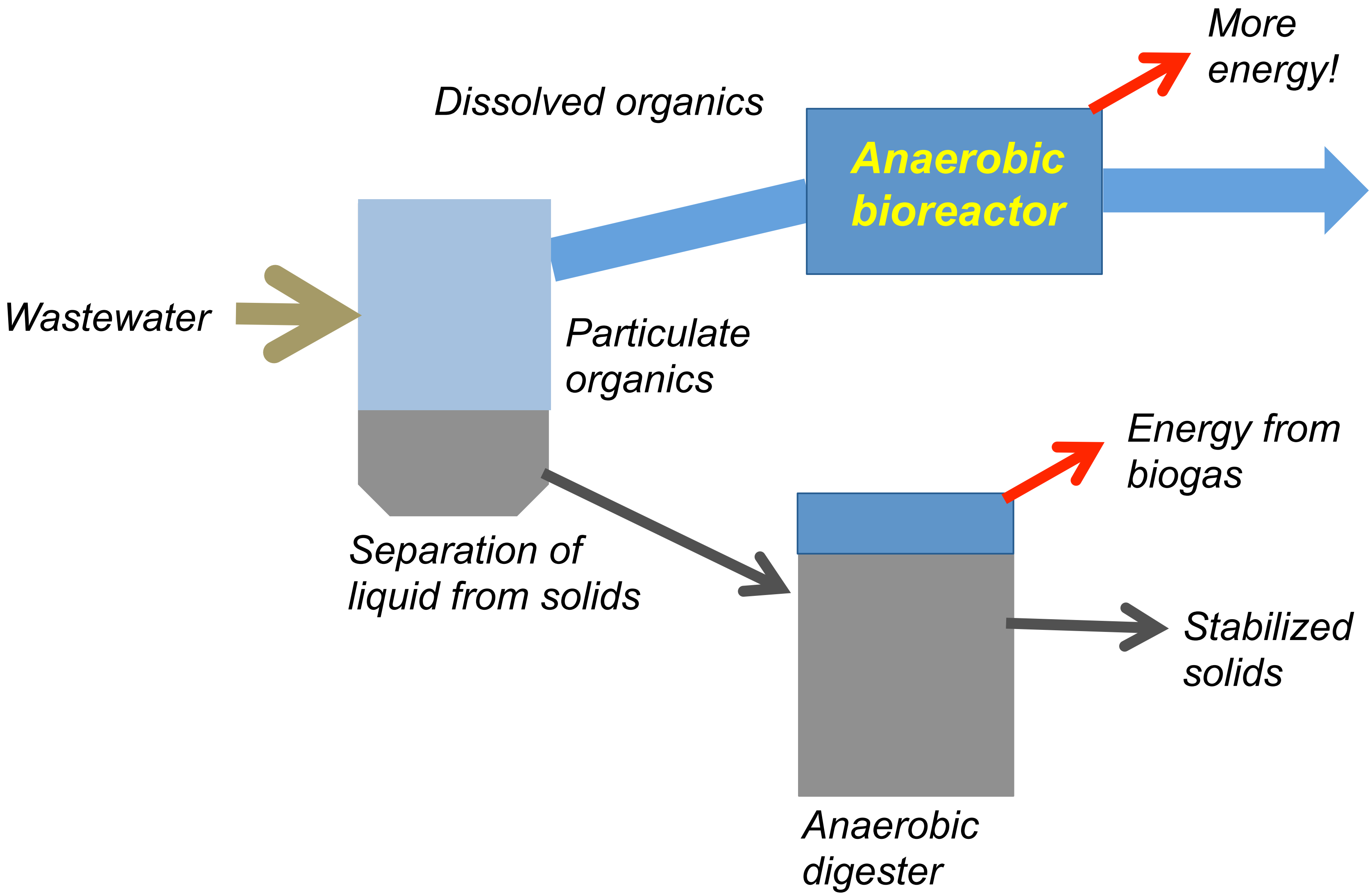
Wastewater contains renewable energy present as organic matter and nitrogen



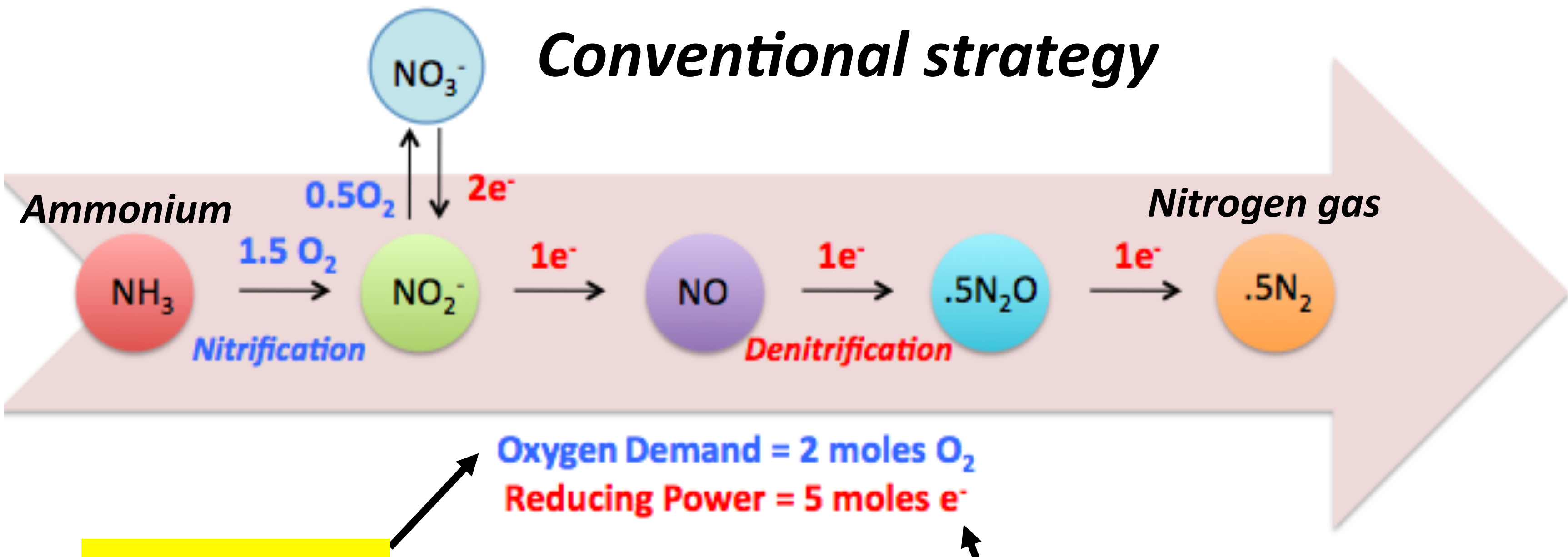
But current treatment typically <u>requires</u> ~0.6 kWh/m^3. About half the energy demand is for aeration.



Future treatment could virtually eliminate aeration



Conventional strategies for nitrogen removal from wastewater consume significant energy.



Power is required to deliver oxygen.

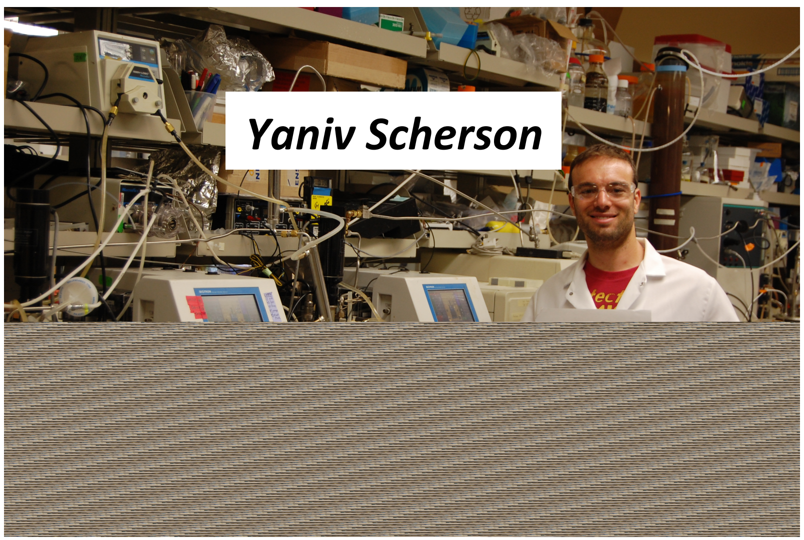
These electrons could have been used to make methane.

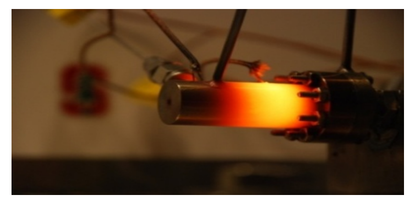
CANDO: Coupled Aerobic-anoxic Nitrous Decomposition

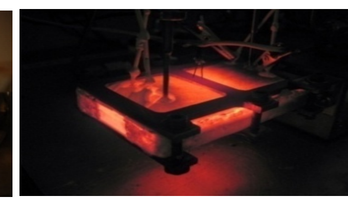
Hot air!

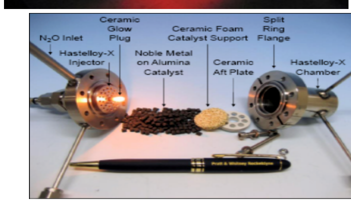
New

Ammonia → Nitrite → N_2O → N_2 ½O_2 82kJ









A few insights

1. Get out ahead
2. Deadlines are critical
3. Cope with uncertainty
4. Tradeoffs (and trades) abound

Sometimes pigs *DO* fly!

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Thank You!

TomKatCenter FOR SUSTAINABLE ENERGY STANFORD UNIVERSITY

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Stanford Woods Institute for the Environment

sdgc STANFORD

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FSE STANFORD | CENTER ON FOOD SECURITY AND THE ENVIRONMENT

ReNUWit: The Urban Water Engineering Research Center

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