



IDEA2017

Sustaining
Our Success

108TH ANNUAL CONFERENCE & TRADE SHOW
June 26-29 | Fairmont Scottsdale Princess | Scottsdale, AZ

Energy - Water - Cooling Nexus for Arid Regions

Presented By:

Henry W. Johnstone, P.E.

**President and Director of Mechanical
Engineering**

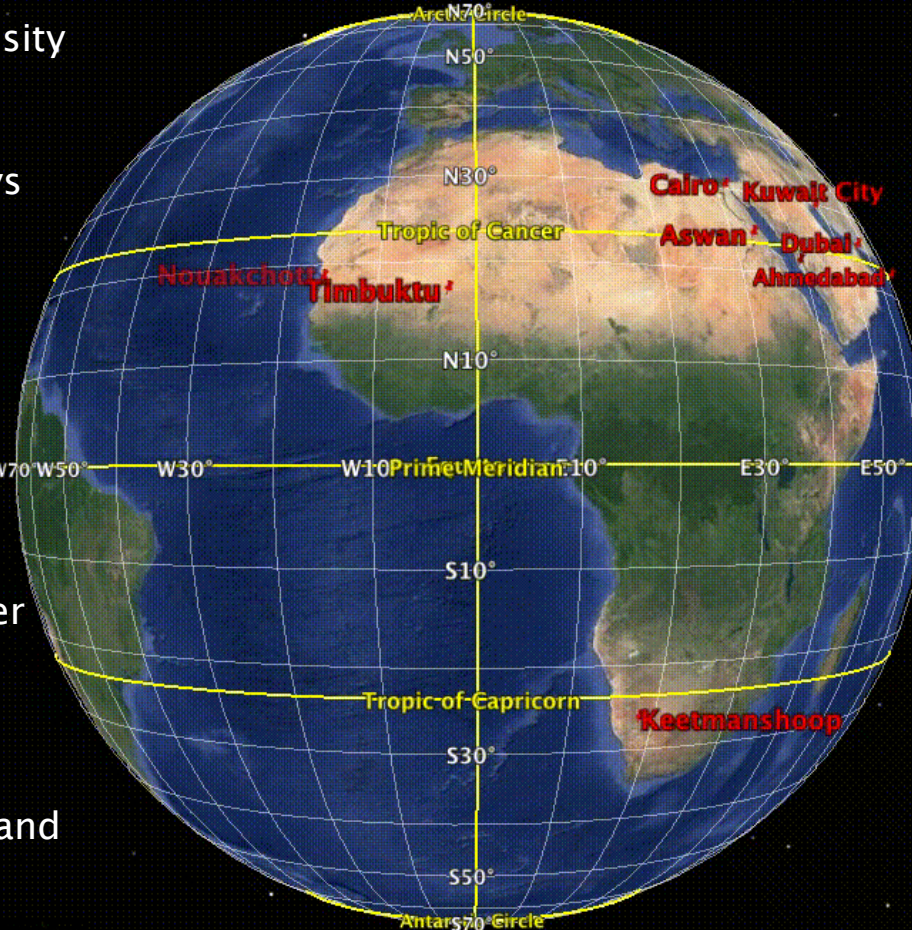
GLHN Architects & Engineers, Inc.



Energy – Water - Air Conditioning Nexus

High Density Urban Mixed Use

- Magnitude and density of population
- Cooling degree days
- Altitude
- Enthalpy of Air
- Source: availability of electric power
- Source: cost and availability of water
- Waste water infrastructure
- Building efficiency and standards



Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Image IBCAO

Google Earth

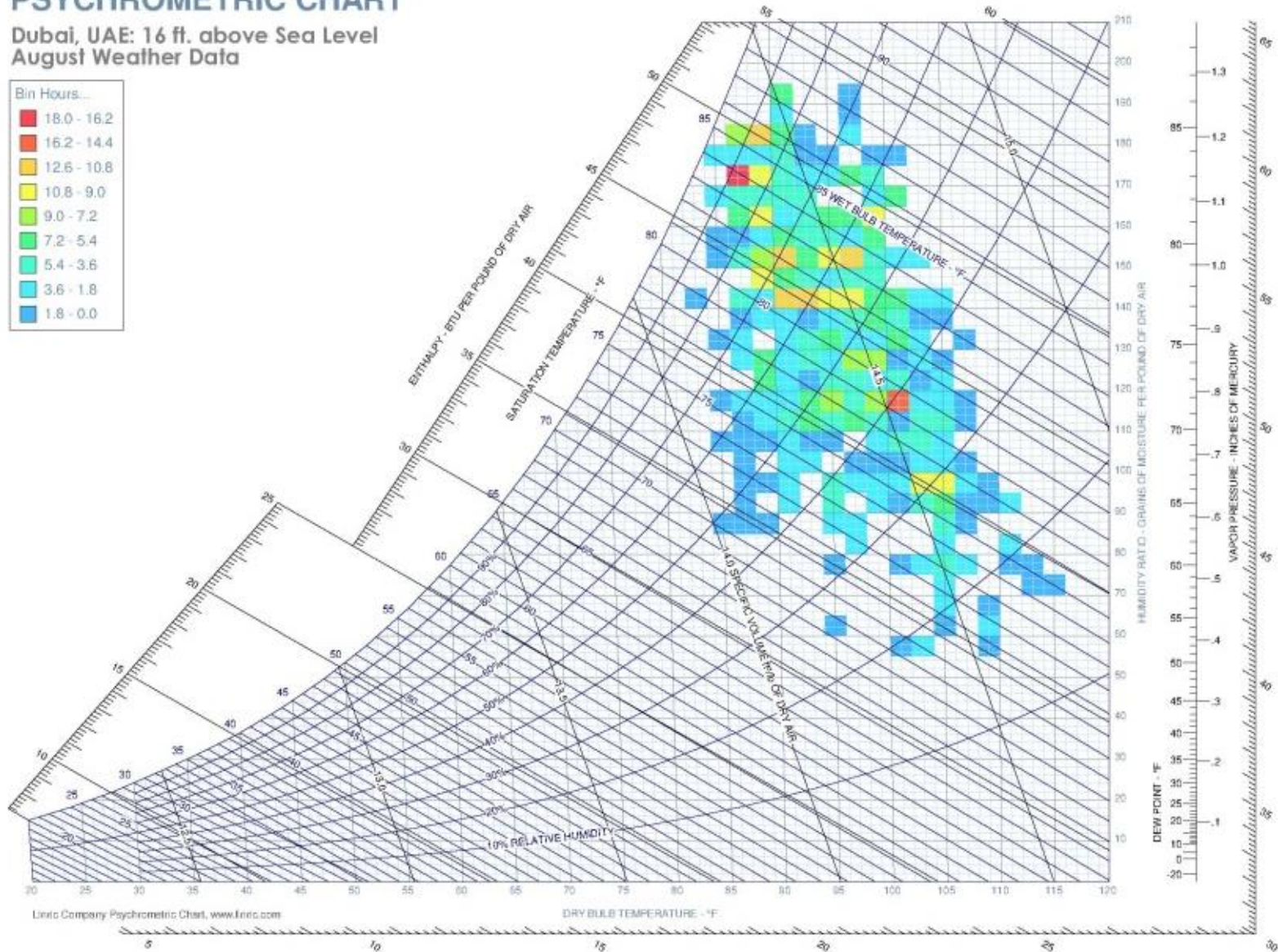
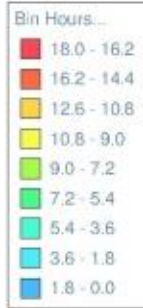
Dubai



Air Conditioning

PSYCHROMETRIC CHART

Dubai, UAE: 16 ft. above Sea Level
August Weather Data

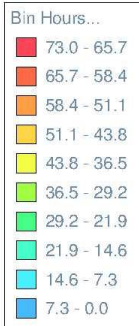


Air Conditioning

GLHN

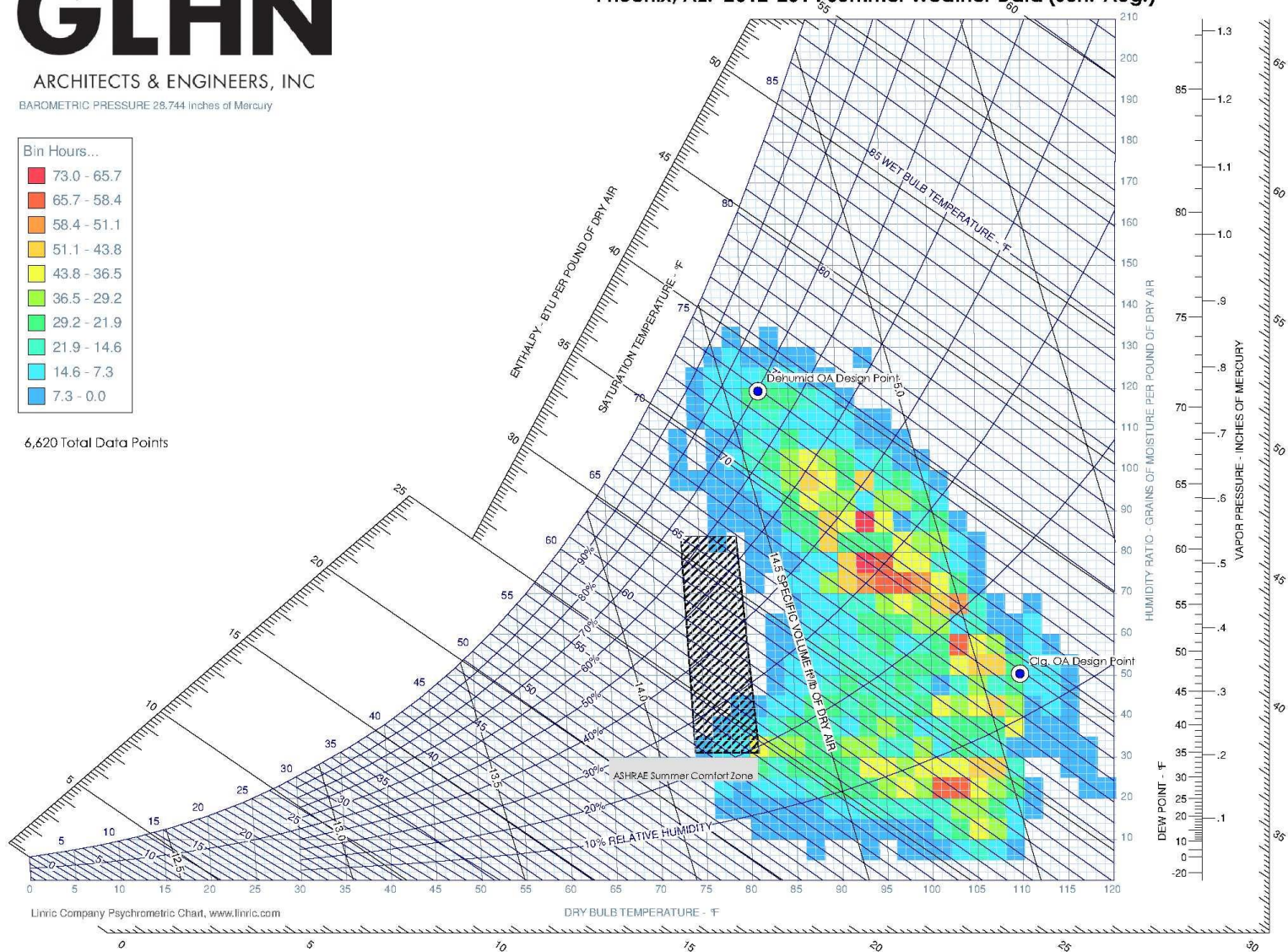
ARCHITECTS & ENGINEERS, INC

BAROMETRIC PRESSURE 29.944 inches of Mercury

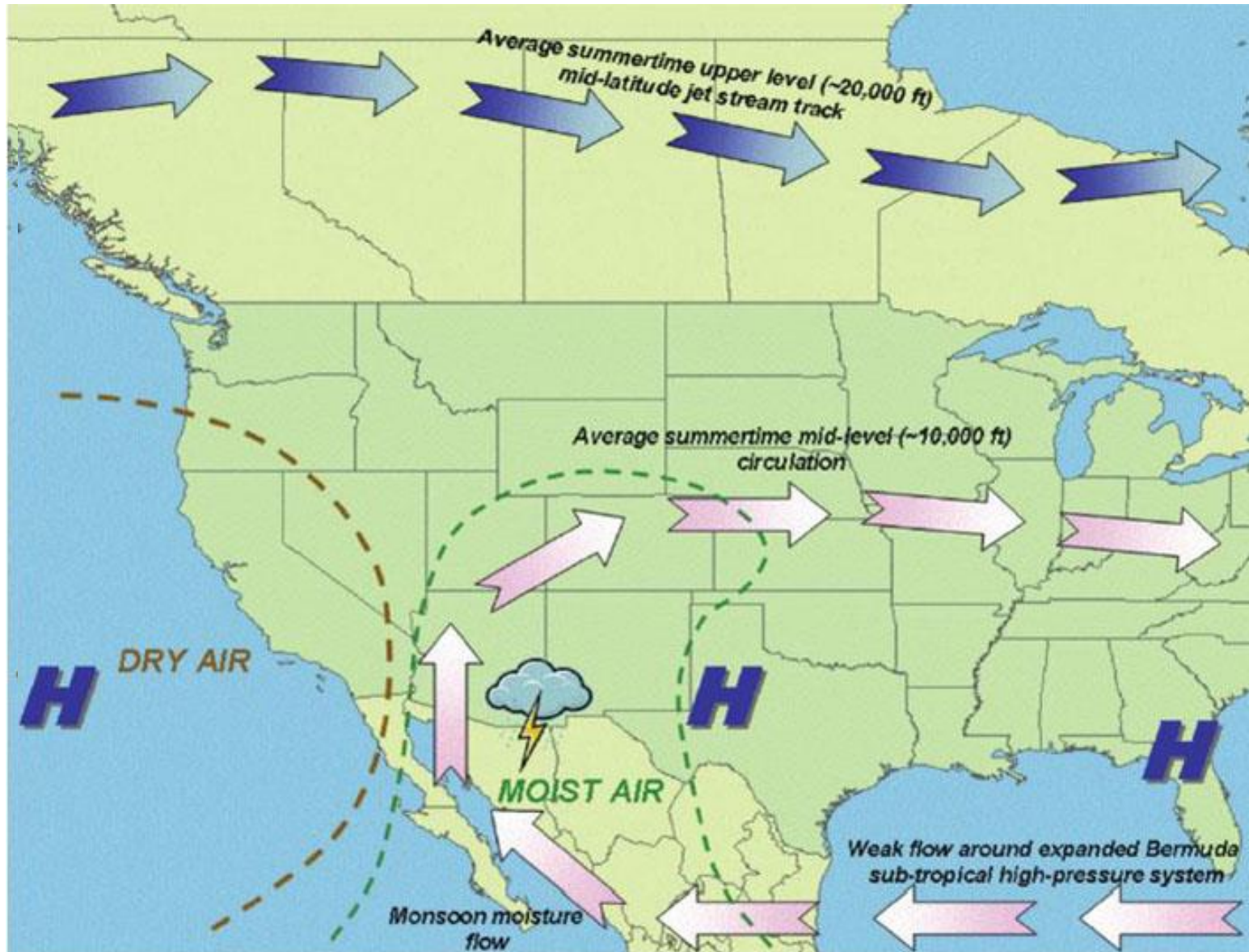


6,620 Total Data Points

Phoenix, AZ: 2012-2014 Summer Weather Data (Jun.-Aug.)

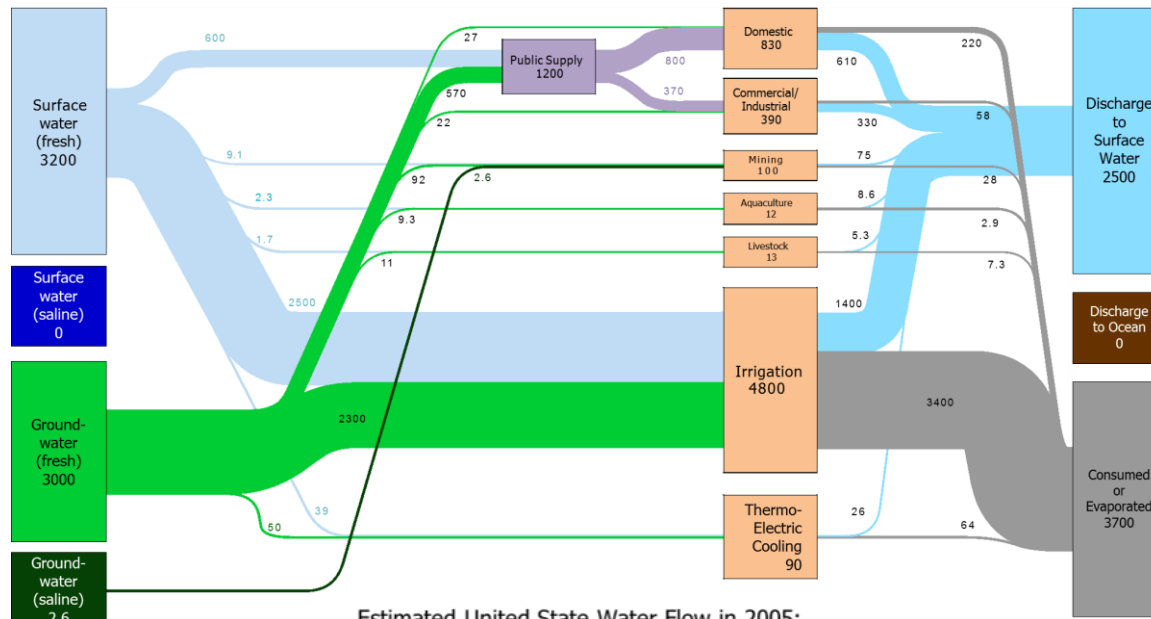


Southern Arizona Case Study

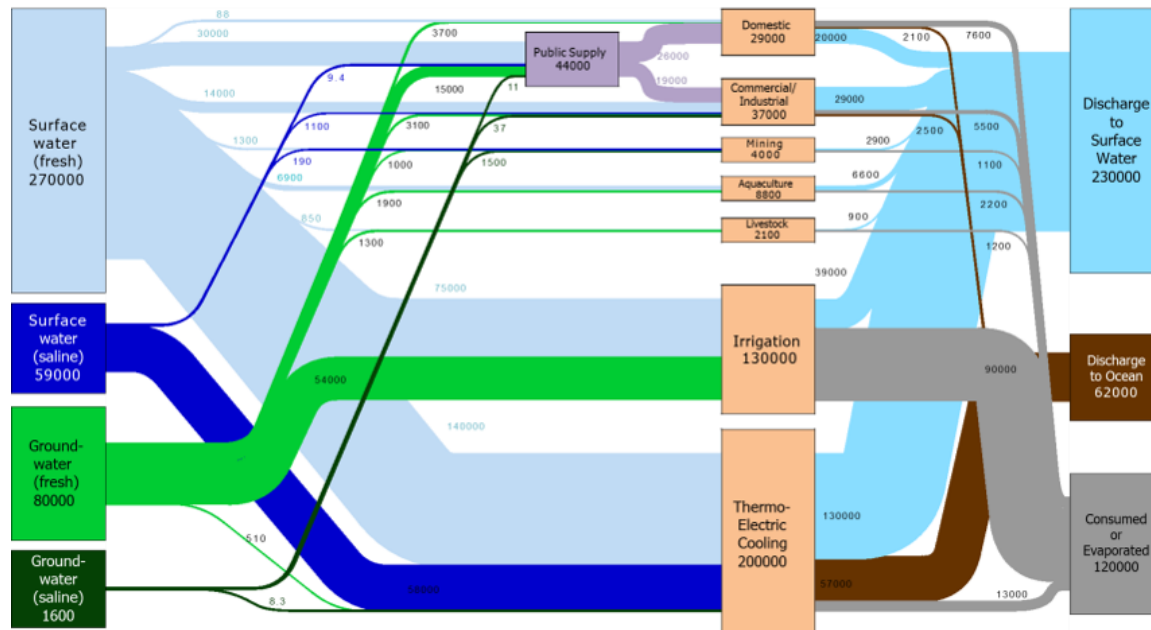


Source: Arizona Public Service, University of Arizona College of Agriculture and Life Sciences

Estimated Arizona Water Flow in 2005:
6200 Million Gallons/Day



Estimated United State Water Flow in 2005:
410000 Million Gallons/Day



Source: Lawrence Livermore National Laboratory

Water In Energy

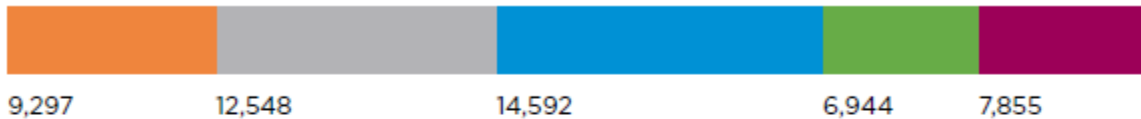
HOW THE PORTFOLIO MAY CHANGE

COMPOSITION OF ENERGY MIX BY RESOURCE (GWH)

2014



2029



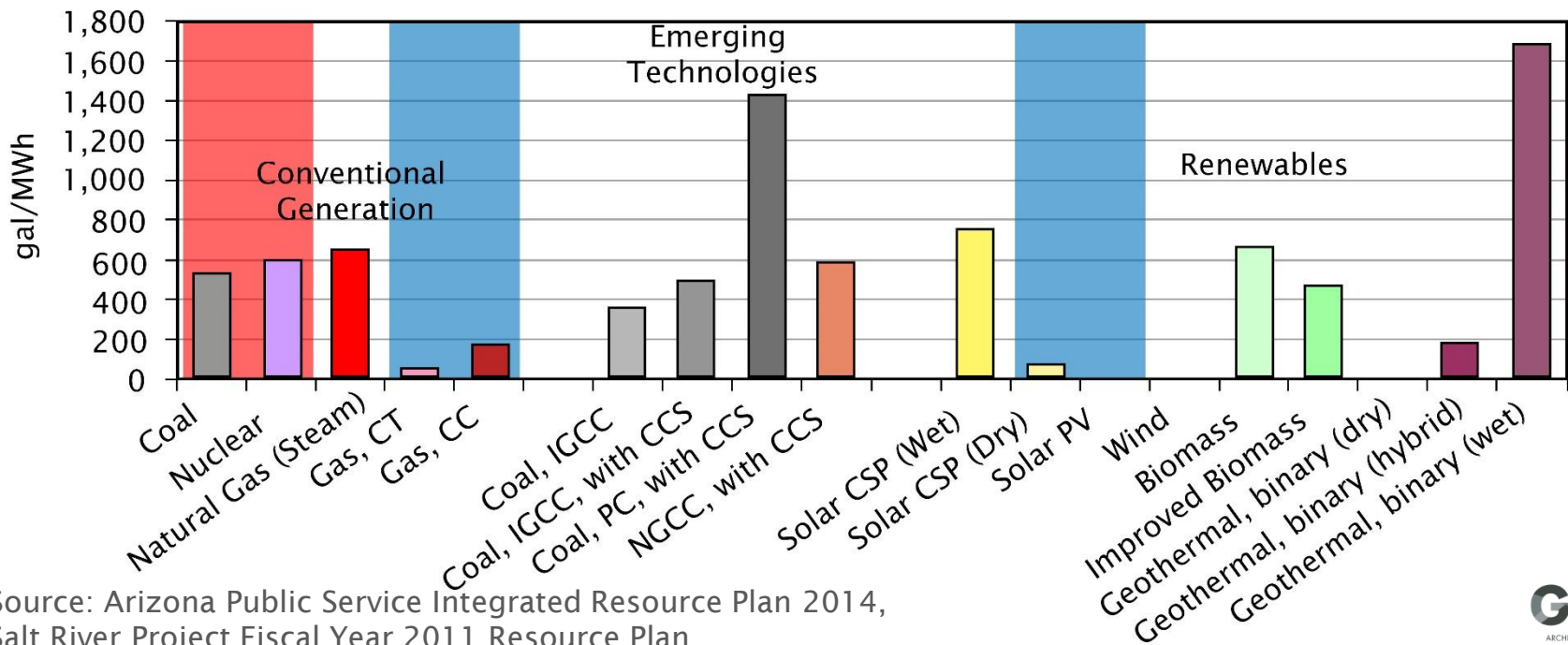
■ Nuclear
 ■ Coal
 ■ Natural Gas
 ■ Renewable Energy
 ■ Energy Efficiency

Figure ES-2 - 2014 vs. 2029 Energy Mix

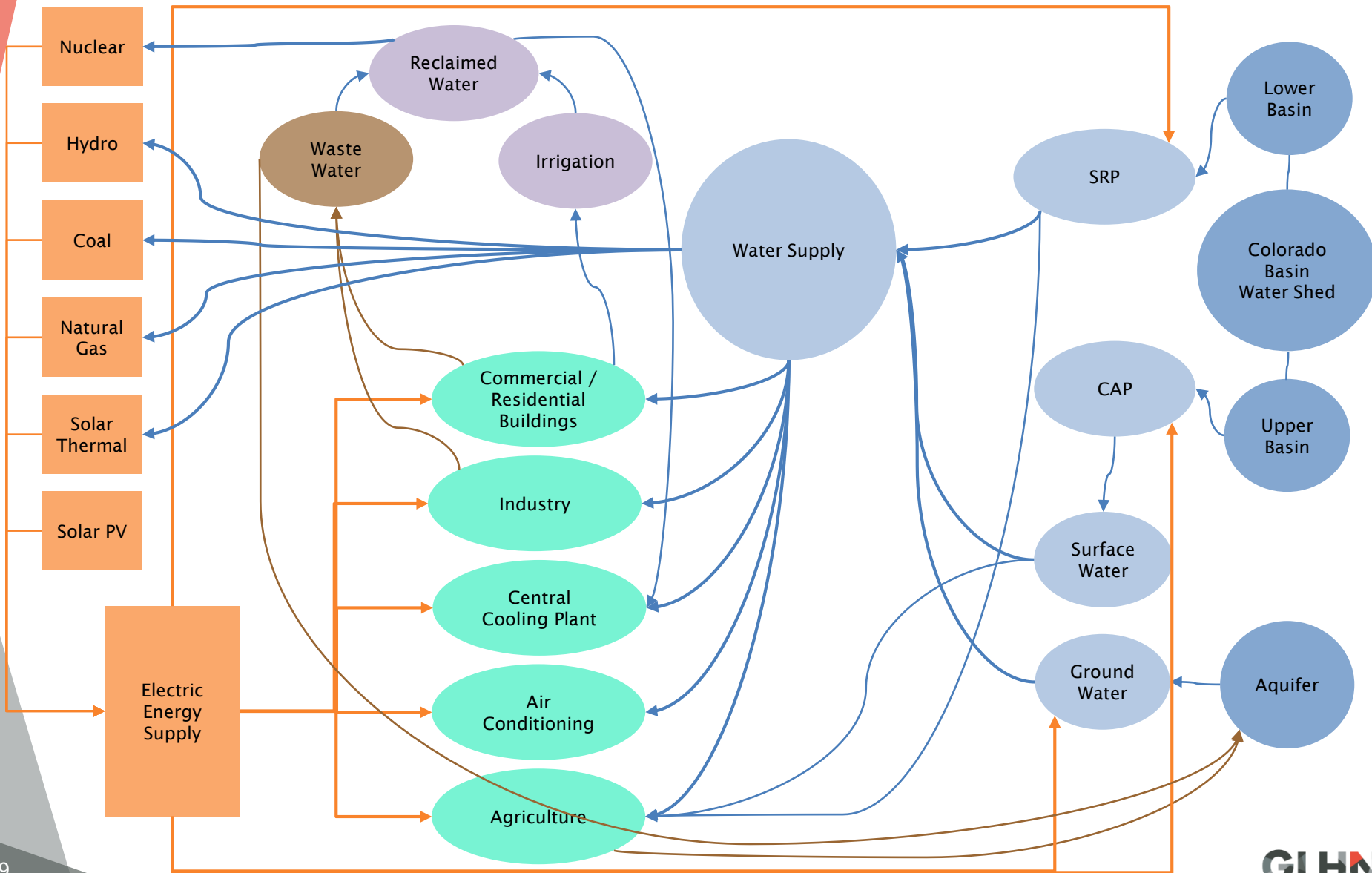
Improves Environmental Performance:

- CO2 Intensity ▼ 14%
- Water Intensity ▼ 24%

Water Intensity of Electricity Generation

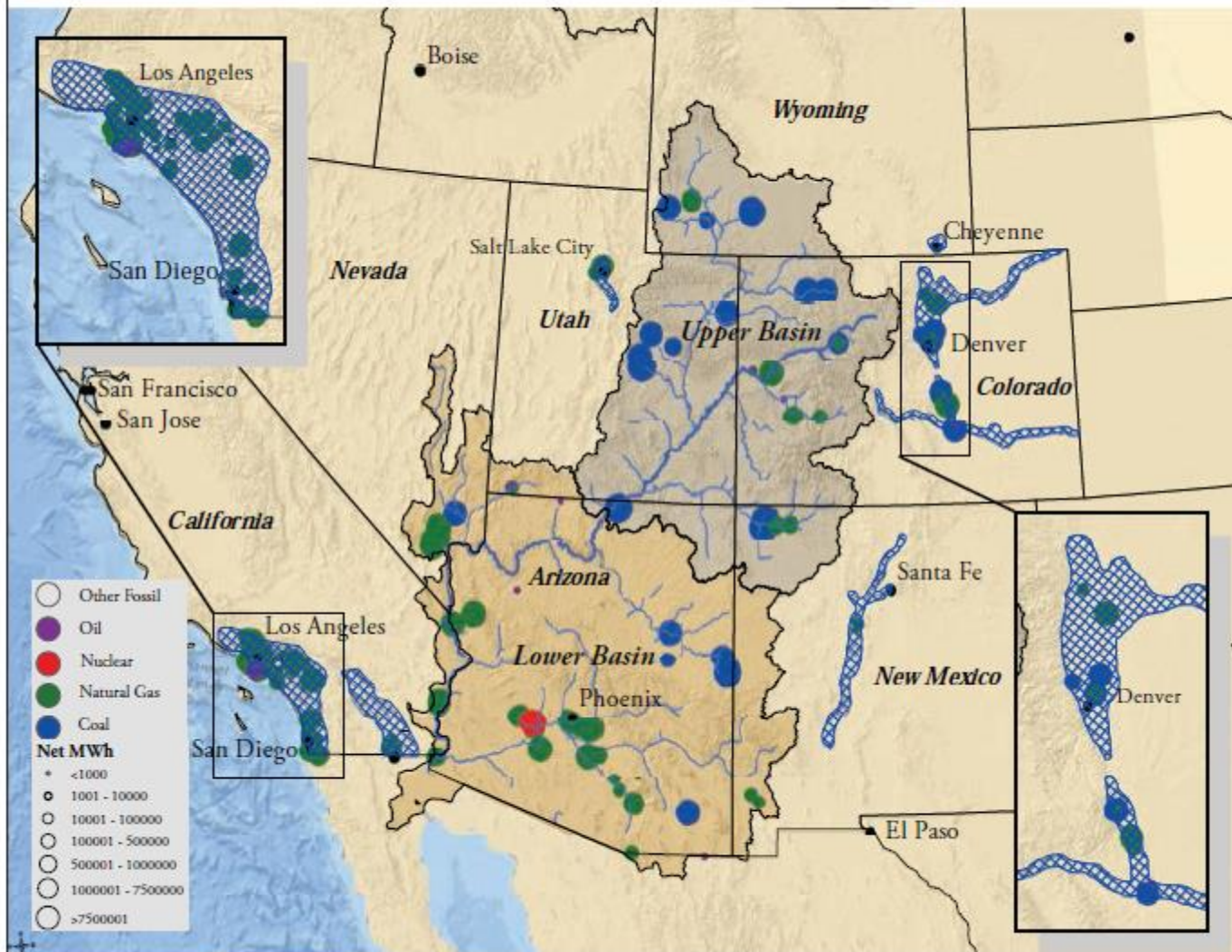


Energy – Water - Air Conditioning Nexus



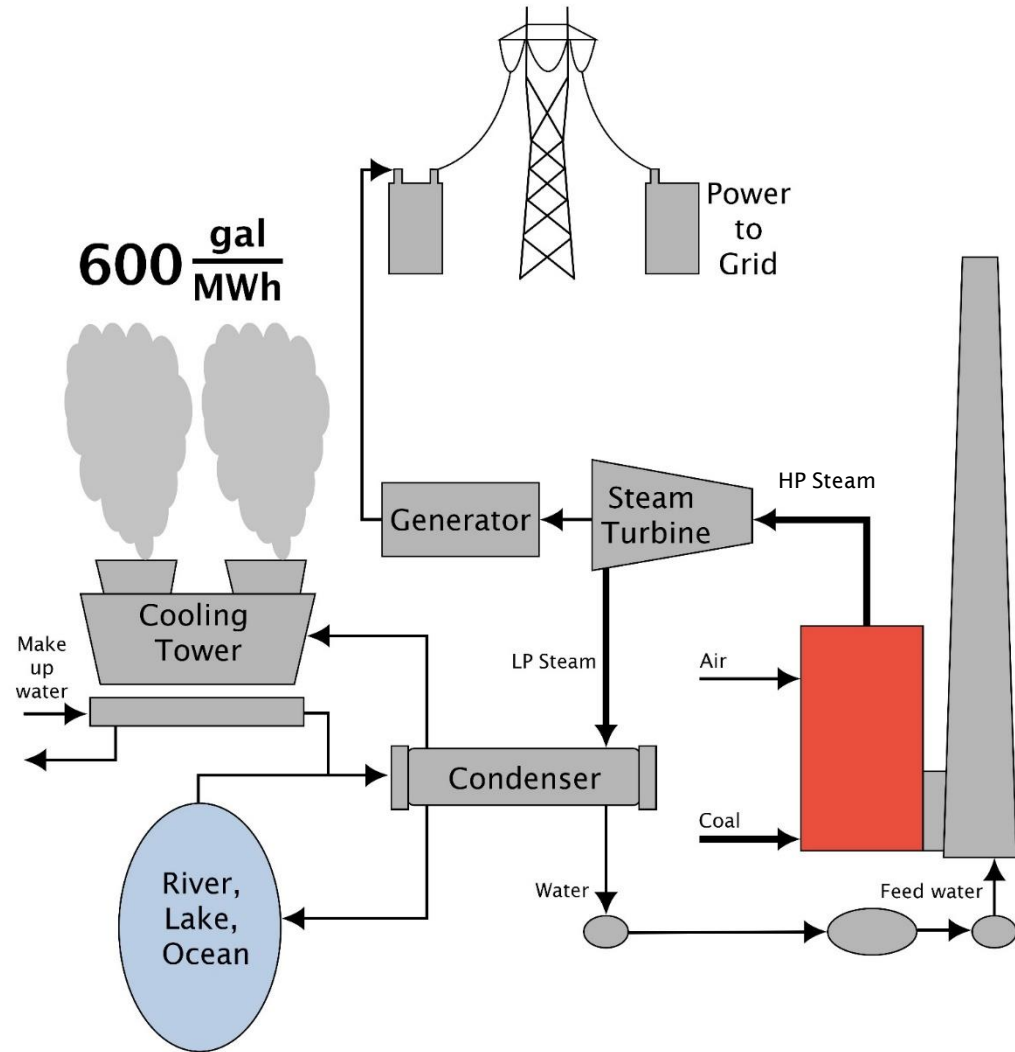
Nonrenewable Energy Generation

Figure 3: Nonrenewable Power Plants by Fuel Type in the Basin



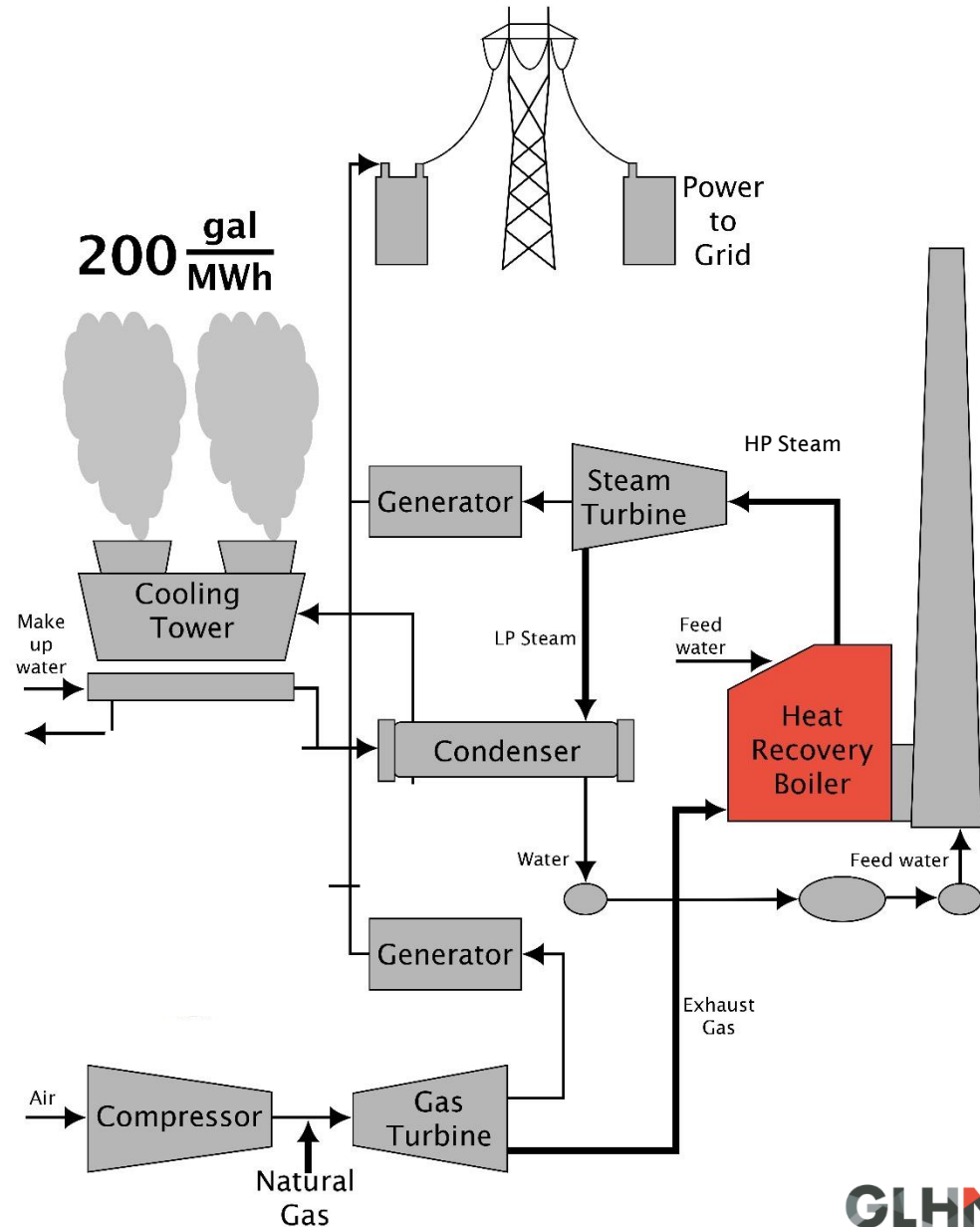
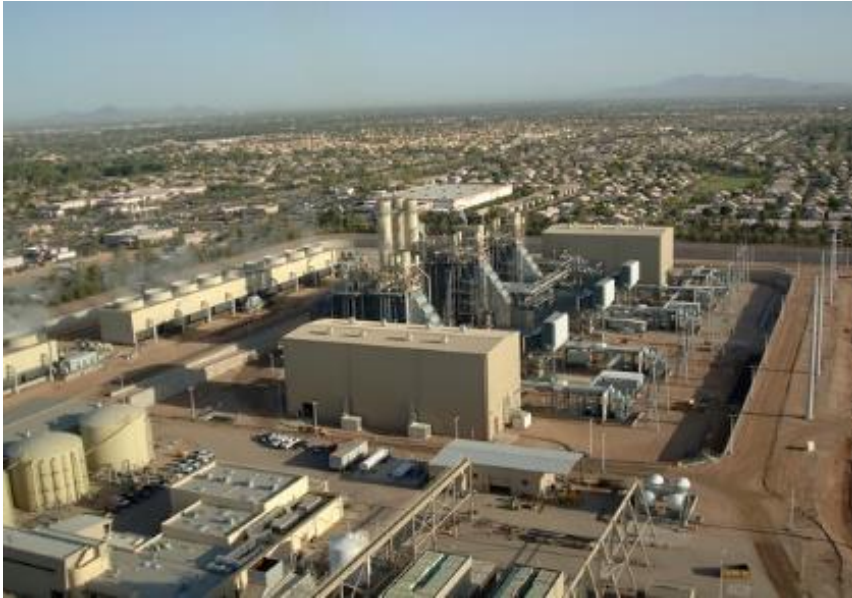
Source: United States Environmental Protection Agency. eGrid Survey. Year 2009 eGRID2012 Boiler, Generator, Plant, State, PCA, eGRID Subregion, NERC Region, U.S., and Grid Gross Loss (%) Data Files. eGRID plant year 2009 data (4/27/12). 2012.

Water in Energy Generation: Coal Fired Steam Cycle



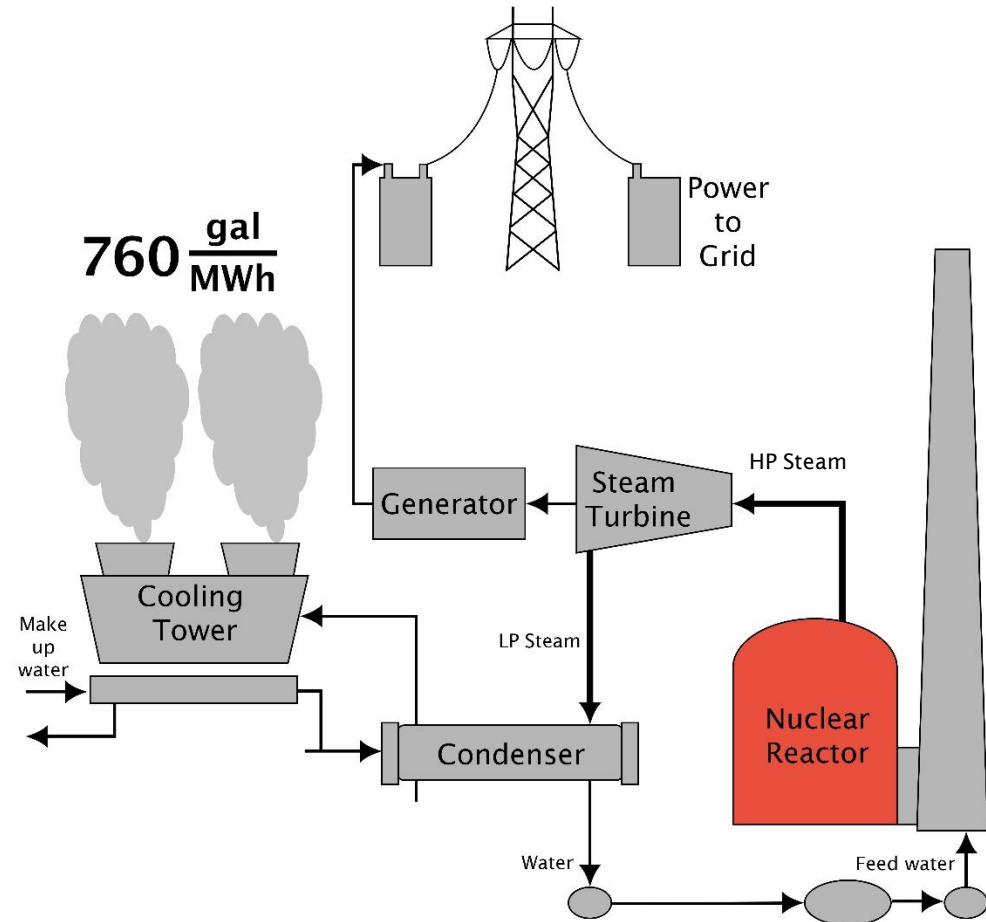
Source: Navajo Generating Station, Wikimedia Commons

Water in Energy Generation: Combined Cycle Gas Turbine



Source: Santan Power Plant Expansion, Salt River Project (SRP)

Water in Renewable Energy Generation: Nuclear



Palo Verde Nuclear Plant

↑ ↑ ↑ Water Reclamation Facility Flow Path



Source: Google Earth, Arizona Public Service

Water in Renewable Energy Generation: Solar

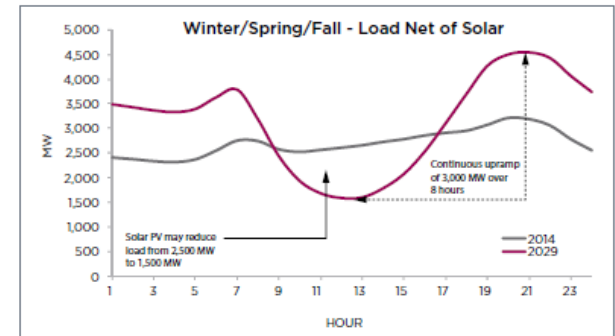


Figure ES-5 - Winter/Spring/Fall - Load Net of Solar

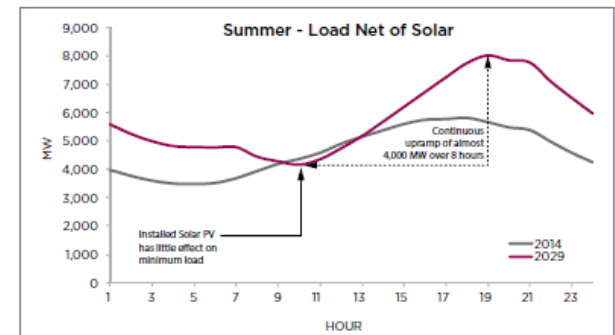


Figure ES-6 - Summer - Load Net of Solar

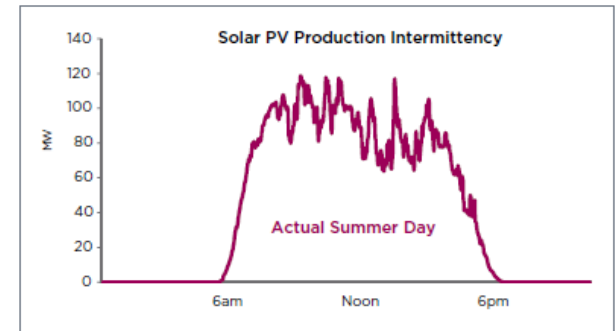


Figure ES-7 - Solar PV Production Intermittency

Source: Arizona Public Service Integrated Resource Plan 2014, Wall Street Journal

Water In Energy Generation

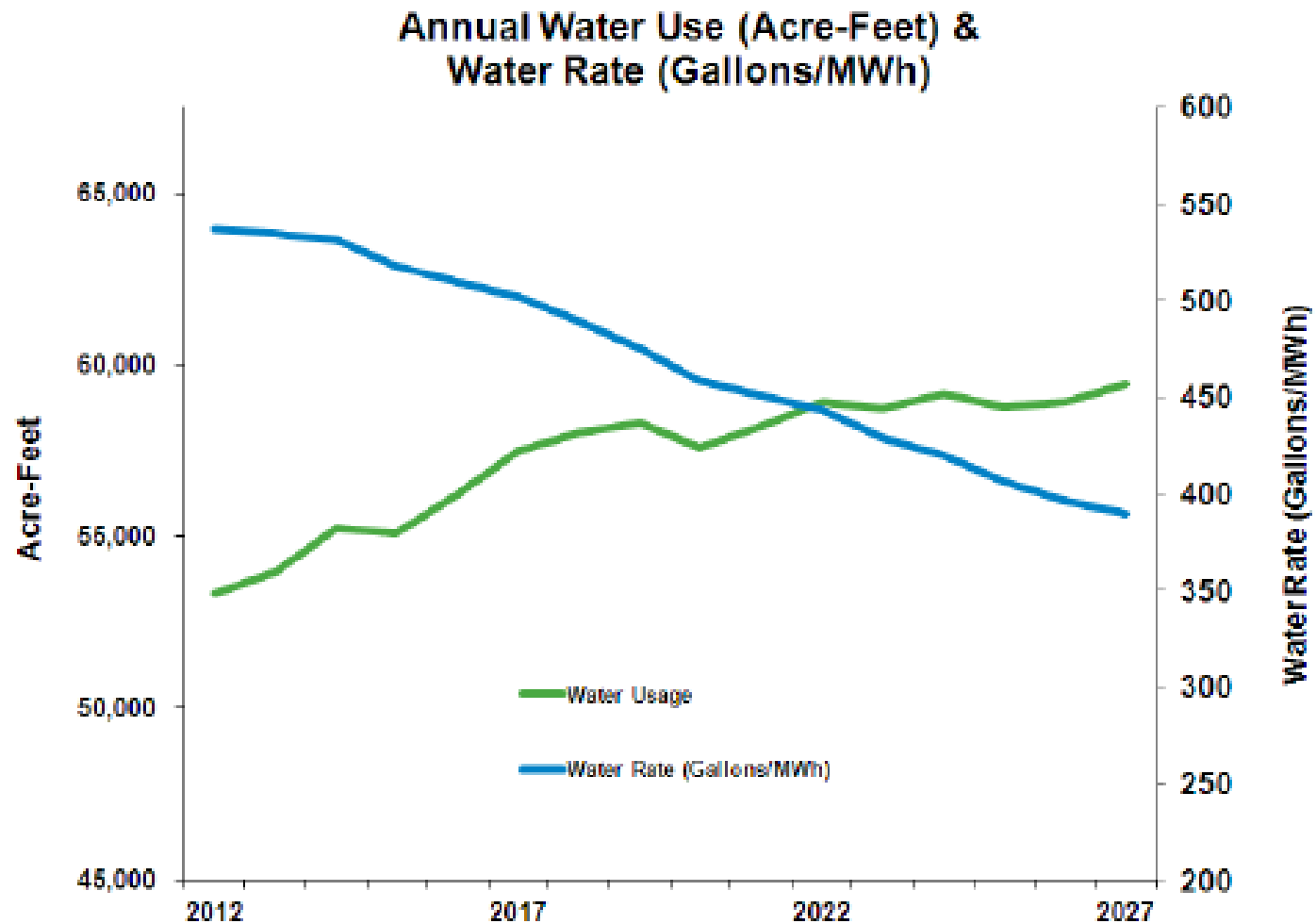
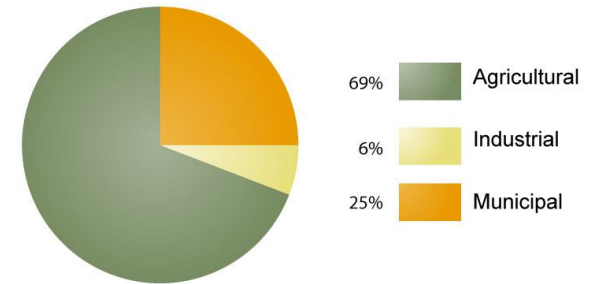


Figure 41 - Forecast of Water Consumption and Intensity

Source: Arizona Public Service Integrated Resource Plan 2012

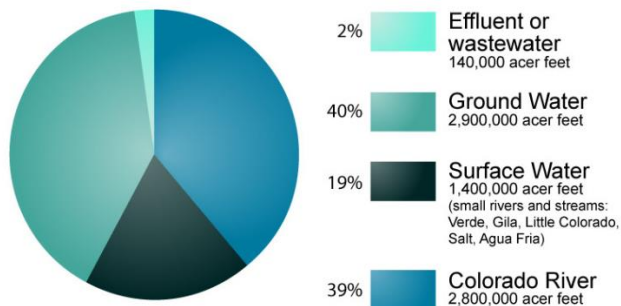
Water

How do we use water?



Values based on Arizona Department of Water Resources
<http://www.azwater.gov/AzDWR/PublicInformationOfficer/documents/supplydemand.pdf>

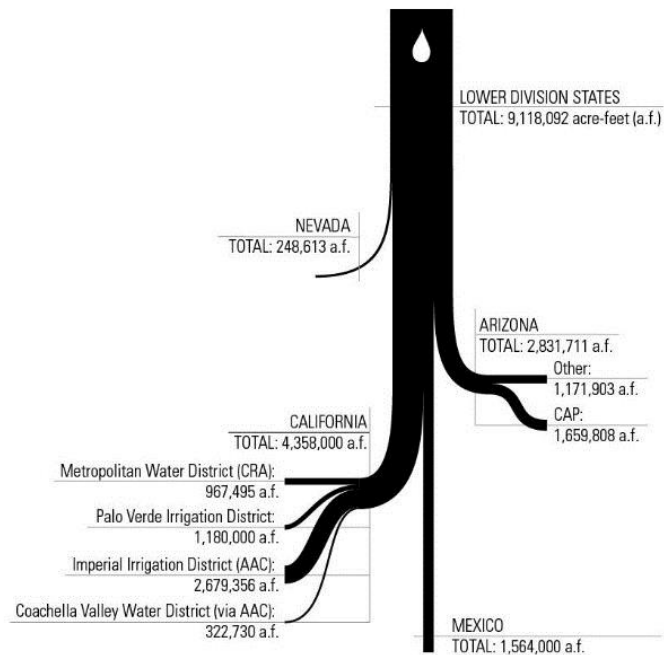
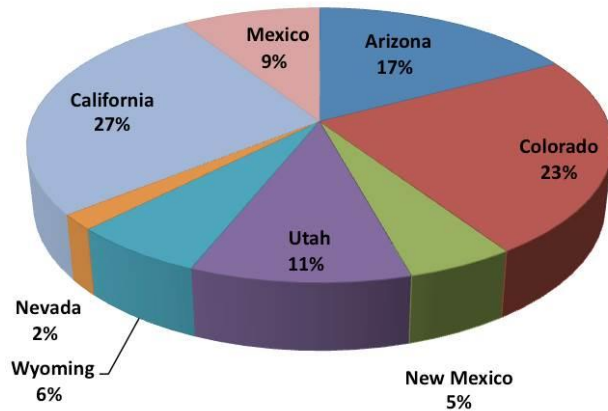
Arizona Water Sources



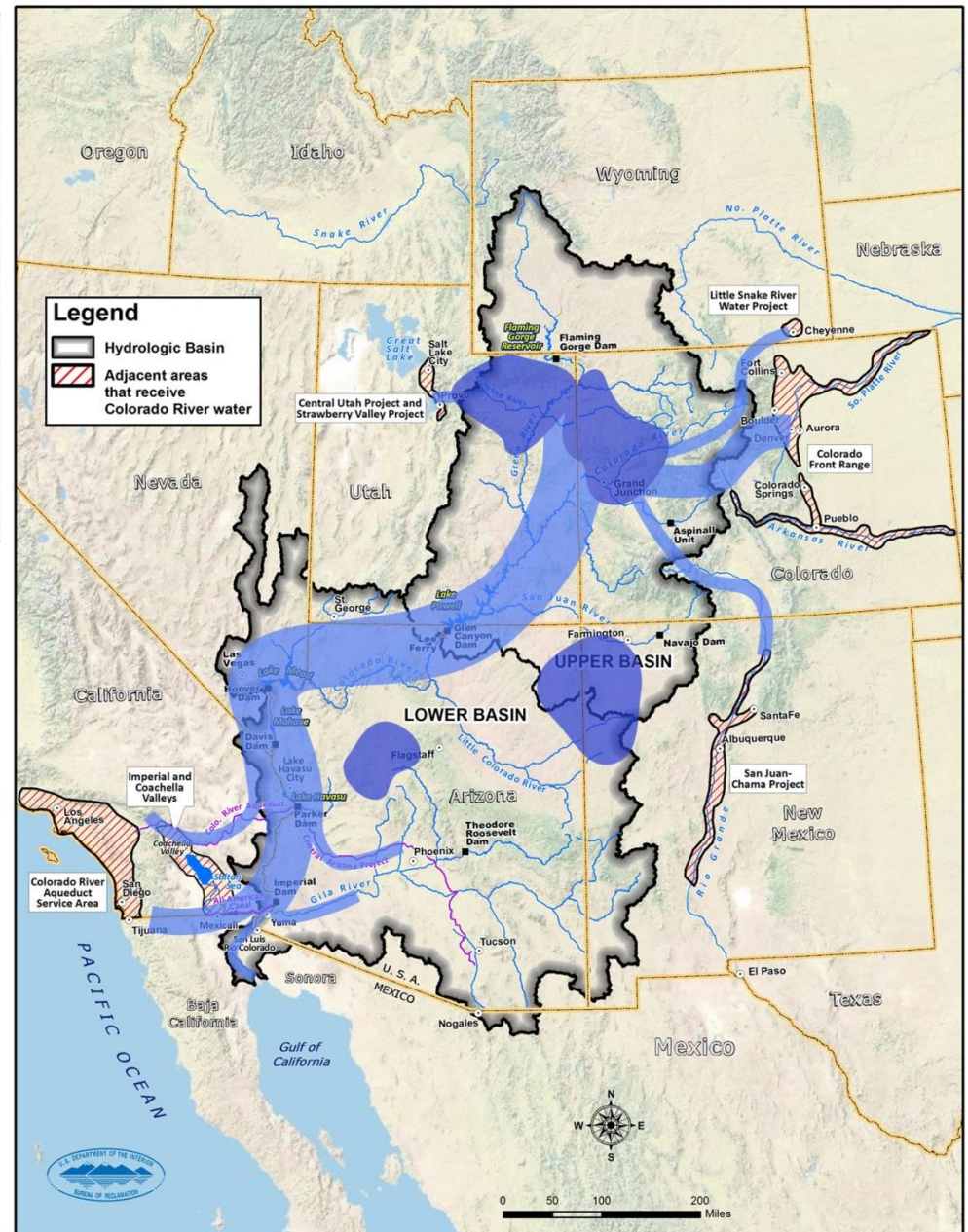
Values based on Arizona Department of Water Resources ABC's of Water
<http://www.azwater.gov/AzDWR/PublicInformationOfficer/ABCofWater.htm>

Water

Colorado River Apportionment

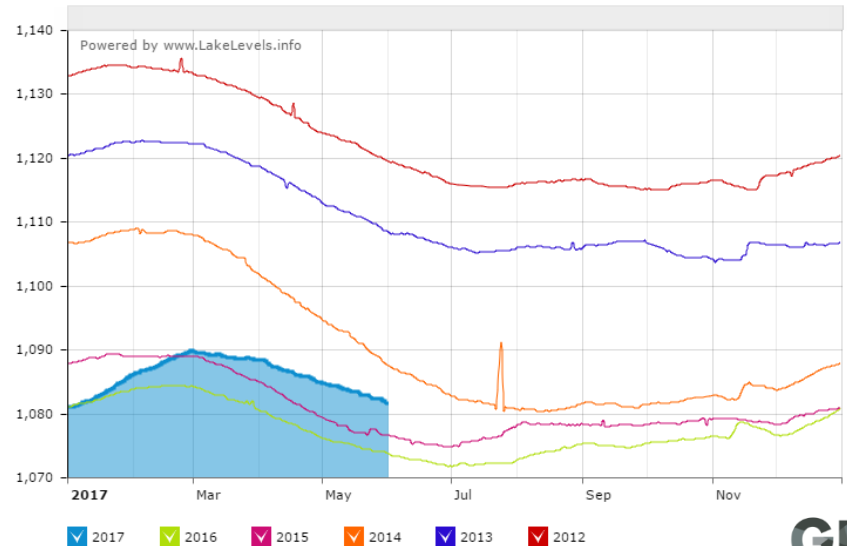


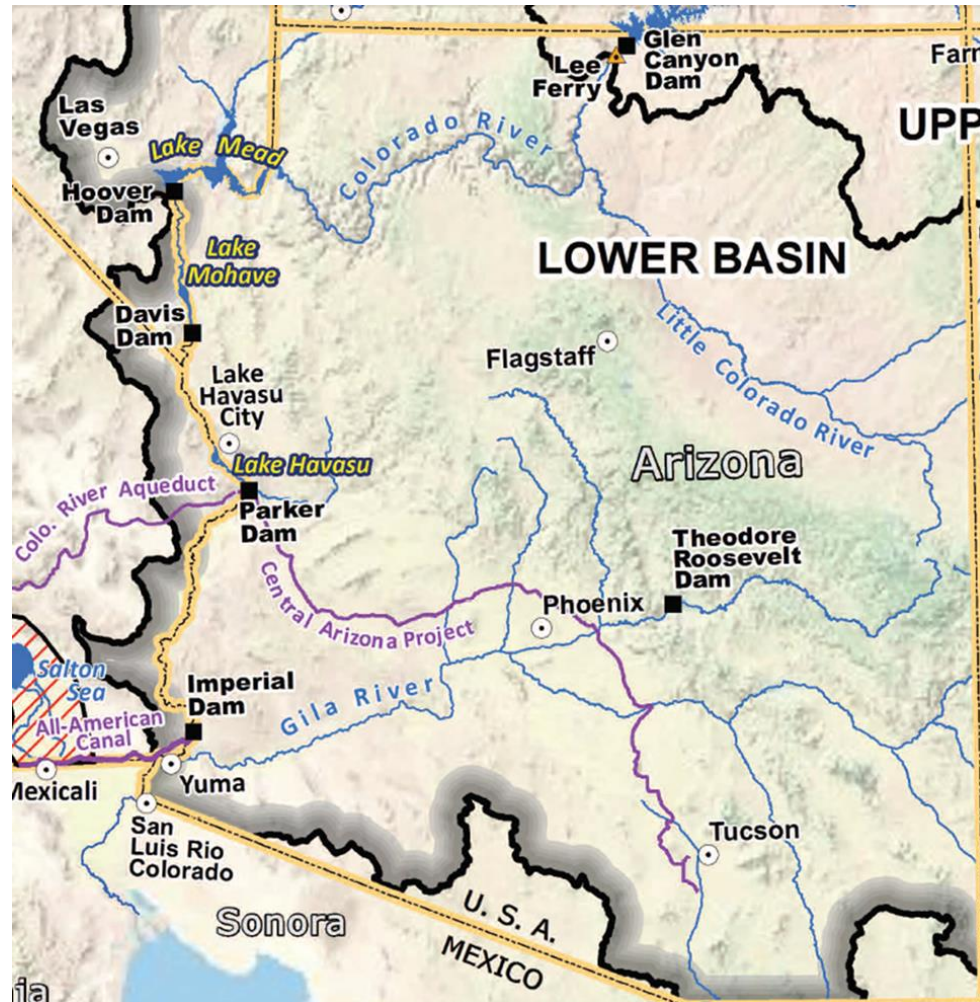
Numbers from the Colorado River Accounting and Water Use Report 2009.



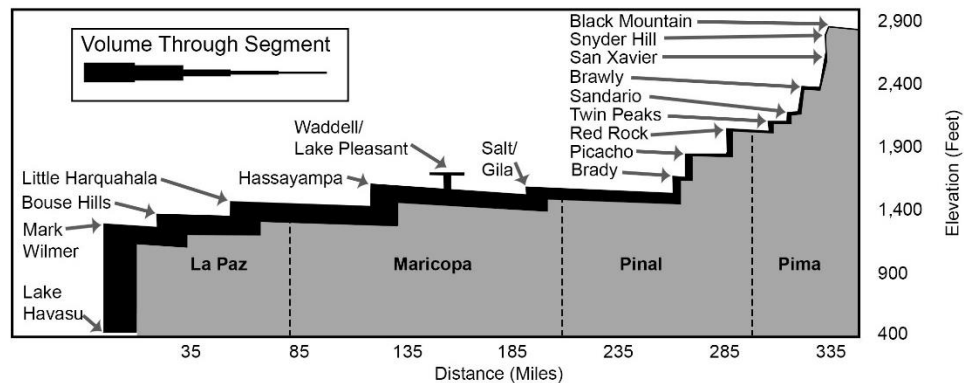
Source: Fei-Ling Tseng Design, US Department of the Interior

Water

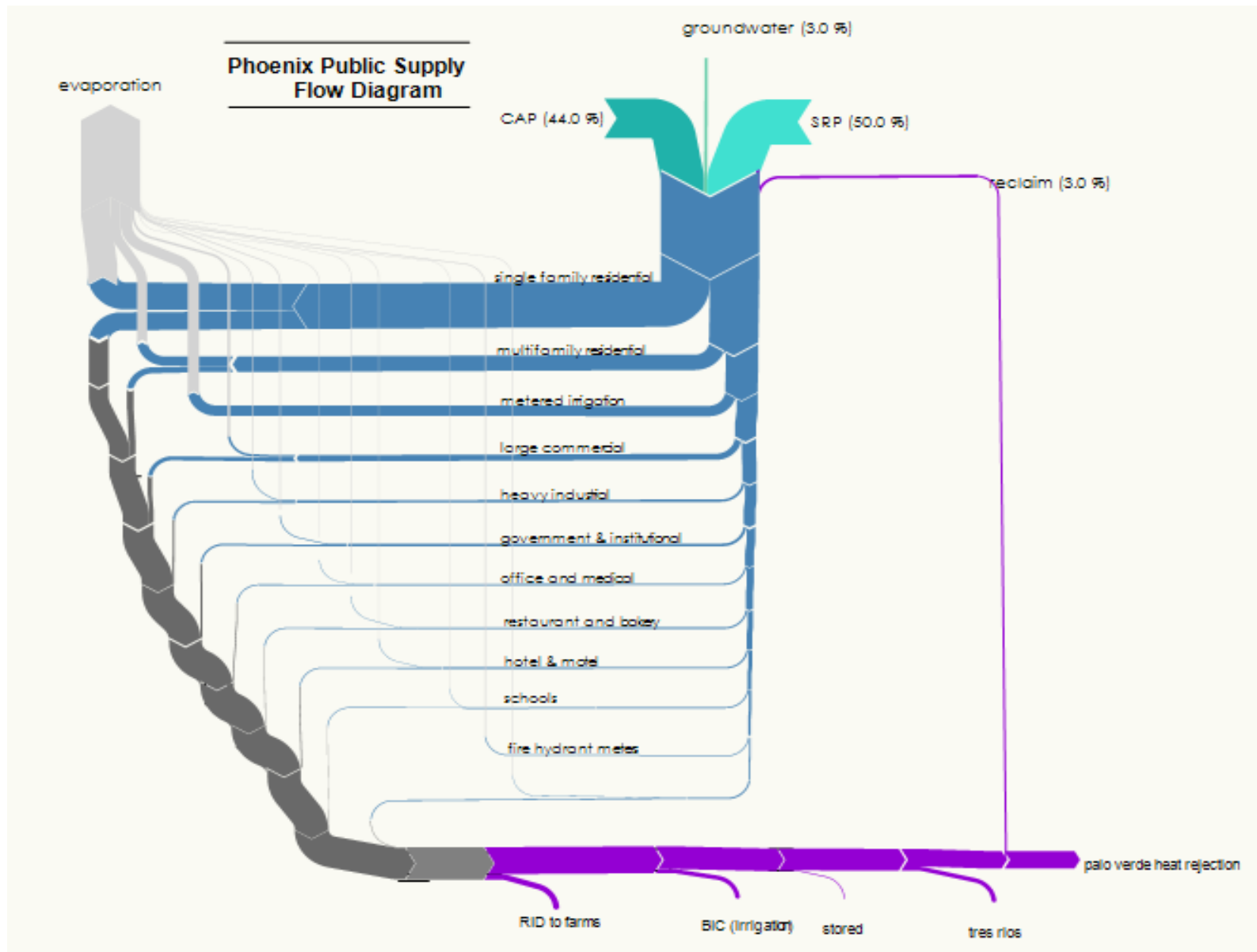




CAP Elevation Profile



Phoenix Water



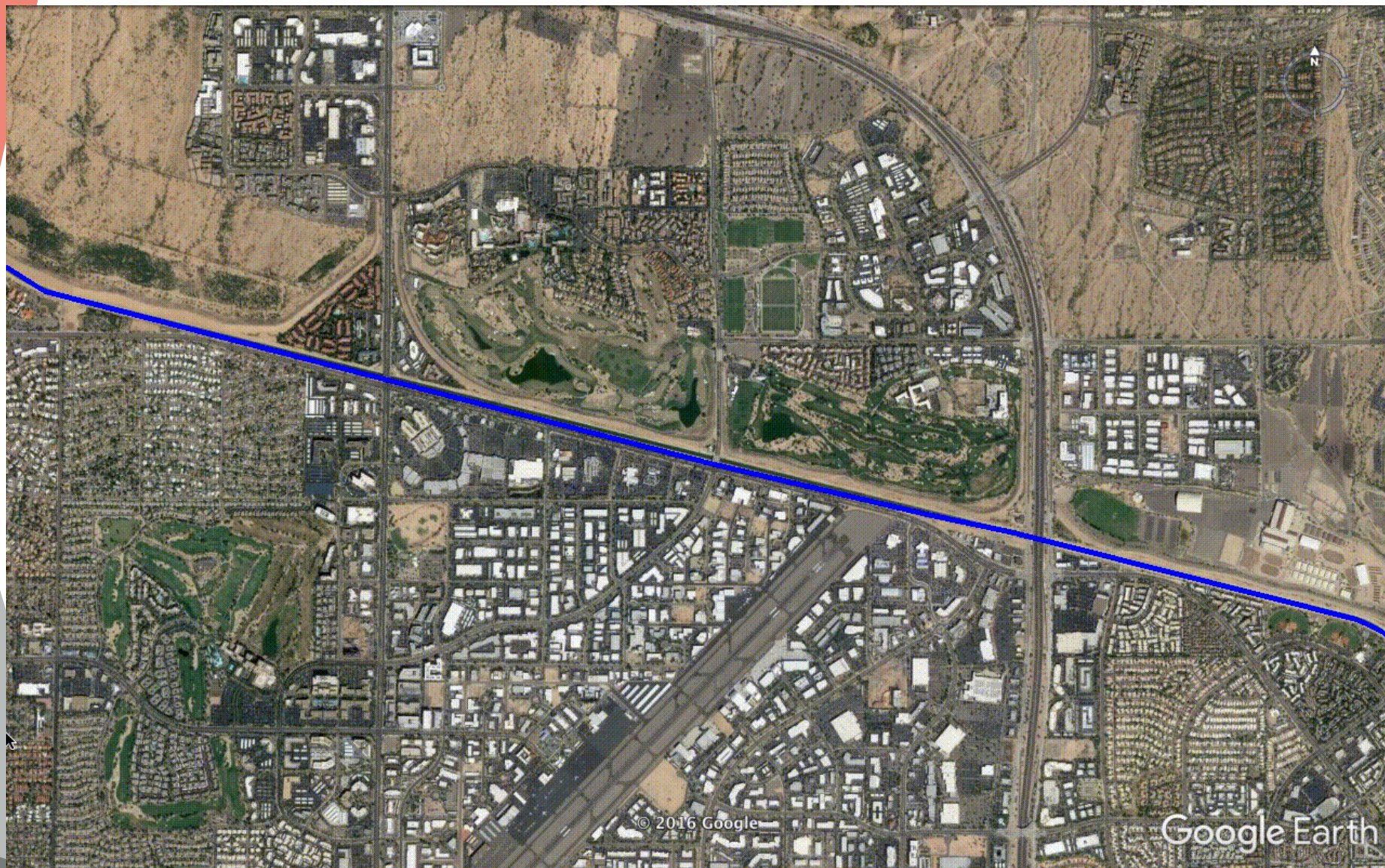
Source: City of Phoenix Water Services Department 2011 Water Resource Plan

Central Arizona Canal at Fairmont Princess



Central Arizona Canal at Fairmont Princess

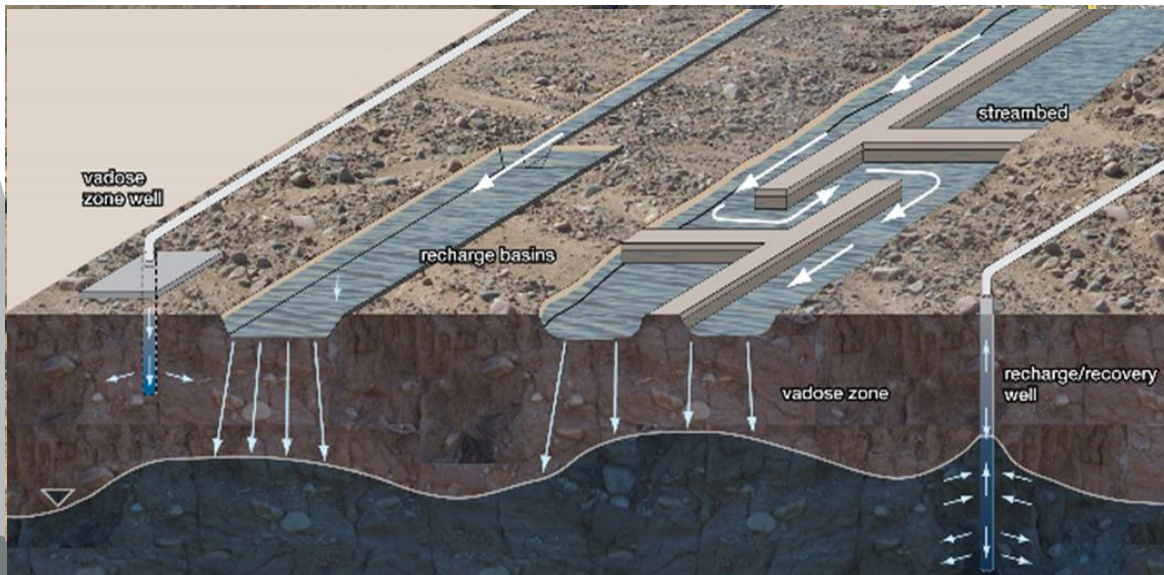
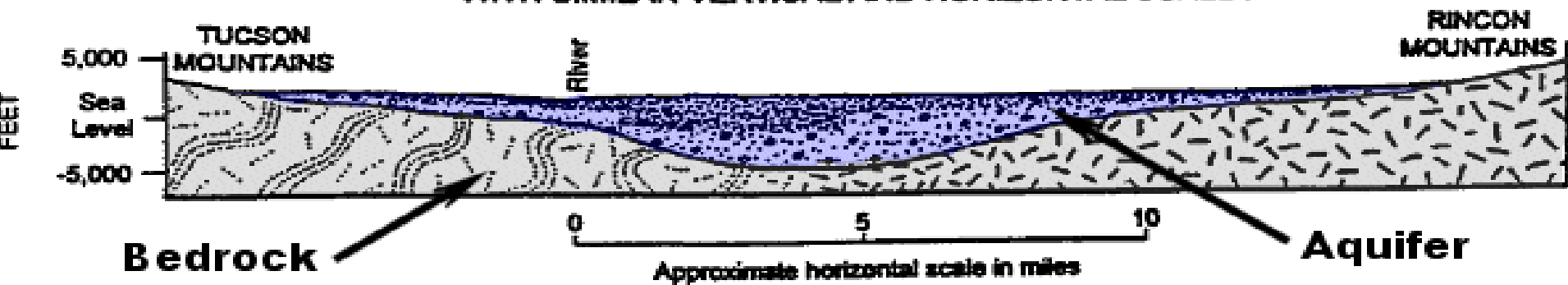




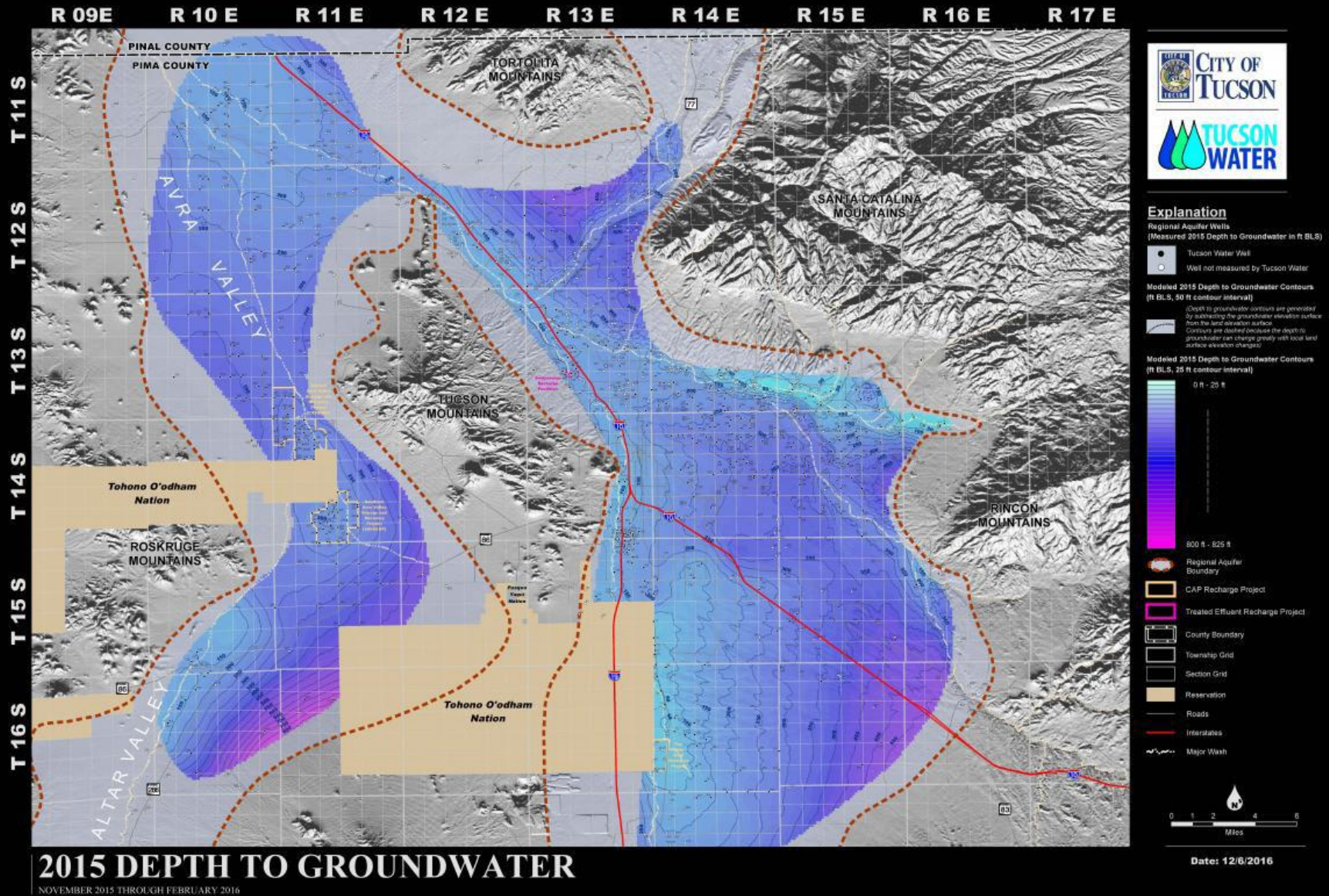
Tucson Water



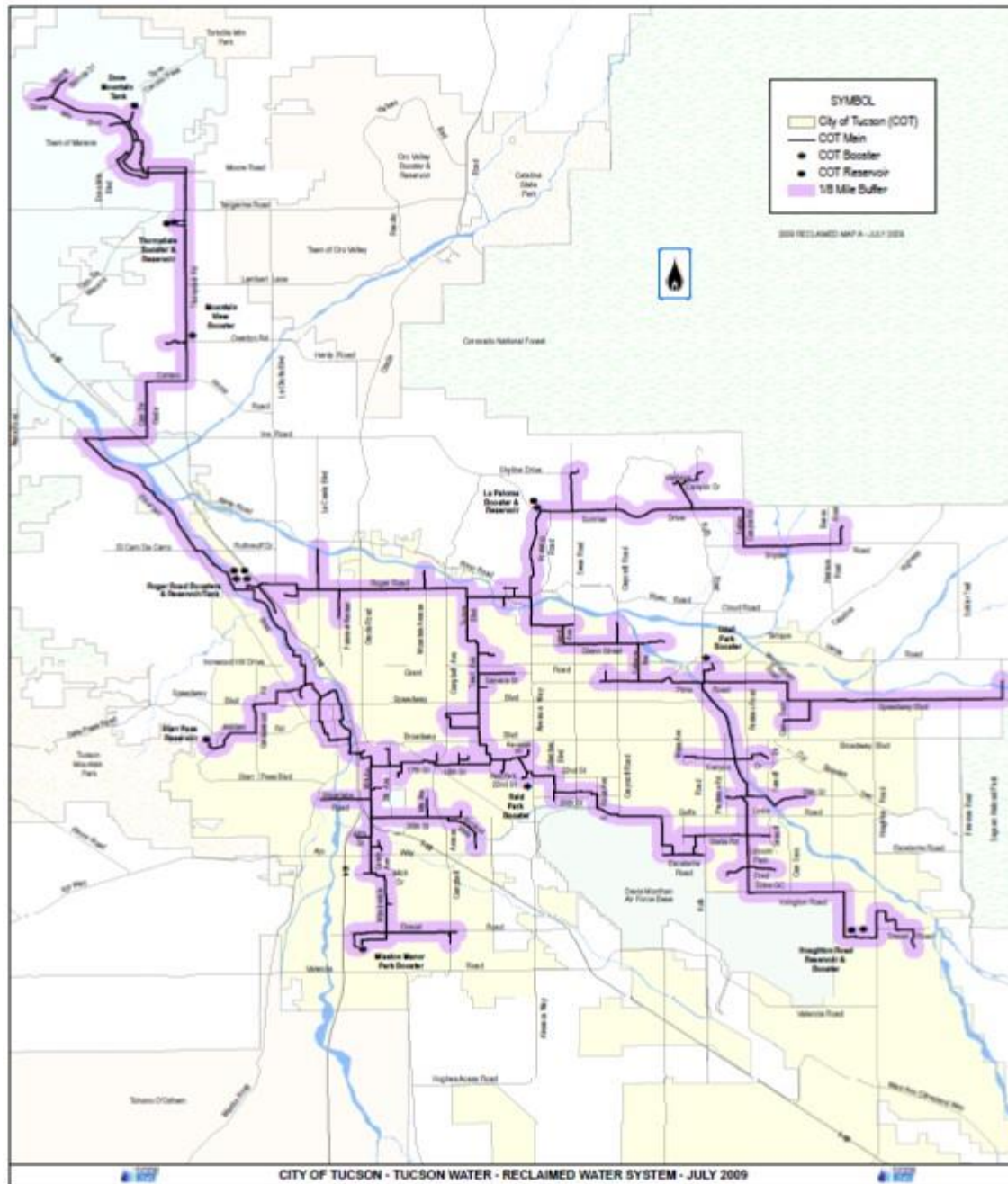
**SCHEMATIC CROSS SECTION OF UPPER SANTA CRUZ VALLEY SUBBASIN
WITH SIMILAR VERTICAL AND HORIZONTAL SCALES**



Tucson Water



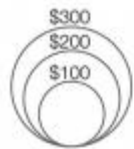
Tucson Reclaimed Water



Source: City of
Tucson

THE PRICE OF WATER: 2015

Combined water, sewer and stormwater prices for households in 30 major U.S. cities.



Water prices pay for treating, pumping, and delivering water, while sewer prices cover the cost of cleansing the water that goes down the drain.

Sewer prices are often higher than water prices because more energy and chemicals are required for treatment. Following the Clean Water Act, the federal government gave grants for new treatment plants during the 1970s and 1980s. Over the past three decades, however, new spending has been cut for local sewer infrastructure.



Stormwater fees are not included in every city's monthly bill. Some cities use general tax revenues to pay for projects to reduce polluted runoff from streets and parking lots. However, these projects must then compete for funds with other departments like police and schools.

Rates current as of April 1, 2015.
Monthly bill calculated for a family of four using 100 gallons per person per day.
Source: Circle of Blue research, based on utility water rates.

 circle of blue

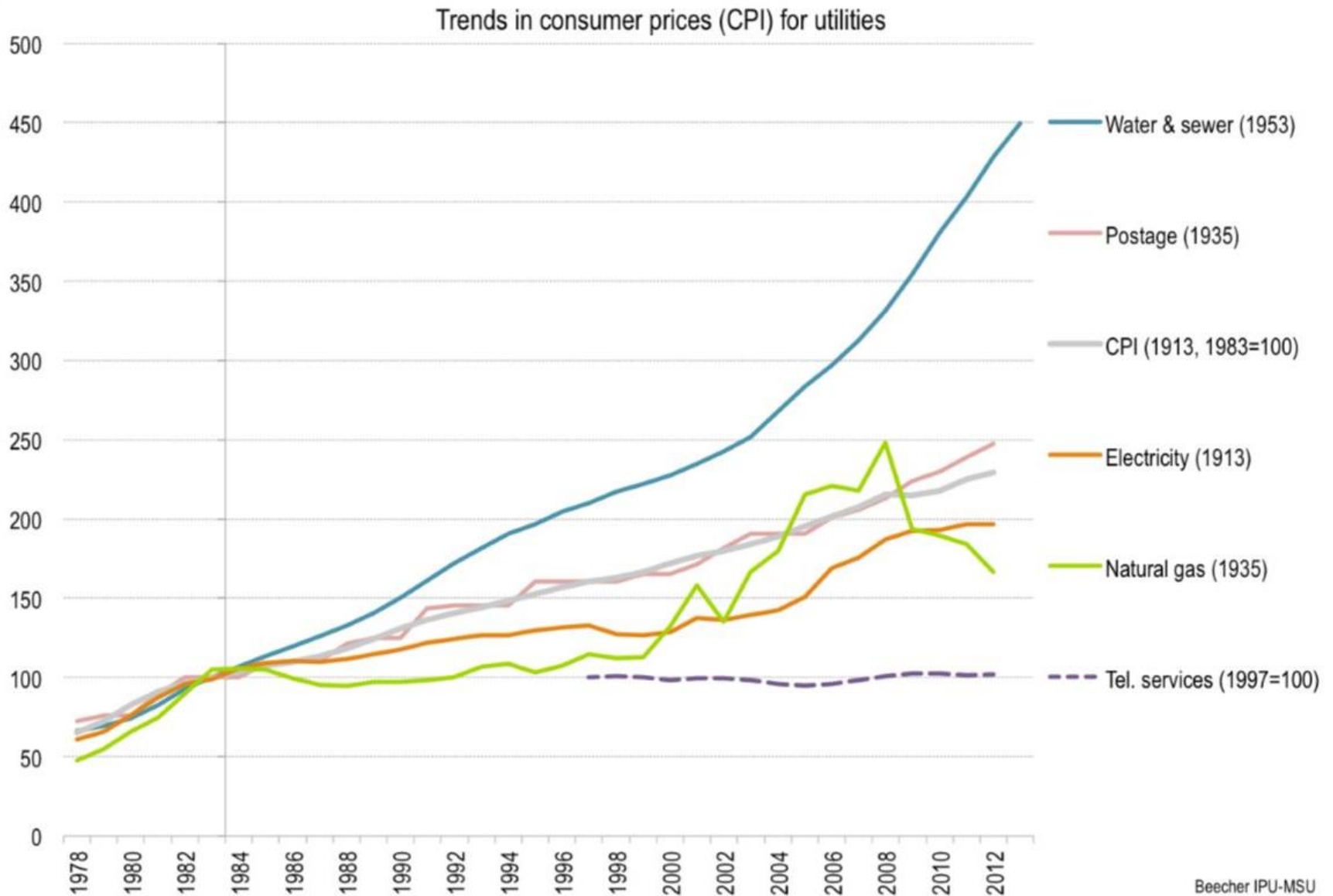
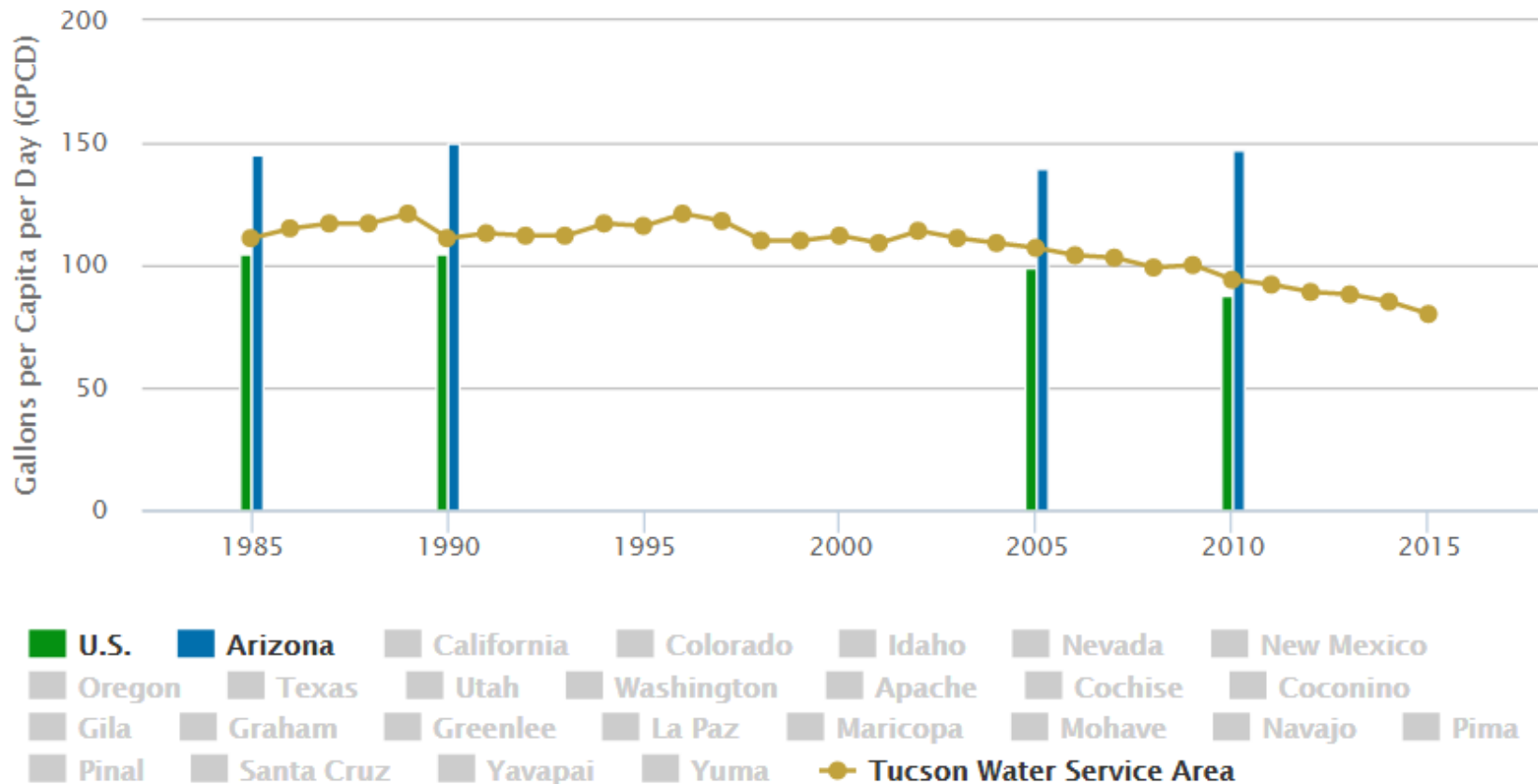


Exhibit 2. Trends in the Consumer Price Index for utilities (general, 1978-2013).

The index is set to 100 for 1982-1984 except for telephone services, where the index is set to 100 for 1997. Year (*) indicates start of series.

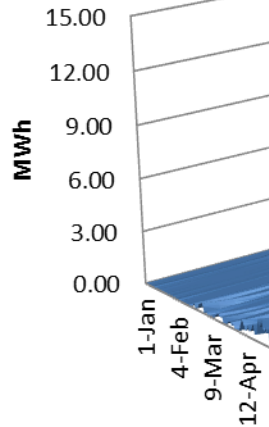
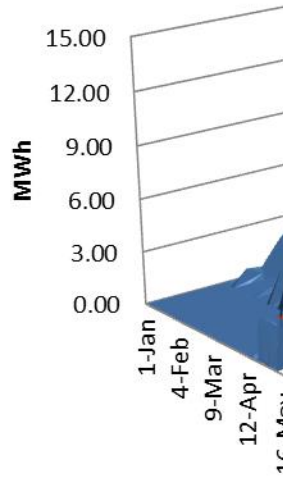
Water In High Density Urban Mixed Use

Residential Water Use



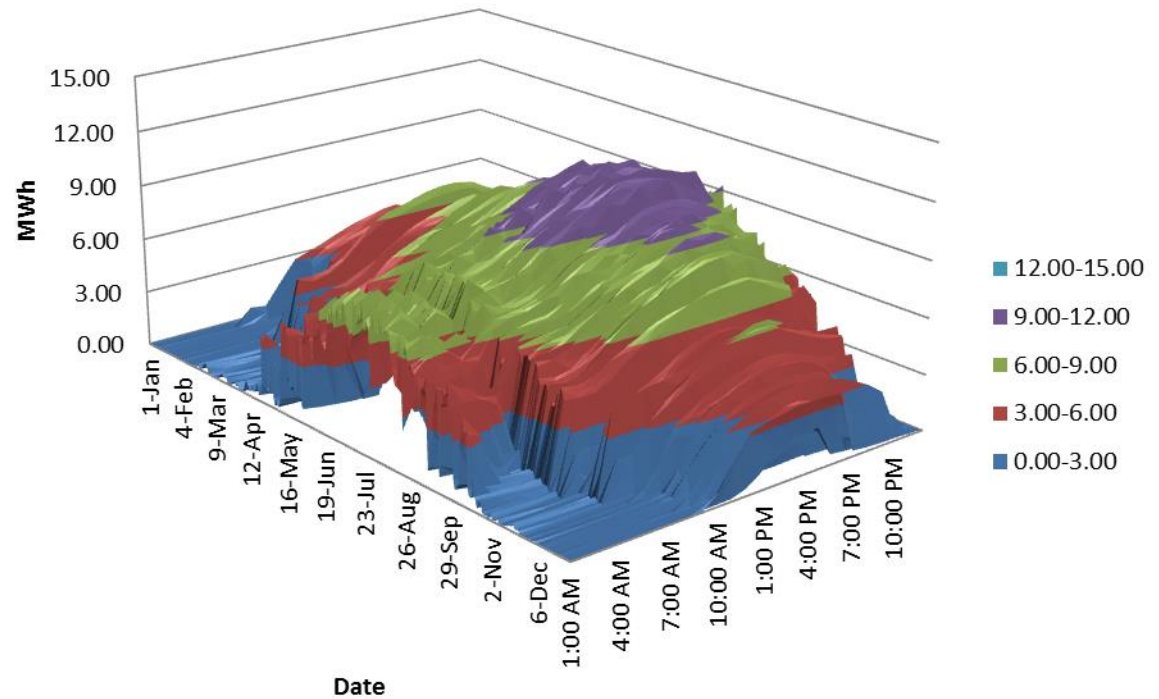
Air Conditioning

annual office
elec chilling



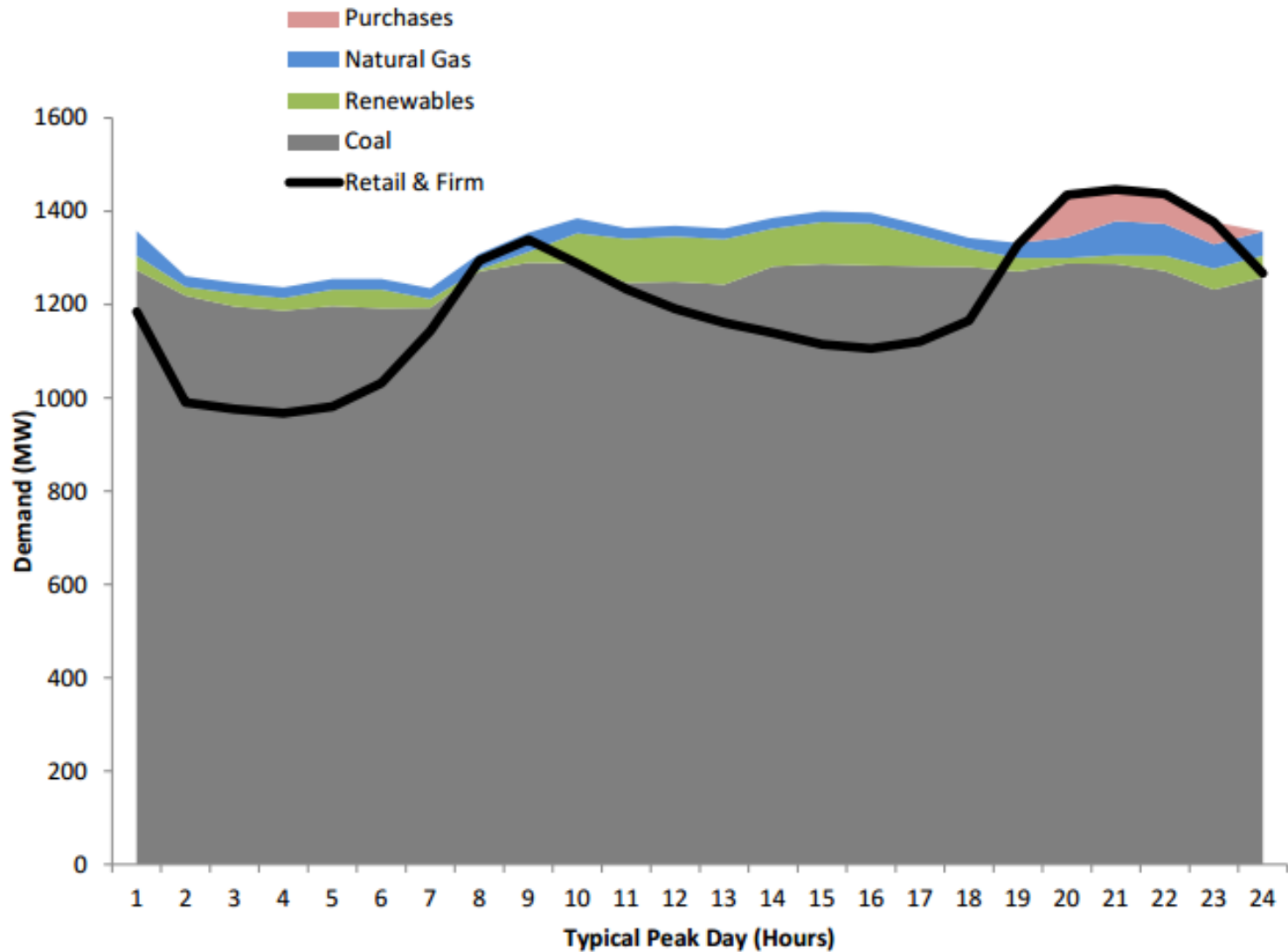
annual midrise apt

annual composite
elec chilling



Air Conditioning In Energy

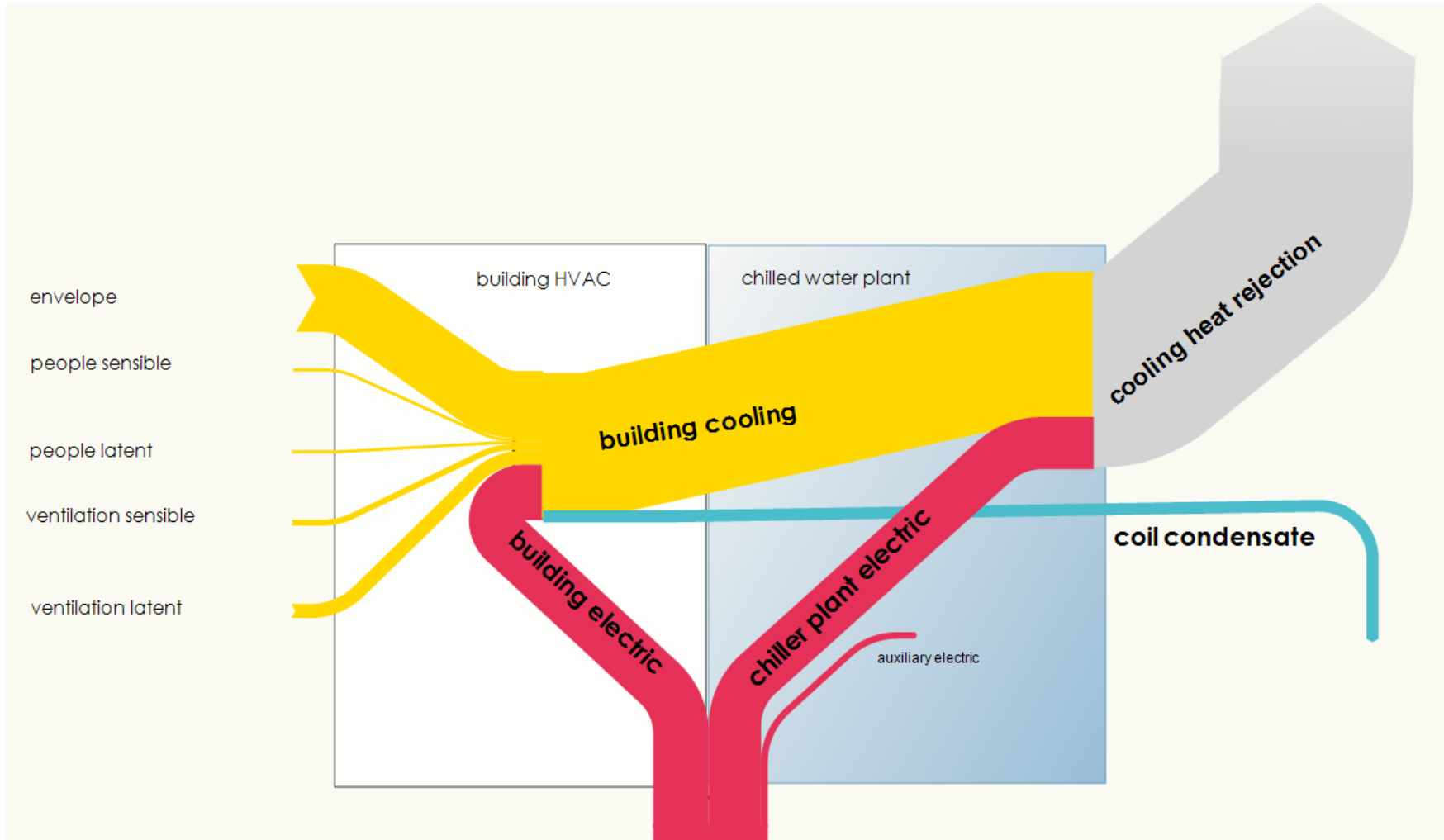
Chart 18 - 2013 Example Winter Day Dispatch



Building Cooling Load

Q_h

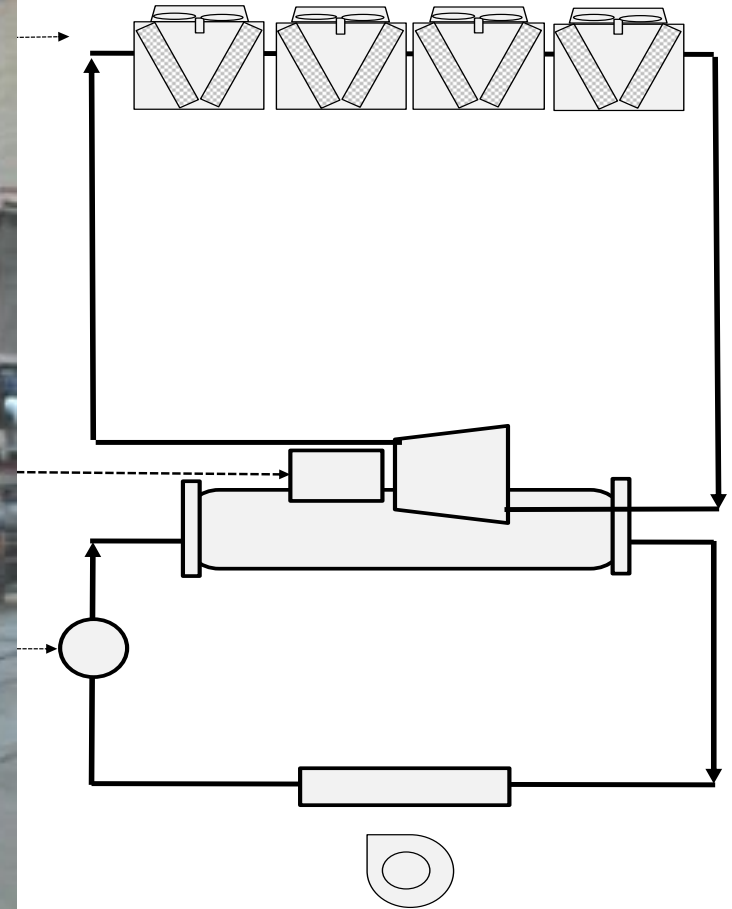
Q_c



W

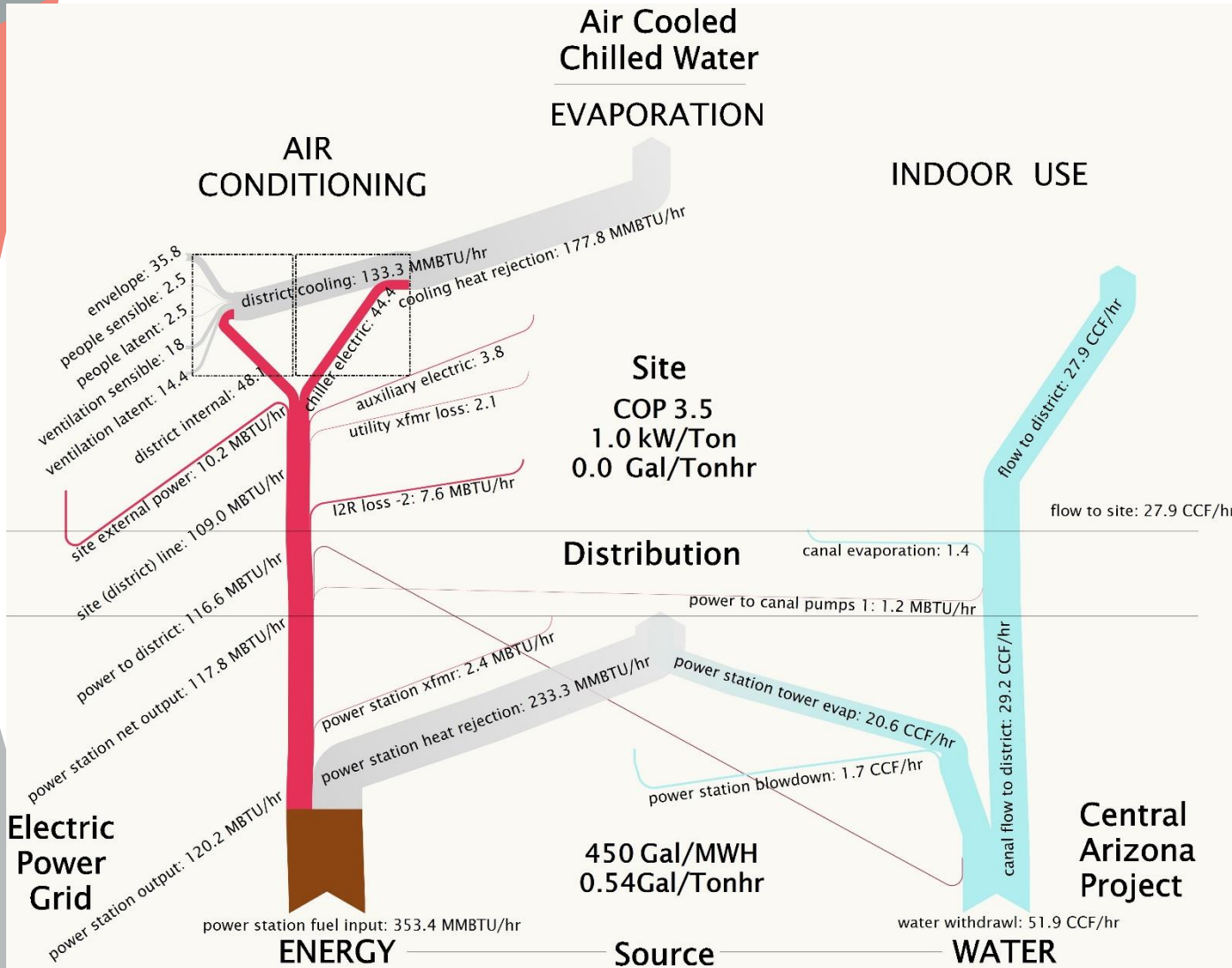
Energy In Air Conditioning

T_h 110 °F



Air Cooled Condenser

Energy - Water In Air Conditioning

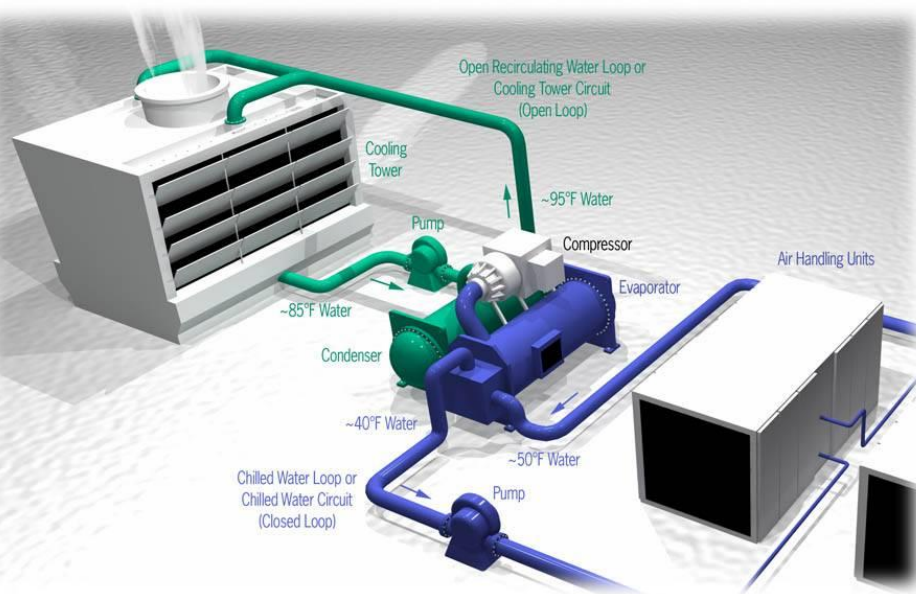
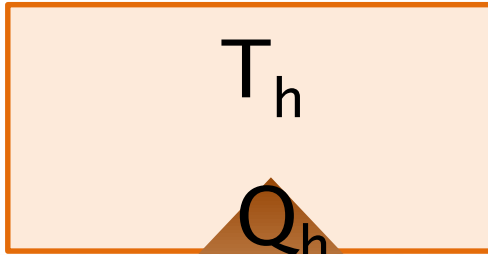


1.0 kW/Ton
COP 3.5
0.0 Gal/Tonhr

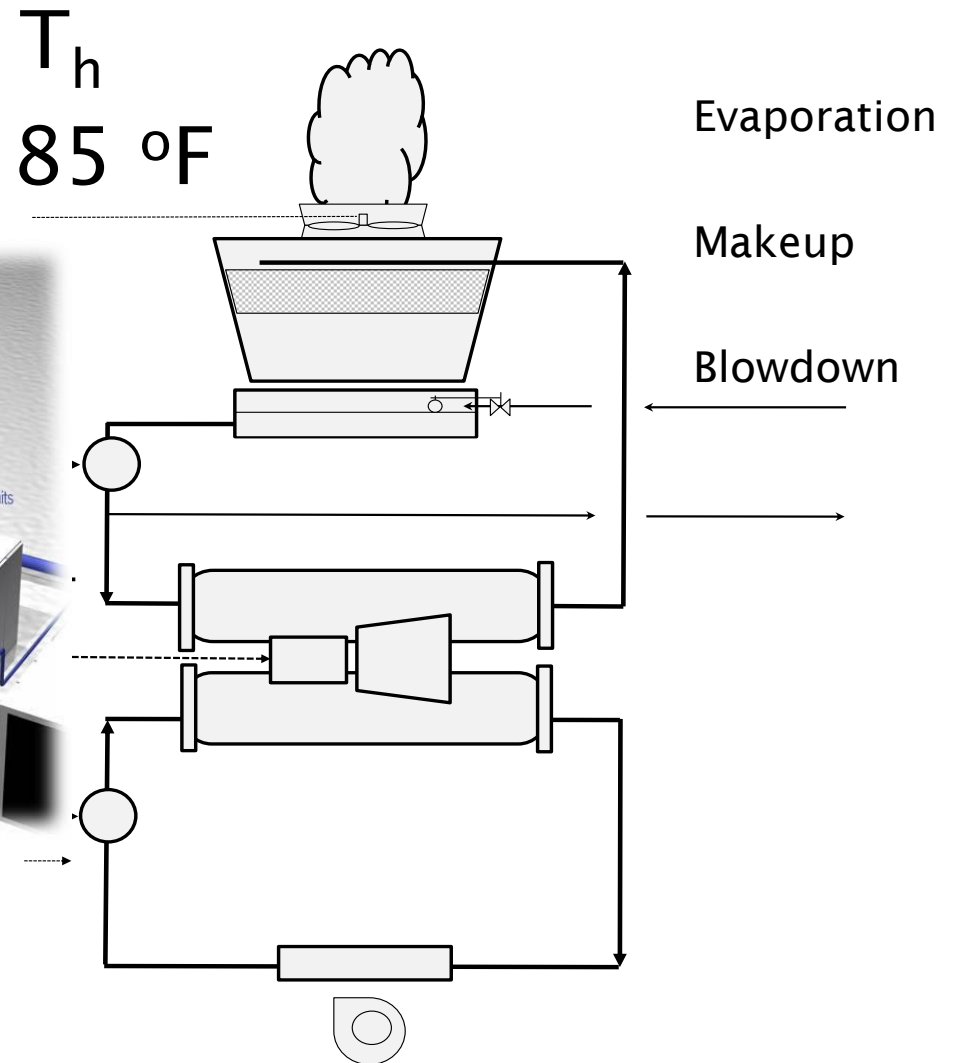
0.54 gal/Tonhr

450 Gal/MWH
0.54 Gal/Tonhr

Energy In Air Conditioning



Heat Engine



Water Cooled Condenser

Water In Air Conditioning

15,000,000 BTU/hr

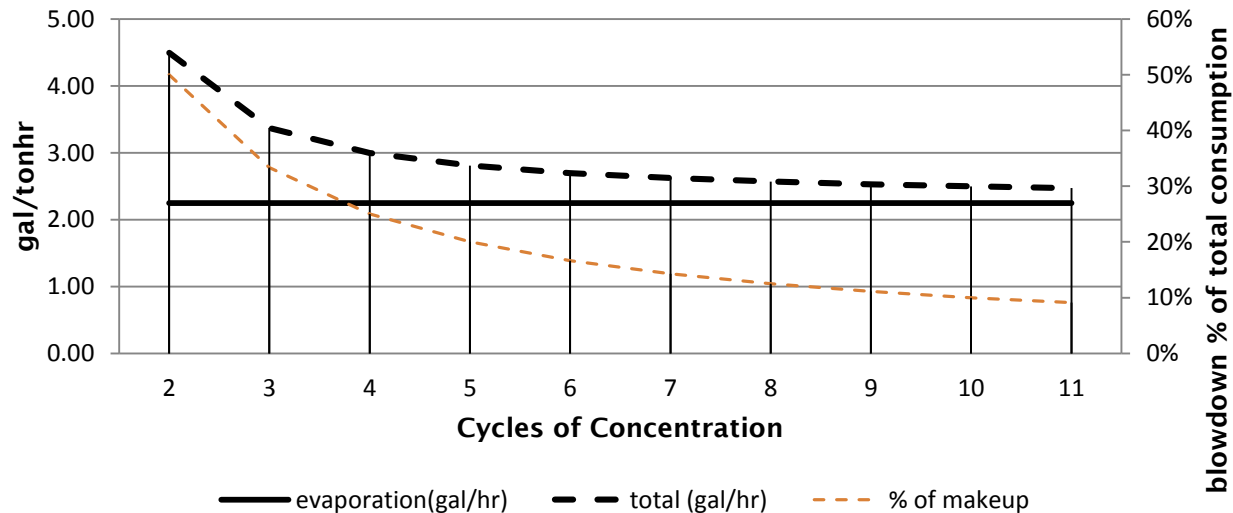
Evaporation: 1.8 Gal/Ton

Makeup: 2.25 Gal/Tonhr

Blowdown: 0.45 Gal/Tonhr

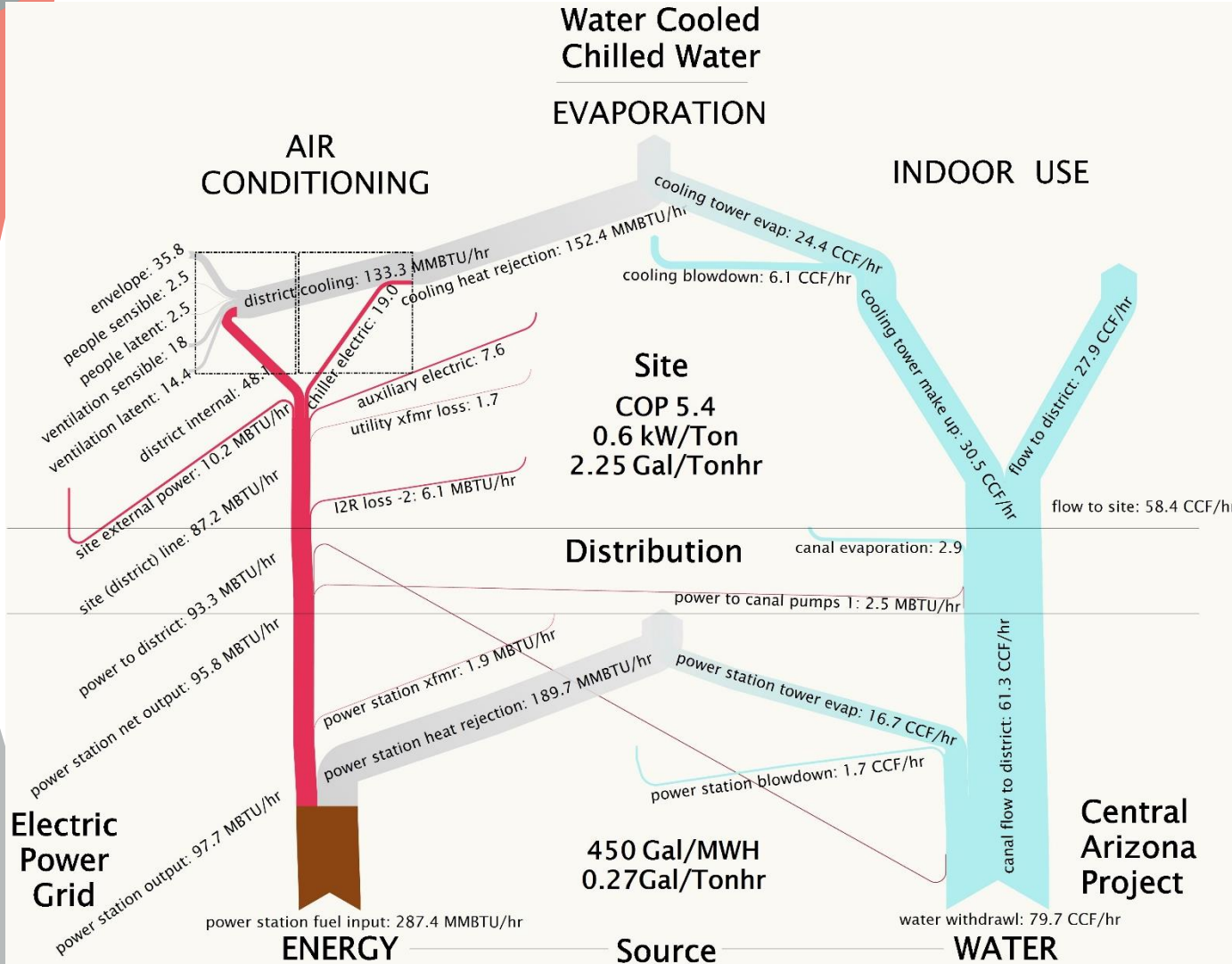
12,000,000 BTU/hr

Cooling Tower Water Consumption



blowdown % of total consumption

Energy - Water In Air Conditioning



COP 5.4
0.6 kW/Ton
2.25 Gal/Tonhr

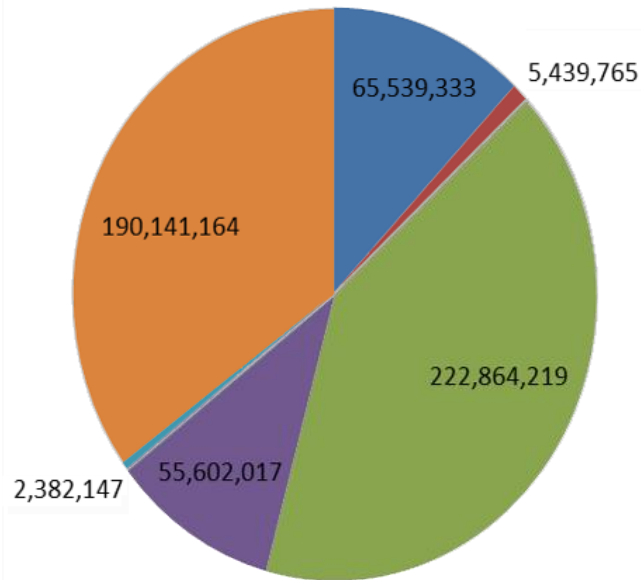
2.52 Gal/Tonhr

450 Gal/MWH
0.27 Gal/Tonhr

Water In High Density Urban Mixed Use

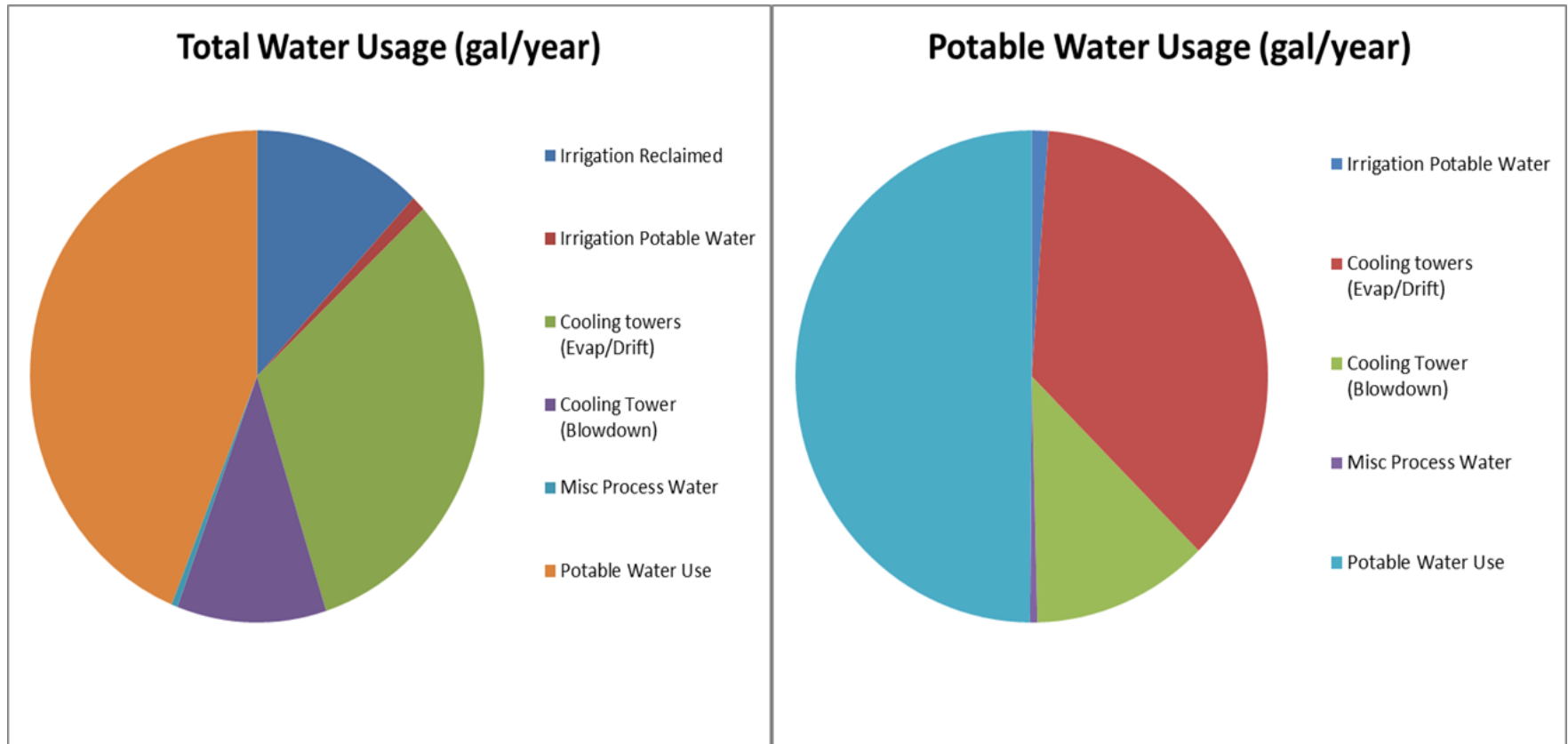
Total Water Usage (gal/year)

- Irrigation Reclaimed
- Irrigation Potable Water
- Cooling towers (Evap/Drift)
- Cooling Tower (Blowdown)
- Misc Process Water
- Potable Water Use



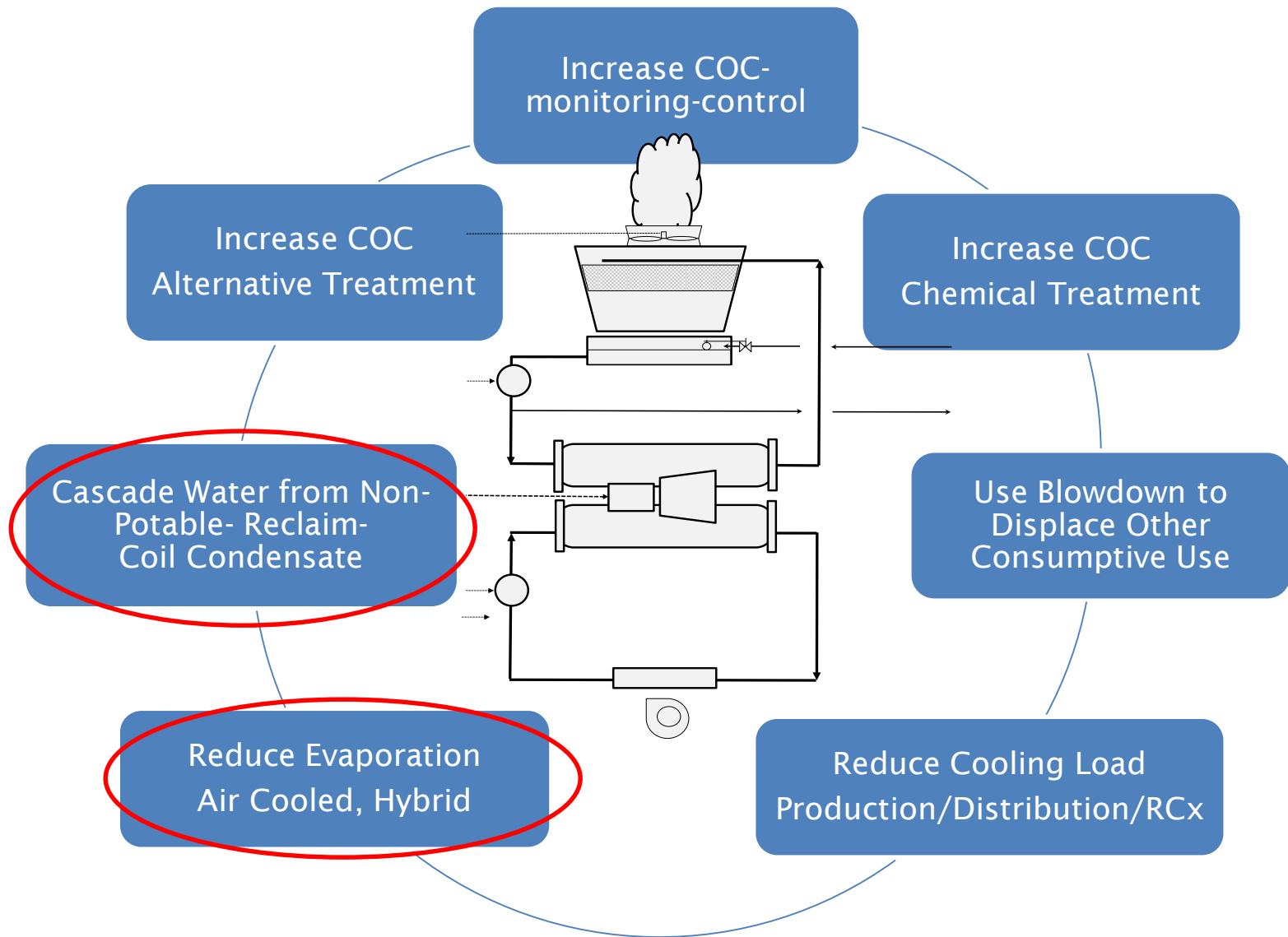
SF	12,000,000	
WATER		
people density	.001	people/SF
number of people	12,000	people
per capita use	44	gpd/person
volume	528,000	gal/day
day/yr	365	day
	192,720,000	gal
AIR CONDITIONING		
peak SF/Ton	400	SF/Ton
peak Ton	30,000	Ton
full load equivalent	2500	hr
tonhr/yr	75,000,000	Ton hr
gallon/tonhr	2.27	gal/tonhr
	179,250,000	gal/yr

Water In High Density Urban Mixed Use



A 12 MSF UNIVERSITY CAMPUS

Air Conditioning Alternatives In High Density Urban Mixed Use



Air Conditioning Alternatives In High Density Urban Mixed Use

Measuring Cost-Effectiveness: The WECER Ratio

To fully appreciate the potential operational savings of the Blue Stream hybrid cooling system, you have to balance water and energy usage costs. This is expressed as the Water_to_Energy_Cost_Equivalence_Ratio or WECER. Simply put, WECER is cost of water (\$/1,000 gallons) divided by cost of electricity (\$/kWh).

Air Conditioning Alternatives In High Density Urban Mixed Use



TSE Challenges

WATER

- **Corrosion** → High concentration aggressive anions like Chlorides, sulphates and ammonia
 - Online monitoring and control of a combination of patented corrosion inhibitor PSO with ortho-PO₄, Zinc and copper inhibitor with Trasar®

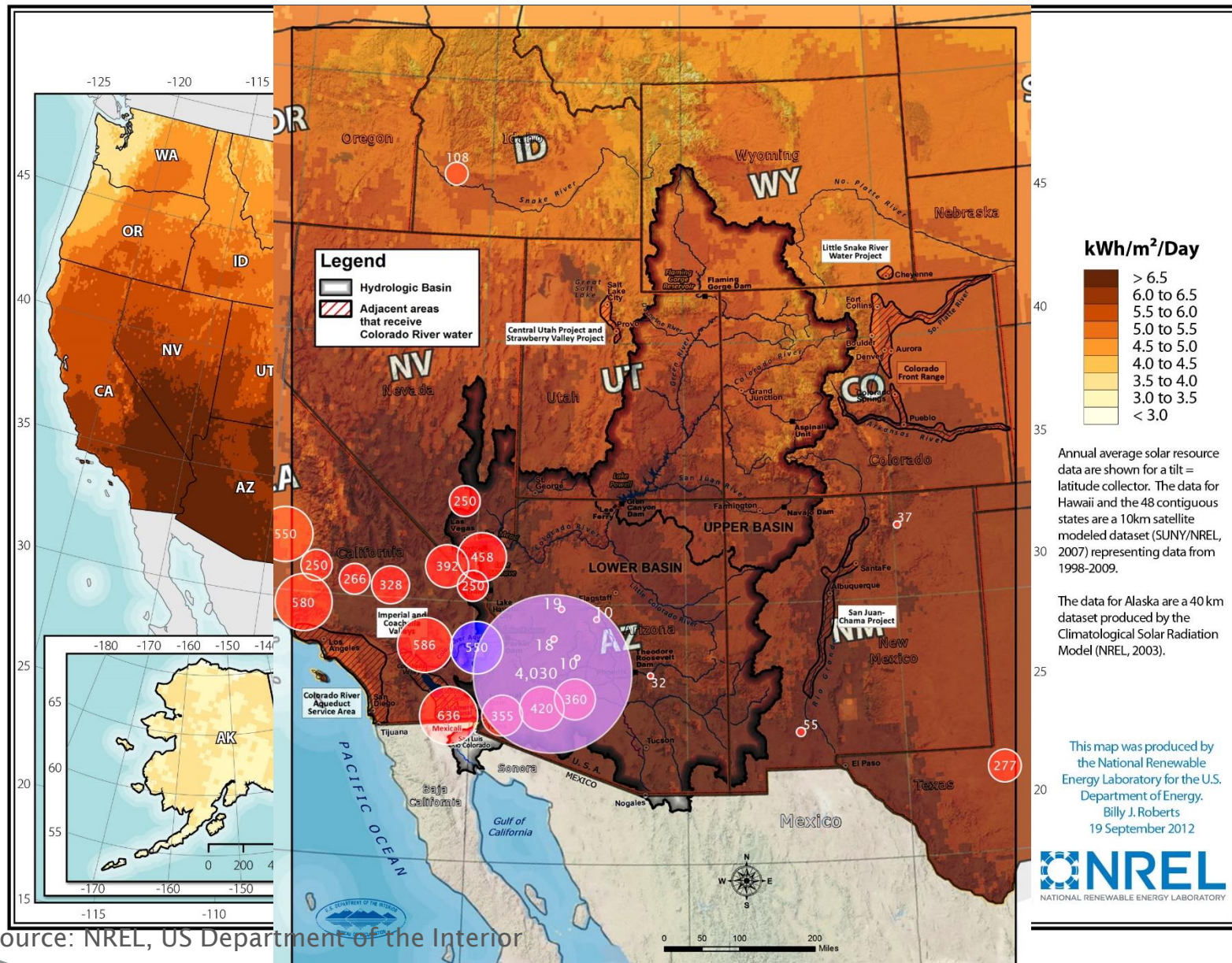
ENERGY

- **Deposits** → High concentration of Phosphate
 - Online monitoring and control of patented dispersant for calcium-phosphate complexes

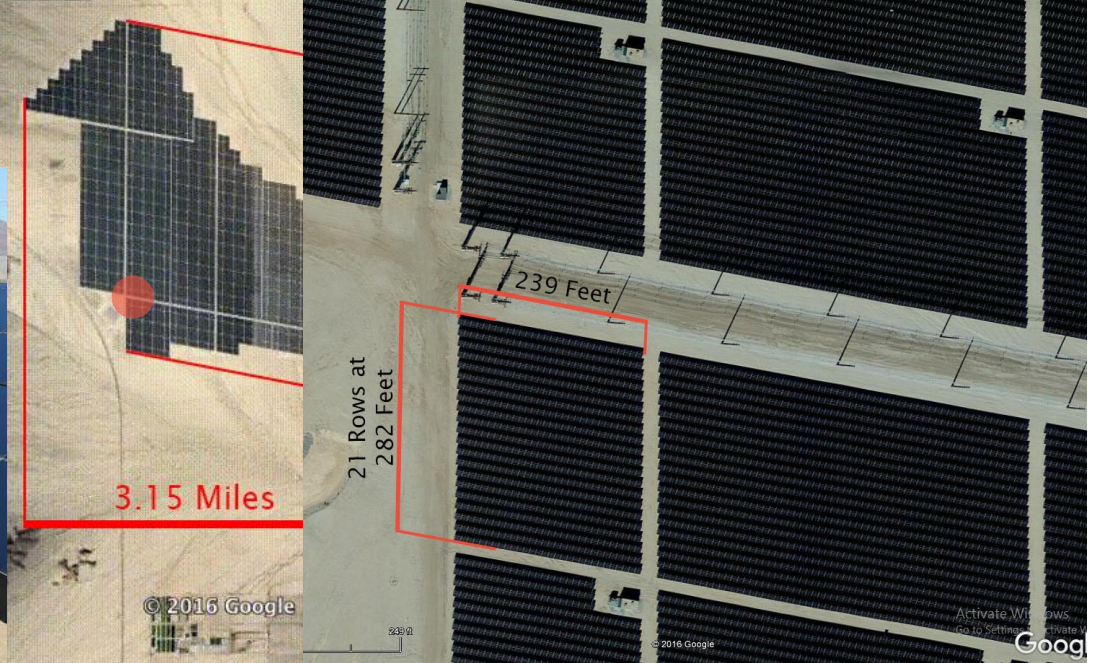
AIR

- **Microbiology** → Health Issues and Slime formation
 - Online monitoring and control of a combination of biocides

Regional Source of Renewable Energy



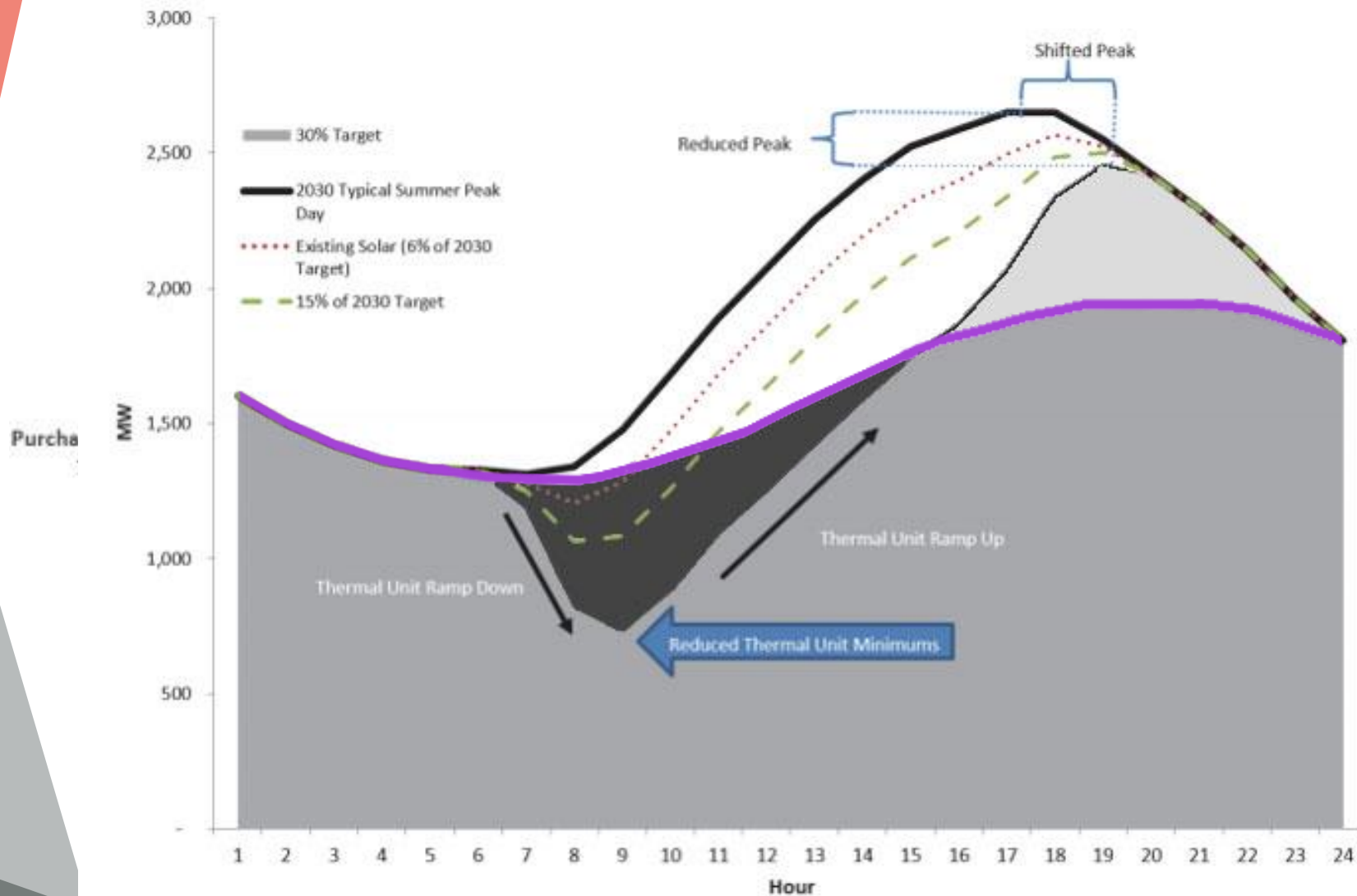
Regional Renewable Energy: Desert Sunlight Solar Farm



Source: Marcus Yam (LA Times), Jay Calderon (The Desert Sun)

Air Conditioning Alternatives In High Density Urban Mixed Use

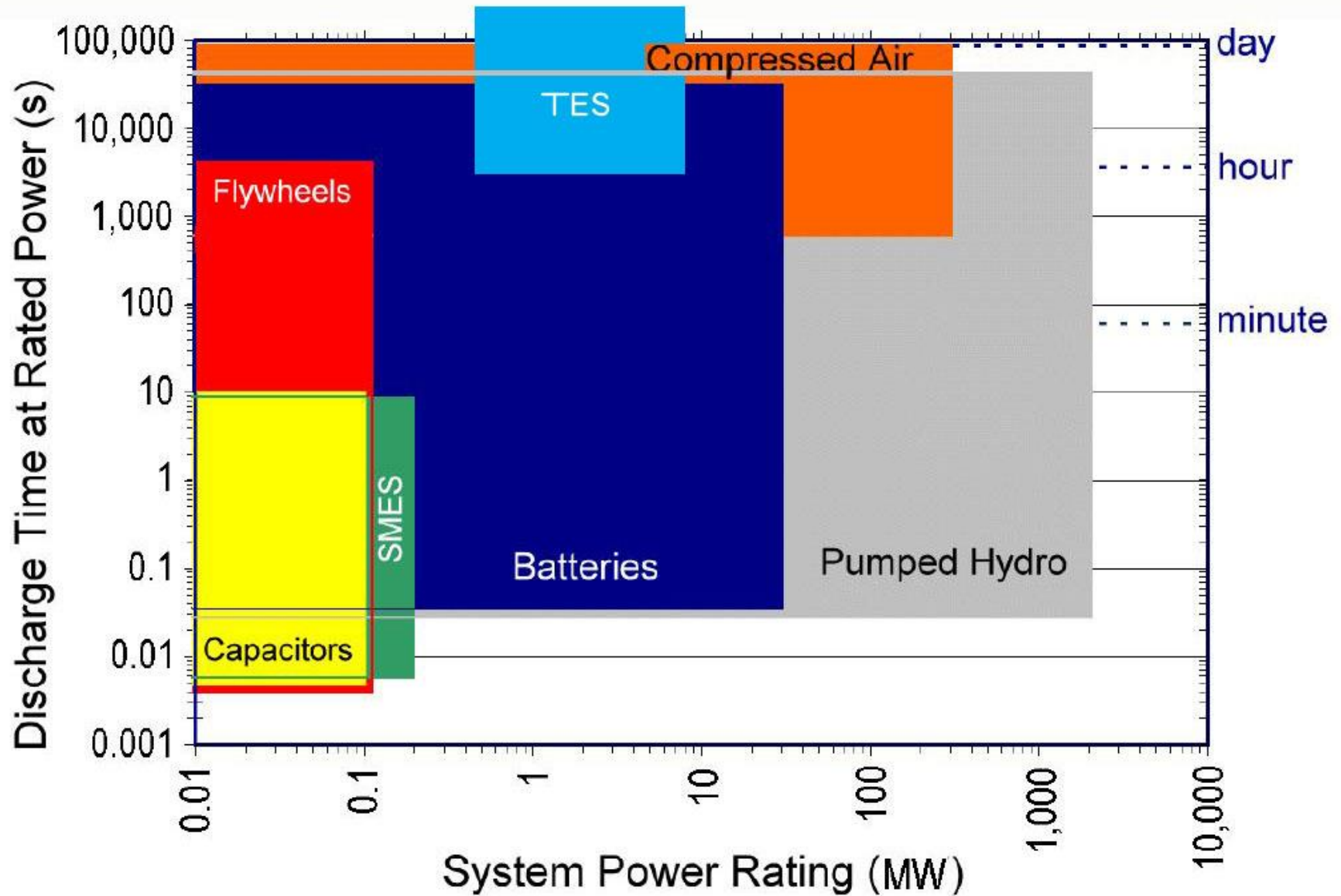
Chart 9 - Impact of Increased Solar Production (Duck Curve)



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ir
ar
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S

Energy Storage



Source: Climatetechwiki.org

Energy Storage





Water Energy Air Conditioning

Complex Inter-relationships

Opportunities

Priorities and Costs

Questions?
hjohnsto@glhn.com



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June 26-29 | Fairmont Scottsdale Princess | Scottsdale, AZ

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