This presentation premiered at WaterSmart Innovations

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Dry Ice: Water Conservation Practices in Cooling Water Systems

Presented by

Jason Millheim, EIT, LEED® AP
Industrial Water Conservation Engineer
Denver Water

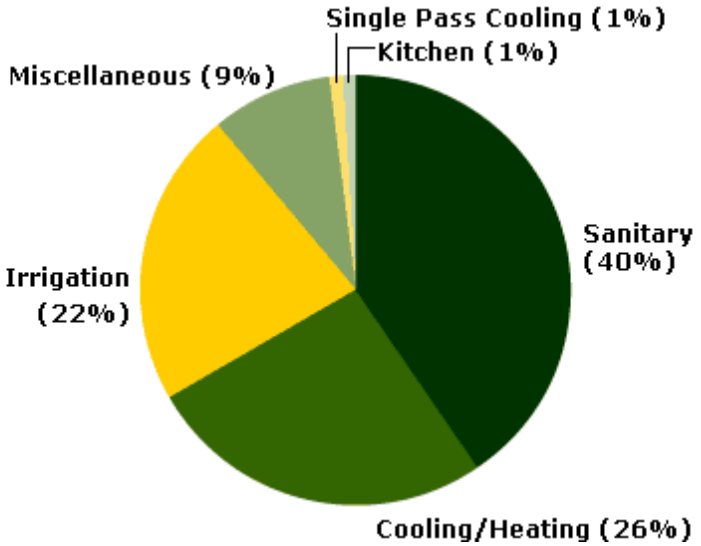
Why do we care?

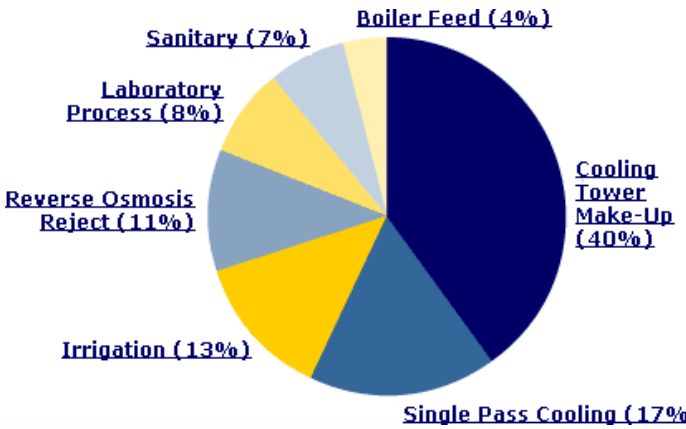
- Save potable water for expanding population
- Reduce water costs
- Reduce water pumping costs (energy)
- Reduce water treatment costs
- Reduce wastewater discharge & costs
- Reduce operating costs
- Save money—lots of money & water

- Water is our most precious resource, and irreplaceable.

Water Consumption

- According to the EPA:
  - Cooling systems account for 26% of total water use in a typical office building
  - 40% of total usage in a typical laboratory.





Cooling Towers

- A cooling tower is a heat rejection device, which extracts waste heat to the atmosphere though the cooling of a water stream to a lower temperature.

- Generally the largest single use of water in a facility without irrigation.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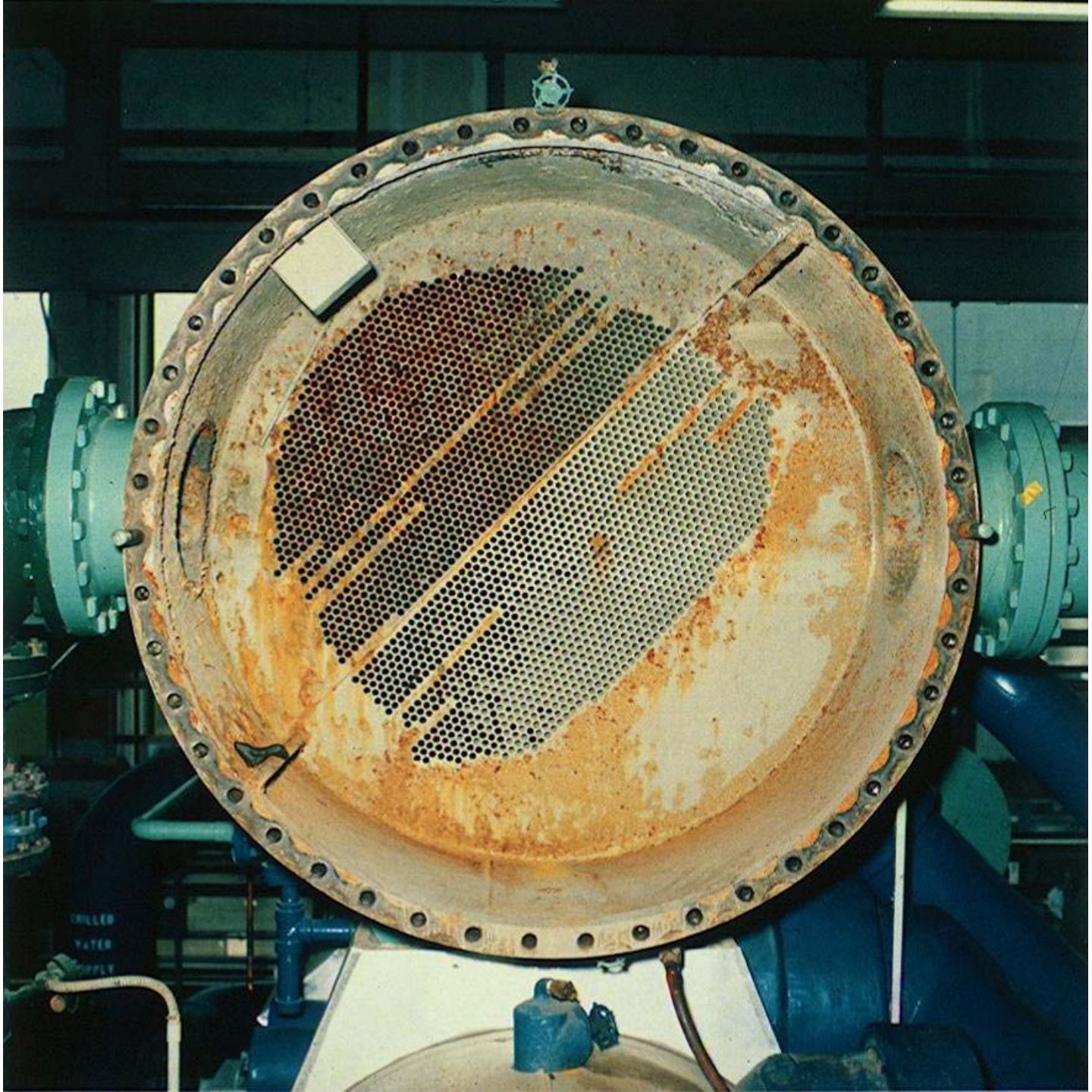
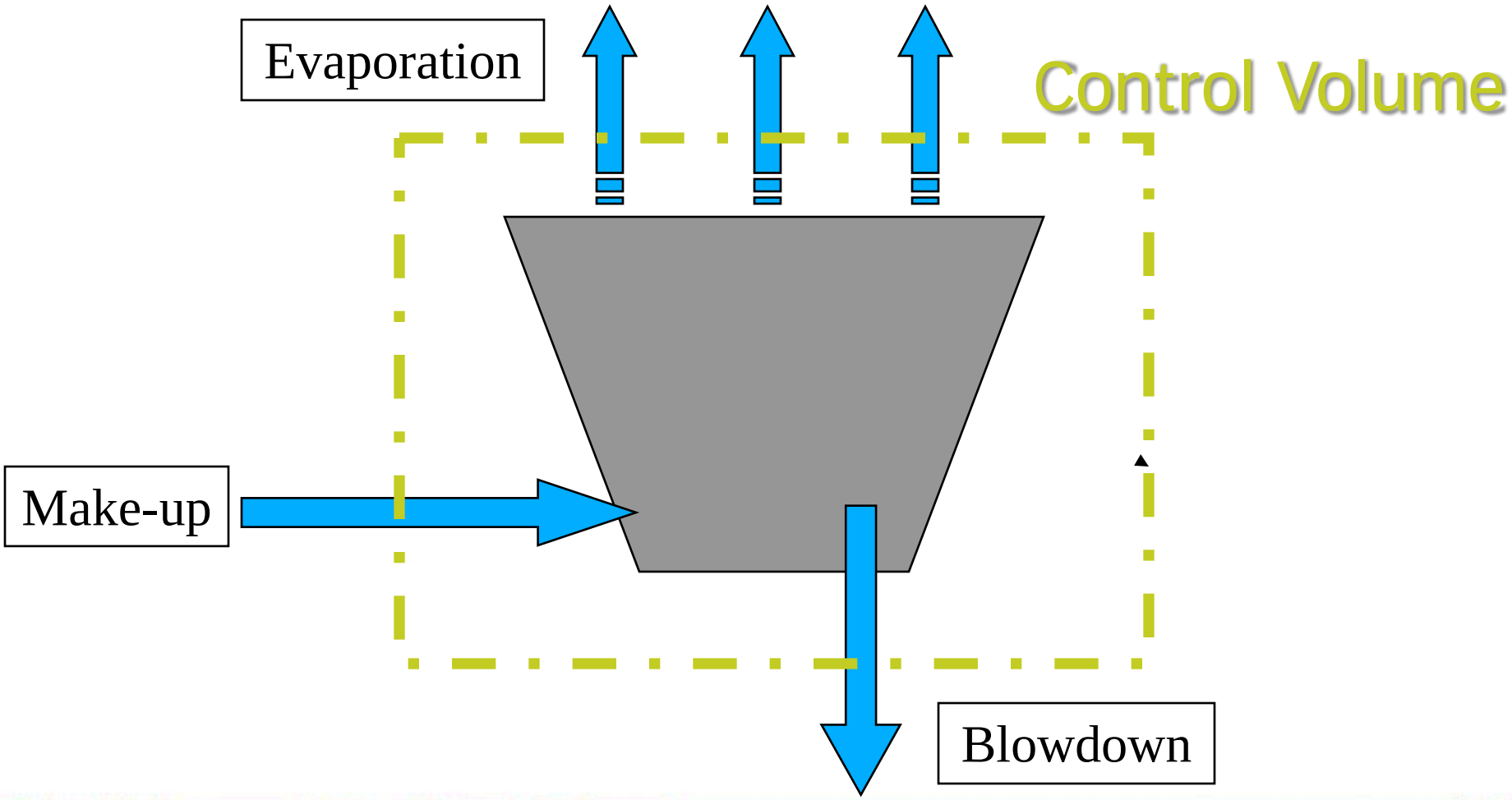
2300 VOLTS



Thermodynamics of Cooling Towers



Thermodynamics of Cooling Towers

Mass balance

$$M = B + E$$

Blowdown

$$B = \frac{E}{C - 1}$$

Cycles of Concentration

$$C = \frac{TDS_{tower}}{TDS_{makeup}} = \frac{M}{B}$$

What about E?

Thermodynamics of Cooling Towers

- Evaporation

$$E = \frac{C_P}{H_V} L \cdot R$$

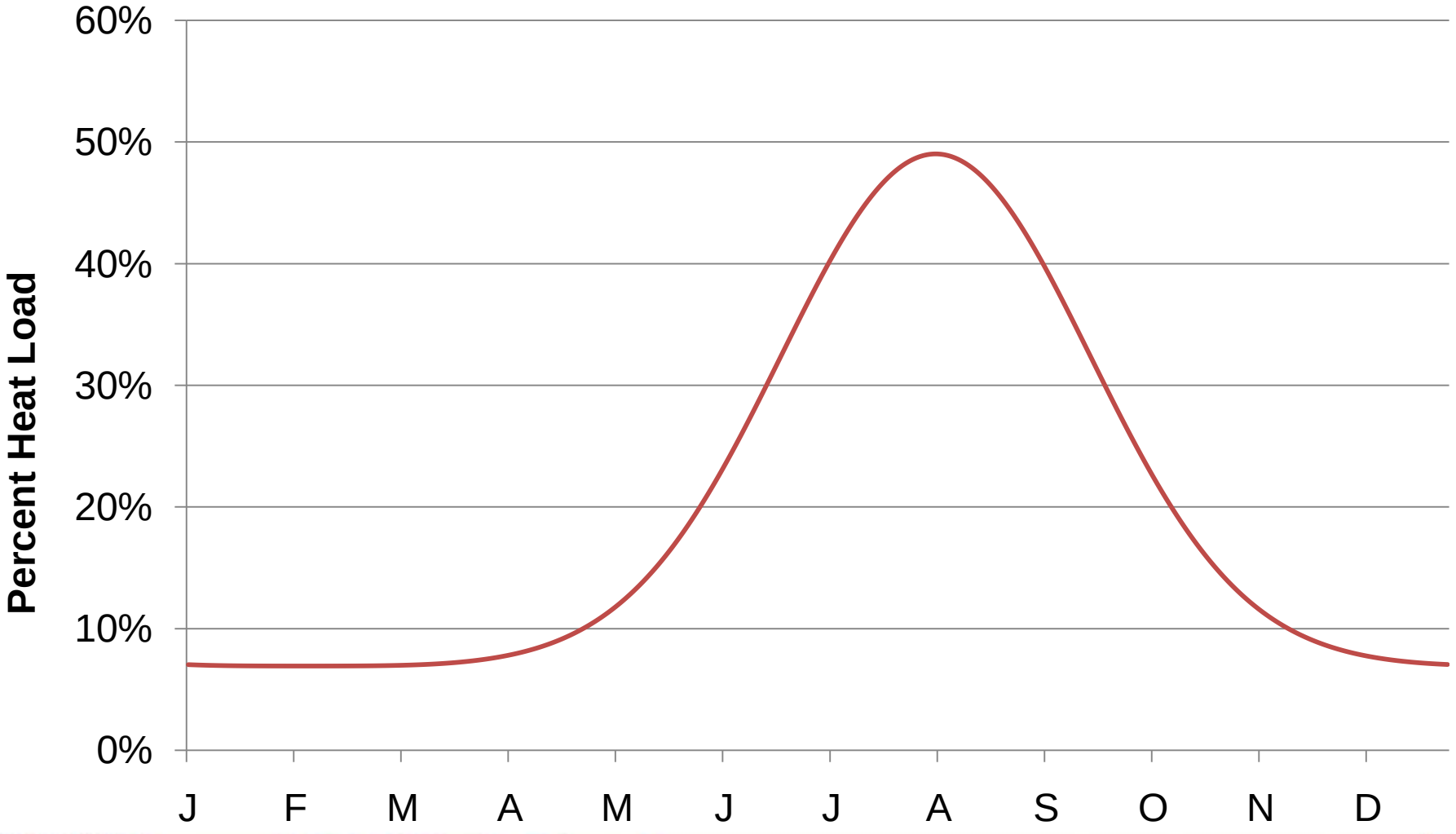
$$Q = \rho\left(C_P L R\right) \div 15{,}000 \frac{Btu/hr}{ton}$$

$$E = \frac{1 \frac{Btu}{lb \cdot {}^{\circ}F}}{971.3 \frac{Btu}{lb}} L \cdot R$$

$$E = 1.8 \cdot Q \cdot \left(\frac{hr}{day}\right) \cdot \%\ load$$

- Note: 1 refrigeration ton = 12,000 Btu/hr, 1 cooling tower ton = 15,000 Btu/hr

Evaporation & Heat Load



Cooling Tower System Requirements

- Protect all equipment to operate efficiently
- Minimize corrosion
- Prevent scale/fouling deposits
- Minimize microbio caused deposits
- Prevent pathogen growth


SCALING
CORROSION
FOULING

Water Treatment Programs

- Traditional chemical treatment
- Green chemical treatment
- Physical water treatment

Traditional chemicals

- Corrosion inhibitors
  - Polysilicates, phosphonates, azoles, etc.
- Scale inhibitors
  - Phosphonates, polymers
- Fouling control
  - Filtration, dispersant & fluidizer polymer chemicals
- Microbio control
  - Chlorine, bromine, ClO_2, ozone, H_2O_2

Traditional chemicals

Water Conservation

- Increase cycles of concentration
  - Quickest method of water conservation
  - No downtime
  - Consult a chemical supplier

$$V_{saved} = M_{old} \frac{C_{new} - C_{old}}{C_{old}\left(C_{new} - 1\right)}$$

Water Conservation

Old Cycles of Concentration	New Cycles of Concentration												
	2	2.5	3	3.5	4	5	6	7	8	9	10	15	25
1.5	33%	44%	50%	53%	56%	58%	60%	61%	62%	63%	63%	64%	65%
2	-----	17%	25%	30%	33%	38%	40%	42%	43%	44%	44%	46%	48%
2.5	-----	-----	10%	16%	20%	25%	28%	30%	31%	33%	33%	36%	38%
3	-----	-----	-----	7%	11%	17%	20%	22%	24%	25%	26%	29%	31%
3.5	-----	-----	-----	-----	5%	11%	14%	17%	18%	20%	21%	23%	26%
4	-----	-----	-----	-----	-----	6%	10%	13%	14%	16%	17%	20%	22%
5	-----	-----	-----	-----	-----	-----	4%	7%	9%	10%	11%	14%	17%
6	-----	-----	-----	-----	-----	-----	-----	3%	5%	6%	7%	11%	13%
7	-----	-----	-----	-----	-----	-----	-----	-----	2%	4%	5%	8%	11%
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	2%	3%	6%	9%
9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1%	5%	7%

Example—800 Ton HVAC Tower

Assume: average 25% heat load, 24 hour/day, 365 day/year

Cycles	Makeup water	Blowdown water
5	15 gpm 10,800 gpd 3,942,000 gpy	3 gpm 2,160 gpd 788,400 gpy
8	13.75 gpm 9,874 gpd 3,604,000 gpy	1.75 gpm 1,234 gpd 450,514 gpy
Savings	1.25 gpm 926 gpd 338,000 gpy	1.25 gpm 926 gpd 338,000gpy
	$1,000/year @ $2.96/1000 gal	$659/year @ $1.95/1000 gal

Total Savings: $1,659/year + chemical costs

Green Chemical Treatment

- High-bonding crystal modifiers
- Originally developed for lead poisoning
- Typically biodegradable & biorenewable

- Reduce blowdown by 90%
- Zero-blowdown possible

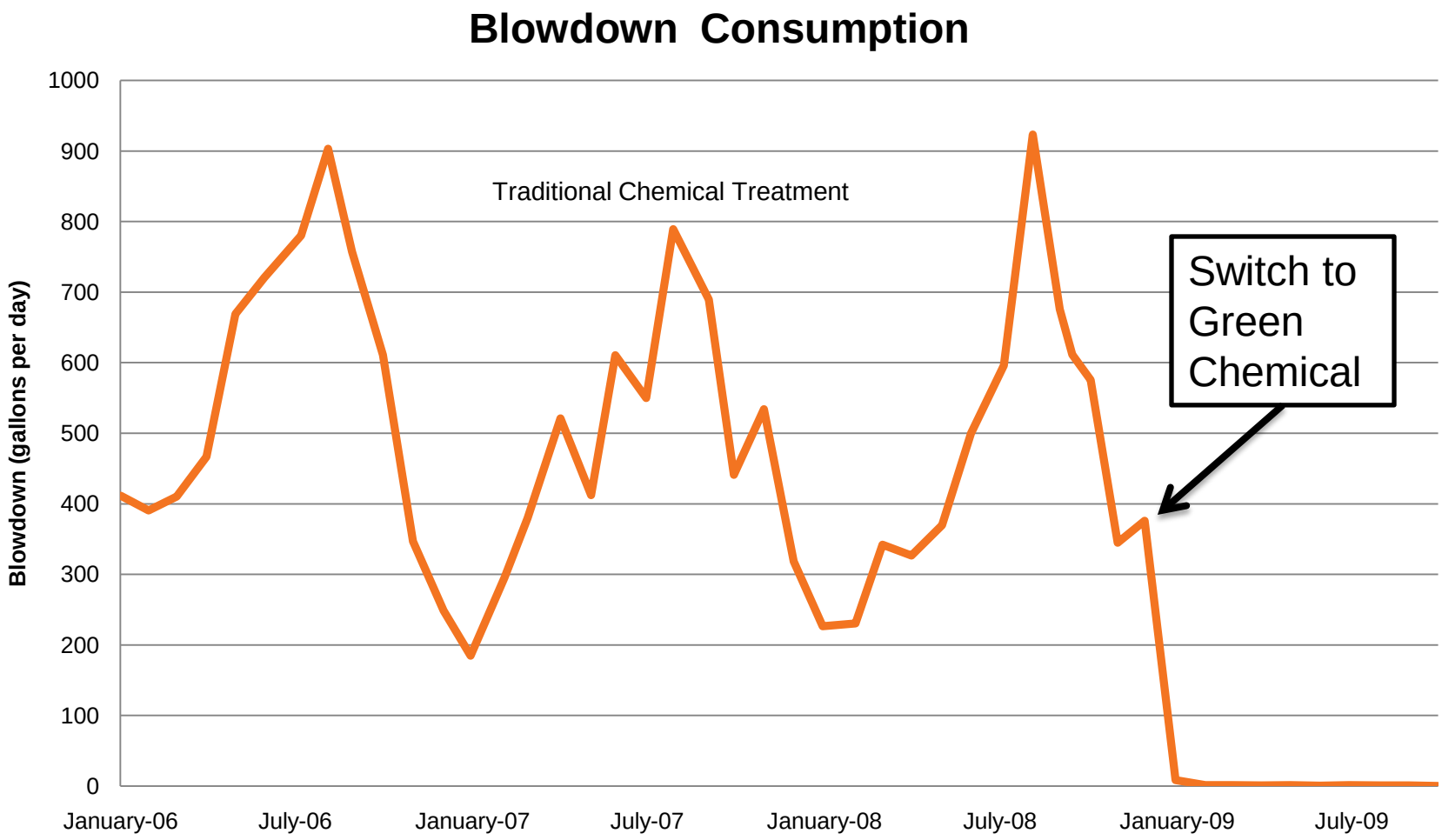
Example—800 Ton HVAC Tower

Assume: average 25% heat load, 24 hour/day, 365 day/year

Cycles	Makeup water	Blowdown water
5	15 gpm 10,800 gpd 3,942,000 gpy	3 gpm 2,160 gpd 788,400 gpy
40	12.3 gpm 8,860 gpd 3,234,500 gpy	0.3 gpm 220 gpd 80,900 gpy
Savings	2.7 gpm 1,940 gpd 707,500 gpy	2.7 gpm 1,940 gpd 707,500gpy
	$2,094/year @ $2.96/1000 gal	$1,380/year @ $1.95/1000 gal

Total Savings: $3,474/year + chemical costs

Green Chemical Treatment



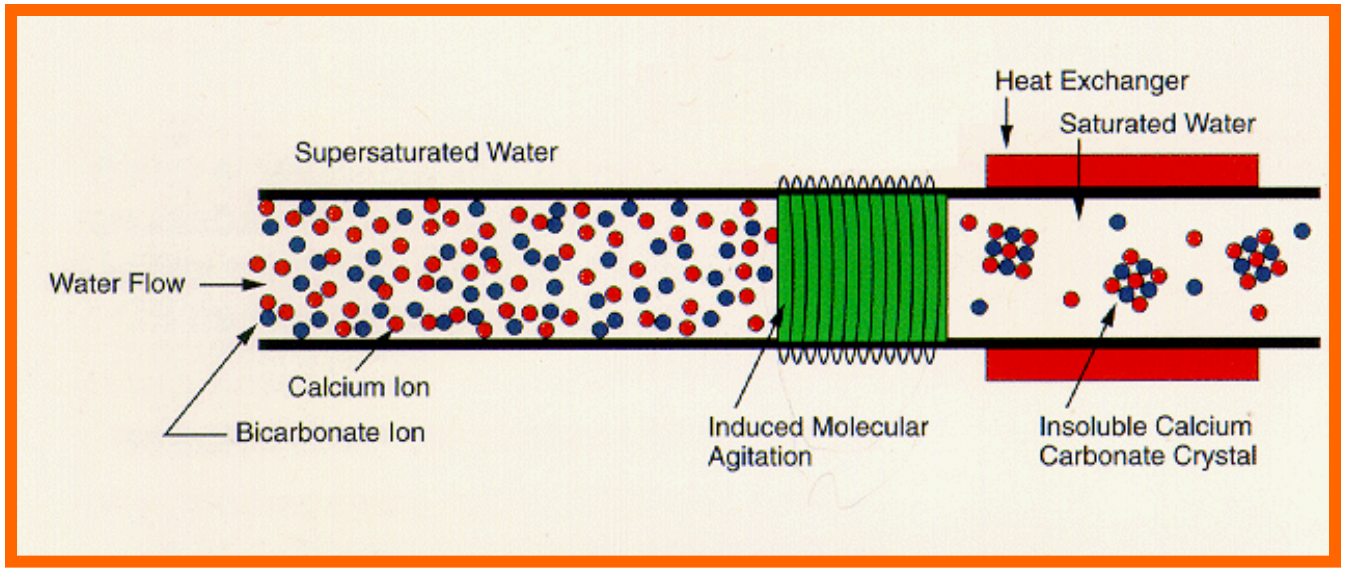
- One 330-ton tower, two chillers and plate & frame heat exchanger
- Approximately 250,000 gallons per year savings

Physical Water Treatment

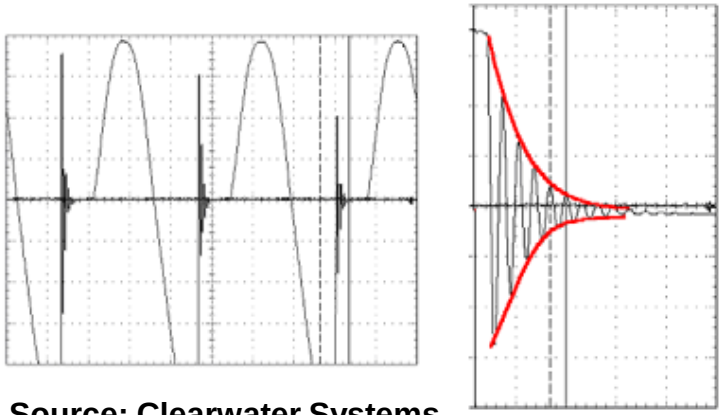
- A non-chemical method of water treatment for the purpose of scale prevention or mitigation
- Typically electromagnetic solenoid coils
- Faraday's Law

$$\int E \cdot dS = -\frac{\partial}{\partial t} \int B \cdot dA$$

PWT Operation



- Pulsed low (60 Hz) & high (10-100 kHz) frequency EM fields



Source: Clearwater Systems

Non-Chemical Water Treatment

- Electrolysis produces a high potential for scaling
- Eliminates chemical handling

- Cathodic reaction:

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

$$Ca^{2+} + 2CO_3^{2-} + OH^- \leftrightarrow CaCO_3 + CO_2 + H_2O$$

Recycled Water

- Viable alternative to domestic water
- Not always available in all areas—yet!

- Denver uses recycled water for irrigation of parks, golf courses, zoo, & power plant cooling towers!

Any Questions?

Thank You for Your Time and Your Attention

Contact

Jason Millheim, EIT, LEED® AP
Industrial Water Conservation Engineer
303-628-6067
Fax 303-628-6238
jason.millheim@denverwater.org

Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
www.denverwater.org