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A River of Energy Solutions

Water Efficient Cooling and Heating Technologies

Brian Boyd – Pacific Northwest National Laboratory

Federal Energy Management Program

The mission of the Federal Energy Management Program is to facilitate the Federal Government's implementation of sound, cost-effective energy management and investment practices to enhance the Nation's energy security and environmental stewardship.

FEMP
Federal Energy Management Program

Agenda

Why water conservation hasn't worked in the past

Where we are today

Innovation in the marketplace

We Recognize The Need, But…

Some good ideas don’t turn out as planned.

Water Conservation Challenges

Cost of water – long payback period

Leaks

Aging Infrastructure

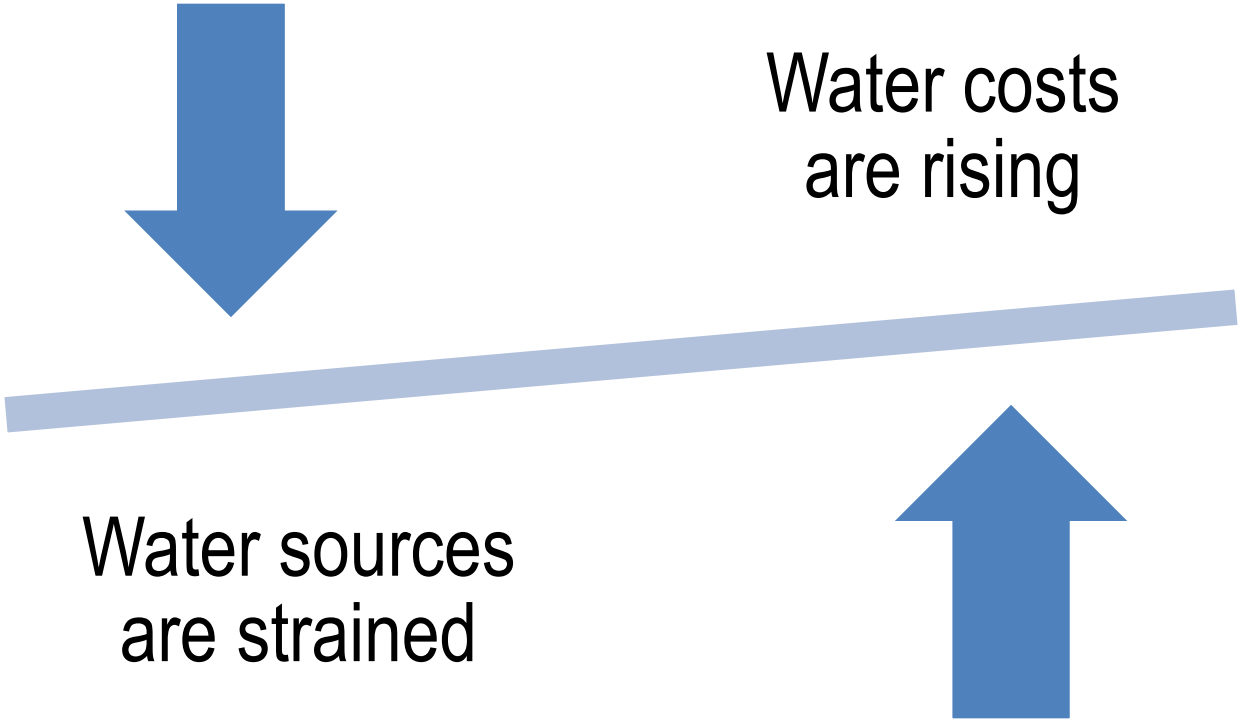
Water Conservation Challenges

Lack of, or inaccurate data

Manpower

Sold a bill of goods

Where We Are Today



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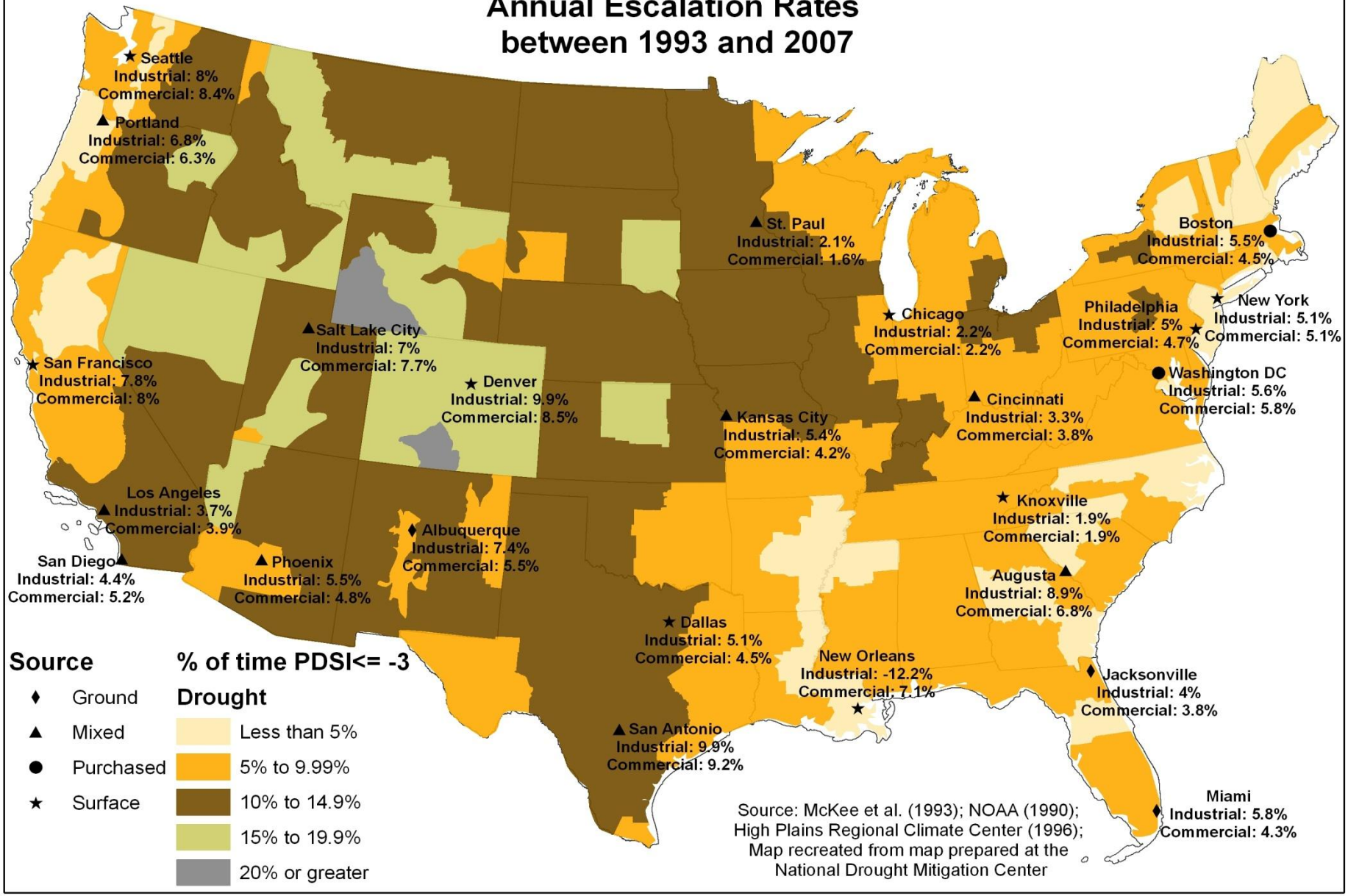
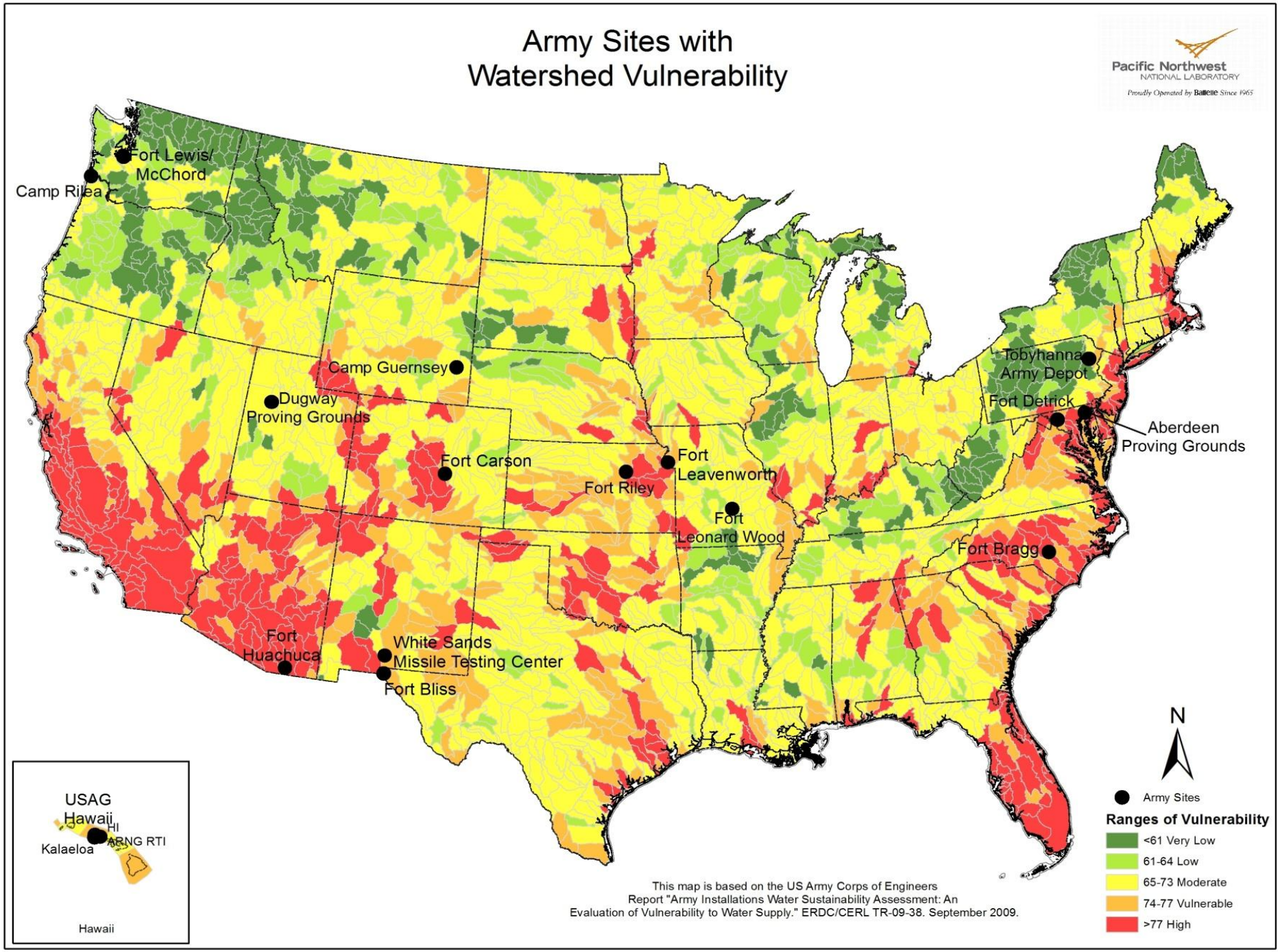
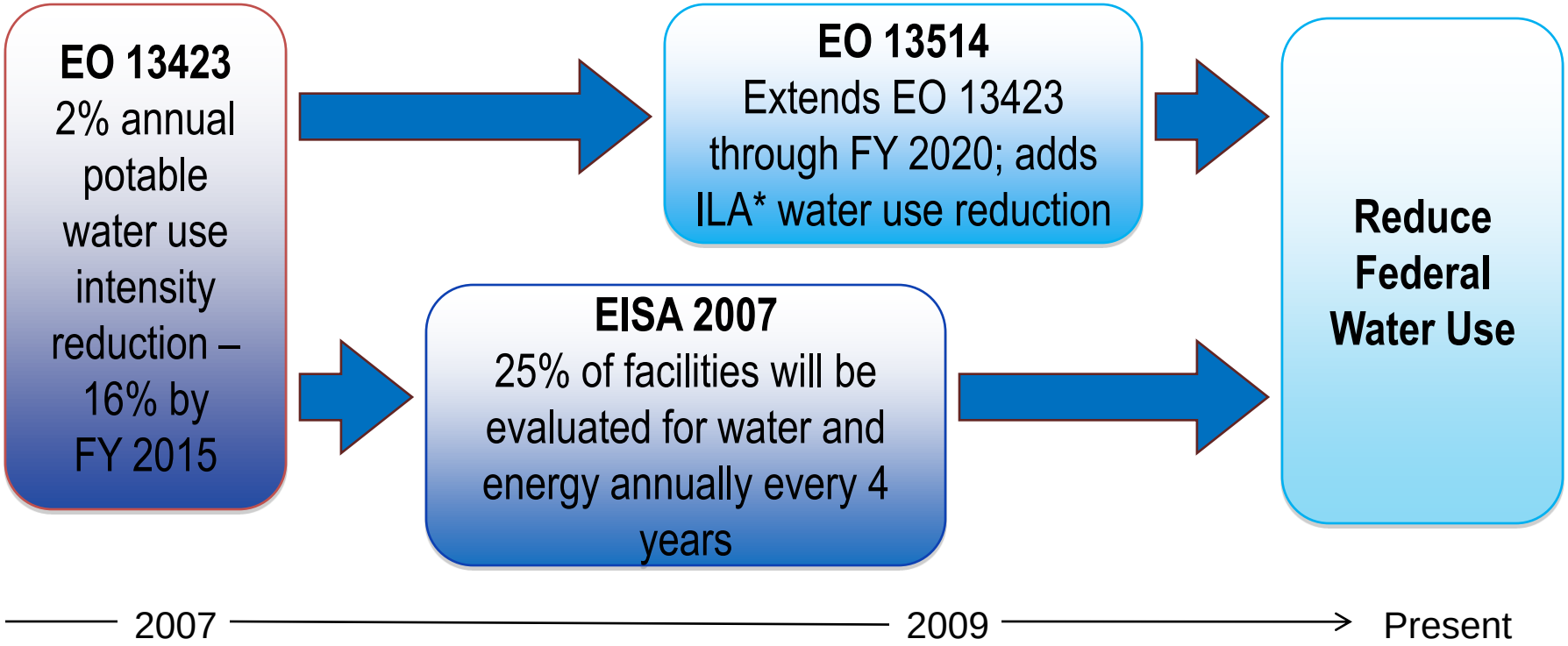
Industrial and Non-manufacturing/Commercial Annual Escalation Rates between 1993 and 2007



Army Sites with Watershed Vulnerability



Federal Policy



*Industrial, landscaping and agricultural

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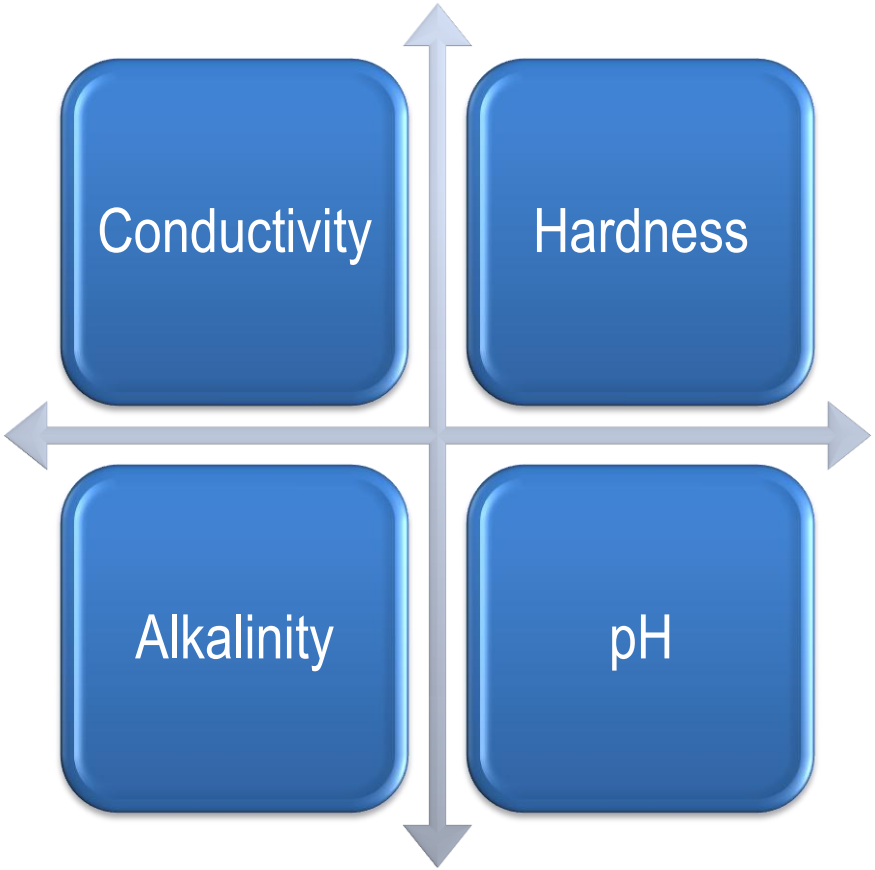
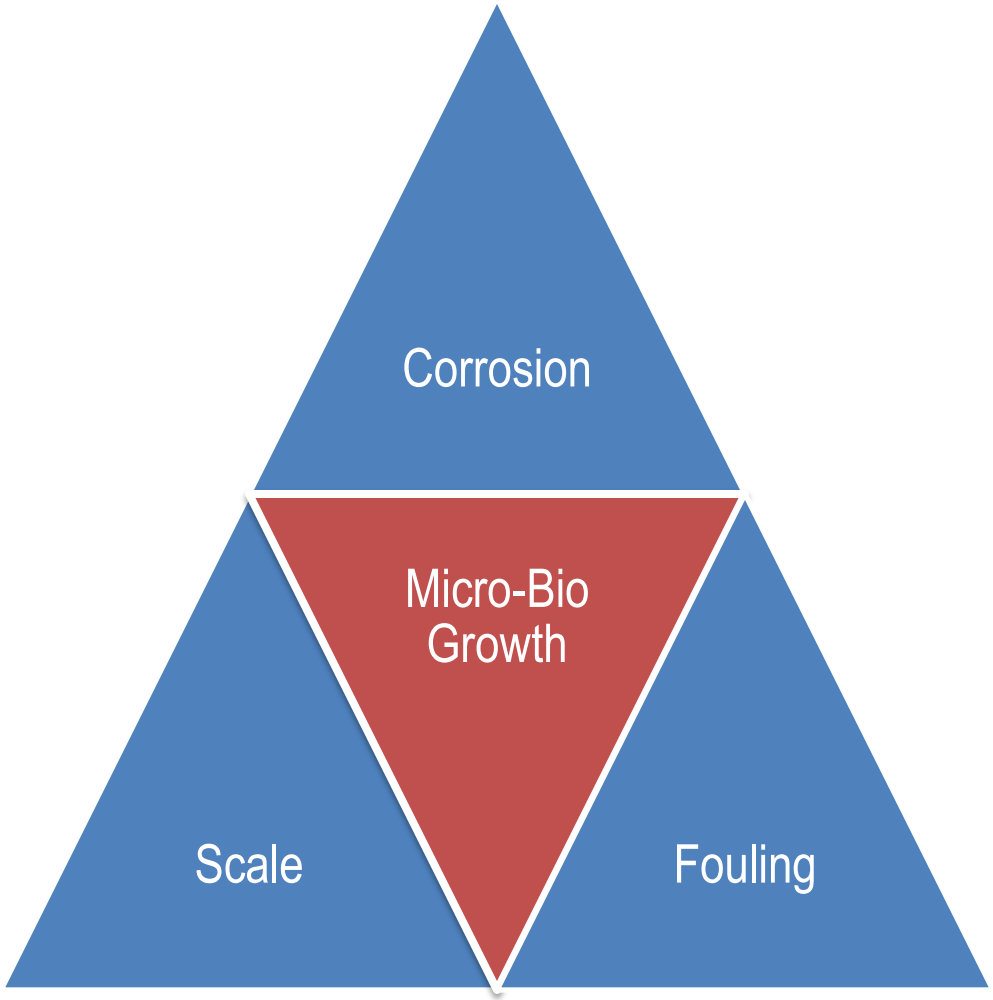
Important Properties of Water



Cooling System Concerns



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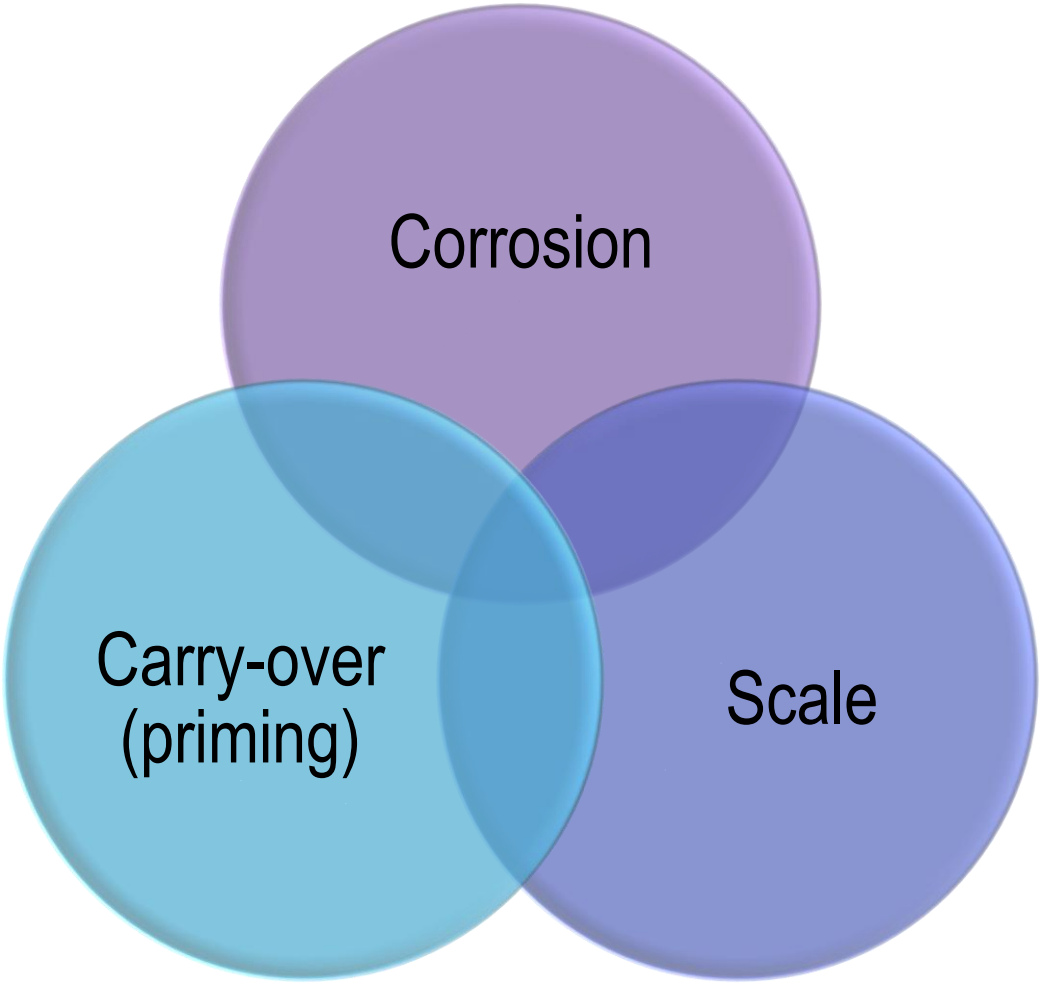
Steam Boiler System Concerns



Performance and Efficiency Opportunities

Automation

- Blowdown control
- Real-time dosing, monitoring, reporting
- Bio-monitoring

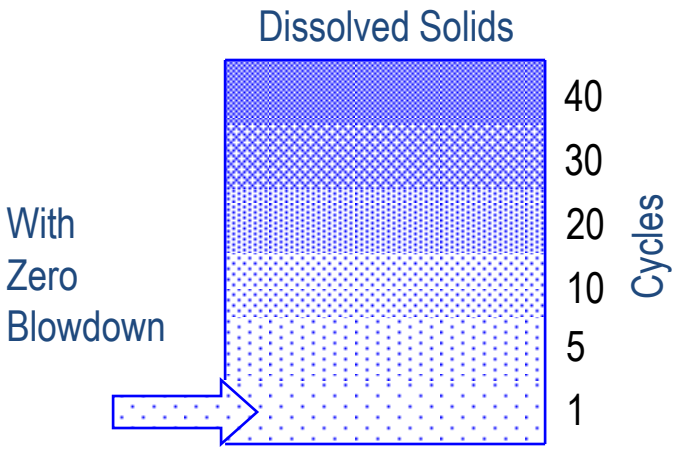
Equipment

- Softening
- Side stream filtration
- Ozone/UV microbiological control (cooling towers)

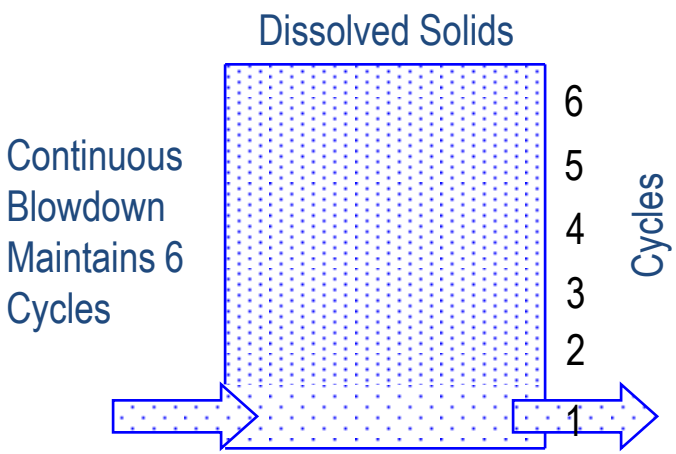
Chemicals

- “Green” programs
- Know your system – includes knowing your treatment program

Impact of Blowdown



Mineral scale will form if the dissolved solids concentration in the cooling water or boiler becomes too high



Blowdown: Deliberate discharge of water to prevent the dissolved solids from getting too high

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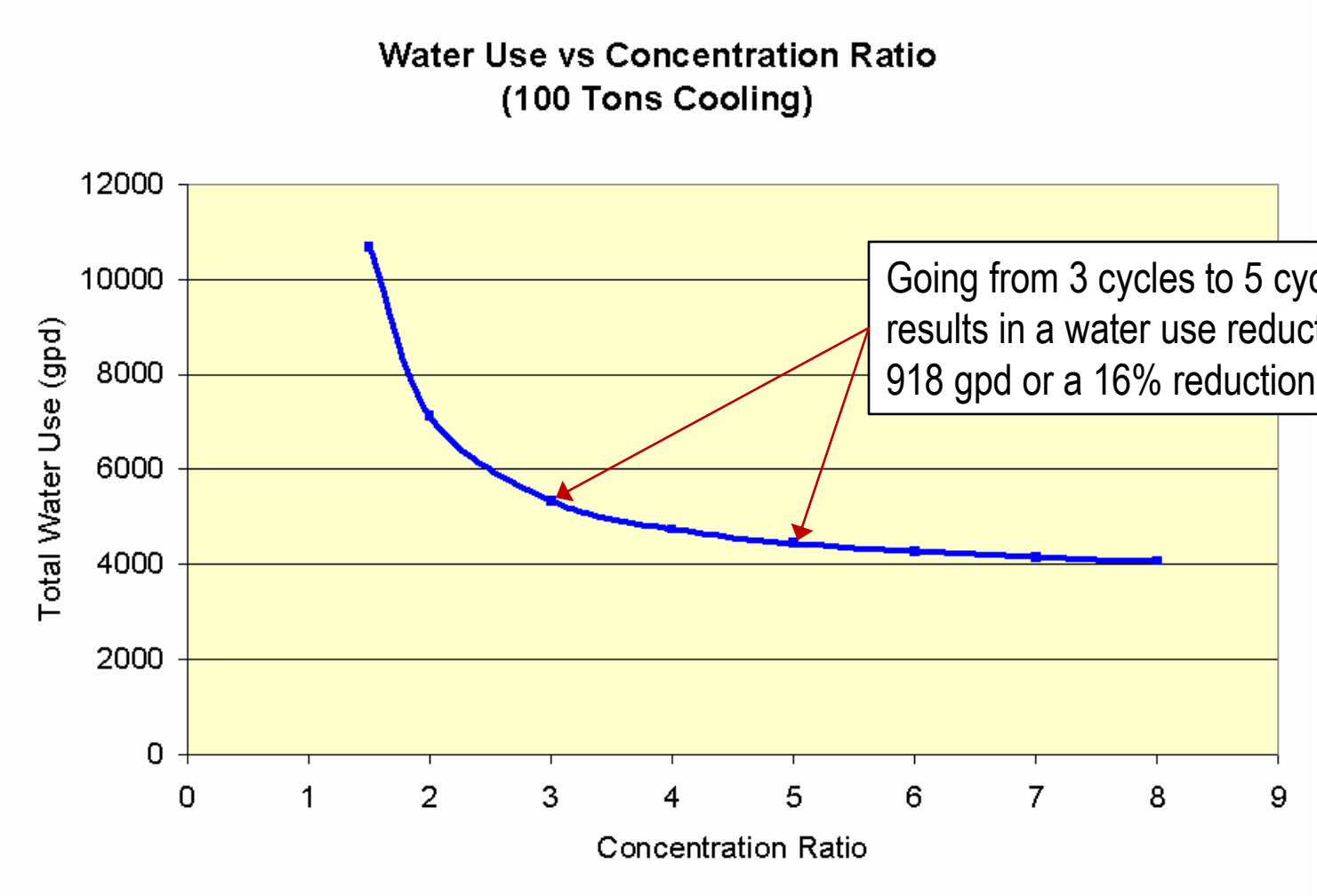
Maximize Cycles of Concentration



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Cooling and Boiler System Control

Efficient operation of the cooling system or steam boiler system is critical to meeting your cooling and heating load requirements

- Is your system running efficiently?
- What are the limiting factors?

Optimal operation of cooling systems or steam boiler systems are dependent on two things

- Maintain good mechanical **control**
- Maintain good chemical **control**

Steam Boiler Limits

Boiler Operating Pressure (psig) (bar)	Total Dissolved Solids - TDS - (ppm)	Total Alkalinity (ppm)	Total Suspended Solids (ppm)
0 - 50 0 - 3.5	2500	500	
50 - 300 3.5 - 20	3500	700	15
300 - 450 20 - 30	3000	600	10
450 - 600 30 - 40	2500	500	8
600 - 750 40 - 50	1000	200	3
750 - 900 50 - 60	750	150	2
900 - 1000 60 - 70	625	125	1

The maximum recommended concentration limits according to ABMA - American Boiler Manufacturers Association

Steam System Example

As an example, let's consider a steam boiler system with the following operating conditions:

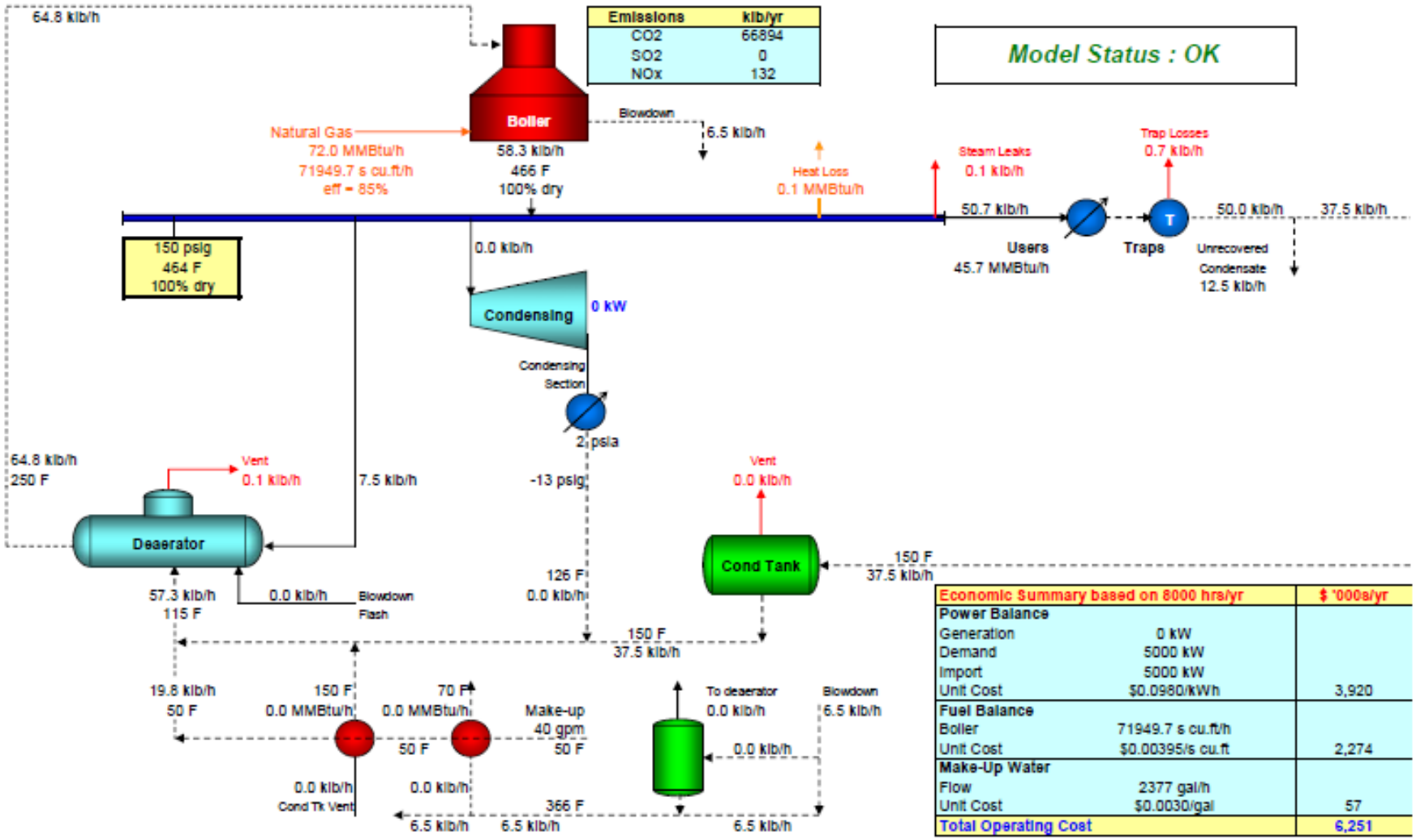
- Header pressure of 150 psig
- End-use steam demand of 50,000 lbs/hr
- Boiler is fired with natural gas at a cost of $3.95/kcf
- Make-up water cost is $3.00/kgal
- 75% condensate return

We'll use DOE's Steam System Assessment Tool* to see the impact of the following improvements:

- Increasing cycles of concentration from 10 to 20
- Increasing the condensate return to 80%

* Available for download at http://www1.eere.energy.gov/industry/bestpractices/software_ssat.html

Base Scenario



Economic Summary based on 8000 hrs/yr		$ '000s/yr
Power Balance		
Generation	0 kW	
Demand	5000 kW	
Import	5000 kW	
Unit Cost	$0.0980/kWh	3,920
Fuel Balance		
Boiler	71949.7 s cu.ft/h	
Unit Cost	$0.00395/s cu.ft	2,274
Make-Up Water		
Flow	2377 gal/h	
Unit Cost	$0.0030/gal	57
Total Operating Cost		**6,251**

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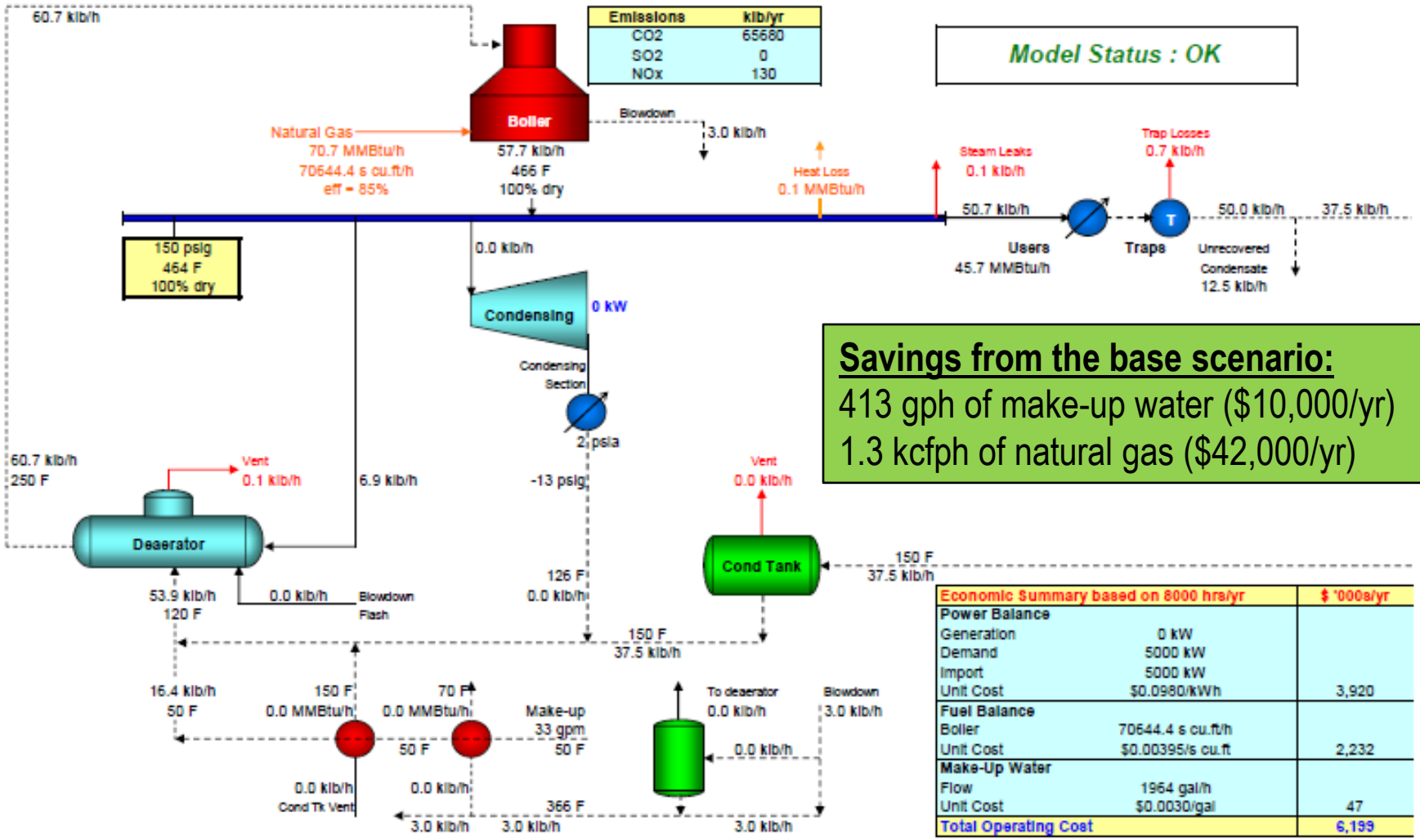
Increased Cycles of Concentration



Savings from the base scenario:

413 gph of make-up water ($10,000/yr)

1.3 kcfph of natural gas ($42,000/yr)

Economic Summary based on 8000 hrs/yr		$ '000s/yr
Power Balance		
Generation	0 kW	
Demand	5000 kW	
Import	5000 kW	
Unit Cost	$0.0980/kWh	3,920
Fuel Balance		
Boiler	70644.4 s cu.ft/h	
Unit Cost	$0.00395/s cu.ft	2,232
Make-Up Water		
Flow	1964 gal/h	
Unit Cost	$0.0030/gal	47
Total Operating Cost		6,199

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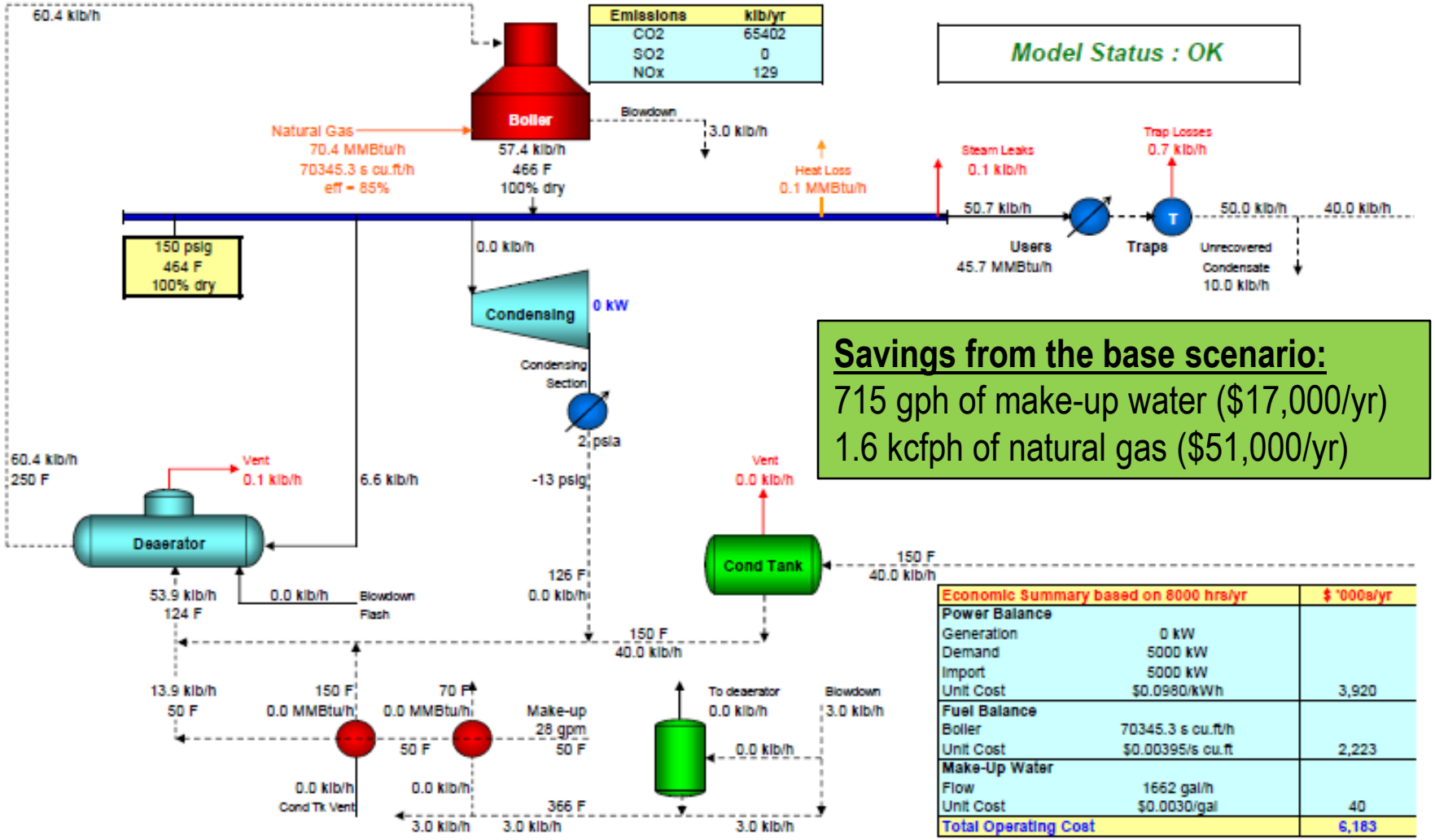
Increased Condensate Return



Savings from the base scenario:

715 gph of make-up water ($17,000/yr)

1.6 kcfph of natural gas ($51,000/yr)

Economic Summary based on 8000 hrs/yr		$ '000s/yr
Power Balance		
Generation	0 kW	
Demand	5000 kW	
Import	5000 kW	
Unit Cost	$0.0980/kWh	3,920
Fuel Balance		
Boiler	70345.3 s cu.ft/h	
Unit Cost	$0.00395/s cu.ft	2,223
Make-Up Water		
Flow	1662 gal/h	
Unit Cost	$0.0030/gal	40
Total Operating Cost		**6,183**

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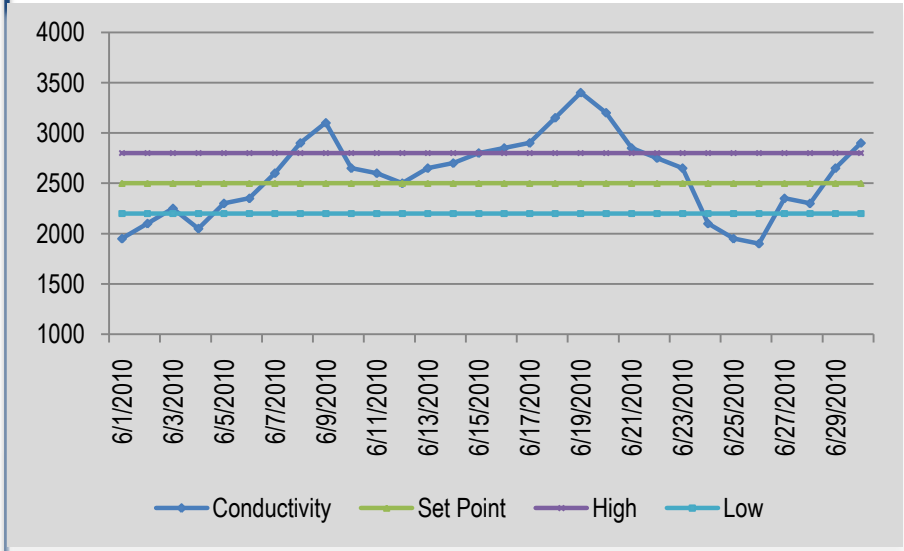
Benefits of Automation

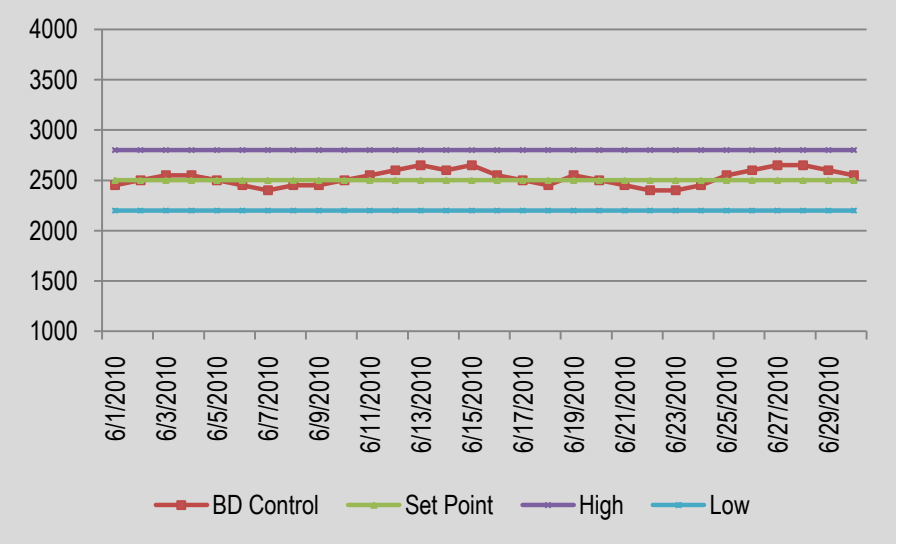
Blowdown controls

Conductivity control	Chemical dosing	Water meter inputs	Alarm relays

Manual or Timed Blowdown



Conductivity Set-point Blowdown



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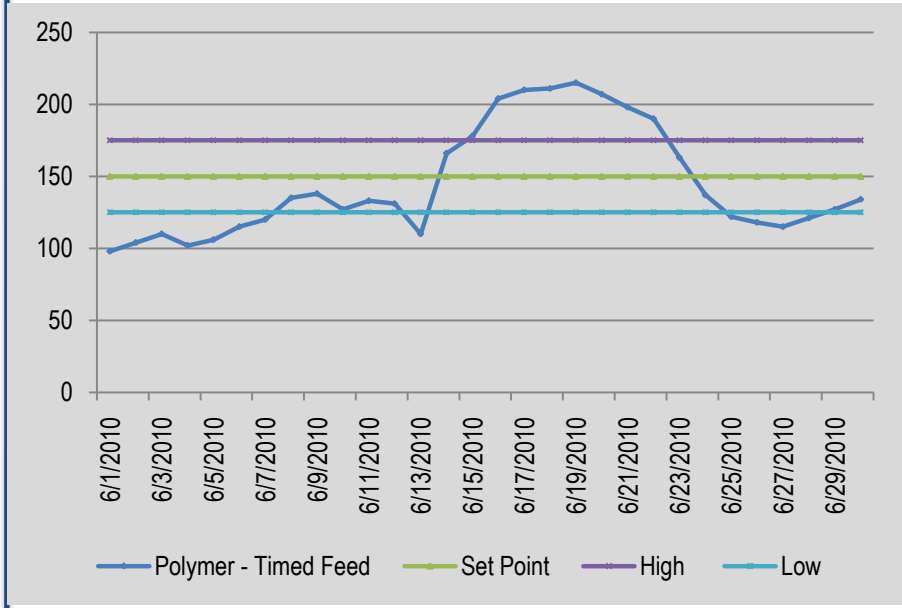
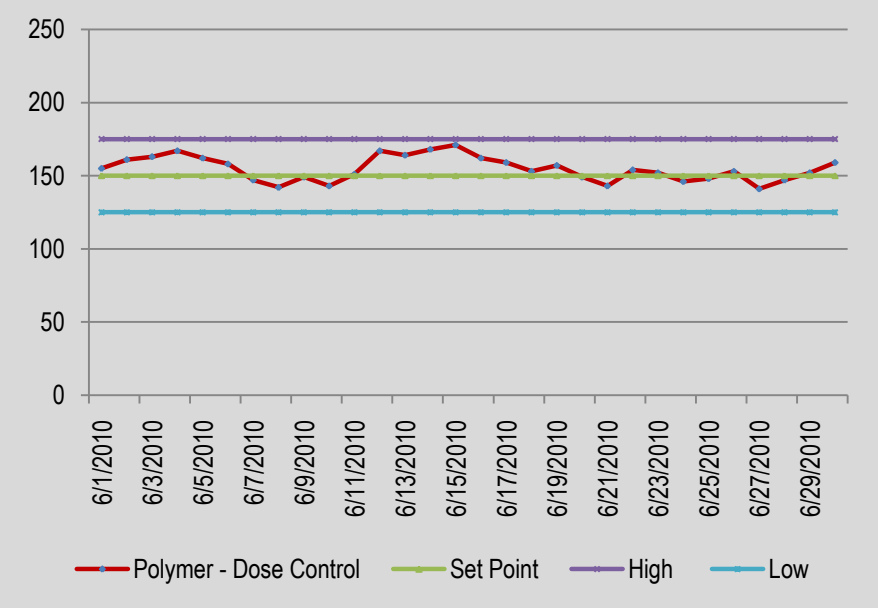
Benefits of Automation

System-wide monitoring and dosing

Conductivity/ blowdown control	pH	ORP	Real-time chemical monitoring and dosing	Continuous corrosion monitoring	Web-enabled reporting	Alarm relays





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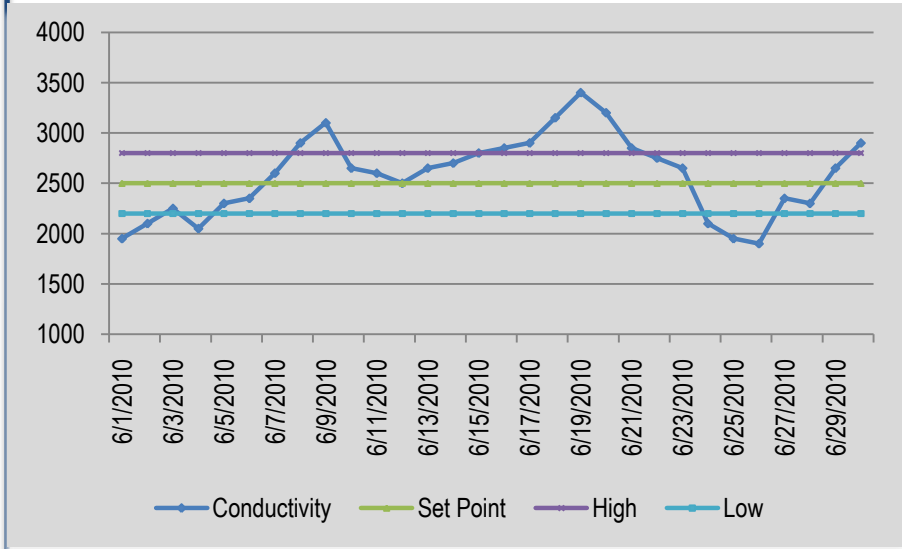
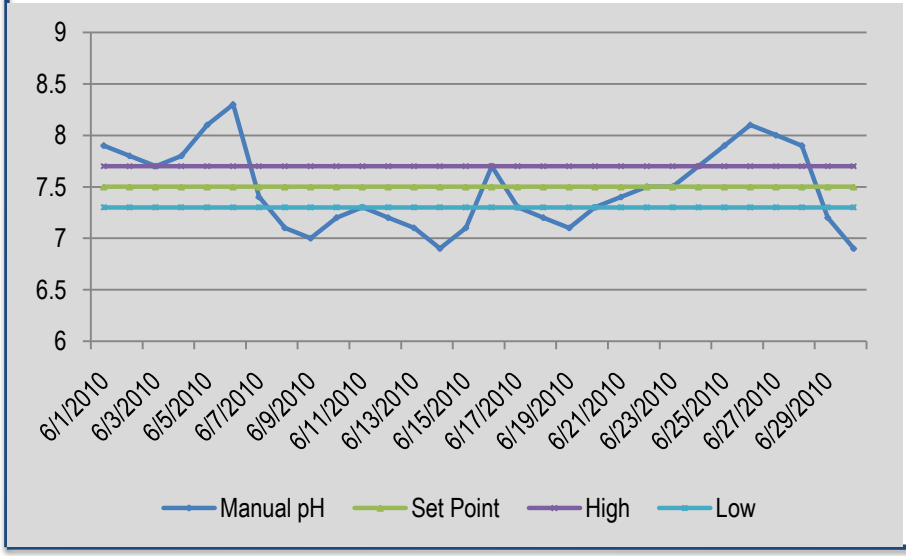
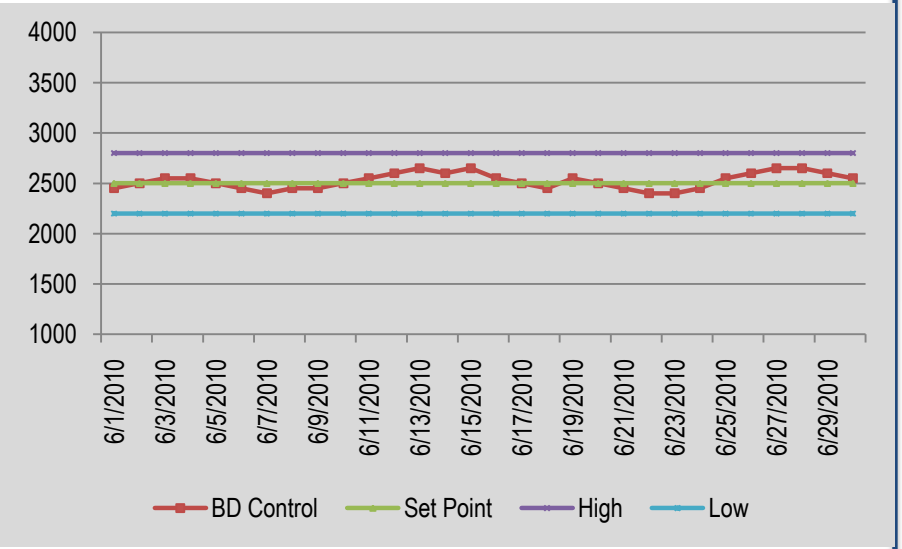
Benefits of Automation

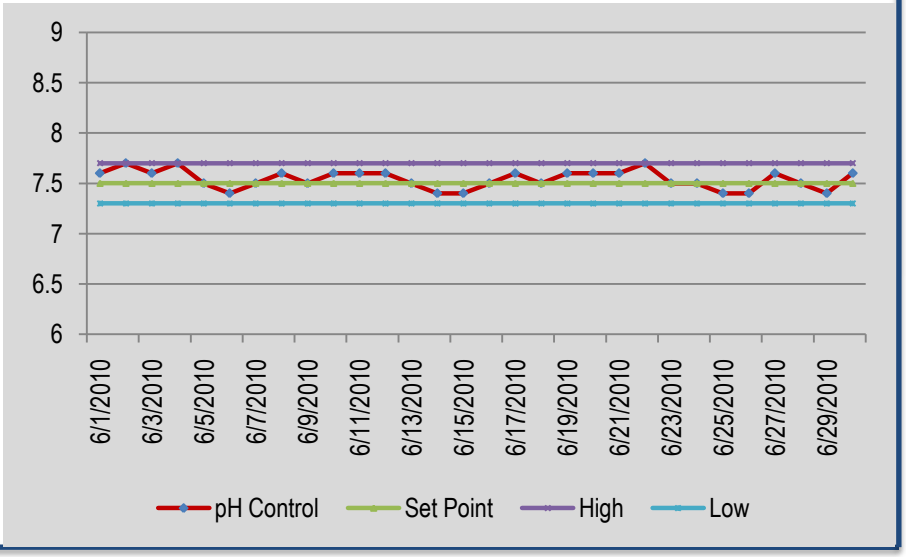
Manual Control



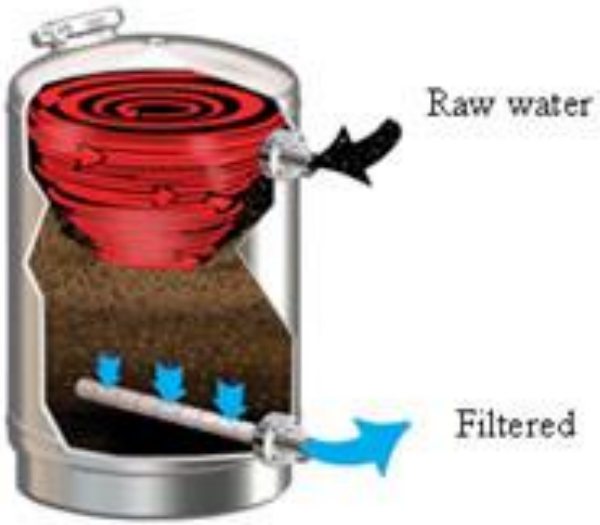


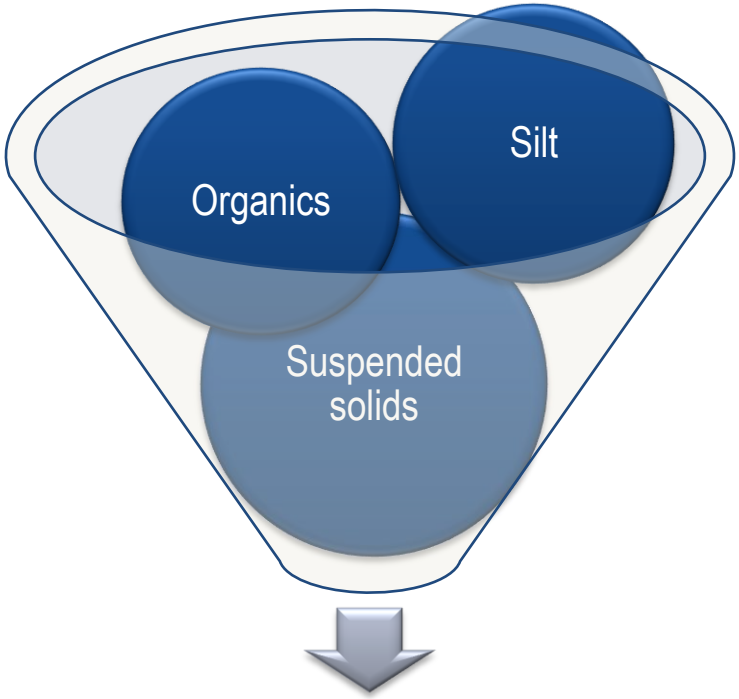
Automated Control





Side-Stream Filtration





Filtration down to 0.45 microns

Softeners

Scale	Corrosion
Minimize or eliminate hardness	Corrosion inhibitors
Make-up or side-stream	Tight pH/alkalinity control
	Manage corrosion rates

The Hidden Enemy

Estimating Techniques

- Measure water use during "off hours"
- Zone flow procedure – isolate zones in distribution system
- Full scale leak detection program
  - Acoustic method
  - Dye injection technique

The Hidden Enemy

Loss Type	Cause of Loss	
Leaks ("real")	• Poor installation • Aging materials • Incorrect backfill • Vibration	• Pressure fluctuations • Excess pressure • Corrosion • Loose or damaged parts in valves and meter boxes
Meter Reading Errors ("paper")	• Aging meters • Water quality impacts • Extreme heat/cold	• Installation errors • Incorrect sizing • Wrong type for application • Non-calibrated meters
Accounting Errors ("paper")	• Overlapping billing cycles • Conversion factor errors • Mistakes in billing procedures	• Changes in buildings such as renovations where new service lines are in place but not metered

Industrial Water Efficiency

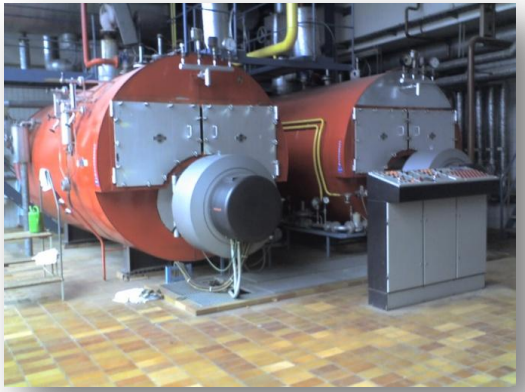
Cooling Towers and Boilers

- Reduce demand – seasonal load and time of day scheduling to reduce heating and cooling demand
- Ensure proper operation – operate according to design
- Consider alternate sources for water supply
- Blowdown controls – maximize cycles of concentration

Vehicle Wash Stations and Other Batch Processes

- Consider alternate sources for water supply
- Maximize recycle (use last stage rinse in first stage wash)

Questions?



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