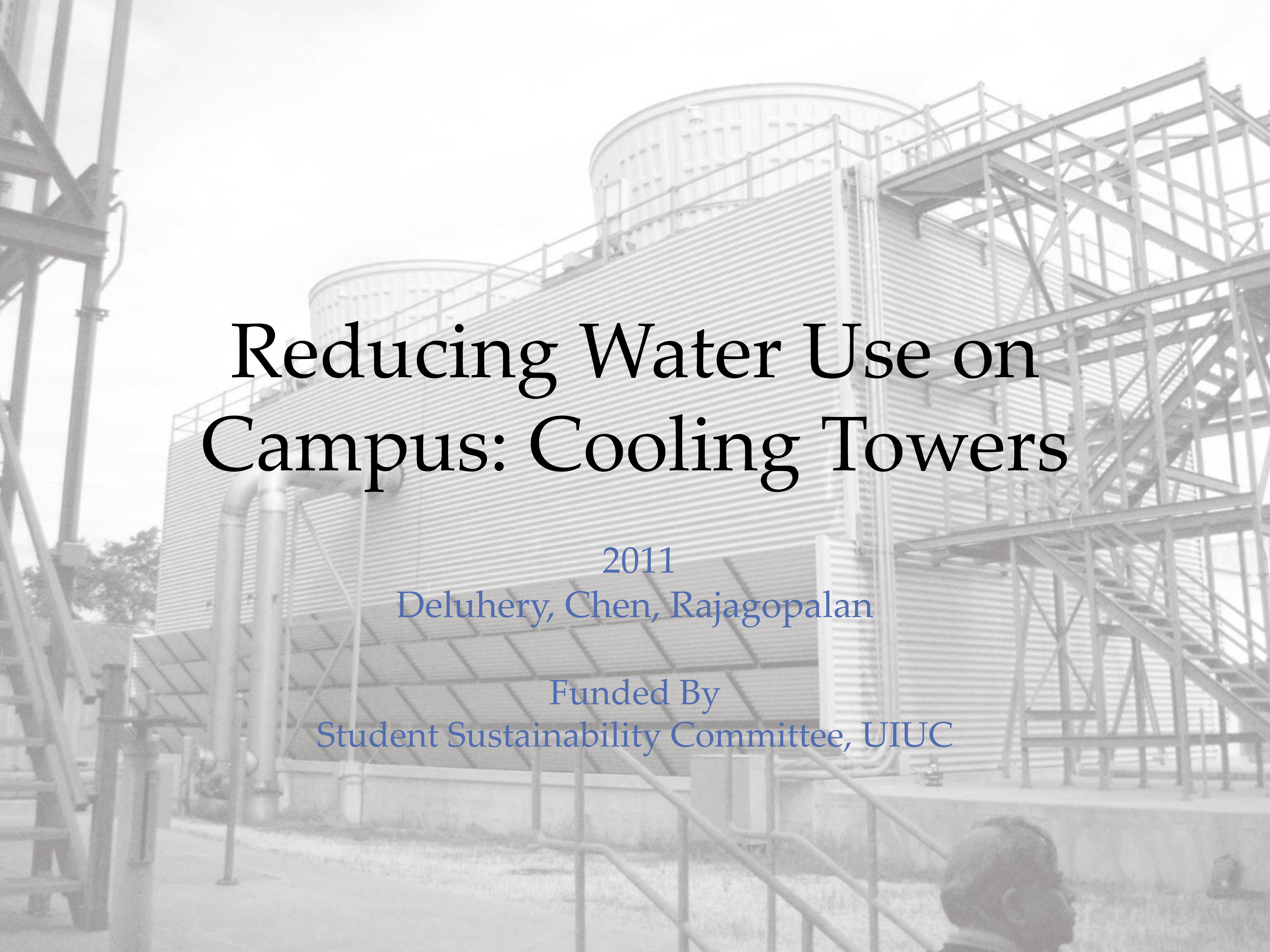


Reducing Water Use on Campus: Cooling Towers

2011

Deluhery, Chen, Rajagopalan

Funded By
Student Sustainability Committee, UIUC

In 2008, the University of Illinois at Urbana Champaign signed on to the American College & University Presidents' Climate Commitment.

In 2010, the completed Illinois Climate Action Plan (iCAP) was published.

"Our intentions are clear and our goal remains ambitious: to be the model of sustainability for all universities in the nation."

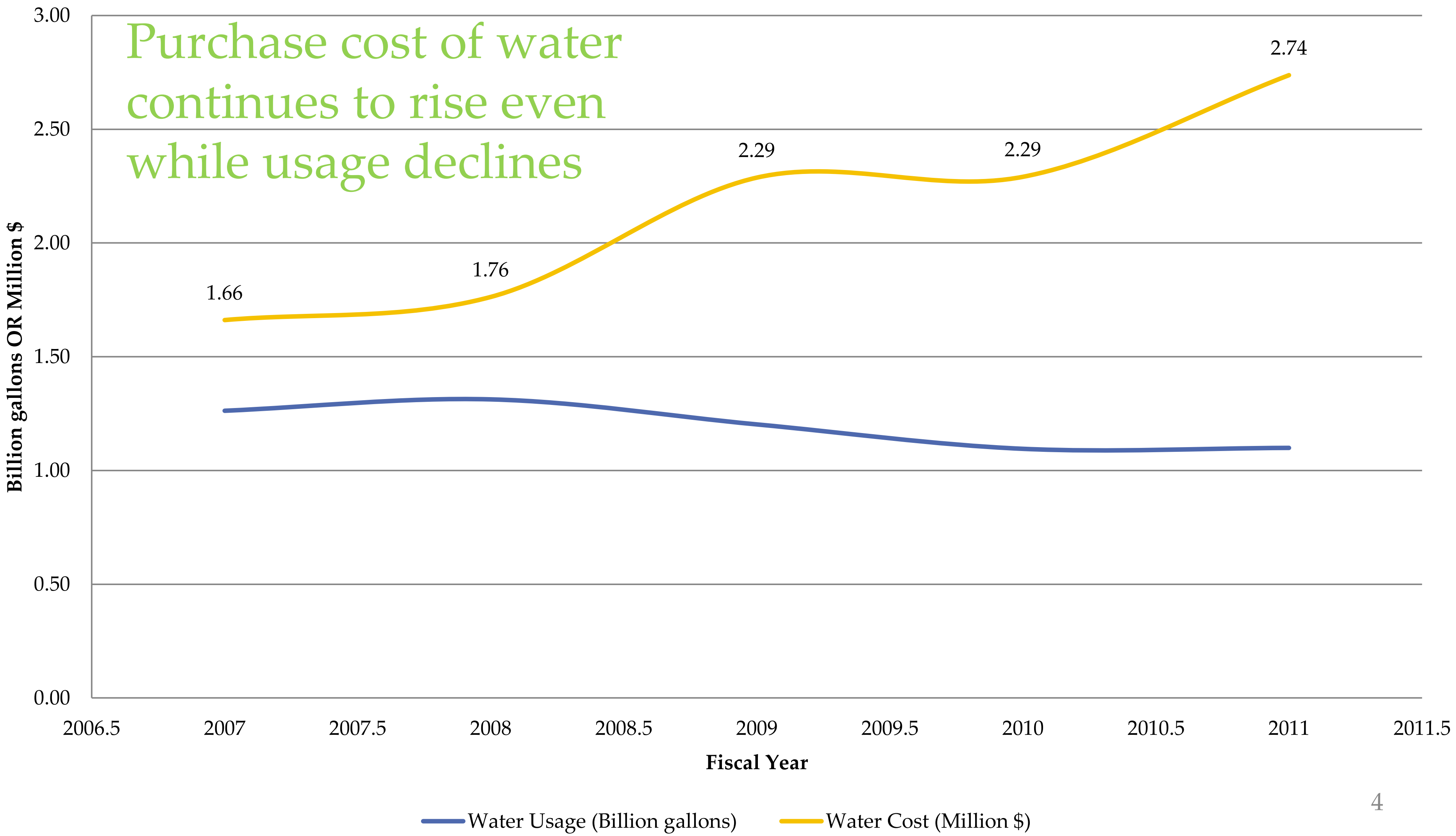
-Robert A. Easter, *Chancellor* (iCAP)

The campus has made a commitment to reducing greenhouse gas emissions, energy and water use.

The University's goal is a 20% reduction of campus potable water consumption by 2015. A 40% reduction by 2025 is envisioned.

Meeting this goal requires closely examining how water is currently used on campus and what opportunities are available for improvement.

Current Campus Water Use and Costs



Project Goals

- Benchmark Water Use in Cooling Towers & at Abbott RO Plant
- Generate Ideas for Improving Water Use Efficiency

Customer/Collaborator – F & S

Project Sponsor – Student Sustainability Committee

Follow-Up

Actions

- Install Trasar 3D monitoring at Oak St and Vet Med Chiller Plants
- Feasibility study of sulfuric acid dosing to increase COC at chiller plants
- Optimize Abbott Cooling Tower and RO as a whole system
- Benchmark softener plant performance at Abbott/other locations

Pilot Studies

- Piloting of Nanofiltration of Oak Street seepage water as make-up for cooling tower
- Pilot investigation of non-chemical water treatment (especially VRTX) technologies for stand-alone towers
- Pilot investigations of non-chemical softening using zeolite based resins

All Campus Water Use FY 2011

When we start to look at how water is used on campus it is clear that the water used at Cooling Towers is a large percentage of the pie. Some advantages of focusing on water conservation at these locations is that they are (a) point sources and (b) actively managed by dedicated and trained personnel.

UIUC Cooling Tower Location Map

http://goo.gl/maps/jf6K

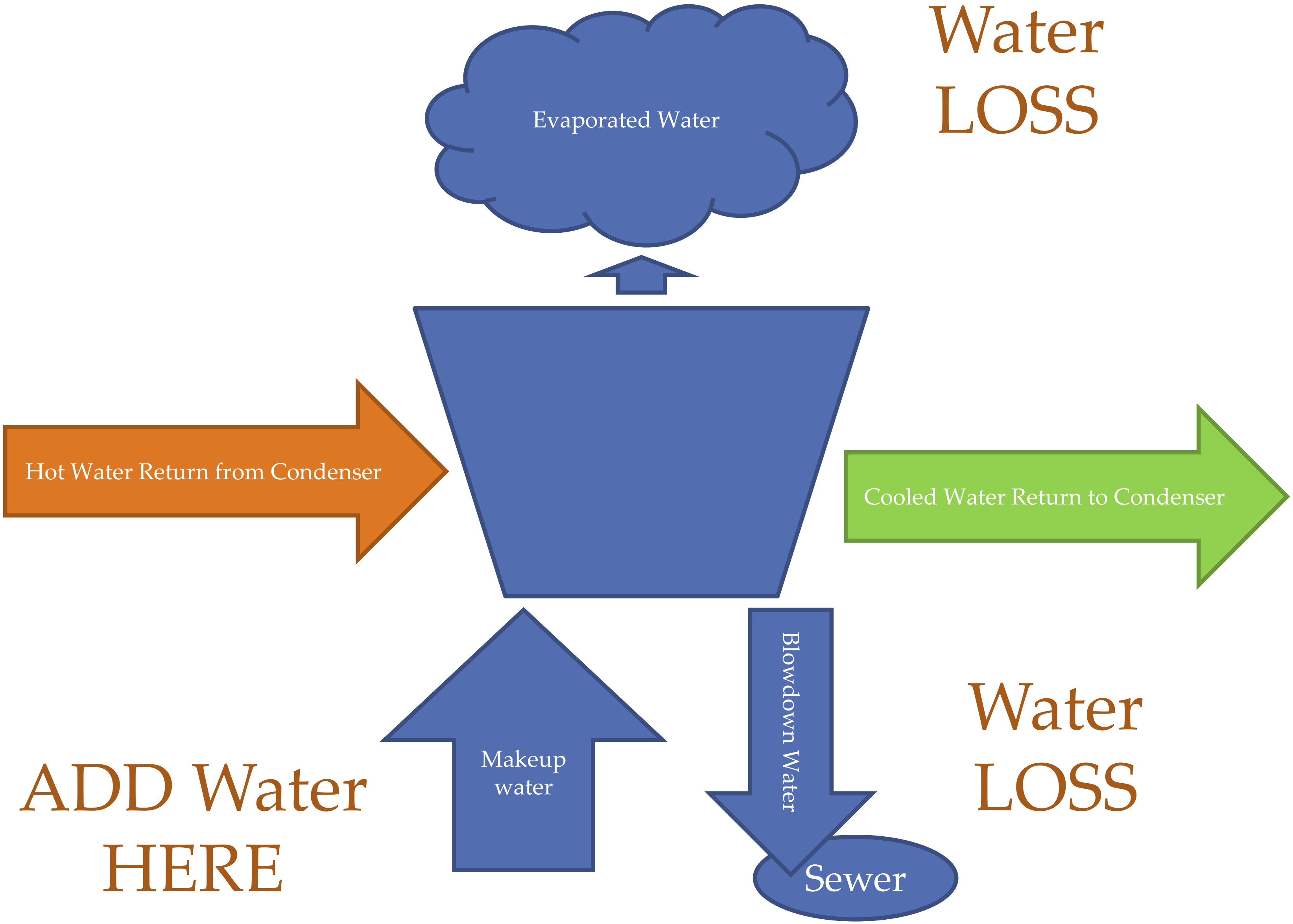
As you can see on the map, Cooling tower locations are spread all over the University Campus. The spatial distribution of towers is a barrier to close monitoring at many locations. The larger Chiller Plants, however, are closely monitored by on-site staffing on a daily basis.

What is a Cooling Tower?

- Equipment that cools water through evaporation

- On campus, primarily used to remove heat from buildings, especially in summer.

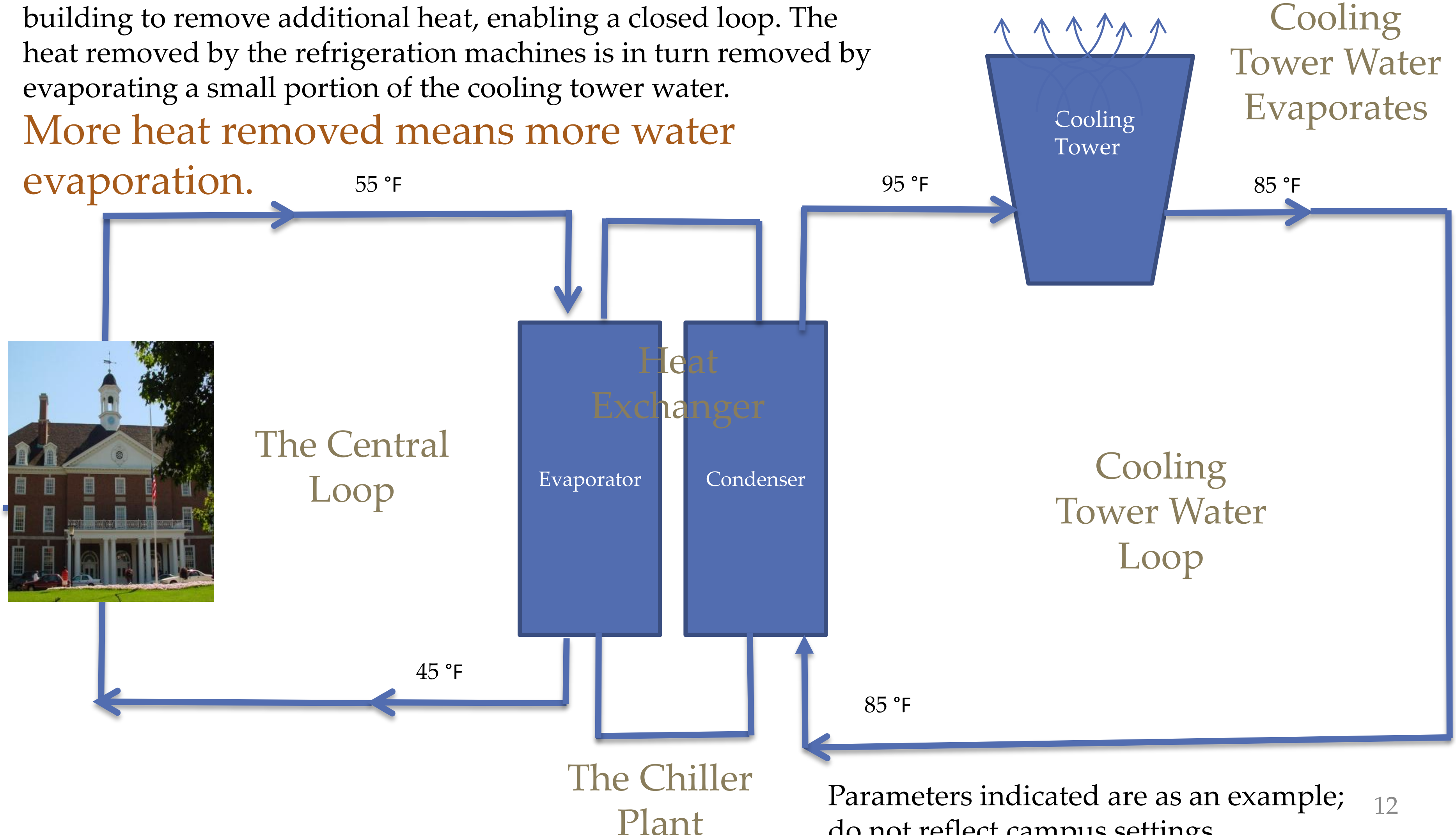
Why Do Cooling Towers Consume Water?



Where Does A Cooling Tower Fit?

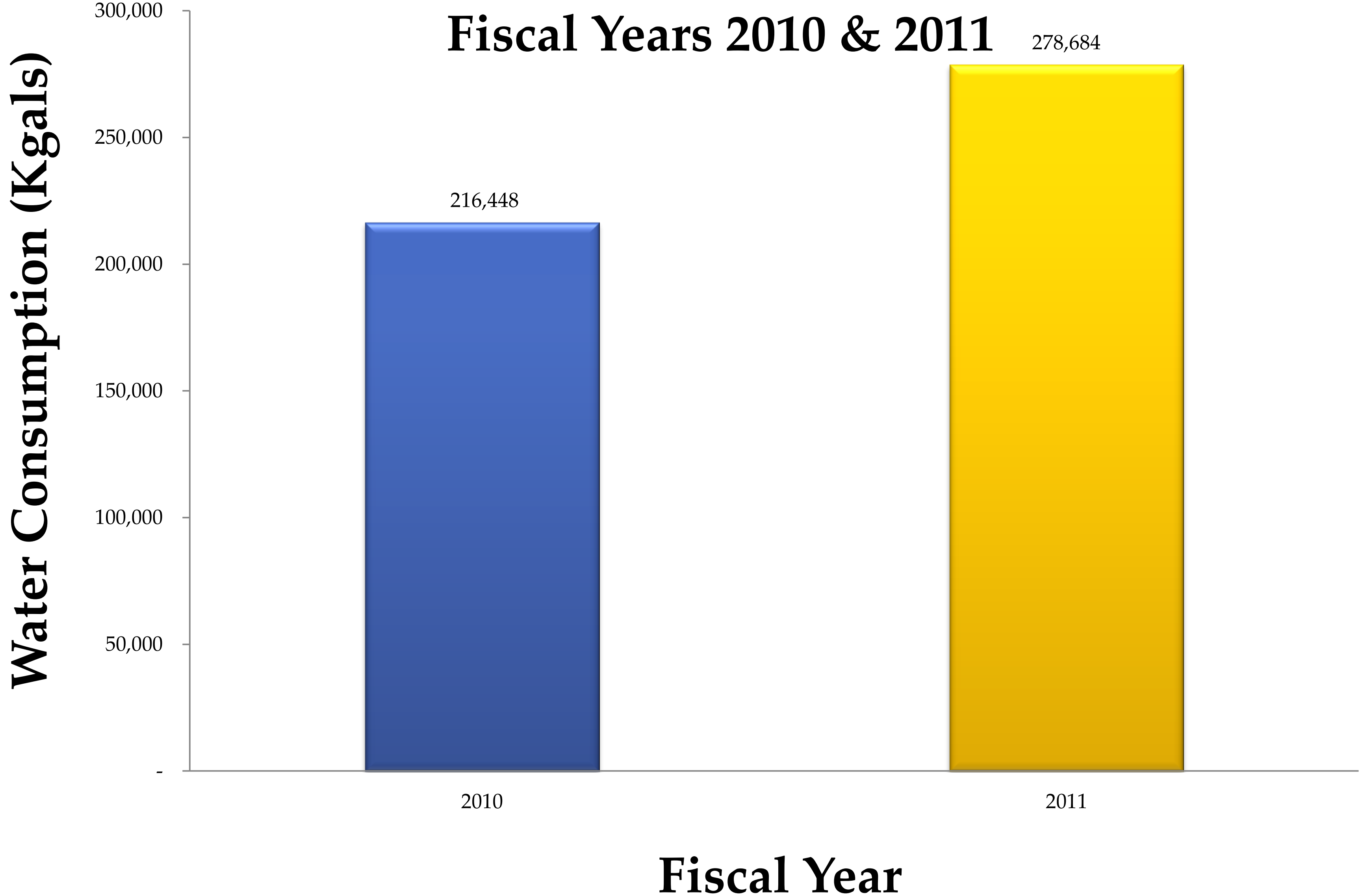
Building heat is removed by chilled water. Giant refrigeration machines remove heat from chilled water and send it back to the building to remove additional heat, enabling a closed loop. The heat removed by the refrigeration machines is in turn removed by evaporating a small portion of the cooling tower water.

More heat removed means more water evaporation.



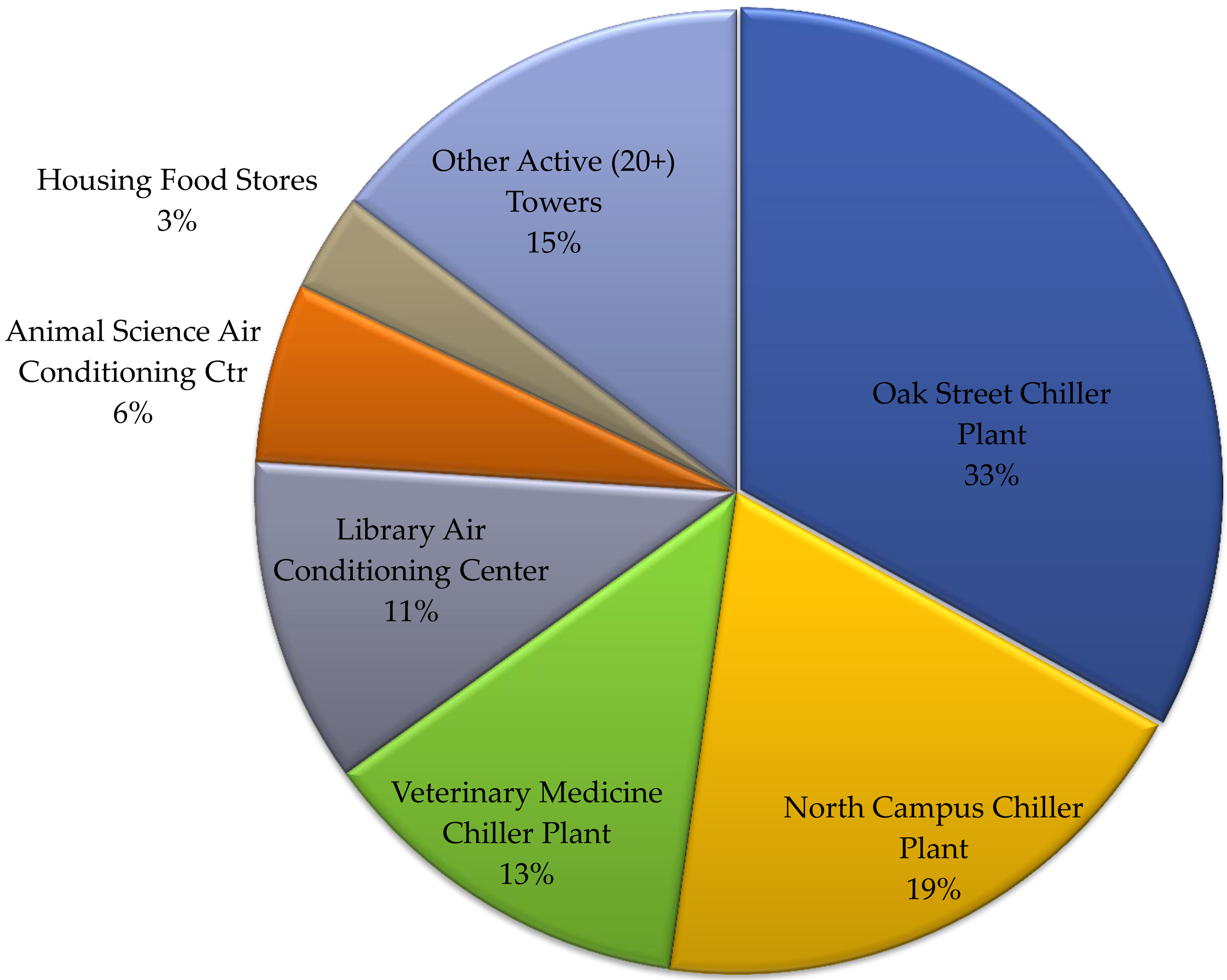
Parameters indicated are as an example; do not reflect campus settings.

Water Consumption Data For All Campus Cooling Towers
Fiscal Years 2010 & 2011



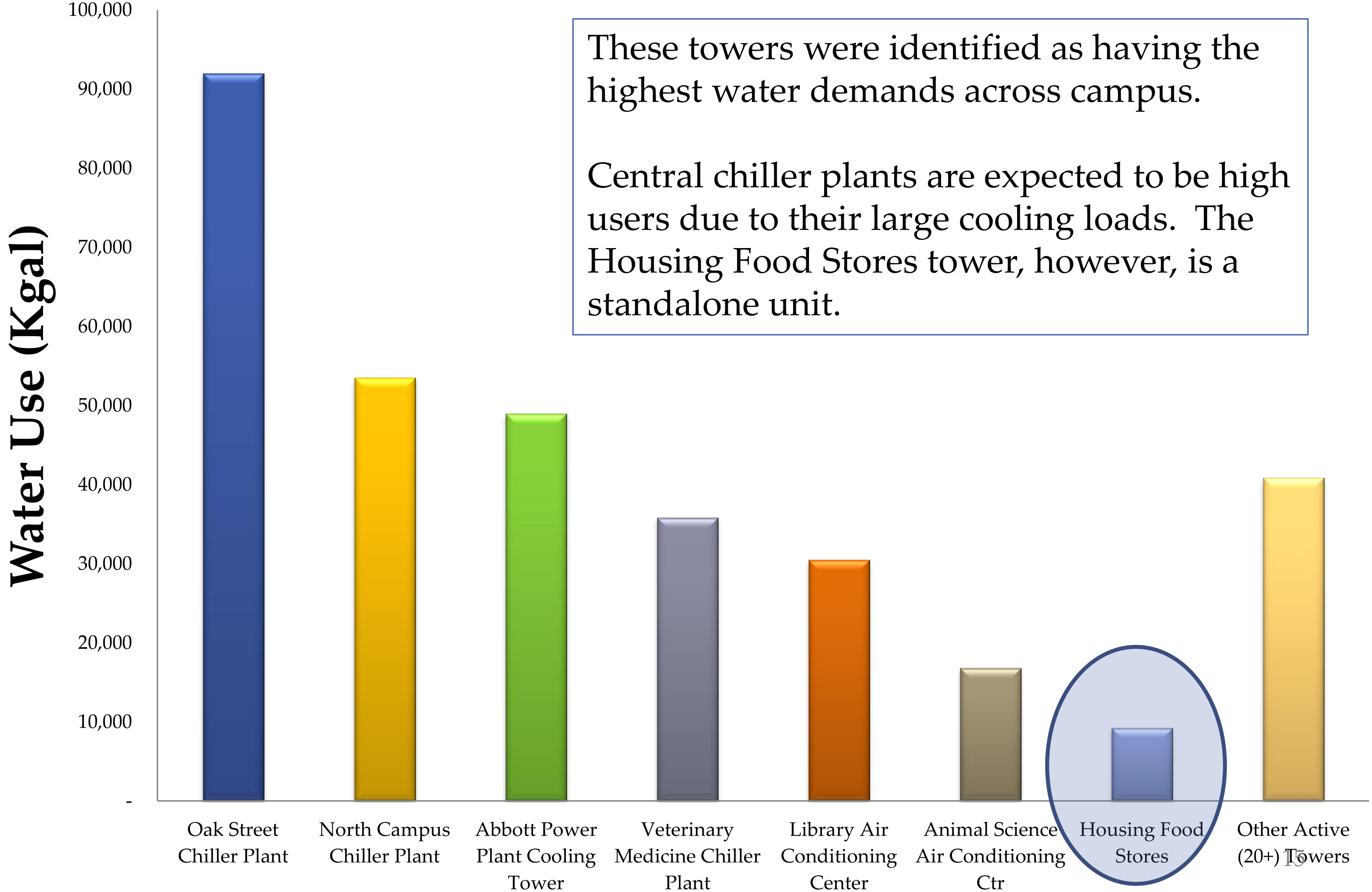
Does not include Abbott

Campus Cooling Tower Water Use FY 2011
Without Abbott Power Plant



* CLSL off for most of the year to bring it onto the loop as a booster chiller.

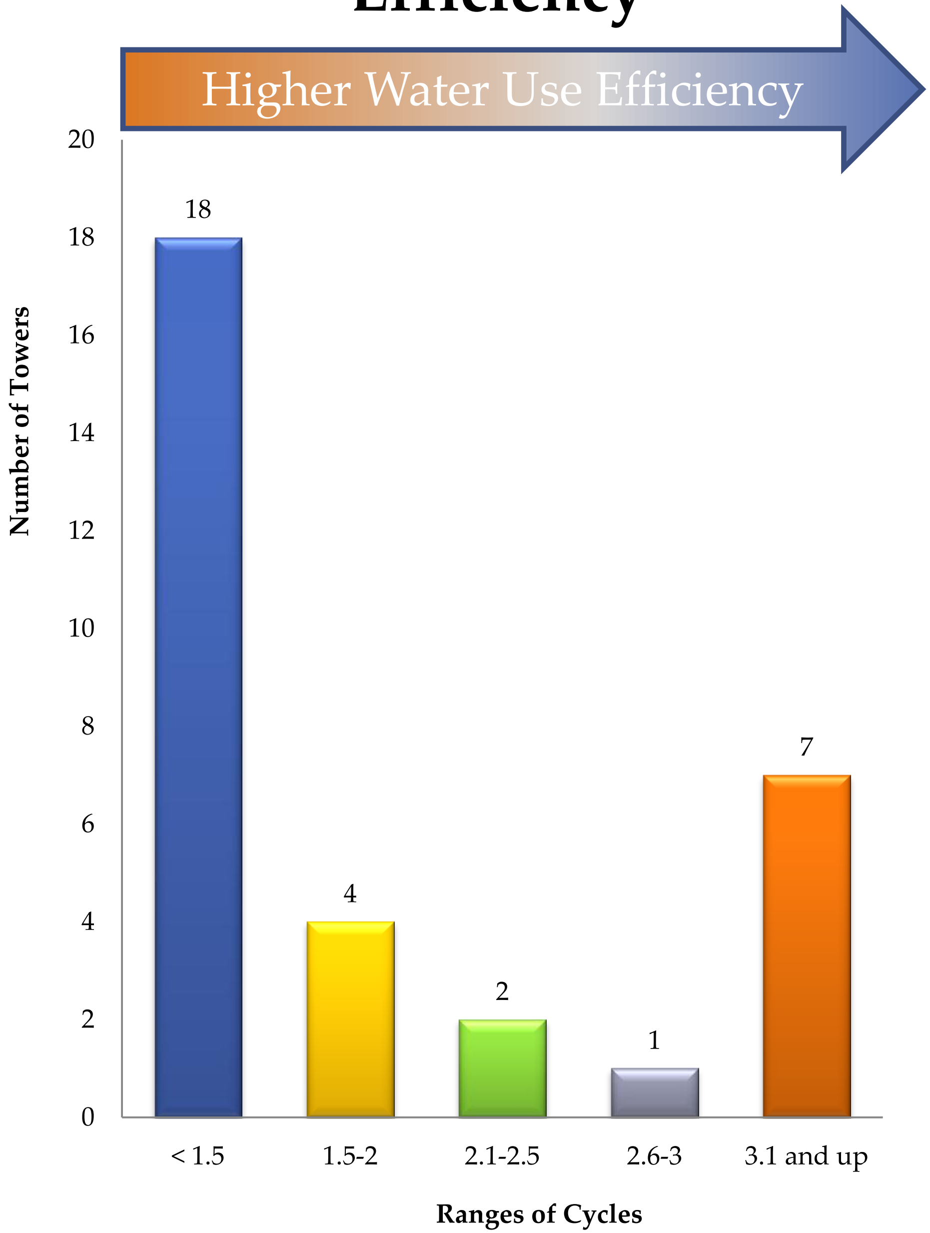
Campus Cooling Tower Water Use
FY 2011



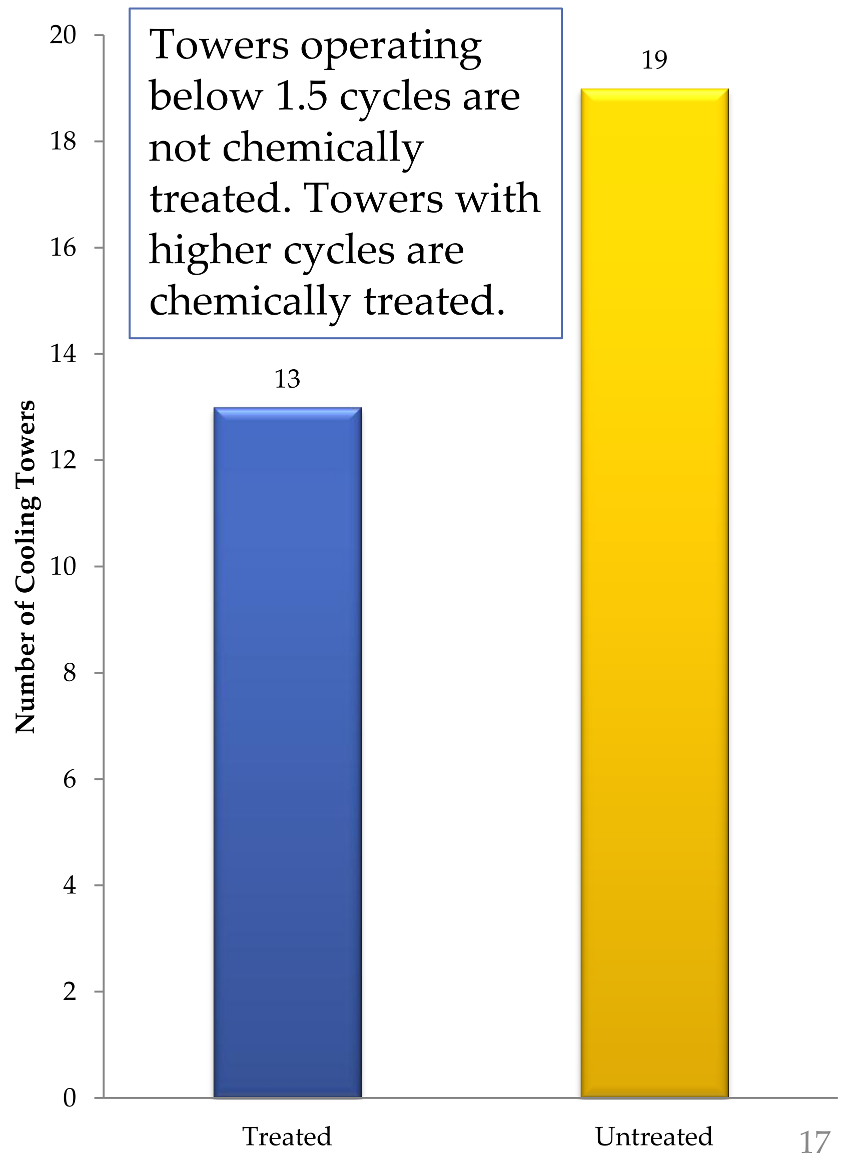
A Little Cooling Tower Jargon

- Cycles of Concentration (COC): A measure of water use efficiency
  - Bigger number is better
  - Typical target: 4-5
- COC dependent on water quality
  - Higher water quality into the tower allows higher target COC
  - Higher quality typically also means more water pretreatment/more $$$

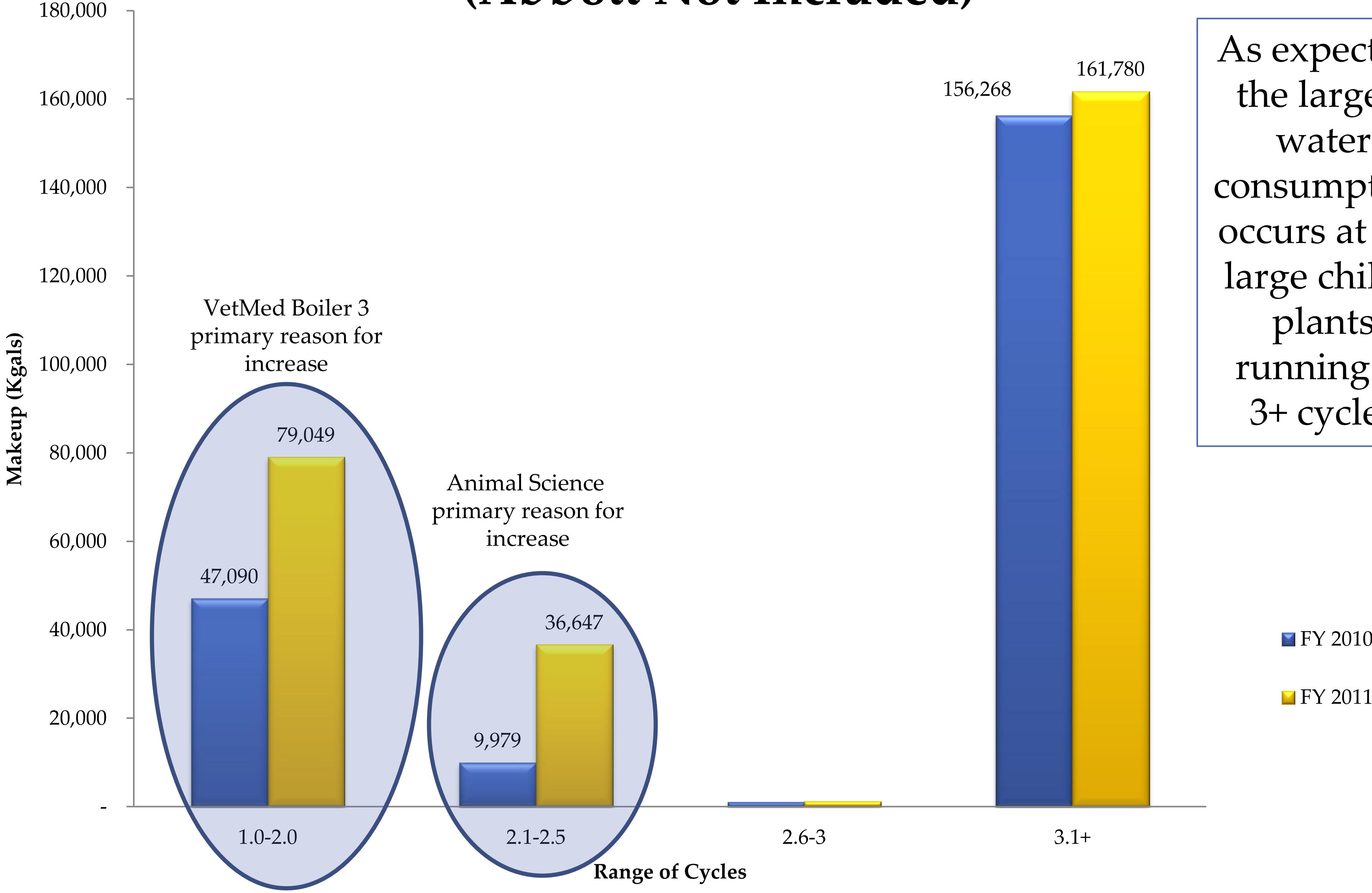
Cooling Towers vs Efficiency



Treated vs. Untreated CT

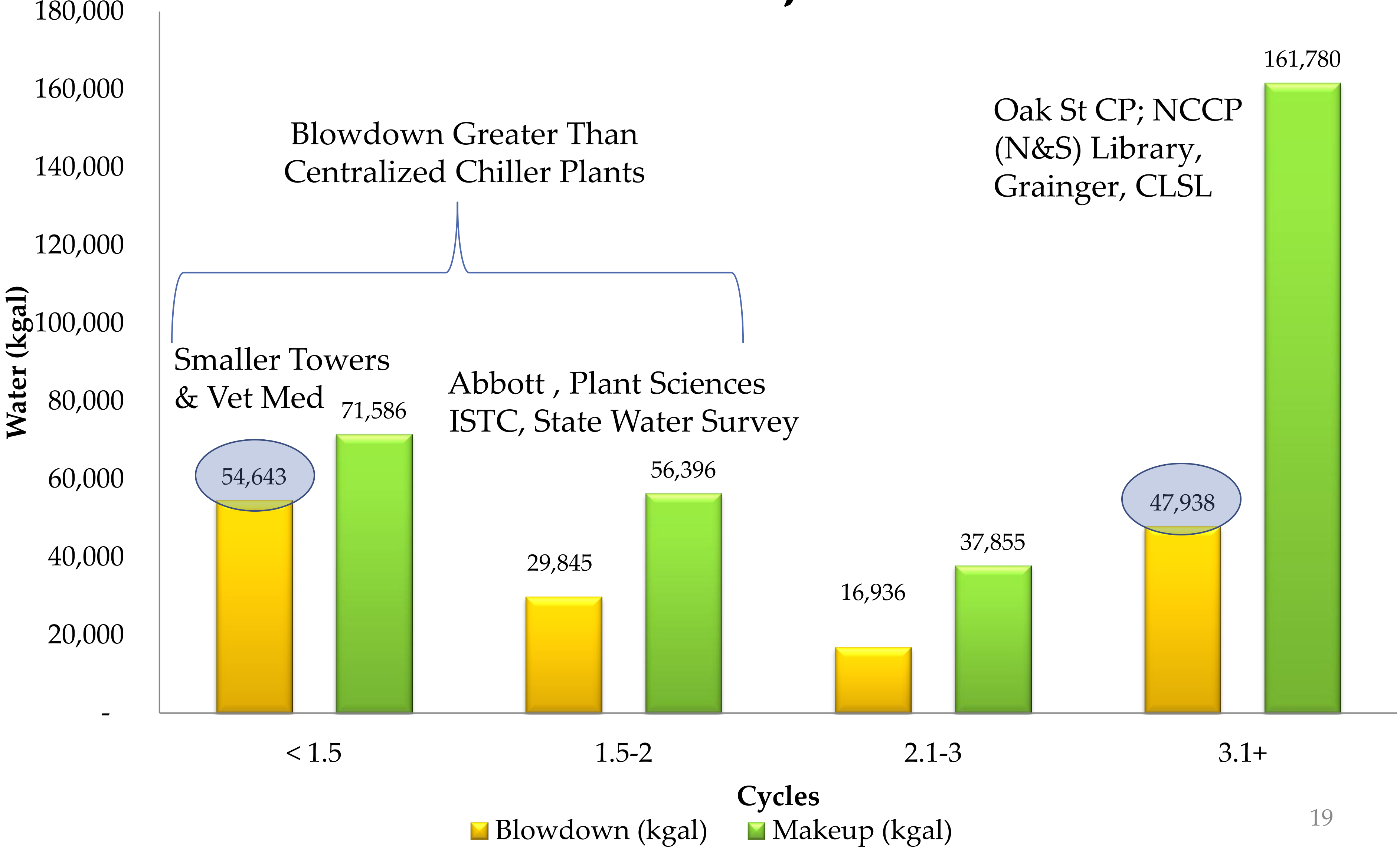


More Heat Removed, More Water Used (Abbott Not Included)

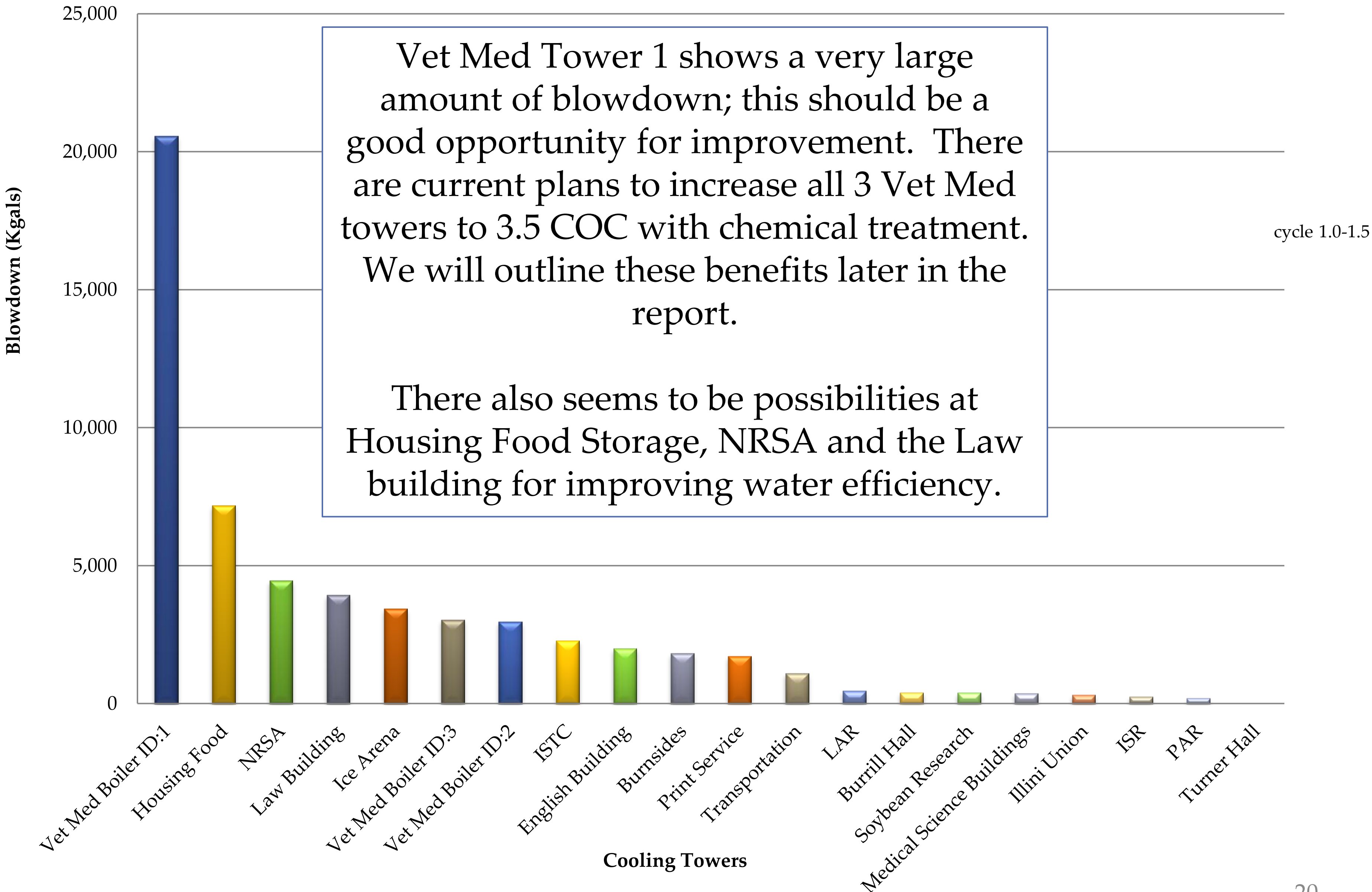


As expected, the largest water consumption occurs at the large chiller plants running at 3+ cycles

Lower Efficiencies Mean More Water Use, More Cost



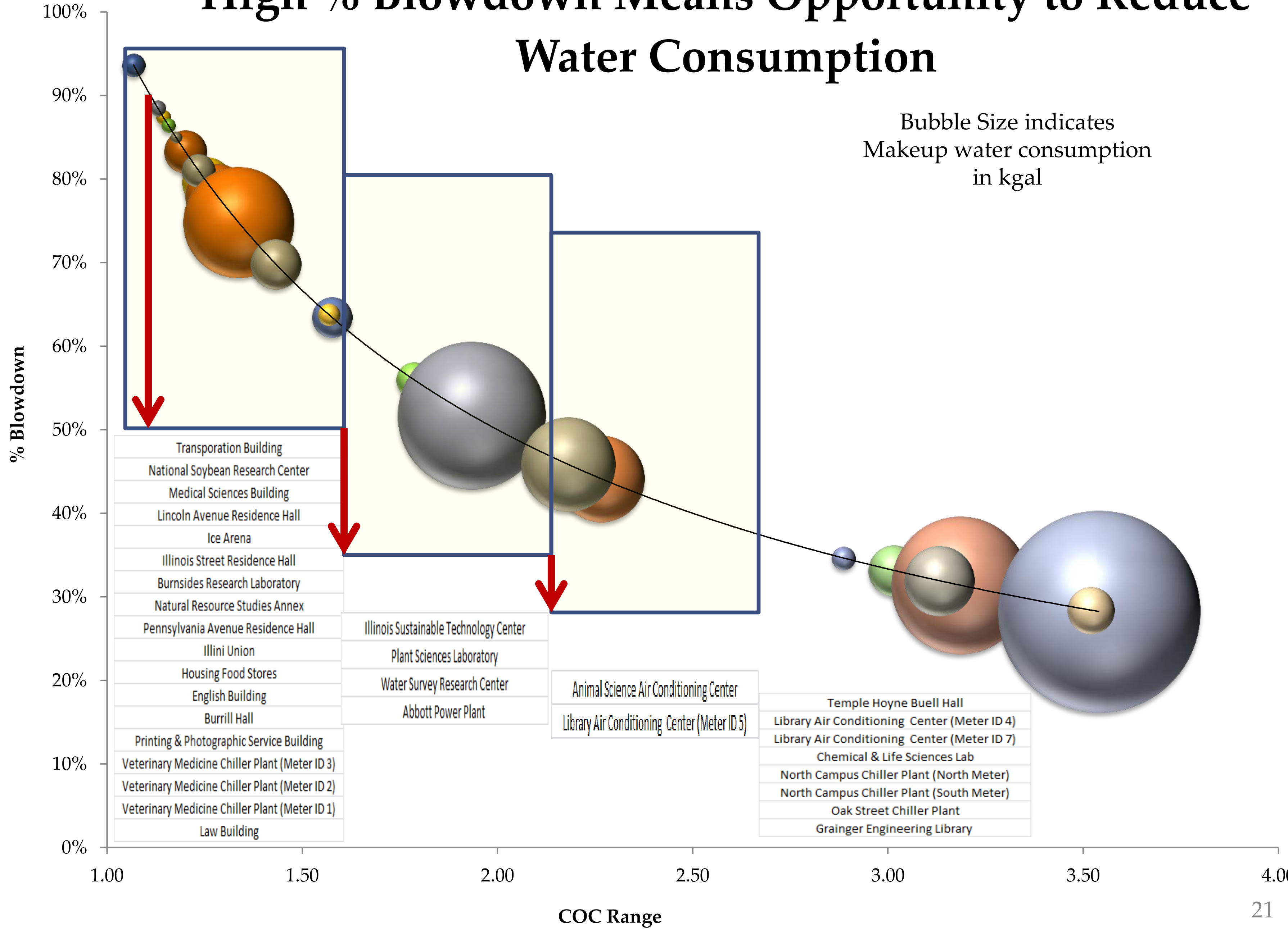
Blowdown - Untreated Towers (FY 2011)



Vet Med Tower 1 shows a very large amount of blowdown; this should be a good opportunity for improvement. There are current plans to increase all 3 Vet Med towers to 3.5 COC with chemical treatment. We will outline these benefits later in the report.

There also seems to be possibilities at Housing Food Storage, NRSA and the Law building for improving water efficiency.

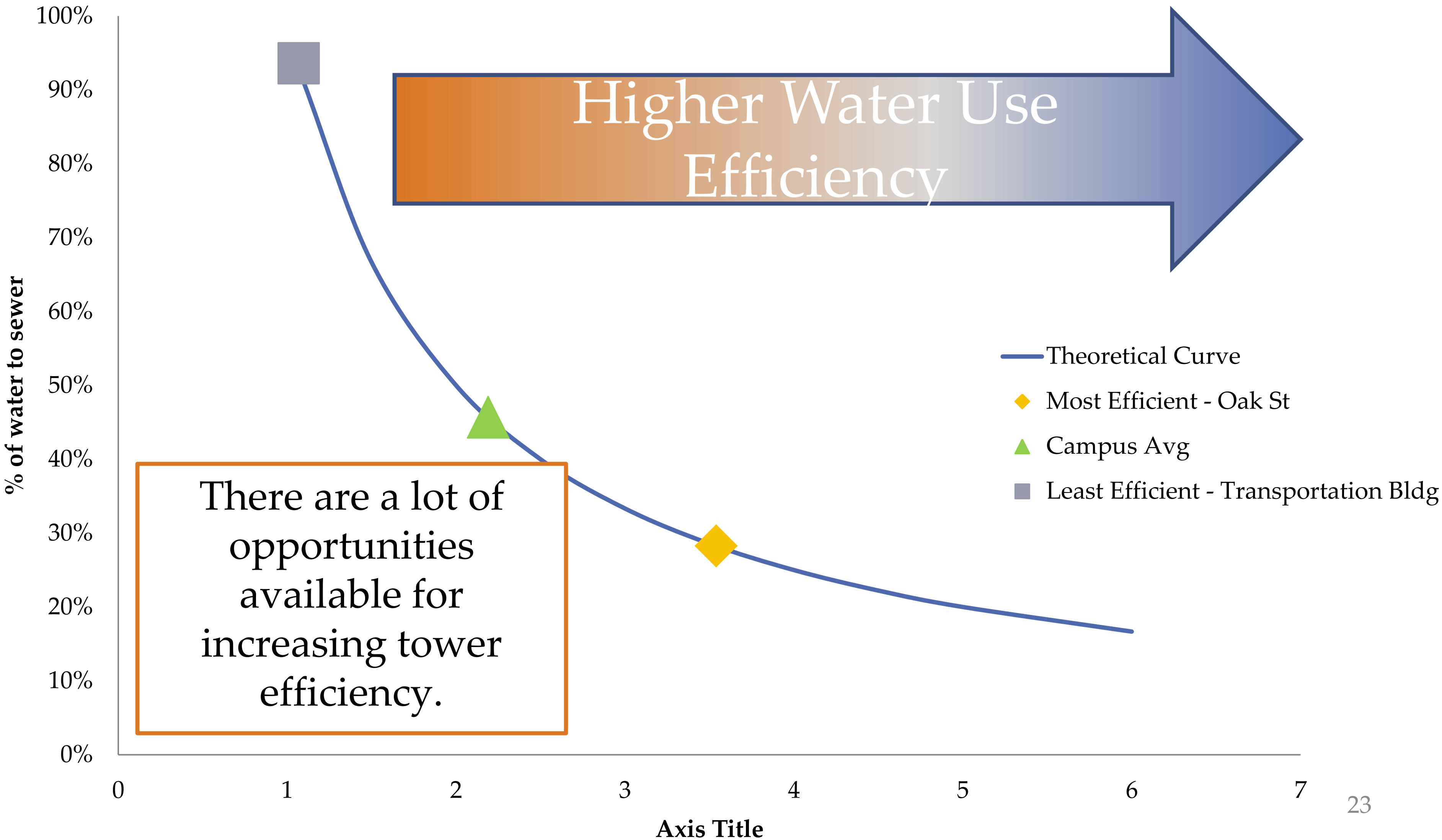
High % Blowdown Means Opportunity to Reduce Water Consumption



Summary
Benchmarking Results

- The largest amount of water is being used at Oak Street Chiller Plant (OSCP) and North Campus Chiller Plant (NCCP).
    - These locations are chem. treated
- Significant water use is occurring at
    - Abbott Power Plant – chem. treated
    - Vet Med Chiller Plant – untreated
    - Housing Food Storage – untreated
    - Natural Resources Studies Annex (NRSA) – untreated
    - Law Building – untreated
- More water, by volume, is going to the sewers from the smaller, lower COC towers than all of the large chiller plants.

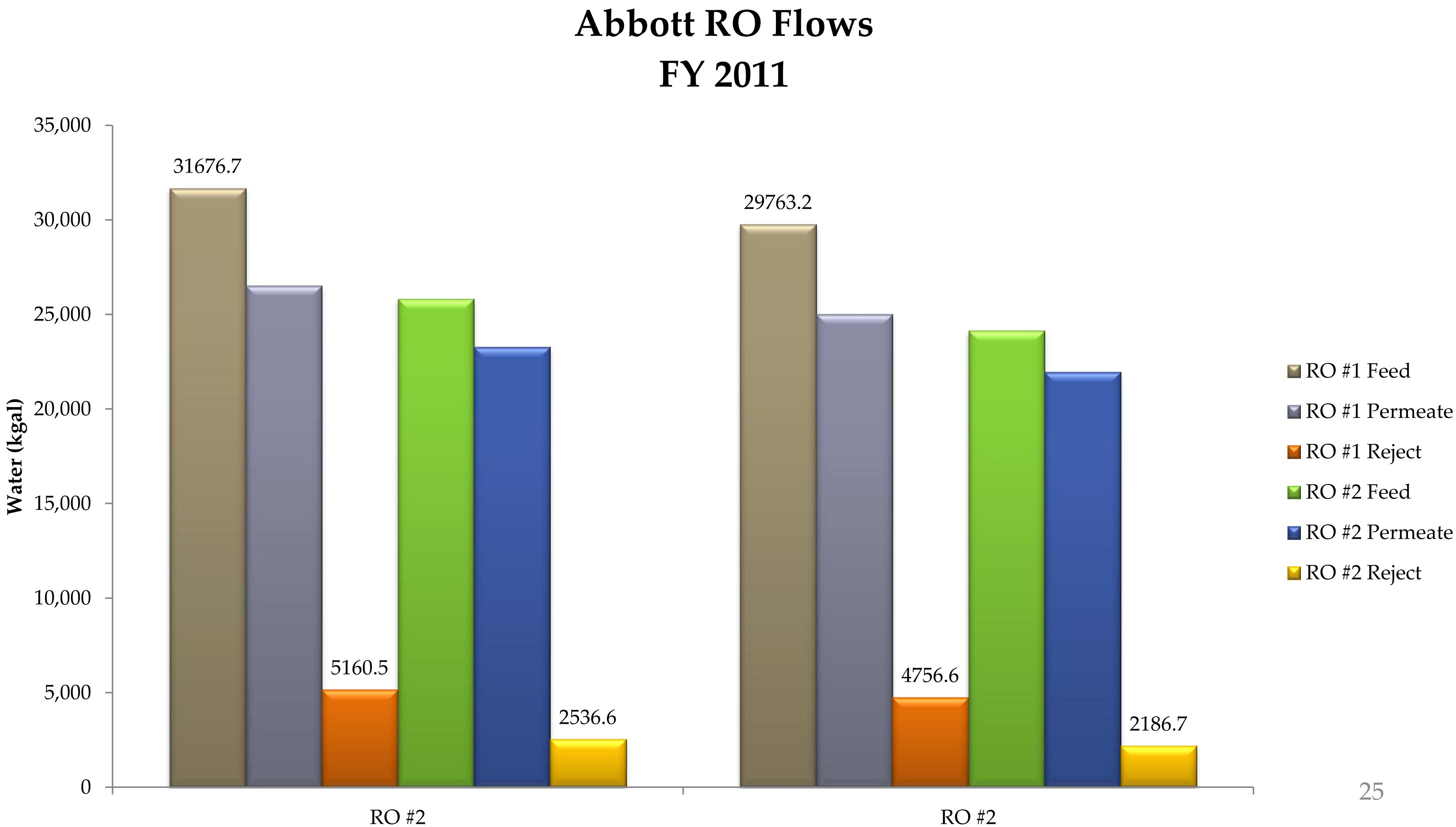
Current Cooling Tower Efficiency



Benchmarking Abbott RO

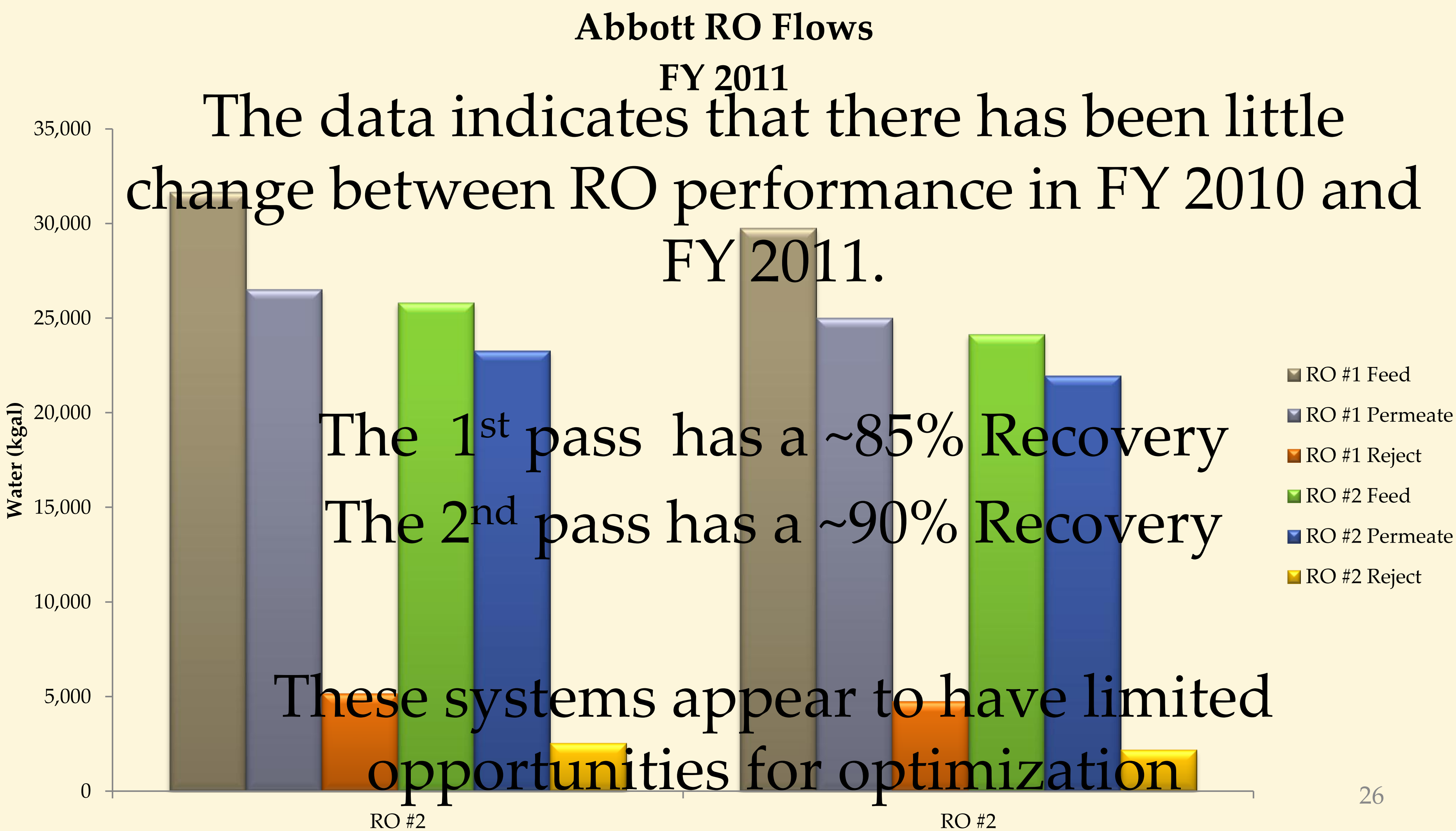
- RO Flow rates at Abbott Power Plant were analyzed over a 2 fiscal year period.

Summary



Abbott RO Flows
FY 2011
Water (kgal)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
31676.7
5160.5
2536.6
29763.2
4756.6
2186.7
RO #2
RO #2
RO #1 Feed
RO #1 Permeate
RO #1 Reject
RO #2 Feed
RO #2 Permeate
RO #2 Reject

Summary



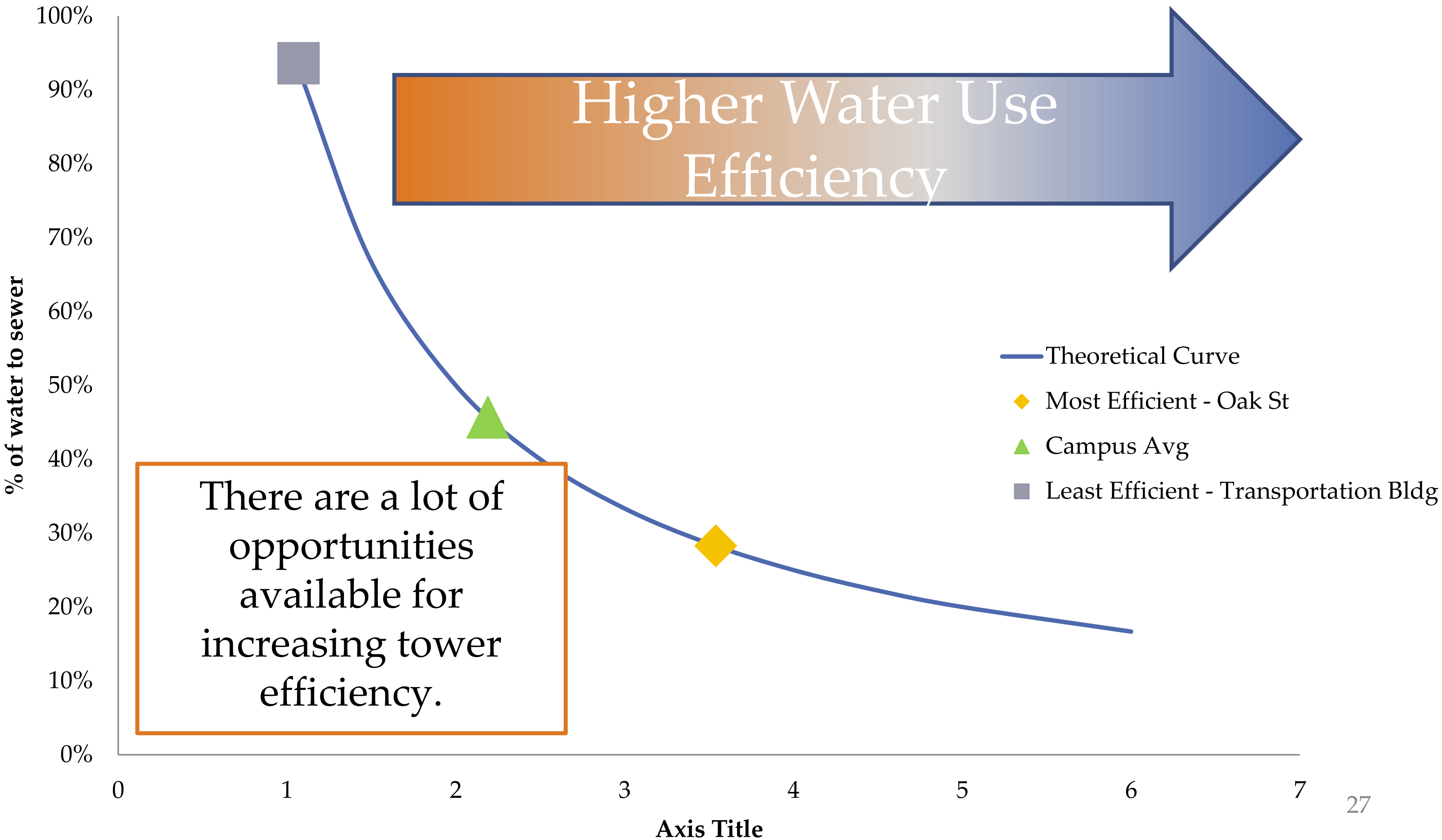
The data indicates that there has been little change between RO performance in FY 2010 and FY 2011.

The 1st pass has a ~85% Recovery

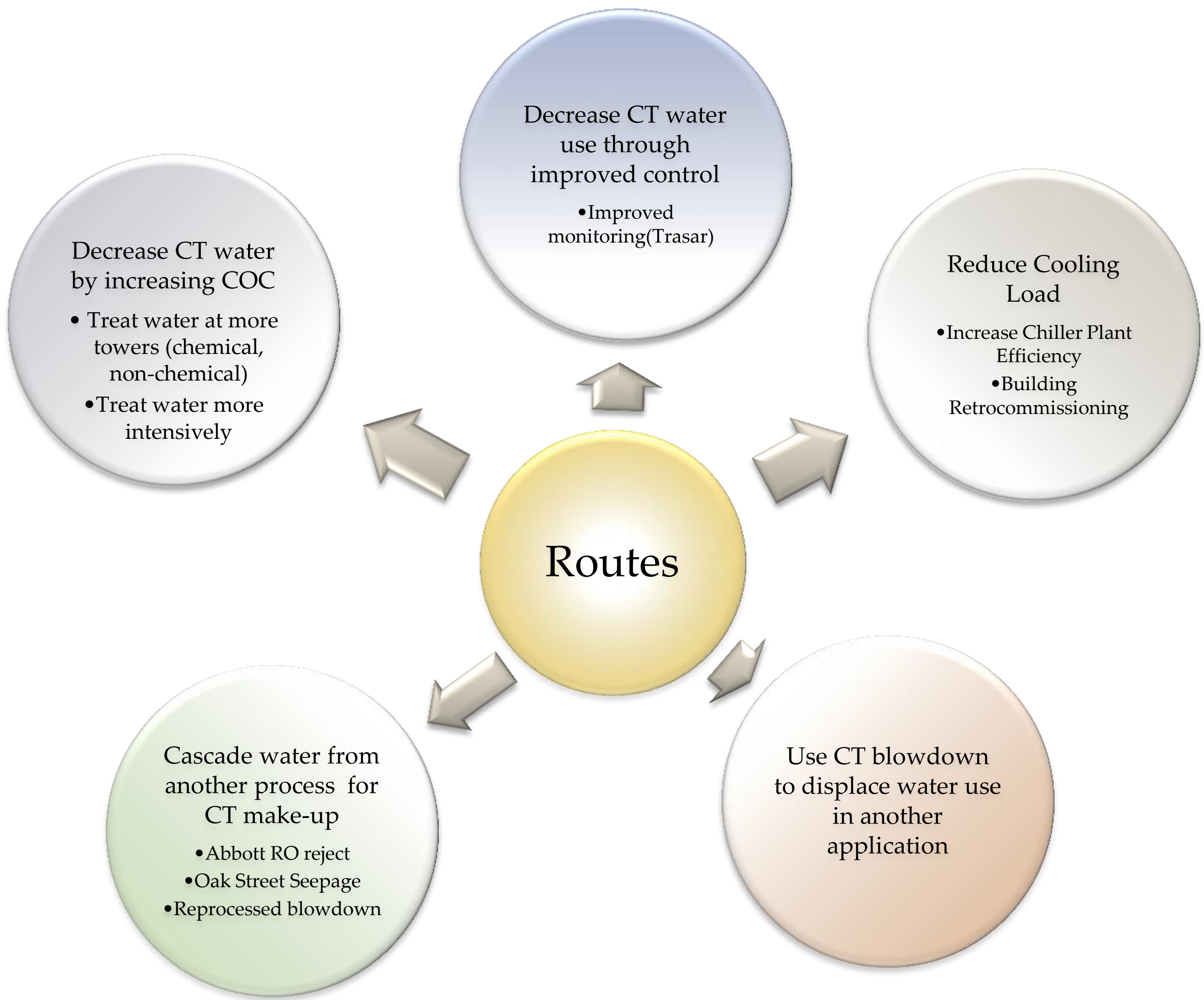
The 2nd pass has a ~90% Recovery

These systems appear to have limited opportunities for optimization

Current Cooling Tower Efficiency



Routes to Water Reduction



ROUTE 1

Decrease CT water use by increasing COC

- Treat water at more towers (chemical, non-chemical)
- Treat water more intensively

Findings

- Evaluated water consumption and cycles of concentration at Campus Cooling Towers.

- We found a significant amount of water savings is possible by modifying operation at only 7 of the towers.

Evaluation Results

- 57.3 Million Gallons total water savings (click to see details)
  - This would represent a 20% savings of total Campus Cooling Tower water use for 2011
  - This would represent a 5% savings of total Campus water use for 2011
- In one year, cost savings could amount to **$136,000***!!

* (based on FY 2011 demands)

Evaluation of Increasing CT Cycles

- Cost calculated by estimating Makeup water demand based on observed cycles of concentration. Included in the cost are:
  - Chemical treatment of Makeup water
  - Water cost of Makeup
  - Sanitary costs of Expected Blowdown (assumed 25% of Makeup is billed for sewer*)

- *Based on billing practice; results in conservative $ savings number;

Isn't saving water only an environmental issue?

Commonly, water is considered cheap.

Cooling Tower water associated costs can be 200-300% higher than the incoming water cost at current water rates.

True Cost of Water

Proper identification of all of the associated costs of running a system better enable you to make an accurate determination of the economic viability of an improvement.

Costs of water at Tower

1. Purchase price of water
2. Chemicals
3. Sewer fees
4. Maintenance of equipment – not included
5. Energy to run cooling tower – not included
6. Direct Labor, Supervision and Administration – not included

(Items 1–3:) We are focusing on these 3 factors.

- Costs used (UIUC Internal Memo, June 28, 2010, Terry Ruprecht to Dempsey)
  - Energy Savings Rate for Water : $2.15/kgal
  - Energy Savings Rate for Sewer Disposal : $ 2.02/kgal
  - Chemical Treatment Costs :
    - $0/kgal for COC < 1.5; $1.08/kgal for 1.5<COC<4; $1.18/kgal for 4<COC<5

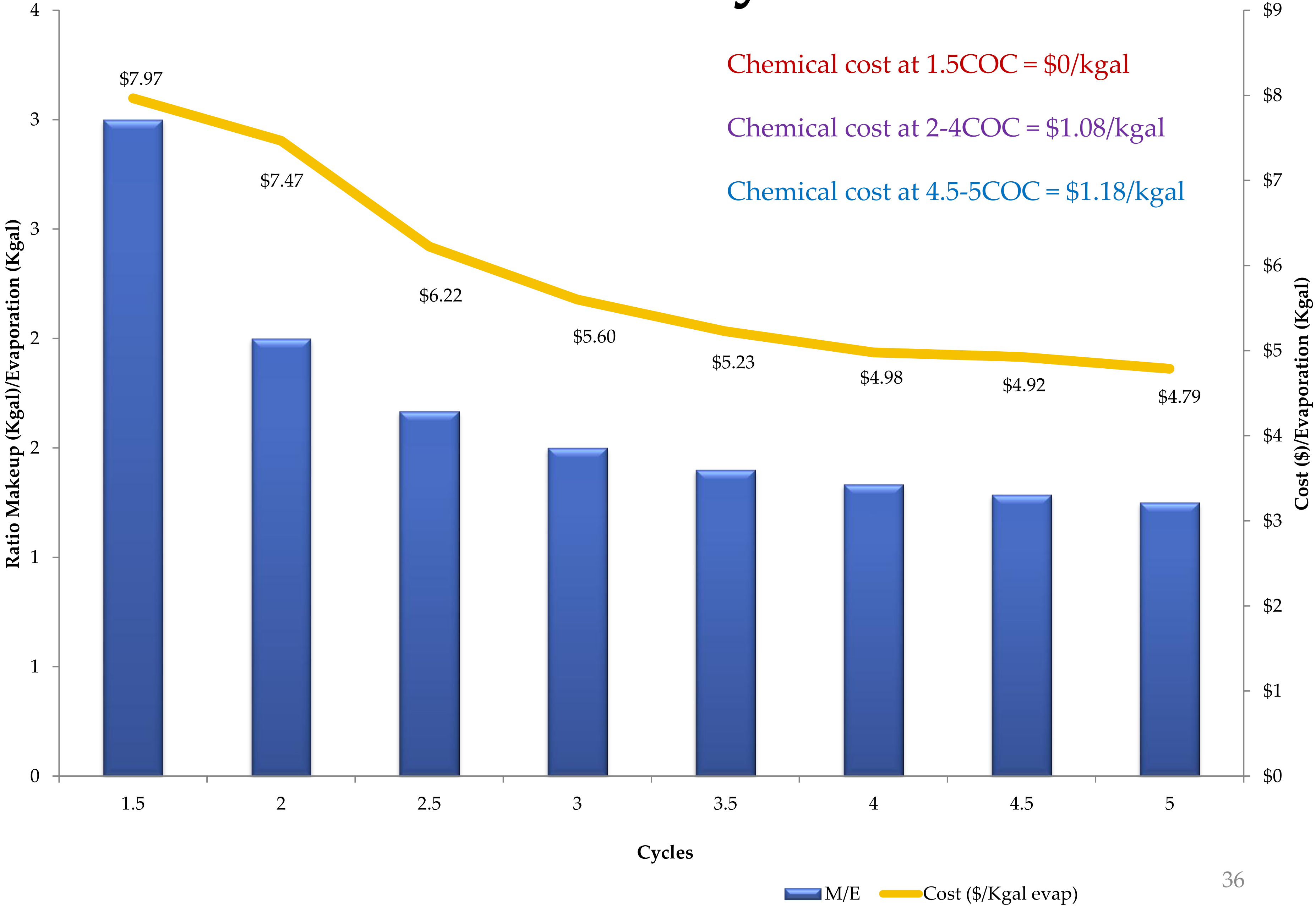
Example Calculation

But if Chemicals add money doesn't treating a tower cost more?

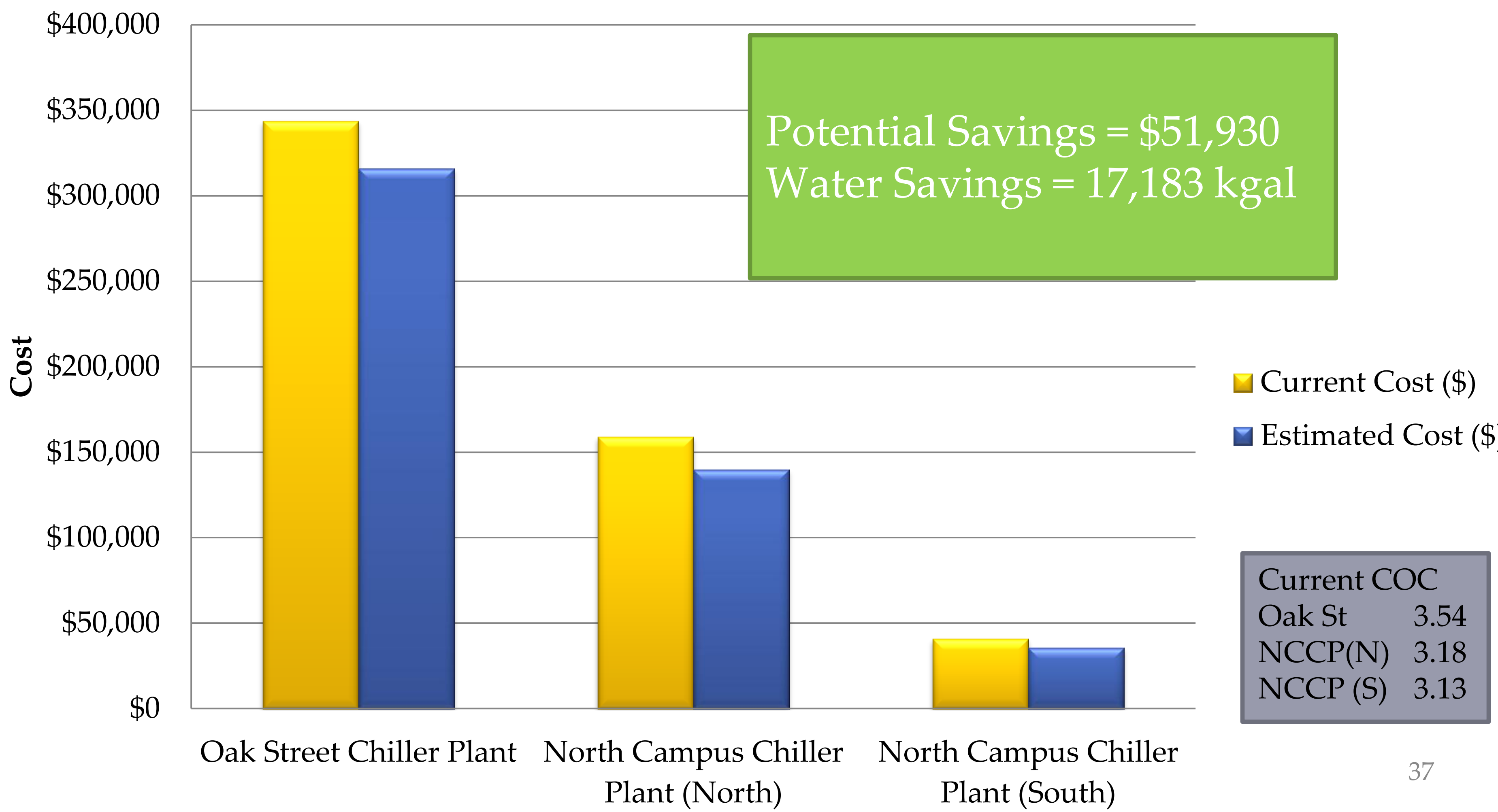
Increased efficiency means less overall water consumed for the same amount of cooling and less water going to the sewer.

With modest chemical fees, you can save more money on incoming water and sewer fees than you pay for chemicals.

Effect of Cycles



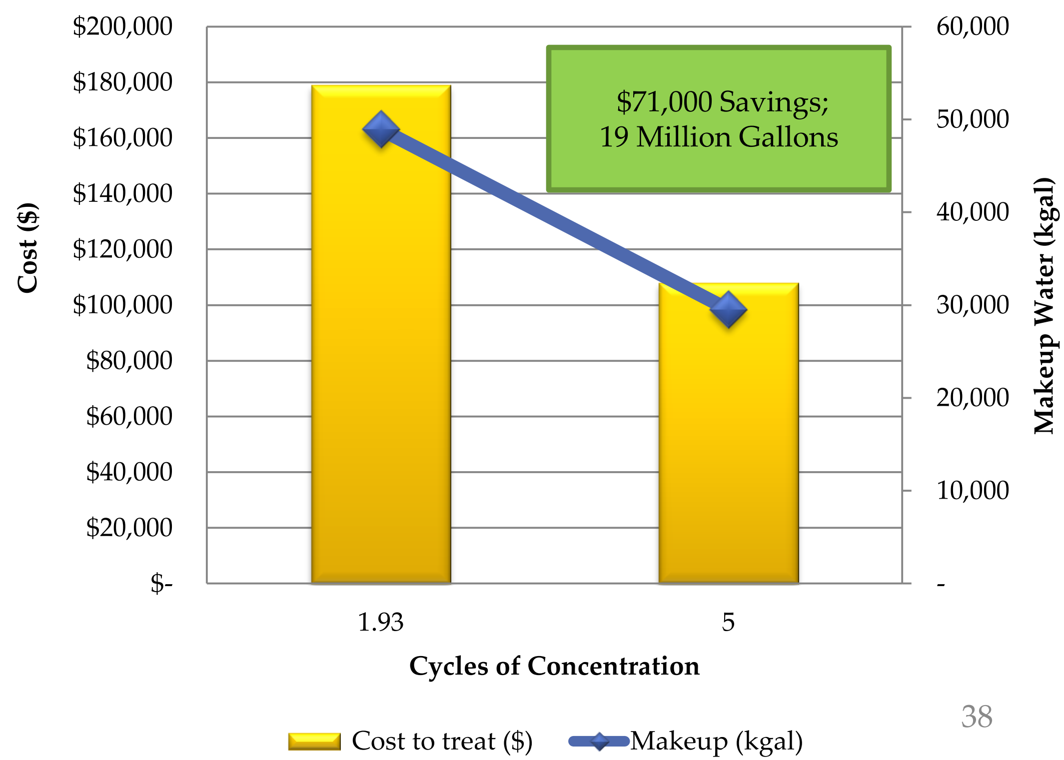
If cycles are increased from the ~3.5 to 5 cycles, estimated water and cost savings are:



Improving Cycles at Abbott

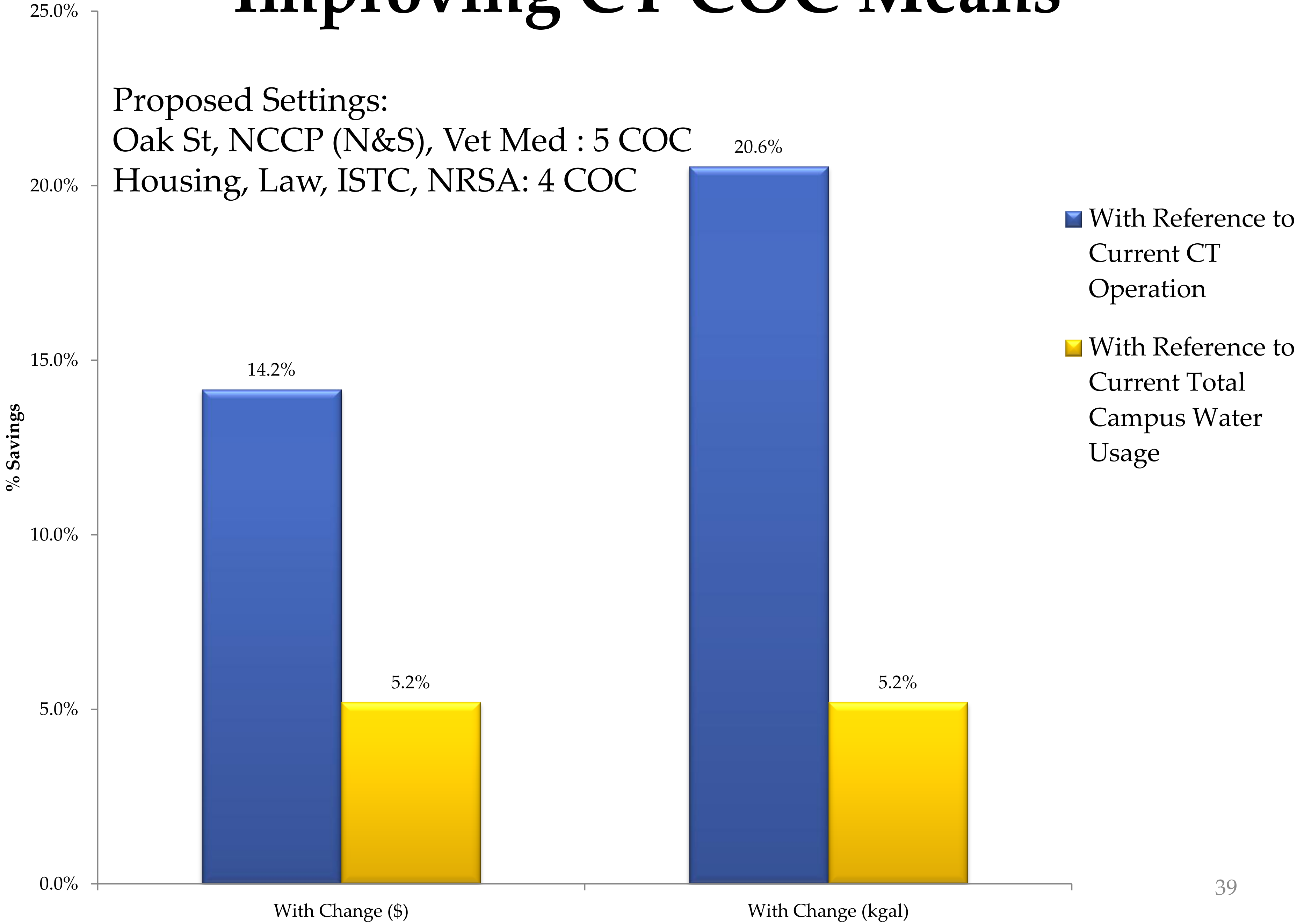
- Current Chemical Management at Abbott is designed for 7 COC.
- The data provided indicates that the tower is running at ~2 COC.
- Improving controls to bring the cycles up to our target of 5 COC or the design of 7 COC can produce significant water and cost savings.

Abbott Power Plant
Cooling Tower Chemical Treatment
Assuming Chemical treatment cost and cooling load are constant



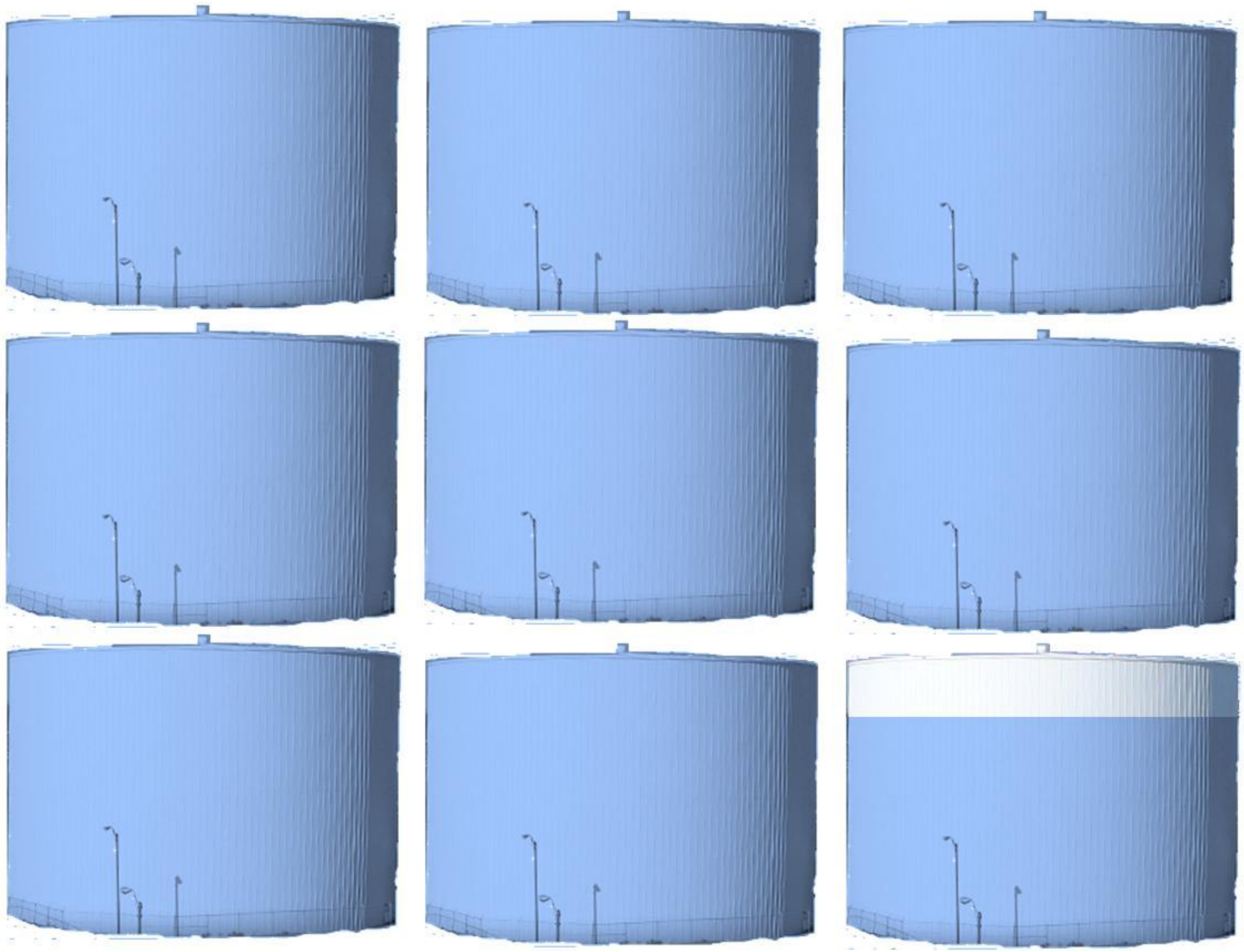
Improving CT COC Means

Proposed Settings:
Oak St, NCCP (N&S), Vet Med : 5 COC
Housing, Law, ISTC, NRSA: 4 COC



Given Thermal Energy Storage Facility is…

Then the proposed water savings of these cycle changes would be like filling the TES almost 9 times



Potential Issues/Resolutions

- Increasing COC requires H_2SO_4 dosing
- Safety Concerns of Storing/Using Acid On-Site
- Resolution:
  - Would Need Robust System Design
    - Need Policies/Procedures for Receipts, Storage, Dispensing, Monitoring, & Containment (Environmental Compliance and DRS)
  - Environmental Regulations Impact Study
    - Modification to CT pre-treatment permits, Homeland Security related storage permits
    - Contacts:
      - Jim Marriott at DRS
      - For OSHA regs (Tom Anderson at DRS)
      - Betsy Liggett at Safety and Compliance
      - Dave Wilcoxen at Safety and Compliance

Is there a way to avoid the use of Chemicals but still increase Cycles of Concentration?

Don’t Like Chemicals?

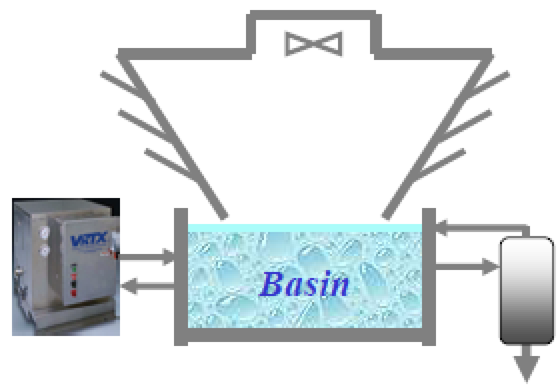
- Non-chemical cooling tower programs are available
- Many such programs are poorly documented and have questionable effectiveness
- One based on cavitation appears to have been more thoroughly vetted. This may be a good candidate for a pilot test.

VRTX Technology

Introduction to Non-Chemical Cooling Water Treatment

VRTX Technology - *How It Works*

- ***VRTX unit and filtration system operate independently***
- ***Both withdraw and return water to sump***
- ***VRTX unit converts dissolved calcium into calcium carbonate colloids, kills bacteria, and removes corrosive gases from water***
- ***Filter system removes suspended solids from recirculating water***

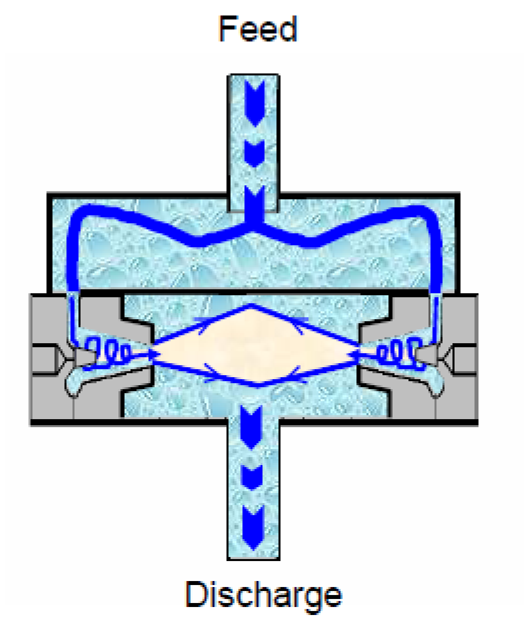


VRTX Cavitation Technology

How Does VRTX Generate Cavitation?

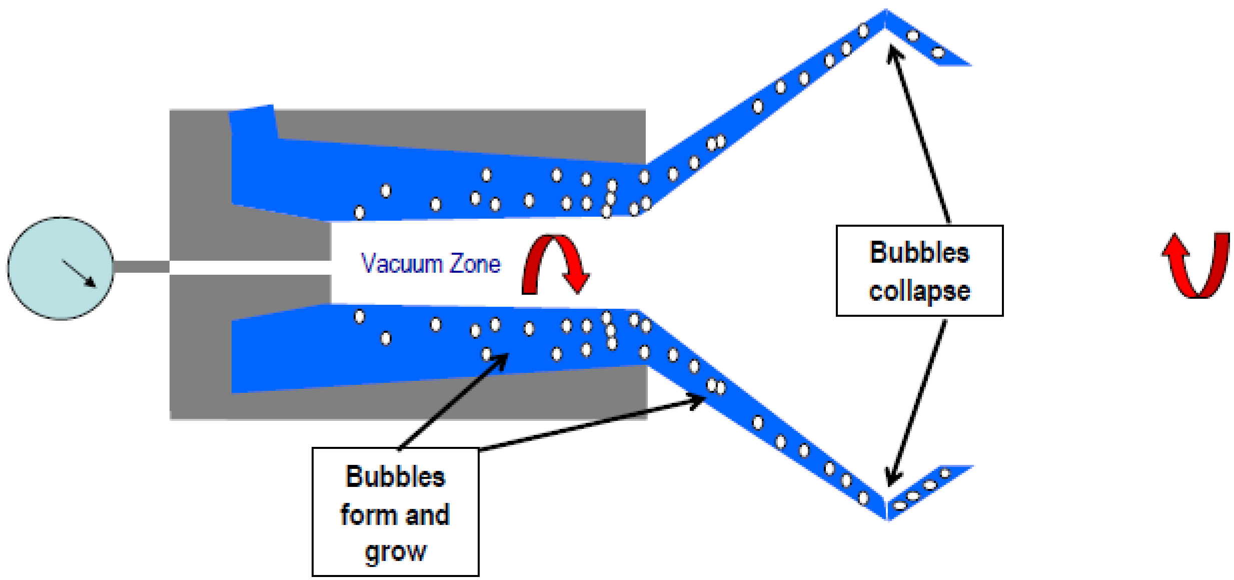
Mechanical device causes significant changes in static pressure in flowing fluid:

- Vacuum condition is optimum for the formation and growth of bubbles
- Two opposite streams collide at the mid-point of chamber (no erosion to nozzle/chamber)



VRTX Cavitation Technology

Fluid Flow Inside of VRTX Nozzle



VRTX Technology

System Description

System Components

- ***VRTX Unit:***
  VRTX chamber, pump
- ***Filtration system***
- ***Suction Strainers***
- ***Blow-down control system***

VRTX Technology - *How It Works*

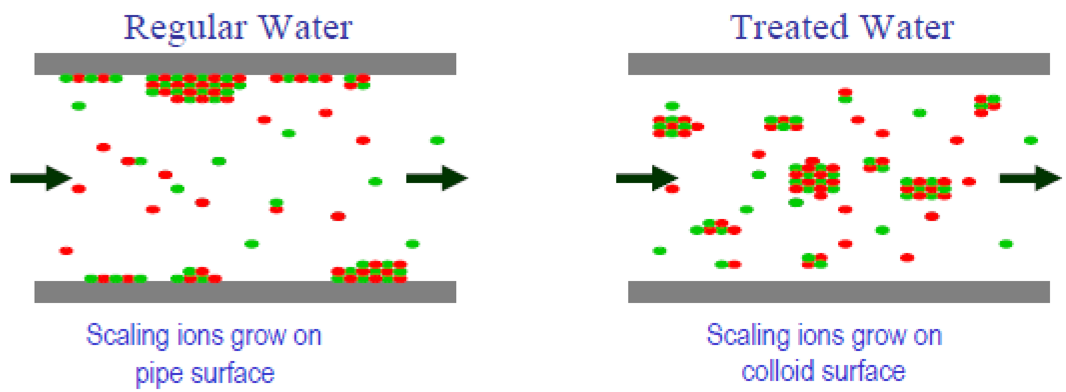
Chemical reactions

- ***Operating conditions force the dissolved calcium and carbonate ions to react and form colloidal, calcium carbonate crystals***
  - $Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + H_2O + CO_2$
  - solution $\xrightarrow{\Delta}$ suspension
- ***Strong vacuum strips CO_2 gas from water and shifts chemical equilibrium to the right***
- ***Hydrodynamic cavitation creates extremely high temperature zone; and the solubility of $CaCO_3$ is decreased***
- ***Dissolved calcium and carbonate ions are dehydrated and combine to form $CaCO_3$***

VRTX Technology - *How It Works*

Chemical reactions

- ***$CaCO_3$ colloids act as incubation sites for dissolved calcium and carbonate ions to grow on***
- ***$CaCO_3$ colloidal crystal growth is thermo-dynamically favored over precipitation on equipment surfaces***

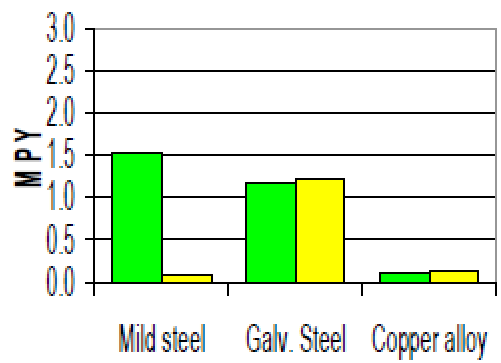


VRTX Technology - *How It Works*

Corrosion Control

- ***Maintaining water at high pH levels (pH > 8.5)***
- ***Removing corrosive dissolved gases***
- ***Controlling bacterial activity***
- ***Eliminating corrosive chemicals***
- ***Reducing suspended solids***

Days Exposed: 179



Days Exposed: 127

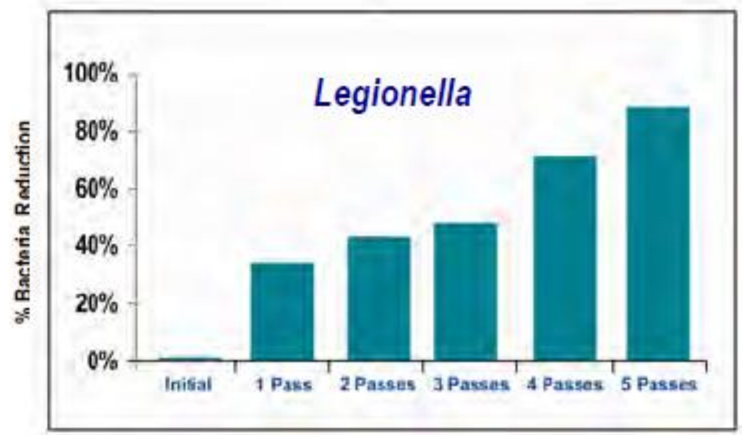
Bacterial Control

How It Works

- Physically ruptures cell wall membranes
  - Dramatic changes in pressure and vacuum
  - Shear and collision forces created by the collision of water streams
  - High temperature and sonic wave produced by hydrodynamic cavitation
- A cumulative effect observed in various installations

Legionella Control

Lab Test Results on Bacteria Kill

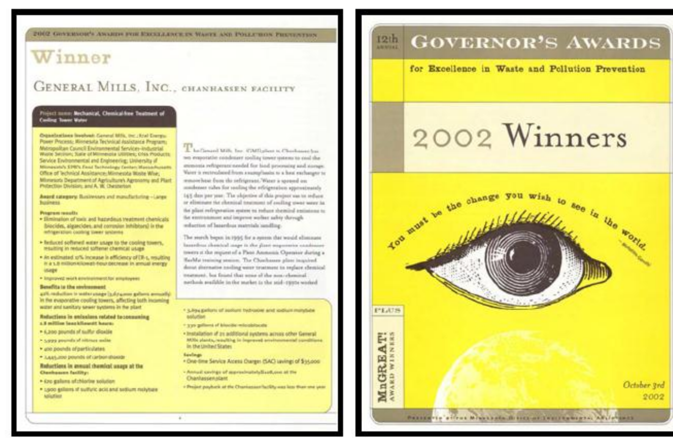


VRTX System with ZGF Filtration

Leadership in Energy & Environmental Design
***LEED* Certification**

US Green Building Council

- ***HDC Technology will give significant advantage toward LEED Goal Achievement and Advancement for buildings in pursuit of LEED.***
- ***VRTX Awarded 2006 AHR Innovation Award in "Green Buildings" Category***

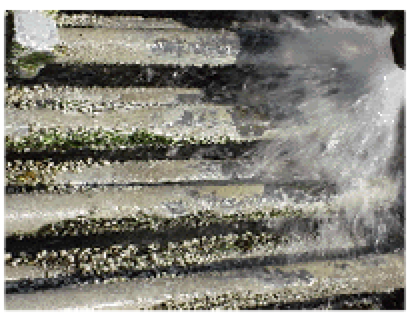


VRTX Technology – *Case History*

Food Processor

Chemical Treatment

- Softened water used as makeup
- Chemical treatment at a cost of $22K / yr
- Scale on condenser tubes 3/8 inches and in basin
- Bacteria counts 50,000 – 75,000 CFU / ml
- Cycles of concentration at 3.0
- Discolored water



VRTX Treatment

- Raw city water used as makeup
- Hard scale significantly reduce
- Bacteria counts 5,000 – 10,000 CFU/ml
- Corrosion 1.8 - 2.4 mpy for mild steel
- Cycles of concentration = 8
- Annual water savings 4.8 million gallons
- Makeup savings > 30%
- Blow-down reduction >70%

The STrategic Envirotechnology Partnership

Green Book Technology Summary Report

Utilizing:

VRTX Technology

A.W. Chesterton Company
5807 Business Park
San Antonio, TX 78218
(210) 661-8800 or (800) 722 0476
www.VRTX-Technologies.com

Prepared by:
Lisa Grogan, Rich Bizzozero, Jim Cain
Massachusetts Office of Technical Assistance
251 Causeway St. Suite 900
Boston, MA 02114-2119
(617) 626-1060
www.state.ma.us/ota

Table 2. VRTX Applications

Site	Industry Sector	Date of Implementation	Results
Pillsbury (MN)	Food Processing and Storage	2000	• Eliminated use, handling, and disposal of treatment chemicals • Substantial water savings • Cycles of concentration increased from 2.9 to 6.3
Richmond Cold Storage, Inc. (VA)	Cold Storage Warehouse	3 Units Installed, 1995, 1996, 1999	• No detectable scale or corrosion problems • Substantial water savings • Cycles of concentration increased from 4 to 18.9
Lancer, Corp (TX)	Plastic Injection Molding	1998	• No system shutdown related to cooling water • Substantial water savings • Cycles of concentration increased from 2.5 to 9
International Paper Co. (VA)	Technology Center	Sept. 1999	• Hazardous chemicals eliminated • Blowdown reduced to <250 GPD from ~1000 GPD • Old scale softened and removed • Cycles of concentration increased from 2.8 to 5.3
Fujitsu Corporation (OR)	Microchip Manufacturing	2 Units Installed, 1993, 1994	• Scale under control • Substantial water savings • Cycles of concentration increased from 4.6 to 33

Operational Parameters		Richmond Cold Stor.	Lancer	Internat'l Paper	Fujitsu	Pillsbury
Cooling Tower Capacity		1200 Ton + 900 Ton	2x350 Ton	1000 Ton	3x300 Ton	~ 1300 Ton
Material of Construction		Galvanized Steel	Galv. Steel	Galv. Steel	Galv. Steel	Galv. Steel
Corrosion Rate		2.0 mpy (mild steel)	Acceptable**	Acceptable**	Acceptable**	0.89 mpy
Function/Duty		Refrigeration	Hydraulic Oil	Test Lab A/C	Mfg. A/C	Refrigeration
Water Source		County Wells	City Wells	County Wells	City-Surface	City-Well
Sump Water Temperatures		Not Measured	90	82	88	75
Size of VRTX unit		3x40 gpm	40 gpm	60 gpm	3x30 gpm	60 gpm
Duration of Water Samples		6 months	13 months	24 months	12 months	3 months
Number of Water Samples		3	> 30	> 30	6	48
pH	Make-up	6.8	7.3	8.2	7.1	8
	Sump	9.3	8.8	9.2	8.9	9.08
Alkalinity (mg/L)	Make-up	24	198	326	38	350
	Sump	374	330	1498	454	1329
TDS (mg/L)	Make-up	34	364	866	68	400
	Sump	1377	1076	4531	2588	1600
Calcium (mg/L)	Make-up	4	174	142	22	73
	Sump	50	201	76	48	28
Magnesium (mg/L)	Make-up	2	72	48	4	34
	Sump	29	503	456	202	403
Chloride (mg/L)	Make-up	6	25	210	12	22
	Sump	113	226	1102	446	100
Cycle of Concentration - VRTX (Prior to VRTX Installation) *		18.9 (4)	9 (2.5)	5.3 (2.8)	33 (4.6)	6.3 (2.9)
Annual water savings (%)		20%	29%	17%	19%	41%
Annual Blowdown Water Savings	%	83%	82%	67%	88%	94%
	gallons	5.0 million	3.3 million	3.5 million	1.5 million	1.5 million

*The number of times non-volatile constituents in makeup water are concentrated by the evaporative cooling tower is the "Cycles of Concentration" (COC) for the cooling tower. If the COC factor is 3, the non-volatile constituents in the blowdown water are three times the concentrations of the makeup water. The blowdown volume (including any drift or leaks) is one third (33%) of the makeup water volume. If the COC increases to 10, then only one tenth (10%) of the makeup water is discharged as blowdown – a "calculated" water savings of 23% (33% - 10%).

**Acceptable: Not measured quantitatively by facility; however, no corrosion prevention chemicals have been added to date.

Pillsbury's VRTX unit, which has a flow rate of 60 gpm, was purchased for approximately $60,000 (including the cost of installation). The company did not provide any specific energy consumption information beyond that used by the system's two pumps (7.5 hp and 1.5 hp, as mentioned previously). Cost savings from water conservation documented in the previous section are listed in Table 7, as are cost savings stemming from the elimination of water softening and treatment chemicals. The Sewer Availability Charge is a one-time savings from the local sewer authority that resulted from Pillsbury's reduced water consumption. Based on these figures, first year savings were in excess of $60,000, indicating a pay back period of less than one year.

Controlling Cooling Tower Water Quality by Hydrodynamic Cavitation

W.A. Gaines B.R. Kim A.R. Drews

C. Bailey T. Loch S. Frenette

ABSTRACT

A field study was conducted to evaluate the performance of a hydrodynamic cavitation device (HCD) for disinfection, scaling, corrosion, and heat-transfer efficiency on a cooling-tower system at an automotive testing facility. Primary findings are: (1) The HCD unit performed as well as the chemical program that it replaced in terms of bacterial control without adding any chemicals (including disinfectants); the bacterial count was maintained at ~10^4 cfu/mL over the course of the study. (2) The HCD unit enabled the cooling system to be operated at comparable cycles of concentration (CoC) to that used during the chemical program, without adversely affecting pH, scaling, or corrosion. (3) The corrosion rates of copper and mild steel were either equivalent or better than those obtained during the chemical program. (4) The use of the HCD unit did not adversely affect heat-transfer efficiency. Long-term effectiveness of this technology was not evaluated as part of this study.

Table 1. Makeup Water Analysis

Calcium (Ca)	26.8 mg/L
Magnesium (Mg)	8.80 mg/L
Chloride (Cl^-)	7.5 mg/L
Sulfate (SO_4)	23.9 mg/L
pH	7.29 S.U.
Silica (SiO_2)	2.38 mg/L
Total alkalinity (as $CaCO_3$)	72 mg/L
Phosphorous (P)	0.29 mg/L
Conductivity	214 micro Siemens

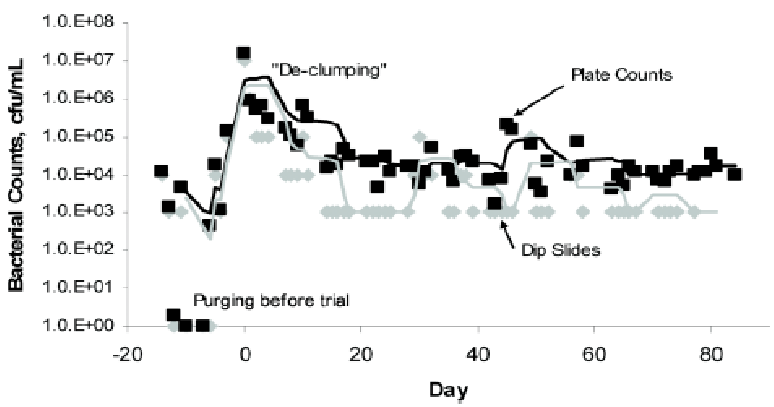
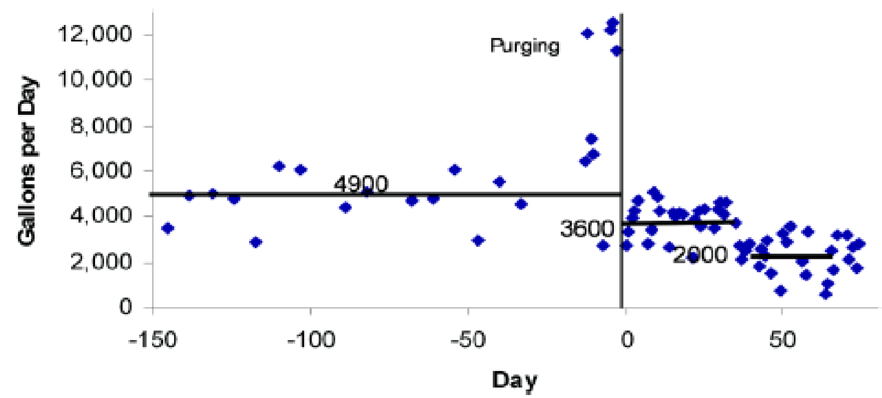


Table 4. Measured Corrosion Rates (mil/year) of Test Coupons

Date	Days Exposed	316L SS	Copper	Galvanized Steel	Untreated Mild Steel	Treated Mild Steel
Historic	23		<0.1		1.3	
Pretrial	61		<0.1			0.5
HCD	65	<0.1	<0.1	4.3	0.3	

Table 2. Cooling Water Cycles of Concentration Before and During the Study Period

	Previous Three Years	150-Day Pretrial	Trial
Average	3.5	4.7	4.9
Standard Deviation	1.4	0.4	0.3



Referrals

- General Mills – New Albany IN: Ted Iverson – 812-941-4332; ted.iverson@genmills.com
- Ed Miniat Meats – South Holland IL: Randy Nelson – 708-589-2400; rnelson@miniat.com
- Preferred Freezer - Chicago IL: Phil Locher – 773-457-7839; plocher@preferredfreezer.com
- Appleton Medical Center – Appleton WI: Richard Helfrich – 920-731-4101
- Engineered Polymers – Mora MN: Tim Joy – 320-679-6786; tjoy@epcmolding.com
- Xavier University – Cincinnati OH: Rob Edwards – 513-745-3855

ROUTE 2

Decrease CT water use through improved control

- Monitoring

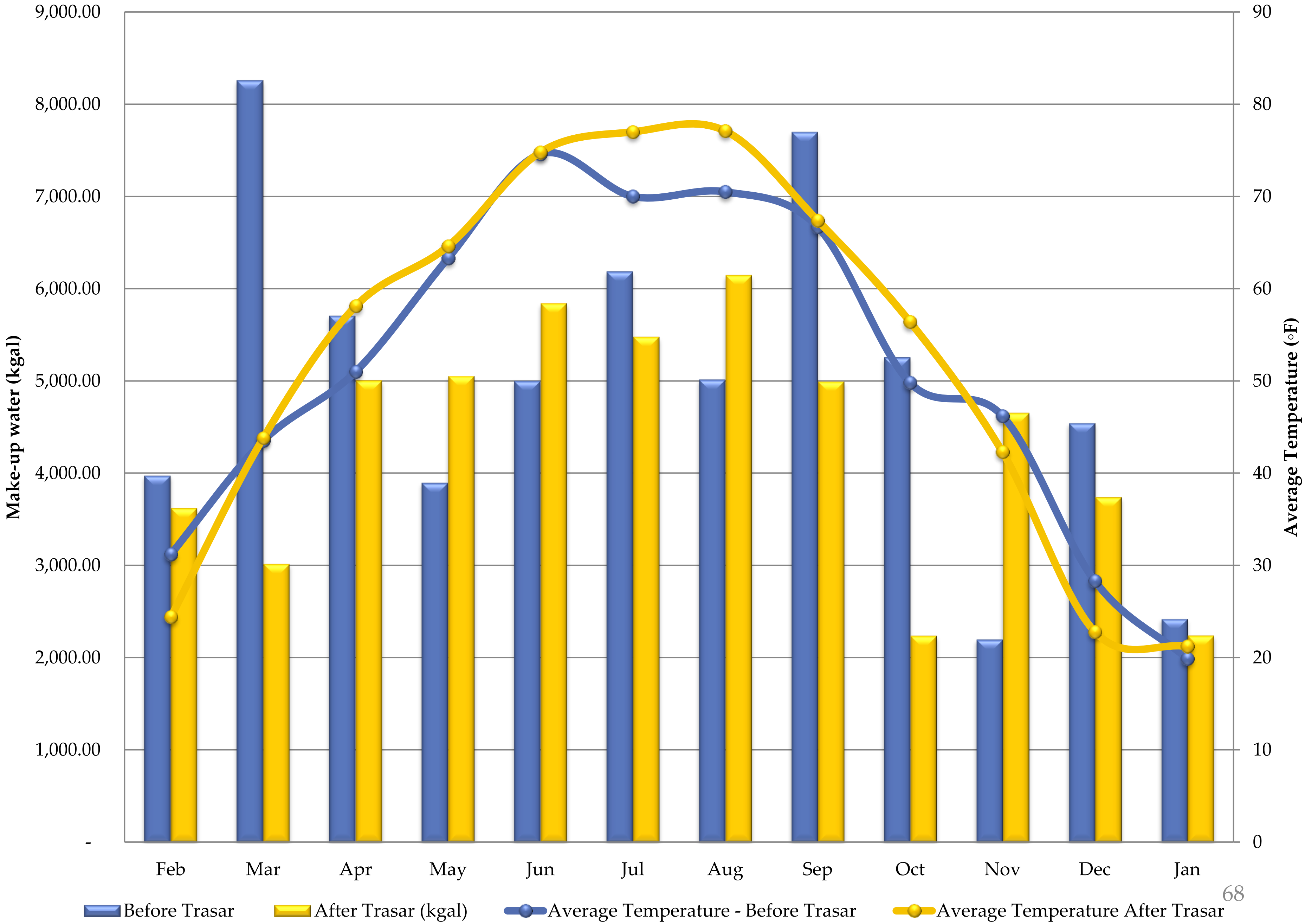
What is Improved Monitoring?

- Quantity of Blowdown is controlled by measurement of objective criteria such as conductivity
- Continuous monitoring is better than periodic monitoring – allows automated control
- Example of one such system – TRASAR 3D from Nalco

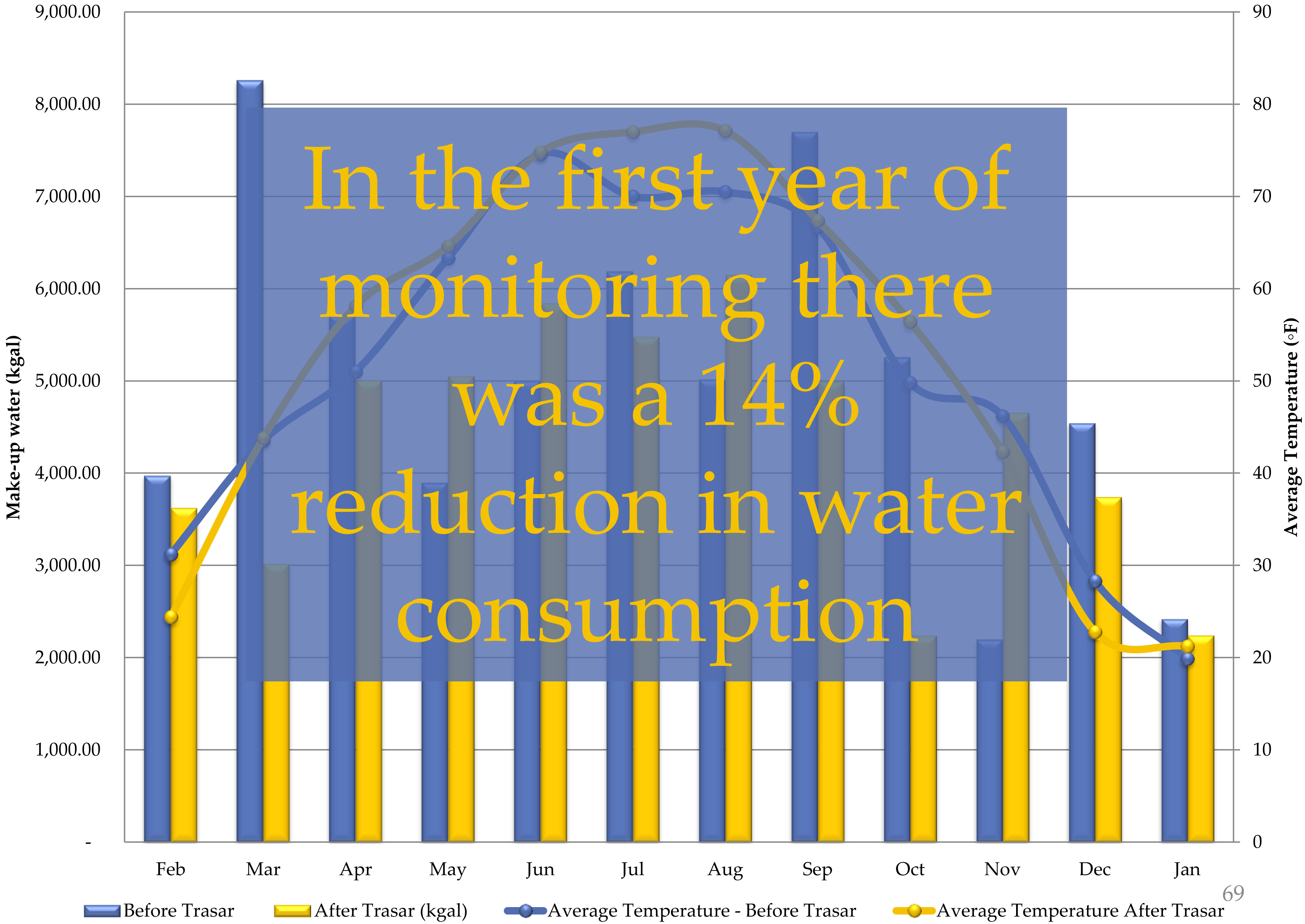
North Campus Chiller Plant Experience with Trasar 3D

What benefits, if any, due to improved monitoring?

Improved Monitoring Reduces Tower Makeup



Improved Monitoring Reduces Tower Makeup



In the first year of monitoring there was a 14% reduction in water consumption

Future of Trasar @ UIUC

The Nalco Representative indicated that units have already been purchased for Oak Street and Vet Med Chiller Plants but are awaiting installation. If additional units are needed for other locations:

– The expected cost of each unit would be $XXXX.XX

– Installations by Nalco have been completed for $2,000-$4,000 per unit.

Closer attention to water use numbers, metering, and prompt remedial action are likely to reduce water lost to malfunctioning hardware.

- At ISTC, during retrocommissioning, cooling tower blowdown control was found to be malfunctioning
- Similar situations have existed at Vet Med based on what we have heard anecdotally.

ROUTE 3

Reduce
Cooling Load

Route 3

How Does One Reduce Cooling Load?

- More energy efficient buildings
  - Lowers cooling load
  - Many pathways to improve efficiency; Outside scope of this project; Only campus efforts with retrocommissioning highlighted
- Efficient energy use at chiller plant
  - Many routes; optimization, condenser heat recovery; combined cooling/heating are all potential routes

An Example of The Energy-Water Nexus On Campus

- Building Retrocommissioning
  - The skilled analysis of a building’s HVAC systems and maintenance program can play a part in reducing the thermal load that a building adds to the Campus Chilled Water System.

A Snap Shot of Existing Retro-X Projects

Retrocommissioned Cooling Towers	Chilled Water Saved per year (MMBTU)	Percentage of CW Saved	Chilled Water Cost per 1 MMBTU *	Estimated Savings
National Soybean Research Center	3,316	37%	$6.93	$22,979.88
Turner Hall	6,223	33%	$6.93	$43,125.39
Animal Sciences Laboratory	3,091	31%	$6.93	$21,420.63
Bevier Hall	2,383	21%	$6.93	$16,514.19
Psychology Building	3,032	18%	$6.93	$21,011.76
Krannert Center for Performing Art	2,698	16%	$6.93	$18,697.14
Chemical & Life Sciences Laboratory	13	1%	$6.93	$90.09
Total Savings	**20,756**		$6.93	**$143,839.08**

Result of these Retro-X projects

Assumptions:
1. Compressor Power/ton : 0.08 kWh/1000 BTU cooling
2. Tower performs 4 cycles

Saved (MMBTU)	Added by Compressor (MMBTU)	Total Heat abated (MMBTU)	Water Consumption abated (Mgal)
20,756	5,665.79	26421.79	3.166

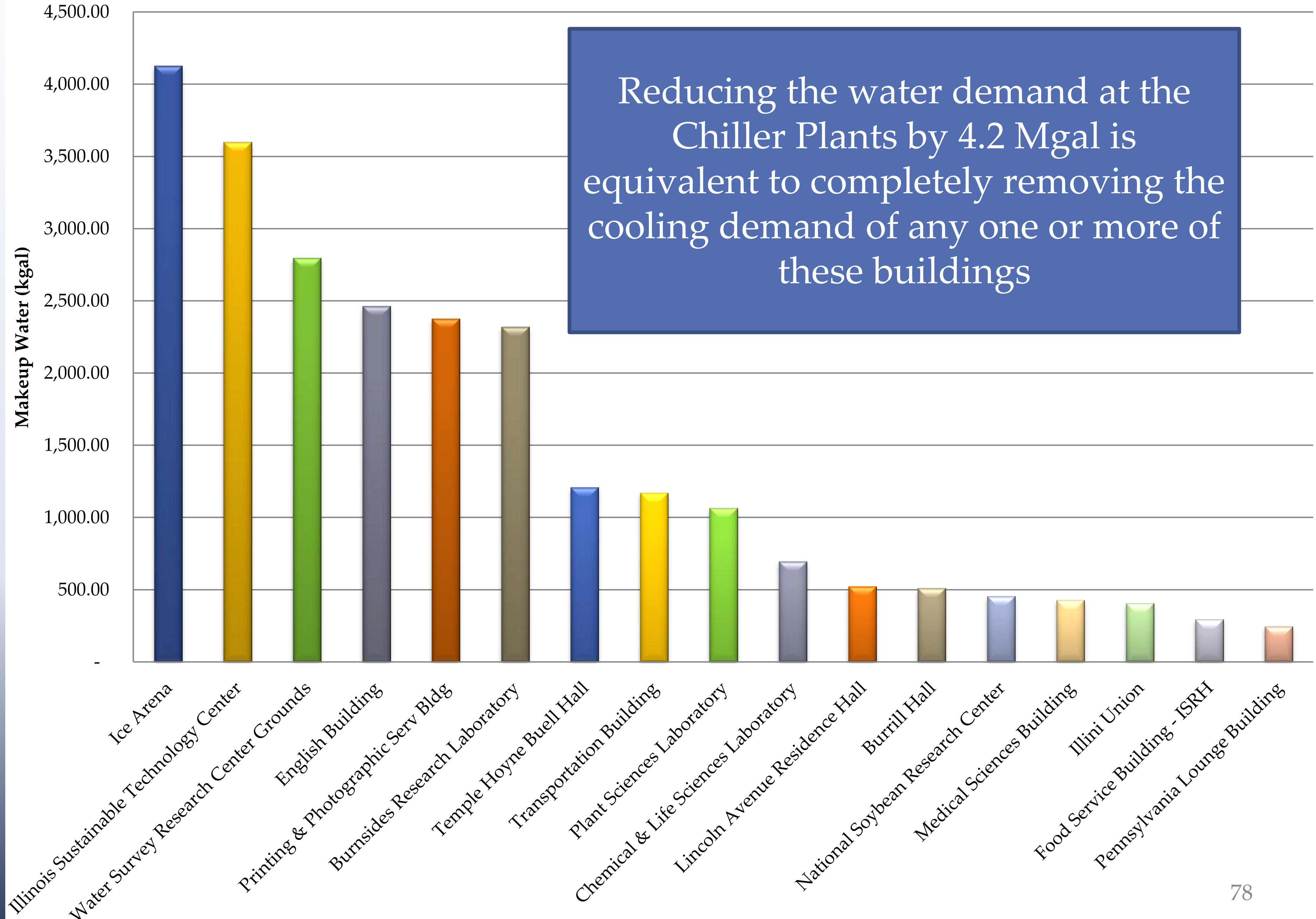
Evaporation (Mgal)	Makeup (Mgal)	Blowdown (Mgal)
3.166	4. 221	1.055

Result of these Retro-X projects

	Incoming Water Cost Abated ($)	Chemical Cost Abated ($)	Sewer Cost of Blowdown Abated($)	Total Cost Abated($)
Treated Tower	$9,075.95	$ 4,599.08	$ 2,131.79	$ 15,766.82

Actual total cost for FY 2011	$ 907,624.23
Retro-X saved in cooling water expenses	$ 15,766.82
Retro-X saved cooling water (Mgal)	4.2

FY 2011 Tower Water Consumption



Route 3

Retro-X

Saved (MMBTU)

Added by Compressor (MMBTU)

Total Heat abated (MMBTU)

Evaporated Water Use abated (Mgal)	Makeup water abated (Mgal)
16.27	21.69

Current Retrocommission projects have resulted in savings of ~21 Mgal water for cooling in the first year after Retrocommissioning

List of Retrocommissioned Buildings

Retro-X

	Savings Rate ($/MMBTU)	Cost Savings ($)
From Retro-X Energy Rate	$6.9300	$739,195.38
Savings from Cooling water	$0.7596	$103,144.27
Total Savings by Retrofit	$7.69	$820,221.77
% Added Savings Represented by Cooling Water	11%	13%

The cost savings from water consumption abatement provides an additional 13% savings to the current calculation used to evaluate retrocommissioning projects.

This demonstrates a great potential for cost and water savings by the University through the continuation of the Retrocommissioning efforts.

The additional cost and fuel savings from reductions in mechanical load have not been included in our calculations and would represent further savings currently unaccounted for.

ROUTE 4

Cascade water from another process for CT make-up

- Abbott RO reject
- Oak Street Seepage
- Reprocessed blowdown

Oak Street Seepage

- Seepage of the order of 50 gpm
- Oak Street Chiller Plant make-up ~200 gpm
- Substantial reductions in cooling tower water usage possible if seepage can be used for make-up

Major Issue

Seepage water quality not suitable without recourse to treatment

Water Quality

Water Quality to Cooling Tower	
Parameters	Value
	mg/L
TDS	176
Calculated TDS	169
Cations	
Na	38
K	2.2
Ca	12.4
Mg	12.35
Sr	0.16
Fe	0
Barium	0.07
Anions	
Chloride	7
Sulfate	0
Bicarbonate as CaCO3	147
Carbonate as CaCO3	14
Fluoride	0.98
Si as SiO2	7.7
OH (mol/l)	0.00
pH at 8.4 C	9.08

Source: Illinois State Water Survey

Needs to be checked

Oak Street Seepage	
Parameters	Value
	mg/L
TDS	986
Calculated TDS	943
Cations	
Na	116
K	1.6
Ca	154
Mg	55
Sr	0.26
Fe	0.2
Barium	0.13
Anions	
Chloride	235
Sulfate	109
Bicarbonate as CaCO3	430
Carbonate as CaCO3	0
Fluoride	ND
Si as SiO2	13.7
pH at 23.6 C	7.6

Caveat: Water quality is likely to be variable; influenced by precipitation pattern

Source: Report to Student Sustainability Committee
By E. Day, N. Grabowski, A. Rennegarbe
Title of Report: Design of a Sub-soil Drainage Water
Distribution System
Date: 12/18/2009
Copy Obtained From: Jim Hopper, UIUC Water Station

Oak Street Seepage - Prior Study

- Report:

Design of a Sub-soil Drainage Water Distribution System
  - By E. Day, N. Grabowski, A. Rennegarbe
  - Report to Student Sustainability Committee

- Suggests that cost of treating seepage water is excessive
  - Evaluated RO as treatment option; major costs identified in descending order
    - Disposal costs of RO reject
    - pH adjustment of RO permeate
    - Energy for RO operation
    - Anti-scalant dosage costs

Prior Study…Observations

- The improved quality of tower water is not reflected in the COC
- Basis for chemical costs are unclear but likely incorrect (Appendix B, Fig 2 suggests that water input is 100% raw seepage with sulfuric acid to control alkalinity rather than RO water)

Oak Street Seepage
Examination of Appendix B Fig 2

Route 4

- Water flow rate = 196 gallons/min = 1.03E5 kgal/yr (196*60*24*365)
- COC = 2.8 = Tower Ca (mg/l) (as modeled by NALCO/Input Ca (mg/l) = 431.2/154
- The Oak Street Seepage water has a Ca content of 154 mg/l; it is likely that Fig 2 uses raw seepage not RO as input
- Furthermore, NALCO model assumes Tower Alkalinity to be at 1.86 meq/l
- Assuming that alkalinity cycles up at 2.8 COC, input alkalinity has to 1.86/2.8 = 0.665
- But Oak Street Seepage is at an Alkalinity of 8.59 meq/l
- Therefore, alkalinity has to be reduced by 7.925 meq/l (8.59-0.66)
- This requires sulfuric acid addition of 7.925 meq/l or 7.925 meq/l*48 mg/meq = 380.4 mg/l
- 380.4 mg/l = 1439.8 mg/gallon = 1439.8 g/kgal = 1.4398 kg/kgal =3.173 lb/kgal
- Sulfuric acid additions per year = 3.173 lb/kgal *1.03E5 kgal/yr = 3.2694E5 lb/yr
- At $ 0.25/lb, annual costs = $81,744 (this # is close to the number in NALCO spreadsheet in Fig 2)
- Therefore $/kgal = 81,744/1.03E5 = $0.79/kgal (reported in Table 1 Appendix B)

Source: Report to Student Sustainability Committee
By E. Day, N. Grabowski, A. Rennegarbe
Title of Report: Design of a Sub-soil Drainage Water Distribution System
Date: 12/18/2009
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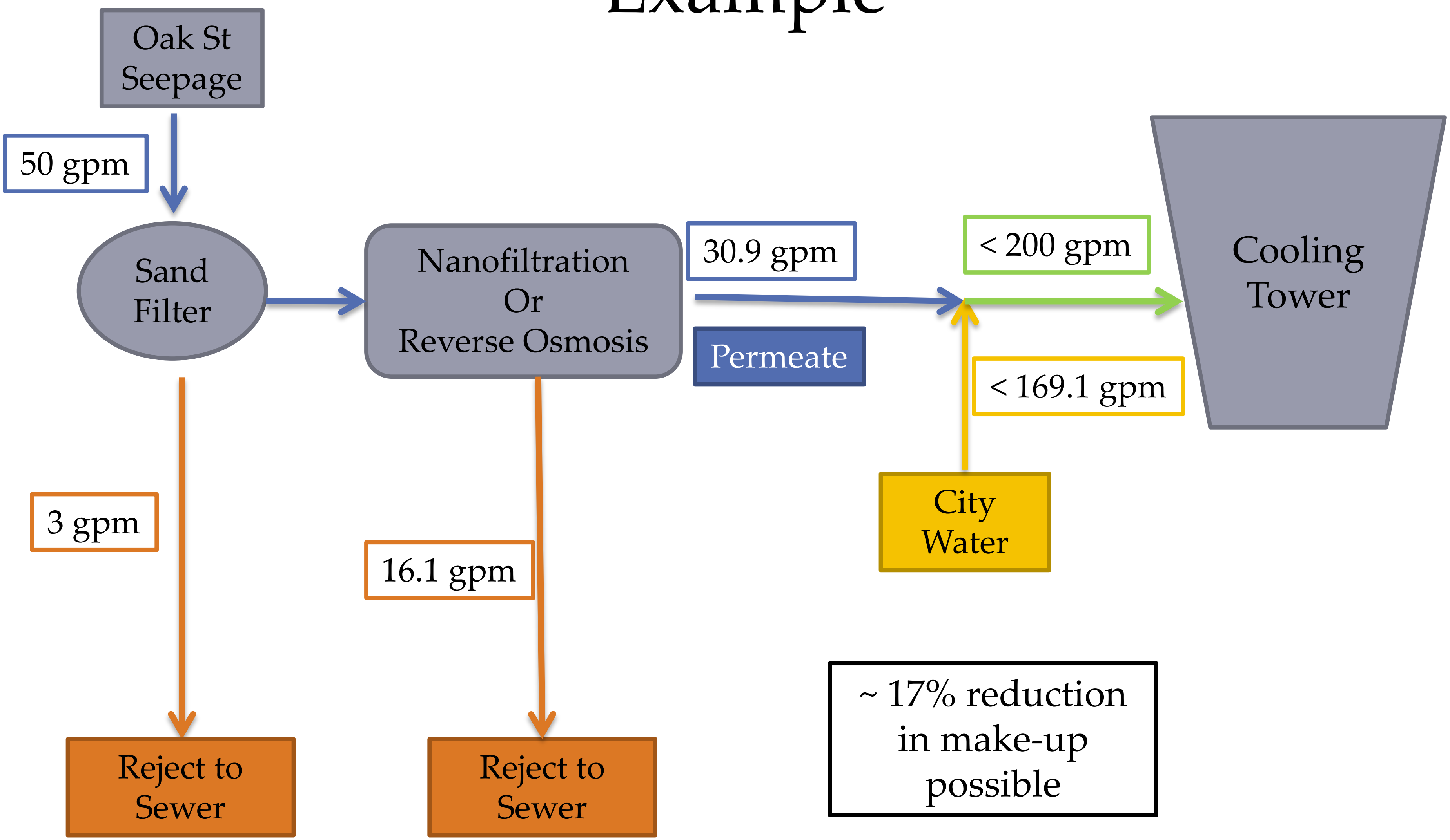
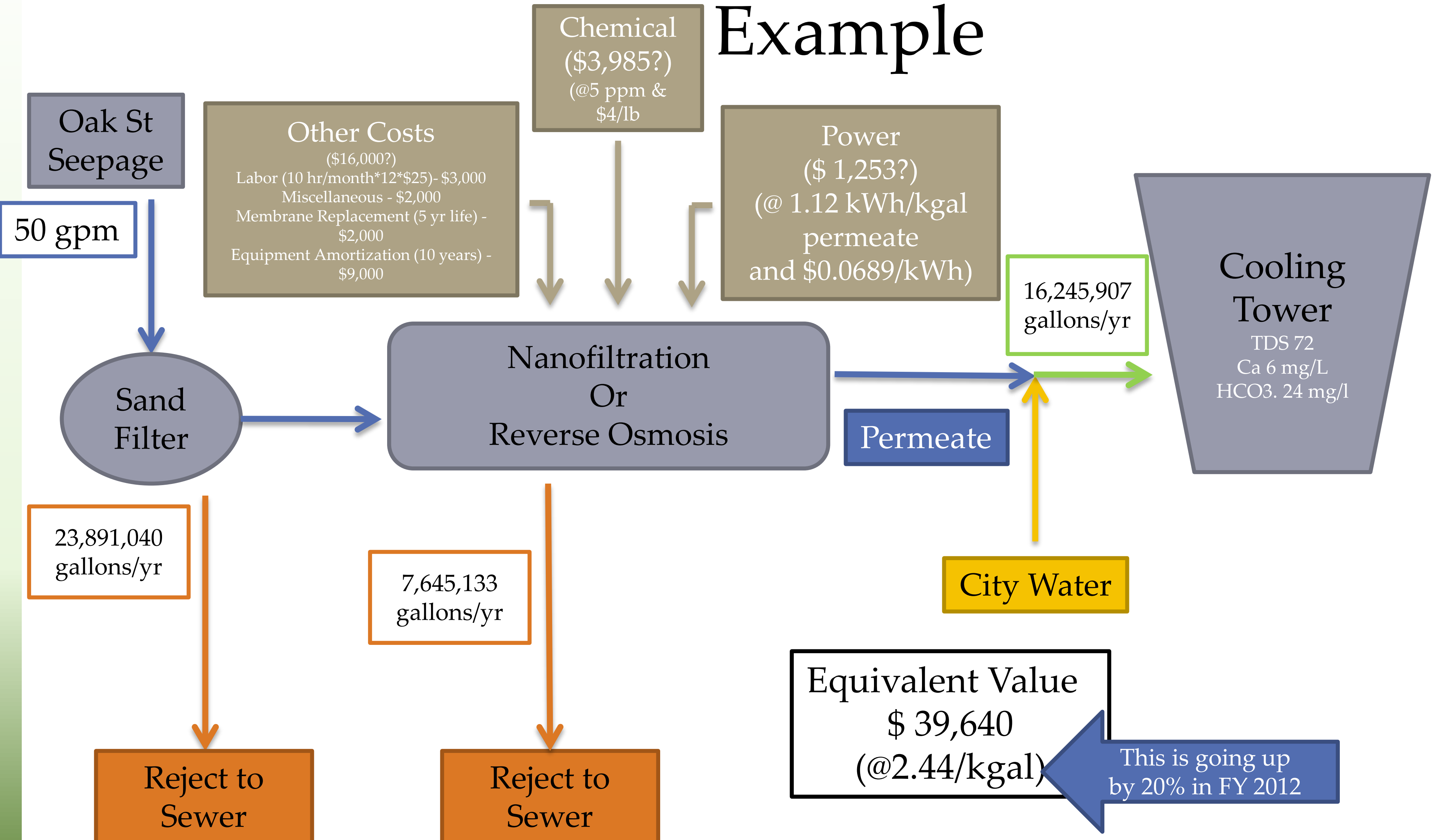
Use of Alternative Water Sources Example



Use of Alternative Water Sources Example



Oak Street Seepage - Summary

- Suggest taking a second look at this opportunity
- Positive cash flow is possible
- Uncertainties with water quality data need to be resolved (paper study/analytical data collection & pilot encouraged)
- If feasible, explore lease/contract option rather than ownership

ROUTE 5

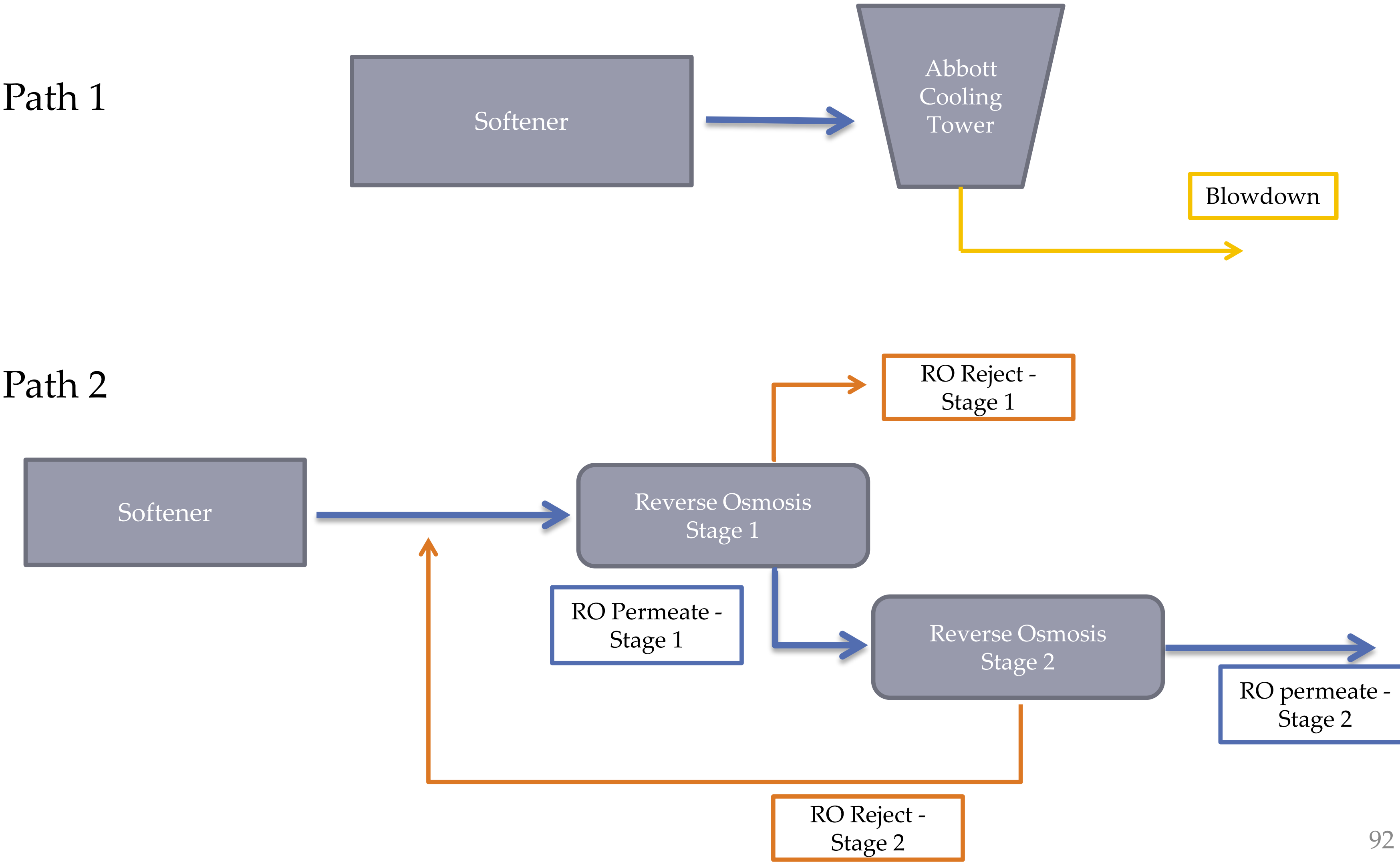
Use CT blowdown to displace water use in another application

Cooling Tower Blowdown as RO Input?

Route 5

- Given the low COC at Abbott Tower and the large use, does it make sense to use the CT blow down as RO input?
- In other words, what benefits might accrue if Tower/RO is optimized as a system?

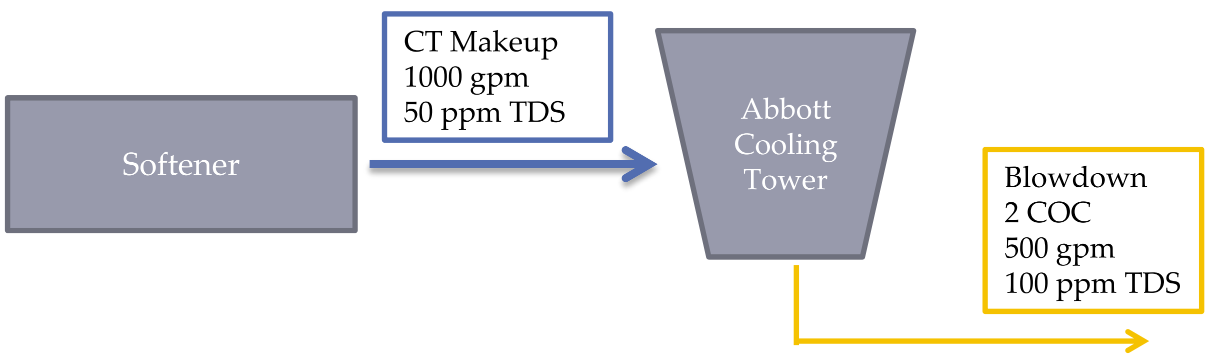
Abbott Water Paths



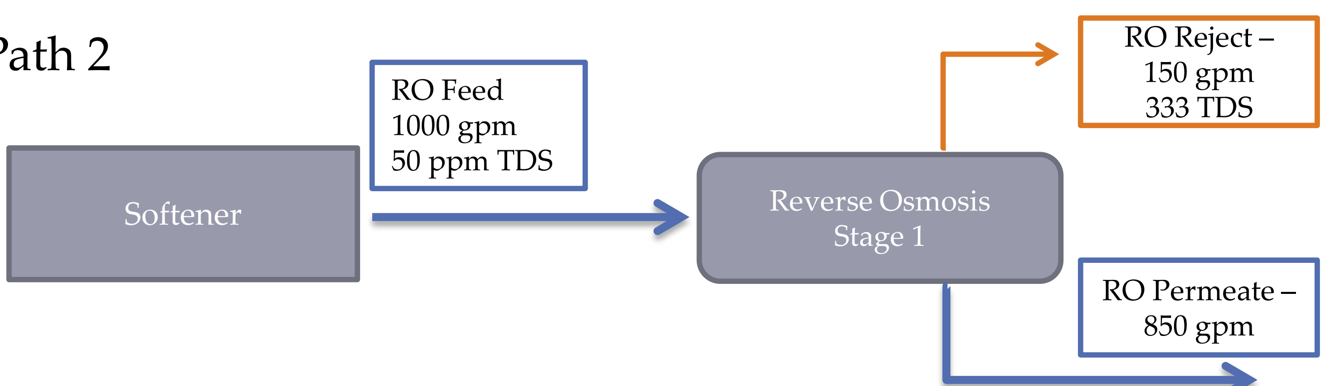
Example: Systems Designed Separately

Baseline
Incoming Water = 1000 (RO)+ 1000 (CT) = 2000 gpm
Total Effluent = 150 (RO) + 500 (CT) = 650 gpm

Path 1



Path 2

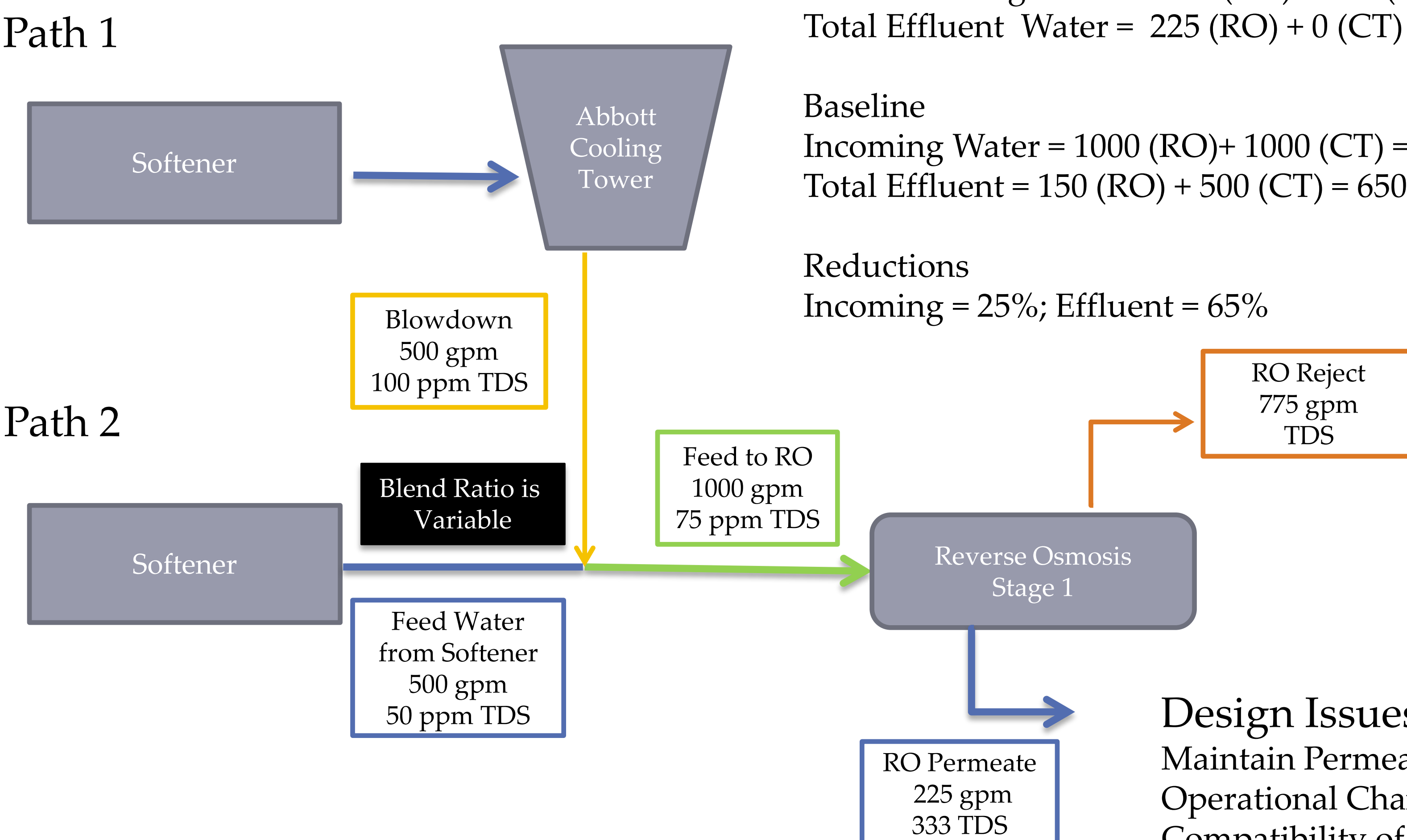


Example: Systems Designed as Parts of a Whole

Total Incoming Water = 500 (RO)+1000 (CT) = 1500 gpm
Total Effluent Water = 225 (RO) + 0 (CT) = 225 gpm

Baseline
Incoming Water = 1000 (RO)+ 1000 (CT) = 2000 gpm
Total Effluent = 150 (RO) + 500 (CT) = 650 gpm

Reductions
Incoming = 25%; Effluent = 65%



Design Issues
Maintain Permeate Production
Operational Changes to RO/CT
Compatibility of Chemicals
& so on

Follow-Up

Actions

- Install Trasar 3D monitoring at Oak St and Vet Med Chiller Plants
- Feasibility study of sulfuric acid dosing to increase COC at chiller plants
- Optimize Abbott Cooling Tower and RO as a whole system
- Benchmark softener plant performance at Abbott/other locations

Pilot Studies

- Piloting of Nanofiltration of Oak Street seepage water as make-up for cooling tower
- Pilot investigation of non-chemical water treatment (especially VRTX) technologies for stand-alone towers
- Pilot investigations of non-chemical softening using zeolite based resins

Appendix

- Untreated Towers – FY 2011 Operation
- Treated Towers – FY 2011 Operation
- Campus Savings Calculation
  - Table of Values
  - Calculation of Incoming Water Savings (kgal)
  - Calculation of Incoming Water Cost Savings ($)
  - Calculation of Total Water Cost Savings ($)
- Utility Rates for FY 2011 Memo from Terry Ruprecht – for Energy Savings Rates
- True Cost of Water Calculation
- Campus Water Bill
- Retrocommissioned Buildings
- Abbott
  - Abbott Cooling Tower Makeup Flow Rates
  - Abbott RO Operation
- NALCO Quotes

	Untreated Towers	Estimated Cycles (FY 2011)	Makeup (Kgal) (FY 2011)	Evaporation (kgal) (FY 2011)	Blowdown (kgal) (FY 2011)
1	Transporation Building	1.07	1,171	75	1,097
2	National Soybean Research Center	1.14	454	57	397
3	Medical Sciences Building	1.16	429	58	371
4	Lincoln Avenue Residence Hall	1.13	523	60	463
5	Ice Arena	1.20	4,128	689	3,438
6	Illinois Street Residence Hall	1.18	295	44	251
7	Burnsides Research Laboratory	1.27	2,322	498	1,824
8	Natural Resource Studies Annex	1.26	5,598	1,140	4,458
9	Pennsylvania Avenue Residence Hall	1.23	247	46	200
10	Illini Union	1.28	405	87	317
11	Housing Food Stores	1.28	9,219	2,033	7,186
12	English Building	1.23	2,464	467	1,997
13	Burrill Hall	1.27	511	109	402
14	Printing & Photographic Service Building	1.39	2,376	661	1,715

	Treated Towers	Estimated Cycles	Makeup (Kgal)	Evaporation (kgal)	Blowdown (kgal)
		(FY 2011)	(FY 2011)	(FY 2011)	(FY 2011)
	Construction Engineering Research Lab	-	-	-	-
	State Regional Office Building	-	-	-	-
1	Plant Sciences Laboratory	1.57	1,065	385	679
2	Water Survey Research Center	1.79	2,798	1,231	1,567
3	Abbott Power Plant	1.93	48,934	23,619	25,314
4	Animal Science Air Conditioning Center	2.27	16,809	9,388	7,421
5	Library Air Conditioning Center (Meter ID 5)	2.18	19,838	10,741	9,097
6	Temple Hoyne Buell Hall	2.89	1,208	789	419
7	Library Air Conditioning Center (Meter ID 4)	3.12	4,822	3,276	1,546
8	Library Air Conditioning Center (Meter ID 7)	3.01	5,793	3,872	1,921
9	Chemical & Life Sciences Lab	3.24	696	481	215
10	North Campus Chiller Plant (North Meter)	3.18	42,568	29,202	13,365
11	North Campus Chiller Plant (South Meter)	3.13	10,939	7,445	3,494

Campus Savings Calculation

	cost savings	Makeup water savings (kgal)	proposed cycles		
Oak St	$ 27,553.63	9,486.04	5		
NCCP -North	$ 19,168.35	6,064.86	5		
NCCP -South	$ 5,207.76	1,632.14	5		
Vet Med	$ 50,940.63	24,287.66	5		
Housing	$ 14,356.32	6,508.71	4		
Law Library	$ 6,497.48	3,368.29	4		
ISTC	$ 3,008.35	1,845.90	4		
NRSA	$ 9,187.20	4,077.91	4		
	Current (kgal)	With Changes (kgal)	$ Current	$ With Changes	
Total Cycle Change savings	0	57,271.51	-	$ 135,920	
FY 2011 Total campus water use	1,099,293	1,042,021	2,737,683		
FY 2011 Total campus CT water use	278,684	221,412	1,141,582	1,005,663	
FY 2011 Campus Water Ex CT	820,609	820,609	2,043,648	2,043,648	
	With Changes ($)	With changes (kgal)		With Change ($)	With Change (kgal)
Total Campus Water	2,595,054	1,042,021.24	Total CT	1,005,663	221,412
Fy2011 Campus water Ex CT	2,043,648		% Savings	11.9%	20.6%

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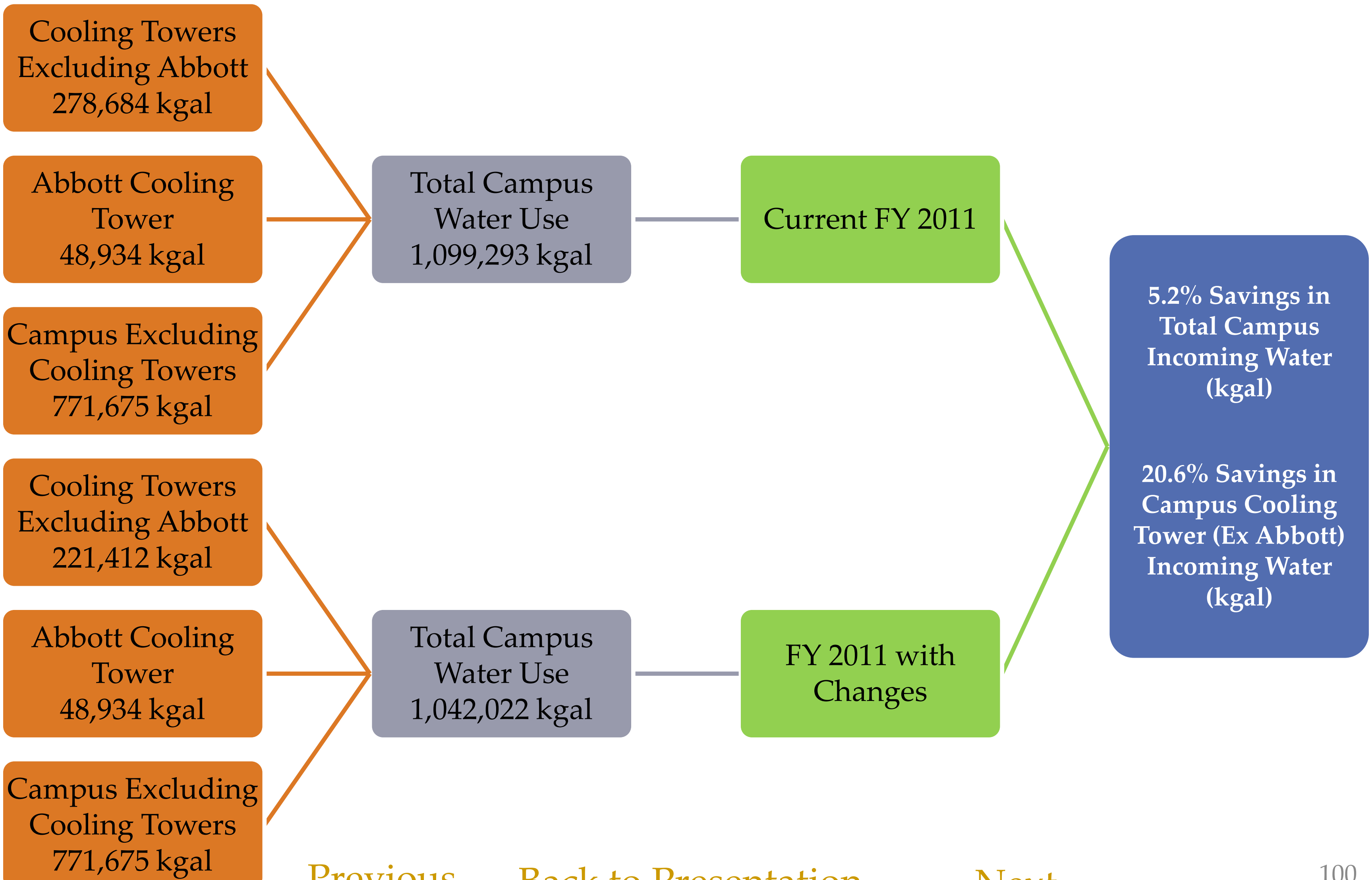
Campus Savings Calculation Incoming Water (kgal)



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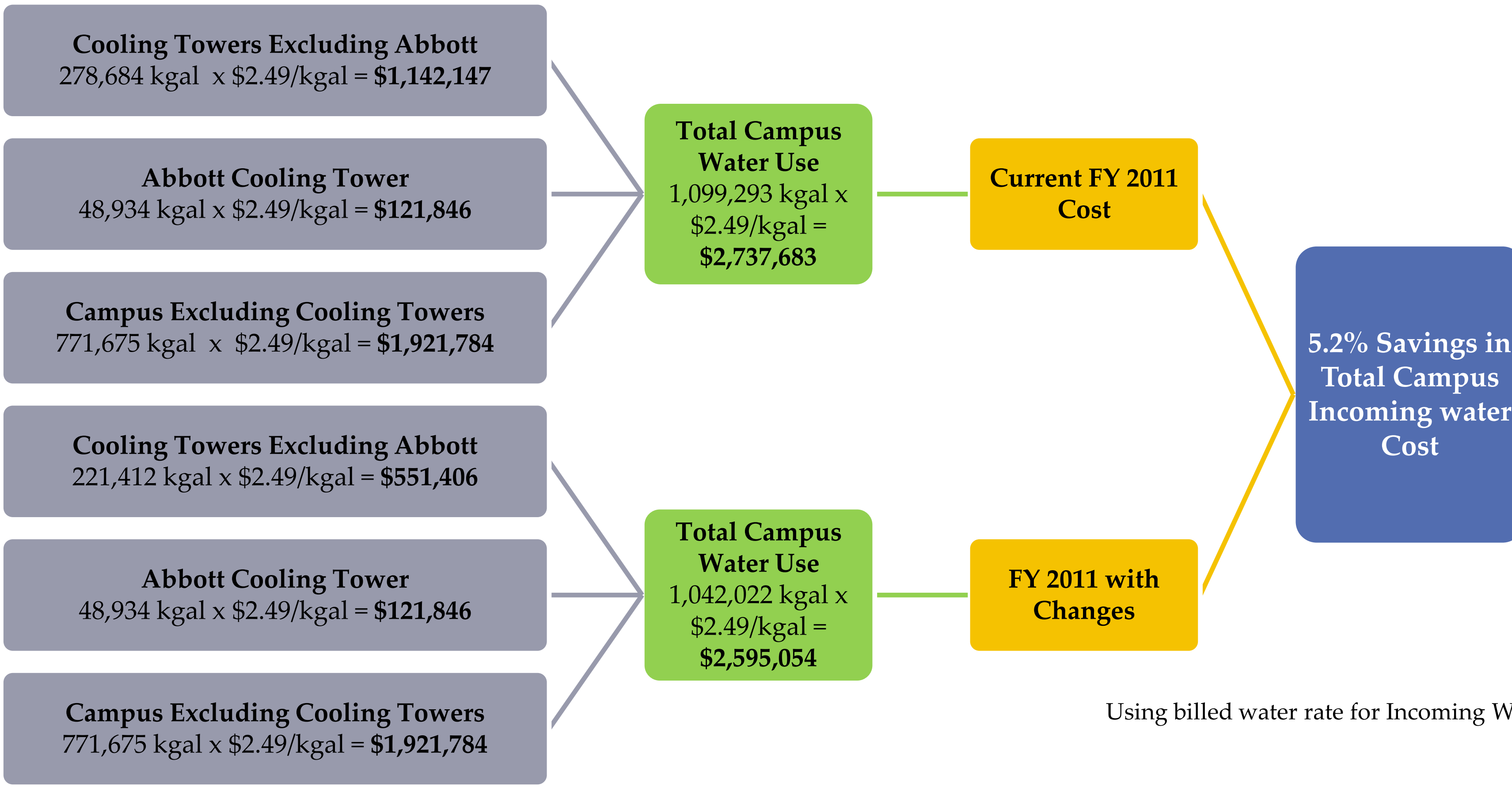
Campus Savings Calculation
Incoming Water Cost ($)



Using billed water rate for Incoming Water

Campus Savings Calculation Total Water Cost ($)

Cooling Towers Excluding Abbott
Incoming water : 278,684 kgal x $2.15/kgal = $599,169
Chemical treatment: 203, 497kgal x $1.08/kgal = $219,533
75,186 x $0.00/kgal = $0.00
Sewer : 278,684 kgal x 0.25 x $2.02/kgal = $140,735
TOTAL COST = $959,437

Abbott Cooling Tower
Incoming water : 48,934 kgal x $2.15/kgal = $105,208
Chemical treatment: 48,934 kgal x $1.08/kgal = $52,849
Sewer : 48,934 kgal x 0.25 x $2.02/kgal = $ 24,712
TOTAL COST = $182,769

Campus Excluding Cooling Towers
771,675 kgal x $2.15/kgal = **$1,659,101**

Total Campus Water Cost $2,801,307

Current FY 2011 Settings

Cooling Towers Excluding Abbott
Incoming water : 221,413 kgal x $2.15/kgal = $476,036
Chemical treatment:
5 cycles : 139,861kgal x $1.18/kgal = $165,035
+ 4 cycles : 66,227kgal x $1.08/kgal = $71,525
Untreated : 15,324 kgal x $0.00 = $0.00
Sewer : 221,413 kgal x 0.25 x $2.02/kgal = $111,813
TOTAL COST = $824,409

Abbott Cooling Tower - Unchanged
Incoming water : 48,934 kgal x $2.15/kgal = $105,208
Chemical treatment: 48,934 kgal x $1.08/kgal = $52,849
Sewer : 12,234 kgal x $2.02/kgal = $ 24,712
TOTAL COST = $182,768

Campus Excluding Cooling Towers - Unchanged
771,675 kgal x $2.15/kgal = **$1,659,101**

Total Campus Water Cost
$2,666,280

FY 2011 with Changes
Oak St, NCCP (N&S), Vet Med to 5 COC
Housing, Law, ISTC, NRSA to 4 COC

14.2% Savings in Campus Cooling Tower (Ex Abbott) Water Cost

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Using Energy Savings Rates for Sewer and Incoming Water

Utility Rates Memo

University of Illinois at Urbana-Champaign

Facilities & Services
Physical Plant Service Building
1501 South Oak Street
Champaign, IL 61820

DATE: JUNE 28, 2010

TO: J.G. DEMPSEY
G. WAAS

FROM: TERRY RUFRECHT

RE: UTILITY RATES FOR FY 2011

For your information, the following is a summary of charge out rates for utilities at the Urbana-Champaign campus for the Fiscal Year ending 30-Jun-2011. These rates apply to all facilities not receiving direct billings from outside utility providers.

Commodity	Unit of Measure	Billing Rate *	Energy Savings Rate **
Steam	$/1000 lbs	$19.8309	$10.4730
Electricity	$/kwh	$0.0791	$0.0497
Chilled Water	$/Mmbtu	$12.8882	$6.9302
Water	$/1000 gal	$2.4435	$2.1521
Sanitary Sewer	$/1000 gal	$2.4368	$2.0262

*Billing Rate – The fully costed rate for billing utilities to campus units. Rates are pending approval by University Administration.

** Energy Savings rate – Fuel and consumable materials costs only. To be used to calculate energy savings for energy conservation projects.

Please do not hesitate to call me at 333-7900 if you have any questions with respect to this material.

CC: K. ERICKSON, T. TEMPLES
M. MARQUISSEE, C. TAYLOR
J. RIX, K. REIFSTECK

BACK

True Cost of water Example Calculation

- Assume constant heat load; i.e., constant evaporation
- Blowdown (kgal/min) = Evaporation (kgal/min)/(COC-1)
- Make-up (kgal/min) = Evaporation (kgal/min)*[COC/(COC-1)]

- Make-up at COC of 3.5 = E*1.4; Blowdown at COC of 3.5 = E*0.4
- Make-up at COC of 5 = E*1.25; Blowdown at COC of 5 = E*0.25

- Costs at 3.5 COC = (E*1.4)*$2.15+ (E*0.4)[a]*$2.02+ (E*1.4)*$1.08 = $5.33*E
- Costs at 5 COC = (E*1.25)*$2.15+ (E*0.25) [a]*$2.02+ (E*1.25)*$1.18 = $4.67*E

- Relative costs $_{COC = 5/COC=3.5}$ = 0.875 (~10% savings)

- Incoming Water Savings $_{COC = 5/COC=3.5}$ = 1.25/1.4 = 0.89 (~10% savings)
- Discharged Water Savings $_{COC = 5/COC=3.5}$ = 0.25/0.4= 0.625 (~40% savings)

*. In previous slide, costs reflect blowdown fixed at 25% of makeup

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Retro-X: Buildings Completed

Building	After (MMBTU)	Before (MMBTU)
ACES Library Info. & Alumni Center	5,224	12,742
Animal Sciences Laboratory	6,852	9,943
Bevier Hall	8,921	11,304
Chemical & Life Sciences Laboratory	2,516	2,529
Coordinated Science Laboratory	12,886	20,704
Foellinger Auditorium	1,049	1,647
Foreign Languages Building	2,785	2,368
Henry Administration Building	3,390	5,170
Illini Union Bookstore	0	0
Krannert Center for Performing Arts	14,387	17,085
Loomis Laboratory of Physics	14,434	19,512
Madigan Laboratory Edward R	19,221	28,025
Mechanical Engineering Laboratory	14,132	22,944
[illegible]	[illegible]	[illegible]

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Campus Water Bill

Usage Month	Calendar Year	Fiscal Month	Fiscal Year	TOTAL WATER COST ($)	TOTAL WATER USAGE (Kgals)	Cost ($/kgal)
Jun	2010	JUL	2011	$262,677	105,925	
Jul	2010	AUG	2011	$274,735	111,716	
Aug	2010	SEP	2011	$283,767	116,120	
Sep	2010	OCT	2011	$288,447	118,314	
Oct	2010	NOV	2011	$233,662	94,154	
Nov	2010	DEC	2011	$198,983	78,631	
Dec	2010	JAN	2011	$201,982	80,621	
Jan	2011	FEB	2011	$174,090	67,691	
Feb	2011	MAR	2011	$177,958	69,637	
Mar	2011	APR	2011	$209,207	83,012	
Apr	2011	MAY	2011	$213,736	85,270	
May	2011	JUN	2011	$224,150	90,067	
12 MO		TOTAL		$2,743,393	1,101,158	2.49

Abbott Cooling Tower Makeup Flow Rates

Month	Makeup (kgal)
FY 2011 Total	48,934
1	6,590
2	4,181
3	3,960
4	2,681
5	2,678
6	2,647
7	4,473
8	4,299
9	4,866
10	3,079
11	3,501
12	5,980
FY 2012 Total	12,843
7	2,880
8	3,532
9	2,292
10	2,231
11	1,908

Abbott RO Operation (pg 1 of 2)

	RO RO1 1st Pass Permeate Flow
	kgal
FY 2010	26,516
Jul-09	2,242
Aug-09	1,437
Sep-09	1,481
Oct-09	1,802
Nov-09	1,852
Dec-09	2,480
Jan-10	3,512
Feb-10	3,674
Mar-10	3,133
Apr-10	1,643
May-10	1,558
Jun-10	1,703

	RO RO1 1st Pass Reject Flow
	kgal
FY 2010	5,160
Jul-09	365
Aug-09	250
Sep-09	272
Oct-09	359
Nov-09	384
Dec-09	521
Jan-10	774
Feb-10	726
Mar-10	628
Apr-10	310
May-10	276
Jun-10	297
FY 2011	4,757

	RO RO1 2nd Pass Permeate Flow
	kgal
FY 2010	25,878
Jul-09	2,119
Aug-09	1,389
Sep-09	1,471
Oct-09	1,794
Nov-09	1,832
Dec-09	2,437
Jan-10	3,422
Feb-10	3,574
Mar-10	3,069
Apr-10	1,643
May-10	1,538
Jun-10	1,589

	RO RO1 2nd Pass Reject Flow
	kgal
FY 2010	2,569
Jul-09	178
Aug-09	139
Sep-09	133
Oct-09	161
Nov-09	176
Dec-09	242
Jan-10	363
Feb-10	386
Mar-10	320
Apr-10	151
May-10	143
Jun-10	176
FY 2011	2,769

Inconsistency in total flow rates noted- see 2nd pass

Abbott RO Operation (pg 2 of 2)

RO RO2 1st Pass Permeate Flow	Sum of Flow (kgal)
FY 2010	24,682
Jul-09	2,784
Aug-09	2,162
Sep-09	1,847
Oct-09	1,696
Nov-09	1,808
Dec-09	1,636
Jan-10	1,427
Feb-10	1,500
Mar-10	1,540
Apr-10	2,184
May-10	2,479
Jun-10	3,621

RO RO2 1st Pass Reject Flow	Sum of Flow (kgal)
FY 2010	4,628
Jul-09	552
Aug-09	430
Sep-09	380
Oct-09	321
Nov-09	308
Dec-09	280
Jan-10	245
Feb-10	264
Mar-10	266
Apr-10	398
May-10	477
Jun-10	707

RO RO2 2nd Pass Permeate Flow	Sum of Flow (kgal)
FY 2010	23,278
Jul-09	2,588
Aug-09	2,013
Sep-09	1,712
Oct-09	1,615
Nov-09	1,727
Dec-09	1,572
Jan-10	1,360
Feb-10	1,438
Mar-10	1,485
Apr-10	2,084
May-10	2,338
Jun-10	3,348

RO RO2 2nd Pass Reject Flow	Sum of Flow (kgal)
FY 2010	2,537
Jul-09	298
Aug-09	228
Sep-09	194
Oct-09	200
Nov-09	196
Dec-09	165
Jan-10	129
Feb-10	134
Mar-10	136
Apr-10	209
May-10	250
Jun-10	297

Inconsistency in total flow rates noted- see 2nd pass

NALCO

Nalco Company
Water and Process Services
1601 West Diehl Road
Naperville, IL 60563-1198
630 305 1000
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District Office
1322 W Northmoor Road
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309.8686.2551 Office
309.296.1647 Fax

April 6, 2011

Jim Hopper
University of Illinois
1117 South Oak Street
Champaign IL 61820

Dear Mr. Hopper:

As we have discussed, I have calculated the cost to treat the cooling systems at the University of Illinois based on 1,000 gallons of makeup water to the cooling systems on campus. I have also included the pounds of treatment that were purchased during FYI 2010. Please keep in mind that the Campus Cooling Make up is un-softened, while Abbott Cooling Make up is softened. As such the treatments are not the same. I have outlined below the cost to treat based on each system below.

	July 1, 2009 to June 30, 2010	
	Total Lbs.	**Total Spent**
3DT289	18,479	$ 51,189.60
3DT265	21,396	$ 46,866.00
ST 70	28,307	$ 54,631.02

Volume Treated		1,000,000	Gallons
Feed Rate 3DT265/89		60	ppm
3dt265 lbs./gal		9.3	lbs.
3dt289 lbs./gal		9.6	lbs.
ST70 (NaOH)		50	pmm
ST70 lbs./gal		11.1	lbs.
Cycles-3DT265		4	
Cycles-3DT289		7	
Cost to Treat 1,000,000 Gallons w/ 3DT265			
Cooling Tower		125.1	lbs.
		13.45	gallons
	$	274.02	Total
Cost to Treat 1,000,000 Gallons w/ 3DT289			
Abbott		71.49	lbs.
		7.69	gallons
	$	198.02	Total
Abbott **Cost to Treat 1,000,000 Gallons w/ ST 70**			
		417	lbs.
		37.57	gallons
	$	804.78	Total

Trasar 265

3DT265 -Campus Towers
Total to Treat 1,000,000 Gallons
$ 1,078.80
Total to Treat 1,000 Gallons
$ 1.08

3DT289 - Abbott Tower
Total to Treat 1,000,000 Gallons
$ 1,002.80
Total to Treat 1,000 Gallons
$ 0.97 + ST70

Please let me know if you have any additional questions or concerns.

Sincerely,

Brett Willey
Nalco Company
309.660.4131
bmwilley@nalco.com

NALCO

July 21, 2011

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Jennifer Deluhery
ISTC
One Hazelwood Drive
Champaign IL 61820

Jennifer:

As we have discussed, I have calculated the cost to treat the cooling systems at the University of Illinois based on 1,000 gallons of makeup water to the cooling systems on campus at 5 cycles of concentration.

Volume Treated	1,000,000		Gallons
Feed Rate 3DT289		130	ppm
Cycles		5	
3dt289 lbs/gal		9.6	lbs
ST70		50	ppm
ST70 lbs/gal		11.1	lbs
Acid Feed Rate		80	ppm
Acid lbs/gal		14.87	lbs
Cost to Treat 1,000,000 Gallons w/ 3DT289			
		216.84	lbs
		22.59	gallons
		$464.04	Total
Cost to Treat 1,000,000 Gallons w/ ST 70			
		417	lbs
		37.57	gallons
		$604.65	Total
Cost To Treat 1,000,000 Gallons w/ Acid			
		667.2	lbs
		44.9	gallons
		$4.94	Total
Cooling Towers 5 Cycles			
Total to Treat 1,000,000 Gallons			
$1,073.62			
Total to Treat 1,000 Gallons			
$1.07			

The increase in Cycles of Concentration will need to be achieved with the use of Sulfuric Acid being fed to the cooling systems. Sulfuric Acid represents a significant safety concern that will need to be addressed prior to increasing the cycles at the University of Illinois. Currently we do not feed Sulfuric Acid to any system on site at the University.

I have also calculated the cost to treat 1000 gallons of make up to the Chilled loop at $19.24/1000 gallons.

As we have reviewed the installation of the 3DTrasar Controllers have shown a savings in water consumption. The installation of the units is dependent upon several factors such as sample line installation and electrical requirements. Installations of the units have been completed for $2,000.00 to $4,000.00.

Please let me know if you have any additional questions or concerns.

Sincerely,

Brett Willey
Nalco Company
309.660.4131
bmwilley@nalco.com

From: Brett Willey <bmwilley@nalco.com>
Sent: Thursday, October 27, 2011 9:55 AM
To: Jennifer Deluhery
Subject: RE: Check on Sulfuric Estimate

Hi Jennifer,

I asked around and found that a ball park price for Acid (bulk) is around $0.16 per lb. In the calculation I used $0.11 per lb. I have updated the info below:

Volume Treated		1,000,000	Gallons
Feed Rate 3DT289		130	ppm
Cycles		5	
3dt289 lbs/gal		9.6	lbs
ST70		50	ppm
ST70 lbs/gal		11.1	lbs
Acid Feed Rate		80	ppm
Acid lbs/gal		14.87	lbs
Cost to Treat 1,000,000 Gallons w/ 3DT289			
		216.84	lbs
		22.59	gallons
	$	464.04	Total
Cost to Treat 1,000,000 Gallons w/ ST 70			
		417	lbs
		37.57	gallons
	$	604.65	Total
Cost To Treat 1,000,000 Gallons w/ Acid			
		667.2	lbs
		44.9	gallons
	$	106.75	Total
Cooling Towers 5 Cycles			
Total to Treat 1,000,000 Gallons			
$ 1,175.44			
Total to Treat 1,000 Gallons			
$ 1.18			
Chilled Loop $ per 1000 Gallons of Make Up			
$ 19.24			

Brett