

MWU Graduate Research Program

August 28, 2018



Al Larson PE, BCEE - Principal Engineer

Introductions

- Dr. Greg Harrington

Started the program in 2002 and has guided and advised all of the grad students in the program

- Adam Luthin

10th Student in the program and is looking at optimizing pump operations around energy

A Brief History of the MWU Grad Program

- Established in 2002
 - A collaborative effort of mutual cooperation between MWU and UW-Madison to promote drinking water research
- 9 Completed Master's Thesis Sponsored
 - Excellent work in water quality, flushing, and energy
- Adam Luthin is Grad Student #10
 - Continues the focus on energy use
 - Anticipated completion 5/2019
- Adam Luthin is Grad Student #10
 - Continues the focus on energy use
- Time for MOA Renewal: 2018 to 2021

Topics

- Water Quality
- Flushing
- Energy

Benefits

- 1500 hours per year
- MWU Access to UW faculty
- Focused research on specific areas
- Detailed thesis on the work

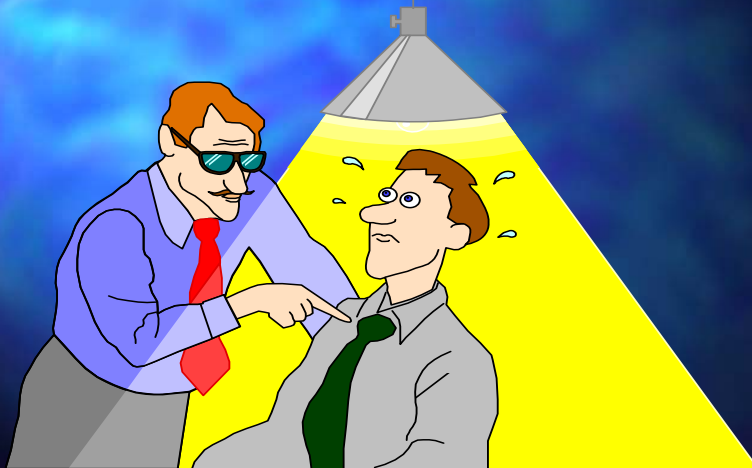
Accomplishments

- Water Quality
 - Chlorine Residuals & Biological Activity
- Flushing
 - Effectiveness/Schedule
- Energy
 - Pump Efficiencies, Well Pump VFD's, and Managing Peak Demand Charges

Economics

- Water Quality Savings
Estimated \$30,000 labor cost savings through the end of 2017
- Flushing Savings
Estimated \$430,000 labor cost savings through the end of 2017
- Energy Savings
Estimated \$95,000 energy cost savings through the end of 2017
- Salary Savings
Since 2002 and estimated salary savings of over \$500,000
- Current Program Cost
Approximately \$45,000 per year

Questions ???



Summary of Graduate Student Research with Madison Water Utility

2002-2018

Greg Harrington, Professor



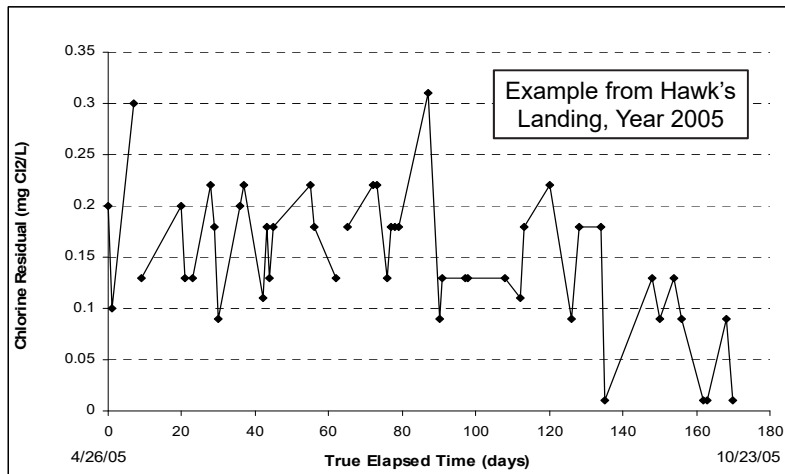
Civil and
Environmental Engineering

UNIVERSITY OF WISCONSIN-MADISON

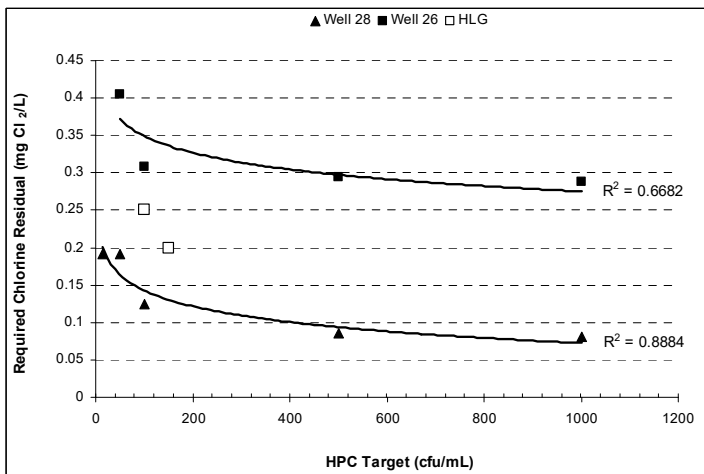
2002-2006

CHLORINE RESIDUAL STUDIES

Chlorine Concentrations Before and During Research



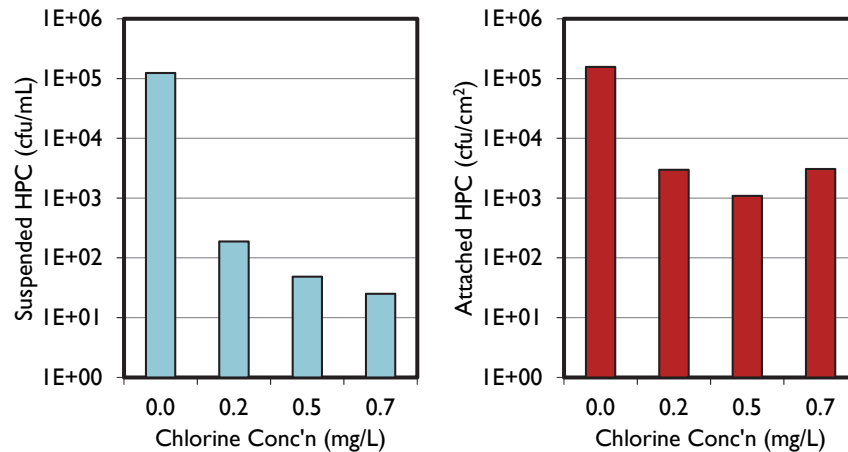
Chlorine Needed to Achieve Microbial Control



Unit Well 3 Area

Chlorine Range (mg/L)	< 0.10	≥ 0.10
Mean HPC (cfu/mL)	797	231
% samples HPC > 100 cfu/mL	37	21
% samples HPC > 500 cfu/mL	16	6
% samples HPC > 1000 cfu/mL	9	5

Pilot-Scale Experiments for Microbial Control



Influence of Unidirectional Flushing on Microbial Quality in Area Served by Unit Well 10

	Sample Period		
	Pre-Flush	7-day Post-Flush	30-day Post-Flush
Mean HPC (cfu/mL)	207	136	177
% samples HPC > 100 cfu/mL	28%	20%	20%
% samples HPC > 500 cfu/mL	12%	3%	3%
% samples HPC > 1000 cfu/mL	5%	2%	0%

Unidirectional flushing produced similar results for chlorine residuals

2007-2012

UNIDIRECTIONAL FLUSHING STUDIES



Suspension of Iron & Manganese Solids

Solids captured from flushing run when hydrant was first opened (mostly iron with some manganese)

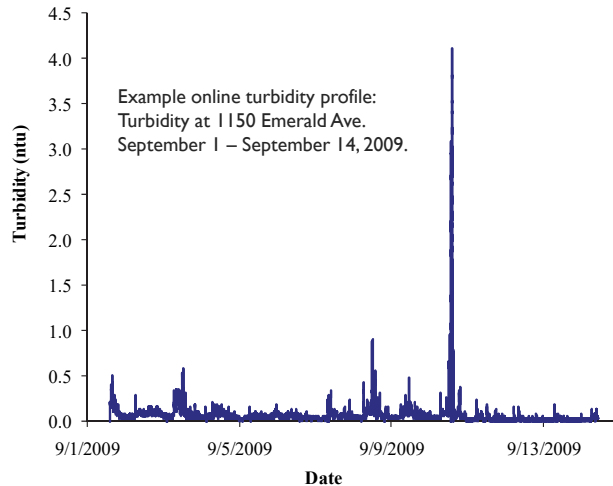


Solids captured from backwash of pyrolusite filter (mostly iron but with more manganese than photos on left)

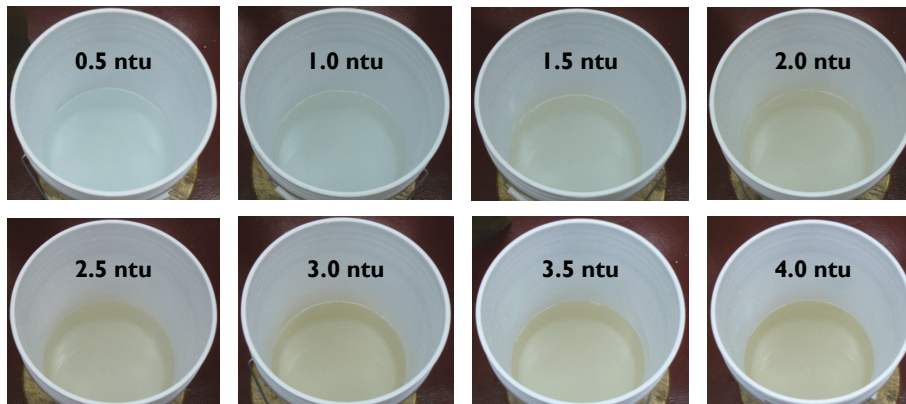


Online Turbidity Monitoring

- Helped define magnitude of observed turbidity events
- Coupled with customer complaint data:
 - Turbidity spikes higher than 2.5 ntu coincided with significant increase in probability of complaints
- Coupled with operations data:
 - 60% of flushing runs produced spike higher than 2.5 ntu along the main being flushed
 - 40% of main breaks coincided with spike higher than 2.5 ntu at a location within a mile of the break

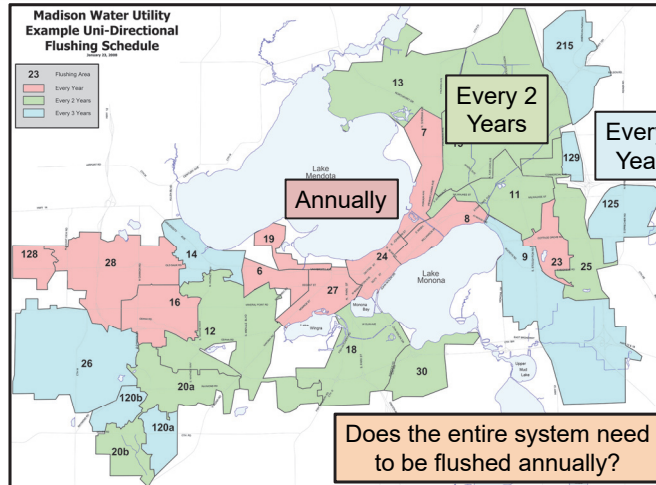
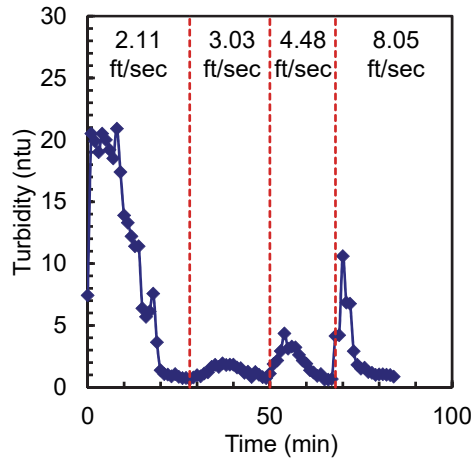


Iron Appearance in 5 Gallon Buckets



Depth of water in each bucket is 4 inches

Flushing Operations (Can we save water and time?)

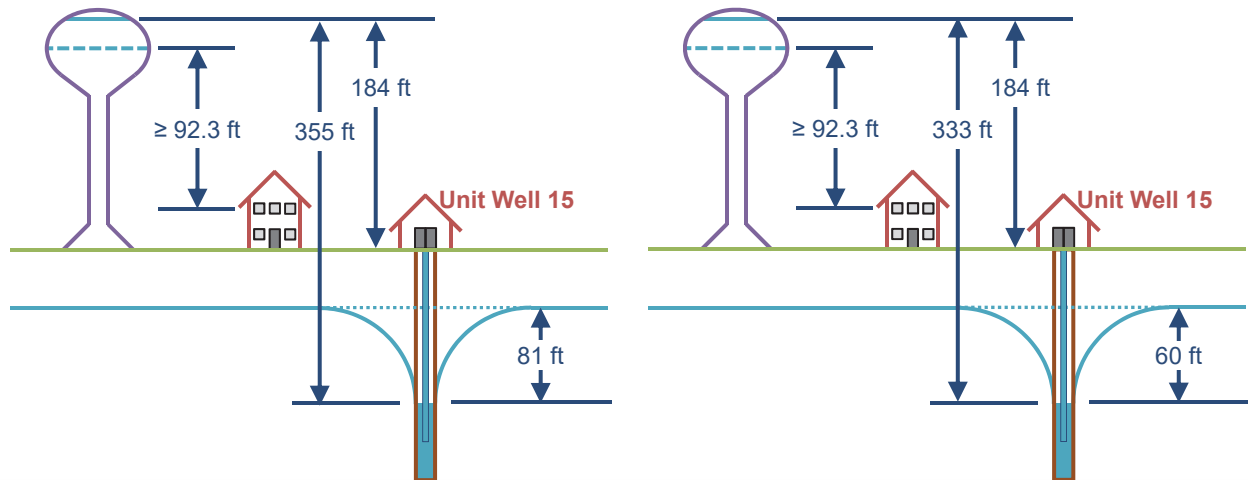


How much water can be pumped into system before flushing needed?
 Unit Well 8: 380 MG
 Unit Well 9: 291,000 MG

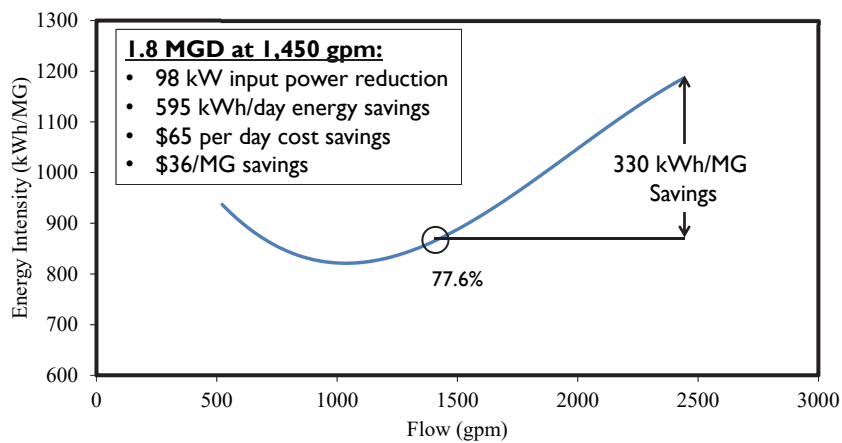
2013-present

STUDIES ON REDUCING ENERGY USE AND COST OF ENERGY

VFD Example: Madison, Wisconsin – Well 15



Estimated Savings from VFD Installation at Unit Well 30



1.8 MGD at 1,450 gpm:

- 98 kW input power reduction
- 595 kWh/day energy savings
- \$65 per day cost savings
- \$36/MG savings

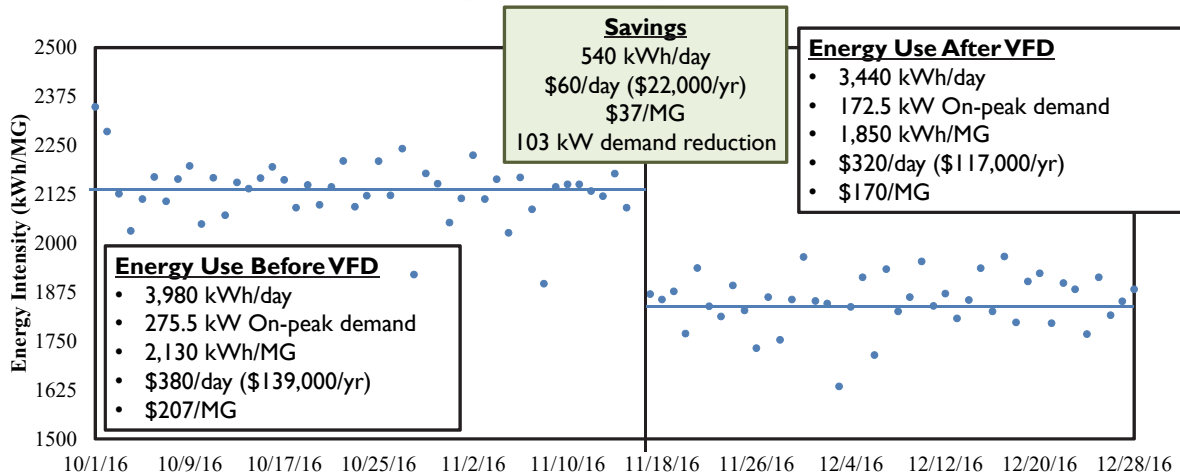
Operation Before VFD

- 1.88 MGD production
- Deep well pump
 - 2,410 gpm for 13 hrs/day
- Booster pump
 - 1,300 gpm for 24 hrs/day

Operation After VFD

- 1.87 MGD production
- Deep well pump
 - 1,450 gpm for 21.5 hrs/day
- Booster pump
 - 1,280 gpm for 24 hrs/day

Observed Energy Savings at Unit Well 30



Savings Over First 6 Months

VFD Operation: December 2016 – June 2017

Savings compared to December 2015 – June 2016:

- 277 kWh/MG energy intensity savings
- \$25.40/MG savings
- 94,550 kWh saved
- \$8,660 saved

Savings compared to June 2016 – November 2016

- 288 kWh/MG energy intensity savings
- \$26.70/MG savings
- 97,940 kWh saved
- \$9,090 saved

Note: this was done on the well with the highest expected savings and other wells will achieve lower savings

Current Student and Goals

- Adam Luthin
 - Native of Belvidere, Illinois
 - BS Mechanical Engineering, University of Minnesota, 2014
 - Quality Engineer for Andersen Corp in New Jersey, 2014-2017
 - Successfully hiked the Appalachian Trail in 2017
 - Began MS Civil & Environmental Engineering in Fall 2017
- Goal: optimize pumping operations for minimum energy use (or minimum energy costs) on a system-wide basis



Pumping Strategies for Energy Optimization

Adam Luthin
8/28/2018



Overview



In 2017...

- MWU spent **\$2.16 Million** on **20.3 GWh** of electrical energy to pump **9.42 billion** gallons of water (PSC, 2017)
- Over 85% of total electricity consumption attributed to pumping (Hamilton, 2009)

What can we do?

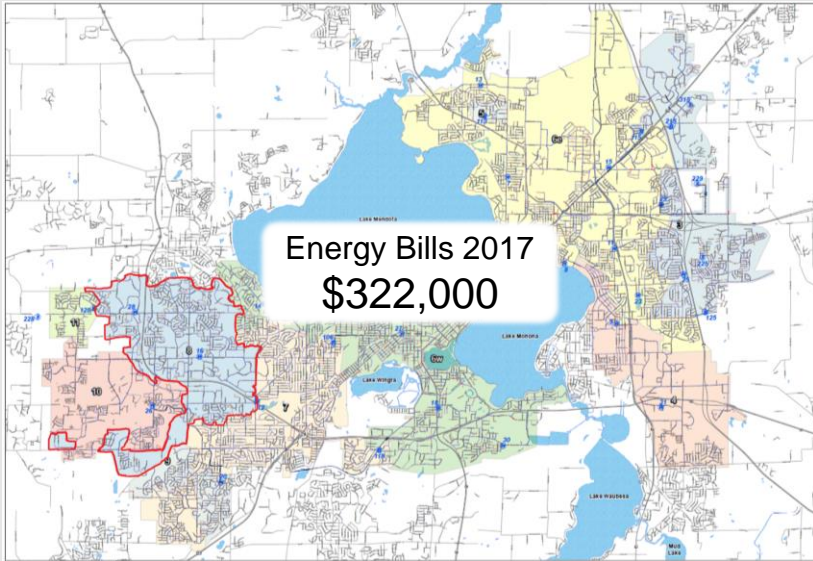
Seek the **Triple Bottom Line!**

- **Environment:** Decrease energy use
- **Economic:** Reduce energy costs
- **Social:** Maintain level of service

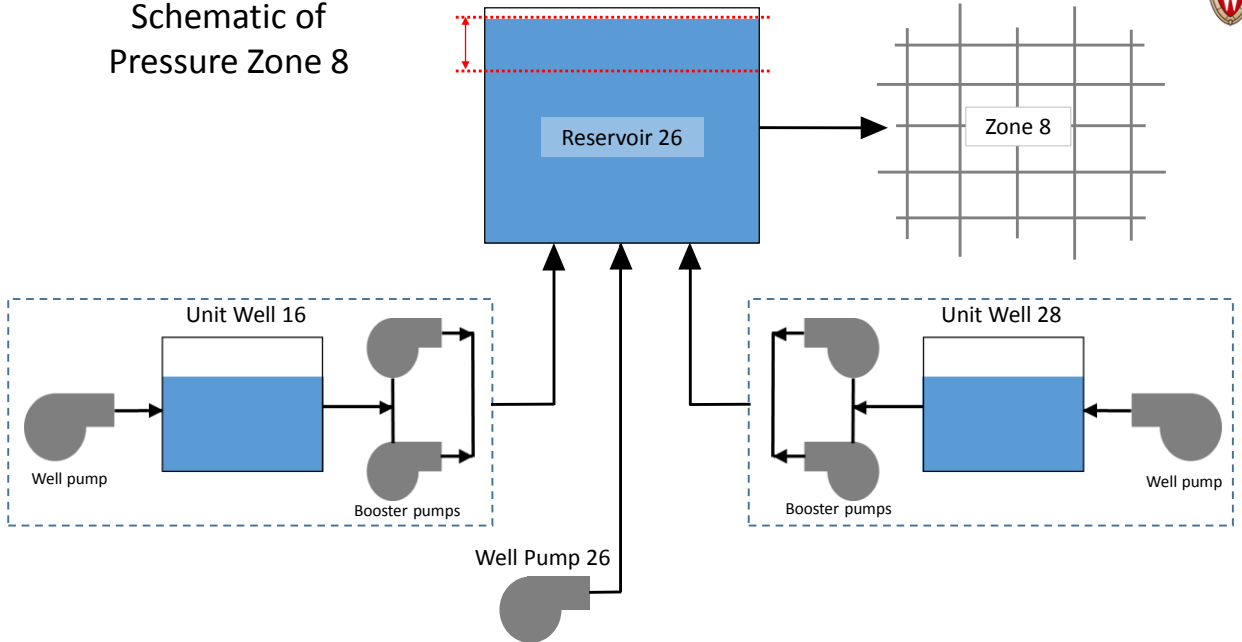
References:

PSC. (2017). *Water Utility Annual Report*. Wisconsin Public Services Commission.
Hamilton, G. (2009). "Driving Energy Efficiency in the U.S. Water & Wastewater Industry by Focusing on Operating and Maintenance Cost Reductions". ACEEE, 6-30 – 6-42.

System Map – Zone 8

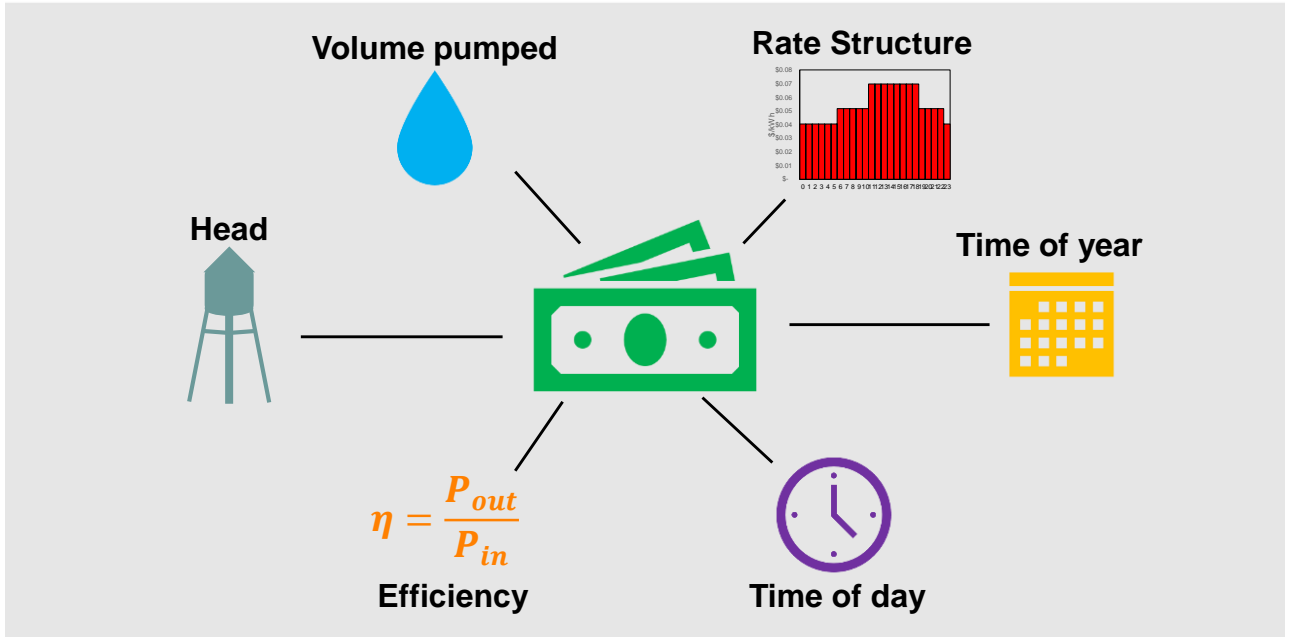


Schematic of Pressure Zone 8

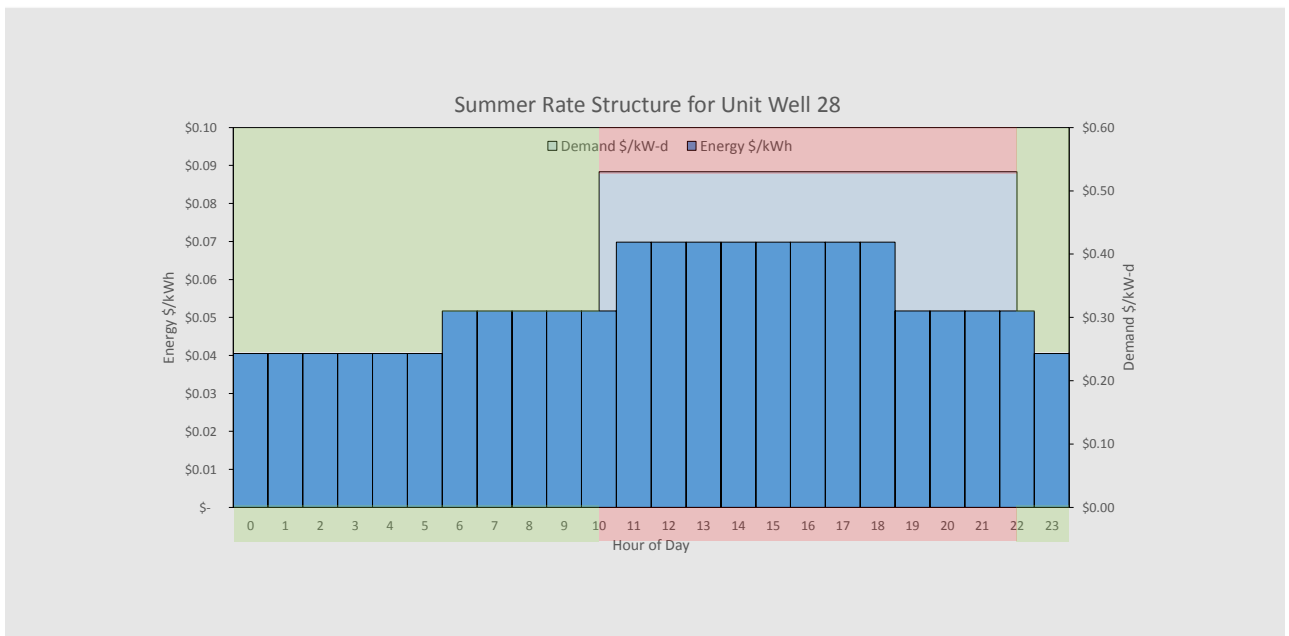




Energy Costs: A breakdown

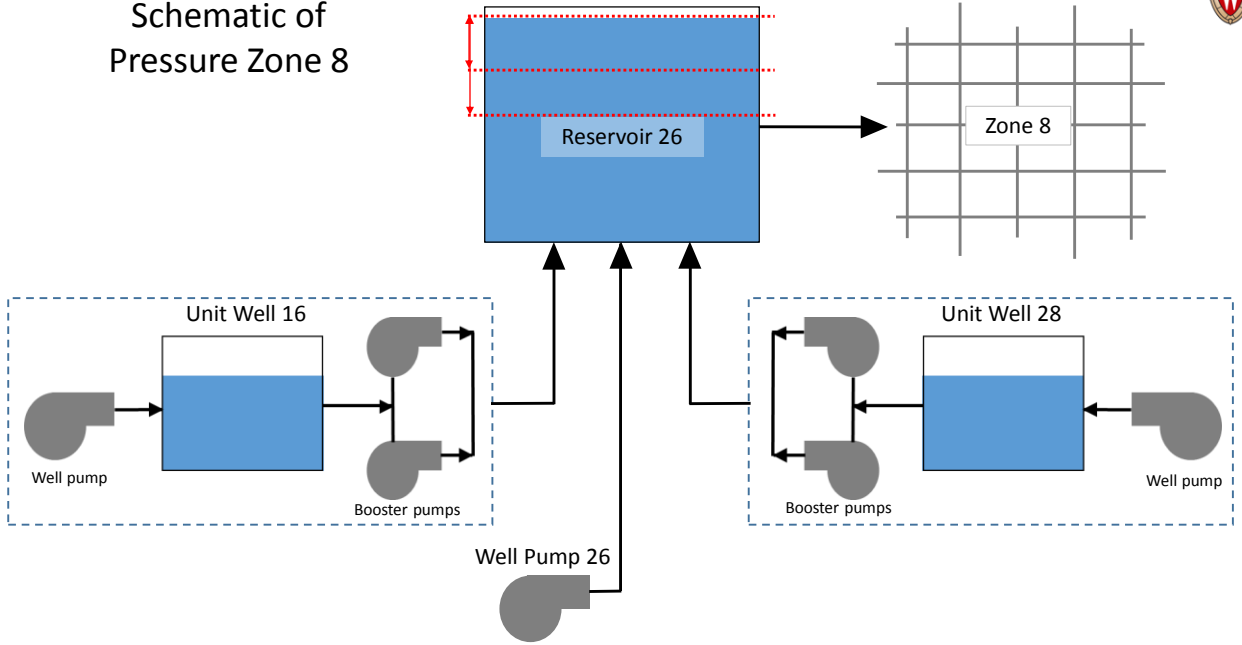


Basics of Rate Structure





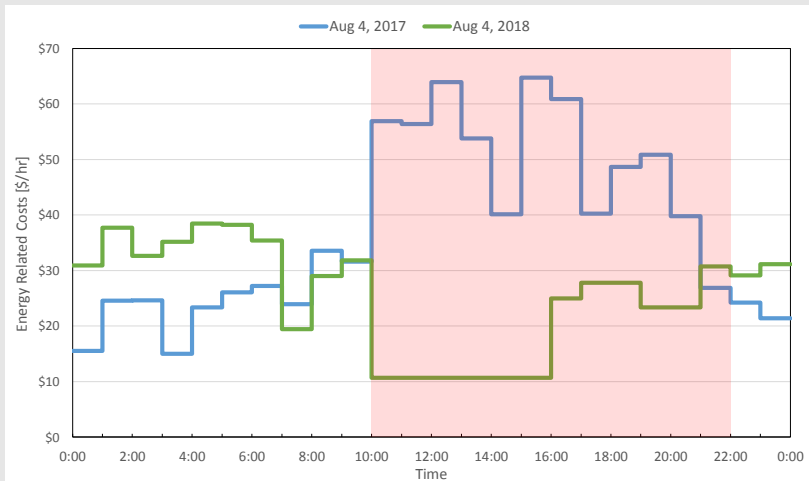
Schematic of Pressure Zone 8



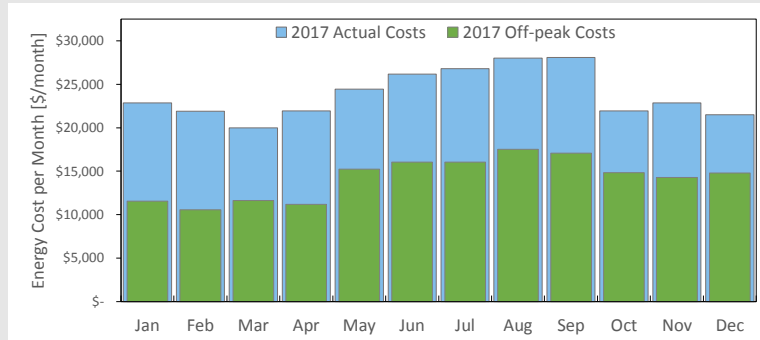
Zone 8 Energy Related Costs



<u>August 2017</u> \$28,000/month	<u>August 2018</u> \$18,500/month	<u>August Savings</u> \$9,500
--------------------------------------	--------------------------------------	----------------------------------



Zone 8 Energy Related Costs



2017 Actual Costs

\$287,000

2017 Optimized Costs

\$171,000

Savings

\$116,000 OR 40%

Difficulties of off-peak pumping



- Pumps **cannot** turn on during on-peak hours
 - All parties need to be made aware
 - Flushing and planned maintenance needs to be scheduled accordingly
 - Unplanned maintenance and fire flow could disrupt this requirement
- Unpredictable water demand can limit savings
- Learning curve expected

Summary



Triple Bottom Line

- **Environment:** Upcoming work will address the reduction of energy consumption
- **Social:** Pilot study revealed level of service was maintained
- **Economic:** Modeling and pilot study suggests energy related savings of up to **\$116,000 / year** or **40%** in Zone 8

Future work

- Energy saving initiatives
- Investigate possibility of spreading learnings to other zones

