

# *Results from 18 Field Monitoring Projects on Rack and Flight Conveyor Dishwashers*



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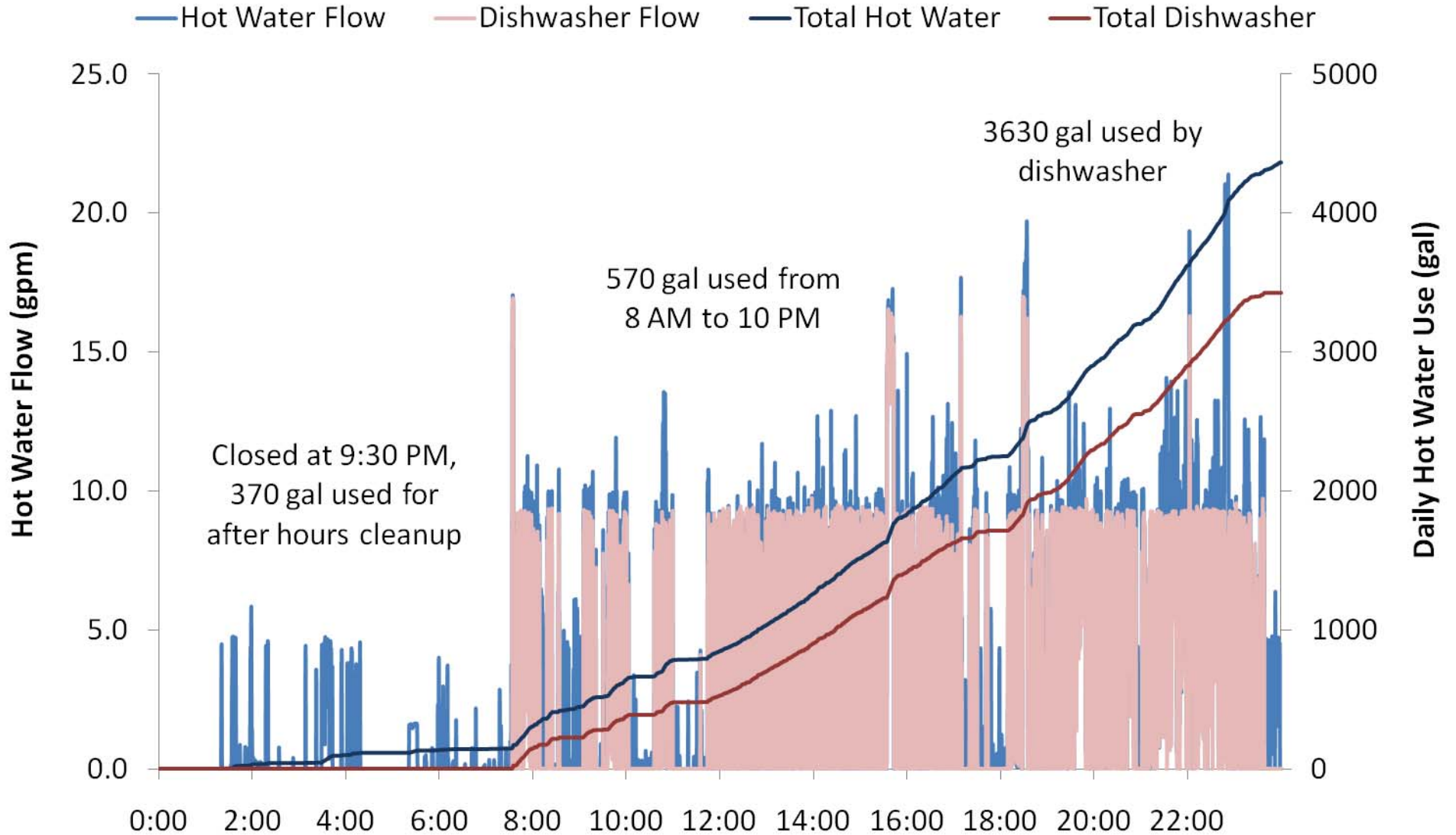
# Restaurants are an Energy and Water Intensive Operation



Responsible for up to 75% of the hot water utility costs.



# Heavy Dishwasher Use in FSR



# Why the scrutiny on dishwashers?

- Theorized that retrofitting to efficient dishwashers would be straight forward, guaranteeing long-term savings like other equipment in commercial kitchens
  - True with smaller batch-style washers
  - False with conveyor dishwashers
- Set out to submeter dishwashers in the field to measure savings potential
- Realized that conveyor dishwashers are pretty complex machines with lots of failure points
- Payback period was good, but there was a problem, how do we guarantee the savings through the working life of the new equipment?



# Research focus areas

- Quantify energy and water use of existing baseline dishwashers and replacement high-efficiency machines installed in the field
- Develop some parameters of baseline equipment to normalize comparison
  - Hours per day of rinse use, conveyor use and daily operating span
  - Normalize to gal/h, therms/h, and kWh/h of rinse operation
- Compare actual water and energy use versus specifications
- Investigate water and energy use profiles to figure out what is normal operation and what is a malfunction
- What goes wrong with old machines and why?
- Verification on if dishwashers hold their specification?

# Monitoring of Rack Conveyors



## Trends

- Most units were found in poor condition.
- Shocking water use for tank fill operation

## Dishwasher Projects

- 6 in Hotels
- 9 School and Commercial Cafeterias
- 3 Full Service Restaurants



# Original Dishwasher in University Kitchen

- Steamy room even with 3 fans going
- Large amount of water and energy use due to old steam distribution system, dishwasher, table layout





# New Dishwasher w/ Heat Recovery

- Significantly more comfortable work environment
  - Removal of steam system
  - Insulated doors
  - Door seal system
- Door actuated drain closure
- Vent fan control
- Energy saver mode
- Built-in booster heater
- Final rinse flow rate specification of 2.2 gpm



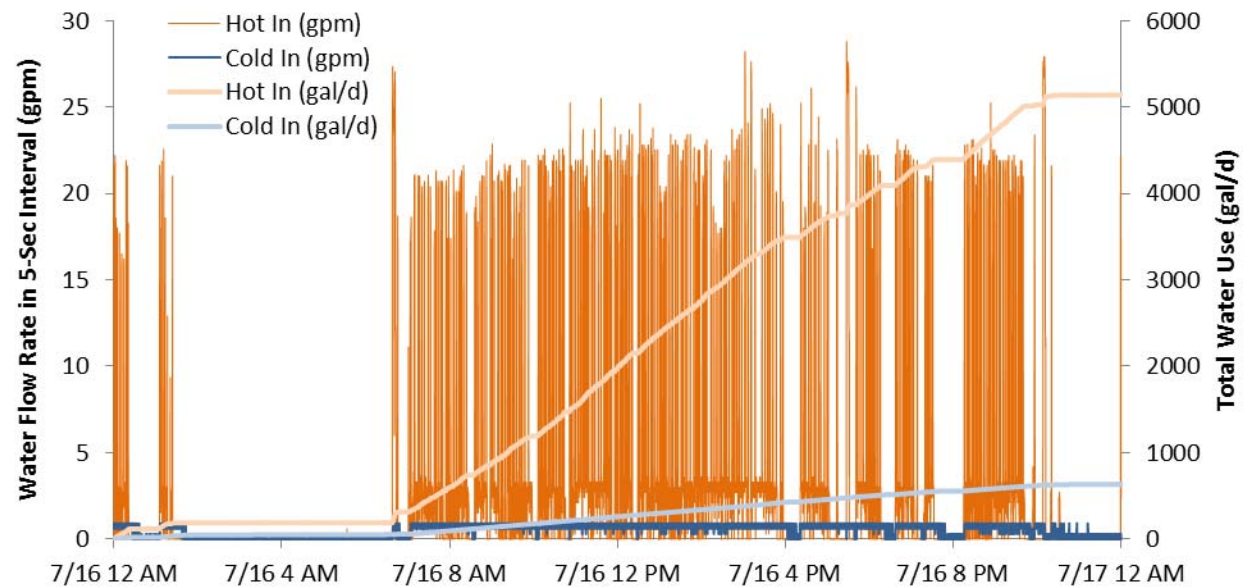
# Preliminary Results From Rack Conveyor Replacement Project

	Water Use (gal/d)	Electricity Use (kWh/d)	Gas Use (therms/d)	Utility Cost (\$/d)	Total Energy Use (therms/d)
Original 108" Rack Conveyor Dishwasher	1372	21	30.2	\$57	31.0
Replacement 86" Rack Conveyor Dishwasher	628	276	3.2	\$52	12.6
Savings Percentage	54%	-92%	89%	9%	59%

Fuel Switching and low hot water supply temp of 120°F responsible for low cost savings

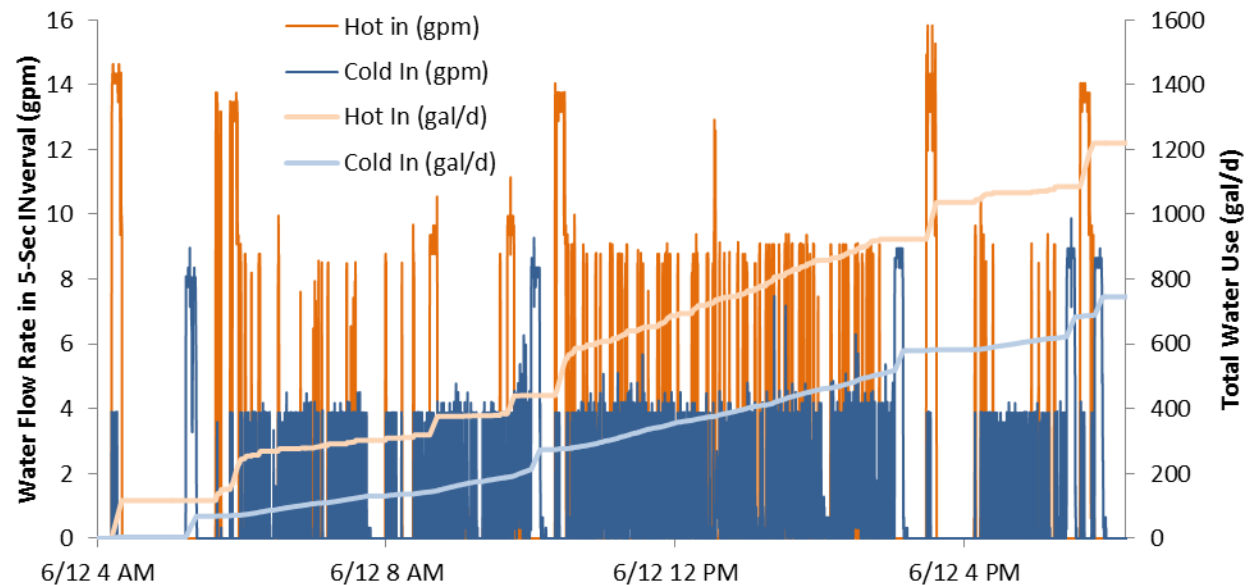
# Original Dishwasher in Work Cafeteria

- 98 gph spec. rinse flow rate
- 189 gph measured rinse flow rate
- The high flow rate and high drain temperatures where causing campus drain pumps to seize up
- Using 2 million gallons of water annually



# New Dishwasher w/ Heat Recovery + Blower Dryer

- 58 gph spec. rinse flow rate
- 71 gph measured rinse flow rate
- More comfortable work environment
  - Insulated doors
  - Door seal system
- Vent fan control
- Energy saver mode



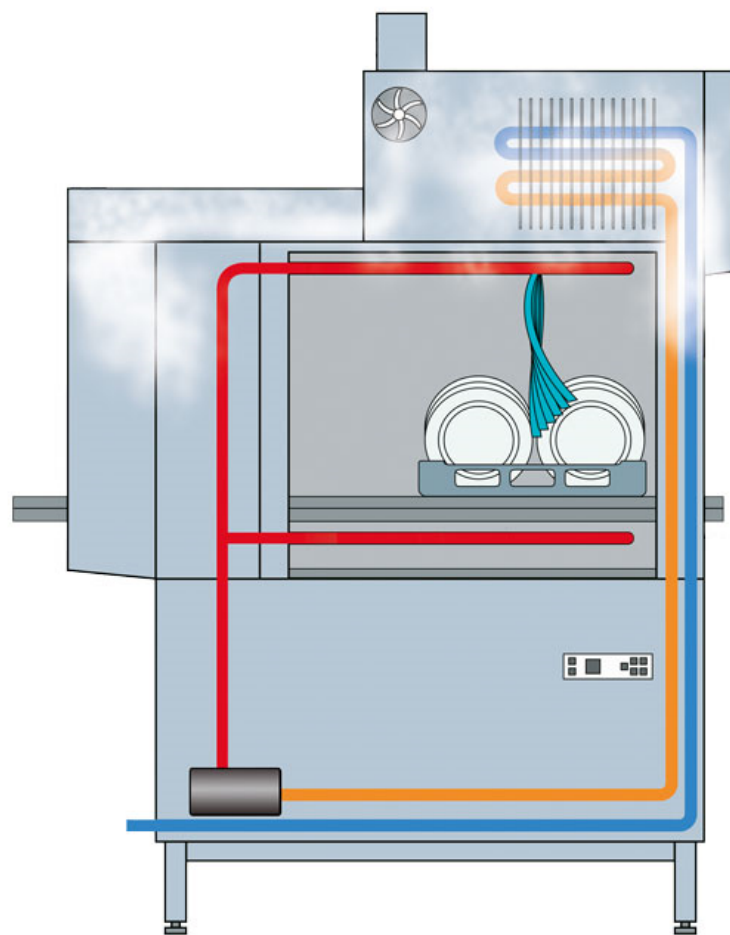
# Final Results From Flight Dishwasher Replacement Project

	Water Use (gal/d)	Electricity Use (kWh/d)	Gas Use (therms/d)	Utility Cost (\$/d)	Total Energy Use (therms/d)
Original Flight Conveyor Dishwasher	5656	668	48.0	\$271	70.8
Replacement Flight Conveyor w/ Heat Recovery + Blower Dryer	1857	931	10.0	\$240	41.8
Savings Percentage	67%	-39%	79%	11%	41%

The addition of a blower dryer on the replacement unit increased overall electricity use

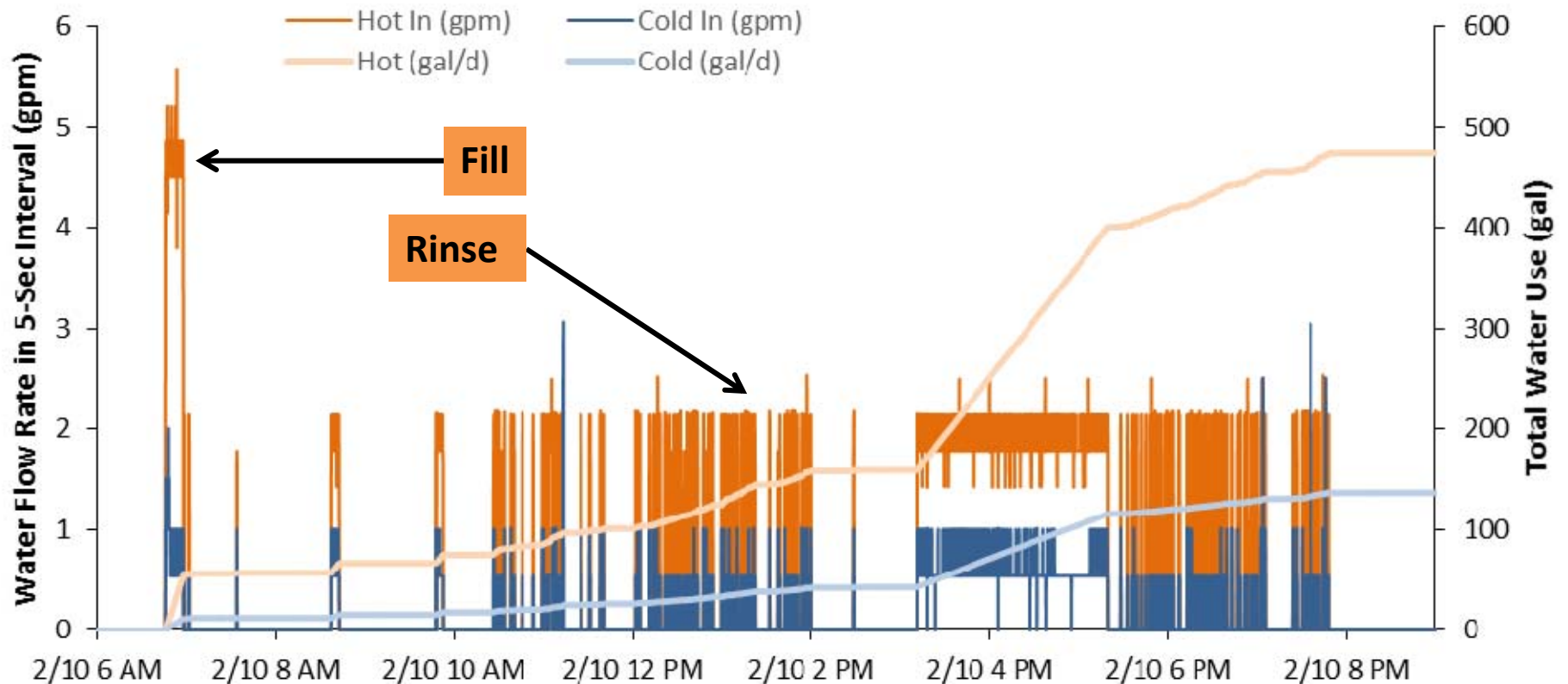
# Commissioning of Dishwashers with Heat Recovery

- Marketing materials of dishwashers with exhaust –air heat recovery imply or state that only cold water is used through the heat exchanger to preheat water used by the booster heater.
- This is true of the flight conveyors tested, but not the rack conveyors.



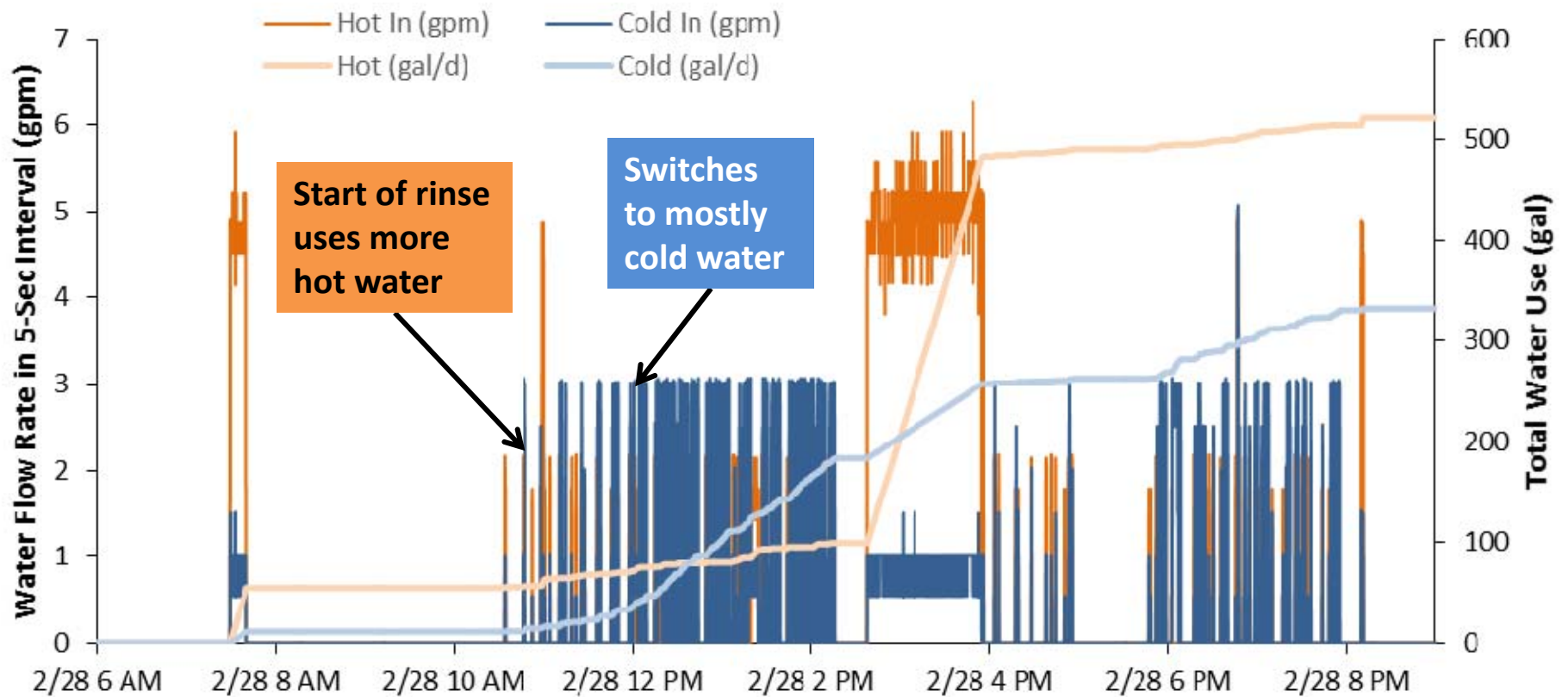
# Commissioning of Two High-Efficiency Unit with Heat Recovery

- As commissioned by the manufacturer's technicians at two sites
- Hot water and cold water used during the rinse cycle at a 2 to 1 ratio
- Heat Recovery device is not performing, **booster efficiency w/ HX of 87%**



# Commissioning of Two High-Efficiency Unit with Heat Recovery

- **Recommissioned at one site**, flow profile has completely changed
- Heat Recovery now performing, **booster efficiency w/ HX of 102%**
- **Savings of \$900 per year**





# Results from 18 Conveyor Dishwasher Monitoring Projects

- Metrics Development: What's the best parameters to use for comparison of dishwashers?

**Answer:** Normalized all data to consumption per hour of rinse operation

- Theoretical dishwasher water use versus actual water use.
- Savings comparison of conventional vs. high-efficiency dishwashers.
- Sizing dishwasher considerations

# Model specifications vs. actual water use for rack-conveyor dishwashers

Dishwasher Make and Model	Specified Rinse Flow Rate (gph)	Actual Rinse Flow Rate (gph)	Theoretical Rinse and Fill (gph)	Machine Water Use Per Hour Rinse Operation (gph)
Old Low-Temp 44"	315	244	328	730
Old High-Temp 44"	290	524	303	542
Old High-Temp 44"	223	215	236	235
Old High-Temp 44"	290	288	303	363
Old High-Temp 66"	290	328	311	389
Old High-Temp 66"	290	221	311	416
Old High-Temp 86"	226	289	259	2194
Old High-Temp 108"	309	319	311	667
Efficient High-Temp 66"	78	89	111	135
Efficient High-Temp 64"	132	172	161	367
Efficient HT 86" + HR	132	147	176	261
Efficient HT 86" + HR	132	152	176	301
<b>AVG. Conventional Conveyor</b>	274	304 (11% ↑)	295	692 (134% ↑)
<b>AVG. High-Efficiency Conveyor</b>	119	140 (18% ↑)	156	266 (70% ↑)

# Model specifications vs. actual water use for flight-conveyor dishwashers

Dishwasher Make and Model	Specified Rinse Flow Rate (gph)	Actual Rinse Flow Rate (gph)	Theoretical Rinse and Fill (gph)	Machine Water Use Per Hour Rinse Operation (gph)
Old High-Temp Flight	336	372	420	605
Old High-Temp Flight	336	357	420	1277
Old High-Temp Flight	336	516	183	1770
Old High-Temp Flight	98	189	163	823
Efficient High-Temp Flight	58	71	145	232
Efficient High-Temp Flight	58	63	145	303
<b>AVG. Conventional Conveyor</b>	277	359 (30% ↑)	361	1119 (210% ↑)
<b>AVG. High-Efficiency Conveyor</b>	58	67 (15% ↑)	145	267 (84% ↑)

Based on rated rinse and tank volume specs:

- Old dishwashers consume 2-3 times more water than predicted
- HE dishwashers consume 70% to 85% more water than predicted

# AVG. Results From Monitoring 18 Conveyors

- Efficient rack conveyor dishwashers on average used 60% less water and 65% less energy than conventional units



**Old:** 690 gal/h  
1,500,000 Btu/h



**New:** 260 gal/h  
530,000 Btu/h

- Efficient flight conveyor dishwashers on average used 75% less water and 55% less energy than conventional units



**Old:** 1120 gal/h  
1,430,000 Btu/h



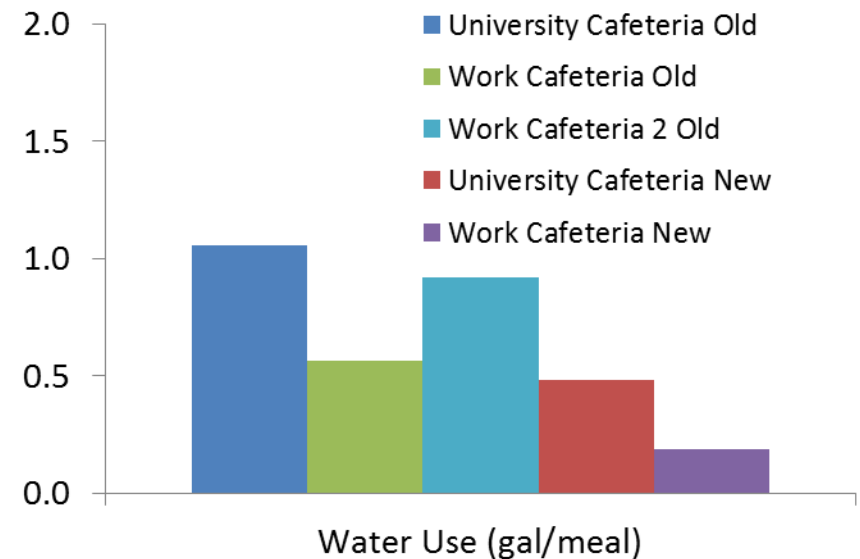
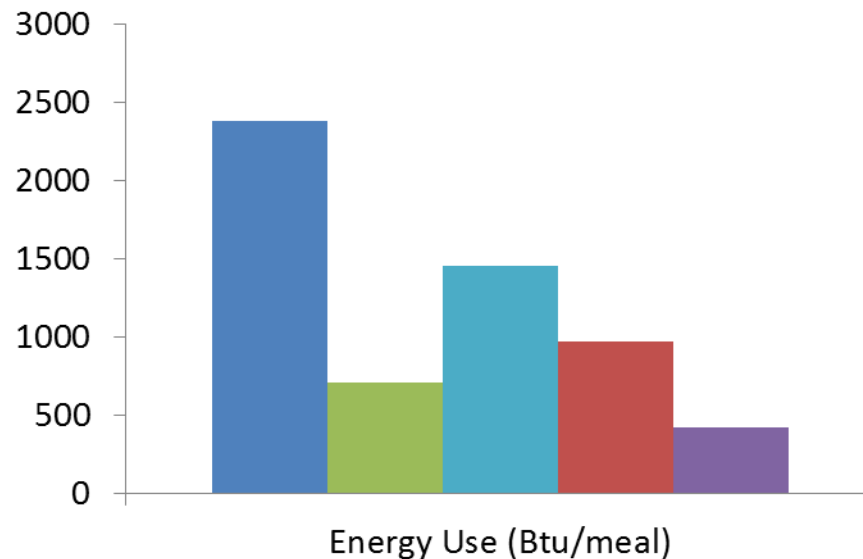
**New:** 270 gal/h  
650,000 Btu/h

# Rinse Flow Rate Should No Longer be the Default Efficiency Parameter

- Rated rinse flow rate accounted for 25%-50% of total use
- Rinse flow rate alone cannot reasonably predict the water and energy consumption in the field
- Incentive and recognition programs (ENERGY STAR<sup>®</sup>, LEED) need to take a more comprehensive approach

Dishwasher Type	Specified Rinse Flow Rate (gph)	Water Use Per Hour of Rinse Operation (gph)	Rinse Divided by Real World Water Use	Data Range (Rinse/Total)
Conventional Rack Conveyor	274	692	40%	10% - 95%
High-Efficiency Rack Conveyor	119	261	46%	36% - 58%
Conventional Flight Conveyor	277	1119	25%	12% - 56%
High-Efficiency Flight Conveyor	58	267	22%	19% - 25%

# Benchmarking: Number of Meals



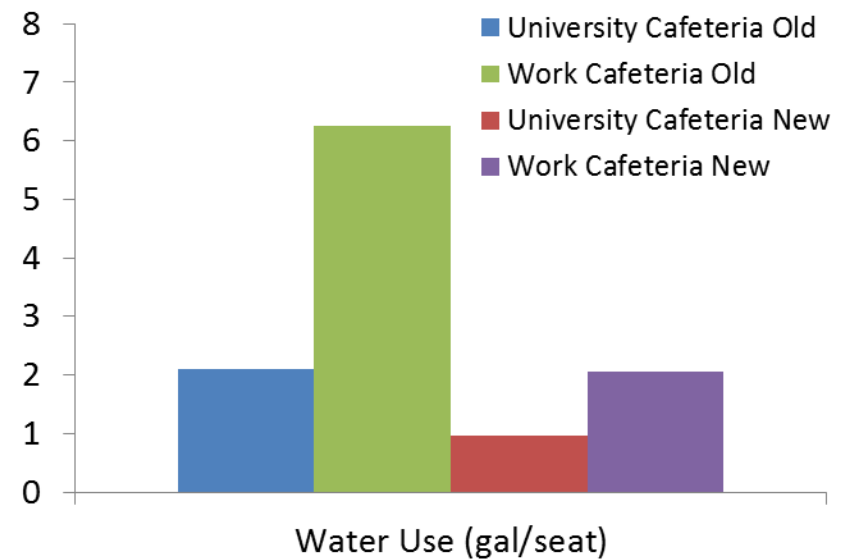
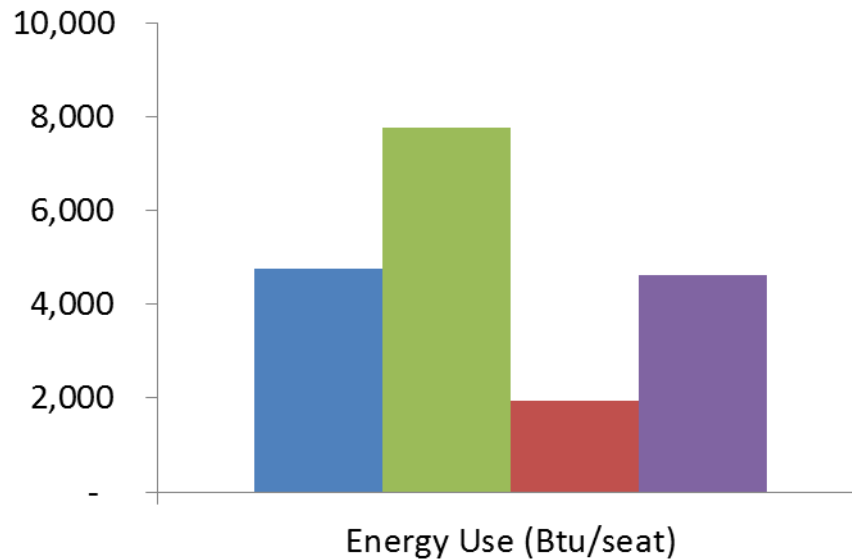
Energy use per meal per day ranges from:

- 700-2,400 Btu/h (old units)
- 400-1,000 Btu/h (new units)

Water use per meal per day ranges from:

- 0.5-1 gal (old units)
- 0.2-0.5 gal (new units)

# Benchmarking: Number of Seats



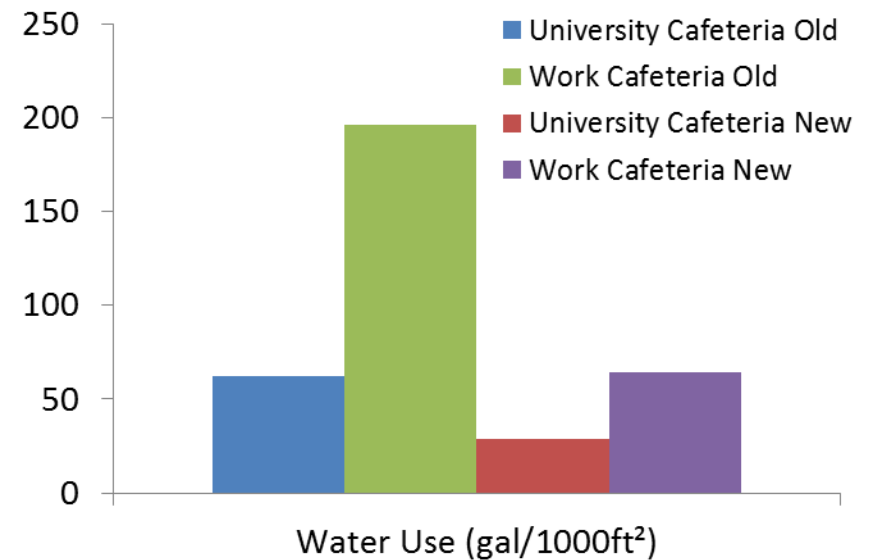
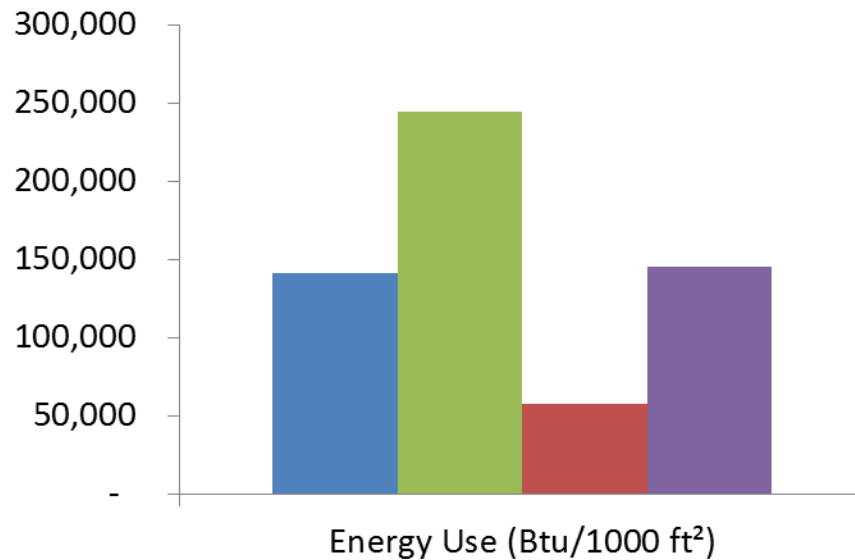
Energy use per seat per day ranges from:

- 4,500-8,000 Btu/h (old units)
- 2,000-4,500 Btu/h (new units)

Water use per seat per day ranges from:

- 2-6 gal (old units)
- 1-2 gal (new units)

# Benchmarking: Facility Size



Energy use per 1000 ft<sup>2</sup> per day ranges from:

- 150-250 kBtu/h (old units)
- 50-150 kBtu/h (new units)

Water use per 1000 ft<sup>2</sup> per day ranges from:

- 60-200 gal (old units)
- 30-65 gal (new units)



# Sizing for Hot Water Demand with Conveyors

## Existing health department sizing guidelines

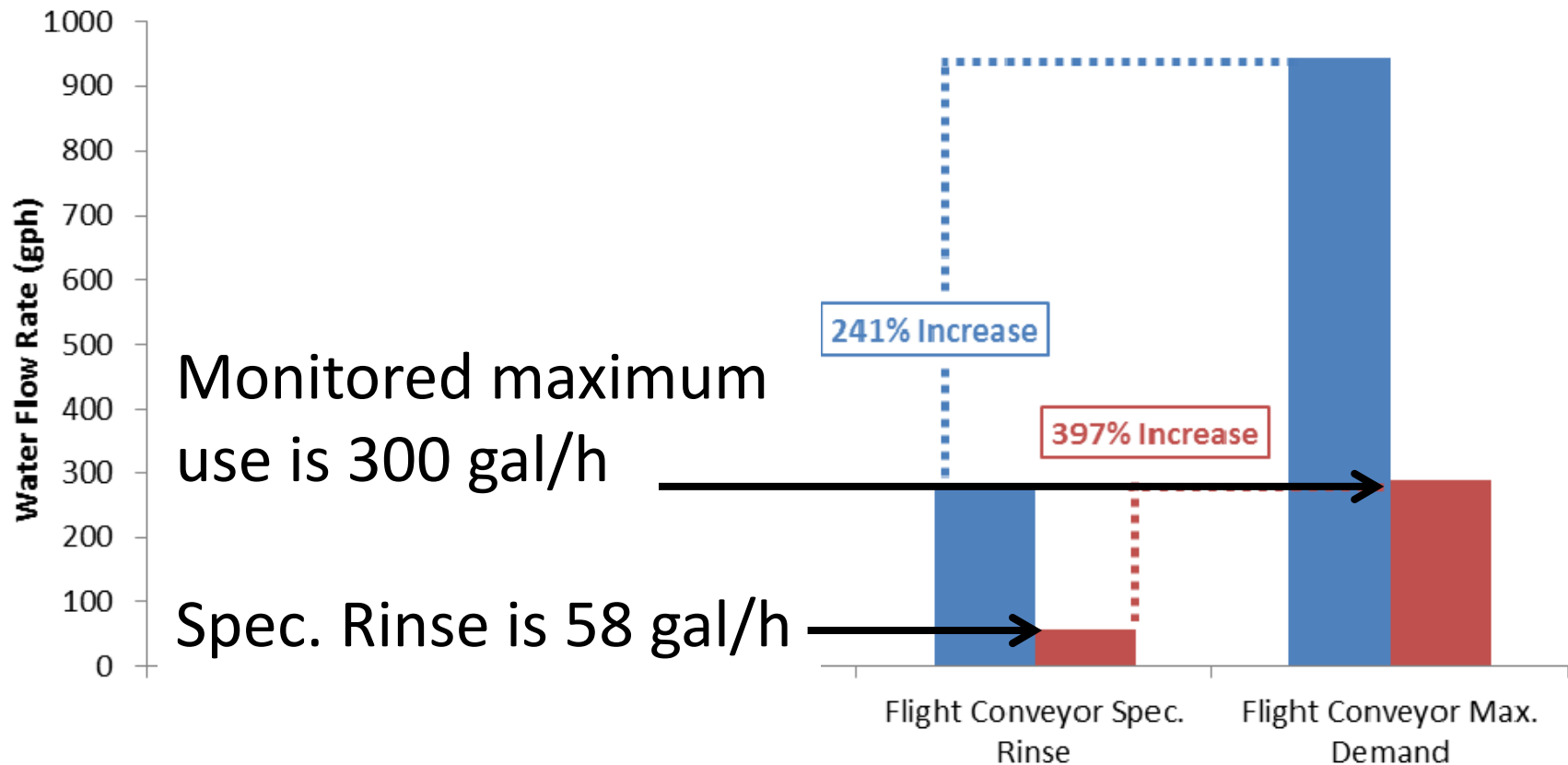
Current water heater sizing procedure involves looking up water use information from NSF listings or spec sheets for:

- Final rinse flow rate (gpm) for sizing tankless
- Maximum hourly rinse use (gph) for sizing storage heaters
- On this particular flight unit, the tank fill water use at 127 gallons is twice that of the final rinse at 58 gallons

	FT1000 Base Series (5.5, 7.5, 9 Load / 8 Center / 5.5, 7.5, 9 Unload)
<b>Machine Ratings (Mechanical)</b> Conveyor Speed – Feet per minute	4.0 - 8.5
<b>Dishes per Hour</b>	14,316
<b>Motor – Horsepower</b>	Pre-Wash - 3½; Wash - 5; Rinse - 5; Dual Rinse - ½; Final Rinse - ½; Conveyor - ⅓
<b>Tank Capacity – Gallons</b>	Pre-Wash - 40; Wash - 40; Rinse - 40; Dual Rinse - 7.2
<b>Rate of Final Rinse – Gallons per minute</b> (Pumped rinse)	.97
<b>Final Rinse Consumption – Gallons per hour</b> (Pumped rinse)	58

# Hot Water Demand Rated vs. Measured

## Rated rinse versus measured maximum hot water use



# Conveyor Dishwasher Hot Water Demand

## Reasons for the disparity

- Overspray from washing large back of the house wares, especially flat wares such as sheet pans and cutting boards was the leading factor
- Leaving the tank drain open was the second leading cause
- Dishwasher components fail and maintenance is not completed



# Operations Causing Overspray



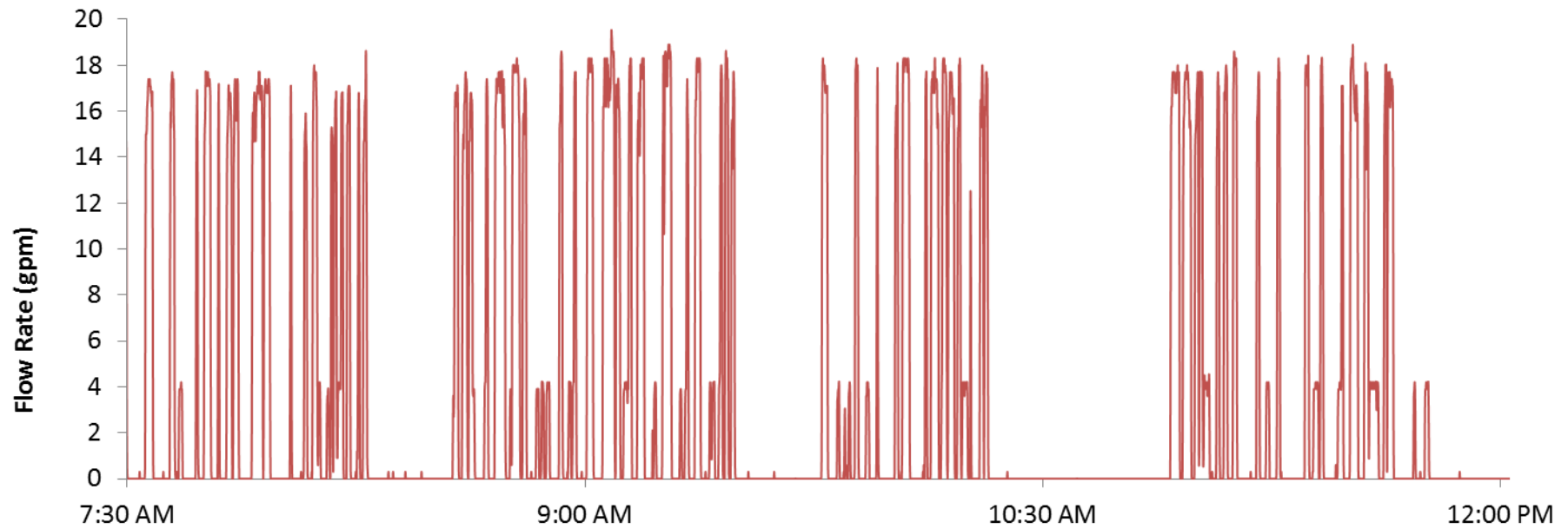
**Water Overspray on  
66" Conveyor =  
540 gal/d of water waste**



# Operations Causing Overspray

**Water Overspray of Old 44" Unit =  
1170 gal/d of water waste**

**Useful Rinse and Tank Fill =  
595 gal/d of water waste**



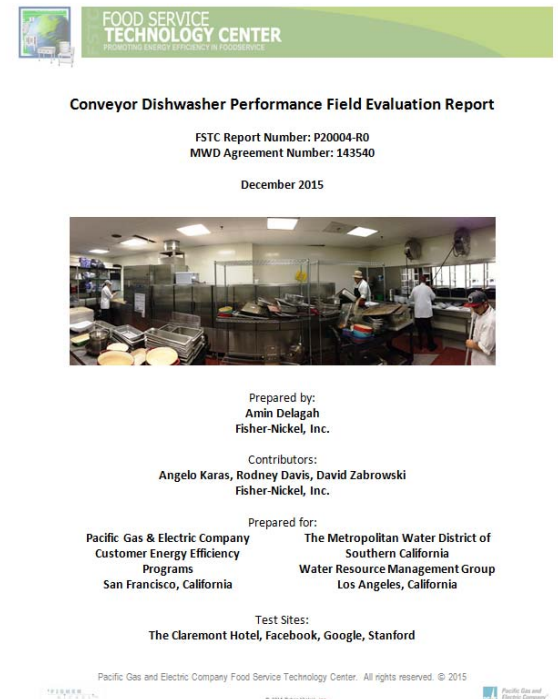
# Check Operations: Look for Operator Error

**Manual Override =  
1740 gal/d of water waste**



# Hot Water Demand Sizing Recommendations

- Need to change sizing guidelines to incorporate tank fill operation
- If the facility is washing back of the house wares, a water waste factor may be added
- Can use specialty racks like sheet pan racks with many rack conveyors



# Summary of Sanitation Room Research

Water and energy savings is only achievable in the sanitation room through a combination of practices:

- Specify properly sized and efficient dishwashers and pre-rinse equipment
- Properly commission equipment to include sub-metering to measuring baseline use
- Training program for staff
- Maintenance program





Or we can Maintain the Status Quo





**Thanks for  
Listening!**

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