Water Management for Evaporatively Cooled Condensers

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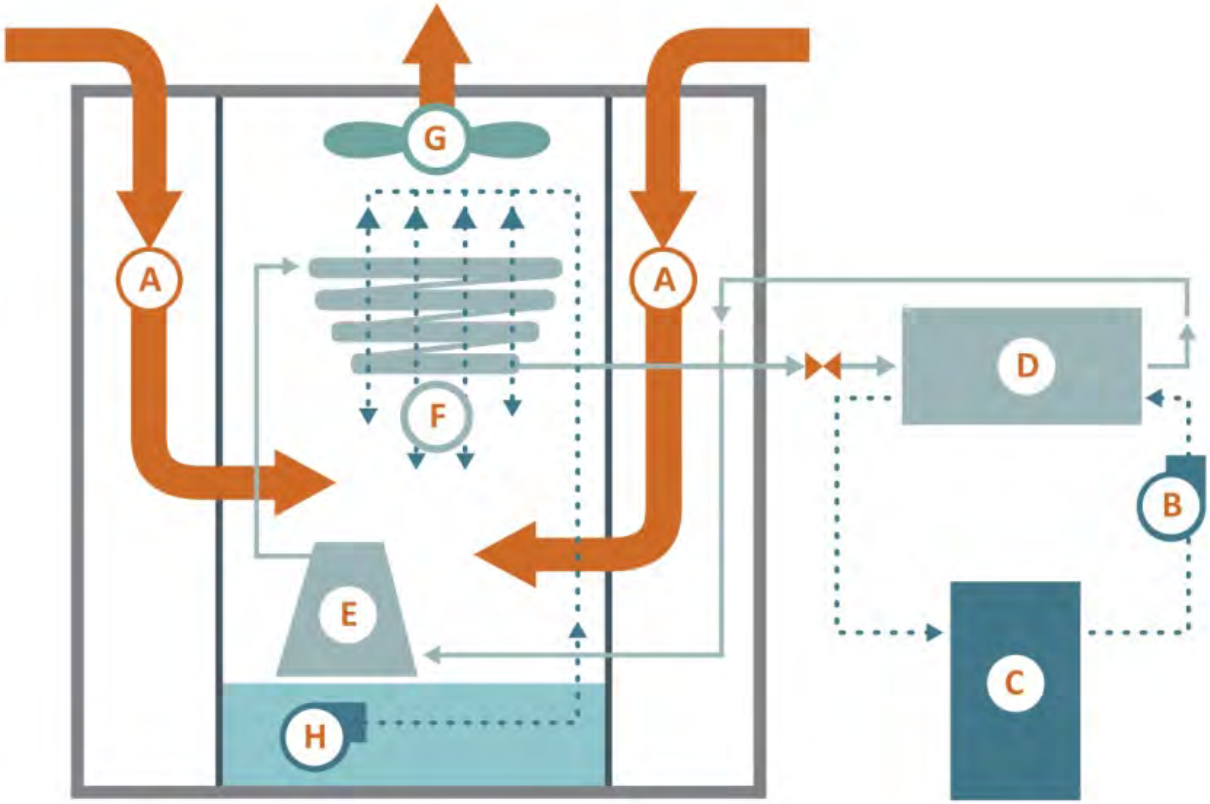
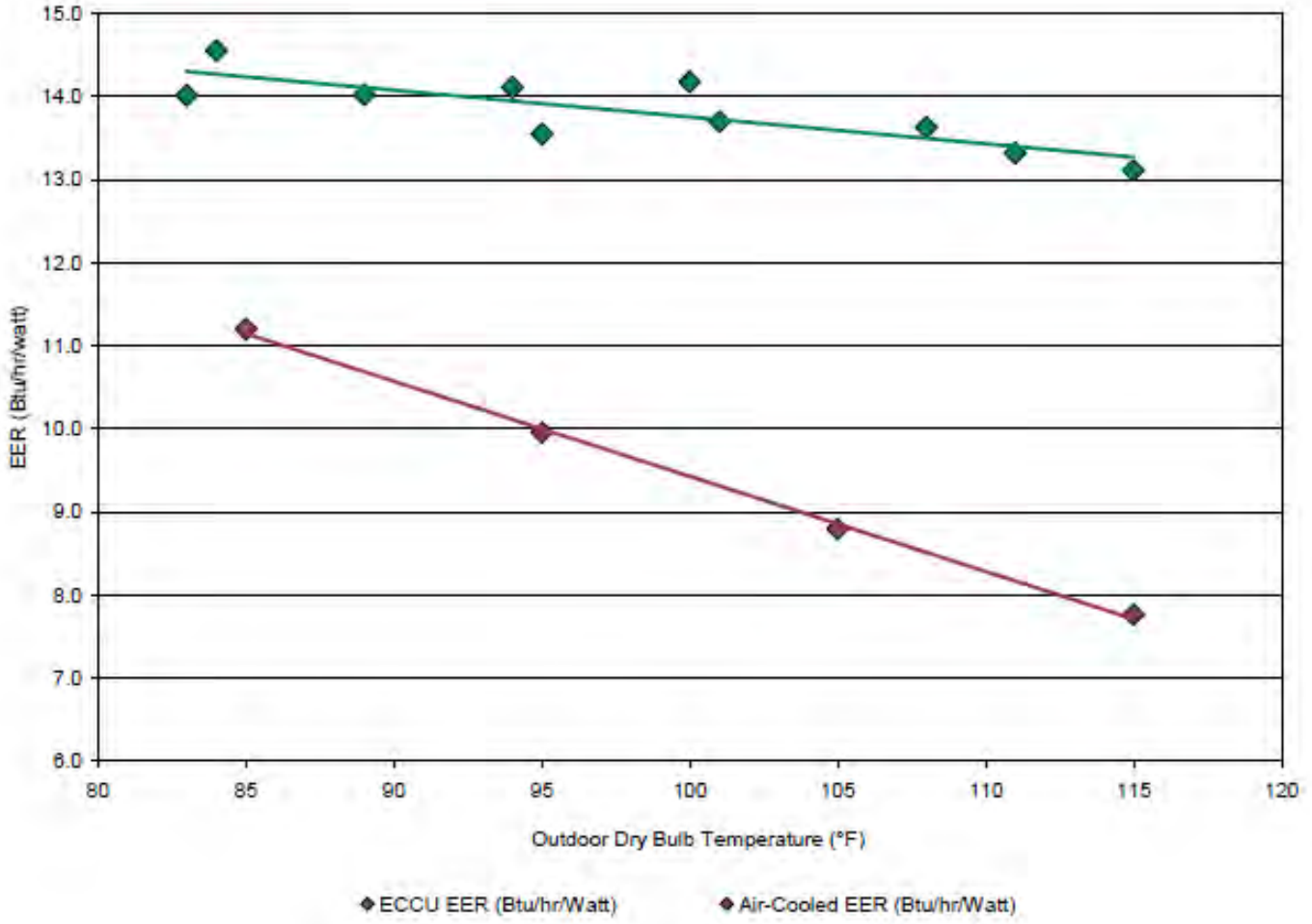
How Evaporative Condensers Work

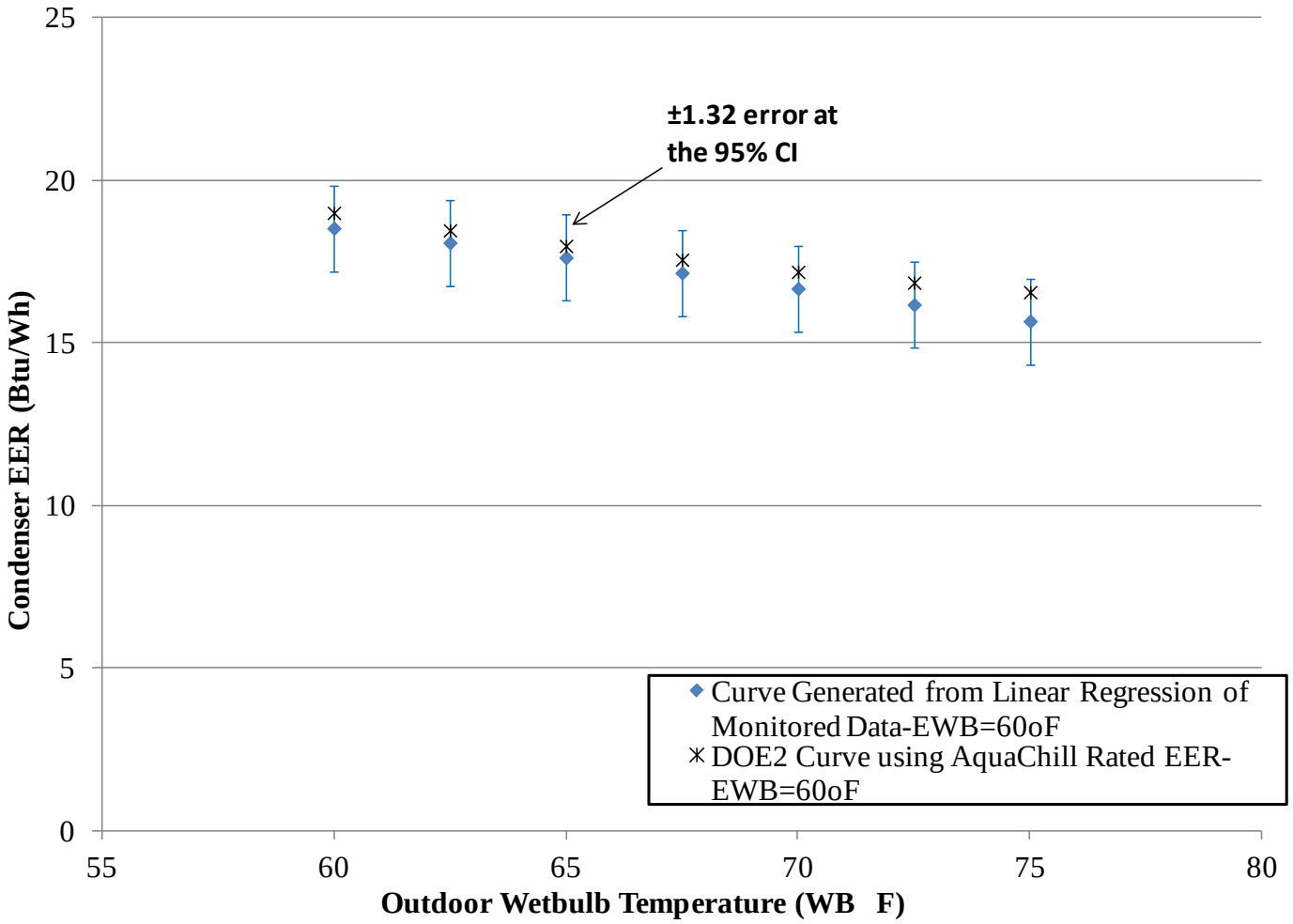


- A Plenums with 95°F airflow at neutral pressure
- B Pump
- C Water heater
- D Water to refrigerant HX
- E Compressor
- F Condenser coil
- G Exhaust blower
- H Sump pump

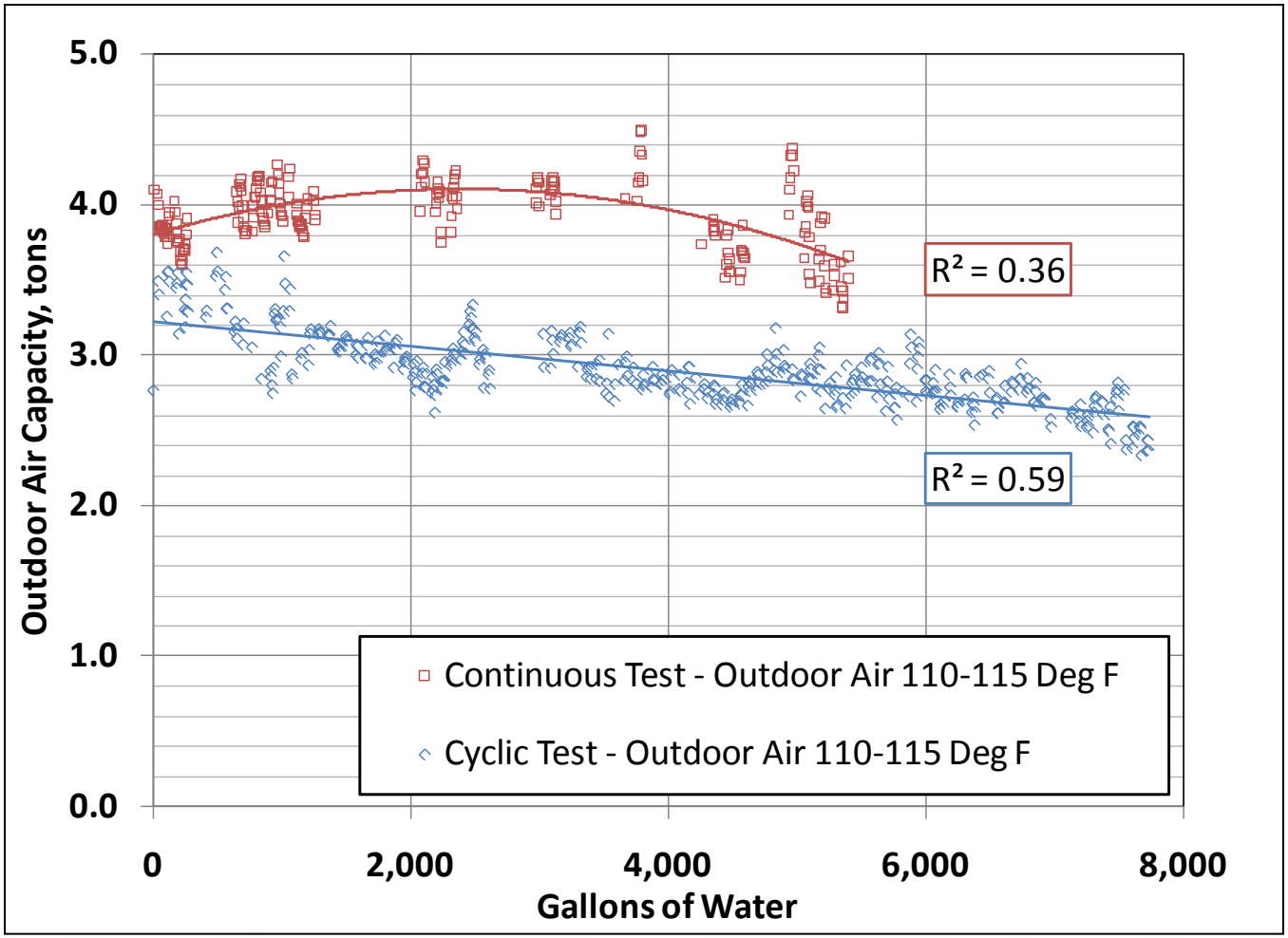
Previous Research – SCE Lab Test



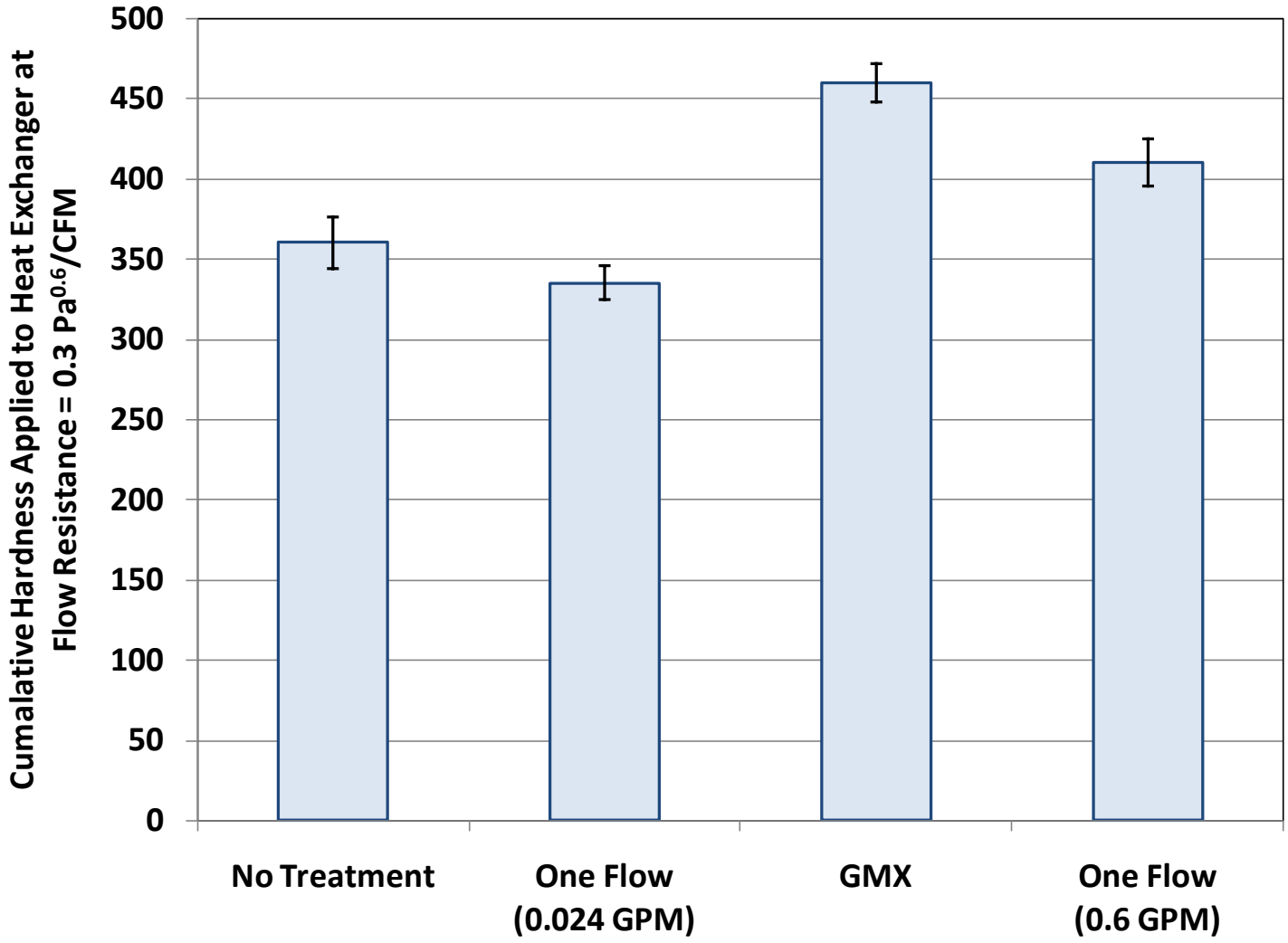
Previous Research – DEG Field Test



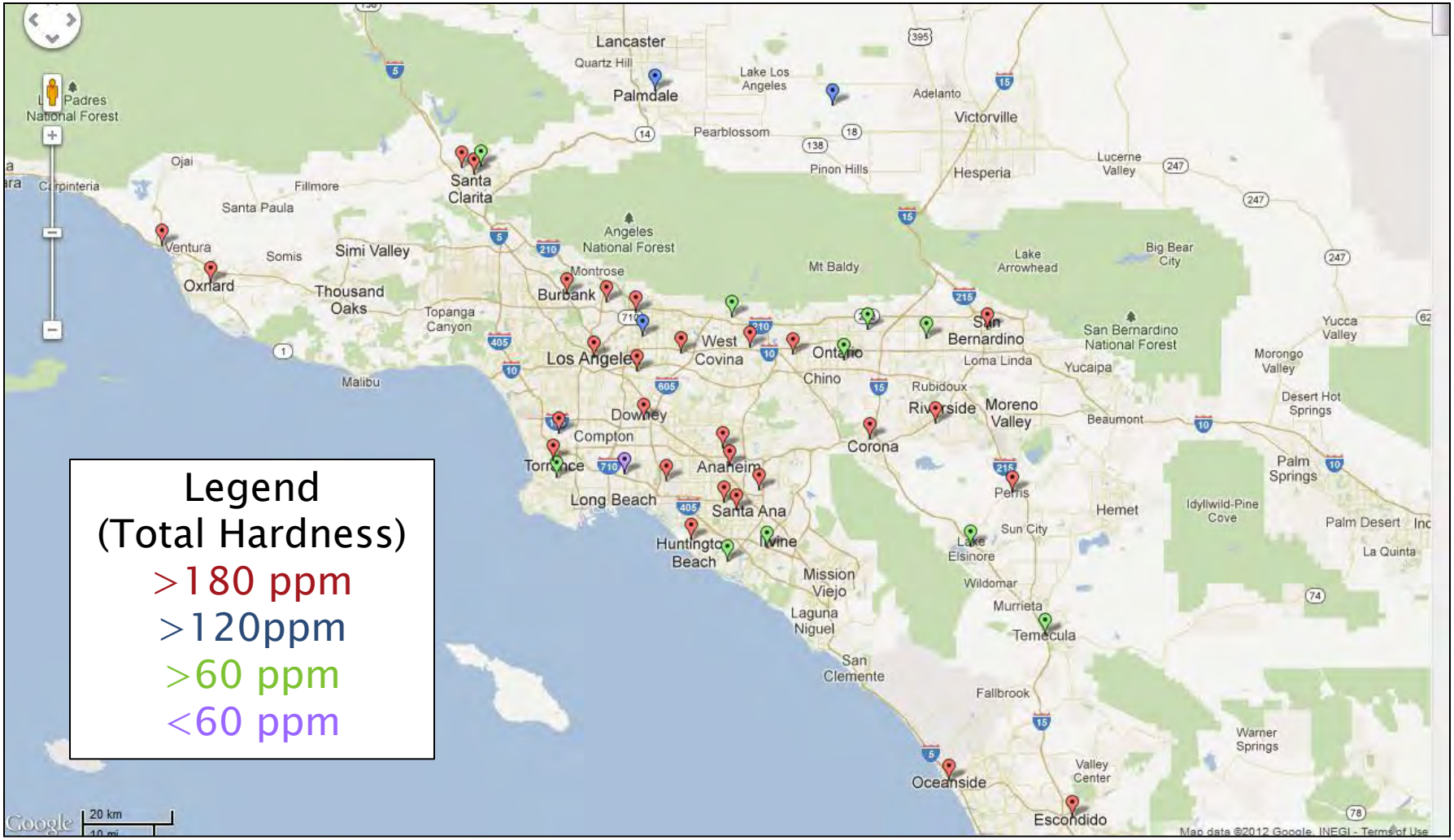
Previous Research – WCEC OASys Life Test



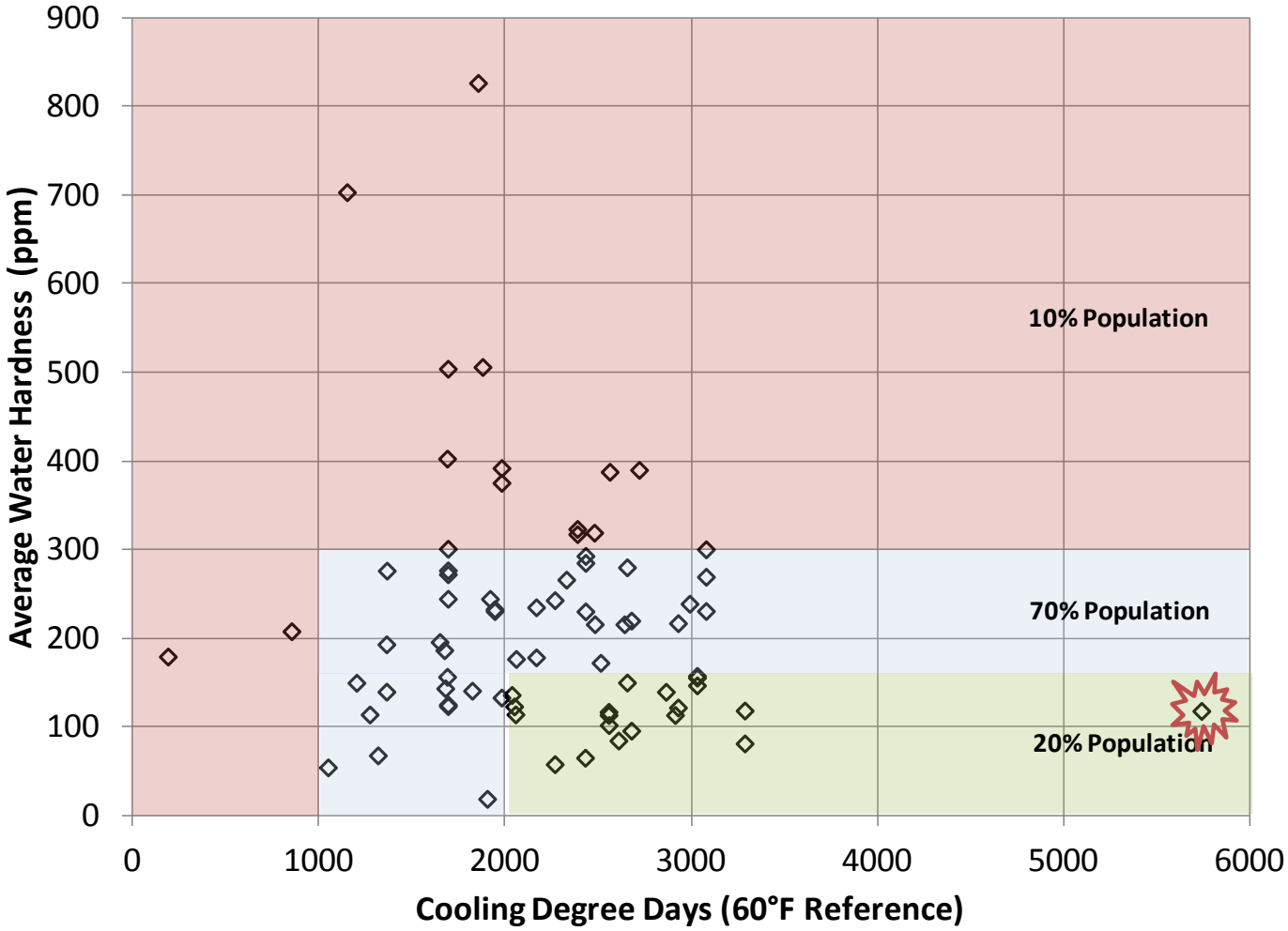
Previous Research – Water Treatment Testing



Water Hardness in Southern CA



Water Hardness in CA, Cont.

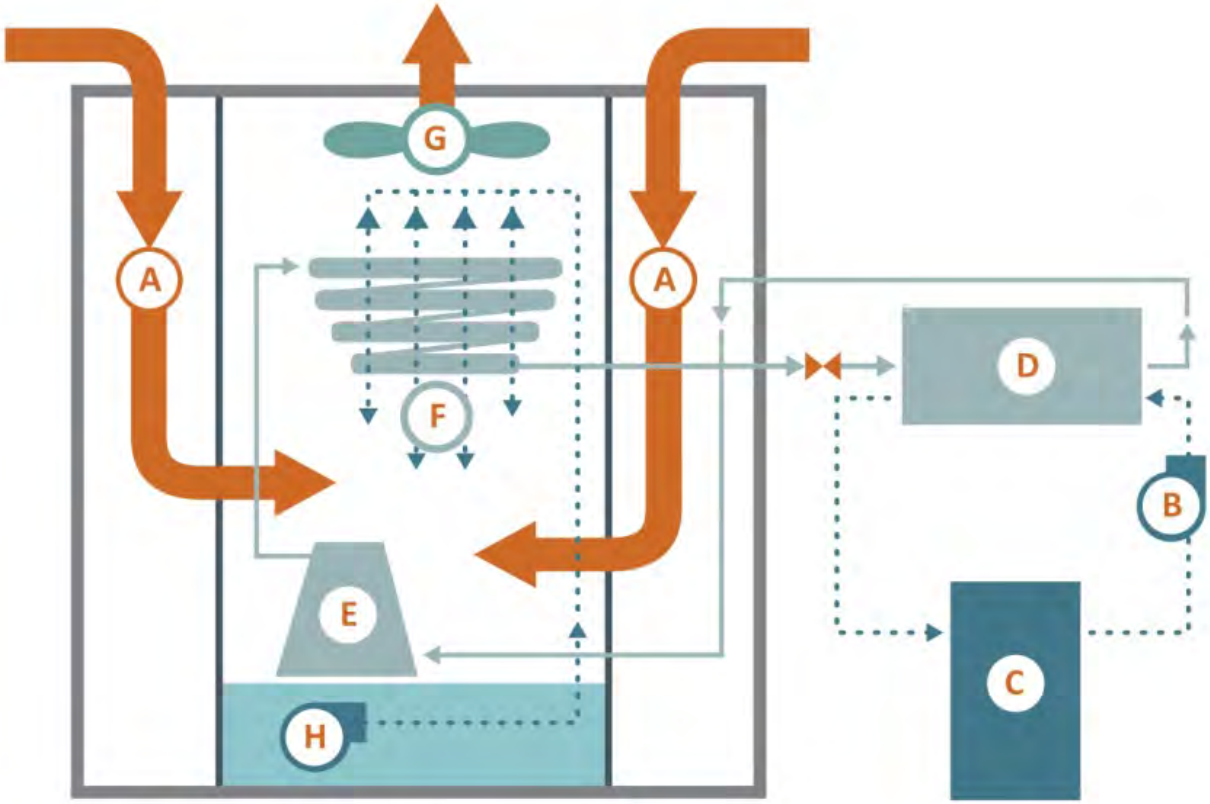


Objectives for SCE Funded Project

- Provide field applicable water management strategy for the Aquachill evaporative condenser (has SCE rebate).
  - Test full scale system with no-bleed (worst case).
  - Evaluate strategies with "small-scale" system.
    - Strategies may be bleed/purge, physical water treatment, and/or chemical water treatment.
  - Demonstrate selected strategy on full scale system.

- WCEC objective
  - Further the understanding of water science and scale formation as it applies to evaporative condensers.

Full Scale Experimental Design



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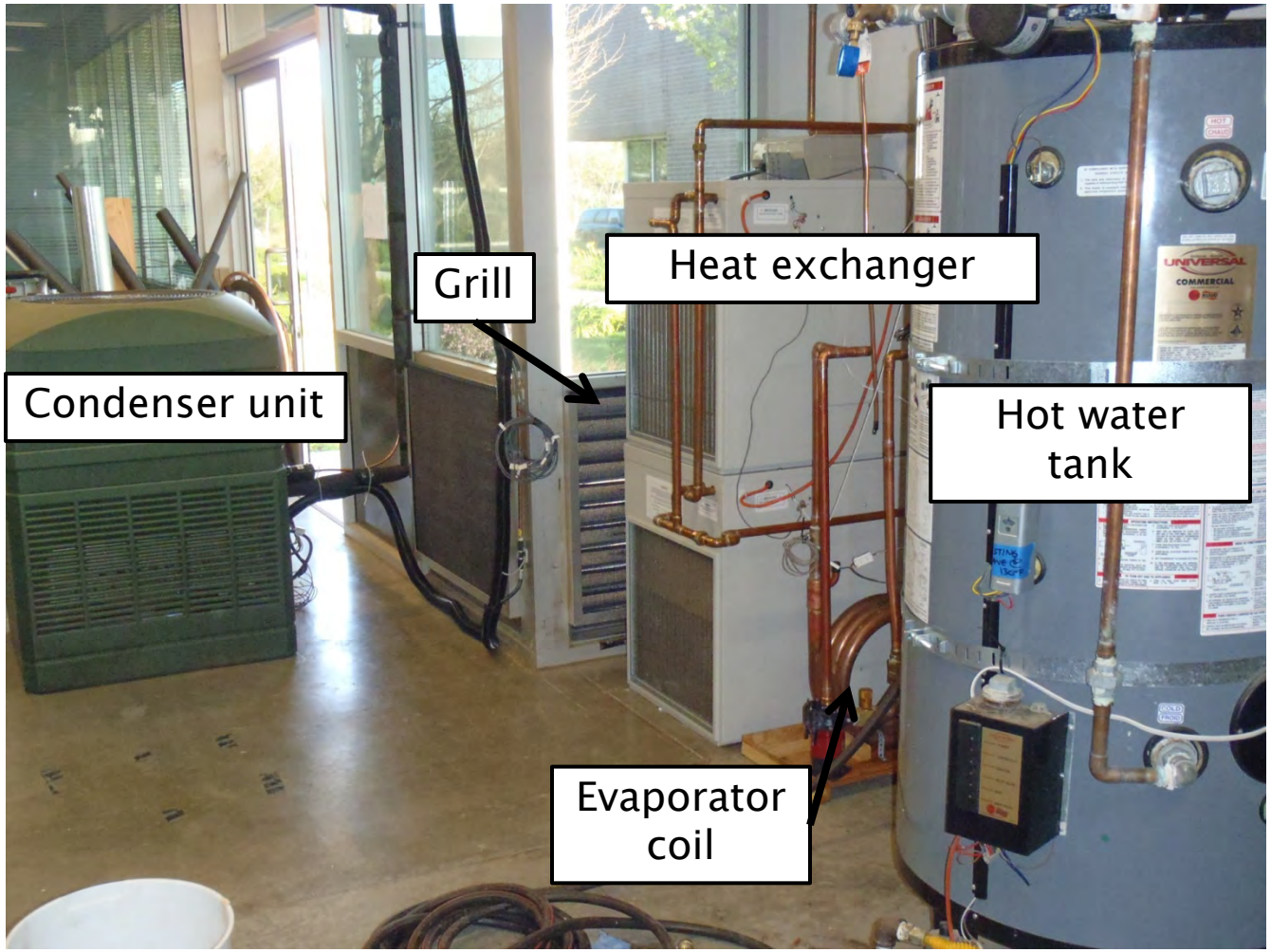
Full Scale Experimental Design, Cont



Full Scale Experimental Design, Cont

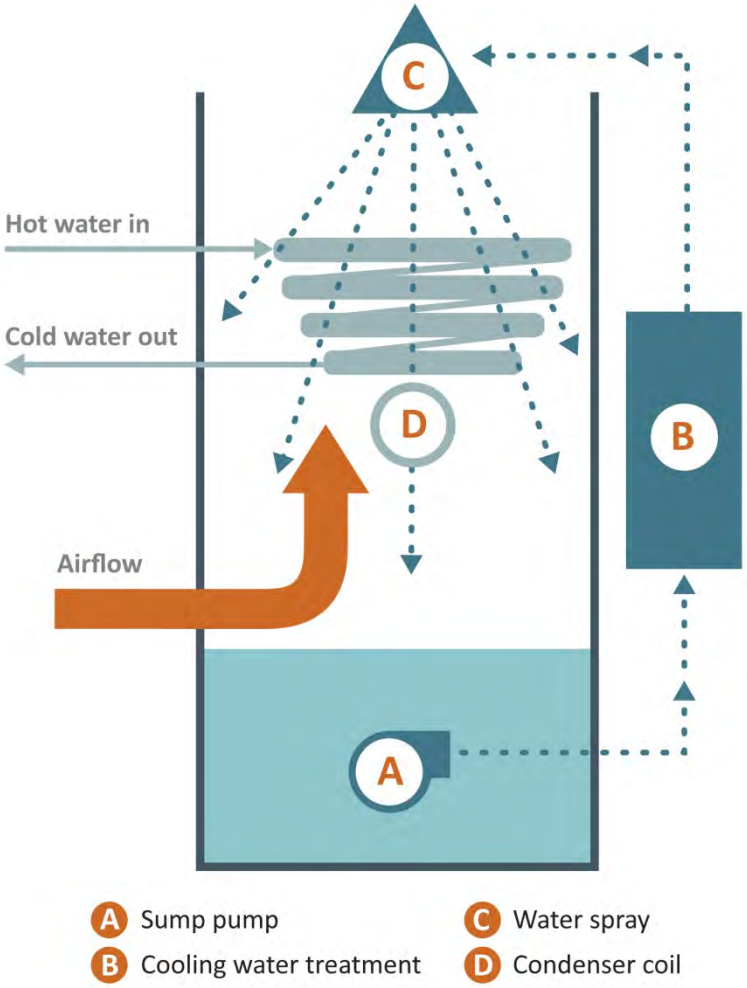
Measurements/Calculations

- T, %RH of input air (control to 95°F)
- Capacity of the system
  - hot water flow rate
  - ΔT
- Total Power
- COP (by division)
- Air pressure differential across grill
- Exit airflow (relative)
- Bleed water removal rate
- Makeup water replenishment rate and conductivity
- Evaporation rate (difference)
- Refrigerant properties

Small Scale Experimental Design

Measurements/Calculations

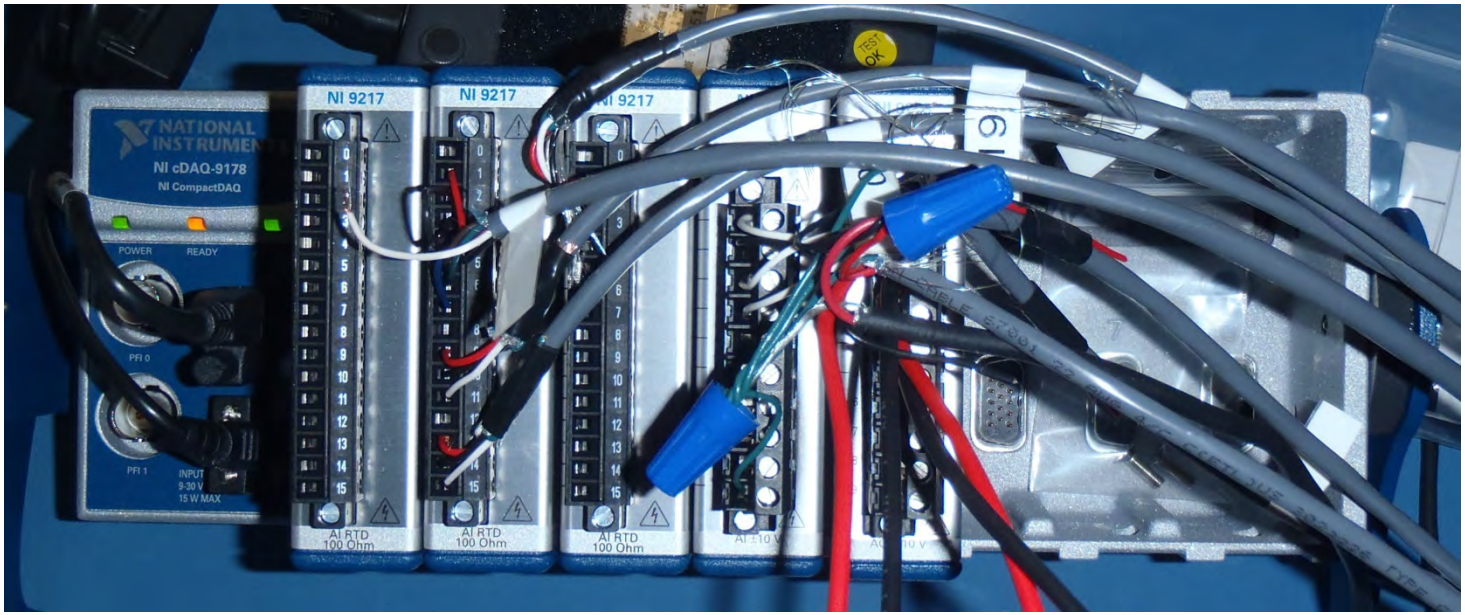
- T, %RH of input air (Control to 95°F)
- Capacity of the cooling coils
  - hot water flow rate
  - ΔT
- Air pressure differential across each cooling coil
- Bleed water removal rate
- Makeup water replenishment rate and conductivity
- Evaporation rate (difference)
- Water conductivity in each sump



Small Scale Experimental Design, Cont

Experimental Design, Both Systems

- Data Acquisition with NI Compact DAQ
- LabVIEW Software to text files
- Sample data at 1Hz, write average 1/min
- On hour on, half hour off is one “cycle”
- Average data for last 30 minutes of cycle



Full Scale Results – Test 1

- 362ppm average hardness input
- 33 lbs of potential scale
- Consistent with coil weight after removal
- 30% Reduction in water flow do to clogged nozzles
- Two failed pumps
- ~30% Reduction in airflow

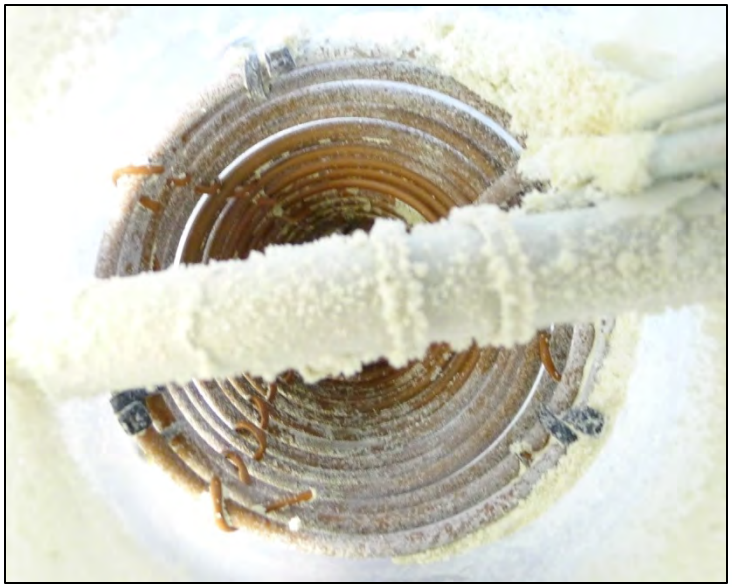
Full Scale Results – Test 1, Cont.

Table 1 – AquaChill performance when new and after 2,074 hours of runtime (11,000 gallons of water) at conditions 95±1°F DB and 64±2°F WB. *Power and EER do not include power for an evaporator fan.

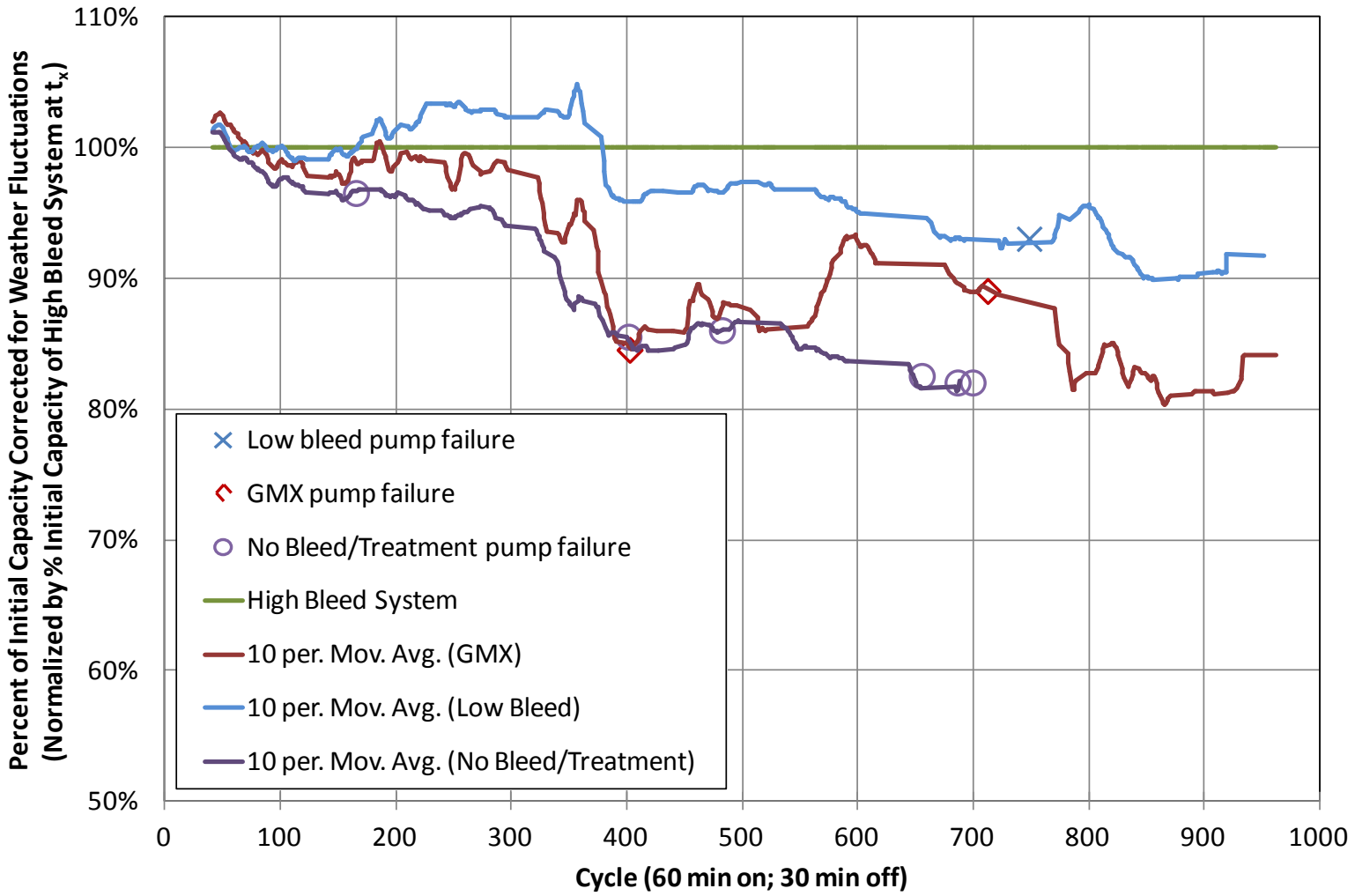
	Capacity (kbtu/hr)	Power* (kW)	EER* (kbtu/hr/kW)
Test Start	34.9	1.80	19.4
Test End (% Change from Start)	31.8 (-9%)	2.15 (+19%)	14.8 (-24%)
Test End + Cleaning (% Change from Start)	31.7 (-9%)	2.07 (+15%)	15.3 (-19%)

Small-Scale Results – Round 1

- Chamber 1 – Low Bleed (+8% water use)
- Chamber 2 – GMX Static magnets
- Chamber 3 – High Bleed (+40% water use)
- Chamber 4 – Baseline



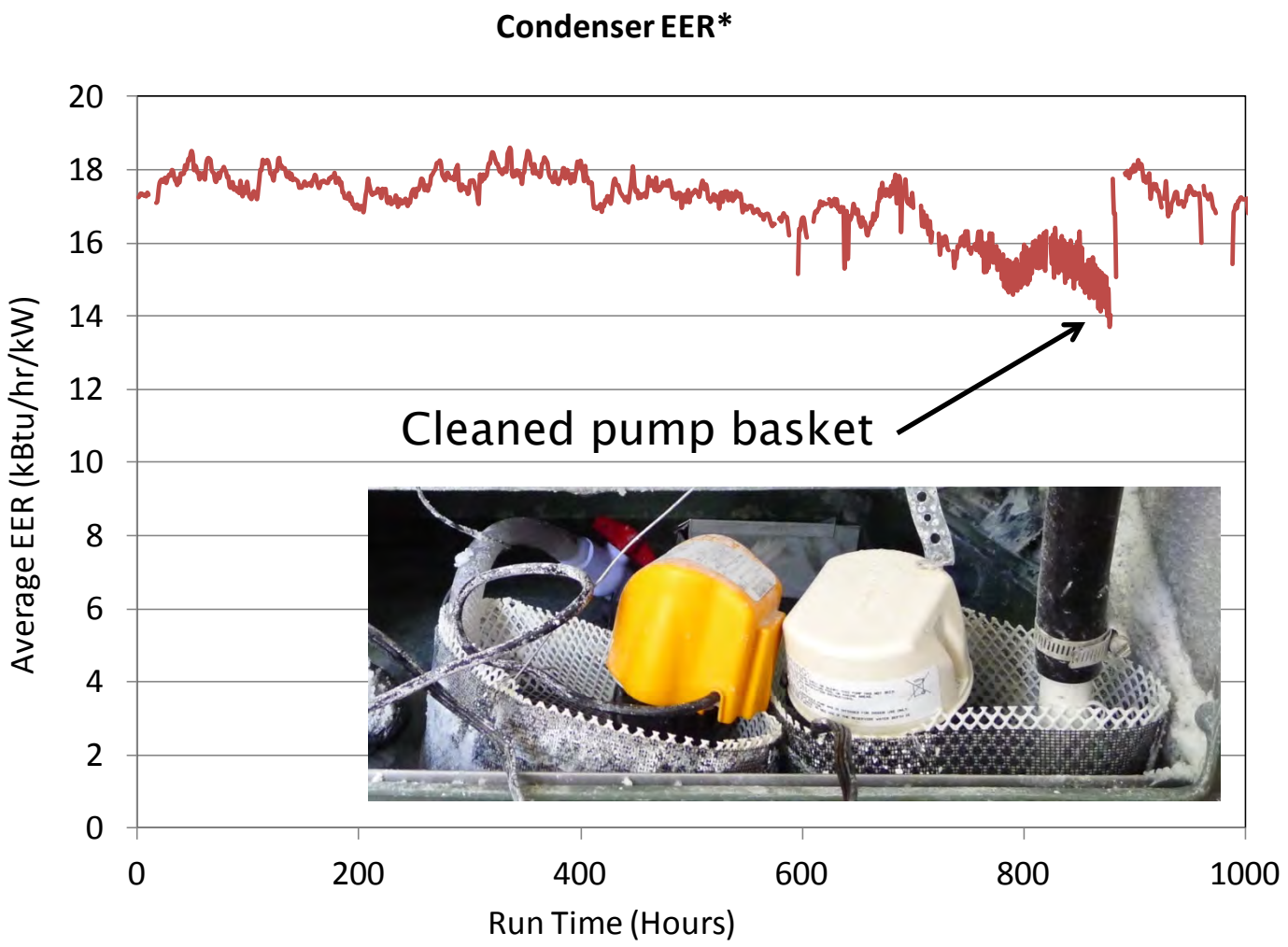
Small-Scale Results – Round 1



Full Scale Results – Test 2

- Low Bleed Rate Implemented
  - Avg = 1.26 gal/hr
  - Beutler recommends >2.5 gal/hr
  - ~5 gal/hr evaporated
  - 1000 hrs completed so far (1/2 way)

Full Scale Results – Test 2, Cont.



Next Steps

- Finish large scale Aquachill test
  (2000 hours, complete June 30th)
- Continue Evaluation of Small Scale – Round 1
  - Scale amounts/composition on coils
- Proceed with Round 2
  - Watreco/vortex device (SCE Interest)
  - Repeat magnets
  - Electro-magnetic device (?)
- SCE Contract up August 31st, future potentially affected by future funding parties