EFFECTIVE USE OF RECYCLED WATER IN COOLING TOWER WITH NEW GREEN TECHNOLOGY

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WBMWD Customer Service

- **Become part of their team.**
- **Engage expert consulting firm to study problem.**
- **Develop analysis and action plan.**
- **Partner on solution.**
- **Continue follow-up.**

WBMWD Customer Service

- **Implemented filter test:**
  - **Filters plugged in short time period – 10 minutes to one week**
- **Studied detention time to meter**
- **Studied detention time on customer side**

Tertiary Disinfected in Cooling Towers

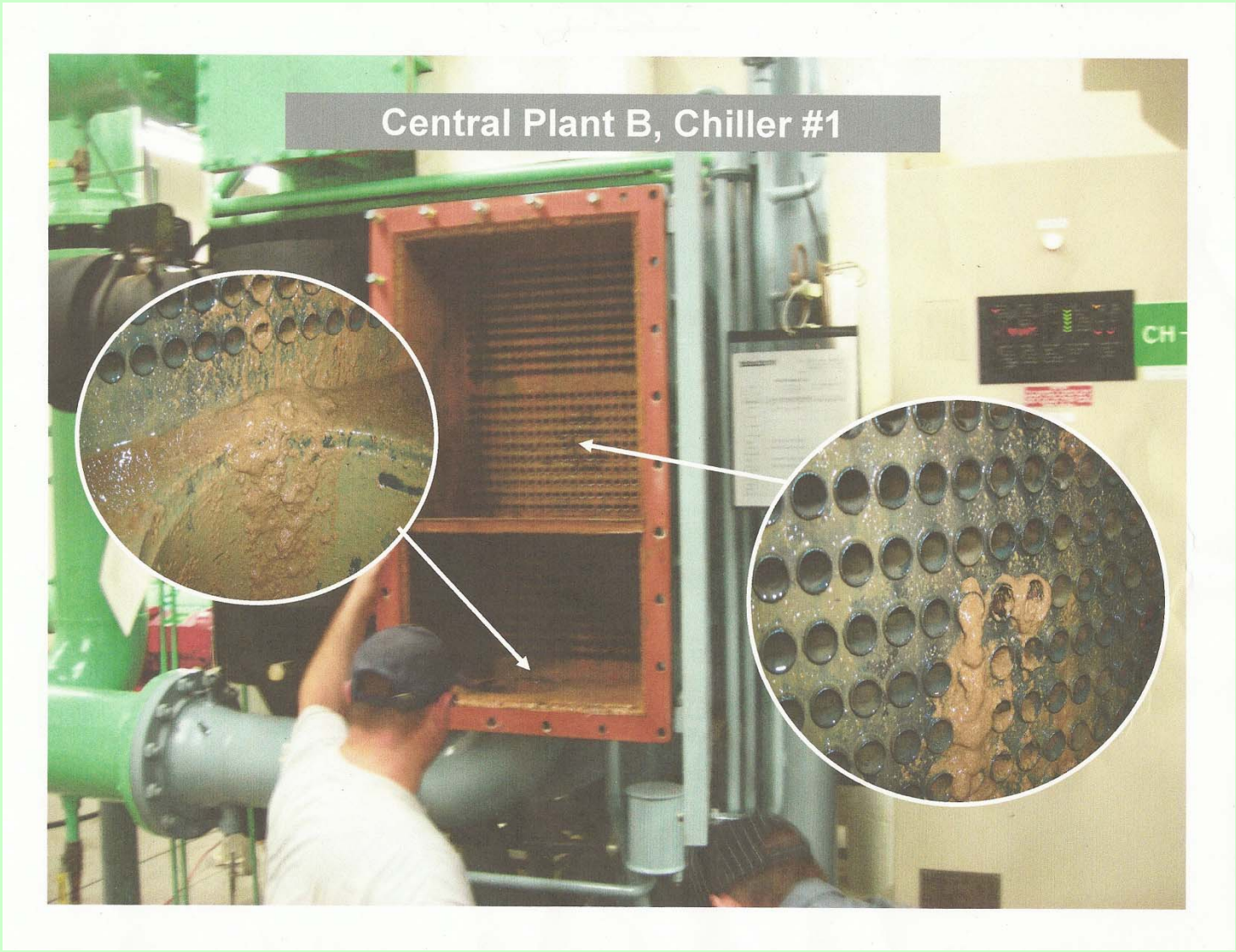
Traditional Treatment requires significant chemical additives to:

- **Inhibit corrosion**
- **Inhibit bio-growth**

Tertiary Disinfected in Cooling Towers

Traditional Treatment results in:

- **Lower cycles of concentration (about 1) / higher water costs**
- **Reduced efficiency of cooling towers**
- **Higher chemical costs**
- **Higher cleaning costs**



Cooling towers have become incubators for biogrowth. WBMWD and customer are researching traditional and non-traditional methods of addressing biogrowth.

Tertiary Disinfected in Cooling Towers

Solution to these issues came from another customer using a non-traditional treatment from:

Water Conservation Technology International (WCTI)

Challenges With Recycled Water in Cooling Towers

- Suspended solids increase fouling
- Ammonia attacks copper / alloys
- Nitrification expense (over treat for irrigation)
- Increased bio-fouling
- Increased scale and corrosion
- Increased water wastage and sewer loading
- Increased chemical cost (2-4X)

Customers Can Control Recycled Water (RW) Quality and Benefits

- High efficiency filtration on site
- High efficiency softening on site
- Reduce water & chemical costs 50-75%
- Water restriction guarantees (RW)
- Green PR / water & energy conservation

Natural Chemistry Process permits Towers to …

- Reduce tower water use by 20-40%
  (9,000-24,000 GPD per 1000 tons load)
- Evaporate over 98% of water used
- Replace fresh water with recycled water
- Save $272 /AF in energy cost using RW
- Operate with natural bio-static water
- Eliminate scale, corrosion and bio fouling

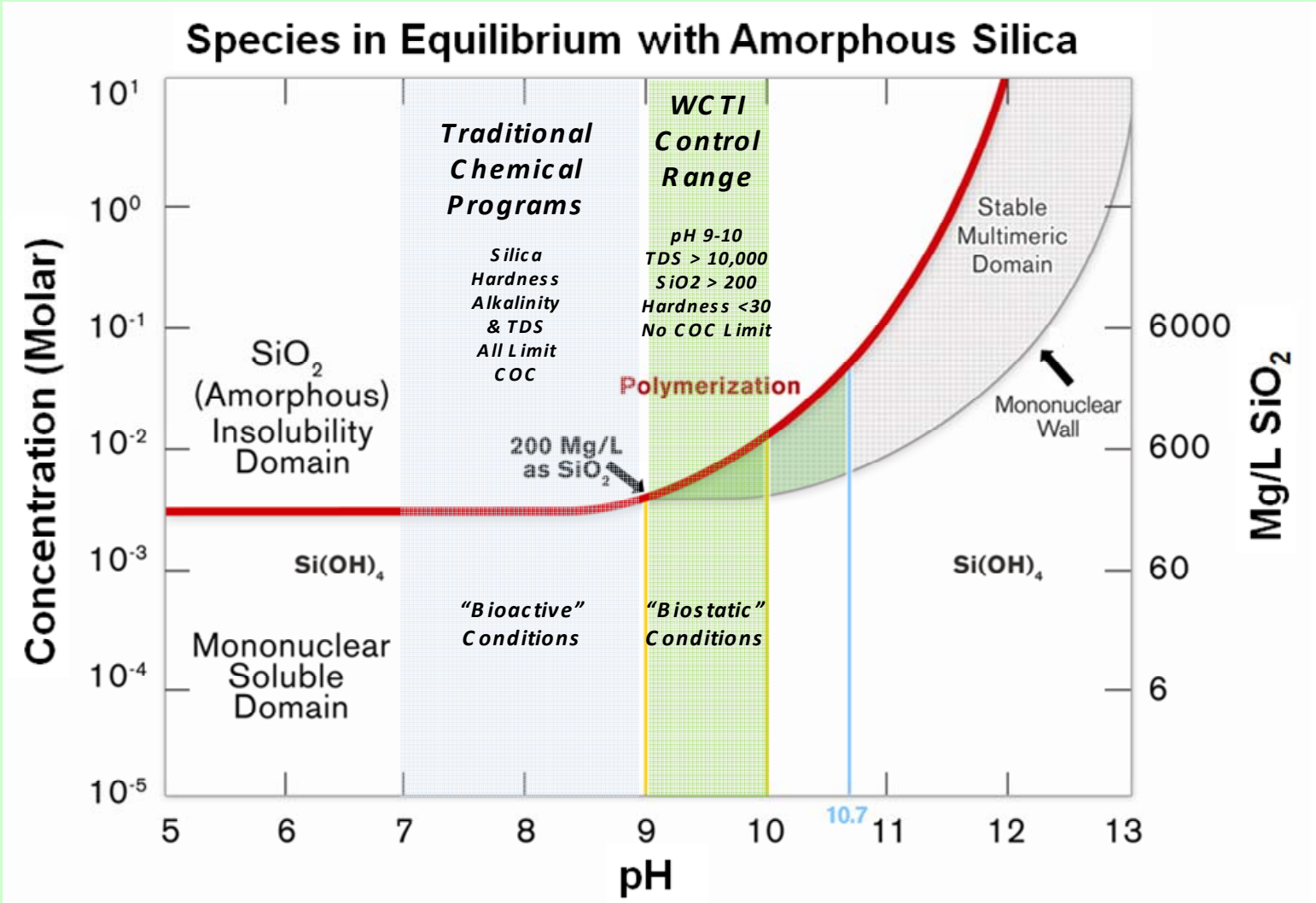
WCTI Corrosion & Scale Control Chemistry R&D

Five US Patents

Foreign Patents

Further Patents Pending

Silica Concentration / pH Dependent Relationship



How The Chemistry Works

- Low solubility ions (Ca/Mg) removed from water
- Remaining TDS in water are very soluble
- Scale limitations eliminated (< 150,000 TDS)
- Soluble silica polymerizes at > 200 mg/L
- Polymerized silica protects metals from TDS
- Excess silica forms non-scaling colloids
- High TDS/pH prohibits bio & pathogen growth

Natural Water Chemistry

- The major surface water minerals are Ca, Mg, Na, Cl, SO_4, alkalinity and silica
- Softening exchanges Na for Ca/Mg and eliminates low solubility salts that scale
- Evaporation of water saturates silica, TDS, and alkalinity (pH) which catalyze polymerization of silica to amorphous silicates
- This form of silica is an outstanding corrosion inhibitor, and does not form deposits

Highly Soluble Sodium Salts Eliminate Scale Limitations

(Solubility of Ion pairs as sodium salts @ 30^{o} C)

- Sodium Chloride (36% ~ 360,000 mg/L)
- Sodium Carbonate (16% ~ 160,000 mg/L)
- Sodium Sulfate (48% ~ 480,000 mg/L)
- Sodium Ortho-Phosphate (26% ~ 260,000 mg/L)

➢ Non-common ion effect also increases solubility (increased calcium solubility in seawater)

Natural Biostatic Water

- Elevated pH and TDS are naturally biostatic to bacteria, spores and viruses
- Hydrolysis of peptide chains occurs as water pH is increased (used in wastewater treatment)
- Proteins & enzymes also denatured by high TDS
- Natural pH/TDS increase as water is evaporated and concentrated by reduced tower blowdown
- Report by Anderson Engineering (water-cti.com)

HES Softening Economy

- Low regenerate use / high efficiency softening (HES) design @ 4# / CF resin
- Exceeds California efficiency standard of 4000 grains hardness removal per pound of salt.
- Typical salt usage cost of $0.12 per 1000 gallons vs $2.00-$12.00 water & discharge cost
- Cooling tower discharge is reduced from 20-40% to 1-2% of total tower water used

Reduce Tower Discharge and TDS Loadings to Sewer (Recycled Water) by 50-100%

TDS Discharge to Sewer with 1000 Ton Tower Load (13,140,000 GPY) Evaporation					
	MU TDS	Tower COC	Discharge TDS	Discharge Gal / Year	Discharge to Sewer # / Year TDS
Tower BD (Chemicals & low COC)	730	2.5	1,825	8,239,000	125,604
ZBD / HES Tower Operation	730	75	54,750	0	0
HES Waste	-	-	22,700	181,028	33,146
Basin Clean (once / year)			54,750	10,000	4,566
Brine Line or Haul	-	-	-	191,028	0

Option C — Raw Water Option with Evaporation Pond

Raw Water

Other Anions Present

Cooling Tower

Blowdown (High TDS)

Evaporation Pond

Water **and** ***Energy*** **savings**
(100 mg/L silica makeup to tower)
Chemical versus WCTI

Performance Measurements	**Chemical Treatment**	**WCTI**
Tower Makeup Discharge	70%	1%
Tower Fill / Exchanger	Visible Scale / Deposits	Removed / Clean Surfaces
Average Planktonic Count	10^4 – 10^5 CFU/ml	10^0 CFU/ml
Average Sessile Count	10^6 CFU/cm^2	10^1 CFU/cm^2
Average Biocide Usage	2.0 – 2.5 gpd	0.05 gpd
Exchanger Amperage Loading	34	25

Auto HQ Tower / West Basin Recycled Water Quality

- Recycled water in central plant towers, Trane copper tube chillers/absorber, co-generation plate & frame exchanger

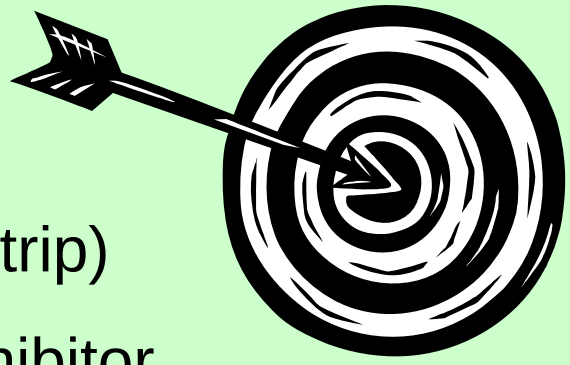
- Ammonia = 38 mg/L
- TDS = 730 mg/L
- Hardness = 224 mg/L
- Total Phosphate = 0.9 mg/L
- Turbidity = 3 ntu average

WCTI Recycled Water Pre-treatment for Recycled Water (HEF & HES)

ZBD / Silica / Azoles
Tower Chemistry Control Targets

AY2

- MU Turbidity: < 0.5 ntu after HEF
- Hardness: MU < 0.5 mg/L, Tower < 30 mg/L
- Soluble SiO_2 : > 300 mg/L (corrosion control)
- pH: > 9.5 (biostatic & NH_3 strip)
- TDS: > 10,000 mg/L (biostatic)
- Ammonia: < 1.0 mg/L (pH / tower strip)
- Tolytriazole: 5-50 mg/L (copper inhibitor, usage minimal with ZBD)



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AY2 Too many acronyms. Reviewer may not allow

Andrew Yang, 1/22/2009

Tower Ammonia Stripping

In a waste stream, ammonium ions exist in equilibrium with ammonia.

$$NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$$

1. Below pH 7, virtually all the ammonia is soluble ammonia ions.
2. Above pH 12, virtually all the ammonia is present as a dissolved gas.
3. Between pH 7 and 12, both ammonium ions and dissolved gas exist together.
4. Percentage of dissolved gas increases with pH / temperature.
5. Elevated pH and temperature favor removal of ammonia from solution as the gas when water is scrubbed over a tower.

ZBD Tower with WCTI Treated Recycled Water as Makeup

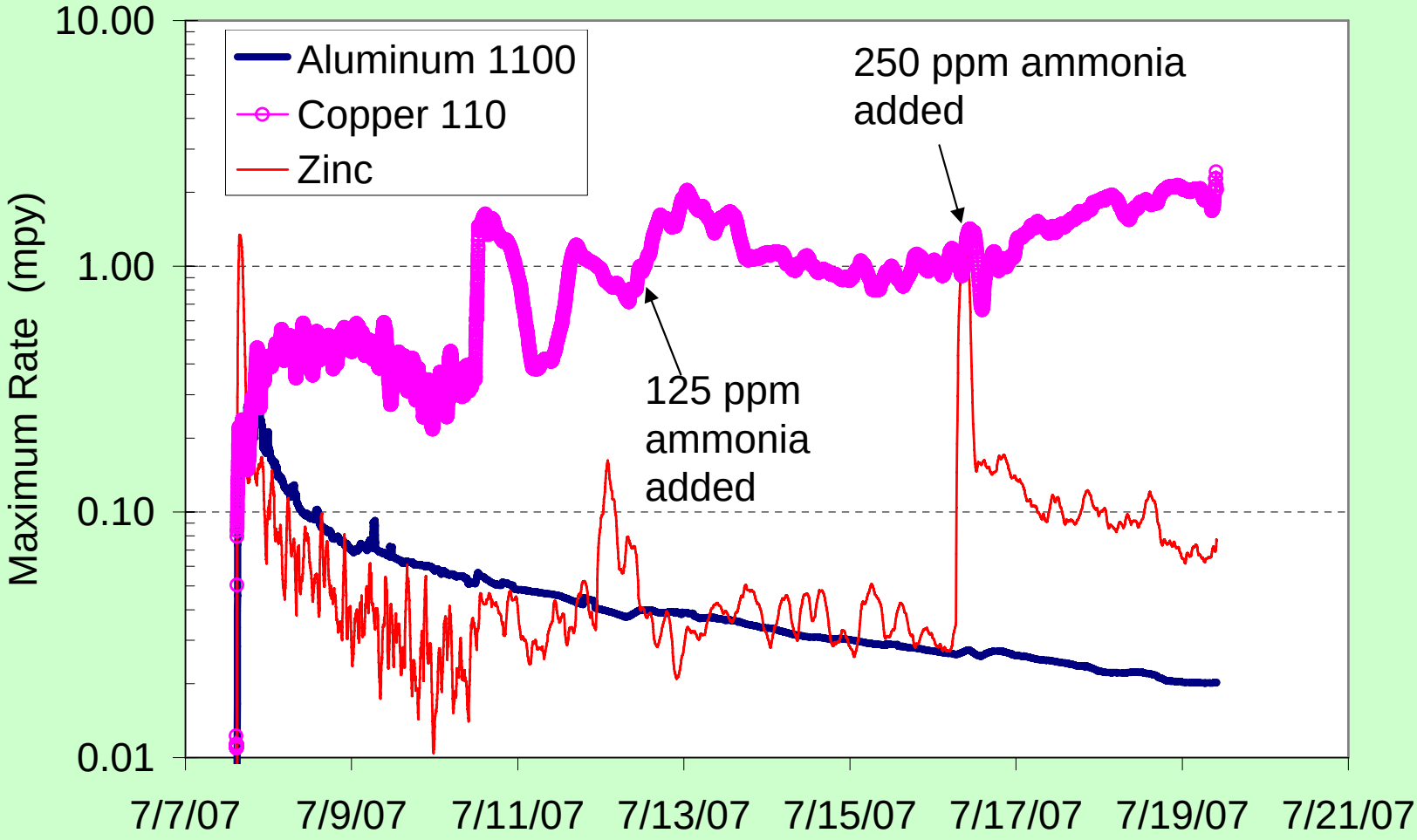
ZBD Tower / Filtered and Softened Recycled Makeup Water COC (Concentration of Chemistry) Ratios			
Sample / Tests	Tower	Soft MU	COC
TDS, mg/L (NaCl Myron L 6P)	30,000	1100	27
Ph	9.8	7.1	NA
Silica, mg/L SiO_2	350	24	15
Calcium, mg/L $CaCO_3$	13	0.2	NA
Magnesium, mg/L $CaCO_3$	6	0.1	NA
Sulfate, mg/L SO_4	3300	127	26
Chloride, mg/L NaCl	5800	214	27
Tot. Alkalinity, mg/L $CaCO_3$	5300	192	28
Ammonia, mg/L NH_4	0.5	34	NA
Total Phosphate, mg/L PO_4	16	0.6	27
TTA, mg/L as tolytriazole	15	NA	NA

Corrosion of Copper Alloys by Ammonia

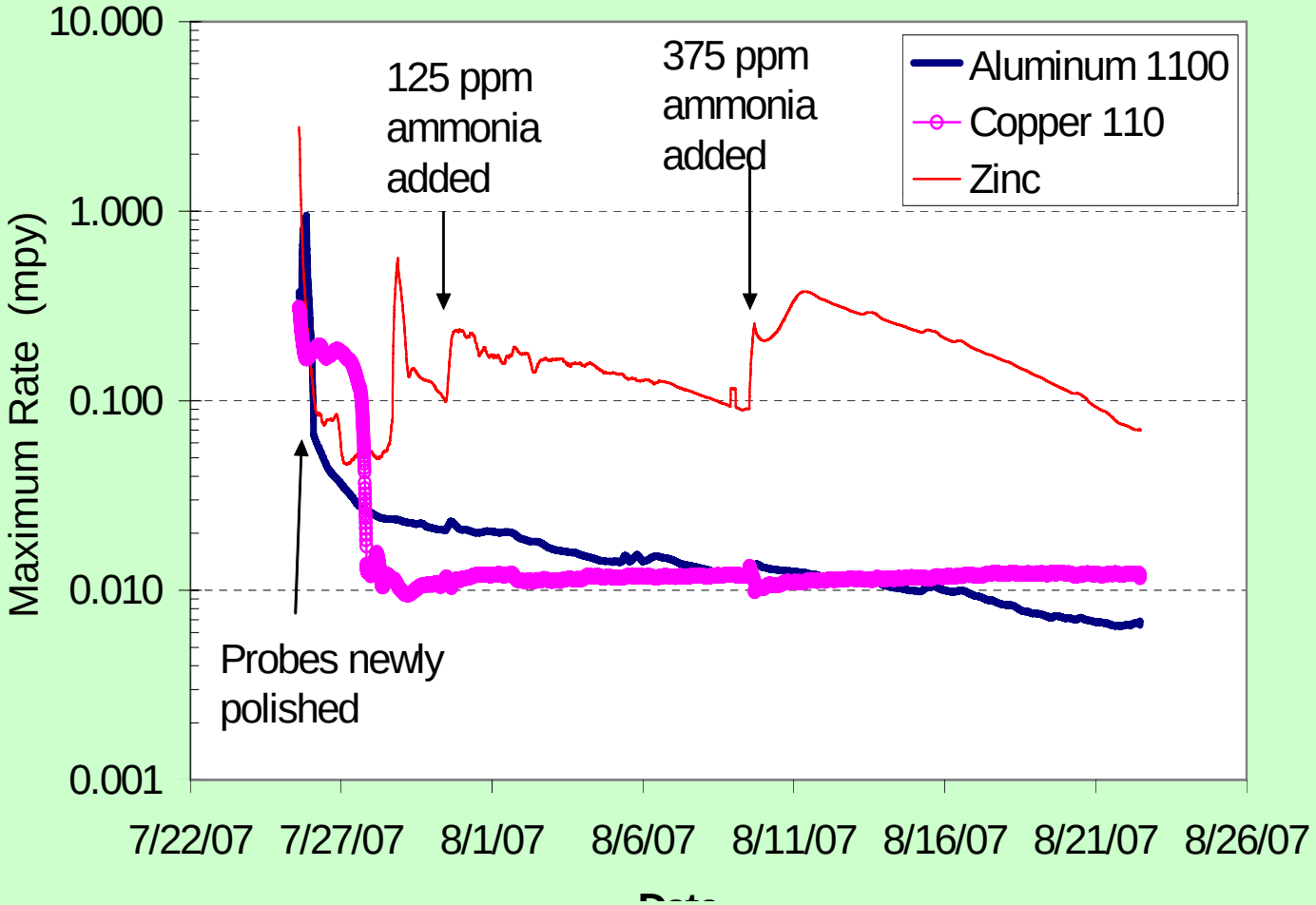
- Ammonia in recycled water is aggressive to brass makeup valves (untreated, failed in less than 12 months, replaced with stainless).
- Don’t use copper pipe for restrooms!
- Typical copper corrosion is presented below.

Corrosion Rates of Copper Alloys in 0.8% Ammonia at 104° F			
Alloy	Corrosion rate		
	mdd	**mpy**	mm/y
Copper	85	**14**	0.36
Cartridge Brass (70:30 Cu-Zn) 260	49	**7**	0.2
Gun Metal (88:10:2 Cu-Sn-Zn) 905	30	**5**	0.1
Copper-manganese alloy (95:5 Cu-Mn)	9	**2**	0.05
Source: After J.A Radley, J.S. Stanley and G.E. Moss, Corrosion Technology 6:229:1959			

Effect of Ammonia on Metals in Silica Treated Water (no TTA)

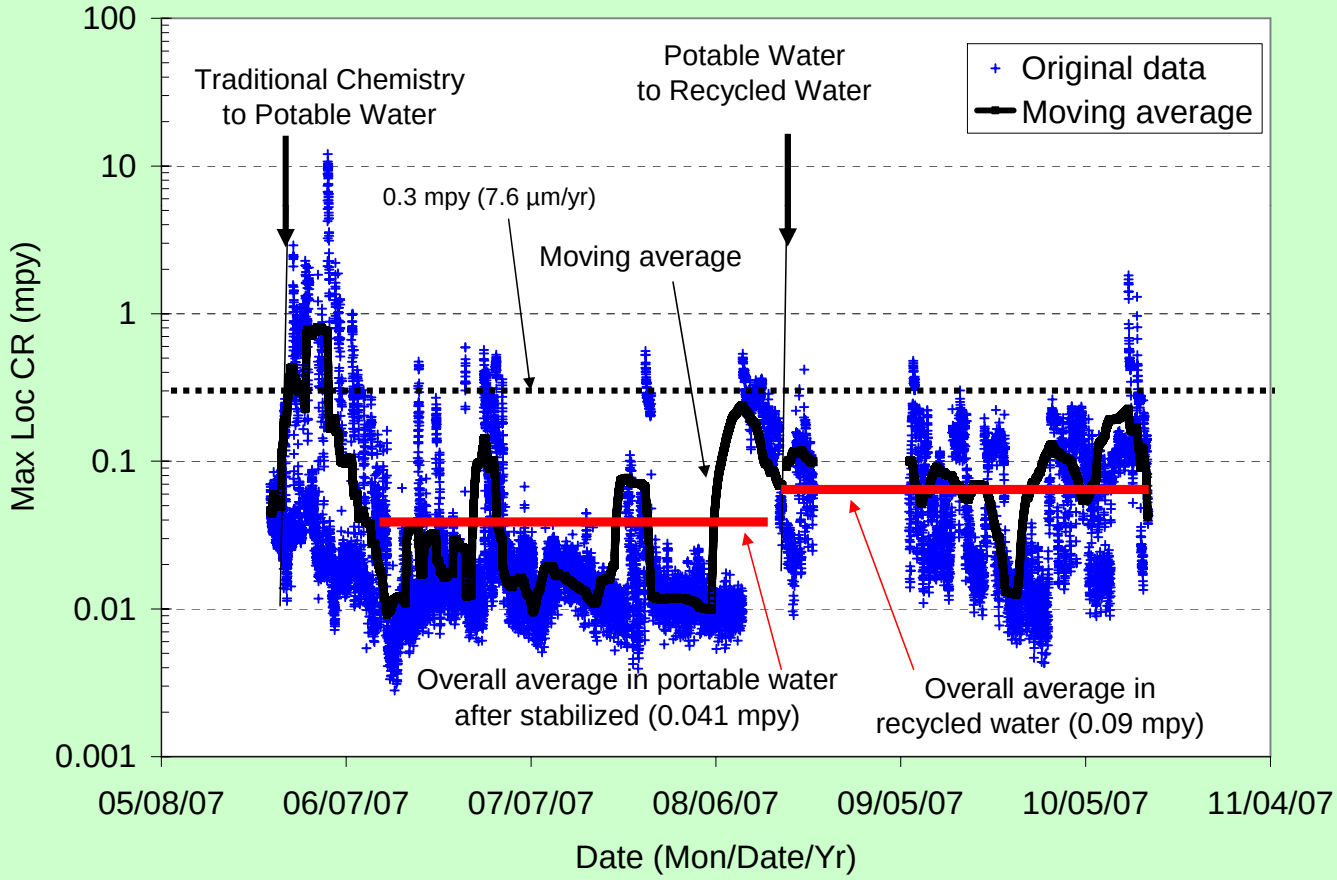


Effect of Ammonia on Metals in Silica and TTA Treated Water



Localized Copper Corrosion (CMAS study)

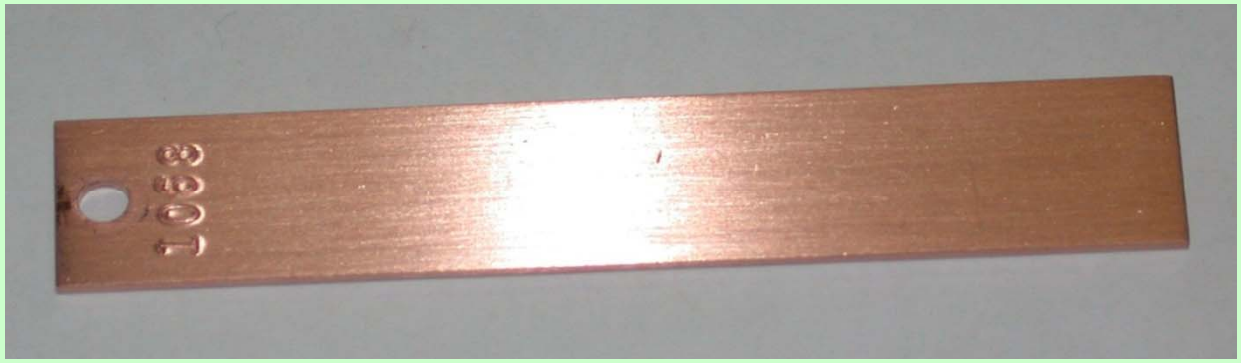
Chemical vs ZBD Potable vs ZBD Recycled



Copper Corrosion Results
(CMAS study)
Chemical / ZBD Potable / ZBD Recycled

- The impact of ammonia (WCTI treated water) on localized corrosion was a very minor increase from 0.04 to 0.09 mpy
- ZDB corrosion rates on potable and recycled water were well below the 0.3 mpy localized rate with chemicals and potable water

Coupon Weight Loss Results



Copper coupon, exposed 99 days, 0.16 mpy corrosion rate (high under mount corrosion bias).

Carbon steel coupon exposed 99 days with 0.426 mpy corrosion rate (high under mount corrosion bias).

Results: ZBD Tower Chemistry Study for Recycled Water

- Ammonia is stripped in tower to < 1 mg/L.
- Ammonia does not affect silica protection of steel, aluminum and zinc.
- Azoles are highly effective for copper protection from ammonia in ZBD water (patent pending).
- Biostatic tower chemistry was not affected by recycled organics and phosphate nutrients.

Current Recycled & High Silica Water Projects

- West Basin – Honda, Toyota, CSUDH, Raytheon, Equinix
- Boeing – Western US
- Major US Data Centers – (industrial reuse / 35-70 silica)
- Major Chip Manufacturing – Philippines (>100 mg/L silica)

Summary: Recycled Use Expansion in Cooling Towers

- 100% fresh water reduction with recycled water
- ZBD reduces water wastage by 20-40%
- Reduced TDS and toxics to sewer
- HEF / HES cost efficient RW quality upgrade
- Quick ROI (< 12 months) from savings
- Water restriction guarantees with RW
- 50% to 75% less cost than chemical treatment
- Green / energy conserving technology