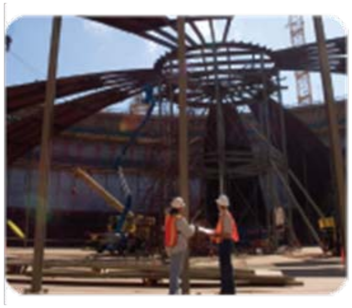



Examination of the Water Quality Impacts of Chlorine Conversion and Carbon Dioxide pH Adjustment at the Medford Water Commission's Robert A. Duff WTP

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Presentation Outline

- Existing Water System Description
- Why Convert?
- Conversion Feasibility Evaluation
- Paper Study and Water Quality Modeling
- Bench Scale Testing
- Recommended Improvements
- Real Data Comparison

Existing Water System

- 2 Water Supplies
- Big Butte Springs (BBS)
  - Year round source
  - Chlorine gas – disinfectant (with scrubber)
- Rogue River – Duff WTP
  - Summer source
  - Diurnal fluctuations in pH and temperature
  - Conventional WTP
    - Ozone - taste and odor (applied to raw water)
    - PACl – coagulant
    - Chlorine gas – Prechlorination and post filtration

Evaluation of Chlorine Disinfection Alternatives

- MWC Considering Conversion from Chlorine Gas
  - BBS scrubber maintenance issues
  - Need for upgrades at Duff WTP
  - Safety, security, and regulatory compliance
- 3 Alternatives Considered
  - Retain Chlorine Gas
    - Add or replace scrubber if needed
  - 12.5% Sodium Hypochlorite
  - On-site Sodium Hypochlorite Generation

Evaluation of Chlorine Disinfection Alternatives

- Evaluation Criteria
  - Safety
  - Equipment Operability
  - Reliability and Redundancy
  - Water Quality Impacts
  - Security and Regulatory Uncertainty
  - Integration with Existing Facilities
  - Capital and O&M Cost

Evaluation of Chlorine Disinfection Alternatives

- Water Quality Impacts
  - Finished / distribution water quality
    - pH
    - Corrosivity
    - Disinfection byproducts
    - Compatibility
  - Coagulation process impacts
    - Coagulation pH
    - Coagulant type
    - Coagulant dose

Water Quality Modeling

- Rothberg, Tamburini & Windsor (RTW) Model
- Evaluate water quality impacts of converting from gaseous chlorine to liquid sodium hypochlorite
  - Coagulation pH (Duff WTP only)
  - Finished water pH
  - Calcium carbonate precipitation potential (CCPP)

Water Quality Modeling Results – Big Butte Springs

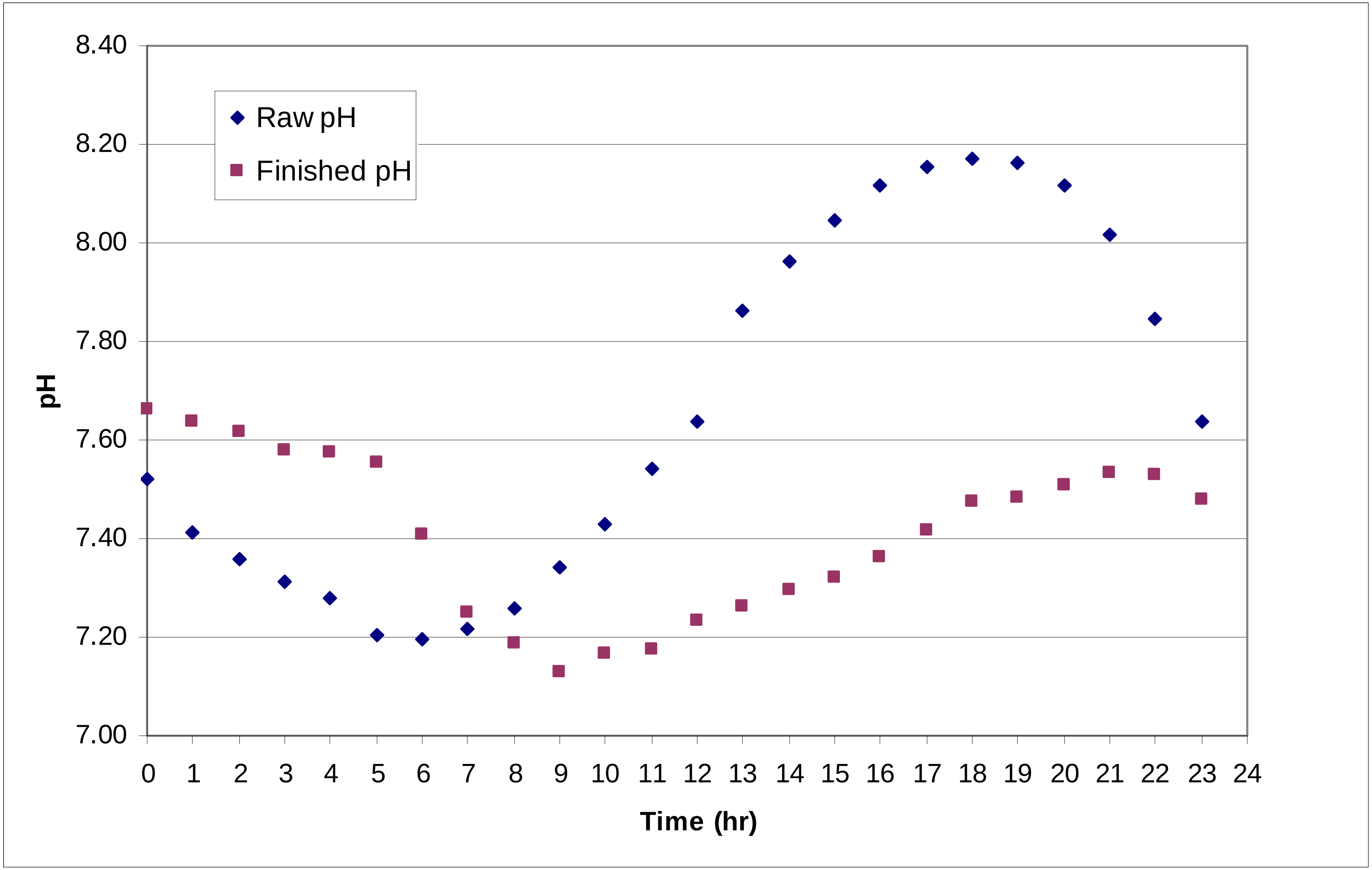
No significant impact

WQ Parameter	Chlorine Gas	Sodium Hypochlorite
pH	6.9	7.0
Alkalinity (mg/L $CaCO^3$)	50	52
CCPP (mg/L)	-34.6	-30.8

Water Quality Modeling Results – Duff WTP

- Duff WTP – 3 scenarios modeled
  - Gas + PACl (existing)
  - Hypo + PACl
  - Hypo + Alum
- Must also consider daily fluctuations in pH and temperature

Diurnal pH Fluctuation – Duff WTP



Water Quality Modeling Results – Duff WTP

Location & Scenario	**Avg**	**Max**	**Min**
Coagulation pH			
Gas + PACl	7.4	7.6	7.1
Hypo + PACl	8.0	8.5	7.3
Hypo + Alum	7.0	7.1	6.8
Finished Water pH			
Gas + PACl	7.3	7.4	7.0
Hypo + PACl	8.3	8.8	7.3
Hypo + Alum	7.1	7.2	6.9
Finished Water CCPP			
Gas + PACl	-9.9	-16.5	-8.2
Hypo + PACl	-3.6	-9.6	-1.7
Hypo + Alum	-13.9	-20.4	-12.1

Water Quality Modeling Results
Duff WTP - Coagulation pH

- Hypo + PACl
  - Raises coagulation pH
  - Daily coagulation pH fluctuation from 7.3 to 8.5
  - PACl less sensitive to pH changes
  - Monitoring of PACl dose required due to large swing in pH
- Hypo + Alum
  - Slightly lowers coagulation pH
  - Daily coagulation pH fluctuation from 6.8 to 7.1
  - Alum more sensitive to pH changes

Water Quality Monitoring Results
Duff WTP - Finished Water pH

- Hypo + PACl
  - Higher finished water pH
  - Longer CT required
  - May increase chlorine residual required for CT compliance
- Hypo + Alum
  - Slightly lower finished water pH

Water Quality Monitoring Results
Duff WTP – Distribution System

- Hypo + PACl:
  - Higher pH
  - Improved CCPP
  - Potential for problems during transition period - twice per year
  - pH compatibility with BBS water

Possible Solutions: Add CO2 to Raw Water *or*
Add NaOH to BBS *or*
Return to Alum and NaOH

- Hypo + Alum
  - Slightly lower finished water pH - could adjust with NaOH

Bench Scale Testing

Goals:

- Compare RTW modeling results
- Confirm impact on coagulation and finished water pH at Duff WTP
  - Hypo + Alum
  - Hypo + PACl
- Evaluate use of CO2 for pH control at Duff WTP
- Determine DBP formation for each scenario with and without pH adjustment

Bench Scale Testing - BBS

- No significant change in pH
- No significant change in DBPs

	NaOH						
6	BBS raw water with bulk hypochlorite addition	0.002	0.001	2.3	7.0	1.61	
* pH value following all chemical addition, including the SDS hypochlorite addition							

	NaOH						
6	BBS raw water with bulk hypochlorite addition	0.002	0.001	2.3	7.0	1.61	
* pH value following all chemical addition, including the SDS hypochlorite addition							

RTW vs Bench Scale – Duff WTP

Test 9		8.8	8.1
	pH = 8.5		
	5.75 mg/L PACl		
	1.0 mg/L hypochlorite		
Test 11		7.0	7.3
	pH = 7.3		
	15 mg/L alum and 1.4 mg/L coagulant aid		
	1.0 mg/L hypochlorite		
*Alkalinity = 30 mg/L, Ca = 12 mg/L, TDS = 60 mg/L, Temp = 14°C			

Test 9		8.8	8.1
	pH = 8.5		
	5.75 mg/L PACl		
	1.0 mg/L hypochlorite		
Test 11		7.0	7.3
	pH = 7.3		
	15 mg/L alum and 1.4 mg/L coagulant aid		
	1.0 mg/L hypochlorite		
*Alkalinity = 30 mg/L, Ca = 12 mg/L, TDS = 60 mg/L, Temp = 14°C			

Bench Scale Testing – Duff WTP Jar Testing

	pH		Coagulant		Chlorine type[1]		Settled pH	Settled turbidity	Filterability index
	AM	PM	Alum, mg/L+ 1.2 mg/L coag aid	PACl, mg/L	Gas, mg/L	Hypo		NTU	
Test 1	7.12			5.75	X		7.1	0.632	1.0
Test 2	7.18			5.75	X		7.2	0.652	1.2
Test 3	7.28			5.75		X	7.5	0.96	1.0
Test 4	7.28			5.75		X	7.1[2]	2.08	1.0
Test 5	7.28		15 (alum only)			X	7.0	1.29	1.1
Test 6	7.28		15			X	6.9	0.695	1.2
Test 7	7.28		15			X	7.1[3]	0.564	1.2
Test 8		8.5		5.75	X		8.0	1.21	2.3
Test 8A		7.93		5.26	X		7.97	1.01	2.7
Test 9		8.5		5.75		X	8.1	0.865	4.2
Test 9A		8.13		5.26		X	8.08	0.212	3.7
Test 10		8.5		5.75		X	7.1[2]	1.02	5.3
Test 10A		8.13		5.26		X	7.2[2]	1.29	9.0
Test 11		8.5	15			X	7.3	0.772	1.3
Test 12		8.5	15			X	7.3[2]	1.04	1.4

(1) Chlorine dose of 1.0 mg/L
(2) pH adjusted with CO_2 to Test 1 value
(3) pH adjusted with caustic to Test 1 value

Bench Scale Testing – Duff WTP SDS Testing

SDS Test No.	SDS condition description	THM, mg/L	HAA, mg/L	Cl_2 initial, mg/L	pH initial*	Cl_2 final, mg/L	TOC, mg/L
1	Duff finished Control sample	0.035	0.027	0.68	7.3	0.28	0.86
2	Duff finished pH 8.0	0.042	0.025	0.63	8.0	0.2	
3	Duff finished pH 8.5	0.049	0.023	0.65	8.5	0.16	
7	O_3 water, AM pH, PACl, filtered, hypochlorite (Coagulation Test 3)	0.038	0.026	0.91	7.6	0.36	
8	O_3 water, AM pH, alum, coag aid, adjust pH to fullscale, filtered, hypochlorite (Coagulation Test 7)	0.046	0.025	0.92	7.5	0.36	
9	O_3 water, PM pH, PACl, filtered, hypochlorite (Coagulation Test 9)	0.058	0.058	>2.2	8.2	> 2.2	
9A	O_3 water, PM pH, PACl, filtered, hypochlorite (Coagulation Test 9)	0.026	0.021	1.32	8.1	0.0	
10	O_3 water, PM pH, alum, coag aid, adjust pH to fullscale, filtered, hypochlorite (Coagulation Test 12)	0.031	0.064	>2.2	7.6	> 2.2	
11	O_3 water, AM pH, PACl, filtered, hypochlorite (Coagulation Test 10)	0.019	0.032	1.3	7.4	0.0	

* pH value following all chemical addition, including the SDS hypochlorite addition

Bench Scale Testing – Duff WTP

Conclusions:

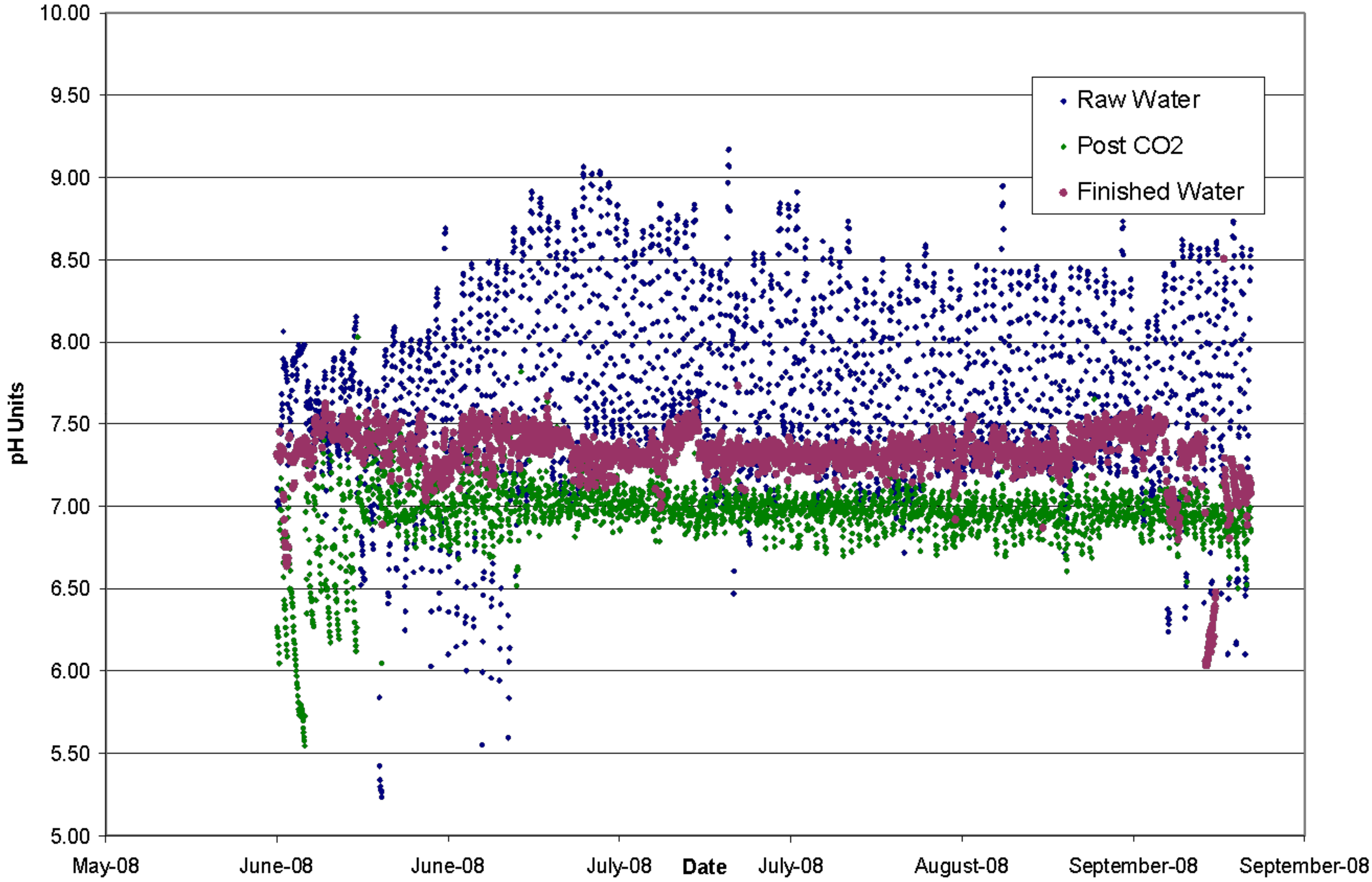
- Hypo + PACl:
  - Increase coagulation pH
  - Increase in finished water pH
  - Slight increase in DBPs
  - CO2 required to maintain current finished water pH and DBPs
- Hypo + Alum
  - Maintains current coagulation pH
  - Caustic and CO2 required to maintain current finished water pH

Preferred Alternative

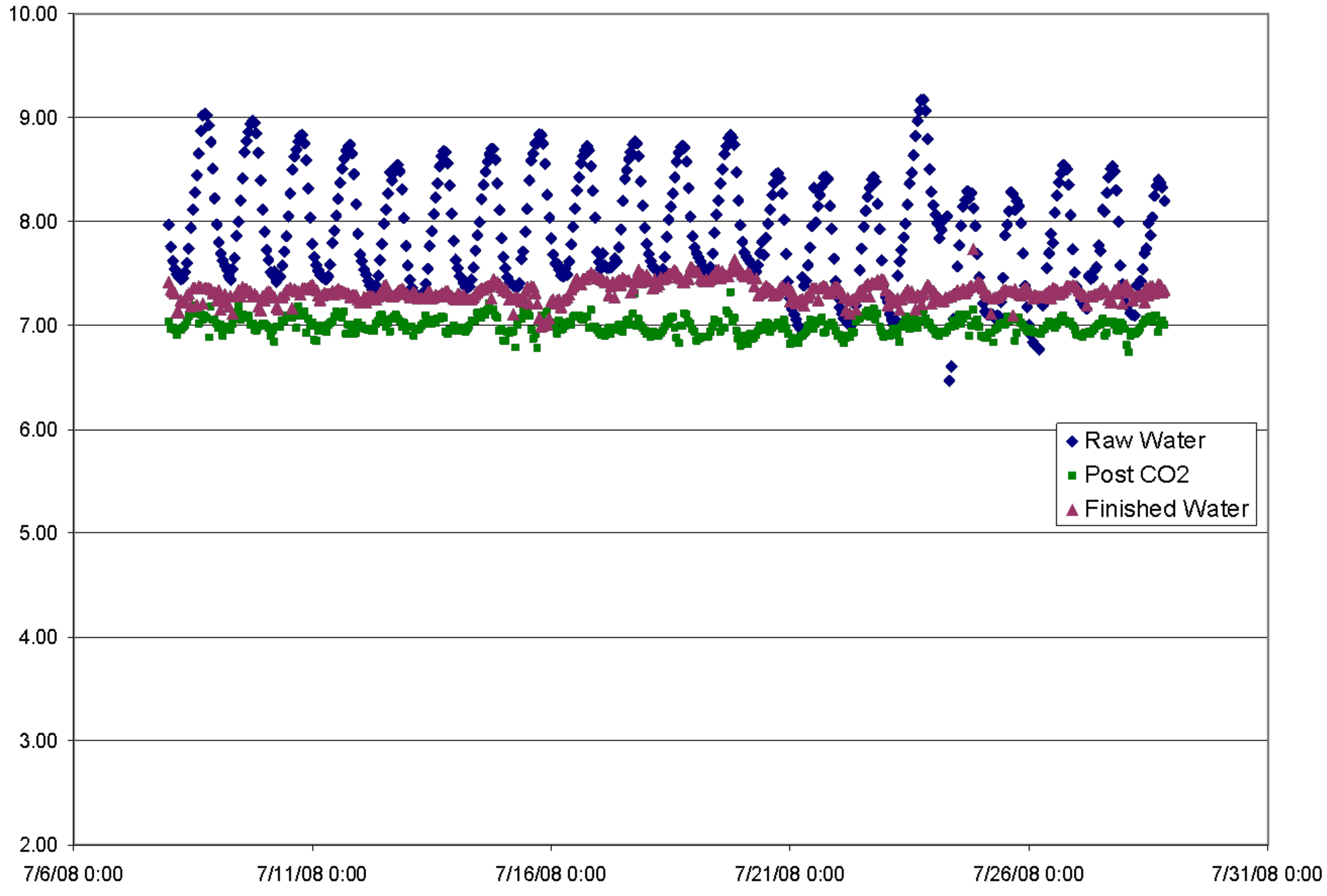
Hypo + PACl + CO_2

- Fewer chemicals required - NaOH and coagulant aid not required
- Maintains PACl – less sludge production
- Additional benefits of CO_2
  - Process stabilization
    - Dampens raw water pH fluctuation
    - PACl dosage fairly constant
  - Less ozone demand and longer CT
  - Stable finished water pH – lead and copper

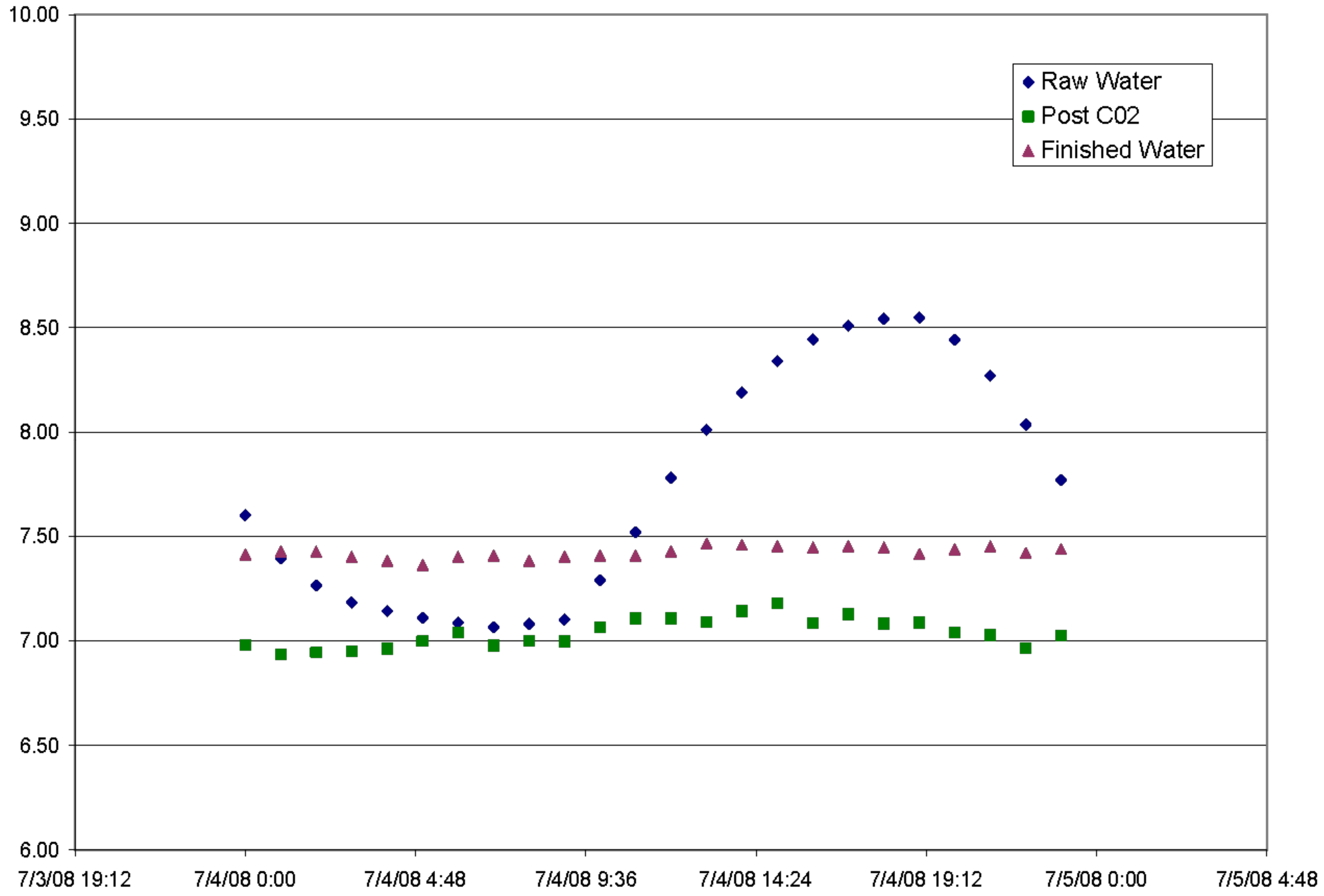
2008 Duff WTP pH



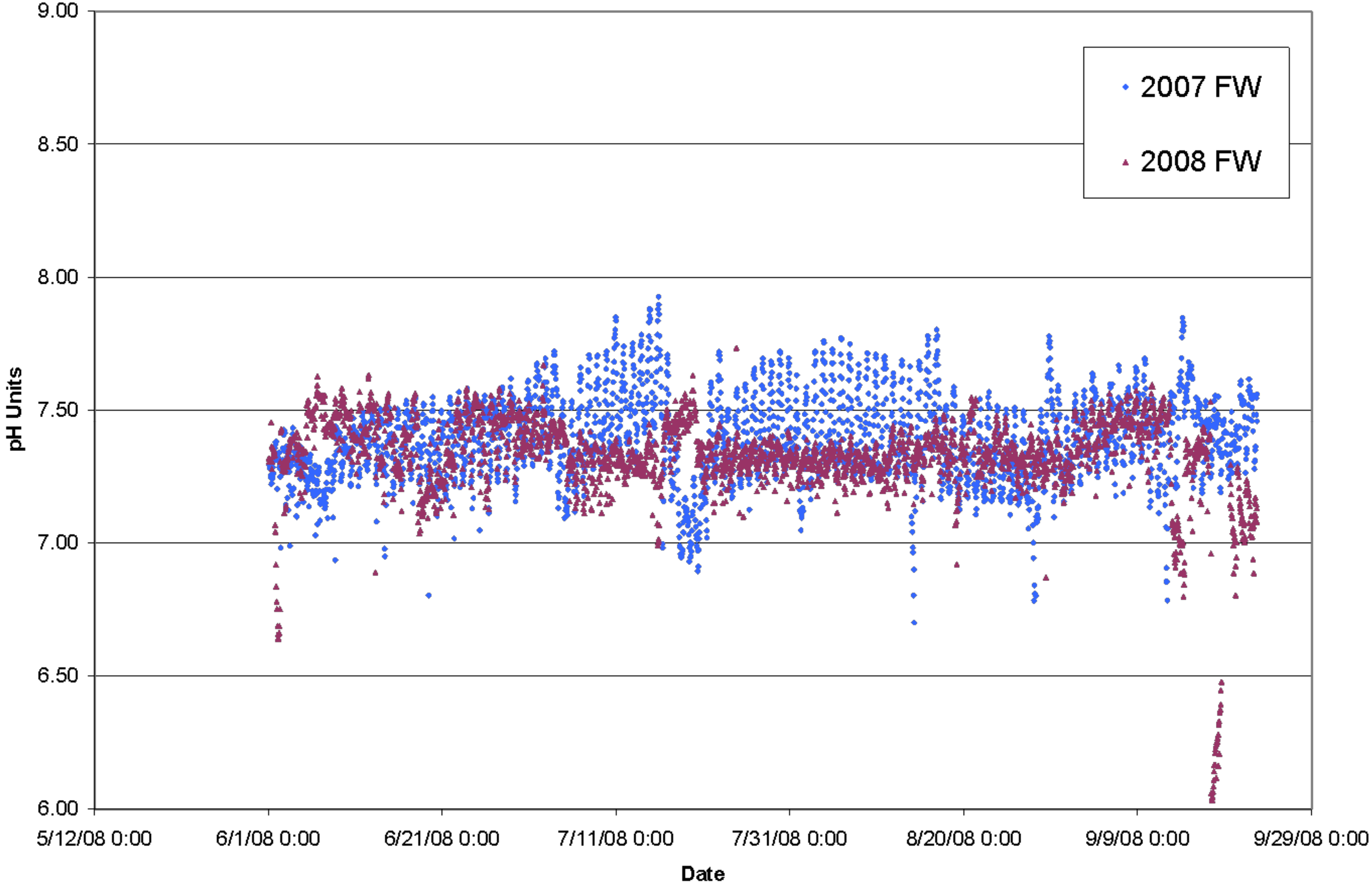
2008 Duff WTP pH



July 4, 2008 Duff WTP pH



2007 vs 2008 Finished Water pH – Duff WTP



2007 vs 2008 DBPs

Sampling Location	TTHM (mg/L)		HAA5 (mg/L)	
	2007	2008	2007	2008
Duff WTP Point of Entry	0.00979	0.01900	0.01590	0.01590
	0.00974	0.00557	0.00786	0.00658
BBS Max Residence Time	0.00127	0.00050	0.00100	0.00100
	0.00050	0.00081	0.00100	0.00100
Duff Max Residence Time	0.01780	0.03090	0.02550	0.02260
	0.01480	0.00873	0.01210	0.01170

Questions?

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