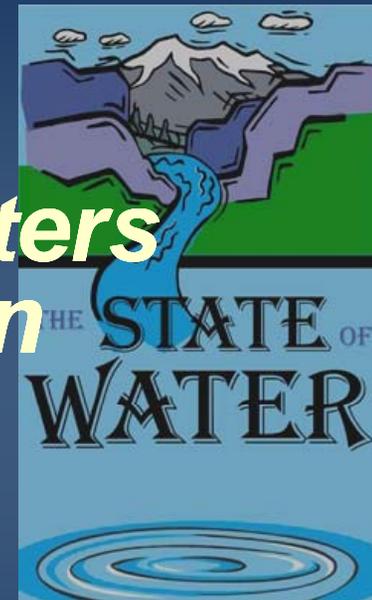


Kennedy/Jenks Consultants

Engineers & Scientists

*Evaluating Roughing Filters
to Improve Microfiltration
Performance*



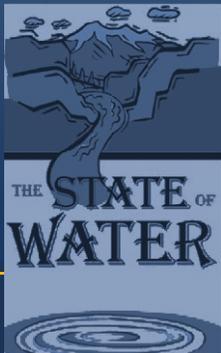
Stephen Booth, PhD



Acknowledgements



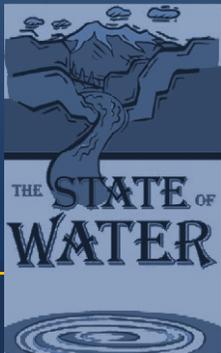
- ▼ Eagle River Water & Sanitation District
- ▼ Avon Drinking Water Facility staff
- ▼ Unifilt Corp.



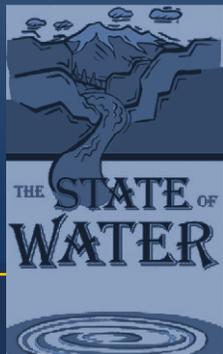
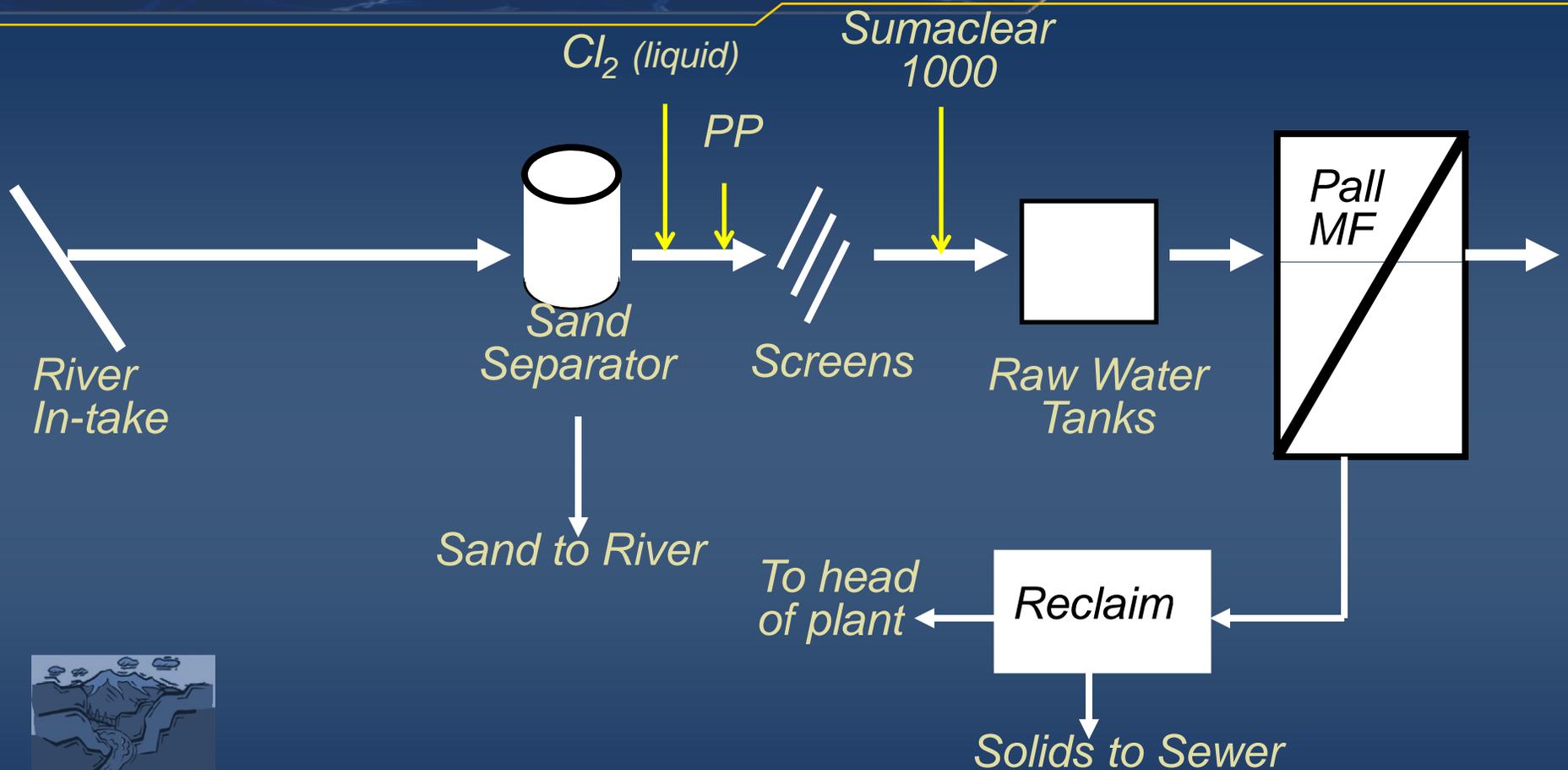
Edwards DWF



- ▼ Membrane Plant
- ▼ 5 mgd installed capacity
- ▼ Ultimate capacity = 10 mgd



Edwards DWF Schematic



Plant: Parking and Road



Roof of Plant with Vegetation



River Intake



Membrane Racks



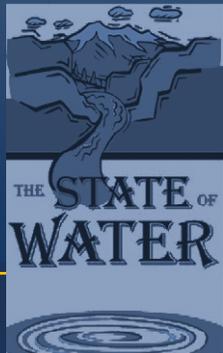
Membrane Racks



Issues



- ▼ TOC removal required
- ▼ High DBPs in the distribution system
- ▼ Spring run-off treatment challenges



Regulatory Requirements (DBPs)



▼ THMs

TTHM Rule MCL: $\leq 100 \mu\text{g/L}$

Stage 1 RAA MCL: $\leq 80 \mu\text{g/L}$

Stage 2 LRAA MCL: $\leq 80 \mu\text{g/L}$

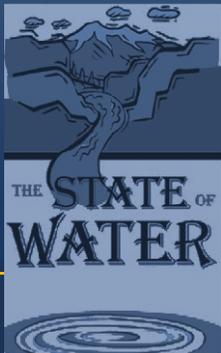
▼ HAA5

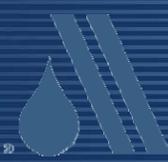
Stage 1 RAA MCL: $\leq 60 \mu\text{g/L}$

Stage 2 LRAA MCL: $\leq 60 \mu\text{g/L}$

▼ Bromate

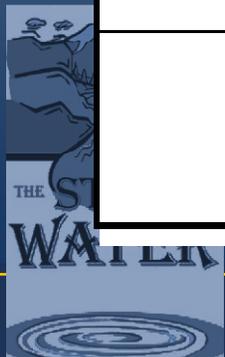
RAA MCL: $\leq 10 \mu\text{g/L}$





DBP Precursor (TOC) Removal

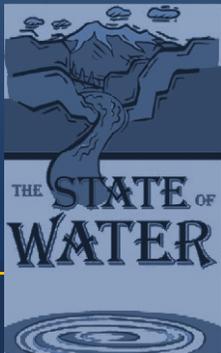
Source Water TOC (mg/L)	Source water alkalinity, mg/L as CaCO ₃		
	0 – 60	>60 - 120	>120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%



Why Roughing Filtration?



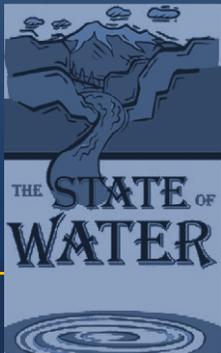
- ▼ Proven technology
- ▼ Remove solids (coagulant) prior to membranes
- ▼ Provide a surface for iron and manganese adsorption



Pilot Study Objectives



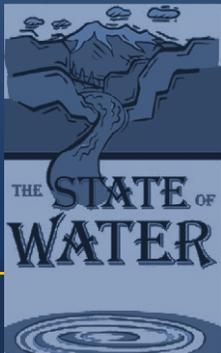
- ▼ Testing during spring run-off
- ▼ Focus on roughing filtration performance and water quality
- ▼ Test ferric and alum as alternative coagulants
- ▼ Test *'high rate'* HLRs



Jar Testing Results



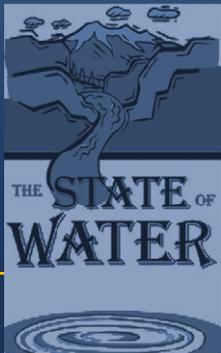
- ▼ Jar tests performed to evaluate different coagulants throughout 6-week study
- ▼ Evaluated trends in performance



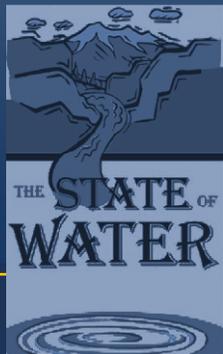
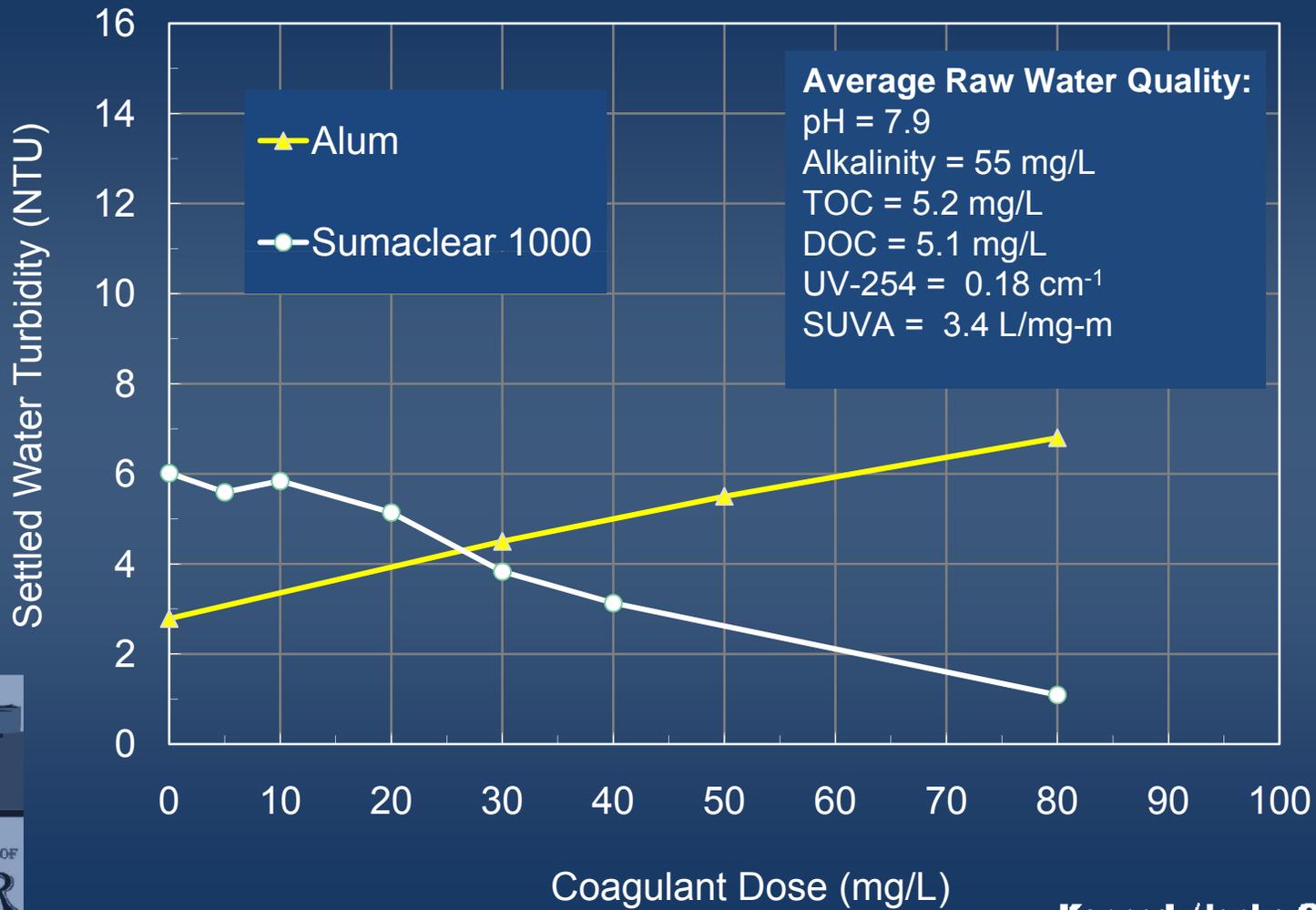
Coagulants



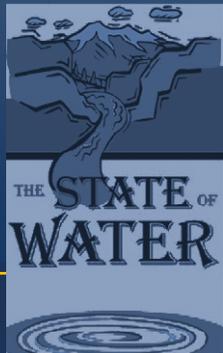
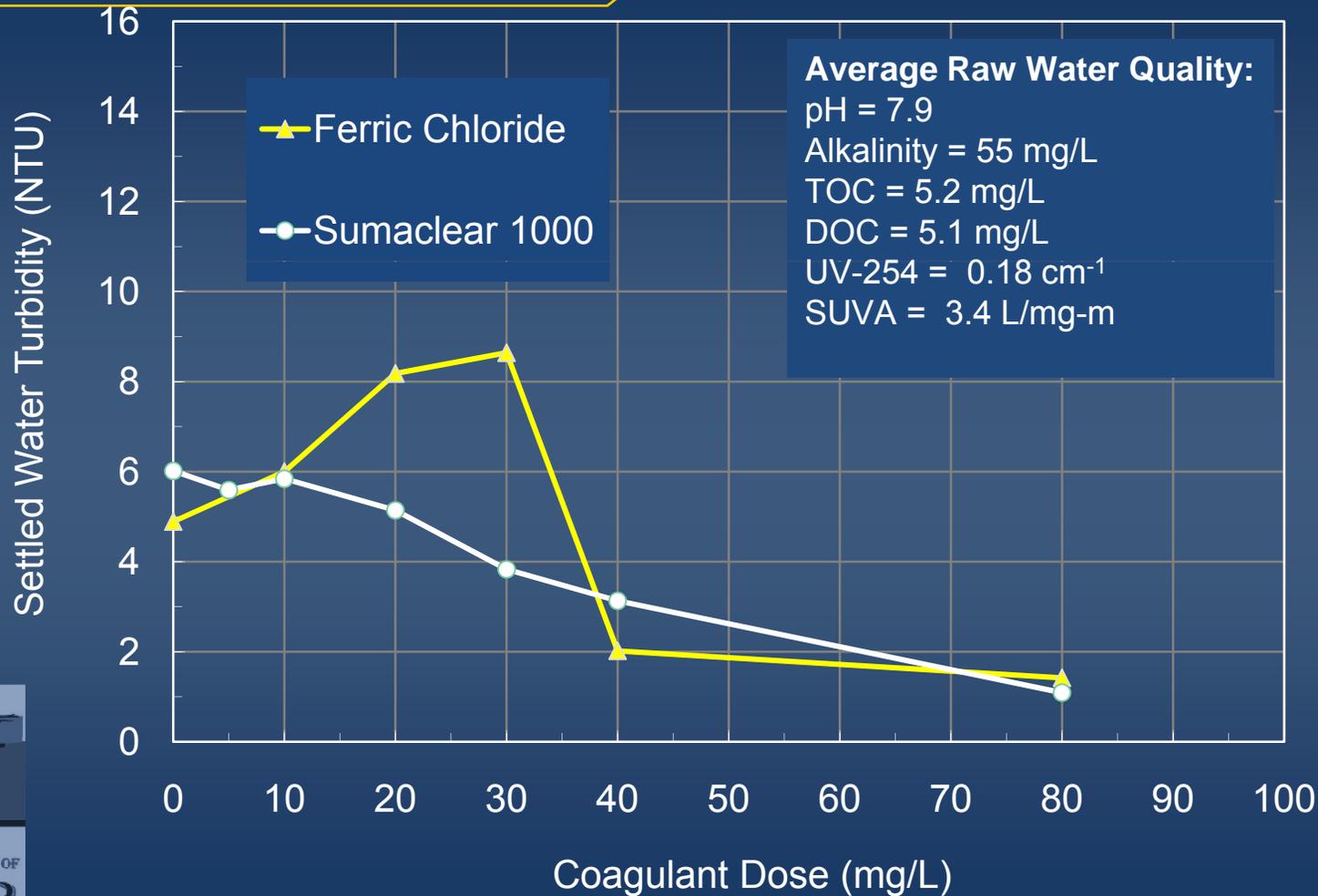
- ▼ Alum = $\text{Al}_2(\text{SO}_4)_3 - 14 \text{H}_2\text{O}$
- ▼ Ferric = FeCl_3
- ▼ Polyaluminum chloride and aluminum chlorohydrate mix



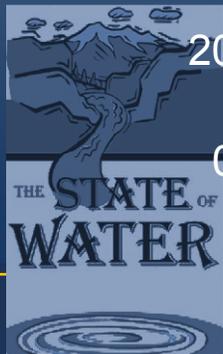
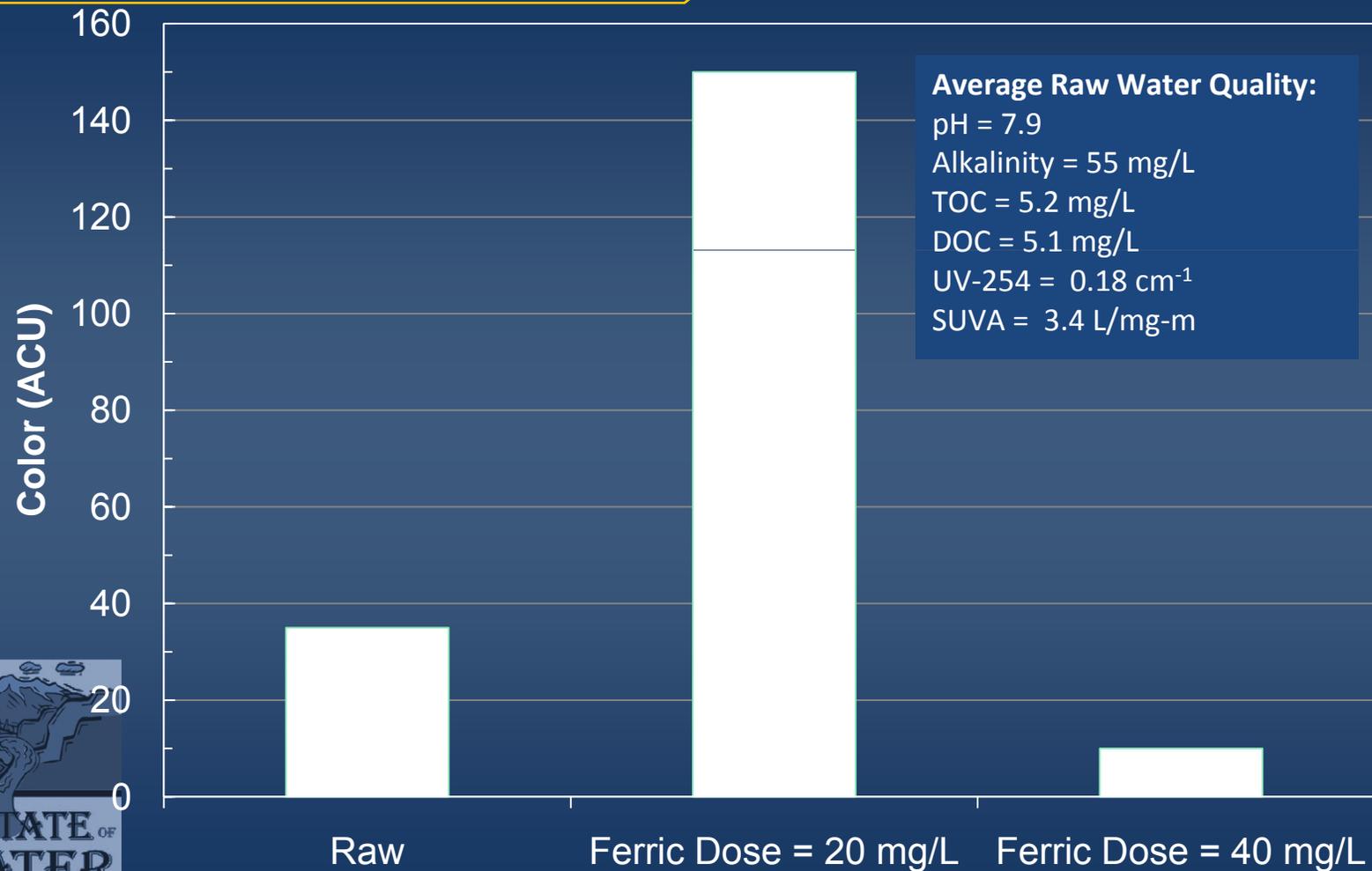
Alum and Sumaclear



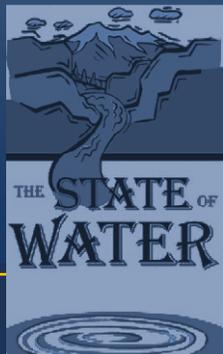
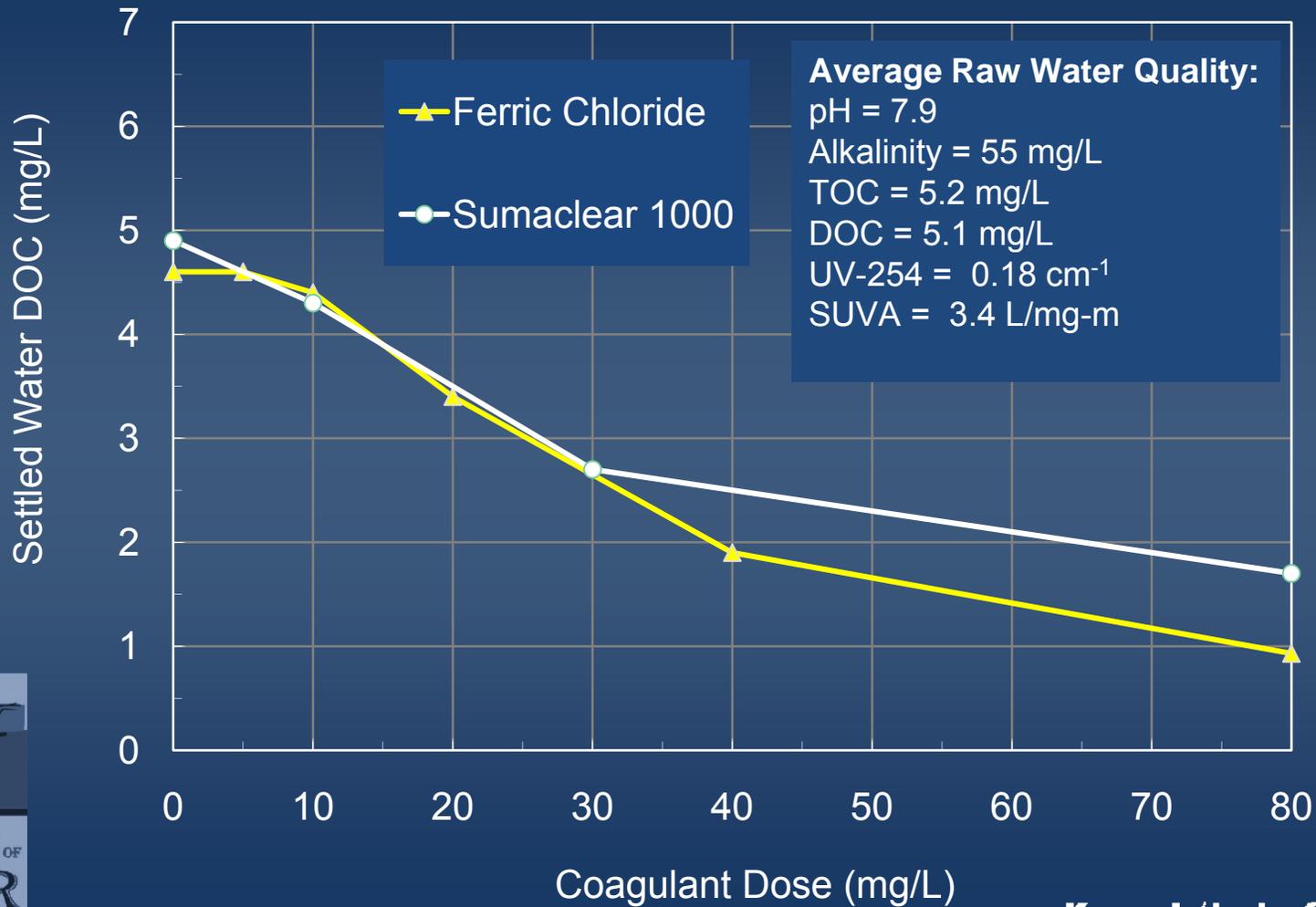
Ferric and Sumaclear



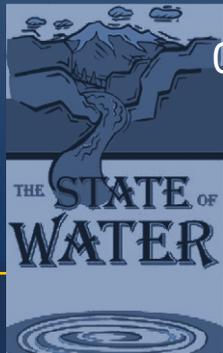
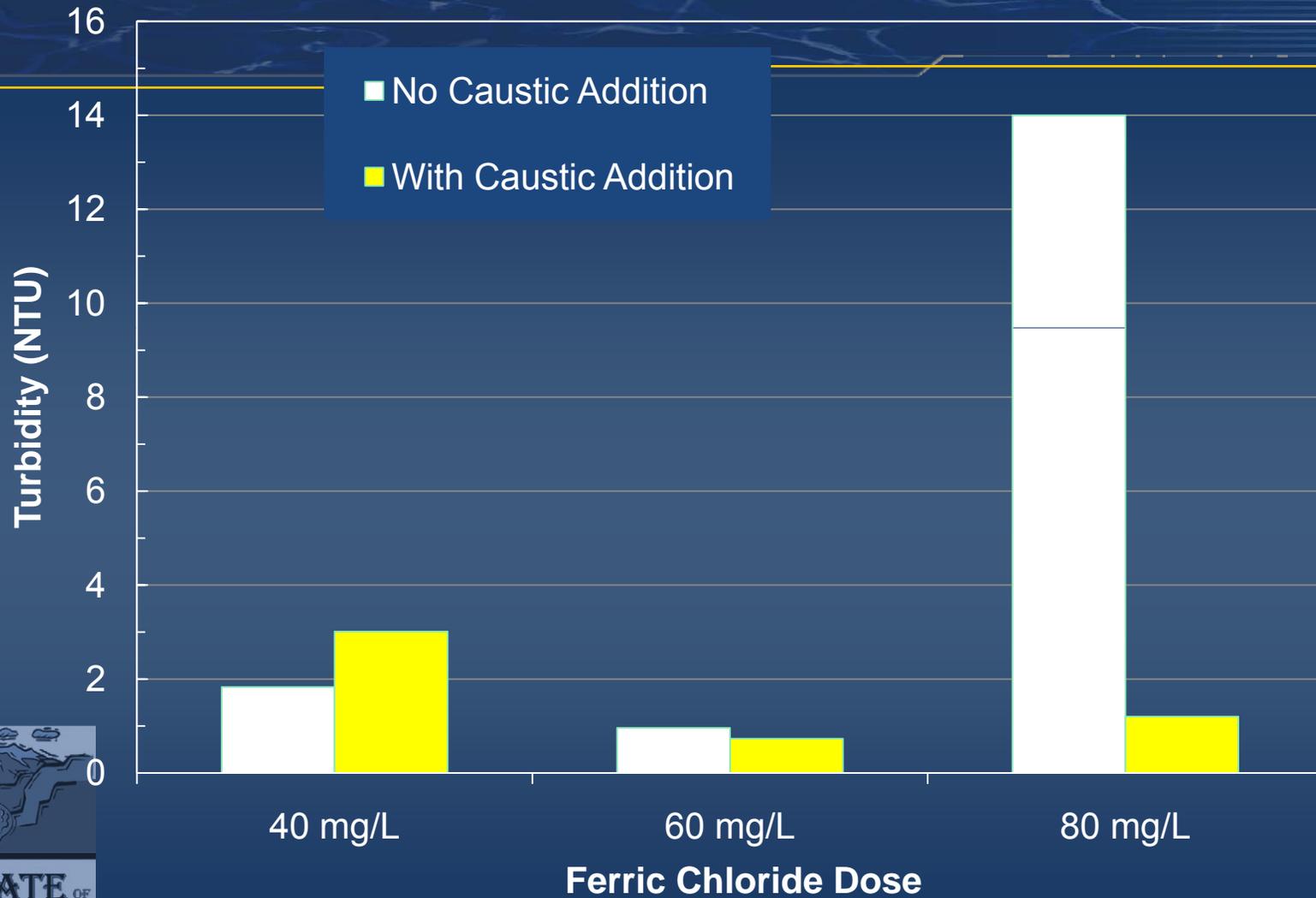
Color Removal Performance



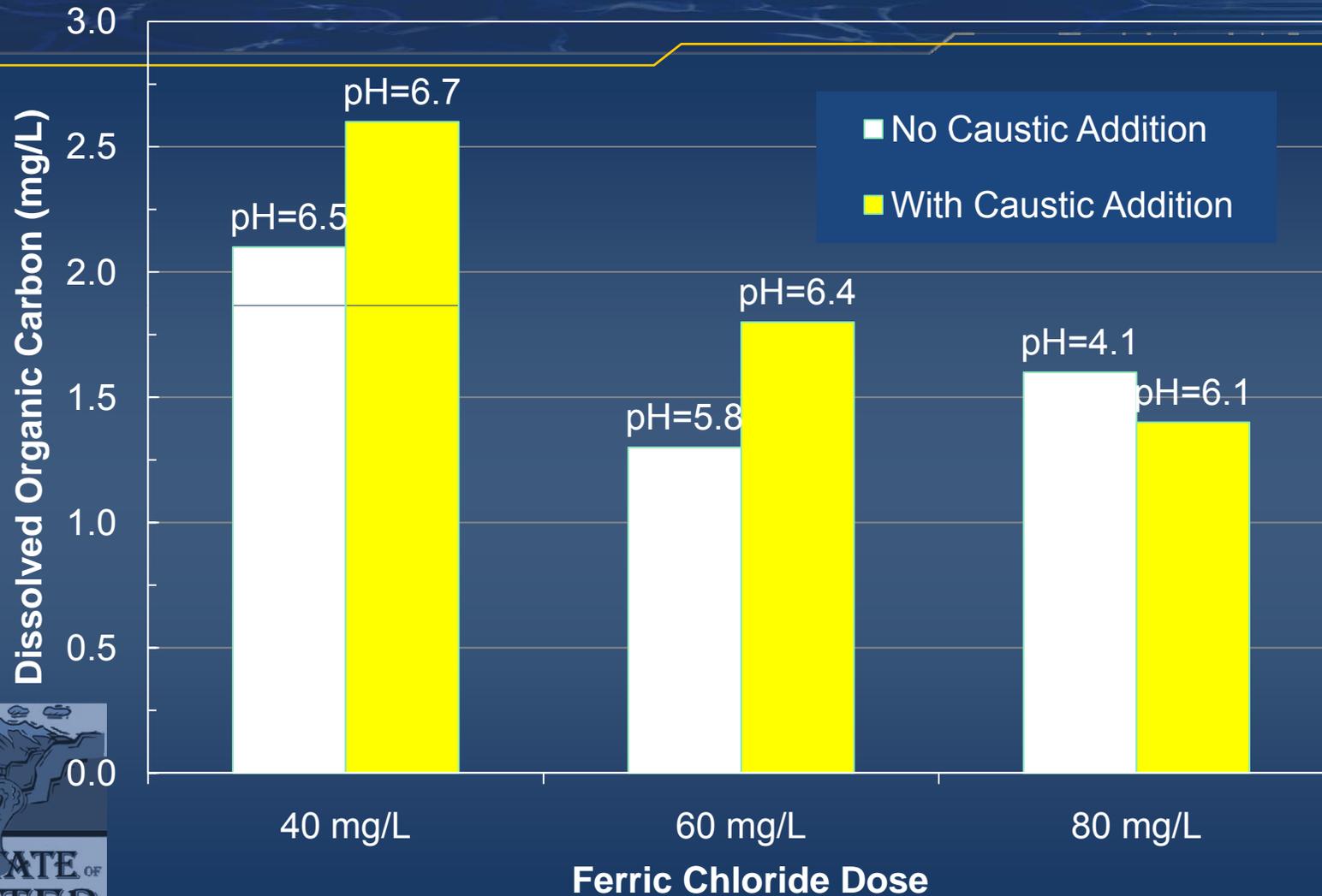
DOC Removal



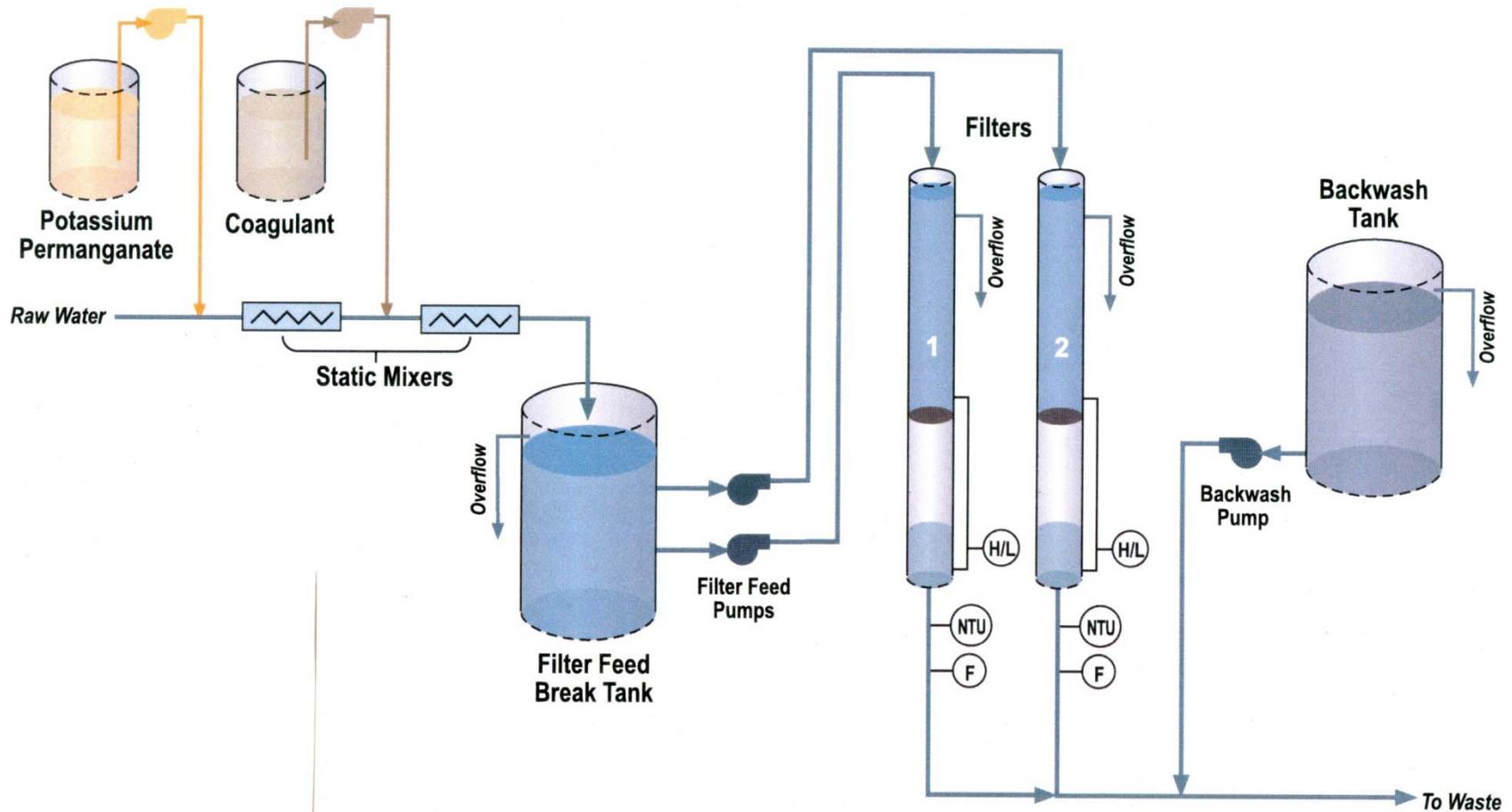
Supplemental Alkalinity



Supplemental Alkalinity

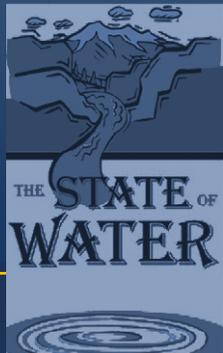


Pilot Plant Schematic





Pilot Plant



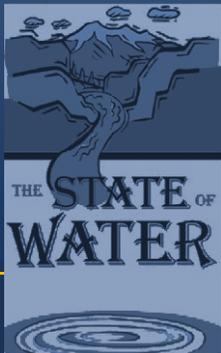
Kennedy/Jenks Consultants
Engineers & Scientists

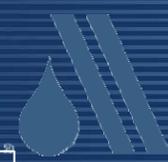
Pilot Filter Media Design



- ▼ Mixed Media:
 - ▮ Anthracite / Sand / Garnet

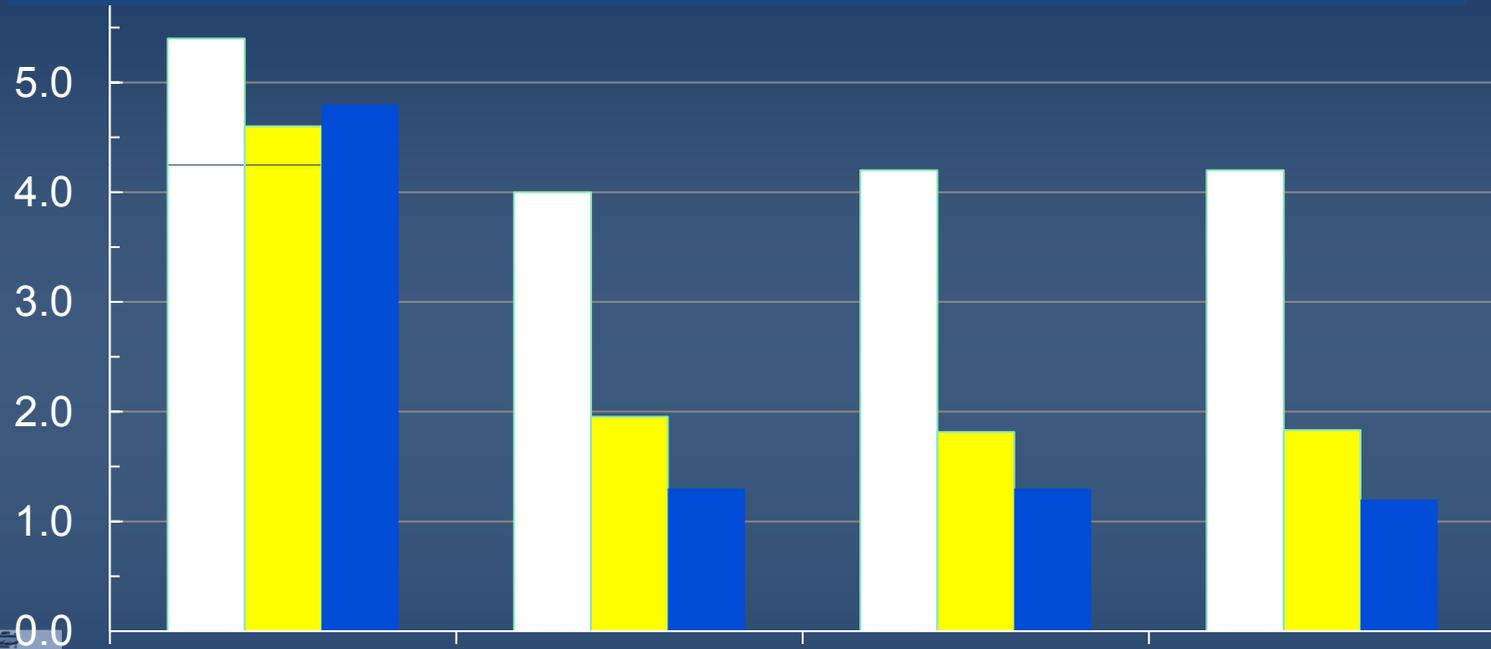
- ▼ Mono-Media Anthracite:
 - ▮ 72 inch depth
 - ▮ 48 inch depth





- 5/21 Ferric ~ 15 mg/L, Filter Effluent pH = 7.2, HLR = 10 gpm/sqft
- 5/29/2008 Ferric ~ 40 mg/L, Filter Effluent pH = 6.4, HLR = 10 gpm/sqft
- 5/28 Ferric ~ 50 mg/L, Filter Effluent pH = 5.9, HLR = 8 gpm/sqft

Dissolved Organic Carbon (mg/L)

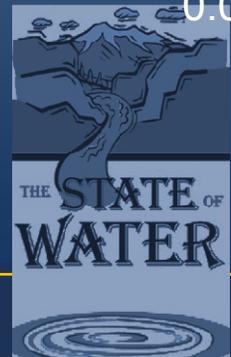


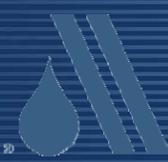
Raw

Mixed Media

Anth 72 in

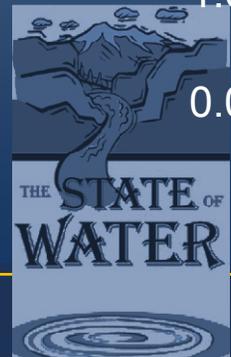
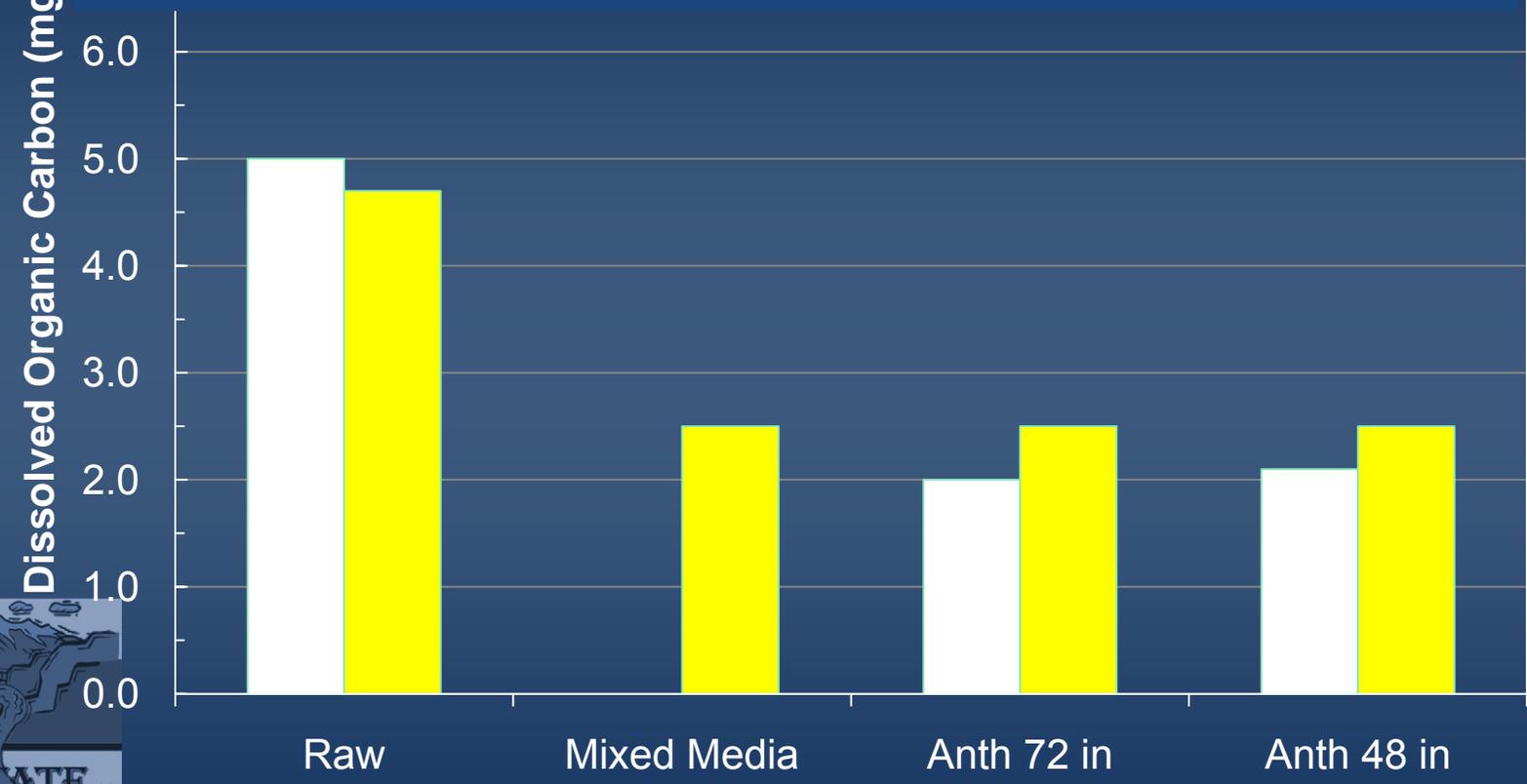
Anth 48 in

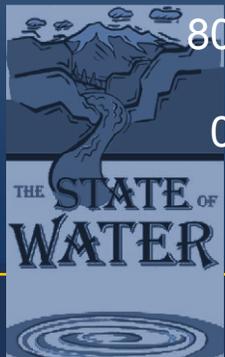
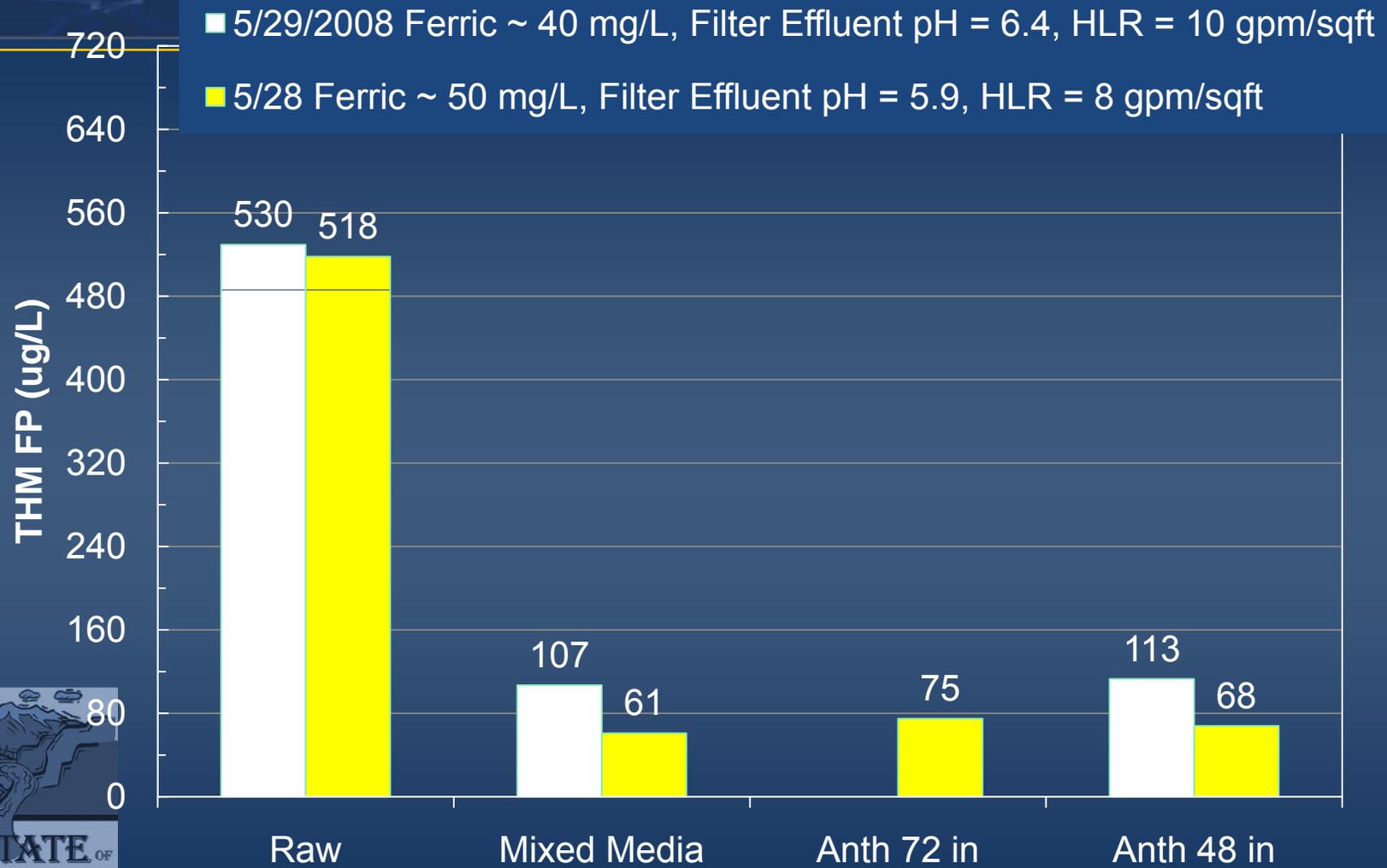
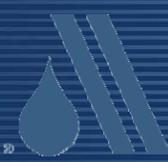


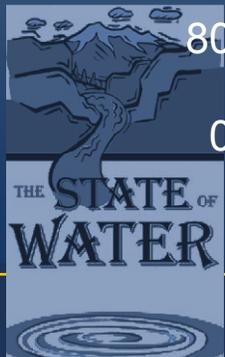
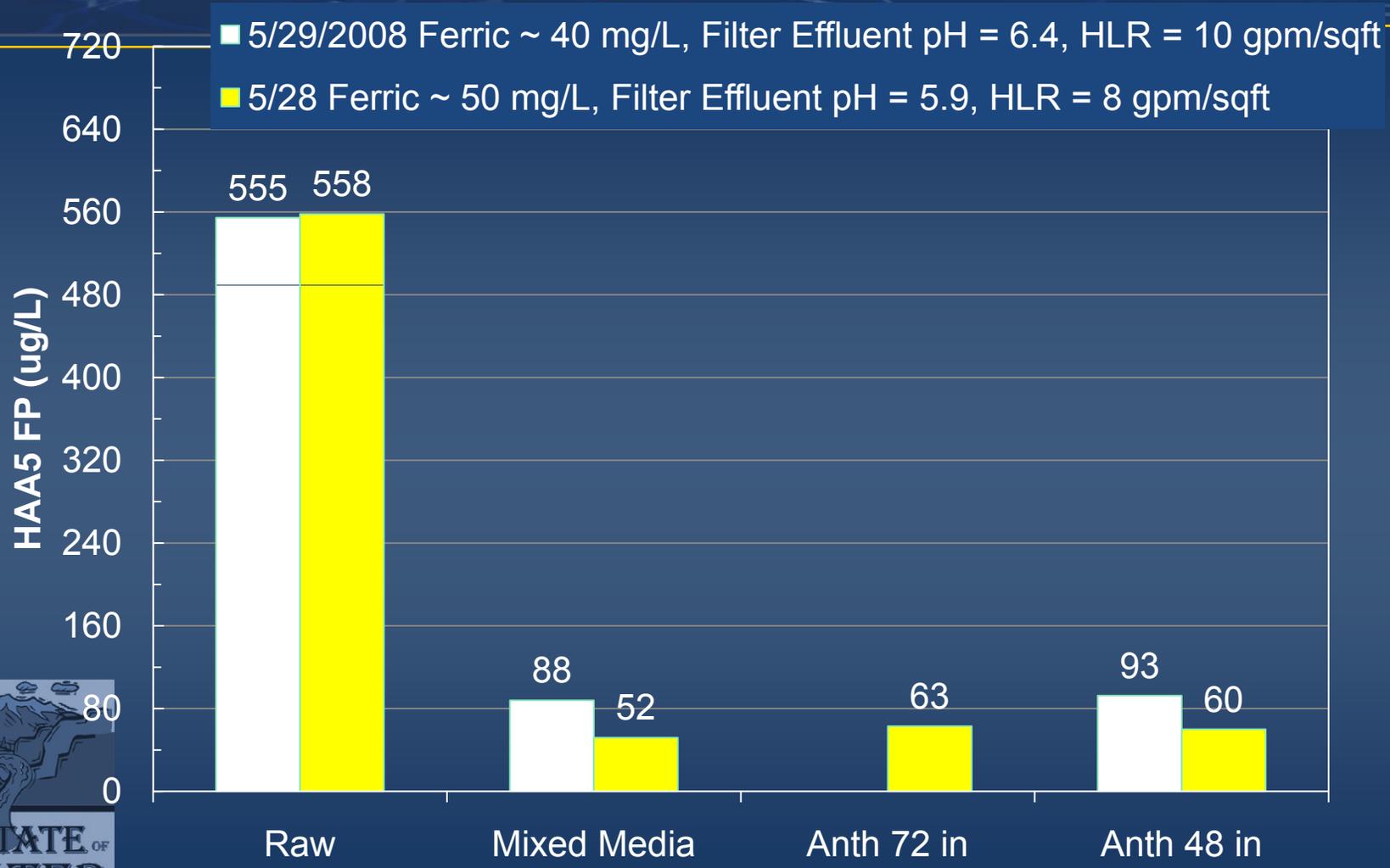
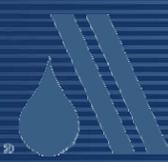


■ 5/9 Nalclear 8156 ~ 100 mg/L, Filter Effluent pH = 7.3, HLR = 6 gpm/sqft

■ 5/27 Sumaclear 1000 ~ 30 mg/L, Filter Effluent pH = 7.8, HLR = 10 gpm/sqft



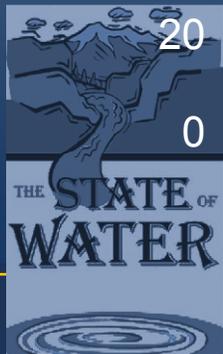
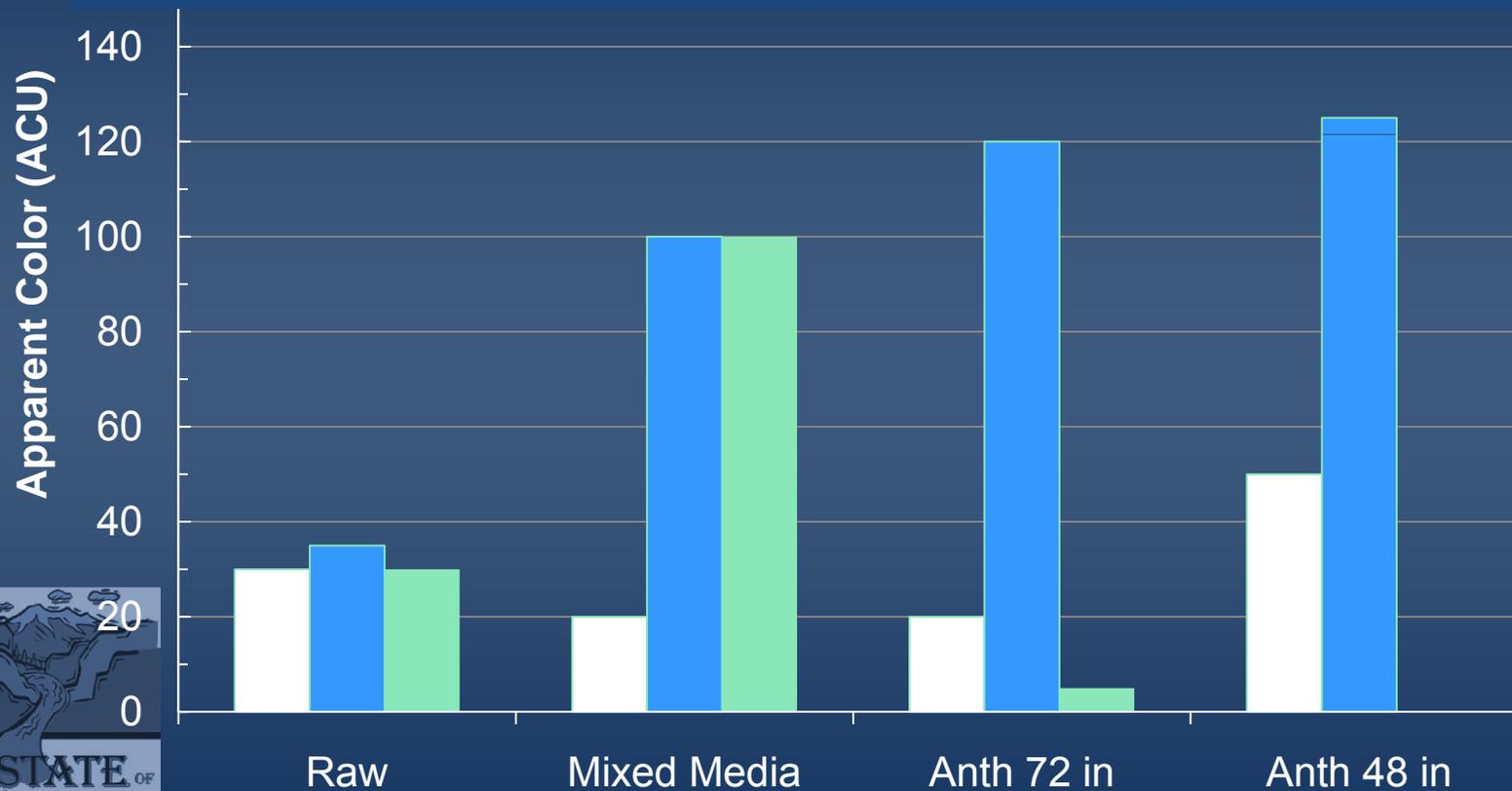




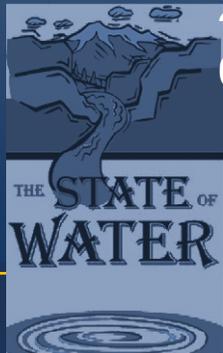
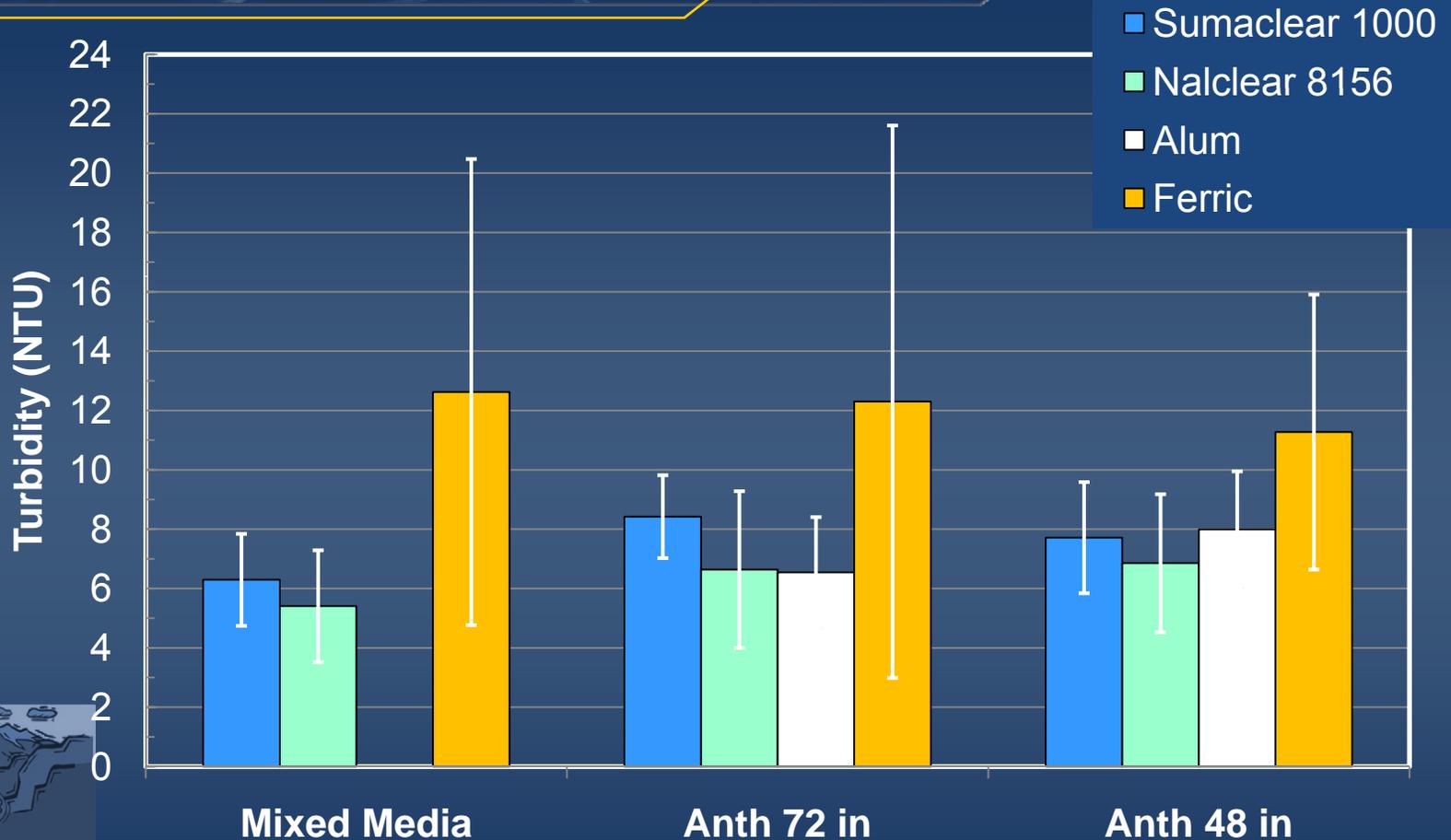
Color Removal in Pilot Filters



- 5/27 Sumaclear 1000 ~ 30 mg/L, Filter Effluent pH = 7.8, HLR = 10 gpm/sqft
- 5/21 Ferric ~ 15 mg/L, Filter Effluent pH = 7.2, HLR = 10 gpm/sqft
- 5/28 Ferric ~ 50 mg/L, Filter Effluent pH = 5.9, HLR = 8 gpm/sqft



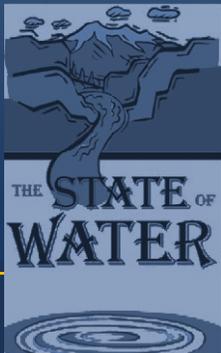
Pilot Filter Turbidity Summary



Summary of Findings



- ▼ Ferric:
 - ▮ Worked well for DOC removal
 - ▮ Good turbidity settled water turbidity (above a critical dose)
 - ▮ Could meet the THM and HAA MCLs
- ▼ Higher filter effluent turbidities than expected
- ▼ Alum didn't perform well



Considerations



- ▼ Granular media roughing filters are viable for improving DOC removal and DBP compliance
- ▼ Coagulant dose adjustment is important
- ▼ Supplemental alkalinity may be required
- ▼ High filter effluent turbidities may be an issue

