Use of CO_2 for Bromate Control

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Acknowledgements

CalFed Bay-Delta Authority

Water Quality Program

Alameda County Water District

Background

- ACWD treats South-Bay Aqueduct (SBA) water, which periodically contains high levels of bromide
- The District uses ozone for T&O control, primary disinfection, and as a pre-oxidant
- Adding ozone to water containing bromide forms bromate, a regulated disinfection byproduct
- pH depression has been proven as the most viable means of reducing bromate formation
- pH depression can be accomplished with a mineral acid (such as H_2SO_4) or carbon dioxide (CO_2)

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What Acid to Use?

- Sulfuric acid vs. carbon dioxide
- If the target pH is 7, chemical costs are comparable
- Sulfuric acid had significant undesirable hazardous materials storage and handling issues
- In order to meet a bromate goal of 5 µg/L, a pH of 6.5 would likely be necessary
- Consistently achieving a pH of 6.5 with CO_2 is cost-prohibitive

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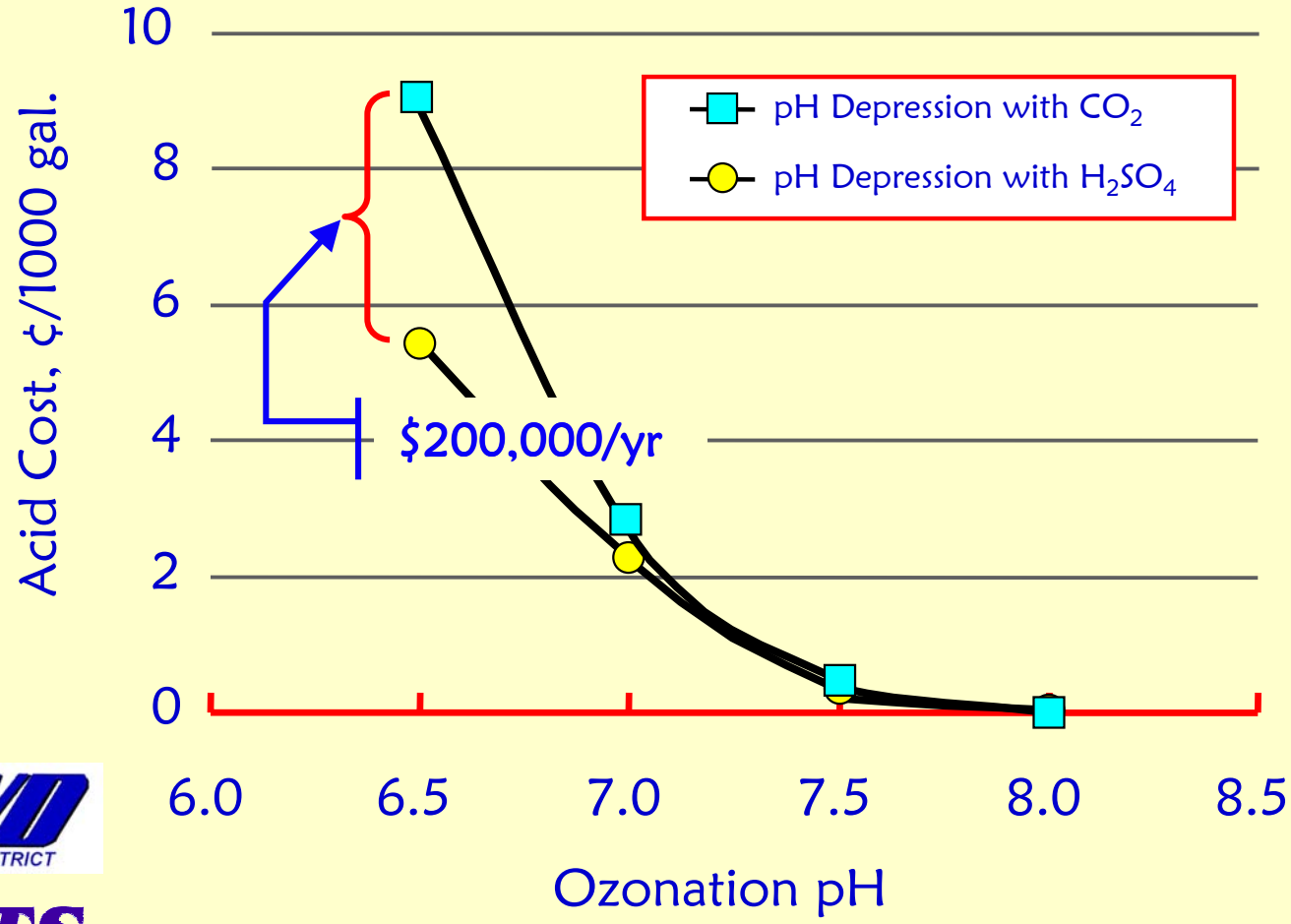
Carbon Dioxide vs Sulfuric Acid

Temp. = 15°C; Alkalinity = 110 mg/L as $CaCO_3$
Finished water pH adjusted to 8.3 with NaOH



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Project Objectives

With no known full-scale experience available, this project had the following objectives:

1. Collect and document full-scale operating data on the efficacy of CO_2 addition for bromate control and its effects on other processes
2. Evaluate two different methods for adding CO_2 into the water
3. Evaluate the possibility of using air-stripping to remove residual CO_2 after ozonation

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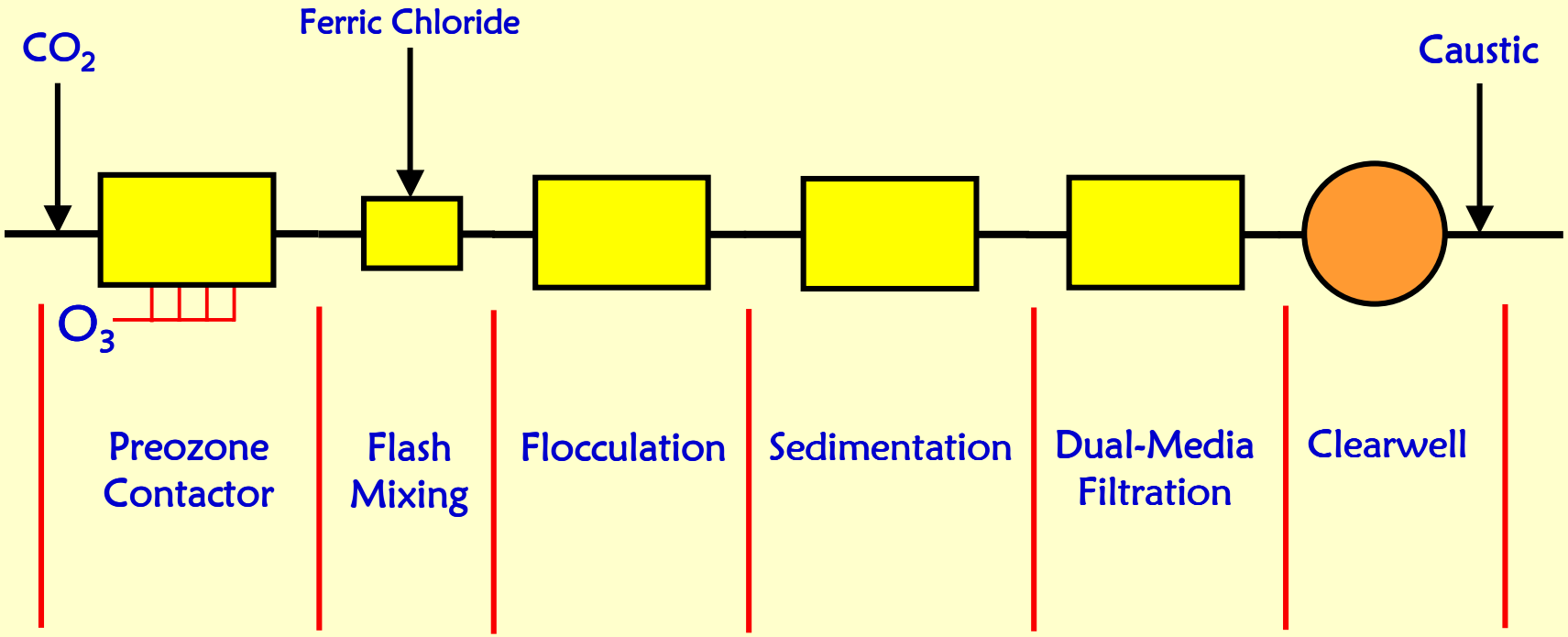
Water Treatment Plant



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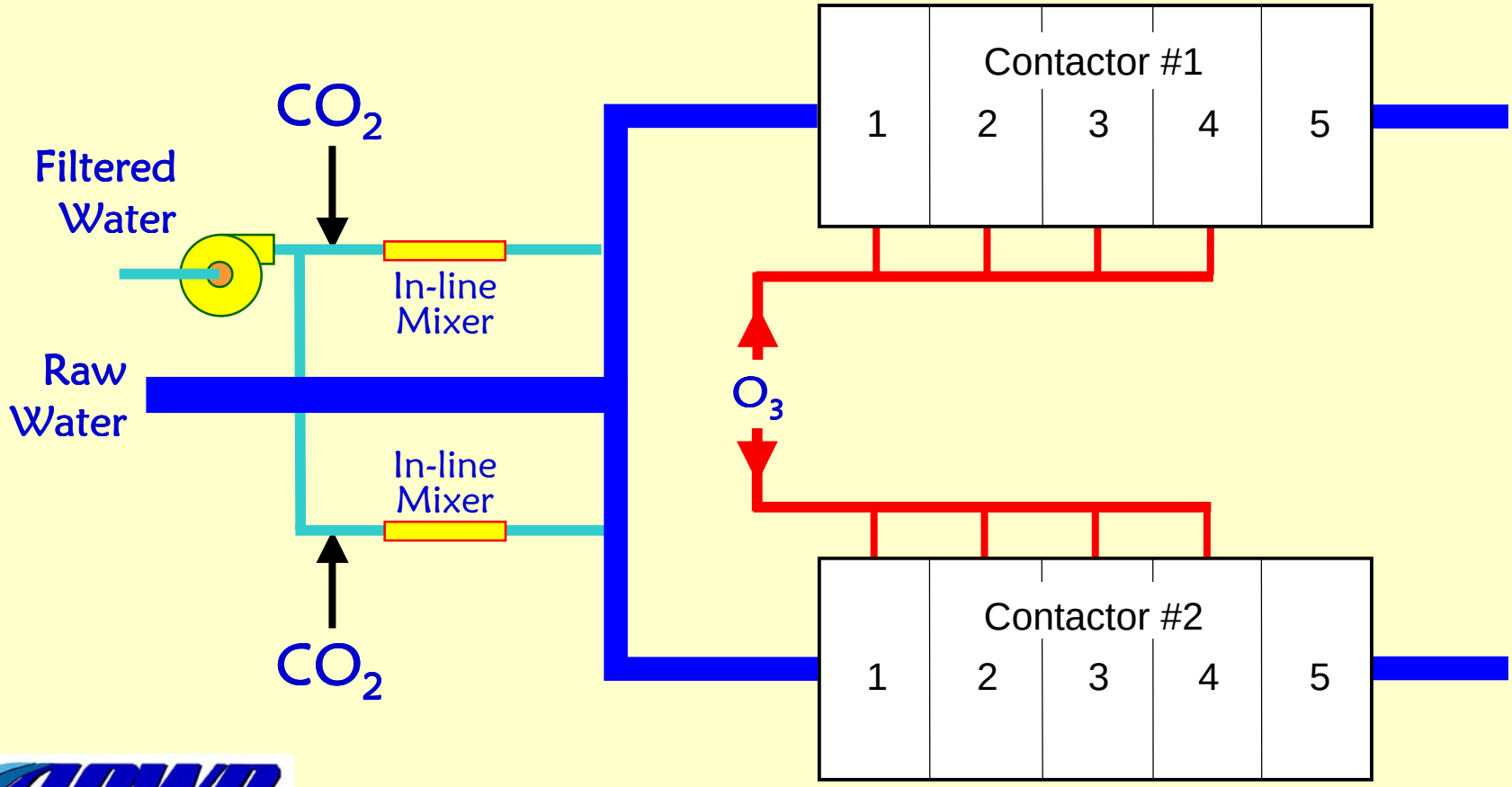
CO_2 Feed System



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CO_2 Tank & Storage Area

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Testing Conditions

- Approximately 40 controlled tests performed at full scale
- Various parameters tested
  - pH: ambient, 7.5, 7.0, 6.8
  - CT: 0.5-log to 2-log *cryptosporidium* inactivation
  - Bromide: 90 – 400 µg/L
- Bromate and O_3 residuals measured throughout each test

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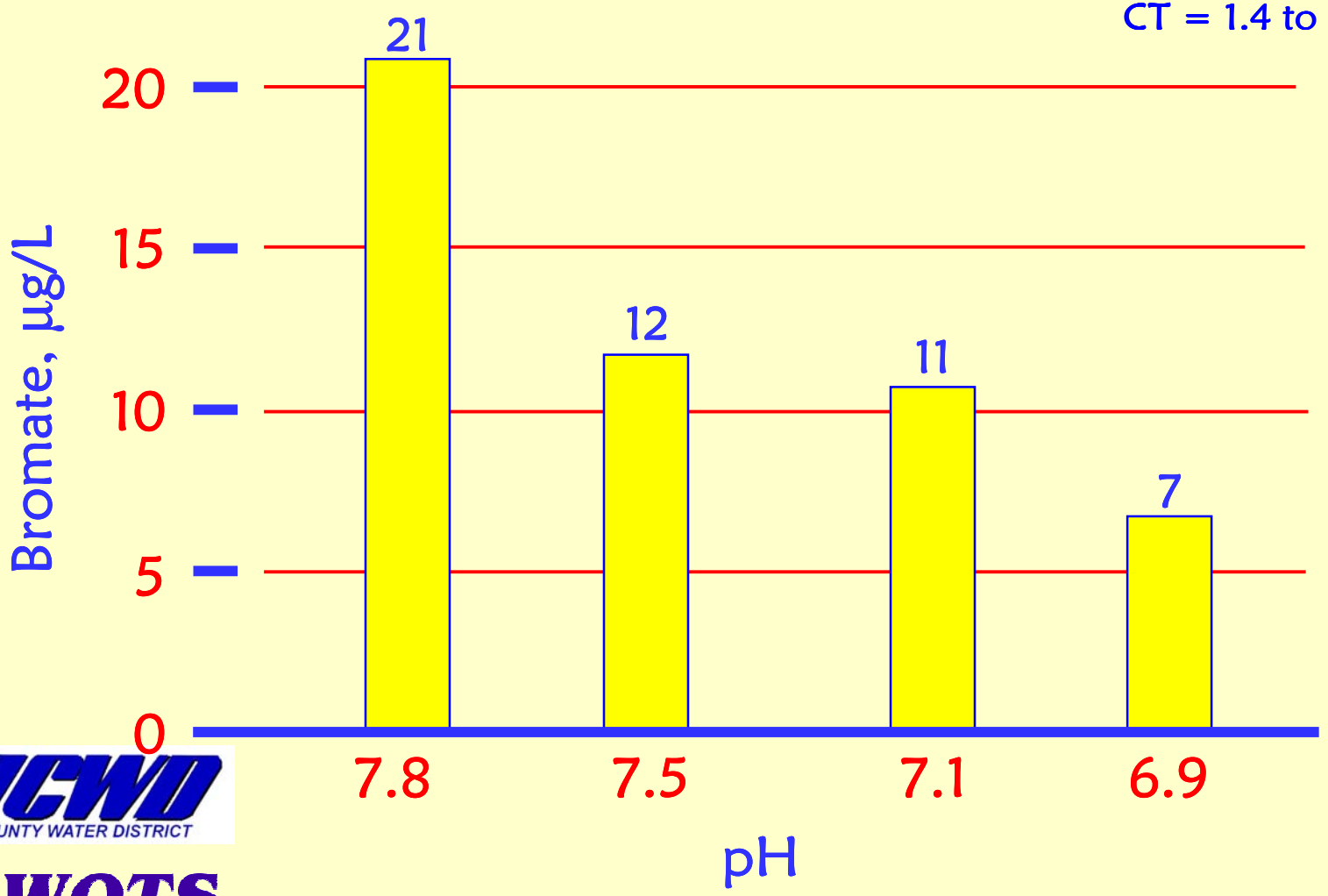
Bromate Minimization – Typical Results

October 2002, Bromide = 300 µg/L
CT = 1.4 to 3 mg-min/L



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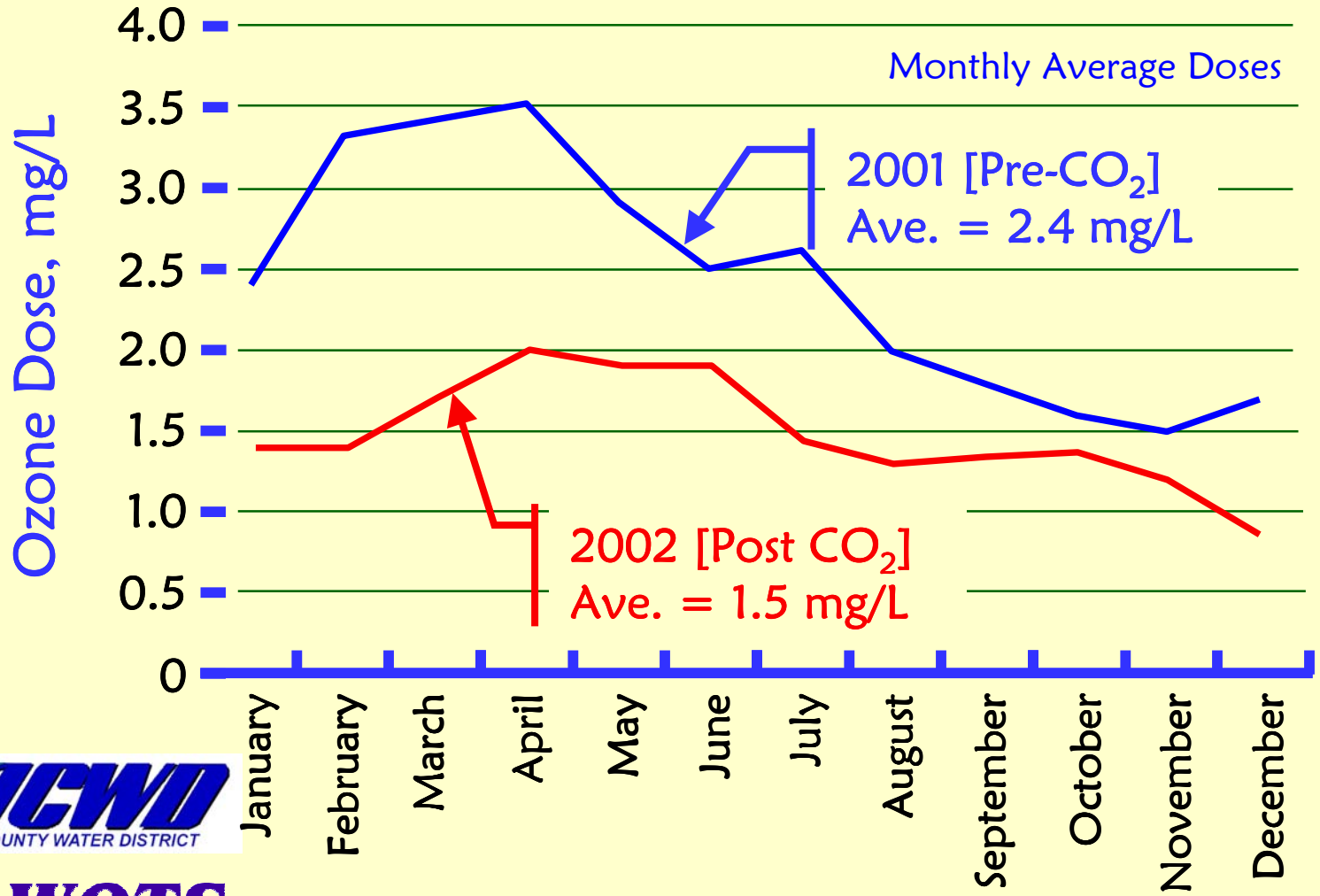
Impact on Ozone Dose



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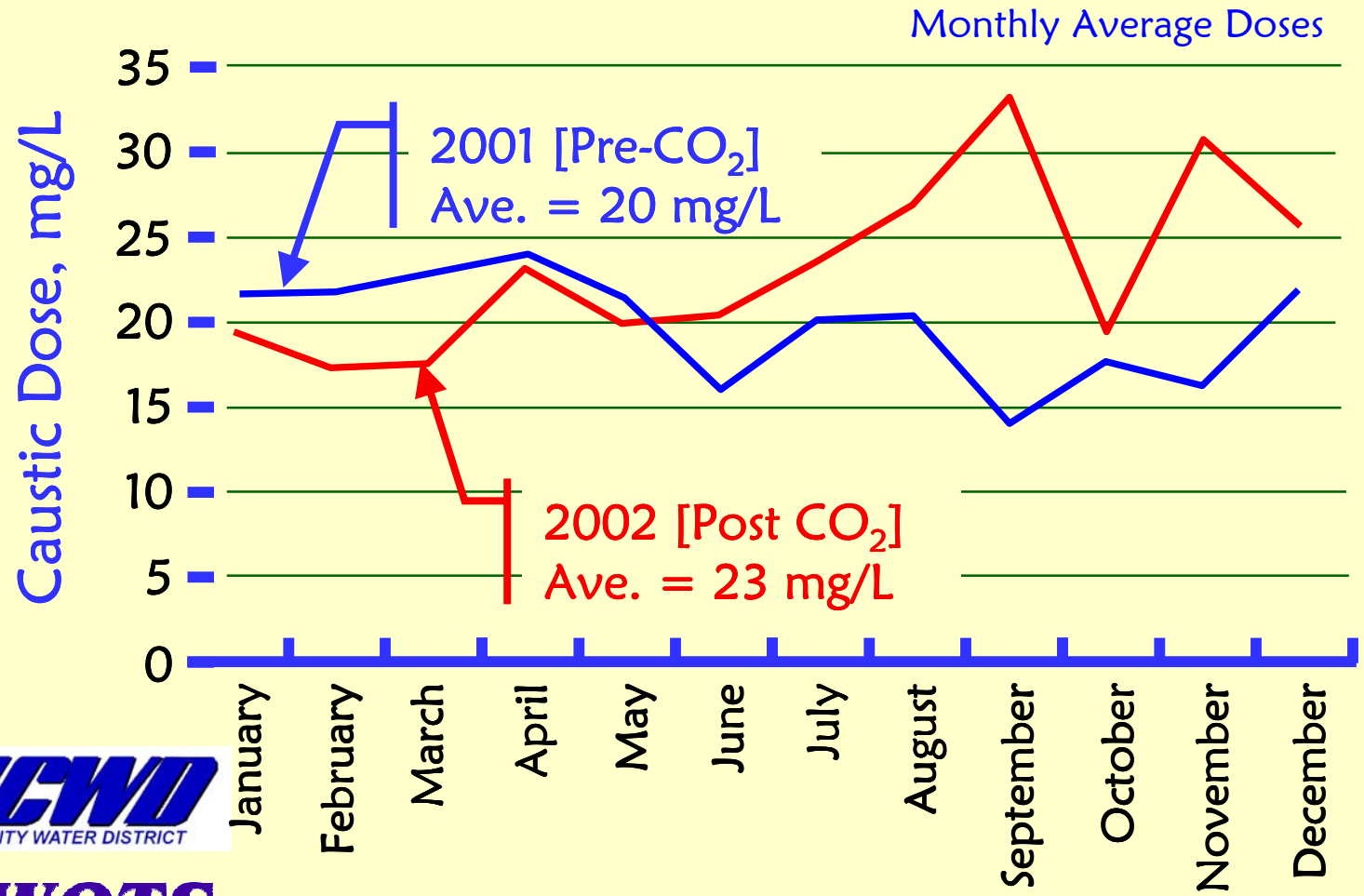
Effect on Caustic Dose



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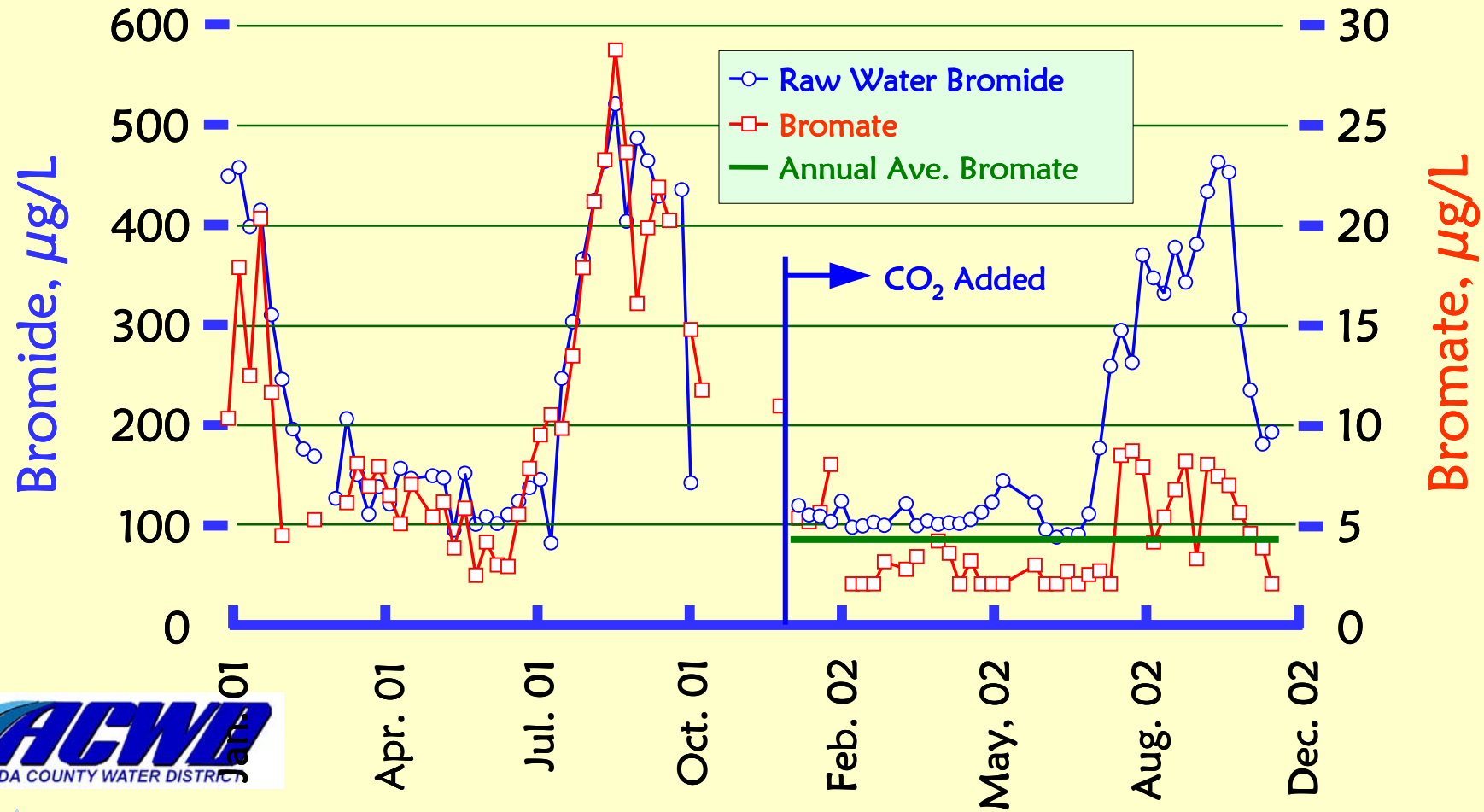
Bromate Before & After

Samples collected once per week



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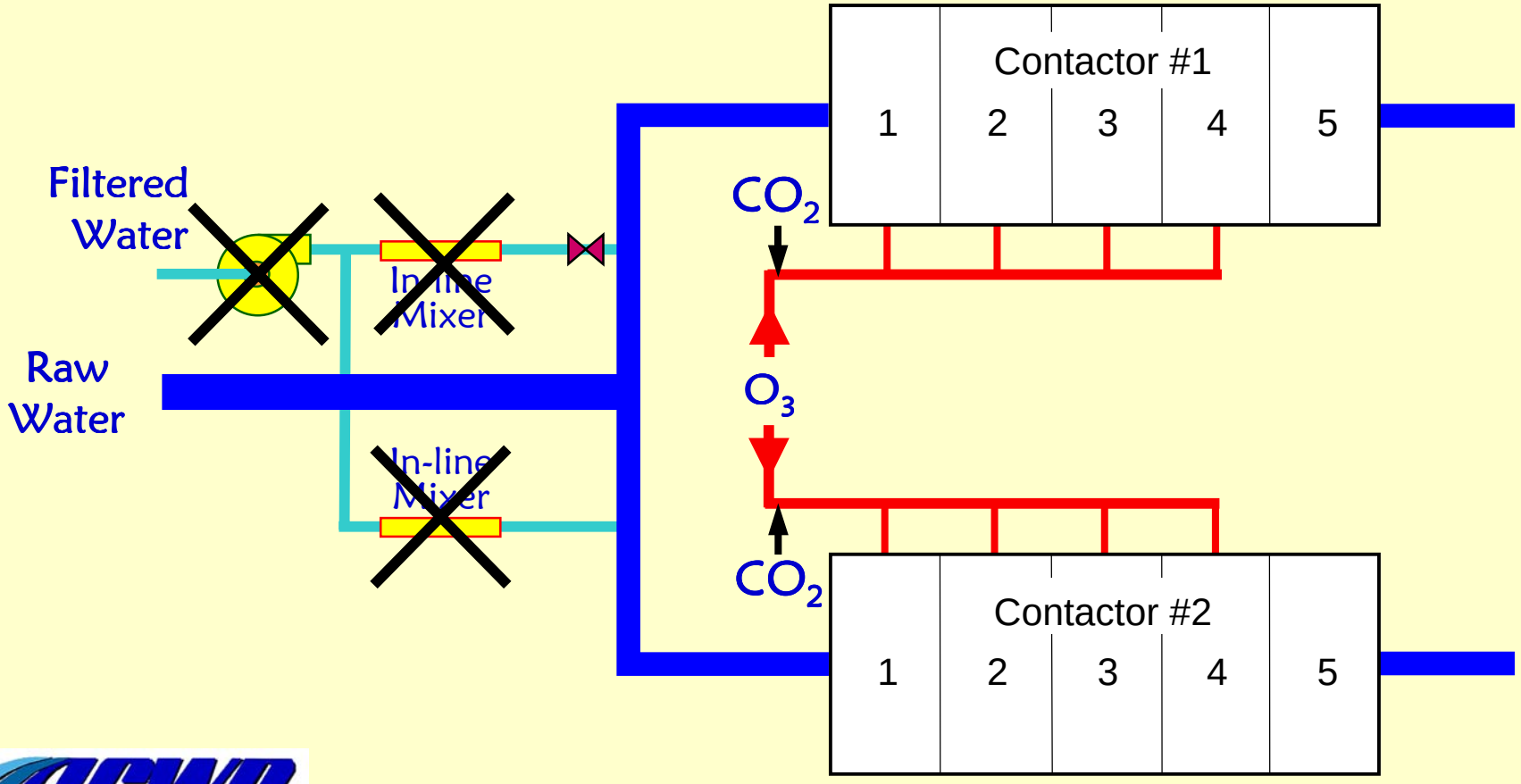
Direct-Feed Method



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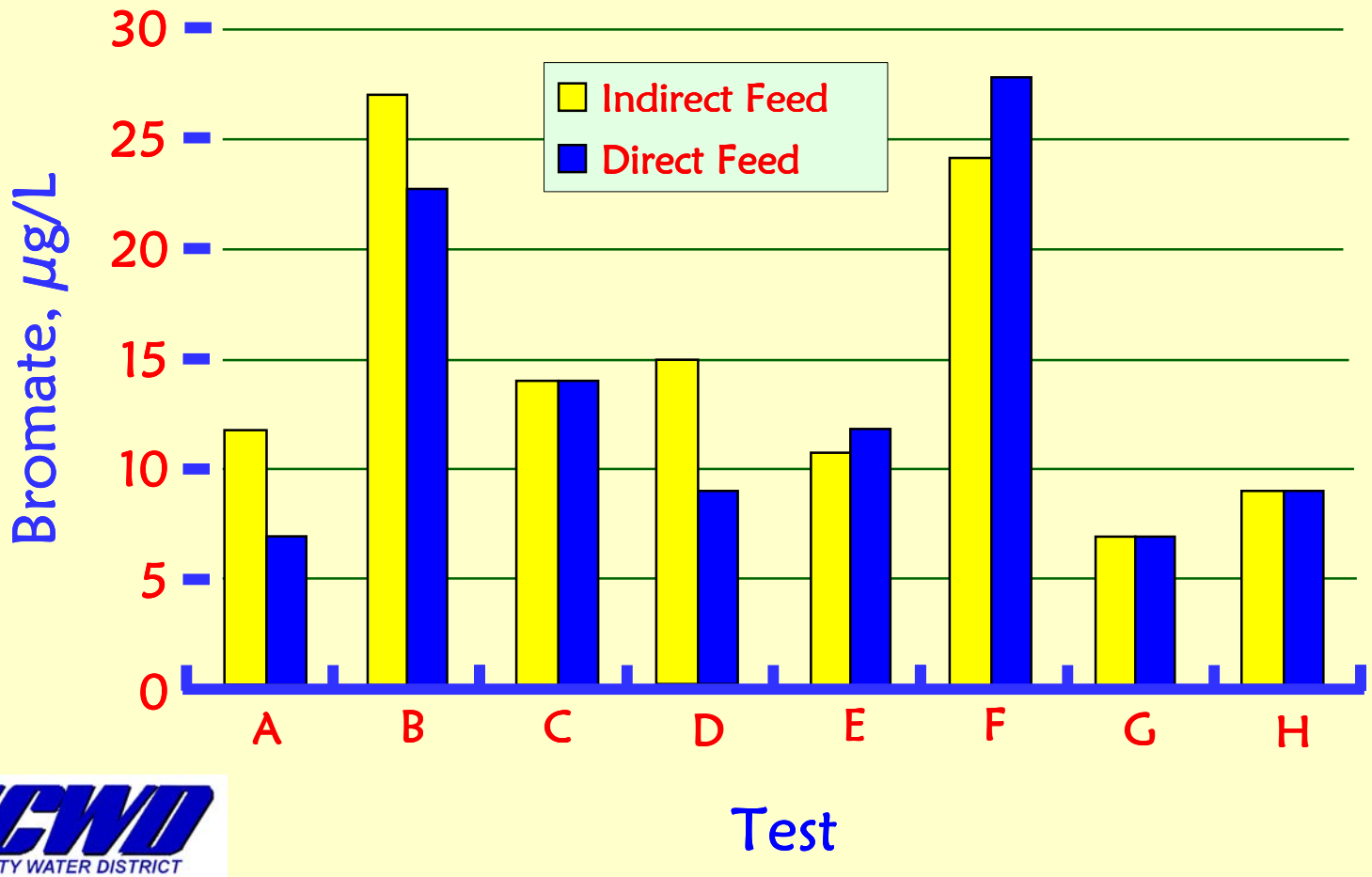
Side-by-Side Comparison



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CO_2 Stripping Evaluation

- Once ozone is fully reacted, low pH is no longer needed
- Can excess CO_2 be stripped from the water at the end of the ozone contactor?
- What is the effect on the subsequent caustic dose?

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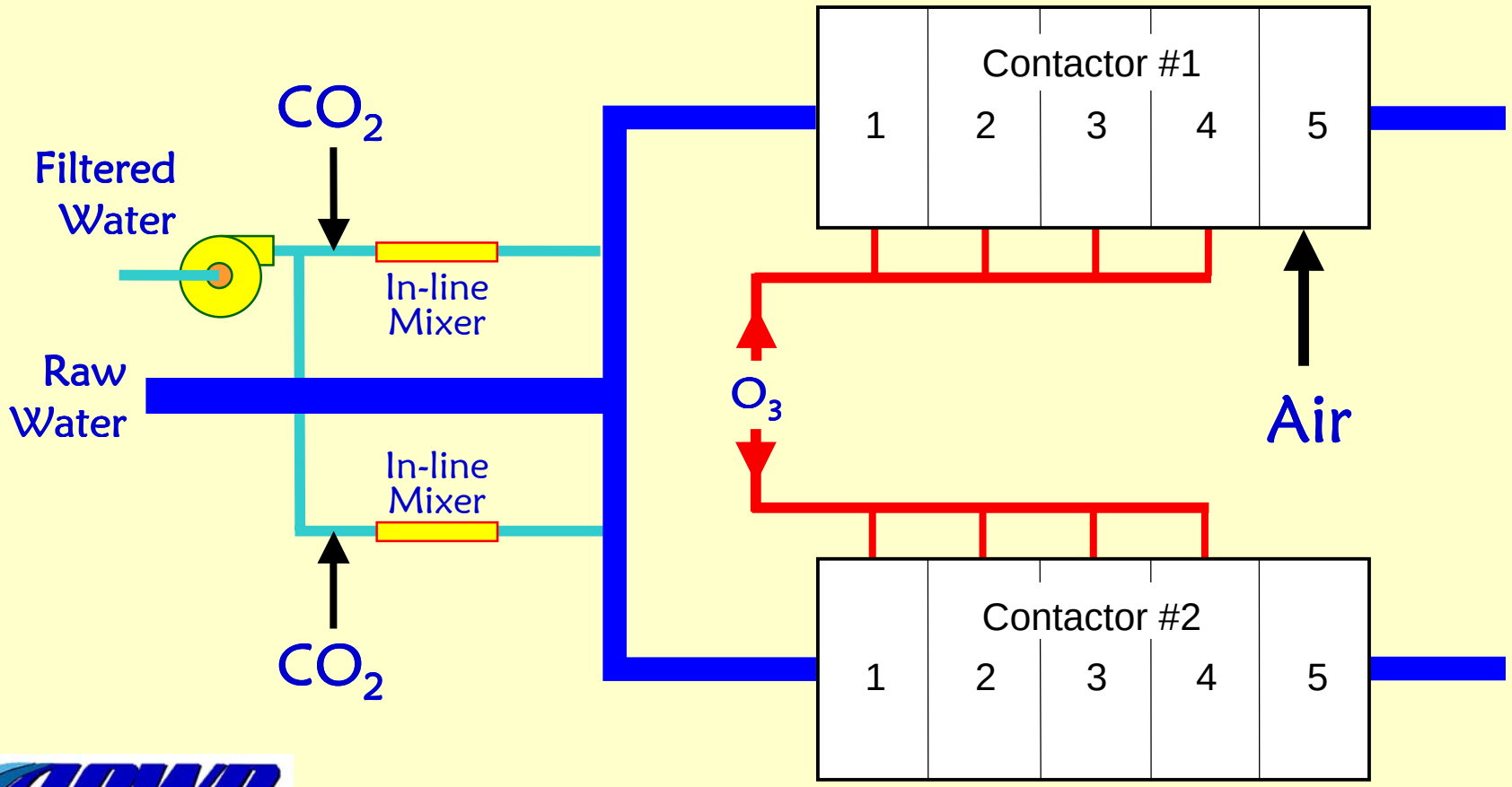
CO_2 Stripping Schematic



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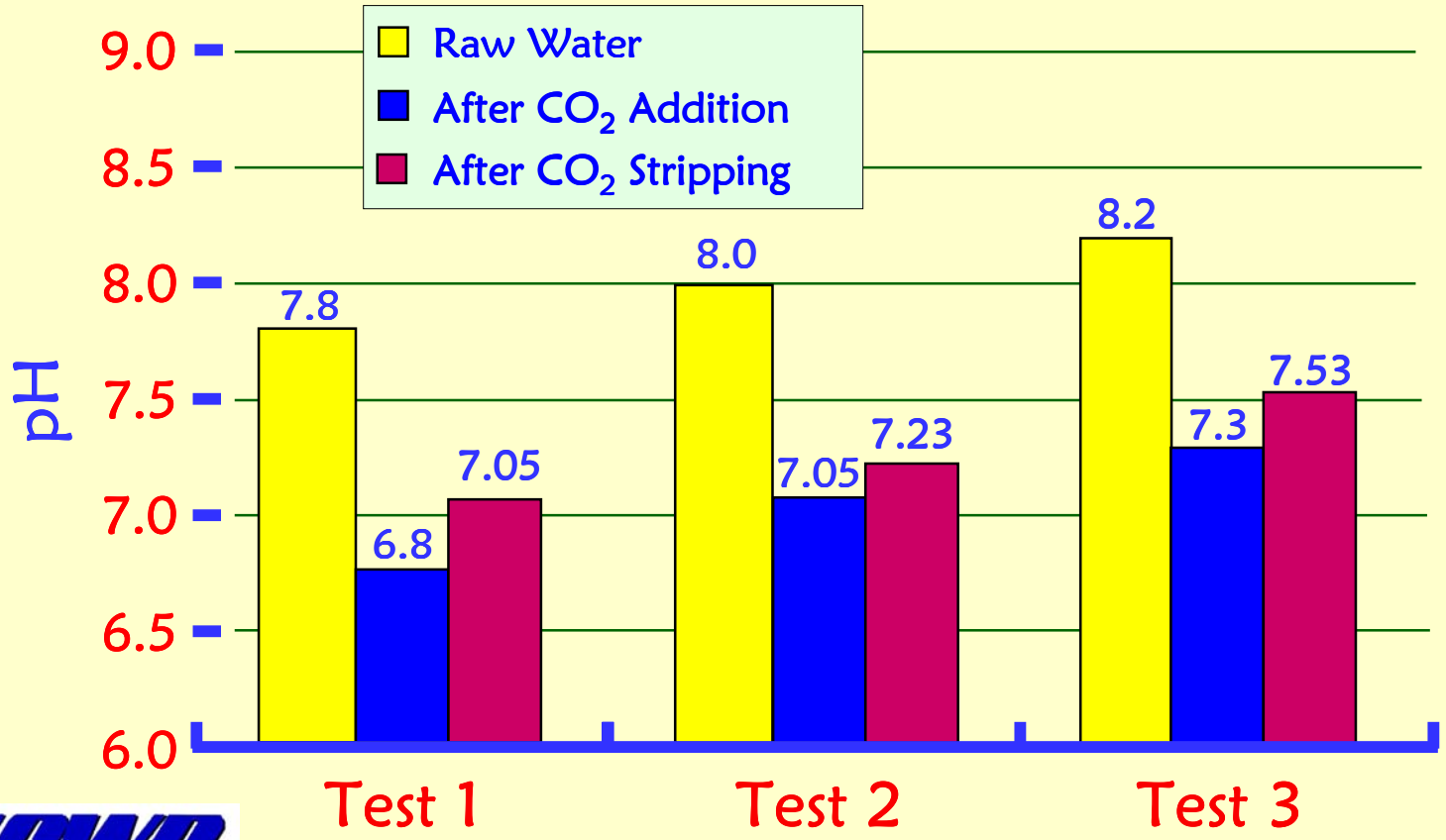
Impact of CO_2 Stripping on pH

February 2003



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CO_2 Stripping Evaluation

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Summary

- CO_2 addition has proven to be an effective and reliable bromate control strategy
- pH target below 7.0 may favors the use of sulfuric acid over CO_2
- Running annual average bromate has been around 5 μg/L
- CO_2 addition reduced ozone dose but increased caustic dose
- Cost analysis showed that the costs of CO_2 and additional caustic were offset by the savings in ozone dose
- The direct-feed method of CO_2 is as effective as the indirect-feed method, and less costly
- Stripping of CO_2 after ozone could reduce treatment cost, but is likely to be more applicable to new plants

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Challenges

- CO_2 is an economical acid when targeting a pH at or above 6.9. pH depression below this value requires a stronger acid (such as sulfuric acid).
- ACWD will have a more difficult time meeting its treatment goals under one or more of the following conditions:
  - If the bromide level in SBA water increases above those experienced during this study
  - If stricter disinfection requirements are imposed on the plant in the future
  - If the bromate MCL is lowered in future regulations

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