Advanced Treatment of Wet Weather Flows

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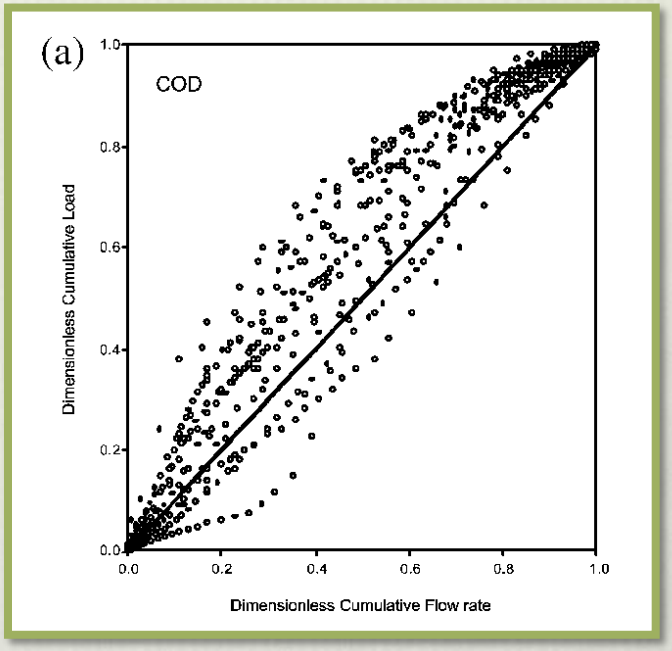
Wet Weather Management

- Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO)
  - What is a CSO?
    - *Overflow resulting from a precipitation event that does not receive minimal treatment* – Milwaukee MSD WPDES Permit
  - Infrequent
    - Allowed **6** CSOs per year, average **4**
  - Public and environmental health risks
    - Pathogens, soluble BOD, micropollutants
  - Infrastructure overburden, basement backups
- Milwaukee, Philadelphia, Detroit, Washington, D.C.

“First Flush” Phenomenon

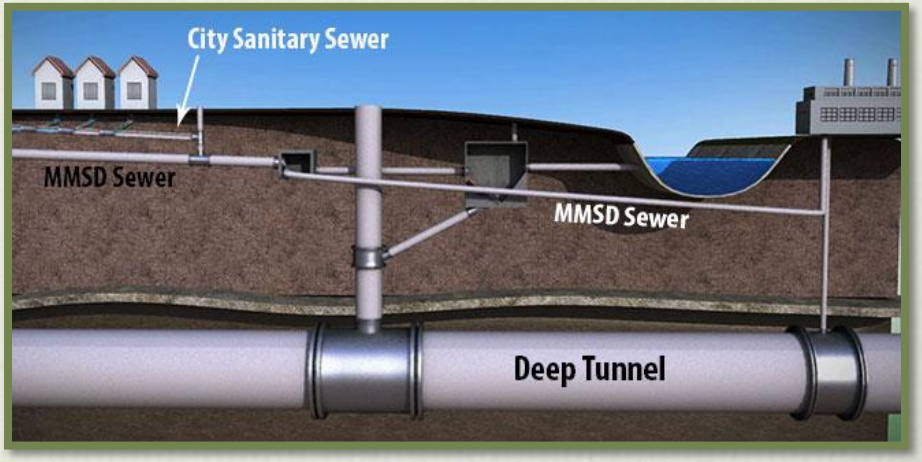
- Defined by a certain percentage of pollutant mass in the first 50% of event volume
  - Higher concentration of contaminants due to settled solids in outfall pipes, runoff
- Unique index of contaminants compared to wastewater
  - High TSS, bacteria, polyaromatic hydrocarbons (PAHs), pesticides

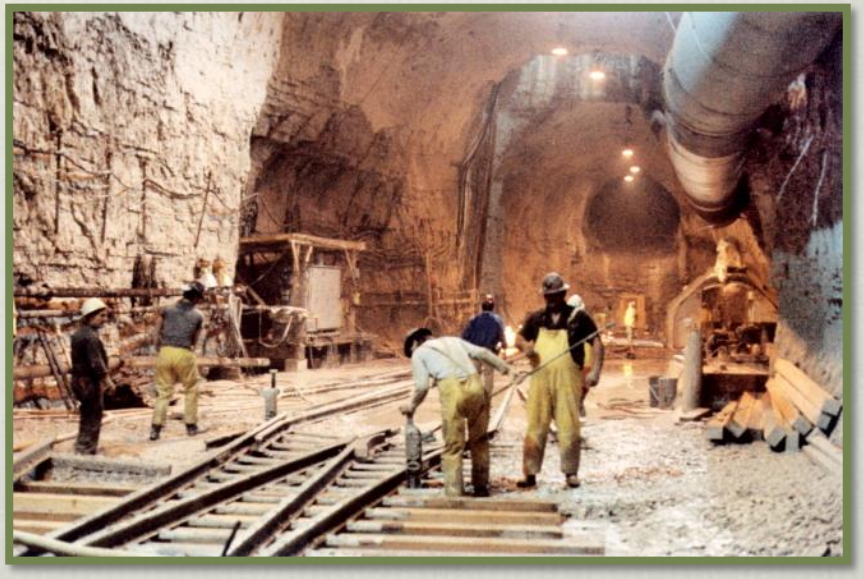


Lee, et al (2002).

Management Challenges

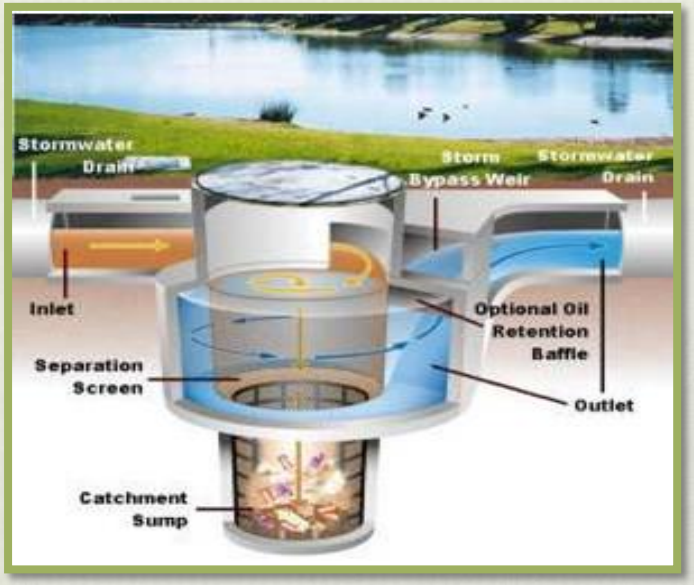
- Treatment vs. Storage
  - Milwaukee Deep Tunnel
    - 86% reduction in overflow volumes after commissioning (1994)
    - Reduced CSOs from 50 to less than 4
- High flows
  - WWTP overburden
  - Basement backups
  - Rapid treatment
  - Compatible treatment technologies





Management Technologies

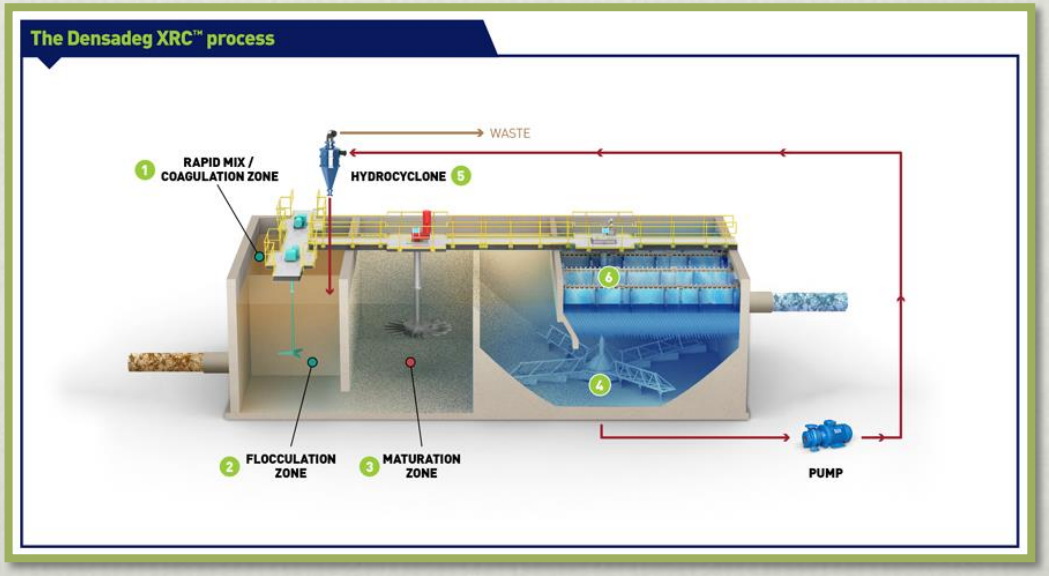
- Gravity separation, Vortex separator
- Biological contact
- Filtration
- Disinfection



- Engineered Wetlands
- High-Rate Retention Treatment/Disinfection
- Coagulation/Flocculation /Disinfection

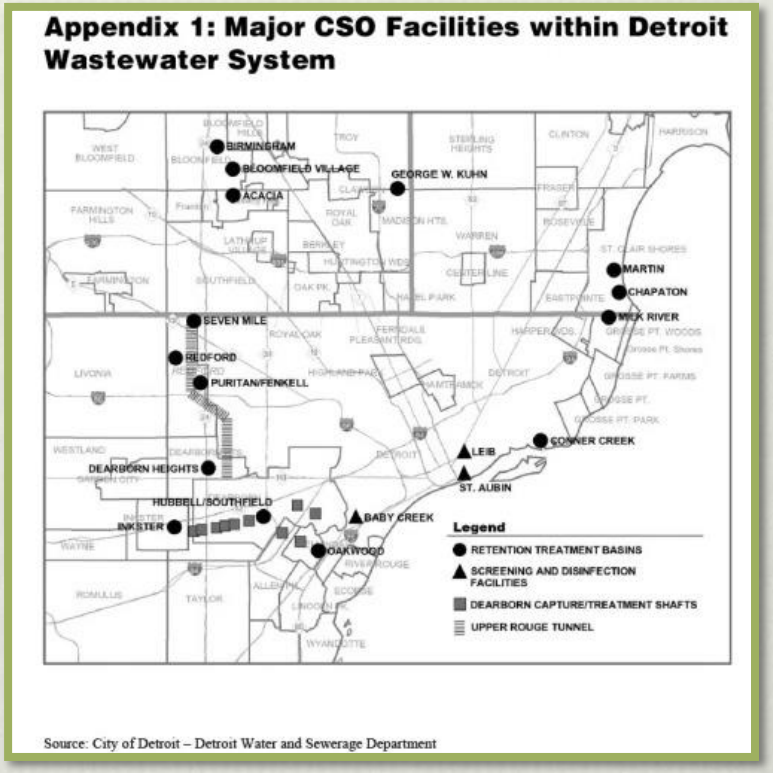
Management Technologies

Degrémont Technologies DensaDeg®



Combined Sewer Cities

- Detroit, MI
  - Economic burden halted storage tunnel construction
  - Construction of Retention Treatment Basins, elimination of CSO locations, and WWTP expansion
  - 90% reduction in untreated discharges since 1992
- Philadelphia, PA
  - Two-thirds service area is combined sewer
  - Green Streets programs
  - Triple Bottom Line Approach
- Cleveland, OH
  - 25-year Project Clean Lake
    - Plant upgrades, tunnels, green infrastructure
    - Long-term treatment of 98% of wet weather flows



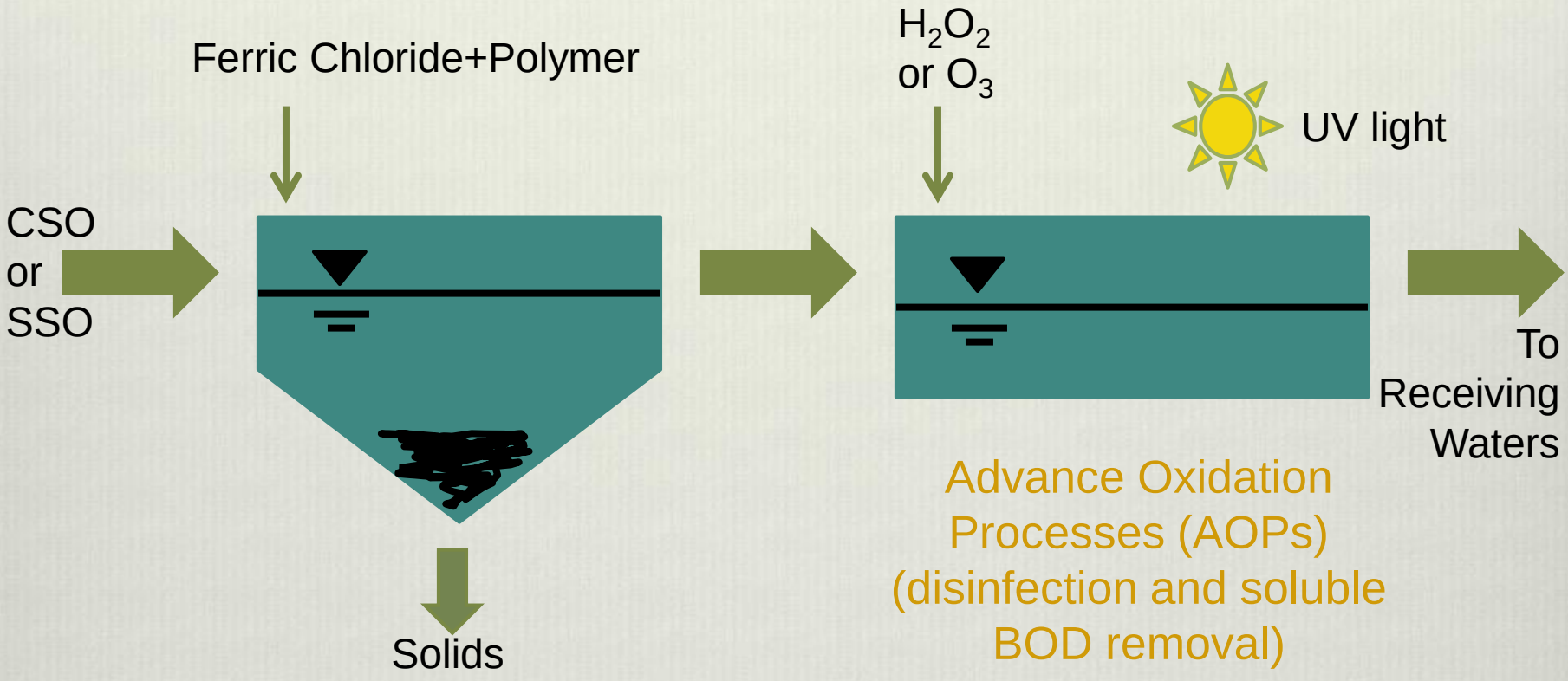
Advanced Treatment

- Advanced Oxidation Processes (AOPs)
  - High rate of reaction, formation of hydroxyl radicals
  - Oxidation of organic compounds
  - Avoid formation of disinfection byproducts
- AOP technologies
  - Ozone, UV light, hydrogen peroxide, peracetic acid, photocatalysis
  - Proprietary:
    - Xylem Wedeco MiPRO AOP: various combinations
    - Evoqua Vanox systems

Use of Advanced Treatment

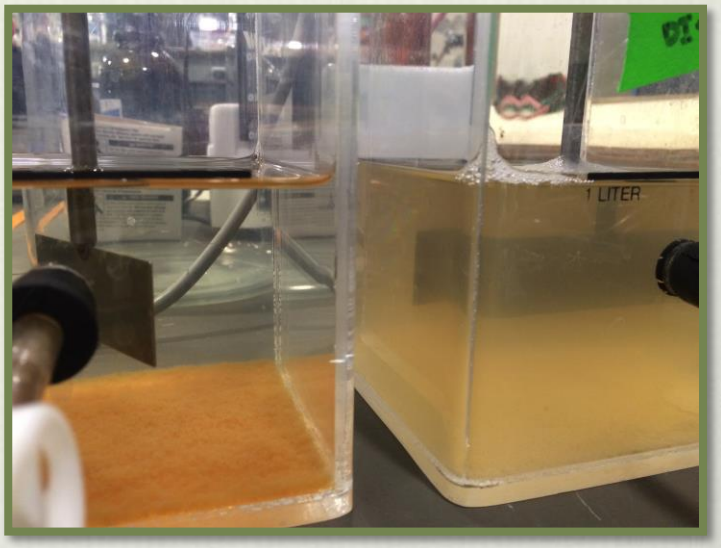
- Industrial wastewater treatment
- Direct and Indirect Potable Reuse
- Drinking water treatment
- Oxidation of micropollutants
- Appropriate for Wet Weather Management?
  - High rate of reaction
  - COD, BOD removal
  - Able to meet permit standards

Proposed Use of AOP for Wet Weather Treatment



WQC Research Approach

- Synthetic Sanitary Sewer Overflow (SSO) wastewater
- Primary treatment with CEPT
  - 95% reduction in turbidity, 50% COD removal
- Apply various AOP and test effectiveness of:
  - *E. Coli* inactivation
  - COD removal
  - Micropollutant oxidation
    - Removal to <0.5 ug/L (detection limit) with CEPT (sorption)

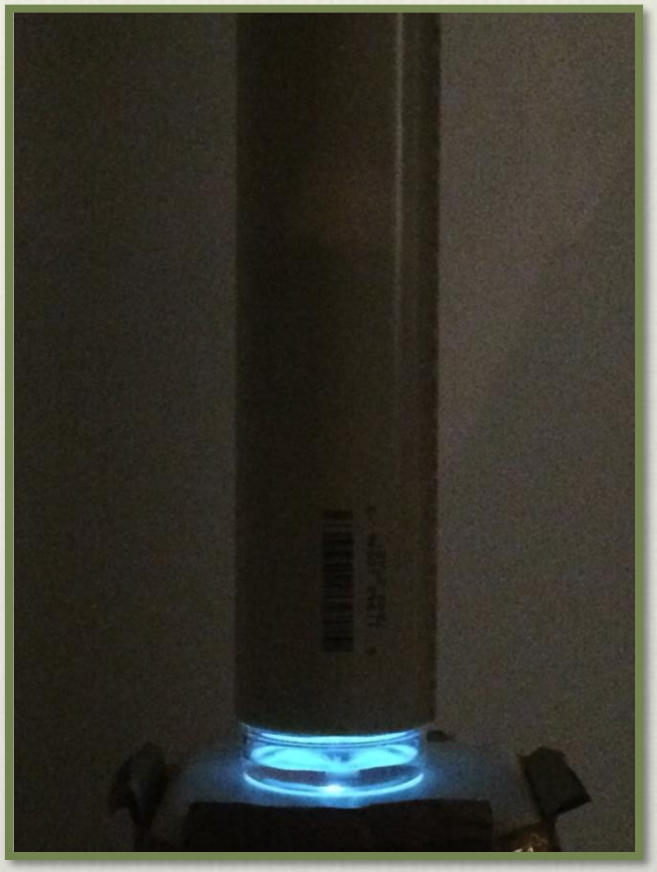


Post-CEPT water and Raw Synthetic SSO Water

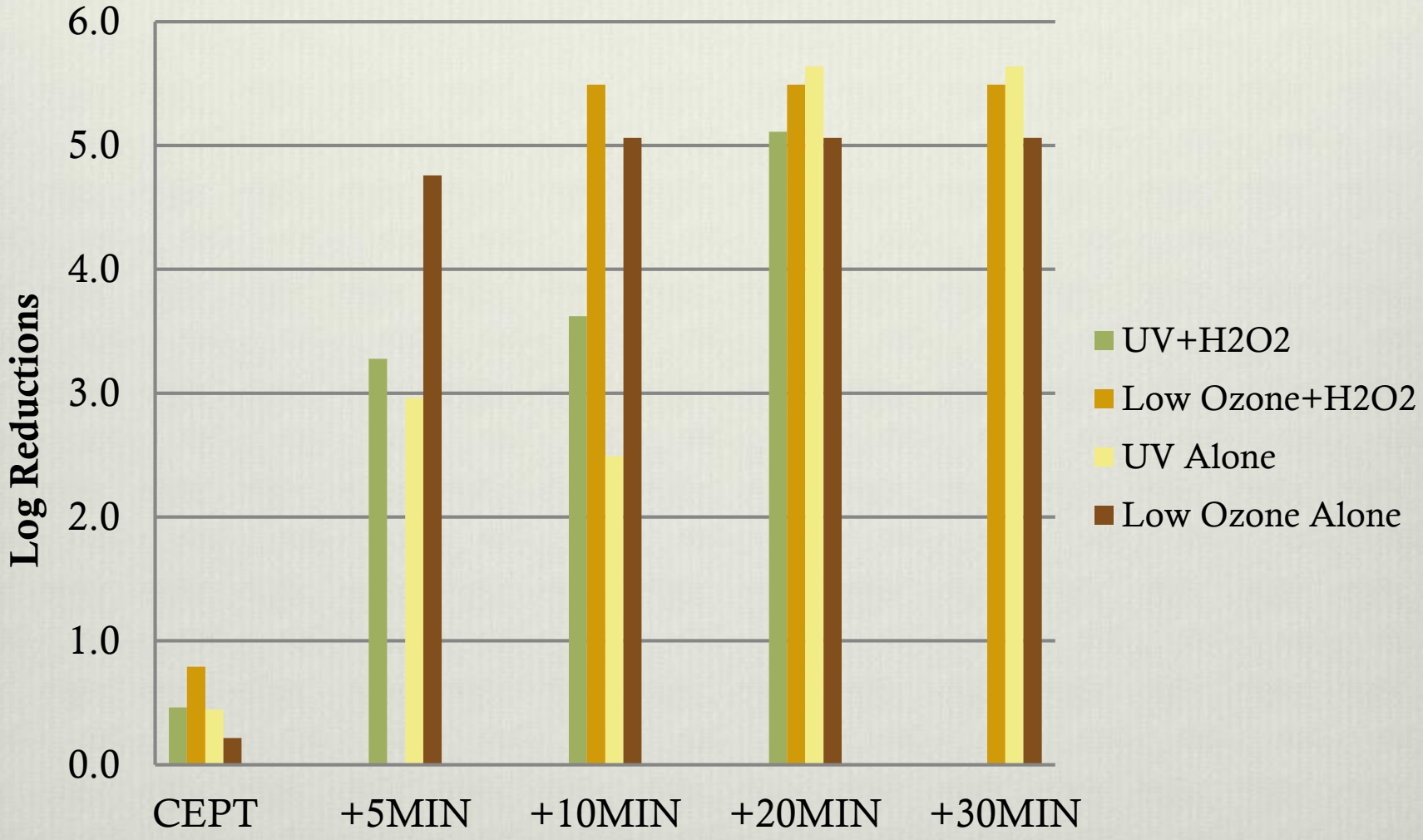
WQC Research: Reactors

Ozone, Ozone+H_2O_2

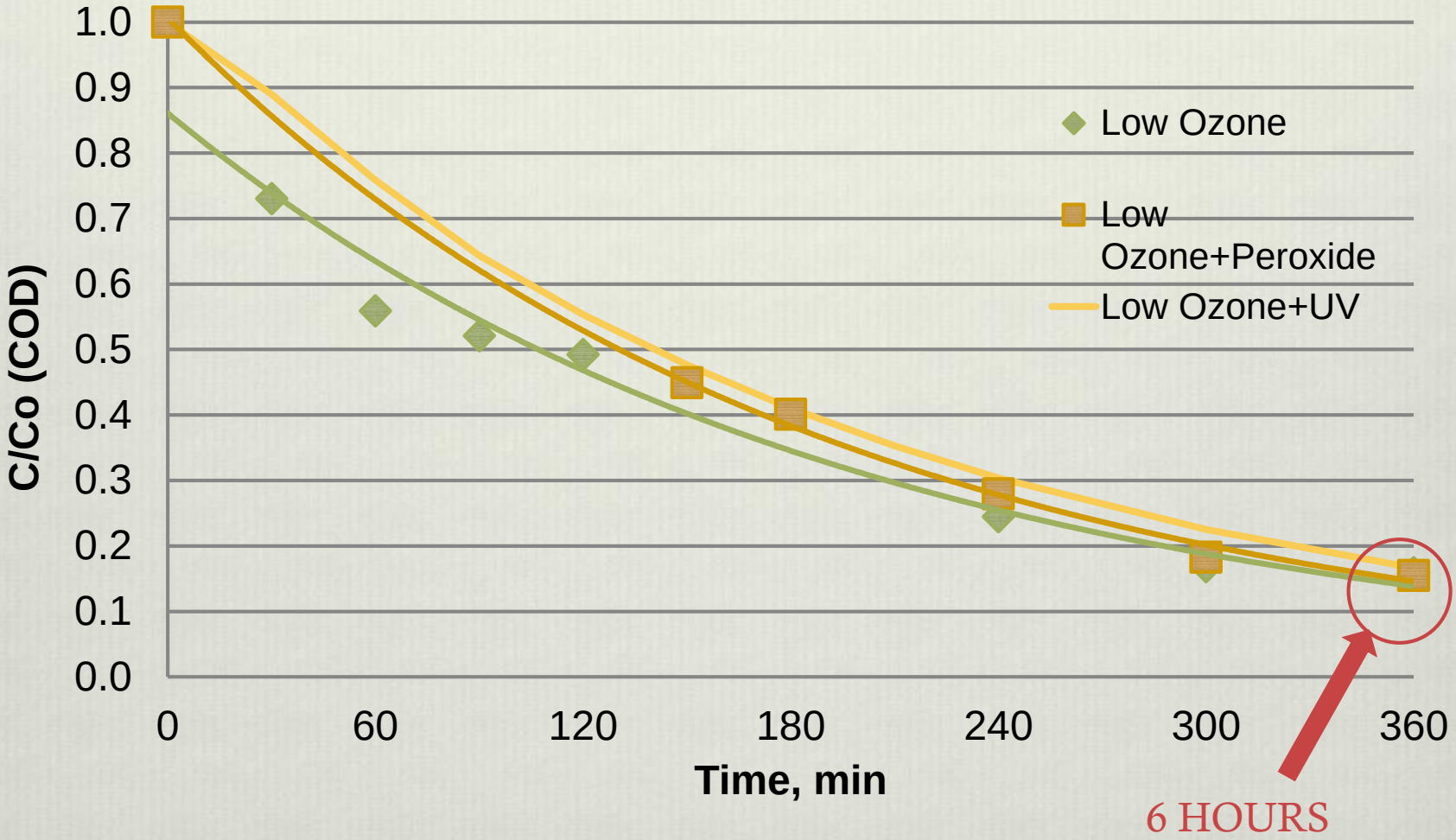
UV, UV+H_2O_2, UV+Ozone



WQC Research: *E. coli* Inactivation



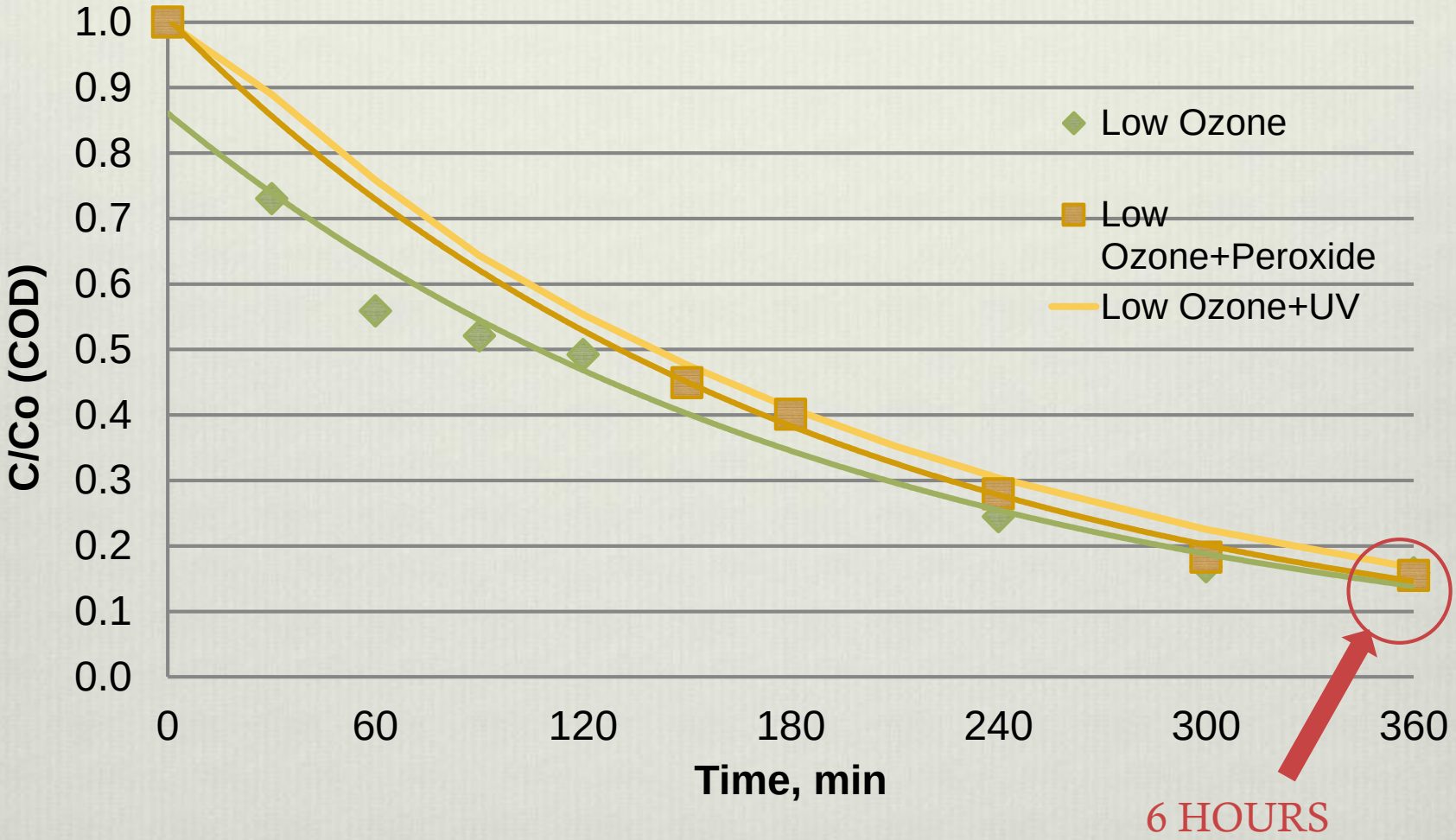
WQC Research: COD Removal



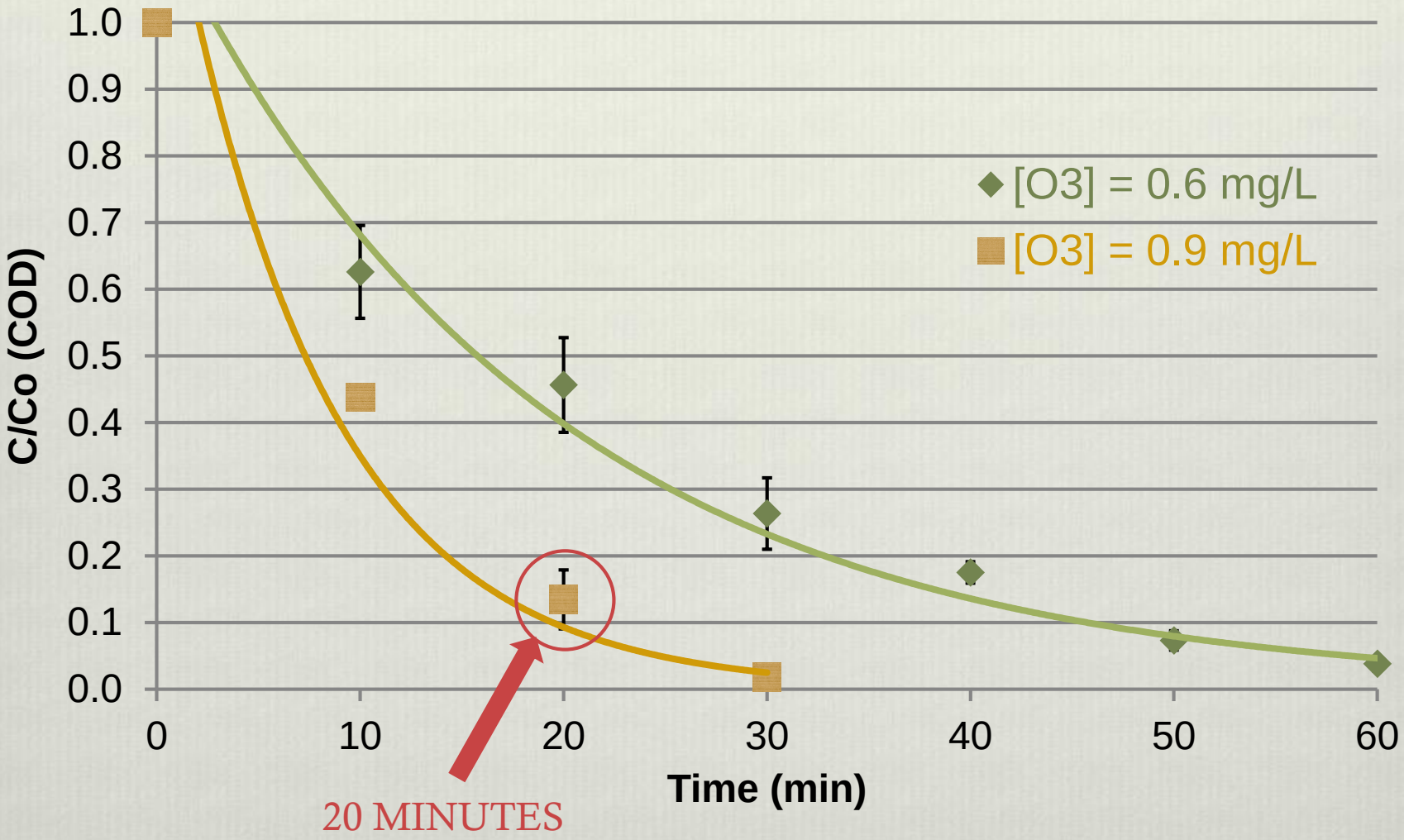
Water Quality Comparison

Parameter	CEPT-AOP Influent	South Shore Influent (average values from December 2015 data; MMSD Technical Memorandum)	CEPT-AOP Effluent	South Shore Effluent
BOD_5 (mg O_2/L)	180	137	17	3.5
TSS (mg/L)	240	223	ND	3.0
Fecal Coliforms (CFU/100 mL)	5.0×10^7	NA	ND	33
Tricolsan (ug/L)	50	2	<0.5	<0.5
Triclocarban (ug/L)	50	2	<0.5	<0.5
NH_3-N (mg/L)	16	11	16	0.57
Total Phosphorous (mg P/L)	5.79	3.54	1.62	0.38

WQC Research: COD Removal



WQC Research: Increasing the Rate of Reaction for COD Removal



WQC Research: AOP Improvement

- Increase formation of hydroxyl radicals
- Increase ozone mass transfer
  - Use oxygen instead of air
  - Bubble suspension, diffusion
- Catalytic ozonation
  - Metal oxides
  - pH adjustment
  - Heterogeneous or homogeneous
- Fenton's Reagent
  - Iron with H_2O_2 (low pH)

WQC Research: Future Work

- Improve rate of reaction, refine catalysis
- Develop a continuous flow system for CEPT-AOP treatment
- Determine system performance with real wastewater
- Identify fate of oxidized micropollutants (toxicity)
- Focused research on nitrogen removal

Benefits of Advanced Treatment

- ✓ No need for large detention facility
- ✓ Avoid having to decide between overflows or basement backups
- ✓ Meet or exceed BOD and disinfection permit requirements for wet weather flows
- ✓ Protect wet weather management infrastructure
- ✓ Can be implemented at a remote location or at the WWTP

Conclusions

- Wet weather management is a persistent challenge
- Existing technologies do not fully address COD/BOD or micropollutants
- Advanced treatment can meet or exceed secondary effluent standards
- Reduce or eliminate impacts on receiving waters during wet weather events

Questions?

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