



CHEMTRADE

Using PACs to Achieve Low-Level Phosphorus Requirements

Joseph Carlston

Chemtrade Logistics

Session M

18 October 2018



CHEMTRADE

Introduction to Poly-Aluminum Chlorides (PACs)



CHEMTRADE

What are PACs?

- **Poly-Aluminum Chloride**
 - Aluminum chloride with added “basicity” to reduce alkalinity consumption
 - Polymeric structure of aluminum; does not necessarily contain added polymers
- **Basicity can range up to 80%**
 - Greater than 80% indicative of Aluminum Chlorohydrate (ACH)
 - 0% basicity = aluminum chloride (AlCl_3)
 - PACs refer to broad family of products
- **Chemical Formula: $\text{Al}_n(\text{OH})_x\text{Cl}_{3n-x}$**



CHEMTRADE

What are PACs?

- **PAC's most prevalent in drinking water treatment**
 - **Developed for turbidity and TOC removal and to reduce need for pH control**
- **Most PAC's not effective for phosphorus removal**
- **Developed a PAC product which demonstrated high rates of P removal**
 - **Mid-basicity PAC**
 - **9% Al vs 4.5% Al with Alum**



- **Phosphate removal mechanism**
 - $\text{Fe}^{+3}/\text{Al}^{3+} + 3\text{H}_2\text{O} \rightarrow \text{Fe/Al(OH)}_3 + 3\text{H}^+$
 - $\text{Fe/Al(OH)}_3 + \text{H}_2\text{PO}_4^- \rightarrow \text{Fe/Al(OH)}_2\cdot\text{HPO}_4 + \text{H}_2\text{O}$
- **Each Fe^{+3} or Al^{+3} produces 3 parts of H^+ (acid)**



- **Phosphate removal mechanism for PAC's**
 - $[-\text{Al}(\text{OH})-]^{2+} + 2\text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + 2\text{H}^+$
 - $\text{Al}(\text{OH})_3 + \text{H}_2\text{PO}_4^- \rightarrow \text{Al}(\text{OH})_2 \cdot \text{HPO}_4 + 2\text{H}_2\text{O}$
- **PAC products are “pre-hydrolyzed” and generate less acid byproduct**
 - **Alkalinity consumption inversely related to basicity**



CHEMTRADE

Advantages over Alum

- **Demonstrated performance to reduce total P to ultra-low levels**
- **Has lower impact on pH and consumes less alkalinity than alum**
- **Higher aluminum concentration, less volume required**
- **Increased settling rates**
- **Increased dewatering capabilities**



CHEMTRADE

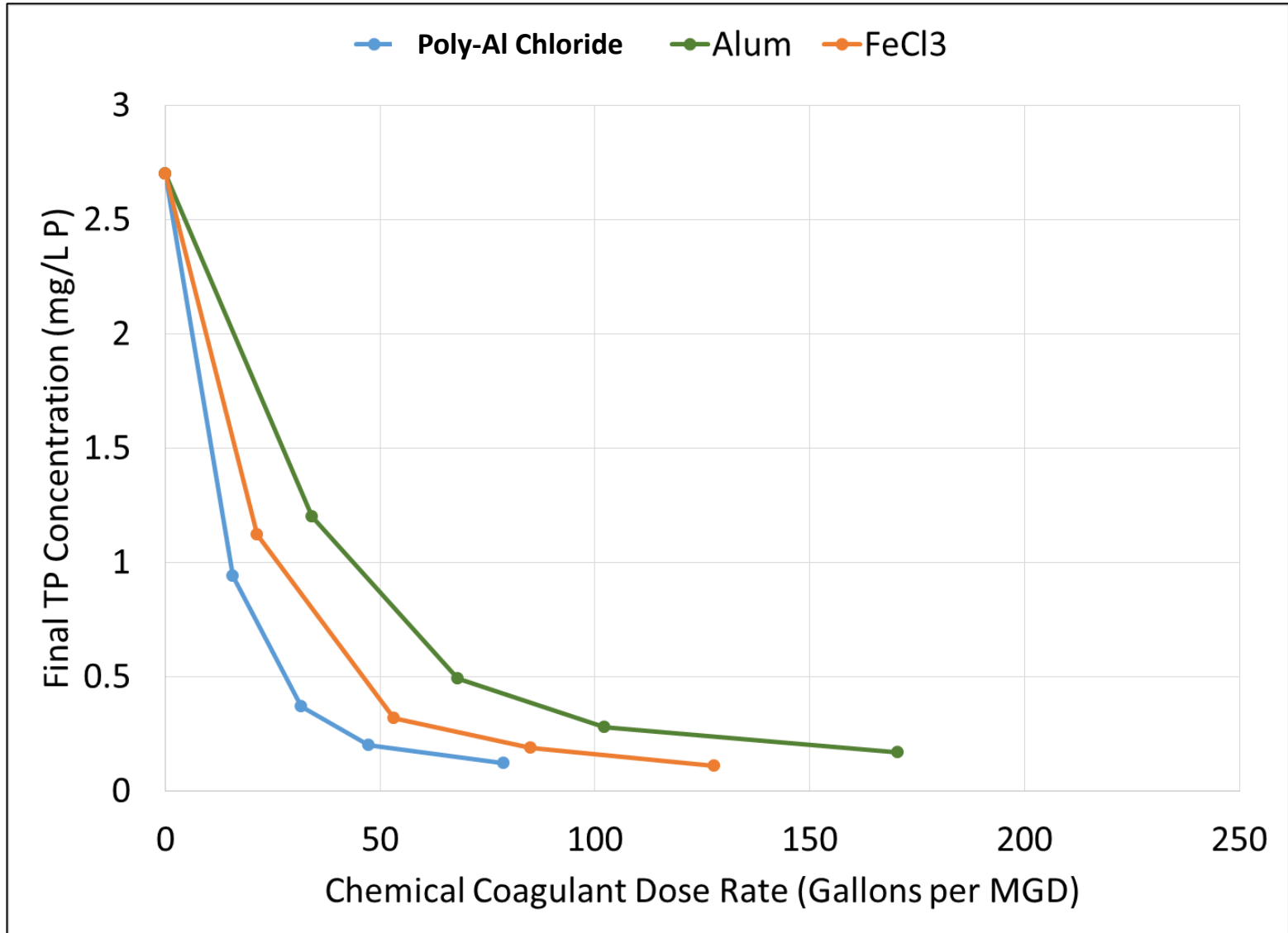
Advantages over Iron-based Products

- **Non-staining**
- **Less corrosive – does not consume as much alkalinity**
- **Less impurities – not a by-product material**
- **Higher active ingredient concentration**
- **Iron can transition between Fe^{+3} and Fe^{+2}**
 - **Fe^{+2} not effective for P removal**



CHEMTRADE

Comparative Performance





CHEMTRADE

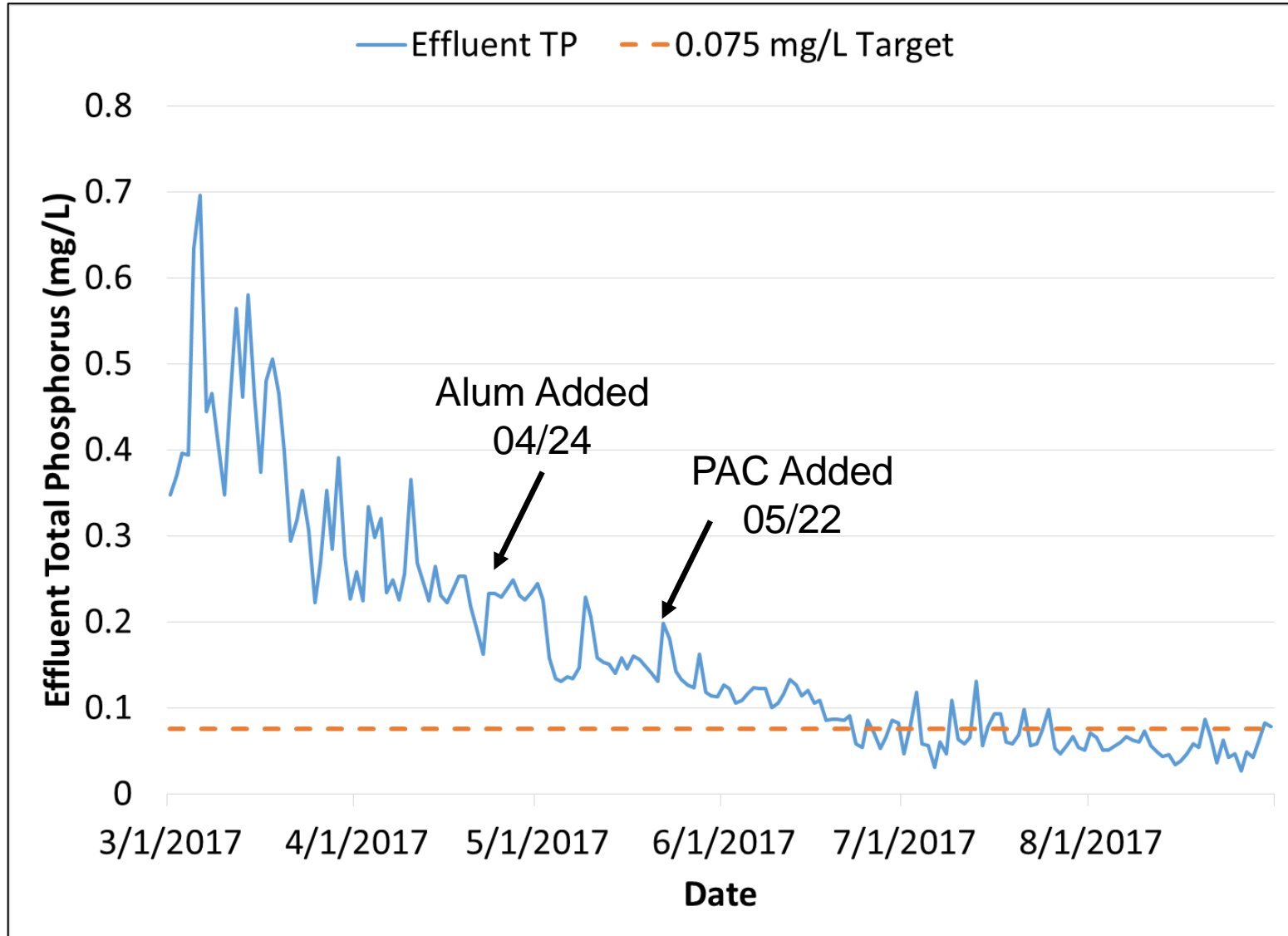
PAC Case Studies

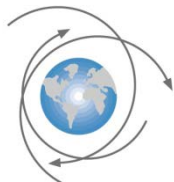


- **Treats ~1 MGD of wastewater**
- **Utilizes oxidation ditch for treatment**
 - **No primary clarifiers or filters**
- **Preparing for upcoming TP target of 0.075 mg/L**



- **Optimized bio-P processes to reduce effluent TP to 0.3-0.5 mg/L**
- **Prepared by testing various chemical coagulants:**
 - **Alum**
 - **PAC**
- **Future testing may involve various independent polymers and filter trials**





- **Volume of PAC added: 120 GPD**

Month	Ave. Effluent Total P
March 2017	0.405 mg/L
April 2017	0.247 mg/L
May 2017	0.155 mg/L
June 2017	0.100 mg/L
July 2017	0.069 mg/L
August 2017	0.056 mg/L



- **Treats ~2 MGD wastewater**
- **Uses combination of oxidation ditch, chemical addition, and anthracite filters for treatment**
 - **No primary clarifier**
- **Preparing for upcoming 0.075 mg/L Total P target**



CHEMTRADE

WI Case Study #2

- **Does not have ability for enhanced bio-P**
 - **Low incoming BOD/VFA's**
- **Previously tested rare earth coagulant**
 - **Stopped use due to increase in price**
- **Switched to PAC product in December 2016**
 - **Maintained average Total P of < 0.075mg/L using approx. 140 GPD**



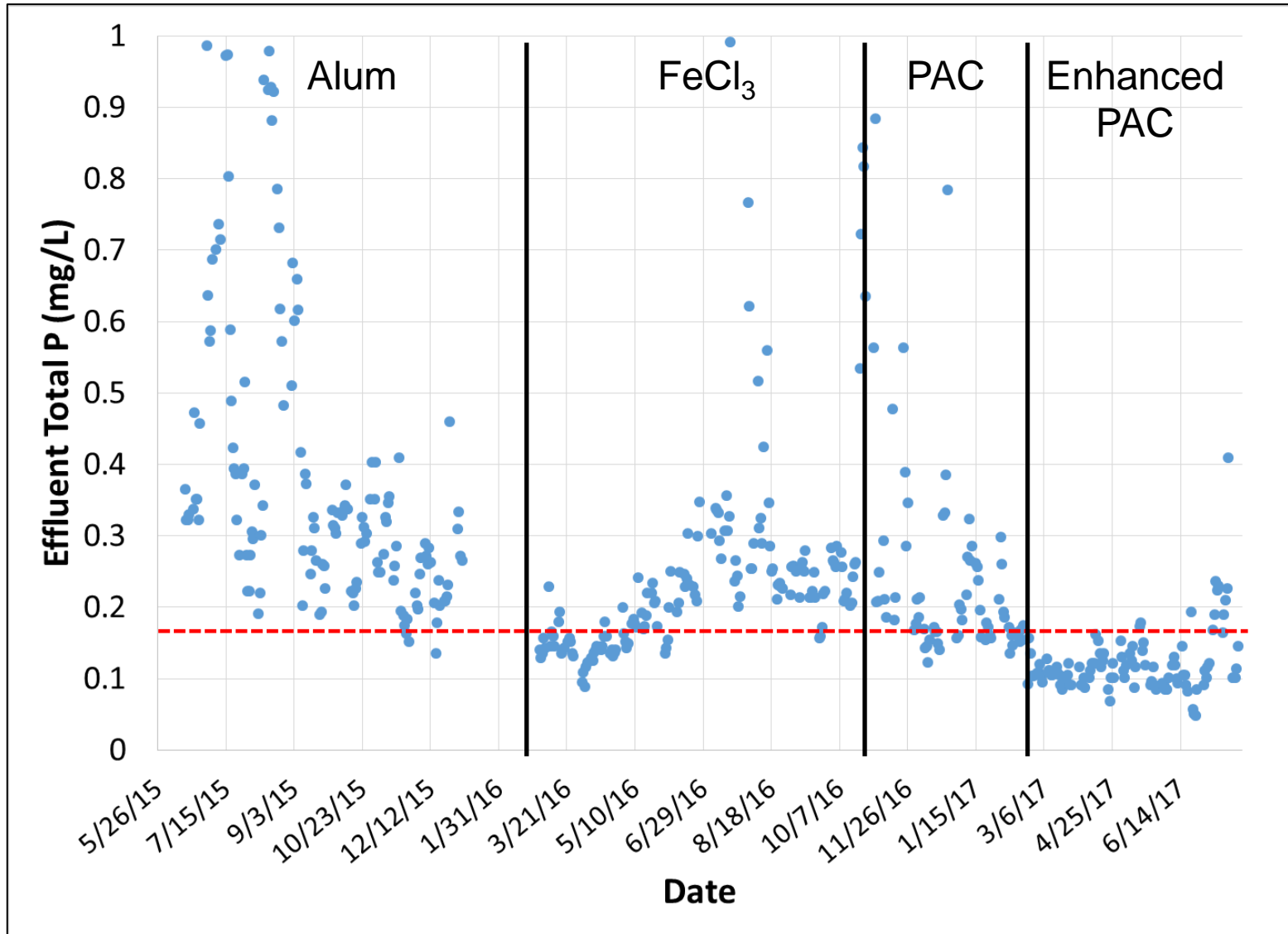
CHEMTRADE

WI Case Study #3

- **Treats 8-10 MGD wastewater**
- **Uses traditional treatment**
 - **Primary Clarification**
 - **Extended aeration**
 - **Chemical P Removal**
 - **No filtration**
- **Future TMDL permits require discharge of < 18 lbs of P**
 - **Equates to ~0.18 mg/L effluent total P**



WI Case Study #3





CHEMTRADE

WI Case Study #3

- **Alum:**
 - Average Volume: 215 GPD
 - Average Effluent Total P: 0.465 mg/L
- **FeCl₃:**
 - Average Volume: 230 GPD
 - Average Effluent Total P: 0.228 mg/L
- **PAC product**
 - Average Volume: 230 GPD
 - Average Effluent Total P: 0.259 mg/L
- **Enhanced PAC product**
 - Average Volume: 200 GPD
 - Average Effluent Total P: 0.121 mg/L



CHEMTRADE

PAC versus Enhanced PAC





CHEMTRADE

Questions?

Joseph Carlston

JCarlston@chemtradelogistics.com