Outline

- Plant overview
- BPR optimization
- Chemical precipitation
Plant Overview

FFUSA Lancaster WWTP Schematic

- T-100: Influent Tank
- T-200: Neutralization Tank
- T-300: Selector Tank
- T-400: Aeration Tank
- T-500: Floc Tank
- T-600: Clarifier
- T-605: Clarifier
- T-650: Float Tank
- T-800: Sand Filter
- T-805: Sand Filter
- T-700: Sludge Tank
- T-1000: Effluent Tank
## Loading and Discharge

### 2017 data

<table>
<thead>
<tr>
<th>Influent</th>
<th><strong>Flow</strong></th>
<th>0.4544 MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>COD</strong></td>
<td>2,300 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>BOD</strong></td>
<td>1,350 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>Tot Phos.</strong></td>
<td>33 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>TKN</strong></td>
<td>81 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>Ammonia</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Nitrates</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Chloride</strong></td>
<td>540 mg/L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effluent</th>
<th><strong>Flow</strong></th>
<th>0.4576 MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>COD</strong></td>
<td>28 mg/L</td>
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<tr>
<td></td>
<td><strong>BOD</strong></td>
<td>1.2 mg/L</td>
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<tr>
<td></td>
<td><strong>Tot Phos.</strong></td>
<td>0.47 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>TKN</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ammonia</strong></td>
<td>0.38 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>Nitrates</strong></td>
<td>&lt; 1 mg/L</td>
</tr>
<tr>
<td></td>
<td><strong>Chloride</strong></td>
<td>390 mg/L</td>
</tr>
</tbody>
</table>
Plant conditions

- **MLSS**: 4,200 to 5,500 mg/L
- **F:M**: 0.08 to 0.12 lb BOD/lb TSS in Aeration tank
- **Sludge Age**: 11 – 14 days
- Ferric Sulfate used for Phosphorus reduction, injected into floc tank before Clarifiers.
Microbiology - MLSS

- Analysis by Ryan Hennessy at Midwest Contract Operations
- The flocs were firm in texture and ranged from 200–650 µm in dimension. Higher life form organisms were low in abundance and included testate amoeba, rotifers, and stalked ciliates. Filamentous bacteria were ranked common in abundance and were not negatively impacting floc structure. Dispersed growth in the bulk liquid between the flocs was ranked common in abundance. This consisted of Nocardioforms and (to a lesser extent) single cell dispersed bacteria. Tetrads were present at very common-abundant in abundance within the flocs (and occasionally dispersed). Globular zoogelea were ranked very common in abundance. Tetrads and zoogelea both grow on organic acids (VFAs). Polysaccharide was overall ranked normal (by staining) with occasional flocs showing elevated levels due to globular zoogelea abundance. Polyphosphate Accumulating Organisms (PAOs) were present at moderate abundance.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rank</th>
<th>Abundance</th>
<th>Cause (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrads</td>
<td>1</td>
<td>Very Common-Abundant</td>
<td>Organic Acids</td>
</tr>
<tr>
<td>Globular Zoogleas</td>
<td>2</td>
<td>Very Common</td>
<td>Organic Acids</td>
</tr>
<tr>
<td>Thiothrix I</td>
<td>3</td>
<td>Common</td>
<td>Organic Acids</td>
</tr>
<tr>
<td>Nocardioforms</td>
<td>3</td>
<td>Common</td>
<td>Fats, Oils, Grease</td>
</tr>
<tr>
<td>Type 0914</td>
<td>4</td>
<td>Some</td>
<td>Organic Acids, Sulfide</td>
</tr>
<tr>
<td>Thiothrix II</td>
<td>4</td>
<td>Some</td>
<td>Organic Acids, Sulfide</td>
</tr>
<tr>
<td>H. hydrossis</td>
<td>4</td>
<td>Some</td>
<td>Low Dissolved Oxygen</td>
</tr>
</tbody>
</table>
Microbiology
Microbiology
Microbiology

PAOs
Neisser positive
1000x

PAOs
Neisser positive
(dark purple)
1000x

Thiothrix
gram stain
1000x

Nocardioforms
1000x gram stain

Courtesy of MCO
BPR Optimization

- Denitrification cycle in Aeration Tank 3:25 - 3:35
- Relationship between temperature and BPR
- Control of fermentation in the EQ tank - air flow regulation
- Augmentation with Sodium Acetate
- Stopped return of liquid from dewatering drum to Influent tank.
BPR – Aeration Tank Denitrification Cycle
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City storm sewer
Pigeon Creek
BPR Temperature
BPR Temperature

Lb Ferric / Tank 300 avg temp

Tank 300 avg temp

Graph showing the relationship between Lb Ferric and Tank 300 average temperature.
BPR Temperature

Ibs Ferric / t300 max

[Graph showing the relationship between Ibs Ferric and t300 max]
BPR Temperature

Ibs Ferric / Tank 400 max temp

Tank 400 max temp
BPR Temperature

Ibs Ferric / Tank 400 avg temp

Tank 400 avg temp
Cerium Chloride

- Jar Tests
  - 40% Solution of 95% CeCl₃
  - Nalco product 8121
  - Heavy metals testing
- Full scale trial
- Engineering student Intern – Taylor Tenor
Jar Test 1

- Started dosage at 5ppm: Saw very little reduction in P
- Increased Cerium Addition at 5ppm increments to 40ppm
- Cerium alone is not a cost effective way to meet the desired phosphorous concentration
CeCl₃

- Jar Test 2
- Polymer addition
  - Polymer clumps crystals together so the sand filters can filter them out
  - Performed Jar Tests
    - Excess Cerium is not beneficial when using polymer
    - Polymer is required at very low doses

Jar Test: Cerium Dosage vs. Phosphorous at 2ppm Polymer Dosage
Cerium Chloride Trial Setup

- Phosphaxes
  - Before and after sand filters to constantly measure phosphorous level
CeCl₃ Full Scale Trial

- Inject Cerium between clarifiers and sand filters
  - Very little competing reactions
  - Plenty of length and flow to mix thoroughly
  - Easily Accessible
  - Started at 7 ppm, reduced to 5 ppm in mid September

- Inject Polymer into the same line downstream, right before the Sand Filters
  - Starting dose dosage 1 ppm to start, stepped down to 0.5, 0.4, 0.1 ppm
- Parkson DynaSands
- Two Sand filters running in parallel
- Coarse Sand
- 10,000 gal each, 0.6 hours HRT
- Cleaned with Sulfuric acid before starting the trial
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City storm sewer
Pigeon Creek
Ferric Sulfate vs. Cerium Chloride

- Average drop in Phos across Sand Filters in August and September was 0.42 mg/L
- Next steps
  - Stop Ferric Sulfate feed and see how much Phosphorus increases
Algae P Removal in Clarifiers

- Clarifiers can be an Algae farm!
- When the Clarifiers are cleaned, Phosphorus levels increase for a day or two, then drop until maximum algae mat thickness is reached.
Algae P removal in Clarifiers