Knoxville Utilities Board - Peak Flow Management and Eliminating Diversions with Biologically Enhanced High Rate Clarification

How to Participate Today

- Audio Modes
  - Listen using Mic & Speakers
  - Or, select “Use Telephone” and dial the conference (please remember long distance phone charges apply).

Submit your questions using the Questions pane.

- A recording will be available for replay shortly after this webcast.
Discussion Outline

Background
- KUB Introduction

Facility Overview, Drivers, Challenges
- Fourth Creek WWTP
- Kuwahee WWTP

Technology Introduction
- Biologically Enhanced High Rate Clarification
- Pilot Summary
- System Design and Schedule

Full-Scale Operation and Performance

Questions

Knoxville Utilities Board (KUB)

- KUB provides electric, natural gas, water, and wastewater services to more than 400,000 customers in and around Knoxville, TN.

- KUB owns and operates four wastewater treatment plants (WWTP)

- In February 2005, a Consent Decree with TDEC, USEPA, City of Knoxville, TN Clean Water Network and KUB became effective with the goal of eliminating sanitary sewer overflows (SSOs).
  - KUB prepared Comprehensive Performance Evaluation (CPE) of our WWTPs and their ability to meet our NPDES permit requirements.
  - The results included the initiation of the Composite Correction Plan and Process Controls Plan
KUB Evaluation

- Four treatment facilities
  - Kuwahee wet weather treatment capacity for 70 MGD increased to 120 MGD
    - NPDES Violations from 2002-2005
      - 39 NPDES Permit violations
      - 126 Diversions and 16 bypasses
  - Fourth Creek WWTP full treatment capacity from 15 to 34 MGD
    - NPDES Violations from 2002-2005 (all associated with wet-weather conditions)
      - 45 total: 28 TSS, 8 settleable, 1 Fecal, 8 BOD
      - 92 Diversions and 12 bypasses

Three-tiered approach

- Fourth Creek and Kuwahee WWTP Improvements
- Peak Storage/SSO Storage
- Collection System Improvements – Reduce wet weather induced I/I
  - Average upgrade of 2% of system annually and pump station upgrades
  - Existing System Optimization (CMOM programs, CEPT, Biological treatment)

KUB Evaluation

Criteria

- Hydraulic and Biological Treatment limitations were found at both facilities
- Confirmation of existing system design capacities
- Performance Evaluation + Hydraulic Modeling
- Wet Weather Diversions (Current and Future) – Frequency, duration and volume

Options

- Collection system improvements won't mitigate diversions completely and is costly
- Detailed Evaluation Alternatives:

<table>
<thead>
<tr>
<th>Diversion</th>
<th>Non-Diversion</th>
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<tbody>
<tr>
<td>CEPT</td>
<td>CEPT + BIOACTIFLO™ with Storage</td>
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<td>CEPT + ACTIFLO® with Storage</td>
<td>CEPT + BIOACTIFLO™ without Storage</td>
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<tr>
<td>CEPT + ACTIFLO® without Storage</td>
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- Both Deep Bed Filters and Full Biological Treatment ranked low and were determined infeasible (Site Constraints, Operational/Maintenance Challenges, BW disposal)
KUB Evaluation

- Detailed Evaluation took into consideration:
  - Performance Evaluation
  - Cost and Non-Cost factors
  - Diversion frequency
  - Implementation impacts

- CEPT option alone, based on modeling, would not be able to consistently meet NPDES permit

- Recommendation
  - Phased implementation of BIOACTIFLO™, to provide secondary treatment to peak, wet weather flows in excess of the capacity of the existing WWTP biological processes
  - Based on Hydraulic modeling of the 2-year, 24-hour storm event
KUB Evaluation

Location: Knoxville, TN
- Originally constructed in 1966
- Outfall into Tennessee River
- Permitted Flow: 10.8 MGD avg, 24 MGD peak
- Effluent TSS: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Effluent BOD$_5$: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Constraints:
  - Wet weather flow measurement peaked at 39 MGD
  - Hydraulic and Biological capacity limitations
  - Prior at 10.8 MGD
    - Primary Clarifier 1.7 hours,
    - Secondary Clarifiers 2.5 hours
Fourth Creek WWTP

- Location: Knoxville, TN, Near Downtown/Univ. of Tennessee
- Originally constructed in the 1950's
- Outfall into Tennessee River
- Permitted Flow: 44 MGD avg, 70 MGD peak
- Effluent TSS: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Effluent CBOD₅: 25 mg/L Daily Avg, 40 mg/L Daily Max
- Constraints
  - Available footprint
  - Industrial Discharges
  - Hydraulic and Biological capacity limitations

Kuwaahee WWTP

- Location: Knoxville, TN, Near Downtown/Univ. of Tennessee
- Originally constructed in the 1950's
- Outfall into Tennessee River
- Permitted Flow: 44 MGD avg, 70 MGD peak
- Effluent TSS: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Effluent CBOD₅: 25 mg/L Daily Avg, 40 mg/L Daily Max
- Constraints
  - Available footprint
  - Industrial Discharges
  - Hydraulic and Biological capacity limitations
Kuwahee WWTP

Technology Introduction
ACTIFLO® for High Rate Clarification (HRC)

- ACTIFLO® for SSO/CSO Treatment
  - Physical / Chemical process using standard coagulation and flocculation practices
  - Uses sand as a ballast to increase the settling rate of the flocculated material
  - Rapid Start-up (15 min’s) and high surface loading rates (50-70 gpm/sf)
  - Small Footprint with Minimal Equipment
  - Exceptional TSS and particulate BOD Removals
  - CON’s – Limited soluble BOD reduction – Doesn’t provide biological treatment of wet weather flows (if required)

Biologically Enhanced High Rate Clarification (BEHRC)

- BIOACTIFLO™ for SSO/CSO Treatment
  - Pairs Contact Stabilization with ACTIFLO®
  - Contact Tank Facilitates sBOD uptake
  - Exceptional TSS and Total BOD Removals
  - Provides 100% biological treatment of all wet weather flows = MEETS SECONDARY STANDARDS
**Ballasted Coagulation and Flocculation**

- Stable particles suspended in water
- Metal Salt
- Micron sand
- Unstable Coagulated Particles
- Polymer Molecule
- Flocculated Particles
- Concentrated Solids

**Process Overview**

1. **ACTIFLO**
2. **BIOACTIFLO**
   - A biological contact tank precedes ballasted clarification
   - RAS/WAS from the main treatment plant is blended with excess flows to facilitate soluble BOD uptake
   - RAS/WAS and suspended solids are removed within ballasted clarification
   - RAS/WAS is continuously returned to the main plant for reuse and regeneration
   - Achieves > 85% BOD reductions for all wet weather flows
Performance in Wet Weather Applications

<table>
<thead>
<tr>
<th>Configuration</th>
<th>TSS mg/l (% Rem)</th>
<th>BOD mg/l (% Rem)</th>
<th>Total Phosphorus mg/l</th>
<th>UV Transmittance %</th>
<th>Geo Mean E. Coli after Disinfection MPN/100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIFLO®</td>
<td>&lt; 15 (85 – 95%)</td>
<td>10 – 40 (40 – 65%)</td>
<td>0.1 – 0.3</td>
<td>65 - 80</td>
<td>&lt; 15</td>
</tr>
<tr>
<td>BIOACTIFLO™</td>
<td>&lt; 10 (90 – 98%)</td>
<td>5 – 10 (&gt; 85%)*</td>
<td>0.1 – 0.2</td>
<td>70 - 85</td>
<td>&lt; 15</td>
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*Note: sBOD reduction in BIOACTIFLO™ contact tank allows for this increased total BOD reduction rate.

Experience / Benefits

- Over 18 years of Wet Weather Treatment Experience
- 26 Wet Weather installations in operation
- 5 BIOACTIFLO™ facilities in operation
  - 3 more under construction / detailed design
- Intermittent or Continuous Use. Same Treatment train can handle variety of operating modes (Primary, Wet Weather, Tertiary)
- ACTIFLO® and BIOACTIFLO™ are cost effective solutions compared to other treatment options and provides the flexibility to handle variability in influent quality/flow
- BIOACTIFLO™ provides full secondary treatment to all wet weather flows
Pilot Testing – Fourth Creek WWTP
- April – May 2010
- SRT - Short

Pilot Testing – Kuwahee WWTP
- Jan – Mar 2010
- SRT - Long
Fourth Creek WWTP – System Design

- 2 x 9.5 MGD ACTIFLO® installed and commissioned in 2014
- Converted to BIOACTIFLO™ in 2018
  - Provisions were made in 2014 to help reduce conversion costs
  - Phased implementation helped identify unexpected issues and resolve them before starting KWTP
- Anticipated Influent Conditions
  - $BOD_5$ (Avg / Max) – 141 mg/L / 230 mg/L
  - TSS (Avg / Max) – 130 mg/L / 260 mg/L
- Effluent Guarantees
  - > 85% removal of $BOD_5$
  - > 85% removal of TSS

Fourth Creek WWTP – Project Timeline

- Phase 1
  - CEPT Pilot testing early 2009
  - BIOACTIFLO™ Pilot testing in early 2010
  - Design and Construction of CEPT + ACTIFLO® + Storage – 2011 to 2013
  - ACTIFLO® commissioning and Performance Evaluation - 2014
- Phase 2
  - Design and Construction of BIOACTIFLO™ – 2016 to 2018
  - BIOACTIFLO™ commissioning - 2018
Kuwahee WWTP – System Design

- 2 x 27.5 MGD BIOACTIFLO™ under construction
- Anticipated start-up – 3Q 2020

Site Constraints
- Existing Pre-Aeration Tank converted into Biological Contact Tank No. 1
- Retrofitted existing Intermediate Storage Basins with ACTIFLO®, Chemical Building, Biological Contact Tank No. 2 and Pump Station

Anticipated Influent Conditions
- $BOD_5$ (Avg / Max) – 135 mg/L / 211 mg/L
- $TSS$ (Avg / Max) – 180 mg/L / 350 mg/L

Effluent Guarantees
- > 85% removal of $BOD_5$
- > 85% removal of TSS
Kuwahee WWTP – System Design

- BCT No. 1
- Headworks
- 2 x 27.5 MGD BIOACTIFLO™
- Chem Building
- Pump Station

Kuwahee WWTP – Project Timeline

- **Phase 1**
  - CEPT Pilot testing early 2009
  - Design and Construction of Storage – 2008 to 2011
  - BIOACTIFLO™ Pilot testing in early 2010
  - Design and Construction of CEPT – 2010 to 2012
- **Phase 2**
  - Design and Construction of BIOACTIFLO™ – 2018 to 2020
  - BIOACTIFLO™ commissioning - 2020
Full-Scale Operation

- Record Rainfall, I&I Issues – Late 2018, Early 2019

- Feb 2019 – Received over 13” rain (4X the 10-yr avg)

- Area wide impacts, widespread flooding lasting for days

![Historical Effluent Flows - Fourth Creek](source.jpg)

Chilhowee Park

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Full-Scale Operation

- KUB treated over 4 billion gallons of water between Jan-Feb 2019
  - 34% increase compared to 2018

- BIOACTIFLO™ helped Fourth Creek handle historic flows and remain in compliance
  - 1 violation due to influent dilution with inflow

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<thead>
<tr>
<th>Fourth Creek WWTP</th>
<th>Average TSS</th>
<th>Average BOD₅</th>
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<tr>
<td>Influent</td>
<td>63.5 mg/L (27 – 150 mg/L)</td>
<td>56.0 mg/L (15 – 140 mg/L)</td>
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<tr>
<td>Effluent</td>
<td>9.1 mg/L (2 – 19 mg/L)</td>
<td>4.6 mg/L (2 – 9 mg/L)</td>
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<tr>
<td>% Removal</td>
<td>81.3% (41% – 97%)</td>
<td>90.5% (80% – 94%)</td>
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Note – Based on 14 events between 12/21/2018 – 3/10/2019