Hands on State Point Training Illuminates Clarifier Operation

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Many individuals and organizations contributed to the concept and delivery of this training:

- Dick Darling – ME DEP
- Scott Firmin – Portland Water District (PWD)
- Leeann Hanson – JETCC
- Steve Sloan – Portland Water District
- PWD East End WWTP Staff
- Al Jellison – City of Bangor
- Bangor WWTP Staff
- Numerous operators who served as trainers
Training Overview

- Hands on training combined with class room instruction
- Step 1 – Conduct a “train the trainer” session
- Step 2 – Conduct training with the assistance of a team of trainers
Class Agenda

• Review secondary clarifier operating concepts
• Learn how to use the State Point Approach
• Conduct column testing to develop plant-specific data
  - 4 Teams with Trainers
• Illustrate clarifier operating scenarios using Dynamic Modeling
• Review how raw data is used to develop Gravity Flux Curve
• Develop Gravity Flux Curve for the data collected and examine actual operating scenarios
What is State Point Analysis?

- **State Point Analysis:**
- Graphical solids mass balance of the secondary clarifiers
- Dependent on:
  - Physical facilities
  - Influent flow
  - Sludge settling characteristics
- Can be used to determine:
  - Allowable MLSS to the clarifiers
  - Minimum RAS rate
  - The capacity of the clarifiers
Gravity Solids Flux = \( \frac{V_0 X e^{-kX}}{16} \)

**State Point**
- MLSS = 3.00 g/L
- Xr = 7.00 g/L
- Influent Q = 2.00 MGD
- Qr = 1.50 MGD (75%)
- SVI = 150 ml/g
- Area = 5,654 sf
- Applied Flux = 15.5 lb/sf-d
- SOR = 354 gpd/sf
- SUR = 265 gpd/sf
Gravity Flux Equation

Gravity Solids Flux = \( \frac{V_0 X e^{-kX}}{16} \)

- \( V_0 \) = Initial Settling Velocity (ft/day)
- \( X \) = MLSS Concentration (g/L)
- \( e \) = Exponential Function
- \( k \) = empirical settling parameter (L/g)

The Gravity Solids Flux defines the zone settling rate in the clarifier
Test Equipment

4 Column Arrangement

Single Column Arrangement
For JETCC Class
Test Procedure

- Measure MLSS and SVI
- Create sample dilutions from 1,000 – 10,000 mg/L
- Thoroughly mix sample
- Pour sample into column using funnel
- Start timer when fill completed
- Mix column contents
- Measure interface level at 1 minute intervals
  - Low MLSS concentrations will settle faster
  - High MLSS concentrations will settle slower
Biddeford WWTP Batch Settling Tests - 12/5/2013 - Raw Data

Example Raw Settling Data

1. 100% MLSS \( \langle 3520 \rangle 
2. 100% RASS \( \langle 6240 \rangle 
3. 50\% RAS/50\% EFF \( \langle 8820 \rangle 
4. 50\% MLSS/50\% EFF \( \langle 1,620 \rangle 
5. 33\% MLSS/67\% EFF \( \langle 1,060 \rangle 
6. 25\% MLSS/75\% EFF \( \langle 820 \rangle 
7. 75\% RAS/25\%EFF \( \langle 12,180 \rangle 
8. 67\% RAS/33\%MLSS \( \langle 1900 \rangle 

Interface Height (inches)

Time (minutes)
Biddeford WWTP Batch Settling Data - 12/5/13 - Culled Data

- Settling Rate (inches/minute)
  - $y = -0.0077x + 22.459$  \[ R^2 = 0.9915 \]
  - $y = -0.003x + 22.082$  \[ R^2 = 0.7615 \]
  - $y = -0.0118x + 21.868$  \[ R^2 = 0.9584 \]
  - $y = -0.0296x + 21.133$  \[ R^2 = 0.9937 \]
  - $y = -1.3255x + 24.514$  \[ R^2 = 0.976 \]
  - $y = -3.3465x + 28.898$  \[ R^2 = 0.9735 \]
  - $y = -2.5098x + 23.622$  \[ R^2 = 1 \]
  - $y = -2.4114x + 23.622$  \[ R^2 = 1 \]

- Incident Lines:
  - 3,520 mg/L
  - 16,240 mg/L
  - 8,120 mg/L
  - 1,620 mg/L
  - 1,060 mg/L
  - 820 mg/L
  - 12,180 mg/L
  - 11,900 mg/L
**Biddeford Observed Settling Velocity (ft/day) on 12/5/2013**

\[ G = V_0 X e^{-kX}/16 \]

**Gravity Solids Flux**

\[ \text{Gravity Solids Flux} = \frac{(533.46 X e^{-0.5X})}{16} \]

\[ y = 533.46 e^{-0.04x} \]

\[ R^2 = 0.9638 \]
**State Point Analysis - Two-80' Clarifiers - Biddeford WWTP - 12/5/13**

**Gravity Flux Curve**

**State Point**
- MLSS = 3.3 g/L
- XR = 12.3 g/L
- Influent Q = 3.0 MGD
- Qr = 1.5 MGD (42%)
- SVI = 75 ml/g
- Area = 10,053 sf
- Applied Flux = 12.3 lb/sf-d
- SOR = 298 gpd/sf

**Graph Details**
- Gsir - Solids Loading Rate (lb/sf-d)
- MLSS Concentration (g/L)

Legend:
- Blue line: Gravity Solids Flux (lb/sf-d)
- Black line: Overflow Rate Operating Line
- Brown line: Underflow Rate Operating Line
Conclusions

• Hands on aspect of the course significantly helped participants:
  – Grasp both theory and math of approach
  – Understand how solids loading rate can be a limiting factor in clarifier operation

• Use of trainers significantly helped students by providing continuous input and feedback during testing

• Limitations of small, unstirred columns was evident
Thanks to all the Coordinators, Plant Staff, Trainers, Participants.