Wastewater Math and Excel Equations

2017 IWEA O&M Seminar
Cindy Fort, P.E. & Troy Casey, E.I.

Wednesday, April 26th, 2017
How to Write Equations in Excel

• Writing Formulas Using:
  – Sum, Average, Round

• Freeze Panes
  – Easier viewing in large spreadsheets

• Creating Trend Graphs
  – Allows for Viewing Trends in Large Sets of Data

• Examples in Excel for Each Upcoming Problem Set
Reading Plans and Calculating Tank Dimensions

- Refer to handouts for aeration tank and secondary clarifier plan and section view
- Dimension Formulas:
  - Circular, \( SFT = \frac{\pi D^2}{4} \) or \( \pi R^2 \)
    - Excel: \=pi()*D^2/4 or \=pi()*R^2
  - Perimeter, \( Ft = 2\pi R \) or \( \pi D \)
    - Excel: \=2*pi()*R or \=pi()*D
  - Rectangular, \( SFT = L \times W \)
    - Excel: \=L*W
  - Perimeter, \( Ft = 2L + 2W \)
    - Excel: \=2*L+2*W
- Calculate the total volume, in million gallons (MG), for aeration tanks and secondary clarifier
- Calculate weir length for secondary clarifiers
- Conversion: 1 cubic foot = 7.48 gallons (divide by 1 million to get MG!)
- Total Number of:
  - Aeration Tanks: 4
  - Secondary Clarifiers: 4
Plans and Tank Volume Worksheet
Food to Microorganism Ratio (F:M)

- \( F: M = \frac{Q_{ww} \times \text{BOD}}{V_{AB} \times \text{MLVSS}} \)
  - \( Q_{ww} \): wastewater flow to activated-sludge process, MGD
  - \( \text{BOD} \): wastewater BOD concentration, mg/L
  - \( V_{AB} \): total liquid volume of biological reactors in service, MG
  - \( \text{MLVSS} \): mixed liquor volatile suspended solids concentration in bioreactor, mg/L

Problem:
Refer to April MRO Sheet 1 on laptops
What is the F:M Ratio for April 5\textsuperscript{th}, 2015?

Excel Formula:
\( =\frac{Q_{ww} \times \text{BOD}}{V_{AB} \times \text{MLVSS}} \)
Mean Cell Residence Time

- **MCRT =** \[
\frac{\text{Sludge Mass in System}}{\text{Sludge Mass Leaving System Per Day}}
\]
- Or,
  \[
  \frac{MLVSS \times V_{\text{Total}}}{(Q_{\text{WAS}} \times WAS_{\text{mg/L}}) + (Q_{\text{Eff}} \times TSS_{\text{mg/L}})}
  \]
  
  - **MLSS:** Mixed liquor suspended solids, mg/L
  - **V_{\text{Total}}:** Total volume of bioreactors in service, MG
  - **Q_{\text{WAS}}:** Waste activated sludge flow, MGD
  - **WAS_{\text{mg/L}}:** Waste activated sludge concentration, mg/L
  - **Q_{\text{Eff}}:** Total effluent flow rate, MGD
  - **TSS_{\text{mg/L}}:** Total suspended solids concentration, mg/L

- Mean Cell Residence Time (MCRT)
  - **Days** that a microorganism stays in the activated sludge system before it is wasted.
  - Longer MCRT = Higher MLSS = More Bug Food
- **Problem:**
  - What is the MCRT for April 10th?
  - **Refer to April MRO Sheet 2**

Excel: \[\frac{(MLVSS \times 8.34 \times V_{\text{total}})}{(WAS_{\text{lbs}} + TSS_{\text{lbs}})}\]
Mixed Liquor Control Strategy & Sludge Wasting

• Control Strategy
  – F:M
    • Waste sludge varies depending on influent BOD concentrations
    • If expecting high influent BOD, operators can build up sludge inventory
  – MCRT
    • Constant amount of sludge is wasted to maintain a target MCRT
    • Most common due to it being the easiest to maintain
  – Constant MLSS
    • Waste based on changes in activated sludge growth rate
    • Works well for smaller WWTP’s (minimal lab analysis)

• Problem:
  • Using the MCRT method, how much sludge would need to be wasted (lbs/day) in order to lower the MCRT to 25 days based on where the MCRT is on April 5th?
  • Refer to MRO Sheet 2 & 3

Formula:

\[ \text{WAS}_{\text{lb/day}} = \frac{\text{MLVSS}_{\text{mg/L}} * 5.8 \times 8.34}{\text{MCRT}_{\text{day}}} - \text{Eff TSS}_{\text{lb/day}} \]

5.8 – volume of aeration tanks
8.34 – conversion factor MGD*mg/l to lbs/day
Sludge Wasting Worksheet
Chemical Phosphorus Removal

- Phosphorus Removal Chemicals:
  - Aluminum Sulfate (Alum)
    - 0.87 Alum to 1.0 Phosphorus Ratio
      - Assuming no other reactions
  - Ferric Chloride
    - 1.8 Ferric to 1.0 Phosphorus Ratio
      - Assuming no other reactions

- Where to add chemical?
  - After Primary Clarification
    - Could be utilized as a feed point in conjunction with a feed point before final clarification when surges in P are expected in the waste stream
    - Can overfeed and negatively affect biomass in aeration
  - Before Final Clarification
    - Knowledge of phosphorus treated during aeration so more accurate and preferred feed location for chemical P treatment.

- Problem for Groups 1-3:
  - How many pounds of Alum would be needed to reduce phosphorus down to 0.7 mg/L?

- Problems for Groups 4-5:
  - How many pounds of Ferric would be needed to reduce phosphorus down to 0.7 mg/L?
    - Above assumes a 1.0 mg/L limit but should be conservative
    - Refer to April MRO Sheets 1 & 2
  - Influent P = 7.4 mg/L
  - Effluent P = 2.4 mg/L
Chemical Phosphorus Worksheet
Conversion Factors

1 Cubic Foot = 7.48 Gallons

Conversion from mg/L to Lbs:

\[
\frac{\text{Million Gallons}}{\text{Day}} \times \frac{mg}{L} \times \frac{3.78 \times 10^6 L}{\text{Million Gallons}} \times \frac{Lb}{453,592.4 mg} = 8.34 \frac{Lb}{\text{Day}}
\]
Questions?

Thank you for attending!!

Cindy Fort, PE
cfort@Structurepoint.com
Troy Casey, EI
tcasey@Structurepoint.com

Presentation is available at: www.Structurepoint.com
NEW AERATION TANK 4A

CONTROL GATE (TOP)
See detail 1, WMS-434

NOTE:
AERATION TANK No. 4 IS SHOWN ON THIS DRAWING.
TANK No. 3 IS MIRROR IMAGE IDENTICAL EXCEPT FOR
RETURN SLUDGE BOX AND STAIRS ON SOUTH END.

NEW AERATION TANK 4B

STAIRS

NEW AERATION TANK 4C

SLICHT THROUGH WALKWAY FOR STOP
GATE, PROVIDE ACCESS TO TOP
PLATE PLACED FLUSHED WITH SLICHT.

SLICHT FOR STOP GATE (TOP)

HNTB CORPORATION

CITY OF NOBLESVILLE, INDIANA
PHASE II - WASTEWATER TREATMENT IMPROVEMENTS
PLANT EXPANSION

NEW AERATION TANKS - STRUCTURAL PLAN
### MONTHLY OPERATION REPORT
#### ACTIVATED SLUDGE TREATMENT PLANT

#### MONTH OF Apr-15

#### BYPASS

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#### O&M Seminar Calculations

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#### RAW INFLUENT

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<th>S.S. - mg/L</th>
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#### PRIMARY EFFLUENT

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### PERCENT CAPACITY

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<td>Overall Treatment</td>
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### COMMENTS FOR THE MONTH:
(I.e. major repairs, breakdowns, process upsets and their causes, etc. in plant treatment process bypass)