Optimizations of the Secondary Wastewater Treatment Operations

Detroit Water & Sewerage Department (DWSD) (Great Lakes Water Authority)

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Background Information
About The Detroit Wastewater Treatment Plant

- One of the largest wastewater treatment plants in the US
- Combined sewer systems
- Average dry weather flow: 650 MGD
- Wet weather:
  - Primary capacity 1700 MGD
  - Secondary capacity 930 MGD
About
DWWTP Secondary Treatment

- Activated sludge process
- High purity oxygen through pipeline from Praxair
- Intermediate Lift Pumps pump primary effluent to the aeration tanks
- 4 aeration tanks – designed capacity of 300 MGD each. Generally, 3 tanks are in service.
- 25 secondary clarifiers with a design flow capacity of 50 MGD each
In 2012

The oxygen cost was over the budget…

- More $ needed
- I was involved in
  - Budget adjustment
  - Oxygen budget projection for the next 5 years

2 rates applied in oxygen billing:
  - regular rate -- <350KSCF/H
  - premium rate -- >350KSCF/H, 2.7 times higher
Questions…

- Why?
- Are we able to cut the oxygen costs?
- How?
Problem Statements

- The plant experienced low flows in recent years
- Had some problems associated with low flows
- Traditional operational approaches sometimes do not work effectively
- Need for change
Days of Each Month with Very Low Flows
(Date points represent average daily flows less than 550 MGD)

(2012—207 days; 2013—80 days; 2014—121 days)
Difficulties experienced at such low flows:

- Difficulty maintaining DO levels (2-4 ppm)
- Significant increase in oxygen usage
- Intermediate Lift Pumps kicked out
- Mixers not running properly
- Increase in total P level in the effluent with longer duration of lower DO
Objectives

- Minimize the impacts of the low flow on secondary operations
- Save operating costs
  - Identify critical factors causing the difficulties
  - Find quick field indicators to develop strategies
  - Improve ways to make accurate and timely decisions in adjusting oxygen feed
Methods

- Evaluated long-term operational parameters of the aeration system:
  - influent and RAS flows, oxygen feed, vent purity, deck level, and DO
- Verified field findings with lab tests
- Demonstrated some methods that operators could use in improving the operations
Results and Discussions
Identifying the problems

1. More oxygen was consumed during the low flow periods
Identifying the problems

2. RAS flow rates to the aeration tanks were kept relatively constant no matter how much the influent flow changed.
Identifying the problems

3. In the month of Oct. 2013, daily F/M ratios ranged from 0.26 to 1.10
Understanding
The Importance and Practical Meanings of
F/M Ratios
VS
Influent / RAS Flow Ratios
Ratios of RAS/Inf on DO Depletion Rates

(Lab Oxygen Uptake Rate Tests)
Effects of RAS/Inf Ratios on Oxygen Feed and DO

**High RAS/Inf at Low Flows**
RAS/Inf=63/148=0.4

**Low RAS/Inf at Low Flows**
RAS/Inf=47/146=0.3
Identifying the problem

4. Some challenges that the Secondary Deck Operators faced
Operators have no control of the flows (primary effluent and RAS flows)
PCC controls the above flows
Operators control the oxygen feed
Due to the sudden change of the flow ratio, sometimes adjusting the oxygen feed ALONE can’t maintain the desired DO
Not all of the available control variables were being used
A lack of communications between the two groups was observed

Operators were in a reactive mode—React to changes of DO
Optimization Efforts

From Reactive Mode to Proactive Mode

(What operators can do...)

MWEA2015 90th Annual Conference
1. Be alert to changes in influent flows

Table 1. Effects of sudden significant flow change on DO (10/20/2013) on Deck 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Flow (MGD)</th>
<th>RAS (MGD)</th>
<th>O2 flow (KSCF/H)</th>
<th>DO (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4am</td>
<td>270</td>
<td>39</td>
<td>40</td>
<td>3.68</td>
</tr>
<tr>
<td>5am</td>
<td>229</td>
<td>39</td>
<td>40</td>
<td><strong>2.86</strong></td>
</tr>
<tr>
<td>6am</td>
<td>201</td>
<td>39</td>
<td>51</td>
<td>1.07</td>
</tr>
<tr>
<td>7am</td>
<td>182</td>
<td>39</td>
<td>72</td>
<td>0.14</td>
</tr>
<tr>
<td>8am</td>
<td>183</td>
<td>39</td>
<td>86</td>
<td>0.22</td>
</tr>
</tbody>
</table>
2. Communicate with PCC

Consider the possibility of lowering the RAS flow to the deck during the low flow period

Table 2. Oxygen usage at low flow

<table>
<thead>
<tr>
<th>Flow (MGD)</th>
<th>RAS (MGD)</th>
<th>RAS/Inf</th>
<th>O2 use (KSCF/H)</th>
<th>Keep DO (2-4ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>60</td>
<td>0.4</td>
<td>130</td>
<td>hard</td>
</tr>
<tr>
<td>150</td>
<td>50</td>
<td>0.3</td>
<td>70-80</td>
<td>OK</td>
</tr>
<tr>
<td>150</td>
<td>40</td>
<td>&lt;0.3</td>
<td>&lt;80</td>
<td>easy</td>
</tr>
</tbody>
</table>
3. Be alert to the changes in vent purity

- Good indicator in predicting the DO trend
- High vent purity is an indication of oxygen waste, must correct sooner.
An aggressive approach to correct vent purity
(10/24/2013 at Deck 1)

<table>
<thead>
<tr>
<th>Time</th>
<th>Vent purity (%)</th>
<th>O2 flow (KSCF/H)</th>
<th>DO (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6am</td>
<td>59</td>
<td>112</td>
<td>1.38</td>
</tr>
<tr>
<td>7am</td>
<td>59</td>
<td>112</td>
<td>1.40</td>
</tr>
<tr>
<td>8am</td>
<td>59</td>
<td>112</td>
<td>1.93</td>
</tr>
<tr>
<td>9am</td>
<td>59</td>
<td>69</td>
<td>2.31</td>
</tr>
<tr>
<td>10am</td>
<td>58</td>
<td>69</td>
<td>2.46</td>
</tr>
<tr>
<td>11am</td>
<td>57</td>
<td>68</td>
<td>4.20</td>
</tr>
<tr>
<td>12pm</td>
<td>56</td>
<td>68</td>
<td>1.73</td>
</tr>
<tr>
<td>1pm</td>
<td>54</td>
<td>69</td>
<td>1.96</td>
</tr>
<tr>
<td>2pm</td>
<td>52</td>
<td>69</td>
<td>2.15</td>
</tr>
<tr>
<td>Oxygen saved</td>
<td>258 KSCF in 6 hrs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A conservative approach to correct vent purity
(7/20/2014 at Deck 1)

<table>
<thead>
<tr>
<th>Time</th>
<th>Vent purity (%)</th>
<th>O2 feed (KCF/H)</th>
<th>DO (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8am</td>
<td>44</td>
<td>63</td>
<td>3.9</td>
</tr>
<tr>
<td>9am</td>
<td>43</td>
<td>53</td>
<td>4.3</td>
</tr>
<tr>
<td>10am</td>
<td>43</td>
<td>53</td>
<td>4.5</td>
</tr>
<tr>
<td>11am</td>
<td>42</td>
<td>52</td>
<td>4.2</td>
</tr>
<tr>
<td>12pm</td>
<td>42</td>
<td>52</td>
<td>4.1</td>
</tr>
<tr>
<td>1pm</td>
<td>41</td>
<td>49</td>
<td>4.3</td>
</tr>
<tr>
<td>2pm</td>
<td>40</td>
<td>49</td>
<td>4.2</td>
</tr>
<tr>
<td>3pm</td>
<td>39</td>
<td>49</td>
<td>4.0</td>
</tr>
<tr>
<td>4pm</td>
<td>39</td>
<td>49</td>
<td>3.6</td>
</tr>
<tr>
<td>5pm</td>
<td>37</td>
<td>49</td>
<td>3.2</td>
</tr>
<tr>
<td>6pm</td>
<td>36</td>
<td>48</td>
<td>3.0</td>
</tr>
<tr>
<td>7pm</td>
<td>36</td>
<td>48</td>
<td>2.9</td>
</tr>
<tr>
<td>8pm</td>
<td>35</td>
<td>48</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Oxygen saved**: 157KCF @Deck 1 in 12 hrs
4. When putting a new deck in service

- RAS/Inf ratio should be lower than the designated ratio
- If possible, the RAS flow should be introduced later than the Inf flow
Case 1 - Started Inf & RAS the Same Time

Case 2 - Started Inf First, introduced RAS 1.5 hrs Later

Case 3 - Started Inf First, Introduced RAS 30 min Later

Flow (MGD); Feed (KCF/H)

DO (mg/L)

Hours after the start up

Technical Programs
<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time lag between Inf/RAS</td>
<td>0</td>
<td>2 hrs</td>
<td>30 min</td>
</tr>
<tr>
<td>RAS/Inf flow ratio</td>
<td>26%</td>
<td>15%</td>
<td>29%</td>
</tr>
<tr>
<td>Oxygen feed rate (KSCF/H)</td>
<td>Started 40K, increased to 91K</td>
<td>Started 26K, increased to 50K</td>
<td>Constant feeding 56K</td>
</tr>
<tr>
<td>Hrs took to get desired DO</td>
<td>12 hrs</td>
<td>2.5 hrs</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Time of the year</td>
<td>7/18/14</td>
<td>3/3/14</td>
<td>11/8/13</td>
</tr>
<tr>
<td>Deck Temp (C)</td>
<td>19</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Total oxygen consumed (KCF)</td>
<td>771</td>
<td>108</td>
<td>157</td>
</tr>
</tbody>
</table>
Result of the efforts on cost reduction
Comparison of Oxygen Costs

Annual cost: 2012-2013 = $4.2M; 2013-2014 = $3.4M; 2014-2015 = $3.2M*

Oxygen cost (M$) vs. Month

- 2012-2013
- 2013-2014
- 2014-2015
- 2012-2013P
- 2013-2014P
- 2014-2015P

Premier Rate (1000$) vs. Month:

- July
- August
- September
- October
- November
- December
- January
- February
- March
- April
- May
- June
Conclusions

- Decreasing the RAS flow was the most effective way in dealing with low flows
- This is ONLY the first step in the optimizations
- More operational changes are needed to improve the processes
- Working together is the ultimate solution
  - Improve communications (operators/controllers/engineers)
  - Important to listen / respect each other’s opinions
- DWSD direction – Automations. They have to be correctly understood, maintained, and calibrated by all the users
Questions?