

**CVEN 5534**  
**Spring 2008**

**BioWin Project**  
**DUE: Thursday April 10, 2008**

**PROJECT INFORMATION**

A wastewater treatment plant is to be designed to treat wastewater with the following characteristics:

| Influent Characteristics |                                   |                                             |                                          |                                          |
|--------------------------|-----------------------------------|---------------------------------------------|------------------------------------------|------------------------------------------|
| Statistic                | Influent Flow<br>MGD<br>(n = 815) | Influent BOD<br>mg/l<br>24 HC*<br>(n = 250) | Influent TSS mg/l<br>24 HC*<br>(n = 250) | Influent TKN<br>mg/l 24 HC*<br>(n = 133) |
| average                  | 1.84                              | 236.4                                       | 256                                      | 27.0                                     |
| median                   | 1.81                              | 238.0                                       | 250                                      | 26.4                                     |
| stddev                   | 0.18                              | 51.8                                        | 49                                       | 4.7                                      |
| max                      | 2.66                              | 425.0                                       | 480                                      | 55.6                                     |
| min                      | 1.44                              | 26.0                                        | 138                                      | 17.3                                     |

\*24-hour composite (HC) which is the daily average

The influent total suspended solids fractions are as follows:

Slowly degradable particulate (VSS) = 0.85 TSS

Inert particulates = 0.15 TSS (no nitrogen in influent inert particulates)

Particulate organic nitrogen in VSS = 0.087 g-N/g-VSS (as COD)

Ratio influent  $\text{NH}_4\text{-N}$ /TKN = 0.8

Discharge permit limits for effluent are as follows:

|                                                                                           |            |
|-------------------------------------------------------------------------------------------|------------|
| BOD                                                                                       | < 10 mg/l  |
| TSS                                                                                       | < 10 mg/l  |
| $\text{NH}_4\text{-N}$                                                                    | < 0.3 mg/l |
| Total soluble nitrogen =<br>$\text{NH}_4\text{-N} + \text{NO}_3\text{-N} + \text{org. N}$ | < 10 mg/l  |

Other Constraints:

Rate of oxygen consumption per tank = 1,500 mg/l/day

Secondary clarifier underflow suspended solids < 10 g/l

1,000 mg/l > Bioreactor MLSS < 2,500 mg/l (as solids mass, not COD)

Secondary clarifier overflow rate,  $(Q/A)_s$ :  $16 < (Q/A)_s < 28 \text{ m}^3/\text{m}^2/\text{d}$

Primary clarifier overflow rate,  $(Q/A)_p$ :  $30 < (Q/A)_p < 50 \text{ m}^3/\text{m}^2/\text{d}$

## PROJECT SCOPE AND ACTIVITIES

The goal of this project is to design an activated sludge treatment process to remove COD, suspended solids and nitrogen from influent wastewater as specified by permit limits and at the same time meeting process constraints, using BioWin software. In addition you will evaluate the effects of plant design and operation on performance and costs. Work in teams of no more than 3.

**Activity 1:** Design the activated sludge process stream consisting of:

1. Influent
2. Primary clarifier (use ideal clarifier component and assume 65% removal of total suspended solids in the tank)
3. Bioreactor(s) for COD oxidation, nitrification and denitrification. Aerated bioreactors should be operated using an oxygen set point. You may use single CSTR's or CSTR's in series, with the reactor number and sequence optimized for treatment performance and cost.
4. Secondary clarifier using the actual clarifier component and the default BioWin model for clarifiers
5. Splitter(s) for recycled activated sludge and sludge wasting. The recycled activated sludge flow rate should be between 0.5 and 1 times the influent flow rate.
6. Mixer(s) for combining influent and recycled flows.
7. Use default kinetic and stoichiometric parameters in BioWin for simulation
8. You may either set the sludge wasting rate and let BioWin calculate SRT ( $\Theta$ ) or control the SRT ( $\Theta$ ) and let BioWin set the wasting rate.

Adjust bioreactor tank configuration, size and operating conditions as well as the biosolids wasting rate or  $\Theta$  to achieve a design that meets the facility operator's objectives:

- Lowest capital costs, as determined by tank volume.
- Lowest operations cost, as determined by cost of energy for air supply and cost of biosolids disposal.
- Ability of the plant to operate at a sustained combined maximum of flow rate and BOD concentration as given in the influent characteristics data (under steady-state condition).

Cost Information:

- Assume cost of waste biosolids treatment disposal is \$600/metric ton (dry weight basis).
- Assume cost of aeration is approximately 1.5 kg-O<sub>2</sub>/hr/kW for a typical diffused air blower aeration system, and the cost of electric power averages \$0.09/kwh.

**Activity 2.** For smaller plants such as the one you are designing, the primary clarifier may be removed. Redo your design from activity 1 omitting the primary clarifier.

**Activity 3.** Do a mass balance for nitrogen on the plant showing distribution and speciation of influent nitrogen (soluble and particulate forms). Nitrogen gas generation rate can be estimated from the nitrate consumption (denitrification) rate reported in BioWin.

## PROJECT DELIVERABLES

**Submit an electronic copy of the BioWin configuration files for your final design for Activity 1 and Activity 2.**

**Written Report (also may be submitted in electronic form)**

### Activity 1

1. Explain how you arrived at your initial process configuration (tank configuration, size, etc.), i.e., what calculations you used and assumptions you made.
2. Show the steps you made to optimize your treatment process sequence and related effects of the changes on performance, and cost.
3. Provide a process schematic including a table of the physical characteristics of the process components, flow rates in pipes and flow splits.
4. Report BioWin output in tabular form including
  - Process state variables for each tank: MLSS/TSS, heterotrophic and autotrophic cells, dissolved oxygen, pH,
  - Effluent Water Quality (COD, BOD, all nitrogen species, solids, pH)
  - Biomass solids generation rate (as metric tons per year dry weight)
  - Oxygen consumption rate
5. Power consumption and cost for aeration (kwh/year and \$/year)
6. Biosolids disposal costs (\$/year)
7. Discuss how the process design and operation factors you varied affected effluent quality, oxygen consumption, and biosolids generation. (You could show this partly in tabular form as output from intermediate simulations as you approached your best design with appropriate commentary.) Your discussion should be complete and indicate your understanding of how process design affects performance and costs.

### Activity 2

1. In tabular form, report the effect of removing the primary clarifier on:
  - a. COD and nitrogen removal
  - b. MLSS/TSS
  - c. Oxygen consumption rate and costs
  - d. Biosolids generation rate and costs
2. Discuss these effects and make a decision about including a primary clarifier in plant design. Your discussion should be a complete explanation of effects you observed in your simulation.

### Activity 3

1. Report the nitrogen mass balance in tabular form, as kg-N/d entering and leaving the plant.
2. Calculate and report the nitrogen content (% dry weight) of the wasted biosolids.