CVEN 5534, WASTEWATER TREATMENT
FALL 2010

BIOSOLIDS DIGESTER MODELING AND OPENCEL EVALUATION PROJECT

The Metro Wastewater Reclamation District (MWRD) uses anaerobic digestion to reduce the biomass, achieve pathogen reduction and to produce a renewable resource in methane gas. The District operates the anaerobic digesters to achieve the required pathogen reduction by controlling the temperature and detention time within the digesters. Digestion performance must be regulatory requirements for a Class B biosolids land application process. The MWRD facility has twelve 100-ft diameter digesters (31-ft sidewater depth), with one of the twelve digesters operating in an acid-gas phase. The total digester volume with all units in service equals 21.2 million gallons.

The Anaerobic digestion complex receives solids from the following unit processes.

- Thickened primary solids from four gravity thickeners
- Thickened secondary solids (WAS) from dissolved air flotation (DAF) systems
- Grease received by scum skimming from primary clarifiers

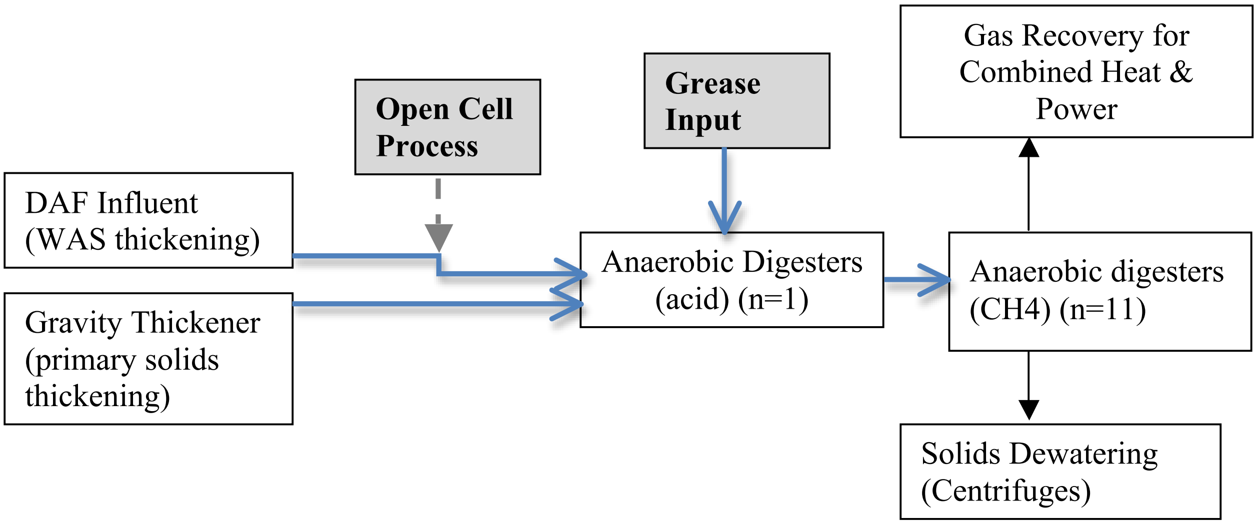
During the digestion process, methane gas is captured and beneficially reused to generate electricity to power our support facilities. MWRD tries to optimize gas production and use of this renewable resource instead of flaring the gas to the environment. The anaerobic digestion complex has two digesters (5 and 6) which have floatable covers while the others have fixed concrete covers.

How should the District operate the anaerobic digestion complex to maximize the gas production within a reasonable financial pay back period. In addition to the financial return on the investment, the teams should also determine what the societal benefit would with the increased gas production. Process improvements to be considered could include the following:

- Use of OpenCEL technology

DATA Provided
Gravity Thickener data: monthly flow and solids loading from ODS reports
DAF data: monthly flow and solids loading from ODS reports
Grease data: monthly loading data from ODS Reports
Cost data for OpenCEL, aeration, natural gas, and biosolids land disposal

Metro Anaerobic Digestion Process



PROJECT SCOPE AND ACTIVITIES

Develop a simulation model of the anaerobic digestion system using BioWin and plant operating data. Calibrate your model with one data subset and verify with a second independent data subset.

I will provide the gas production and anaerobic data also as a check.

Compare model output of gas production and digester destruction to plant performance and to permit limits in steady-state conditions. Predict the variability of gas production through the month and how to optimize or increase the production through various technologies. Calculate a financial return on investment effluent quality throughout the day. The effect of diurnal variation should be considered using a dynamic simulation method in BioWin. Long-term variability may be considered as a set of steady state simulations with a range of influent flow and water quality data selected to fit Metro data or using a dynamic simulation in BioWin. Identify the limiting element (process) of the treatment system with regard to capacity and effluent quality.

PROJECT DELIVERABLES

Submit a report showing the anaerobic digestion impact of the OpenCEL process on digester performance, and related impacts on biosolids disposal, energy, and liquid treatment, including costs and environmental impacts of adding.

1. Simulate anaerobic digester performance using BioWin steady-state simulation of the AciMet system at Metro.
   a. The AciMet process means that one of the 12 equal-sized digester tanks at Metro (the acid tank) receives the entire flow of mixed primary and waste activated sludge. The effluent from the "acid" digester is then distributed evenly among the other 11 tanks, which is where the bulk of the methane production occurs. The "acid" digester has a short residence time, relative to the methane-producing tanks. Use the flow and constituent data from the Metro Digester spreadsheet. You want to match the Metro data for digested sludge in terms of total solids (TS), volatile solids (VS), volatile solids reduction.
   b. Show BioWin simulation configuration information, input data, including WW fractions and any kinetic or stoichiometric parameters you adjusted to calibrate your model, in tabular form. In another table, compare conditions in acid and methane digesters to Metro data for TS, VS, %VS reduction, gas generated and methane content, pH, ammonia, COD, and alkalinity.
   c. Discuss how well your BioWin model was able to simulate plant digester data, and what factors might account for differences.

2. Now simulate digester performance adding the OpenCEL process using BioWin steady-state simulation.

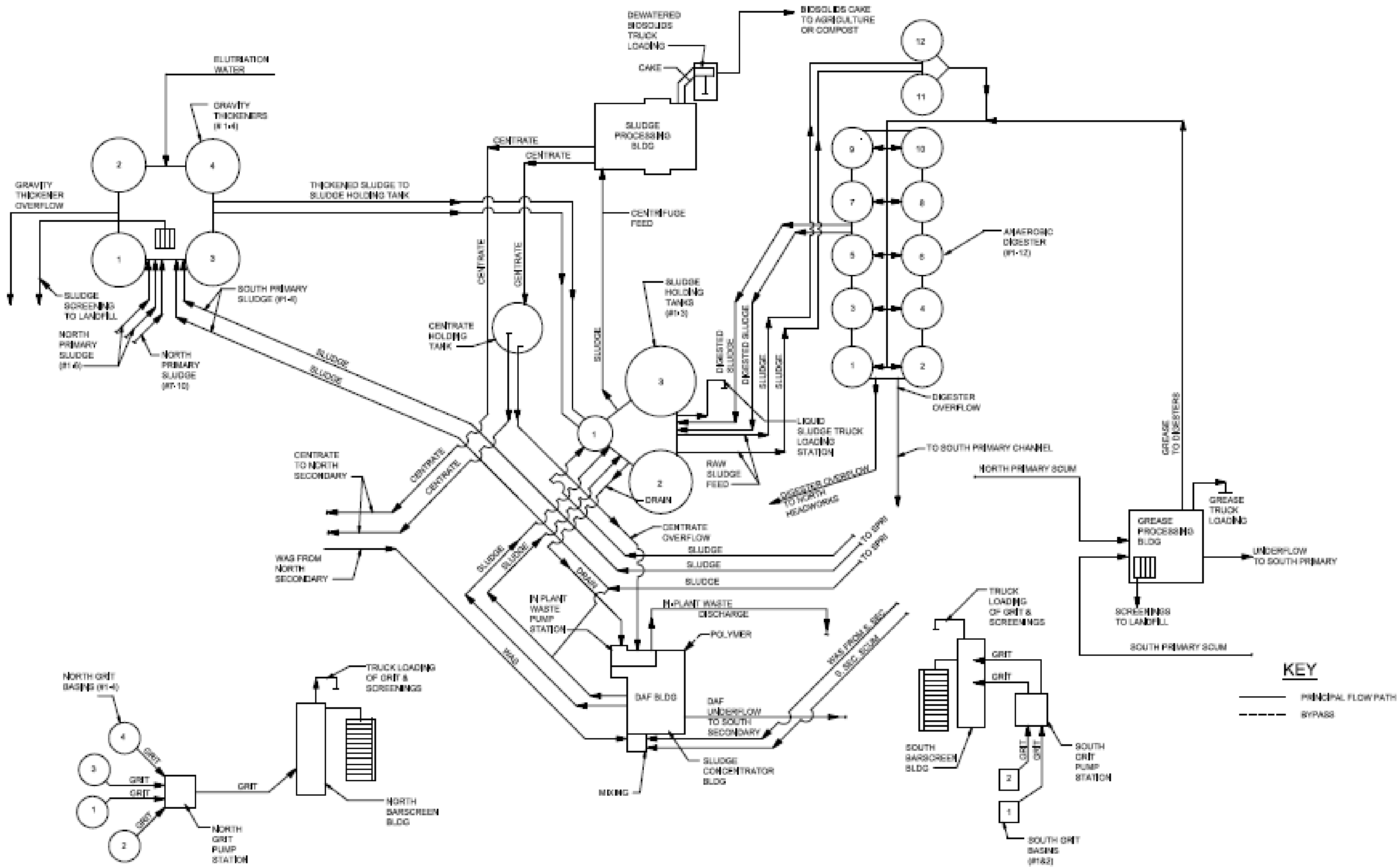
   a. Do this by increasing the hydrolysis rate for the anaerobic digester organisms, since the effect of the electric current added with OpenCEL is to blast cells apart, essentially like hydrolysis. OpenCEL claims a 25-35% increase in gas production. It is not clear if that is for the WAS fraction only or the total gas produced. I will try to get an answer. In the meantime, assume the increase is for the WAS fraction only.
   b. Show BioWin simulation configuration information and describe how you simulated the OpenCEL process addition. In a table, compare the simulated BioWin performance with and without OpenCEL. In addition to gas generation TS and VS reduction, consider other factors:
      i. Ammonia released and returned to the activated sludge process via the centrate.
      ii. Assuming the heavy metals will still be associated with the solids fraction, estimate a concentration increase factor for metals, given that there will be fewer solids produced, but the same metals, with the OpenCEL process. Kuchenrither handed out a biosolids metals sheet in class.
   c. Discuss the effects of the OpenCEL process on digester performance

3. Discuss the costs and benefits of the OpenCEL process considering the following:

    a. Cost of the OpenCEL system:
        i. **Capital: $27,860,000 annualized over 20-year equipment life.**
        ii. **Annual: $1,106,000.**
    b. Value of additional gas generated, assuming is can be used as a substitute for methane in heating or generating electricity. **2007 price for natural gas in the US was ~$0.25/m^3. Alternately, Metro's estimate is $8.25/MMBtu for natural gas.** Calculate this on an annual basis assuming no change in flows or composition.
    c. Value of extra volatile solids reduction.
        i. Benefits: reduction in disposal costs. **Cost for land application of dewatered biosolids is estimated to be $500/dry ton (average of MetroGRO farm, private composting, and private farm application costs).** Calculate land disposal benefit on annual basis.
        ii. Costs: increased treatment costs, expressed as oxygen demand, for soluble ammonia and COD added to centrate and returned to the activated sludge process. **Cost of oxygen addition for conventional aeration system is estimated from the power requirement of 1.5 kg-O2/hr/kw and cost of electricity for blowers can be assumed to be $0.06/kwh.** Estimate added aeration costs on an annual basis.
    d. Economic decision model.
        i. Cost/benefit ratio or net benefit (or cost) analysis. Bring all costs to an annual basis by discounting the capital cost of OpenCEL over its 20-year life, or calculate present worth value of annualized costs and benefits over n=20 years.
        ii. Return on investment. Calculated by subtracting present worth of capital costs from future worth (t = n = 20 years) of net benefits.

4. The non-monetary costs and benefits that Metro staff should consider including factors such as

    a. labor training and monitoring requirements,
    b. risk/safety concerns in OpenCEL process operation,
    c. possible need for increased gas storage,
    d. impact on land disposal of biosolids if metals concentration factor is high, and
    e. any other factors you think are important.


ELUTRIATION WATER
GRAVITY THICKENERS (#1-4)
GRAVITY THICKENER OVERFLOW
SLUDGE SCREENING TO LANDFILL
SOUTH PRIMARY SLUDGE (#1-6)
NORTH PRIMARY SLUDGE (#1-6)
NORTH PRIMARY SLUDGE (#7-10)
THICKENED SLUDGE TO SLUDGE HOLDING TANK
CENTRATE
SLUDGE PROCESSING BLDG
DEWATERED BIOSOLIDS TRUCK LOADING
CAKE
BIOSOLIDS CAKE TO AGRICULTURE OR COMPOST
CENTRIFUGE FEED
CENTRATE HOLDING TANK
SLUDGE HOLDING TANKS (#1-3)
DIGESTED SLUDGE
SLUDGE
LIQUID SLUDGE TRUCK LOADING STATION
RAW SLUDGE FEED
ANAEROBIC DIGESTER (#1-12)
DIGESTER OVERFLOW
TO SOUTH PRIMARY CHANNEL
DIGESTER OVERFLOW TO NORTH HEADWORKS
DRAIN
CENTRATE OVERFLOW
TO SPRI
CENTRATE TO NORTH SECONDARY
WAS FROM NORTH SECONDARY
IN PLANT WASTE PUMP STATION
IN-PLANT WASTE DISCHARGE
POLYMER
DAF BLDG
WAS
DAF UNDERFLOW TO SOUTH SECONDARY
WAS FROM S. SEC.
S. SEC. SCUM
SLUDGE CONCENTRATOR BLDG
MIXING
NORTH PRIMARY SCUM
GREASE TO DIGESTERS
GREASE PROCESSING BLDG
GREASE TRUCK LOADING
UNDERFLOW TO SOUTH PRIMARY
SCREENINGS TO LANDFILL
SOUTH PRIMARY SCUM
KEY
PRINCIPAL FLOW PATH
BYPASS
NORTH GRIT BASINS (#1-4)
GRIT
NORTH GRIT PUMP STATION
TRUCK LOADING OF GRIT & SCREENINGS
NORTH BARSCREEN BLDG
TRUCK LOADING OF GRIT & SCREENINGS
SOUTH BARSCREEN BLDG
SOUTH GRIT PUMP STATION
SOUTH GRIT BASINS (#1&2)