CENTRAL CARBON MUNICIPAL AUTHORITY
WASTEWATER TREATMENT FACILITY
LEHIGHTON, CARBON COUNTY, PENNSYLVANIA

NPDES # PA0063711

WASTEWATER TREATMENT EVALUATION

APRIL - MAY 2017

Prepared by:

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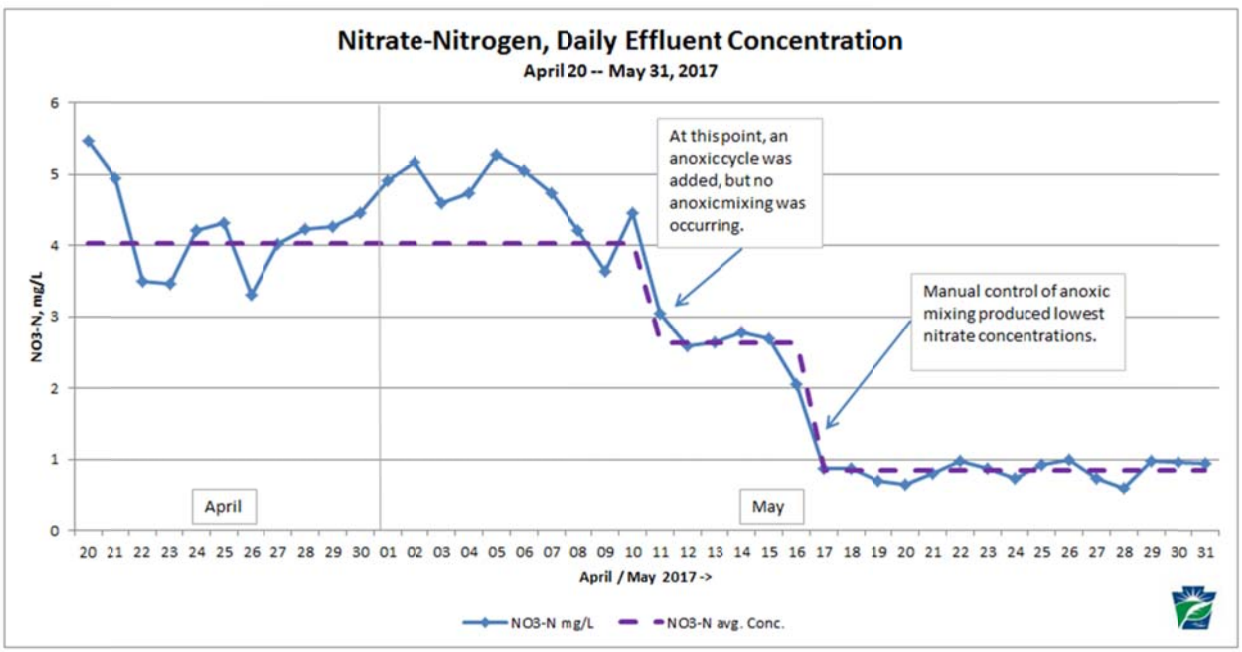
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

Executive Summary:

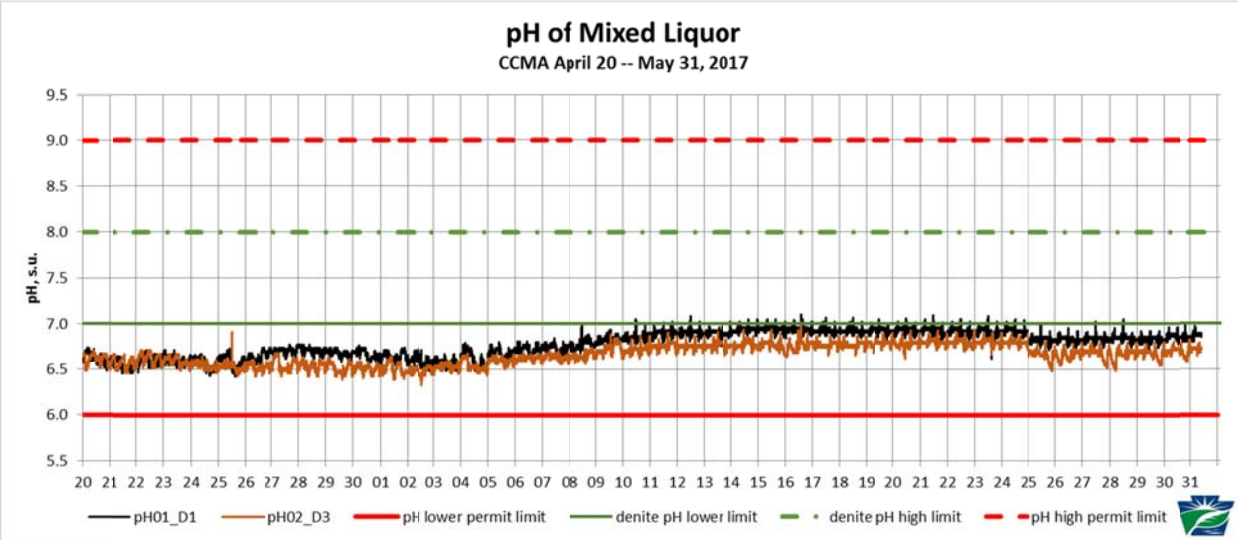
For six weeks from late April through May, 2017, DEP staff conducted a Wastewater Treatment Evaluation (WTE) at the Central Carbon Municipal Authority's (CCMA) wastewater treatment facility located along the west bank of the Lehigh River near the Borough of Lehighton in Carbon County, Pennsylvania. The purpose of the WTE was to monitor and optimize the integration of a denitrification phase into the facility's supervisory control and data acquisition (SCADA) program whereby it was expected by the owners and operators that improved biological nutrient removal (BNR) would enhance the effluent water quality, resulting in improvements to the watershed and to the Delaware Bay to which the river ultimately flows. The treatment facility at the time was operating in compliance with its existing NPDES Permit limits, although it had past excursions for total suspended solids. EPA staff requested use of the DEP's instrumentation to aid in optimizing BNR operations at this facility.

At this facility, nitrate-nitrogen concentrations were already modest in comparison to those of most non-BNR plants, at less than ten milligrams per liter, despite the absence of supplemental alkalinity. This was likely due to the long settling interval for clarification. During the WTE, the Kruger Process timing cycles were adjusted to include and anoxic cycle for denitrification, resulting in a 34% drop in nitrate concentration. Because proprietary SCADA programming could not be easily changed to activate automatic anoxic mixing, the operator next manually controlled the anoxic mixers. After making these two adjustments, the facility reduced its effluent nitrate-nitrogen by 80% while maintaining virtually complete nitrification.



Graph 1: Effluent nitrate-nitrogen concentration effectively dropped by 80% as a result of enacting a denitrification cycle in the Kruger Process SCADA programming. No supplemental alkalinity was added at the time.

Following completion of the field data collection, the SCADA programming was modified by its contract vendor, Veolia, to make the anoxic mixing automatic. The operator reported that the change from manual anoxic mixing to automatic anoxic mixing did not reduce nitrate-nitrogen much further. DEP believes that this was due to lack of supplemental alkalinity, which would have been necessary to bring mixed liquor pH up from an average 6.7 s.u. to the ideal concentration range of 7.5 s.u. to 8.0 s.u. needed for optimal denitrification.



Graph 2: MLSS pH did not rise into the 7.9-8.0 s.u. range required for optimal denitrification. This is evidence that nitrification is producing more acid byproduct than can be neutralized without supplemental alkalinity in the form of lime, carbonate, bicarbonate, caustic soda, or magnesium hydroxide.

There may have been additional need for supplemental carbon to drive the denitrification process; however, due to the size of the facility and the costs of obtaining supplemental carbon during the limited time of the WTE, this could not be evaluated. DEP staff believes that alkalinity and pH are the limiting factors in optimizing the denitrification process.

In addition to evaluating the Kruger process, DEP lent a motor timer for use with the aerobic digester blower. Staff attempted to employ intermittent aeration at the digester to further denitrify decanted supernatant, but the proprietary SCADA software would not allow its use, and incorporating an anoxic phase into the digesters would have incurred additional monetary outlays that were not available at that time.

Recommendations:

Consult with your facility engineer to:

1. Reprogram the SCADA controls to permit use of existing subsurface mixers during the denitrification phase and to allow for an adjustable anoxic treatment period for the digesters.
2. Add supplemental alkalinity to the process to maintain sufficient mixed liquor alkalinity, possibly greater than 150 mg/L as $CaCO_3$. Alternatives to lime addition, such as the use of 61% magnesium hydroxide (Magnesia) were discussed, but not priced, during the evaluation.
3. If after the alkalinity issue is resolved and denitrification does not improve then consider adding supplemental carbon at the outer ditches during anoxic periods. Engineers typically recommend using wood alcohol (methanol,) but it may be possible to secure a steady supply of food processing waste as a cheaper substitute.

4. Continue to explore energy efficiency opportunities throughout the facility. A significant energy saving project was identified, about $6k/year, which could provide a funding stream for alkalinity chemicals.

Wastewater Treatment Evaluation:

DEP's Wastewater Technical Assistance Program (WWTAP) offers a wastewater treatment evaluation (WTE) that comprises round-the-clock monitoring of key treatment parameters with laboratory and practical experiences in order to optimize effluent quality, often above permit requirements, by making process changes that do not typically involve capital projects. The WTE may be thought of as a custom-tailored trouble-shooting and comprehensive site inspection that aims to solve common wastewater treatment problems through interaction with licensed wastewater treatment operators. DEP operates this program as part of a federal grant to reduce nutrient pollution in waters of the United States.

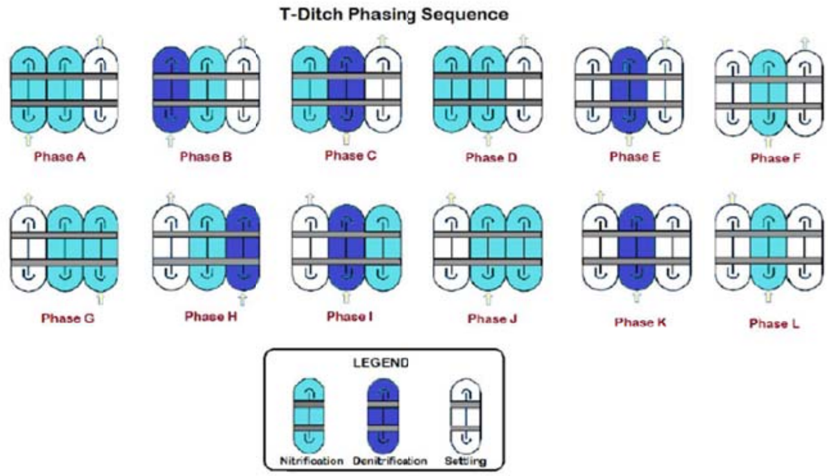
The CCMA facility is permitted for up to 1.6 MGD annual average flow with an organic capacity of 2,936 lb/day as BOD_5. Treatment includes a Kruger Process triple oxidation ditch that provides secondary activated sludge treatment with clarification and includes a main pumping station, fine-screening and grit-removal headworks, ultraviolet (UV) disinfection, and effluent freshening operated under NPDES Permit # PA0063711. The facility presently monitors and reports nutrients, including nitrite-nitrate, ammonia nitrogen, total Kjeldahl nitrogen (TKN), and total phosphorus. Since 2014, the facility also monitors its effluent on a quarterly basis for copper, zinc, aluminum, iron, and manganese.

Solids management processes include sludge thickening, aerobic digestion, decanting, and disposal to 38,400 s.f. of reed beds or alternative disposal to the Hazleton Sewer Authority Solids Management Program. Chemical addition includes provision for Lime addition as process alkalinity enhancement, but it is not presently used. In the past, polymer flocculants have been used to assist in sludge settling.

The evaluation took place without the use of Kruger Process programming for a denitrification phase, whereby subsurface anoxic mixing would occur. Instead, the facility operator extended the idle time for the aeration brush rotors while continuing to provide raw wastewater as a carbon source. The resultant reduction in effluent nitrate was effective, considering this modified intermittent “ON/OFF” aeration approach. Lime addition was not provided. Following this evaluation, the facility operator has also considered employing intermittent aeration at the aerobic digesters; however, the SCADA programming would not permit the use of analog timing devices to control aeration there.

Equipment was deployed on April 20, 2017, following initial consultation with US EPA Outreach Staff and with the Superintendent of the CCMA facility. CCMA had recently become interested in an un-used feature of the Kruger Process oxidation ditches' SCADA program that would optimize effluent quality. The illustration below shows the triple-ditch phasing sequences for BNR at this facility. Prior to this WTE, the facility had no overriding concerns to add denitrification to its treatment, although the NPDES permit renewal in 2014 began requiring “monitor and report” values for nutrients, without actual loading limits.

The phasing diagram shows denitrification in dark blue, nitrification in cyan, and clarification in white:



DEP placed eight in-line probes into ditches one and three, while the central Ditch no. 2 operates continuously as an oxic zone and the ditches to either side cycle through phases leading to the decanting of clarified secondary effluent. The probes included: pH/Temperature, Oxidation/Reduction Potential (ORP,) Dissolved Oxygen (DO,) and Total Suspended Solids (TSS.) A probe for Total Organic Carbon (TOC,) calibrated against 5-day Biochemical Oxygen Demand (BOD_5,) was installed at the raw influent splitter, and probes for nitrate-nitrogen and ammonia-nitrogen were installed into a wet well immediately preceding the ultraviolet (UV) disinfection system. A schematic for probe placement is provided as Attachment B. Probes were connected to a supervisory controller network (not SCADA) and thence to two datalogging systems, one local for the benefit of facility staff, and the other remote, for DEP's data acquisition and evaluation. Laboratory equipment was also deployed for checking and calibrating the in-line probes.

During the first two weeks of the project, background data was recorded by the probes. The facility was already operating well within its permit limits, with ammonia-nitrogen barely detectable at 0.010 mg/L and nitrate-nitrogen varying between 4.0 and 6.0 mg/L. Alkalinity concentrations were between 0 and 40 mg/L routinely, with the pH of the treatment tanks typically in the 6.6 to 6.8 SU range. Nitrification acidifies water, and the raw wastewater is already pH-deficient at the head of the plant. Denitrification will return some alkalinity to the system; however, the amount is insufficient to recover all that lost to complete nitrification. CCMA was equipped with a lime silo and delivery system for managing process alkalinity; however, it has never been used. It should be noted here that facilities where alkalinity is not managed may encounter periods of reduced performance during which increasing acidity of the mixed liquor inhibits biomass growth and reproduction, resulting in loss of denitrification, followed by incomplete nitrification.

At the end of this project:

- Effluent Total Nitrogen (TN) concentration was reduced by over 75%. Quarterly test results below compare values for similar and cool weather treatment conditions:
    - June 2016 – 8.65 mg/l TN
    - March 2017 – 8.98 mg/l TN
    - June 2017 – 1.82 mg/l TN

  This translated to a 79% reduction in nitrate-nitrogen loading to the Lehigh River.
- An energy saving potential was identified with the aerobic digesters, where savings of up to $6k/year could provide funding for alkalinity chemicals.

ATTACHMENT A: PROJECT TEAM

--for the Central Carbon Municipal Authority		*--for PA DEP*
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ATTACHMENT B: PROCESS SCHEMATIC & PROBE PLACEMENT

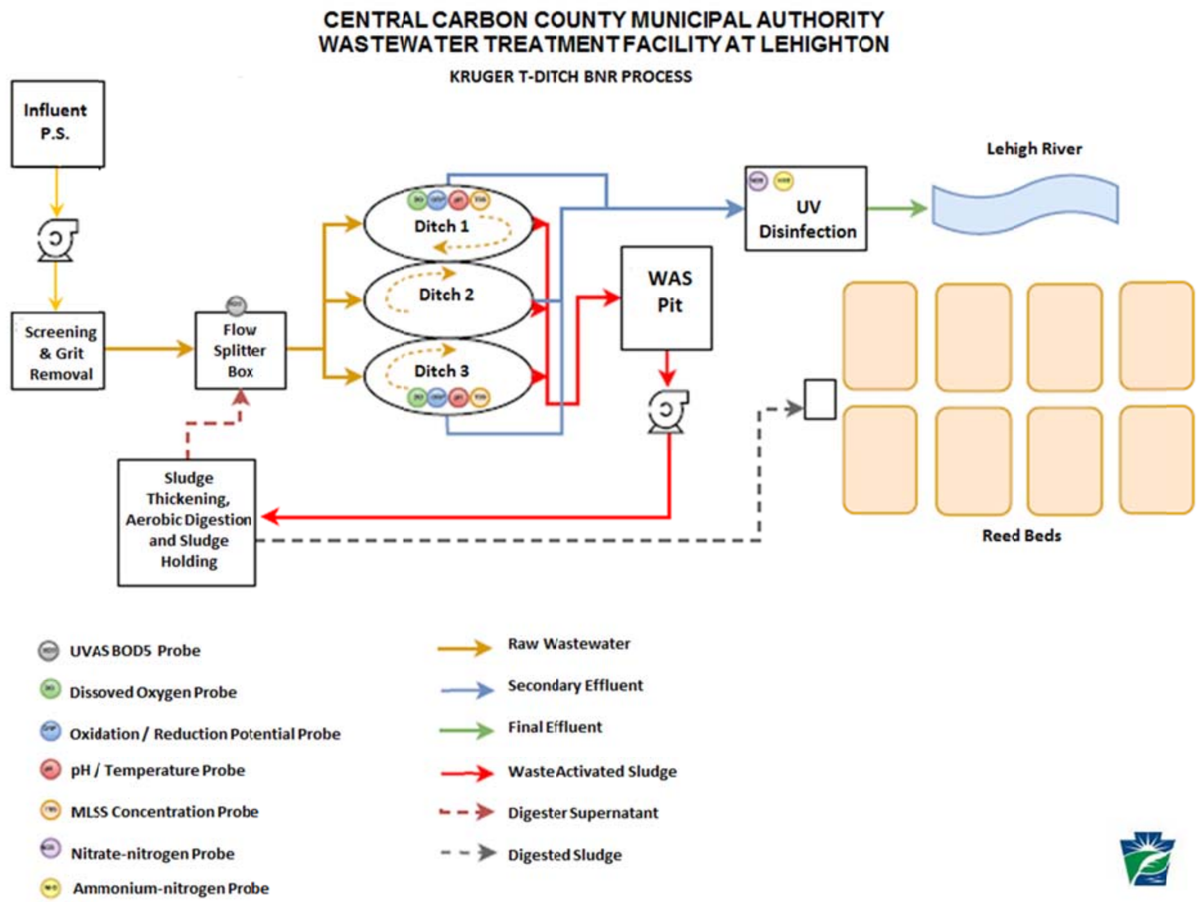


Figure 1: Process Diagram of CCMA including WTE sensor location.

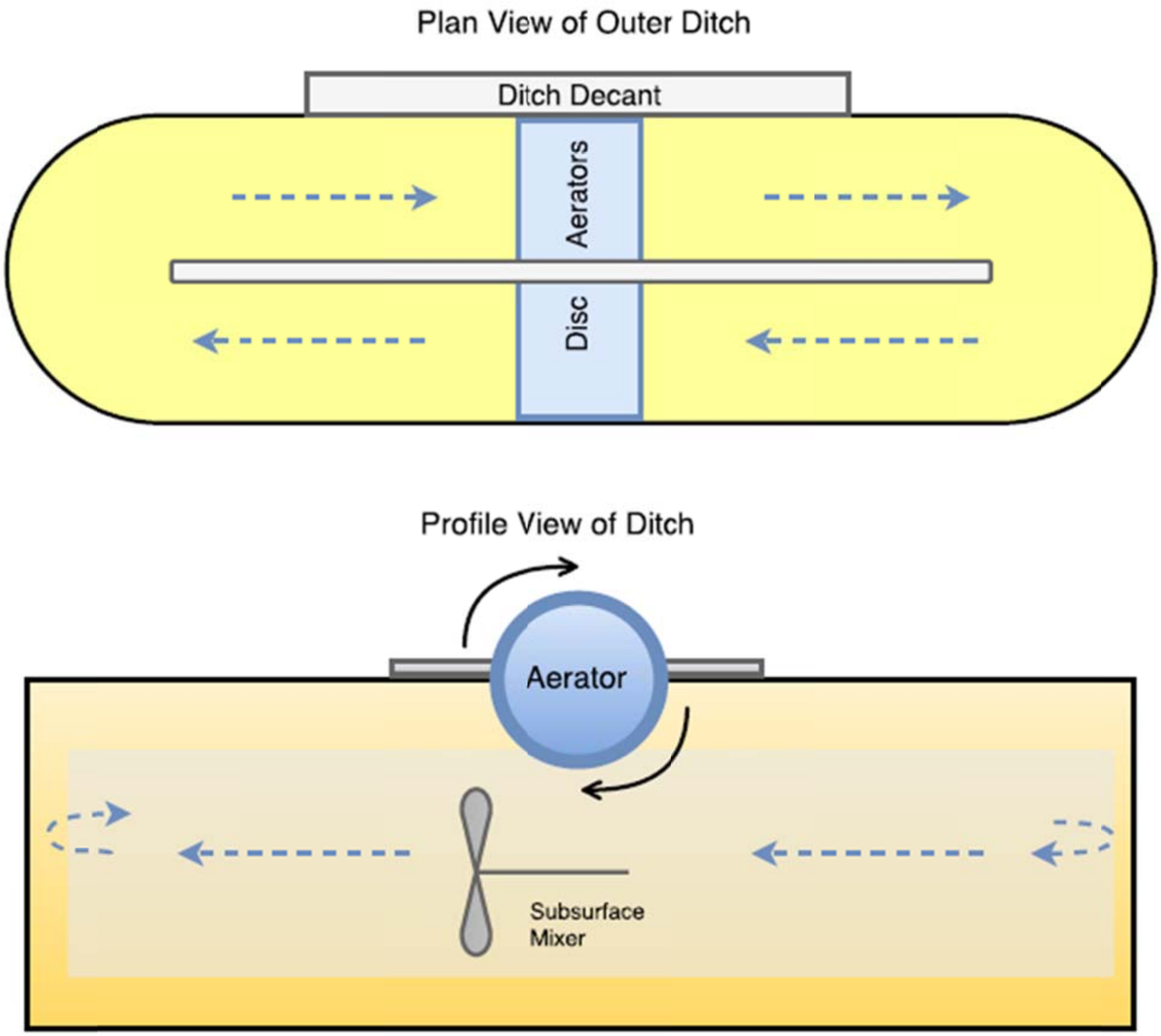
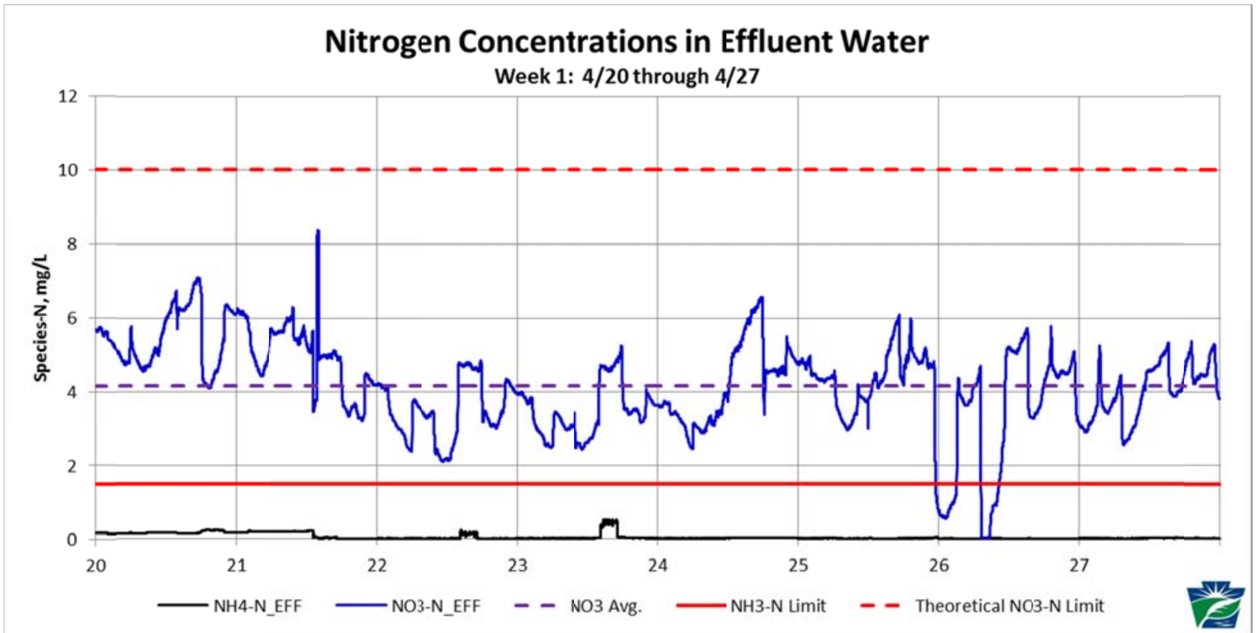
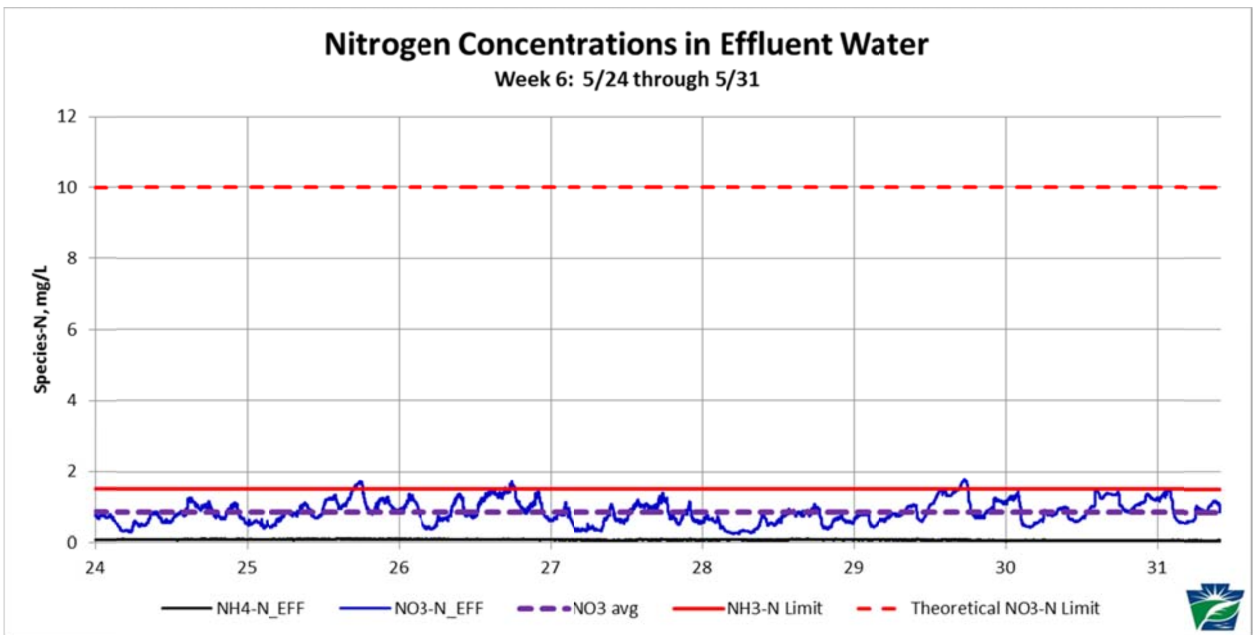


Figure 2: Plan and Profile views of the Oxidation Ditch.

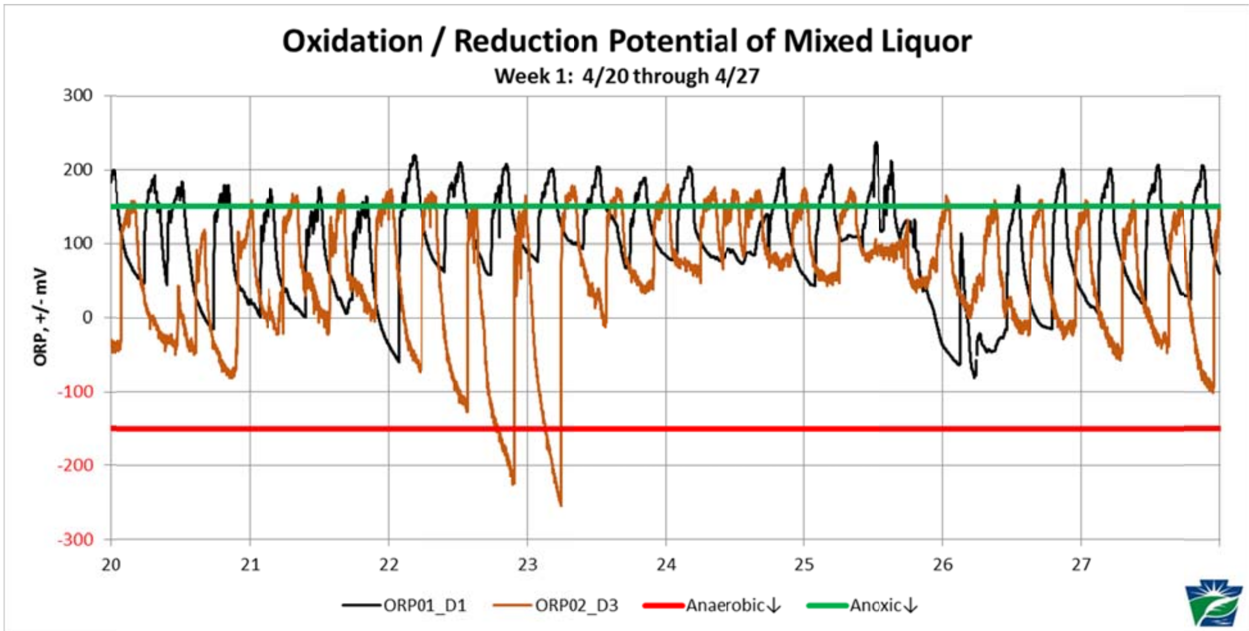
ATTACHMENT C: PARAMETER / TIME GRAPHS



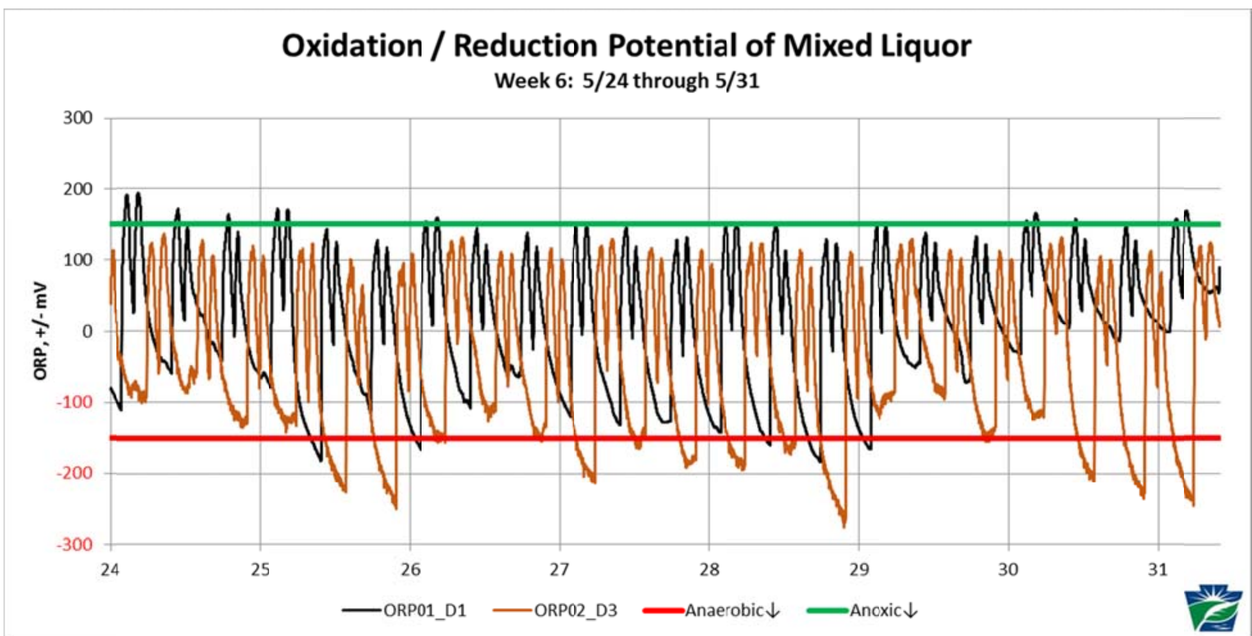
Graph 1: NO_3-N concentrations prior to activation of anoxic cycle were in the 4 to 6 mg/L range, while NH_3-N could be considered to be fully oxidized.



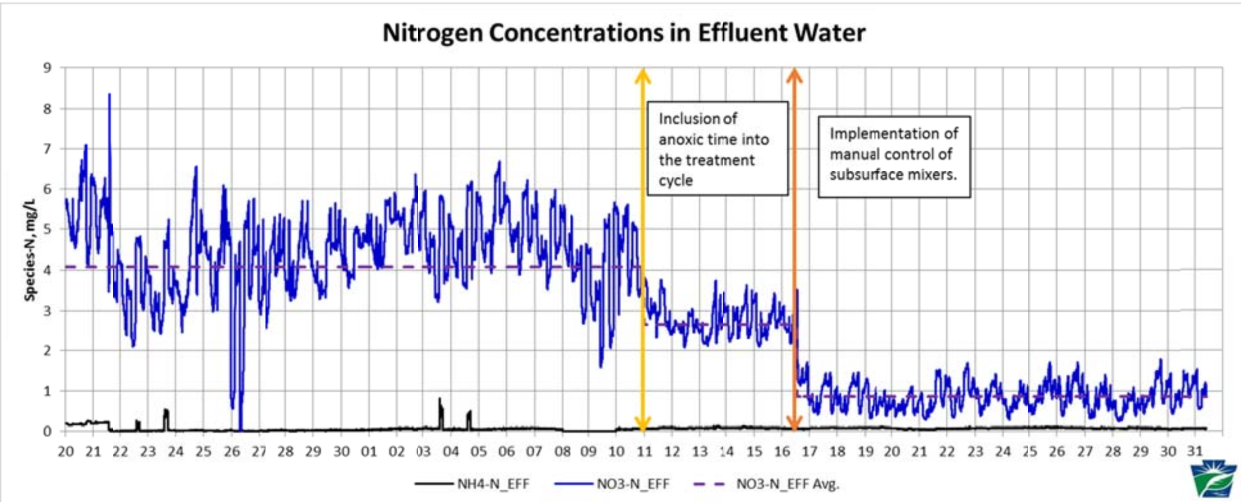
Graph 2: NO_3-N concentrations after activation of anoxic cycle dropped to between 0.3 and 1.8 mg/L.



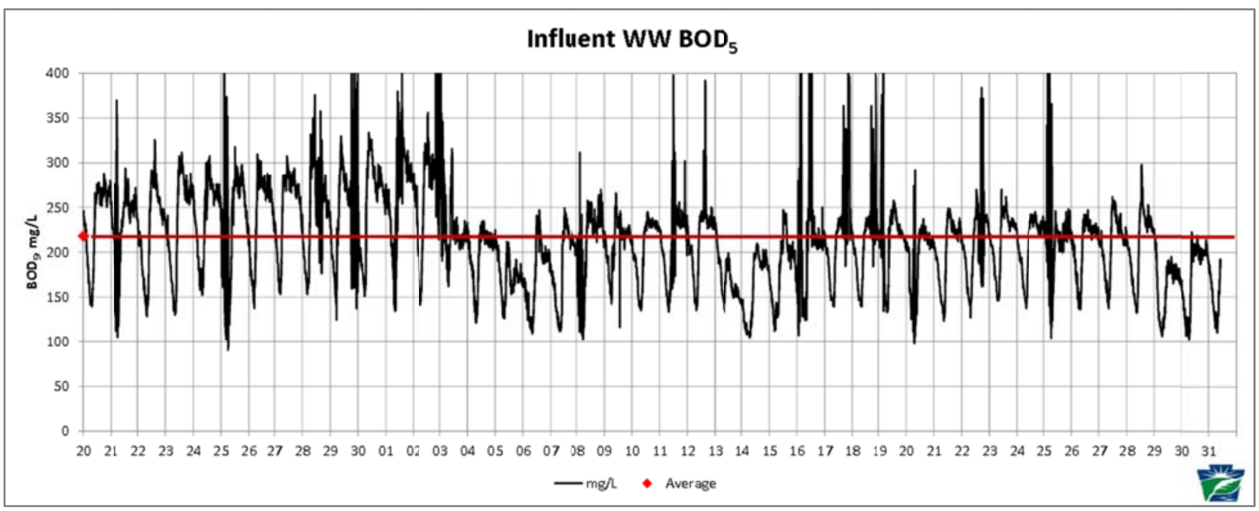
Graph 3: Oxidation Reduction Potential prior to activation of anoxic cycle.



Graph 4: Oxidation Reduction Potential after activation of anoxic cycle.



Graph 5: Nitrate-nitrogen concentration in effluent water dropped as the anoxic cycle was implemented, but the SCADA program did not have coding to energize the anoxic mixers. When the operators activated the anoxic mixers manually, greater reductions in nitrate-nitrogen occurred.



Graph 6: Raw wastewater influent was measured with a Total Organic Carbon (TOC) probe that is calibrated against 5-day Biochemical Oxygen Demand (BOD_5). The spikes in this graph represent periods during which the aerobic digesters were decanted. The values for BOD_5 generally conform to those expected of domestic wastewater, with little industrial or institutional contribution.

ATTACHMENT D: RECORD PHOTOGRAPHS

Photo 1: TOC probe at Influent Splitter

Photo 2: Nutrient probes at Disinfection wet well

Photo 3: Sensors in one of two outer ditches

Photo 4: Ditch settling (clarification) stage

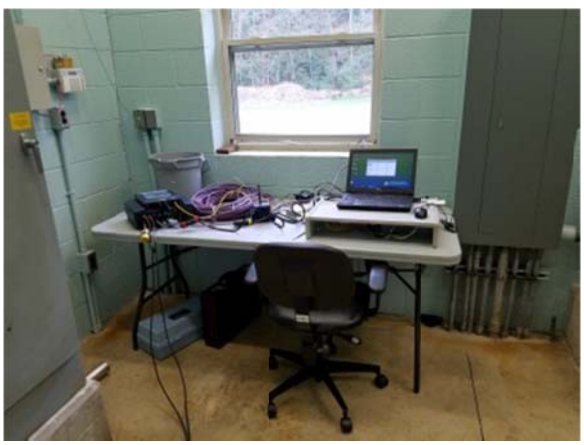


Photo 5: Data collection station

Photo 6: Brush replacement in April 2017

ATTACHMENT E: OBSERVATIONS & FIELD NOTES

In-line Probe Records

1. Aerators in the ditches are automatically controlled by DO set points (1.5-3.5 ppm)
2. The NO3-N concentration dropped approximately 75% when the plant was in BNR mode. Further reduction should be possible if the alkalinity concentration is improved.
3. pH increased slightly (+0.3) in each ditch due to additional denitrification during the manually-controlled anoxic mixing period; however, the mixed liquor is generally deficient in alkalinity
4. Oxidation/Reduction Potential observations:
   a. Nitrification occurs in aerobic conditions above +150 mV, after most carbon waste has been oxidized. Denitrification occurs in anoxic conditions between +150 and -150 mv. Below -150 mV, septicity and anaerobic conditions produce incomplete by-products such as alcohols, organic acids, ketones, and esters. Sulfate is reduced to hydrogen sulfide gas.
   b. Prior to implementation of the anoxic treatment cycle, Ditch #1 ranged between 0 to +200 mV and Ditch #3 ranged between -50 to +150 mV for the first two weeks.
   c. During anoxic mixing, Ditch #1 ranged between -100 to +150 mV and Ditch #3 ranged between -200 to +100 mV for the remainder of the study.

Digester and Sludge Thickening

EPA staff suggested cycling the digester blowers intermittently in an attempt to remove TN, increase pH, and improve settleability. DEP and facility staff installed a timer to cycle the blower, but when the blower was timed off an alarm was triggered in the SCADA. Facility staff will have the SCADA contractor add a timed anoxic cycle to the SCADA programming instead of using a mechanical timer, so that energy savings may be optimized.

Conclusions

The plant appears to be capable of consistently producing effluent to meet the potential 10 mg/l limit of TN (especially if the mixers are activated).

Timing digester blowers may save approximately $6k/yr.

50 HP brush rotor motor x 50% load x 0.746 kW/HP x $0.07/kWh x 12 hr/day x 365 day/yr = $5,718/yr

Analysis of lab data:

Microscopy:

During the week of May 15 there was a decrease in settleability and increase in what we assume to be low F:M filaments in one of the outer ditches. In response, facility staff changed the phase schedule of the ditches. This changes the organic and hydraulic loading schedule in an attempt to evenly distribute the loading between the two outer ditches in order to maintain a steady state for the biomass. If the programming can be changed to have an odd number of phases per day instead of the present even number of phases per day, there may not be a need to flip the ditches as often.

Oxygen Uptake Rate (OUR) Test:

CCMA operates a fully competent process monitoring laboratory with dedicated laboratory staff. DEP finds that the process monitoring is adequate for operation of the facility, but DEP staff recommended that the laboratory routine be supplemented by adding the oxygen uptake rate test as a quick analysis of the health of the biomass and the relative loading conditions. During the WTE, DEP and EPA staff demonstrated the OUR test and its interpretations. Like microscopy, this test ought to be performed at least once or twice per week. In addition, the test should be performed whenever slug loads or influent toxicity is suspected. While the test does not identify specific causes or toxins that inhibit biological activity, it will provide a quick analysis of biological activity that may lead the operators to more definitive, confirmatory tests after operational measures have been taken to control the operation.

Following is an example of an OUR test record: