LIGONIER TOWNSHIP WATER AND SEWER AUTHORITY
DARLINGTON WASTEWATER TREATMENT FACILITY

LIGONIER TOWNSHIP, WESTMORELAND COUNTY, PENNSYLVANIA

NPDES # PA0254401

WASTEWATER TREATMENT EVALUATION

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

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Executive Summary

Technical Assistance staff from PA Dept. of Environmental Protection (DEP) conducted an evaluation of the Ligonier Township Municipal Authority (LTMA) Darlington Sewage Treatment Plant (STP) in Westmoreland County from October 2018 through January 2019. Following personnel changes at the facility, which had been experiencing process control issues, DEP was invited by the LTMA's superintendent to perform an instrument-based evaluation of the facility's potential for biological nitrogen removal (BNR) through timed aeration cycles. The evaluation produced some findings and recommendations that may enhance plant performance, if enacted.

The Dutchland pre-stressed concrete extended-aeration activated sludge treatment facility consists of two parallel treatment trains of secondary aeration tanks and dual hopper-style secondary clarifiers. These are preceded by a flow equalization tank that employs a simple bar rack for removing trash, although most of the collection system and pumping stations employ grinder pumps that macerate such material. Secondary clarifiers for each train employ no mechanical skimming system, and both return activated sludge and surface scum are ejected using air-lift pumps. Downstream from the clarifiers is a dual ultraviolet light (UV) disinfection tank followed by an effluent reaeration/buffer tank, with a final outfall alongside Loyalhanna Creek. Waste solids are manually consolidated, gravity-thickened, and trucked off site for treatment and disposal elsewhere.

Although slow to start due to relatively tight budget constraints, the facility operators were able to achieve quantifiable reductions in effluent nitrate-nitrogen, following successful nitrification of ammonium wastes, after experimenting with timed aeration cycles and including anoxic mixing by submersible grinder pumps. January effluent data demonstrated a nitrate reduction from a metered high of 47 mg/L to as low as 0.8 mg/L and an overall reduction of 96% at a time when effluent nitrite was undetectable, and ammonium was below 0.1 mg/L.

Recommendations:

During site activities, DEP staff observed many desirable operational practices at this facility, including adoption of nutrient monitoring in the process control laboratory and automation of testing for effluent pH and dissolved oxygen, where immersion probes connected to the facility SCADA alarm notification system are being piloted alongside routine compliance testing required by the NPDES Permit. It is to be hoped that the side-by-side study will validate the use of continuous immersion probes for NPDES effluent testing compliance.

Based on observations and experiences during the evaluation, discussions with facility staff and regulators, and recent trends in wastewater treatment, DEP suggests the following recommendations for advancing the capabilities of this treatment facility. These recommendations are divided into two categories, those that may immediately improve BNR treatment (short-term completion) and those that may require evaluation and implementation by the agency's consulting engineers (long-term):

Things to do to improve BNR treatment:

1. Adopt a continuing program of BNR using timed aeration cycles combined with anoxic mixing, adjusting dissolved oxygen residuals and solids retention times to optimize both nitrification of TKN (total Kjeldahl nitrogen) and denitrification of nitrite/nitrate-nitrogen to achieve consistent removal of total nitrogen.
2. With enhanced process monitoring, it is suggested that the facility operators automate data collection using a locally installed desktop computer at the facility. All intermediate process monitoring and control data should be electronically recorded so that pollutant

loadings, treatment efficiencies, energy consumption, cost-to-treat, and other process control parameters can be retained, evaluated, and charted. Doing so will aid in optimizing the treatment processes.[1]

3. Build on the recent use of magnesium hydroxide for alkalinity adjustments, maintaining aeration tank alkalinity above one hundred (100) milligrams per liter concentration or better. Use of an alkalinity calculator to adjust dosage relies on adopting regular testing for total Kjeldahl nitrogen (TKN) on samples of raw wastewater composite samples. This test is usually beyond the capabilities of in-house staff and should be outsourced to the laboratory the performs the regular NPDES compliance testing.
4. Purchase a chemical digestion/heater block for continuing to monitor total nitrogen, total phosphorus, and chemical oxygen demand as part of routine laboratory practice. Equipment listing is provided in Attachment B, with a supplemental price range.
5. Although the NPDES Permit lists an 8-hour composite sampling requirement for this facility, and because the facility presently uses automated composite samplers for influent and effluent, DEP recommends that the operators employ 24-hour timed or flow-proportional sampling for all compliance testing and for some process monitoring testing.
6. All facility staff should be cross trained in the different aspects of operations and maintenance, since team depth ensures consistent compliance with permit limits while buffering employee turnover. DEP encourages the facility owners to support the continuing education requirements of staff licensing.
7. Review and update eDMR Supplemental Report forms provided for supporting data that accompanies the discharge monitoring report. Some of the existing DMR submissions are on obsolete or damaged forms. Under the most recent Permit, it is required to report
    a. UV disinfection intensity daily in mW/cm^2;
    b. Effluent cBOD once weekly, in mg/L concentration and lb./day loading;
    c. Effluent TSS once weekly, in mg/L concentration and lb./day loading;
    d. Effluent ammonium-nitrogen twice per month in mg/L concentration.

   The regional office would have provided updated forms at the time of Permit issuance, and the Excel spreadsheet versions are available at the DEP website. Attachment H, following, lists the current effluent Permit limits.
8. It is suggested that the facility's wastewater collection be re-evaluated to provide increasingly more precise understanding of the organic and hydraulic loading and how underloading may adversely affect the treatment process. If a summer cabin is counted as an entire Effluent Domestic Unit (EDU) when, in reality, it is occupied rarely and contributes only periodically to the treatment facility's daily loading, then it is not truly an EDU of demand. And if the treatment facility remains chronically underloaded despite the best optimism for future use, then the facility's aeration blowers ought to be "right-sized" for their current use and, perhaps, even exchanged for lower capacity rotary lobe blowers that more efficiently accommodate use of power inverters.

Long-term Improvements:

1. The facility's consulting engineer should evaluate instrumentation and technologies that can be used to enhance automation of BNR at this facility. Use of pH, DO, ORP, and UV probes, if connected to controllers regulating alkalinity, dissolved oxygen, and the duration of the anoxic mixing cycle, will optimize BNR while reducing overall energy cost.

[1] DEP anticipates that eDMR data entries will eventually be reduced to daily data entry of test results and meter readings, eliminating the need for loading calculations and supplemental attachments on the Discharge Monitoring Reports. To achieve this, each treatment facility will require on-site computers with internet access.

2. Because instrumentation is sensitive to damage from comminuted rags and detritus, DEP suggests that the existing screening and pretreatment facilities be re-evaluated. Rags and detritus damage more than just immersion probes: combined with grease, they clog pumps and valves, damage aerators, and can jeopardize UV disinfection.
3. Since the facility appears to be underloaded much of the time, it is recommended that the facility owner pursue additional sources of wastewater for treatment. As had been discussed during the on-site phase of this study, the presence of easily accessible carbonaceous material is vital to denitrification of nitrate-nitrogen. Moreover, general experience with wastewater treatment suggests that facilities operate more efficiently when the organic loading is consistent and reliable. At present, the facility receives on average only 22% of its rated hydraulic load and 15% of its rated daily organic loading. The operators have noted that much of the LTMA's collection system waste is directed to other treatment facilities: Some of this capacity should be "clawed back" to allow the Darlington plant to operate more efficiently, but this is a matter for facility owners, their engineers and attorneys.[2]
4. In the absence of dedicated waste stream, the operators may consider receiving hauled or trucked-in wastes, provided these are not prohibited by the facility's NPDES Permit, the haulers are reliable, and that every load is tested and confirmed prior to introduction. Installation of a septage receiving station at the plant headworks may be necessary to efficiently receive hauled wastes while minimizing spillage and malodors.

[2] Some discussion ensued with the operators regarding proposed construction of another treatment facility in a different part of the township: The evaluator's initial thought was that it would be more sensible to convey that area's wastewater to this underutilized treatment facility before contracting construction of another treatment facility, costs of the collection system and pumping stations notwithstanding.

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Wastewater Treatment Evaluation:

In 2014, an extended aeration activated sludge treatment facility became operational near the Village of Darlington in Westmorland County under NPDES Permit # PA0254401. Darlington and Ligonier Township are located a few miles southwest of Ligonier Borough, with the treatment facility located along Loyalhanna Creek, its receiving stream, between eastbound and westbound portions of US 30. Darlington consists of several all-season residences and small businesses, seasonal cabins, and a moderately-sized recreational entertainment venue, the Idlewild Waterpark. The collection system consists of seven (7) small-flow pumping stations that channel flow primarily to the Borough of Ligonier's WWTF but also to the Darlington plant. Attachment H lists the NPDES Permit limits for the facility.

During late summer 2018, LTSA hired a new superintendent to oversee operation of the water and wastewater treatment utilities. Other staffing changes supplemented the full-time complement. The superintendent contacted DEP operations staff (Thomas Brown,) with whom he had previously evaluated treatment works in Somerset County, and requested analysis for potential biological nitrogen reduction at the Darlington WWTF, *with a view to the combined benefits of increasing effluent quality while reducing operational and energy costs and the potential for effluent violations noted by previous administrators*.

DEP staff from the Bureau of Clean Water, Operations Division, set up equipment on site at the facility in late October. Attachment A lists the evaluation team and treatment facility staff who worked on the project. The monitoring equipment includes continuous-recording immersion probes for various physical and chemical parameters and supplemental laboratory process monitoring equipment. A schematic of the immersion probe network is provided in Attachment B and some photographs follow in a collection in Attachment D. A portable data acquisition network was constructed to allow both localized data collection in the secondary aeration tank and at the final effluent reaeration buffer tank, just prior to the facility outfall. Probes in the aeration tank included dissolved oxygen, pH/temperature, oxidation/reduction potential, and suspended solids. Final effluent probes included those for nitrate and ammonium nitrogen, and dissolved oxygen and pH/temperature. When it became available, a probe for total organic carbon (TOC) was placed in the raw wastewater influent splitter box. This probe is calibrated to approximate incoming biochemical oxygen demand (BOD_5).

Monitoring was done locally using data collection and graphical display at a table set up in the blower/control building, and remotely using a wireless data server and portable wi-fi device. DEP staff checked the data system remotely ever two days and collated data onto a graphical spread sheet twice per week throughout the deployment.

Since the facility laboratory had already been equipped with high-quality analytics, only a few pieces of the technical assistance portable lab were required: DEP lent a digestor block for use with Hach colorimetry tests, and they provided a solids-by-volume centrifuge as a substitute for the existing gravimetric solids oven and scale.

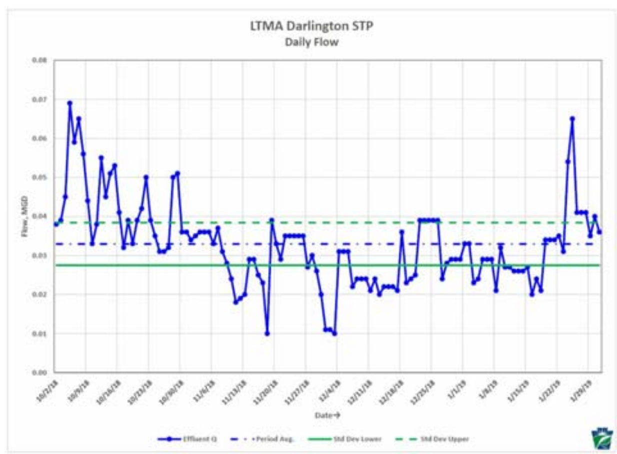
Facility operators were by then performing daily nutrient checks for parameters that did not include digestion: Ammonium, Nitrate, Nitrite, and Alkalinity. Use of the digestor block allowed them to also test for Total Nitrogen (TN,) Total Phosphorus (TP,) and Chemical Oxygen Demand (COD.)[3] Although the gravimetric solids test is the "gold standard" for quantifying

[3] COD test is an independent measure of the organic matter in a wastewater sample rather than a substitute for the 5-day BOD_5 test; however, it may be used for process monitoring when frequently

activated sludge concentration and loading, it is a test that requires up to four hours of laboratory attention, practically impossible for most operators of small facilities where the job entails operations and maintenance of the collection system, pumping stations, and also of the potable water distribution system. In Darlington's case, the second part of the gravimetric solids test, the volatile solids test used for calculating mean cell residence time (MCRT,) was not being performed.[4] By adding the solids-by-volume test to the process monitoring regime, operators can reduce the need for gravimetric determination to once or twice per month and then use the Weight to Concentration Ratio (WCR) to normalize volumetric solids for MCRT calculations on all other days.[5]

Because of time constraints on operations staff, it is not possible to staff a process monitoring laboratory daily. DEP recommended that, for this size of treatment facility, process monitoring should be done once or twice per week, more often if the facility is experiencing a process upset. A list of recommended tests and frequencies is provided as Attachment E.

The facility superintendent stated that, when he first began work at this facility, both of its two treatment trains were in service but hardly necessary. He subsequently reduced operation to one train, with the other remaining idle until needed. In the interim, he moved that idle train's DO probe to the final effluent buffer tank to continuously monitor effluent DO, which has a minimum limit of 4.0 mg/L. He also added a pH probe there and connected both to the facility's telemetry system. DEP staff instructed him to seek a permanent approval of using these immersion probes for effluent compliance monitoring under the NPDES Permit, providing that he first conducts a parallel study of the traditional grab-sample method with the new telemetry method. It is to be expected that the telemetry, provided it is well-maintained and documented, will be superior to the grab-sample method of checking the effluent DO and pH once per day.[6]



Graph 1: Daily and Average Flow during WTE

Facility Description:

The Darlington WWTF is designed for 0.156 MGD with an organic loading of 323 lb./day; however, its four-year flow averages 0.035 MGD with loadings of about 49 lb./day. This is but 21% of design flow. During 2017, the 3-month maximum flow was 0.48 MGD and organic loadings were 50 lb./day with a 1-month maximum load of 102 lb./day.[7] Due to

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indexed to the 5-day BOD_5 test. In most domestic wastewaters, BOD5 will be about 40% to 60% of COD. The presence of industrial waste in the sample will skew the percentage. BOD measures biodegradability, while COD oxidizes both biodegradable and non-biodegradable waste. The typical ratio for landfill leachate is only 10%. The trick is to index the test against one's own wastewater characteristics and adjust process control accordingly.

[4] VSS test requires use of a muffle furnace to remove volatile content, with VSS determined by subtracting ash from total suspended solids. Values are typically 70%-85% of TSS.

[5] See Activated Sludge Operations & Maintenance, OM9, Water Environment Foundation, Alexandria, VA, 1987. This test regime is considered the "Al West Method."

[6] It still helps to have visual confirmation of effluent quality; i.e., someone checking the effluent buffer tank for oil sheen, floating or suspended solids, or other material, on a daily basis.

[7] 2017 Municipal Wasteload Management ("Chapter 94") Report, March 2018.

the low flow and organic loading, the
superintendent has idled one of two treatment trains to improve biological quality and efficiency in the active unit. At present, the mixed liquor suspended solids runs about 2,400 mg/L where about 1,340 lb. of solids are under aeration.

The facility has hopper-style secondary clarifiers with no moving parts and includes air-lift pumps for return activated sludge (RAS) removal and air-lift scuppers for foam and scum. Without mechanical scraping, settled sludge had tended to denitrify and rise in the clarifiers, leading to solids losses.

Wastewater enters the facility at a main pumping station and is transferred to a small equalization tank equipped with a primitive bar rack. Most trash and plastics are macerated by grinder pumps at individual sewer users and at pumping stations and subsequently passes into the WWTF where it may hang up on aeration diffusers and interfere with transfer pumps, scuppers, and other equipment. Screenings large enough to be trapped by the bar rack are manually removed to an on-site dumpster.

Secondary effluent from the clarifier passes through an ultraviolet light disinfection array before being re-aerated in a small buffer tank prior to release to Loyalhanna Creek, adjacent. Excess biomass is manually wasted by operators to a sludge holding tank where it is gravity thickened and later removed off-site for further processing and disposal. Last year, the facility estimated removing 7.3 dry tons of sludge solids, which may have been from 37% to 181% of expected volume, based on the reported sludge management calculations.

Chemical treatments used at this facility have included coagulants and metal salts; however, the chemical feed system was not being used at the beginning of the evaluation. Sacks of powdered bicarbonate and lime were initially observed, but facility alkalinity was very low when measured using test strips. When the operators began running anoxic mixers to enhance BNR during January, they also began adding magnesium hydroxide dissolved into water as an alkalinity enhancement.

The facility adds poly-aluminum chloride (PAC) for inorganic phosphorus precipitation. Biological phosphorus reduction was not evaluated during this study, as biological phosphorus removal requires dedicated treatment facilities converting soluble orthophosphate to inorganic polyphosphate that is wasted with the excess biomass.

Wasted biomass is stored in aerated sludge holding tanks, periodically gravity-decanted, and then hauled off-site for further treatment and disposal.

Observations:

An immediate impression during site reconnaissance was that this four-year old facility is underloaded. While not unexpected for a plant that is only four years old, low flow and low loading will hinder the new operators' attempts to consistently achieve BNR. Following some simple modifications to process control, the operators achieved stable nitrification followed by denitrification, where data showed that timed aeration and anoxic cycles will reduce nitrate to nitrogen gas, decreasing total nitrogen in the final effluent.

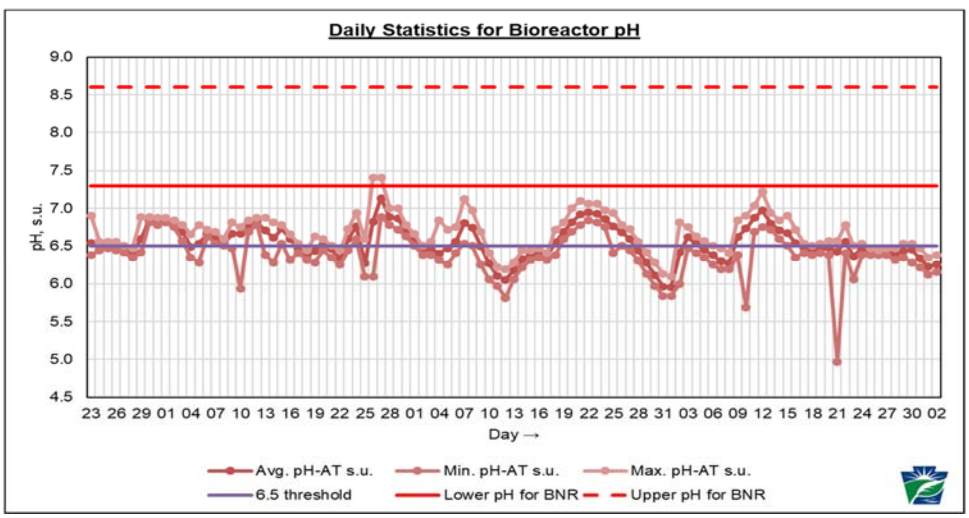
Plant operators sought to achieve biological nitrogen removal (BNR) through the use of timed aeration cycles in a single biological reactor, similar to that of sequencing batch reactors or oxidation ditch configurations that allow for oxic and anoxic cycling. BNR requires four essential elements:

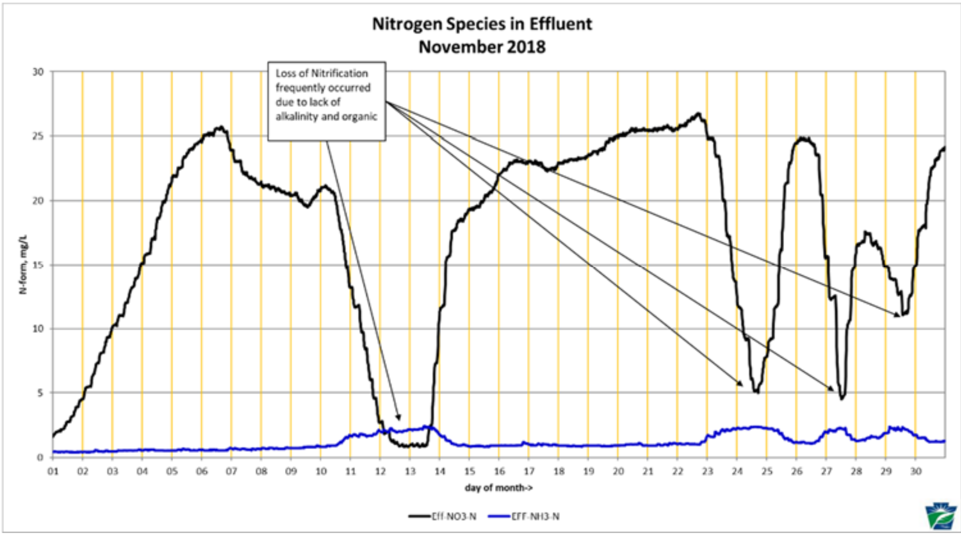
- a population of healthy facultative bacteria to denitrify the products of ammonium destruction;
- anoxic treatment conditions where the oxidation/reduction potential of the biomass is maintained between +150 mV and -150 mV, (ideally between 0 and -50 mV;)
- ample nitrate ion dissolved in the mixed liquor;
- anoxic mechanical mixing of incoming raw wastewater with the activated sludge biomass and the nitrate-rich water.

Nitrification had to first be stabilized by monitoring and increasing aeration tank alkalinity and attempting to control pH. The treatment process nitrifiers produce nitrous and nitric acid as byproducts, which lowers system pH. When pH approaches 6.5 s.u., nitrification progressively fails, often resulting in excessive nitrite formation followed quickly by no ammonia treatment. Over the course of the evaluation, the operators changed their alkalinity addition from one 50 lb. bag of bicarbonate per week to addition of twelve-to-thirty pounds per day of magnesium hydroxide as wetted powder solution in water. They had to modify the chemical feed line to do this, adding a new metering pump and building a mixing station where the sacks of magnesium hydroxide could be dissolved into an open 100-gallon vat. The pH did not markedly improve, but enough so that the nitrifying bacteria continued to fully convert ammonium and the denitrifying bacteria remained healthy enough, also.

Following are graphs of various parameters monitored during November and January, showing conditions prior to and following implementation of BNR through timed aeration cycles with anoxic mixing. Additional graphs for the entire period are provided in Attachment C.

Graph 1: pH at the start of the evaluation showed occasional drops below the 6.5 s.u. threshold at which nitrification of ammonium wastes begins. This is usually remedied by addition of alkalinity to provide buffering capacity for the biological reactions.





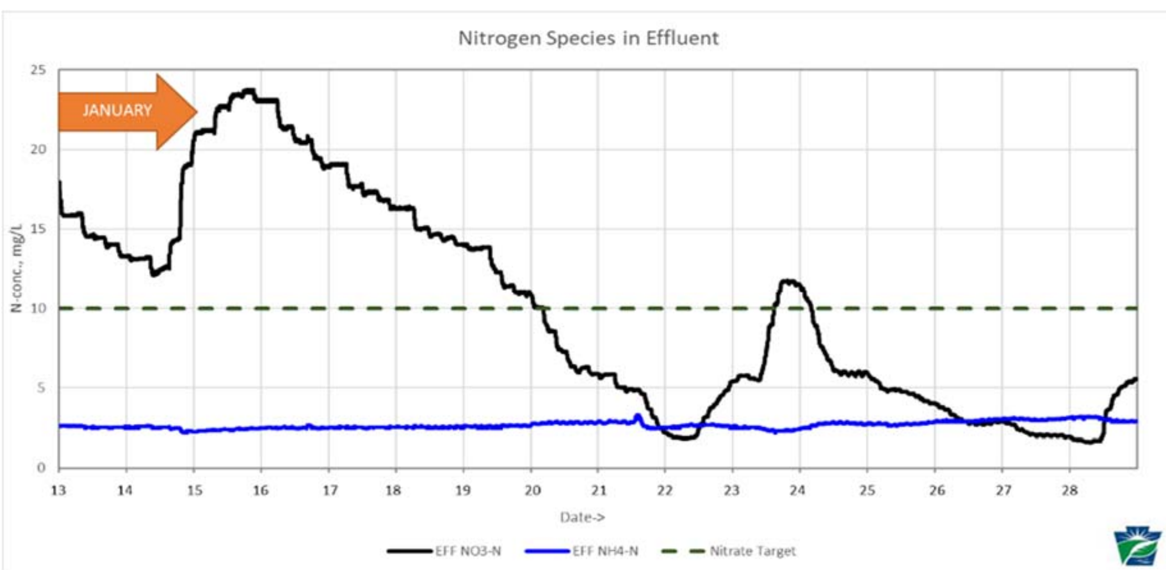
Graph 2: November ammonium and nitrate in plant effluent: This shows five (5) incidents of nitrification loss that resulted from decanting of stagnant digester supernate into the aeration tank, which depleted dissolved oxygen while simultaneously overloading the biomass with unstable organic matter.

The dissolved oxygen depletion shown in the graph following coincides with this overload.

As a result of seeing the graphical output from the DEP's immersion probes, facility staff modified the way they decant their sludge holding tanks after consolidating solids prior to removal.

Another missing element was added in January: subsurface anoxic mixing during the timed anoxic periods. This was achieved employing two small grinder pumps installed into the aeration tank with modified outlets that created a mild vortex in the aeration tank to keep biomass, raw wastewater, and nitrate well mixed for the full anoxic period. After some trial and error, placement of the pumps was achieved to prevent their dislocation in the tank.

This portion of the graph record of January 2019 Effluent Nitrate-nitrogen and Ammonium-nitrogen shows the anoxic depletion of nitrate-nitrogen when all the elements were finally present, as seen on the next page:



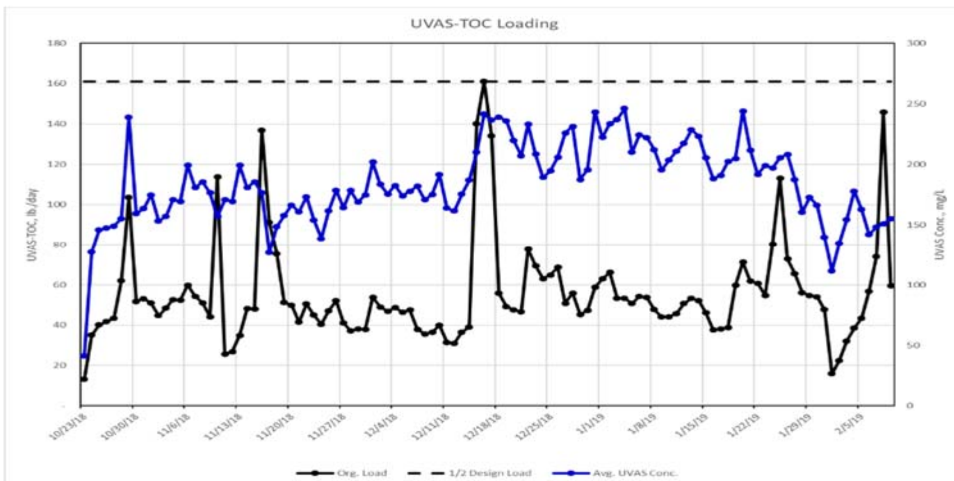
Graph 3: Nitrate Reduction achieved in January with addition of complete anoxic mixing.

Reduction of nitrate-nitrogen occurred because of timed anoxic mixing periods following addition of subsurface mixing to the aeration tank. Two submersible trash pumps added to the bioreactor operated alternately to the aeration blowers, mixing the contents of the aeration tank as though it were a single sequencing batch reactor, allowing denitrification to take place in the presence of carbon from raw wastewater and the nitrate ion created from prior nitrification cycles.

Chronic Underloading Suspected

Continuous monitoring of the organic carbon present in the raw wastewater at the flow equalization tank demonstrated ongoing organic underloading of the facility, averaging 186 mg/L or 57 lb./day throughout the evaluation. The design organic capacity of this facility is 322 lb./day. The ultraviolet absorption spectrophotometer probe (UVAS) is bench calibrated by Hach, the manufacturer, to the five-day biological oxygen demand (BOD_5) standard and holds well its annual bench calibration, with onsite adjustments to match the laboratory record of BOD_5 concentration. Also, obvious has been the fact that only one of two bioreactors is used by LTMA to treat incoming wastewater, which would work efficiently at a loading rate of 161 lb./day.

Graph 4: UVAS-TOC Loading and Concentration: the TOC loading averaged 186 mg/L with an average period load of 57 lb./day. The design organic load for each bioreactor, individually, is 161 lb./day.[1]



Chronic underloading is not uncommon in new treatment facilities, as they are designed for thirty to forty-year life span. It presents many problems for the operators:

- the facility tends to be oversized for the current waste load;
- centrifugal blowers are not easily adjusted to regulate dissolved oxygen levels in the bioreactors, leading to over oxidation of the activated sludge;
- high dissolved oxygen residuals hinder the desirable anoxic phase of biological nutrient reduction where no oxygen can be present for the denitrification process, where certain facultative bacteria are able to scavenge oxygen from soluble nitrate ion in solution and use it as a proton receptor in cellular respiration. These facultative organisms prefer easily available dissolved molecular oxygen for respiration, but they will use nitrate when DO is less than 0.2 mg/L overall and when average oxidation / reduction potential is optimally between 0 and -100 millivolts. DO will poison this process.
- chronic underloading, generally, allows undesirable bacteria, filamentous organisms, to compete more successfully for scant organic carbon and micronutrients, resulting in problems with sludge settleability in secondary clarifiers, solids carryover that hinders disinfection treatment, and high solids losses to the receiving stream.

There are remedies to this. Many wastewater treatment operators will employ supplemental carbon sources, most often animal feed (dog food) or hauled-in wastes, to make up for shortfalls in organic loading. These remedies are usually inconsistent:

- Animal food is usually bought on the cheap. Many operators use dry dog food which is high in fats and oils that don't easily break down. Also, complex carbohydrates may require more than the design retention time to be broken down. This complexity invites filamentous organisms that hinder settleability of the biomass.
- Other animal feed and some types of food wastes lack diversity of nutrition; for example, some operators add sucrose (table sugar) which lacks micronutrients and amino acids required by bacteria for protein production.
- Hauled in wastes are sometimes excellent sources of organic loading to supplement underloaded processes; however, receiving them requires an extra level of surveillance and testing that is beyond the staffing and testing abilities of small treatment systems such as LTMA.

Some waste products are useful, though: non-fat dairy products such as whey powder or non-fat milk powder work well, but with monetization of food wastes by industrial manufacturers (e.g., selling it as hog feed supplement,) such sources are increasingly out of reach for municipal treatment budgets. Dog food, on the other hand, may be useful if it is "pre-digested" prior to dosing into the biomass as supplemental organic loading. The kibble should be mixed into unchlorinated effluent water and acidified using hydrochloric acid. Laundry detergent such as Tide or septic tank enzymes are also added to break down proteins and complex carbohydrates. The mixture is aged overnight in a heated space such as the blower room and then fed either to the equalization tank or directly to the biomass. Supplemental organic loading dosage is calculated by subtracting the daily organic load already available in the equalization tank from the design organic load for the facility, or in the case of LTMA where only one of two bioreactors is used, half of the design organic load.

Other commercially available supplemental sources, such as Micro C or methanol, are better suited to meeting the carbon requirements of denitrification but are prohibitively expensive to use generally to make up organic loading for the plant. All of this is predicated on the theory that the treatment system is being operated to a constant food-to-mass ratio or mean cell residence time; otherwise, the method doesn't work.

BNR Fails In Absence of Alkalinity Control

Alkalinity as Calcium carbonate ($CaCO_3$) is critical to the conversion of ammonia nitrogen to nitrate, a process known as nitrification. The LTMA plant appears to be operating at the bare minimum alkalinity, causing nitrification to frequently fail, as is indicated in the nitrogen graphs shown above. Nitrification is a two-step process: first, nitrosomonas converts ammonia to nitrite, then nitrobacter convert the nitrite to nitrate. Nitrosomonas, the ammonia-oxidizing bacteria (AOB) is actually converting ammonia to nitrous acid, a metabolic product that decreases the pH of the mixed liquor. When the MLSS pH drops below 6.5 s.u., the nitrification process stops. Nitrobacter, the nitrite-oxidizing bacteria (NOB) cannot convert nitrite to nitrate under such conditions, either.

The remedy for this situation is to add supplemental alkalinity into the mixed liquor by employing a great variety of available sources. Some of these are listed in Attachment F, following. Most treatment plant operators use lime or soda ash, but they typically just empty sacks of powdered material into the bioreactor when, in truth, the material should be dissolved in water, mixed in a day tank, and dosed over the course of the day using a chemical feed pump.

LTMA alkalinity typically measured between 40 mg/L and 90 mg/L during the evaluation. Using an alkalinity calculator devised based on raw wastewater total Kjeldahl nitrogen (TKN) or its analog, ammonia-nitrogen (70% of TKN in most domestic wastewater,) it is possible to calculate the alkalinity demand of the raw wastewater and to provide the difference in alkalinity loading that is absent from the existing biomass. The basis for calculating alkalinity dosing is detailed in Attachment G: Calculating Alkalinity Demand.

During the evaluation, DEP staff recommended the use of Magnesium hydroxide as an alkalinity source. The benefits of using this over other sources have been:

- Magnesium hydroxide [$Mg(OH)_2$] provides twice the hydroxide alkalinity of other sources such as flake caustic soda [NaOH];
- It is relatively non-toxic and will not drive pH outside of the range required for nitrification;
- It cannot be overdosed: excessive doses of $Mg(OH)_2$ will not kill off the biomass;
- It is very safe for staff to handle using regular personal protective equipment (PPE such as dust mask, safety glasses, vinyl apron, and nitrile gloves.)

LTMA staff purchased palletized sacks of magnesium hydroxide powder and installed a day tank, mixer, chemical feed pump, and a feed line to the equalization tank. Toward the end of the evaluation, they were supplementing alkalinity to maintain good nitrification.

Supplemental Carbon Required for BNR Success

As stated earlier, LTMA's facility lacks enough organic loading. To enhance denitrification, supplemental carbon is sometimes used. The SBRs at LTMA are designed to use raw wastewater as the carbon source for denitrification during the anoxic treatment cycle, but more may be needed. The most popular product on the market for this is called "Micro C," a proprietary blend of organic carbon and micronutrients. Other sources of supplemental carbon include wood alcohol (methanol) or glycerin.

DEP has had great success in some projects using waste sugar or waste molasses as supplemental carbon for denitrification in modified Ludzack-Ettinger treatment systems.[8] In such cases, the material was dissolved into water and metered into the anoxic zone treatment tank, providing carbon for denitrificans bacteria for cellular reproduction.
LTMA's facility is fairly remote from large food manufacturers, which makes finding waste sugars difficult and transportation costs high. Sometimes, brewery or winery wastes may be substituted. DEP recommends that LTMA's staff continue searching for supplemental carbon sources as part of an overall search for ways to boost organic loading to this facility.

Process Monitoring and Laboratory

LTMA's superintendent has enthusiastically endorsed adding additional process monitoring tests to the routine surveillance and operation of the facility. Attachment F: Recommended Monitoring Tests and Frequencies lists several process monitoring tests that are useful for the operation of small treatment facilities. The testing frequency is based on normal operation. When starting a new process or recovering from a plant upset, more frequent monitoring is always recommended. It is recommended that the facility owner provide basic laboratory equipment.

Testing has improved greatly with the administration of a new superintendent. As part of the

[8] Bryn Athyn Borough STP Evaluation, 2015.

optimization program, DEP staff typically recommend more frequent monitoring of MLSS that is necessary to maintain a Food-to-Mass balance at this facility. DEP had provided a Solids Centrifuge for volumetric solids accounting (Al West Method) while on site: this solids test is less time consuming (15-minutes) than the traditional oven-and-balance method, and solids monitoring should be done at least twice per week, perhaps as often as sludge settleability tests are performed. The goal is to operate this plant based on its design Food-to-Mass Ratio.

If it is possible, all influent and effluent sampling should be based on 24-hour, flow composited sampling. For compliance reporting, this sampling is typically done on a certain day throughout the reporting cycle. For process monitoring, though, it may be useful to characterize the influent waste stream by sampling on a rotating basis, across the calendar, to characterize both raw wastewater and finished effluent over the entire week. (Test Wednesday, then next Monday, then Saturday, then Tuesday, etc., to cover all the possibilities.) Wastewater strength should be frequently tested and characterized. (An Oxygen Uptake Rate test can suspect toxicity in an otherwise innocuous raw wastewater sample.) Microscopy should be done regularly. (Lack of abundant indicator organisms may suggest underloading, overoxidation, toxicity, or a need for bioaugmentation.) And since nutrient probes are very expensive, more frequent nutrient testing using colorimetry kits in the lab will help further the knowledge base required by the operators to react to rapid changes at this treatment plant.

Continuous Monitoring Immersion Probes

During the evaluation, facility operators expressed interest in additional continuous monitoring immersion probes to the process. Facility staff appear fully capable of installing such equipment without need of external contractors, as effluent pH and DO monitoring was installed before DEP recommended it. Development of a full-scale SCADA system for this facility, however, may require additional contractor expertise, although installation of SCADA is the next logical step in automating the facility and its pumping stations. DEP endorses these aspirations.

The facility is currently equipped with dissolved oxygen monitoring of one of the bioreactors and the effluent wet well.[9] Effluent pH monitoring was installed at the wet well with the possible intent of automating the NPDES Permit-required effluent monitoring especially during weekends and holidays when staffing is at a premium. DEP policy endorses the use of continuous monitoring for treated effluent, although the electronic reporting systems, eDMR and EPA's ICIS, do not yet have coding for this level of monitoring. (The recognized procedure is to physically sample the effluent, bring the sample into the wastewater lab, and test its pH and dissolved oxygen residual on the bench, recording the test results and the instrument calibration record in a bound log.)

Energy Conservation

The Darlington wastewater treatment facility was well-designed for energy efficiency, employing variable speed drives to operate high efficiency electric motors. Some reservations were expressed regarding use of the centrifugal blower technology in this application, because the blowers appear to be oversized for the current loading at this plant. It should be remembered, though, that these facilities are typically designed for thirty to forty years of service; thus, a new facility will almost always appear to be oversized. During the evaluation, plant staff considered

[9] LTMA staff relocated one of the DO probes from the unused second bioreactor to the effluent wet well because it was underutilized in its previous location. At some point, installation of a third DO probe at the second bioreactor will be necessary, when the tank comes into regular service.

modifications that may help reduce the excess of dissolved oxygen in the mixed liquor that will "poison" the denitrification phase of BNR that requires anoxic conditions for success. The present DO feedback loop controlling the blower air intake valves can be optimized to limit excess DO residual, provided that the plant underloading issue is first resolved.

It would be useful to provide a separate air compressor—a "jockey" blower—at the effluent buffer tank to provide for continuous, low pressure aeration of the water being discharged even when the main blowers are off-line. As for the main aeration blowers, it may be useful to have the facility's consulting engineer evaluate "right-sizing" at least one of the blowers to meet the present-day oxygen demand while maintaining the other blowers on standby for future increases in organic loads.

ATTACHMENT A: EVALUATION TEAM

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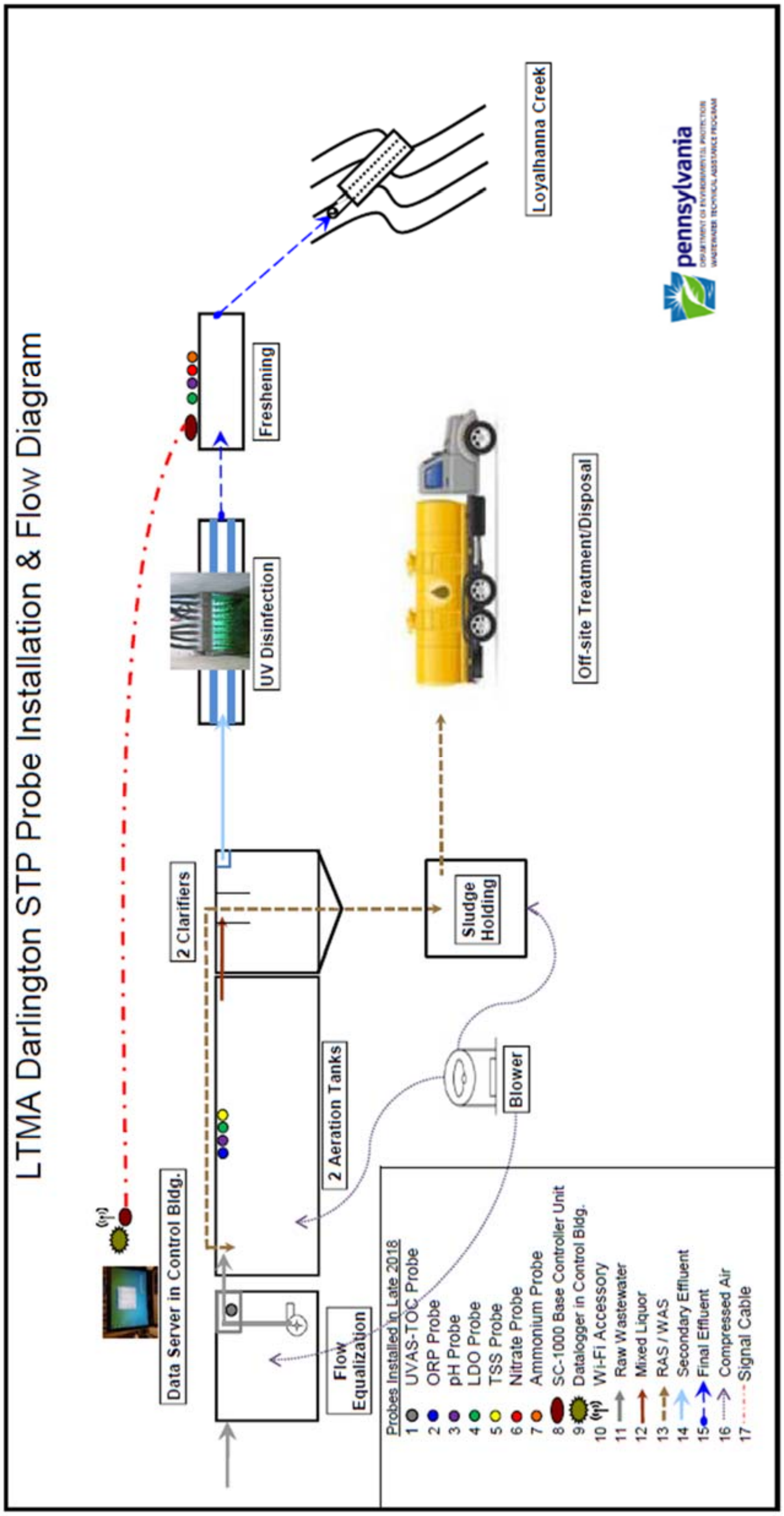
ATTACHMENT B: EQUIPMENT PLACEMENT SCHEMATIC



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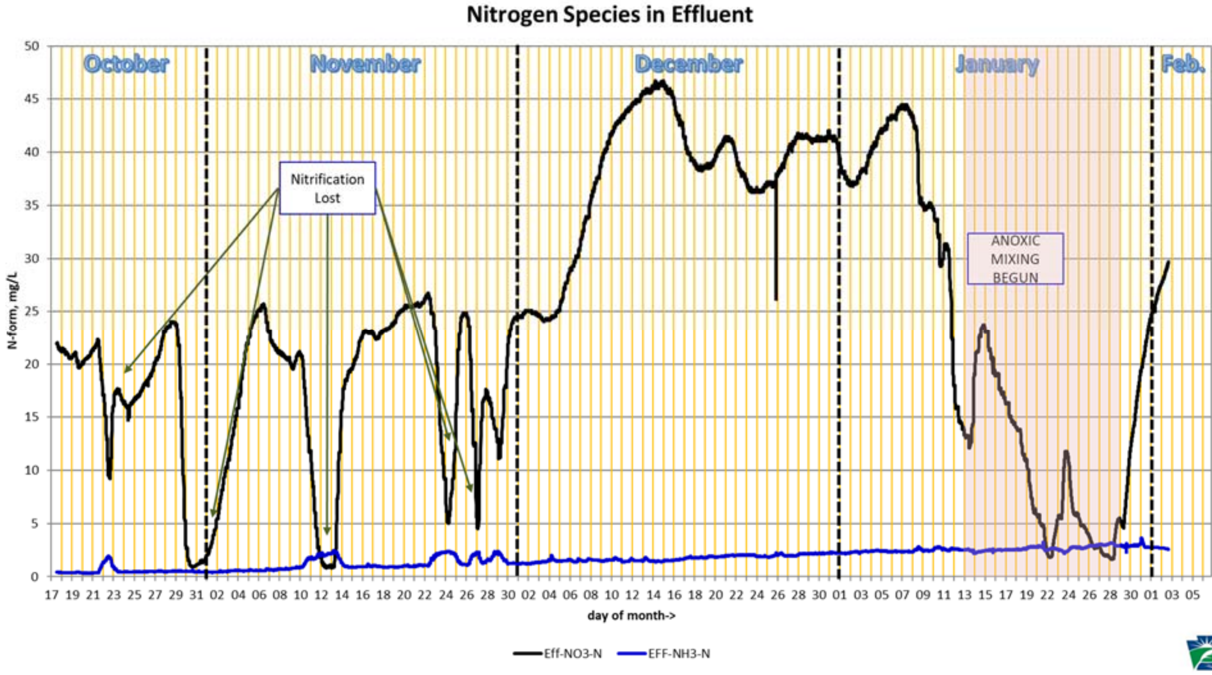
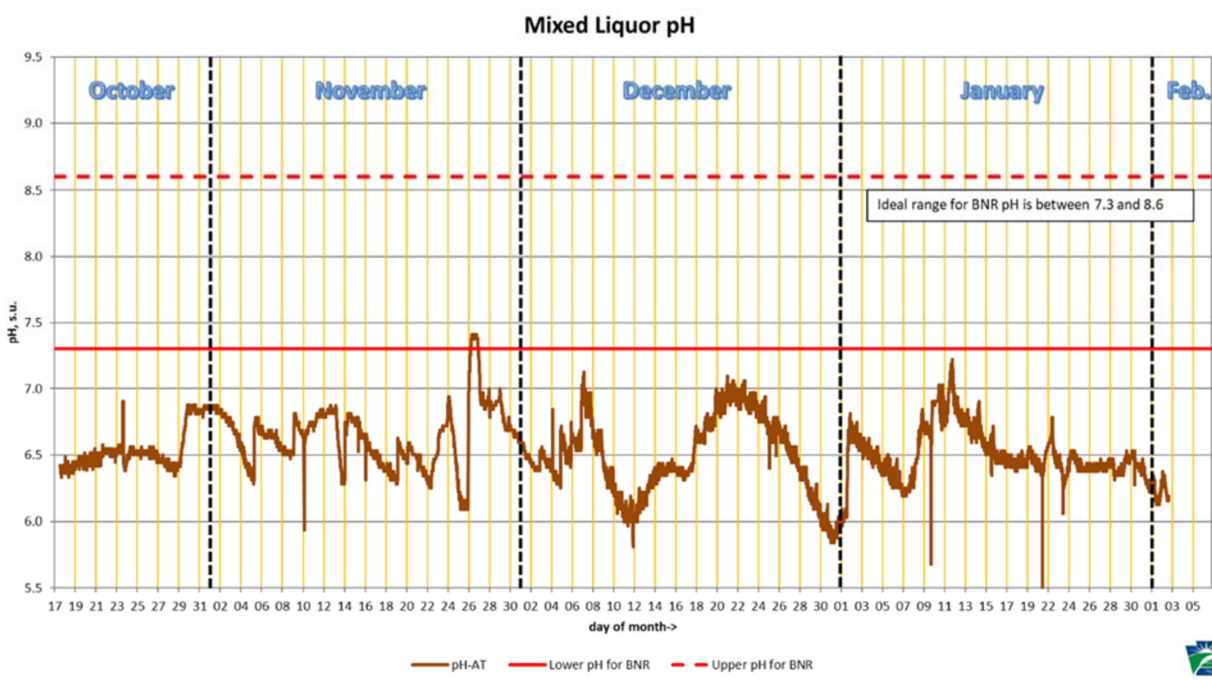
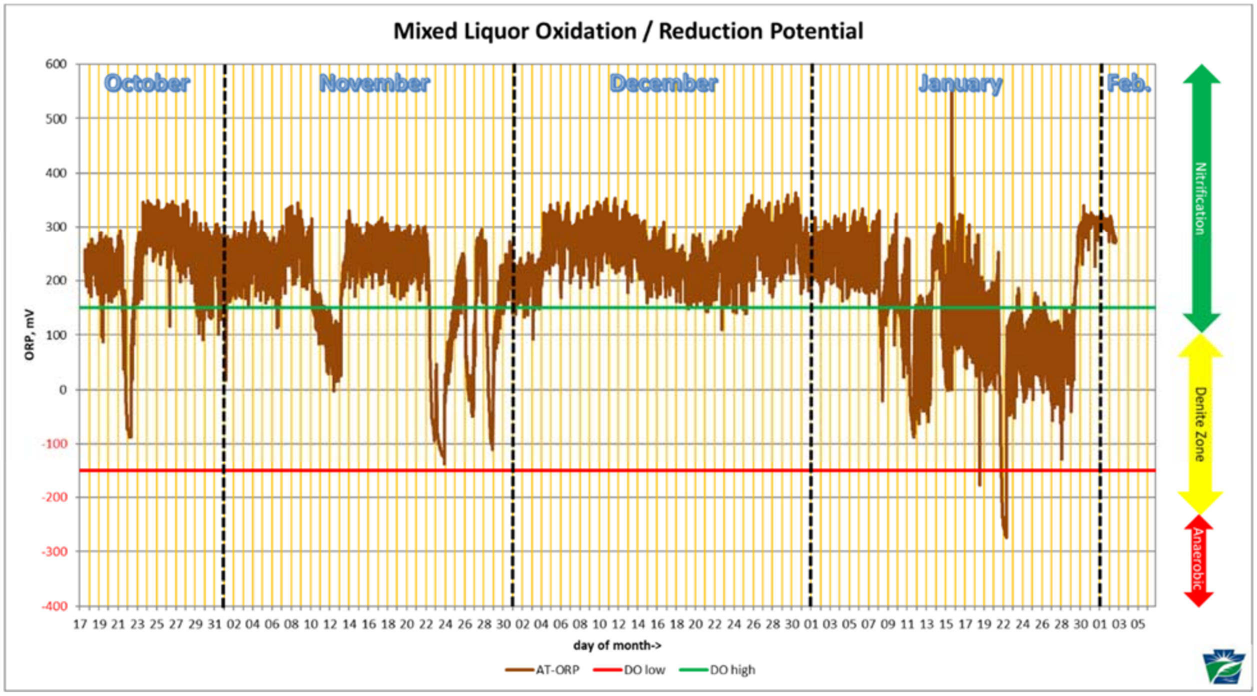
ATTACHMENT C: EXAMPLE DATA GRAPHS



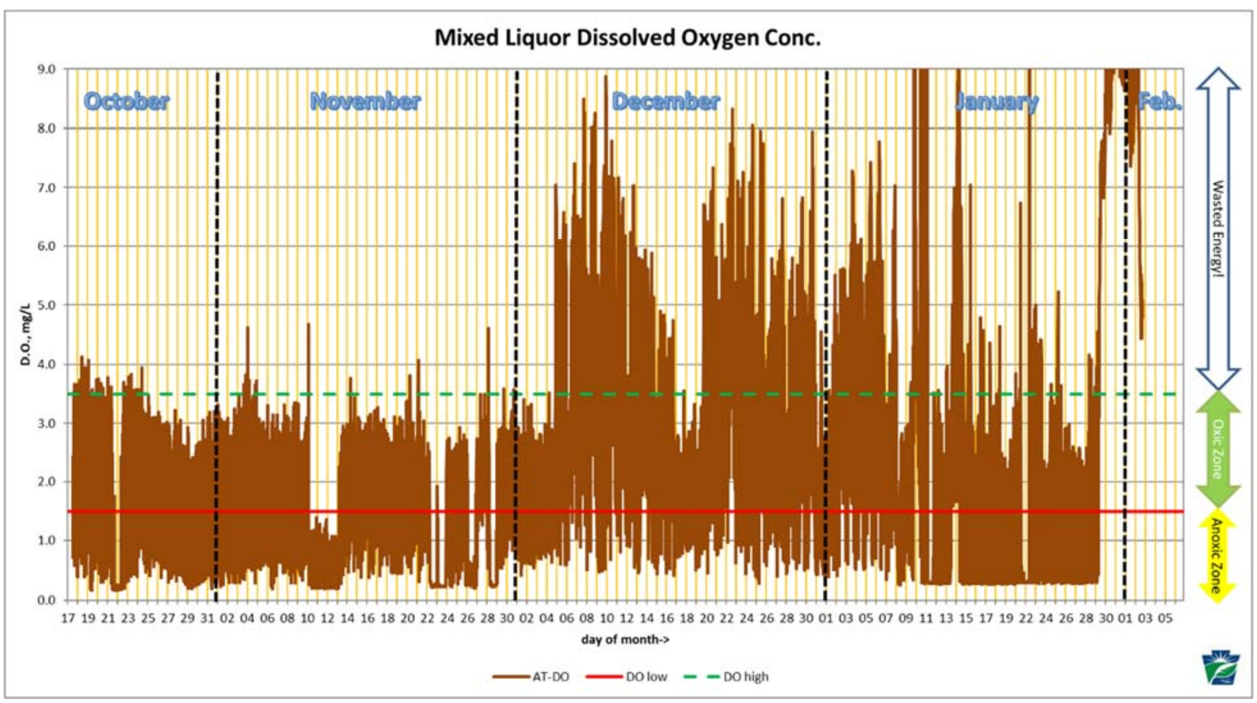
In this chart, the nitrate and ammonium concentrations reflect nitrification losses in October and November, where ammonium increases, nitrites are not formed by the bacteria. Nitrates peaked in December when nitrification succeeded in the presence of magnesia, and this nitrate is seen to be converted to nitrogen gas in January, once the anoxic mixing pumps were installed. .



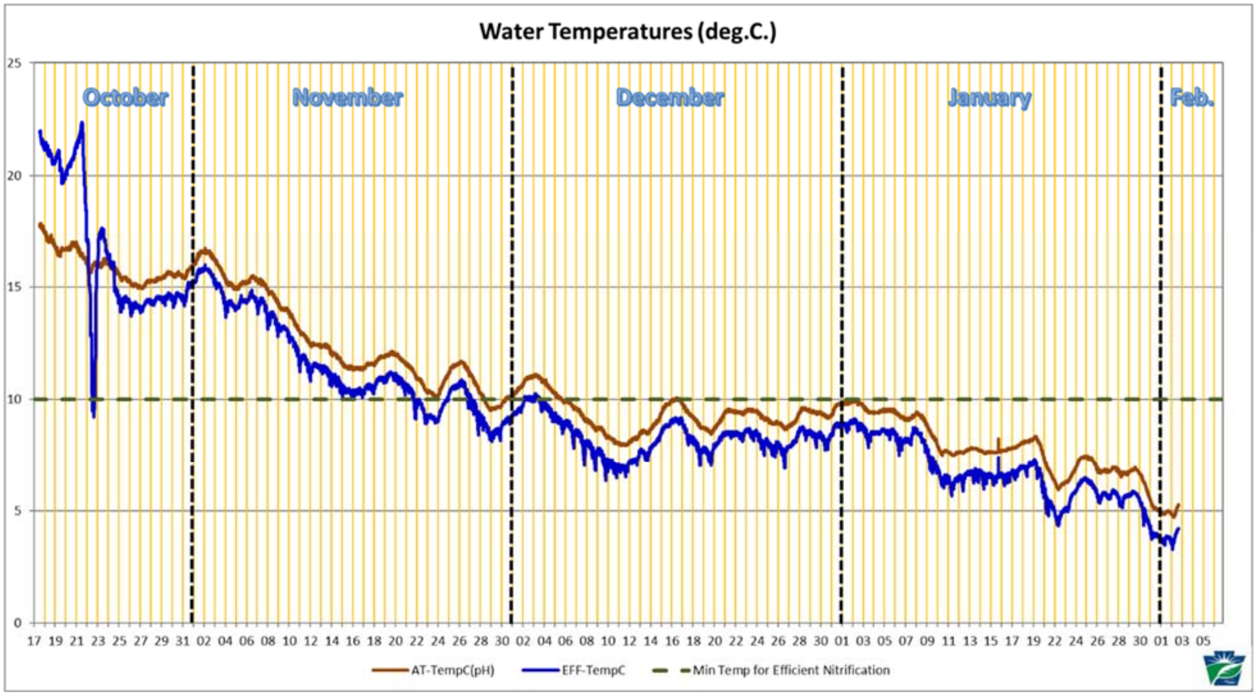
The water of LTMA's collection system is alkaline deficient, and biological nitrification produces nitrous acid as a biproduct, lowering mixed liquor pH. This pH recording shows that pH was often barely enough to maintain nitrification. In January, with alkalinity and anoxic mixing, the pH still had not approached the desired pH setpoints (in red) over neutral pH.



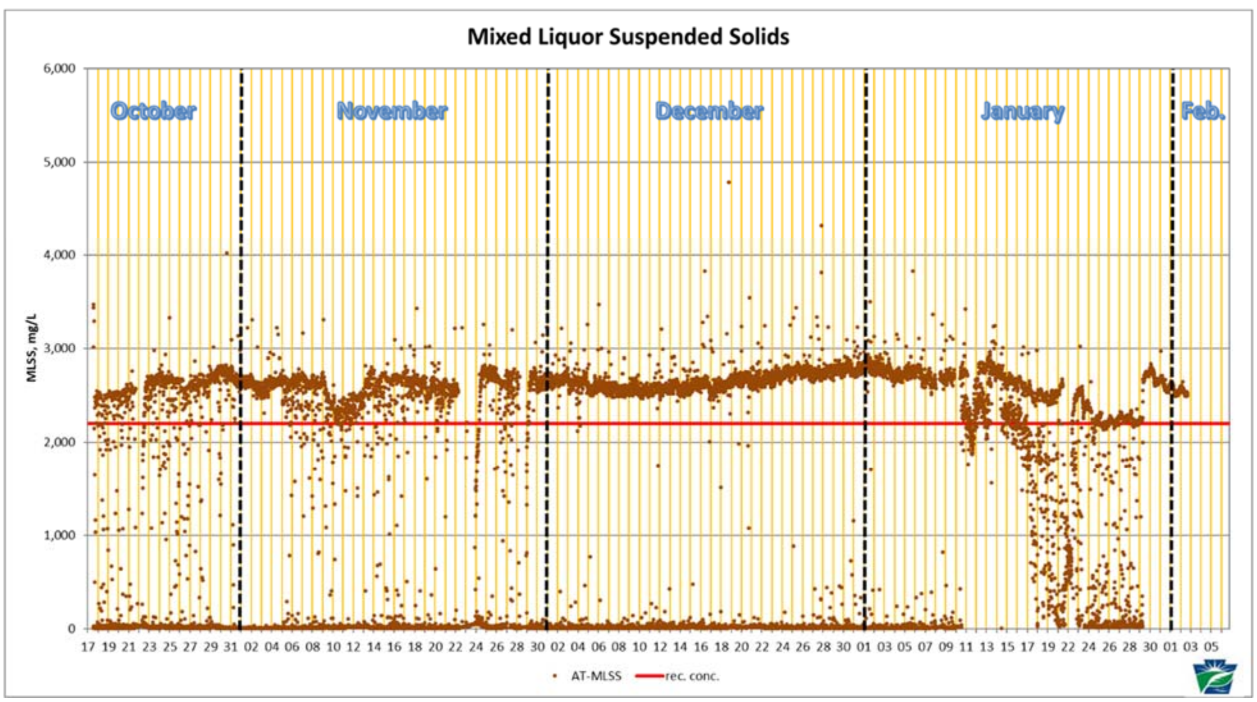
ORP tended to reside in the oxic zone during much of the evaluation. (Oct-early Jan) Once anoxic mixing had begun, the meeting of denitrifier bacteria with both food (BOD) and Nitrate ion under anoxic conditions allowed the bacteria to successfully strip oxygen from the nitrate, reducing nitrogen to molecular nitrogen gas.



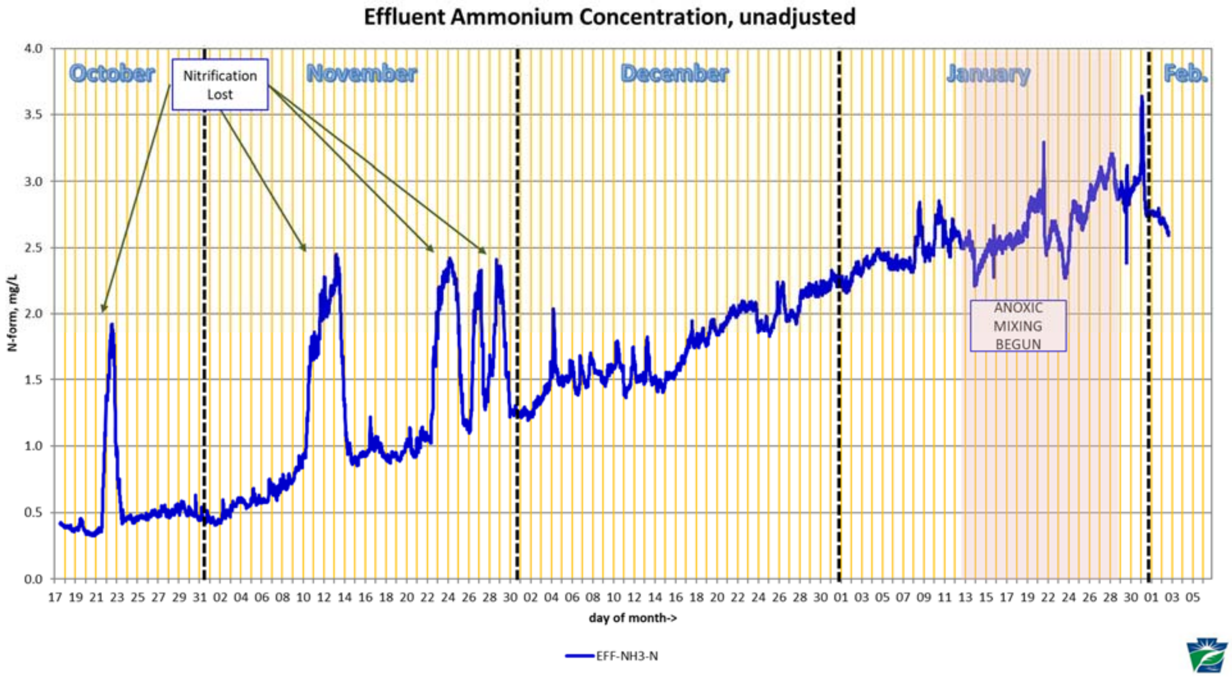
Generally, the variable frequency drives (VFD) controlling the aeration blowers, combined with the DOcontrolled aeration valves, regulate mixed liquor dissolved oxygen within set ranges to save energy; however, after December, the controls were less reliable as cold water and low influent BOD loading combined to retain oxygen. Note, though that the anoxic periods did achieve oxygen depletion. Oxygen "poisoning" is considered a great hindrance to biological denitrification.



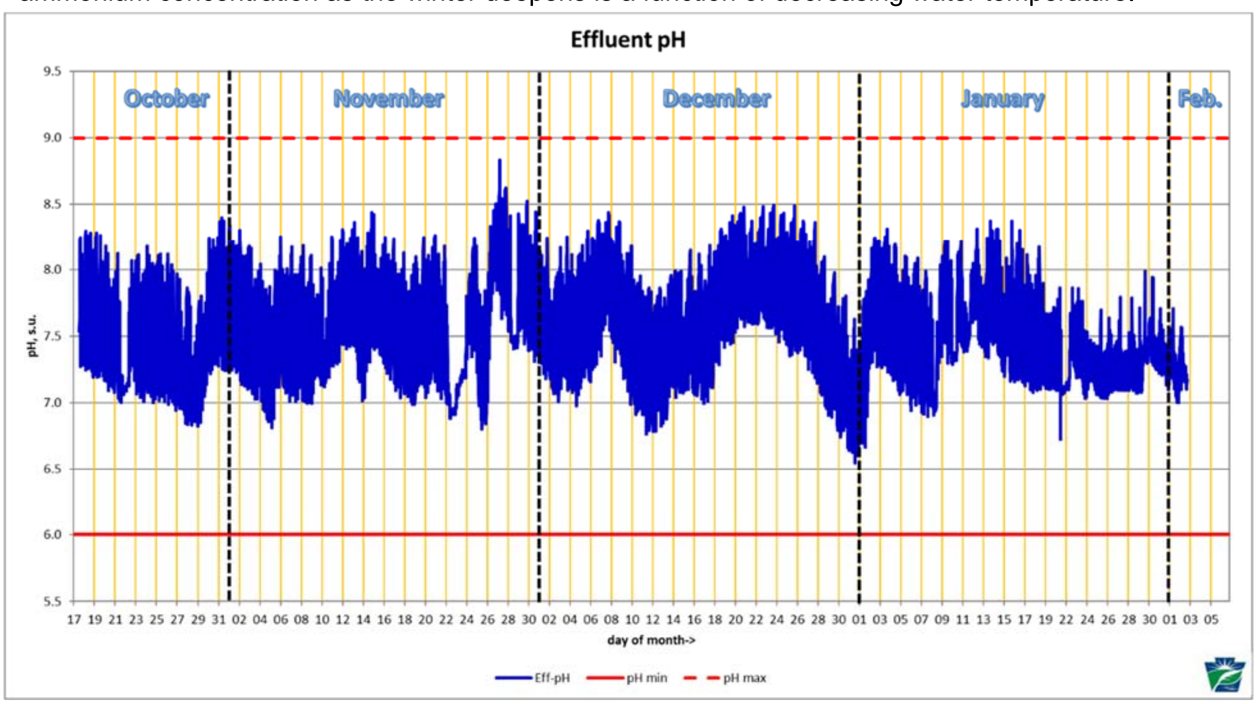
The temprature profile shows decreasing water temperature as winter advances. Since the biomass is temperature-sensitive, its metabolic rate and treatment efficiency falls as the water becomes colder. At 10 deg. C., which is 50 deg. F, nitrification efficiency drops off, and it vanishes below 5 deg. C.



The mixed liquor suspended solids concentration shown here displays solids concentrations generally in the upper 2,000 mg/L range. When aeration was curtailed by the automatic valves, the solids settled into a sludge blanket, dropping below the detection level of the solids probe (thus appearing as zero.) Only during anoxic mixing in January did the solids remain evenly distributed throughout the water column.

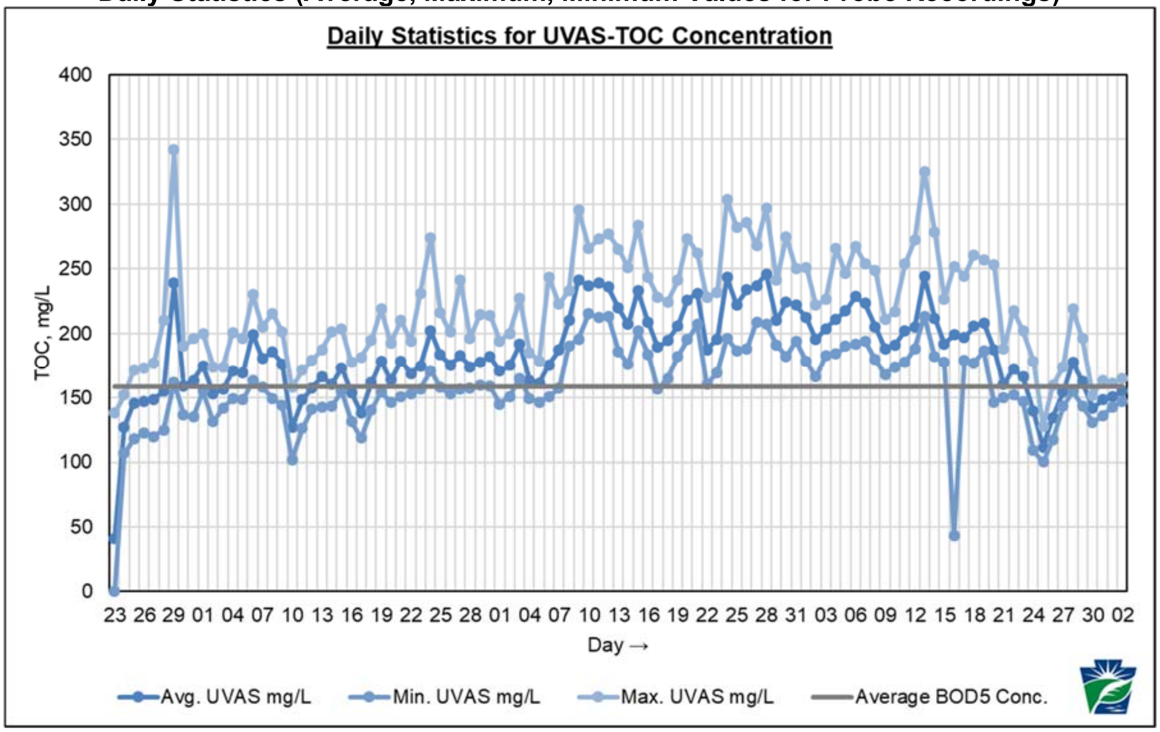


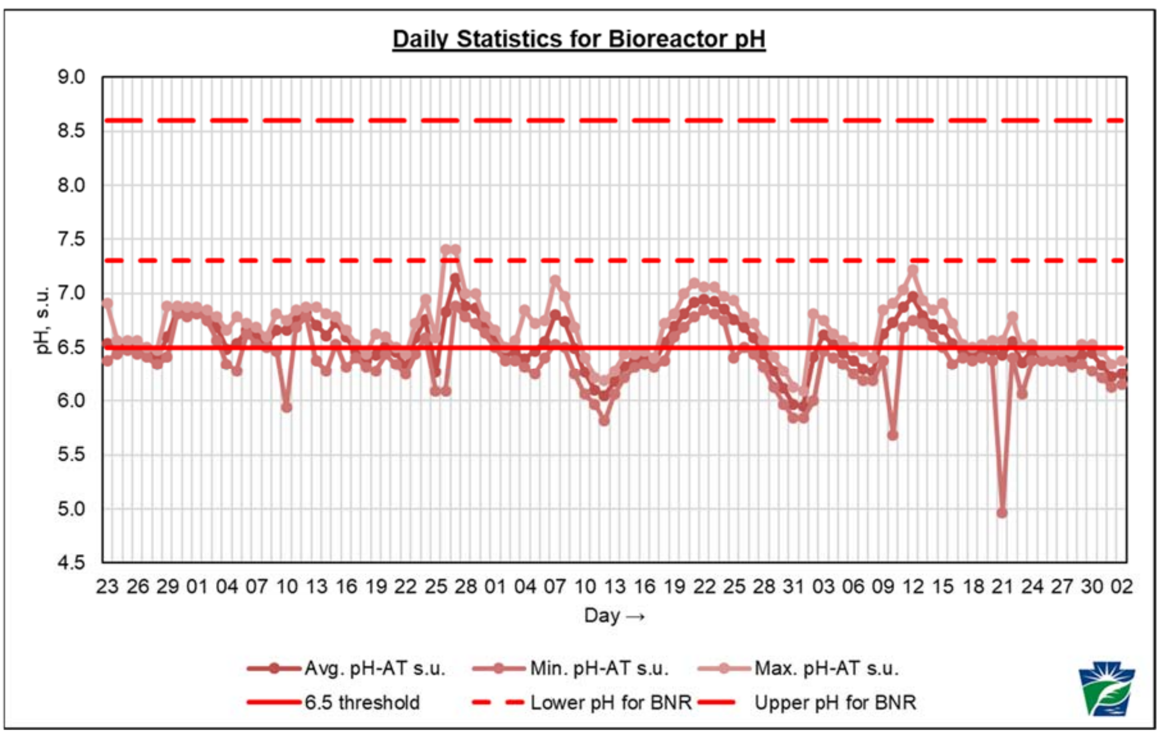
The spikes during October and November represent periods where nitrification was lost due to low influent BOD loading and low aeration alkalinity and pH as noted in the report. Although the ammonium probe became less precise as time passed, it did reflect qualitative improvements in nitrification once the magnesia began to stabilize the biomass under aeration. The gradual rise in ammonium concentration as the winter deepens is a function of decreasing water temperature.

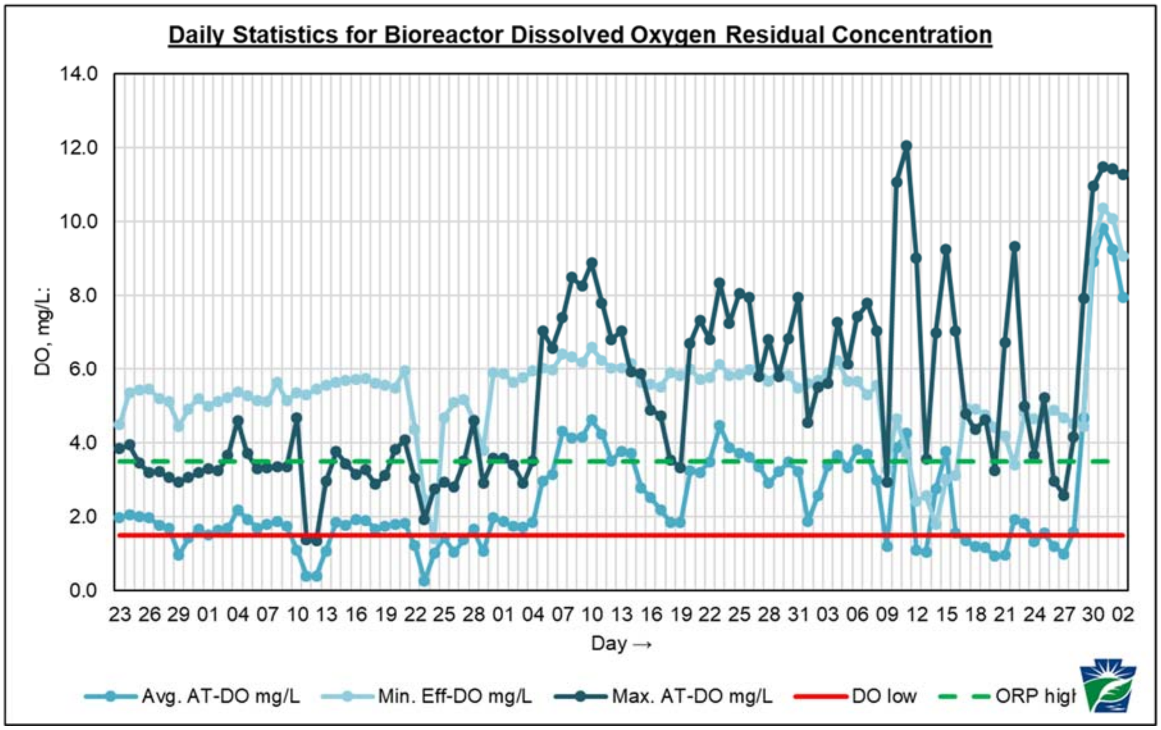


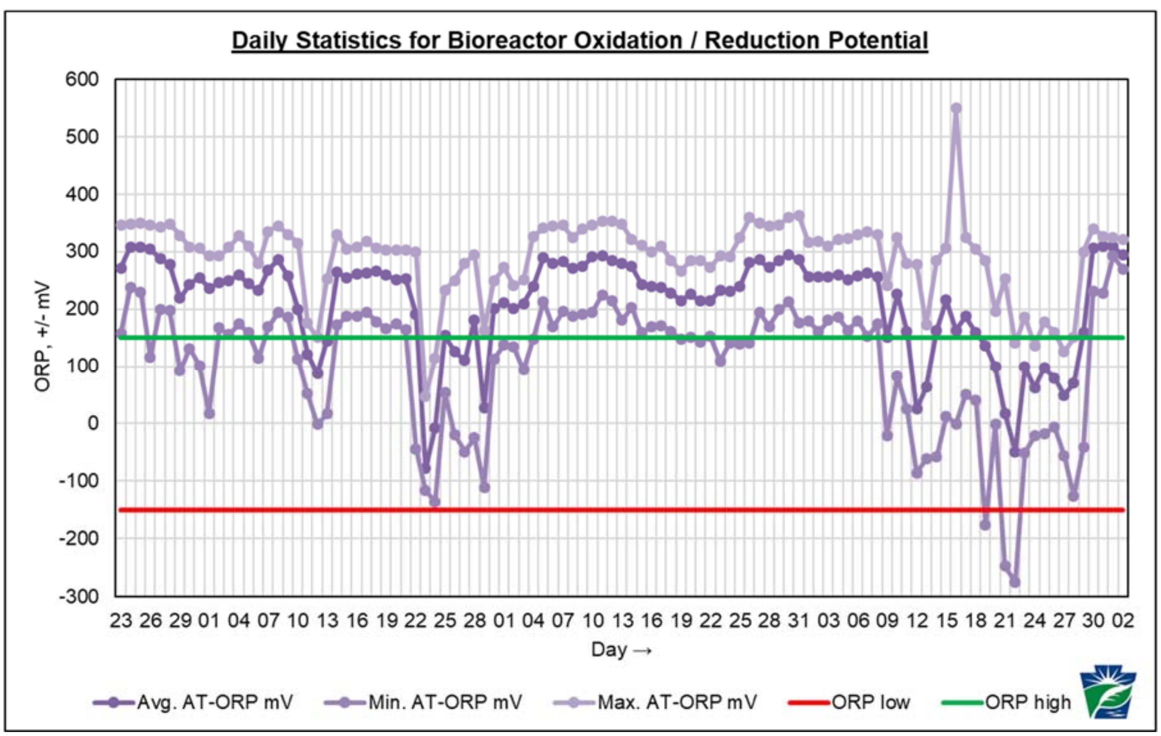
Effluent pH: The probe detected daily pH swings occurring during periods of very low or no flow through the effluent buffer tank. This tank is aerated, and the pH likely changes as a result of pumping atmospheric air with carbon dioxide into the standing water at zero flow conditions.

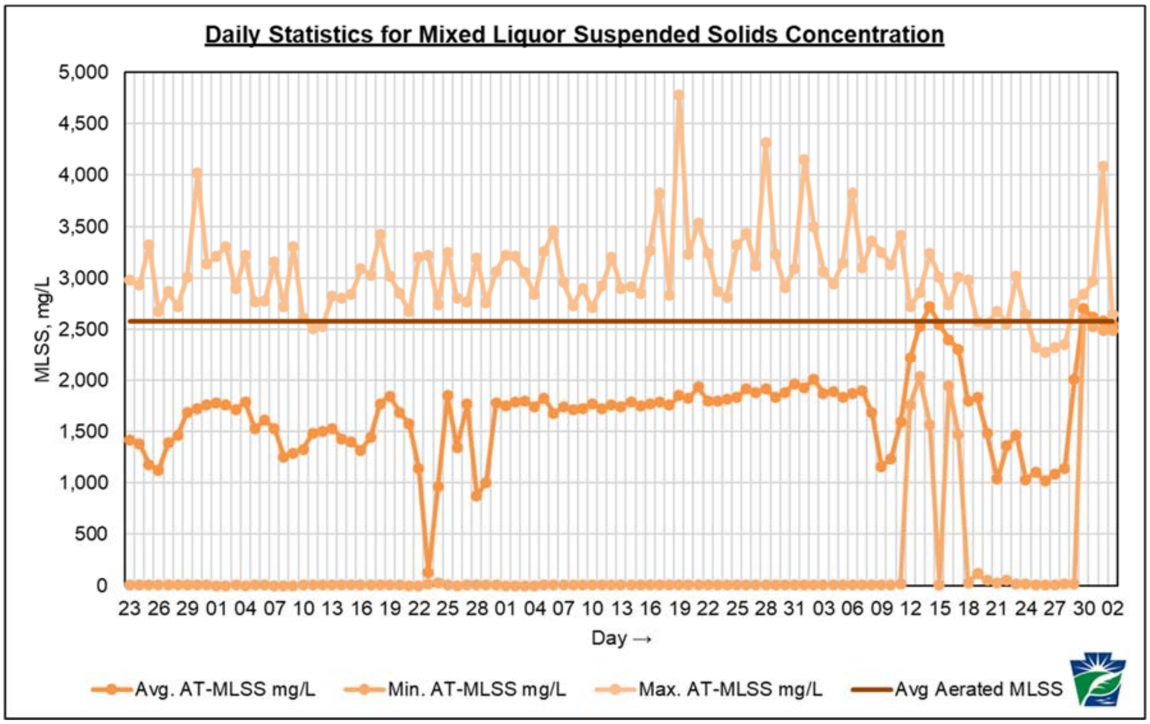
Daily Statistics (Average, Maximum, Minimum Values for Probe Recordings)

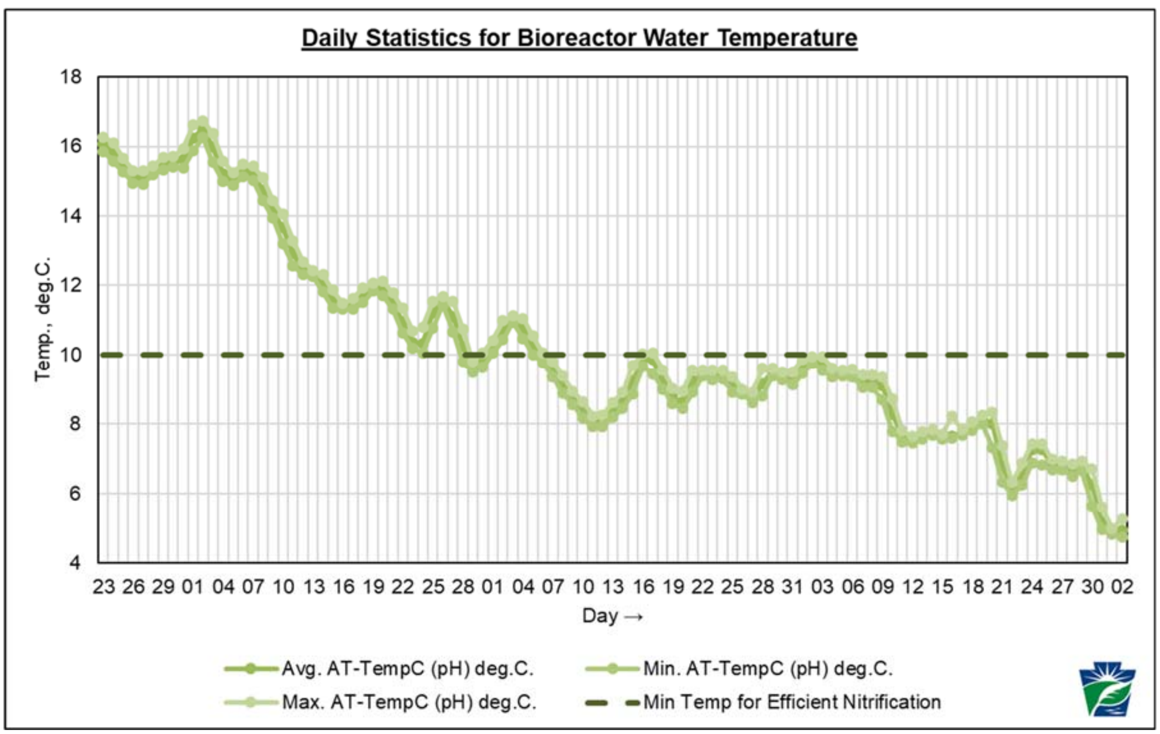


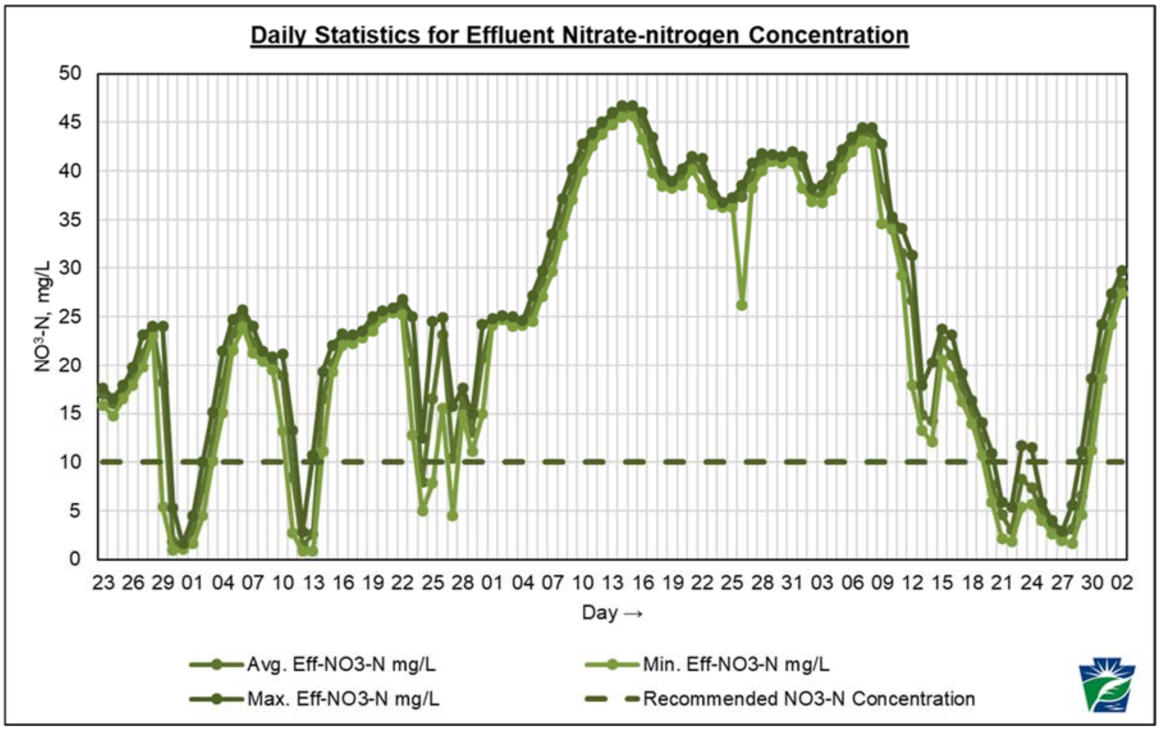


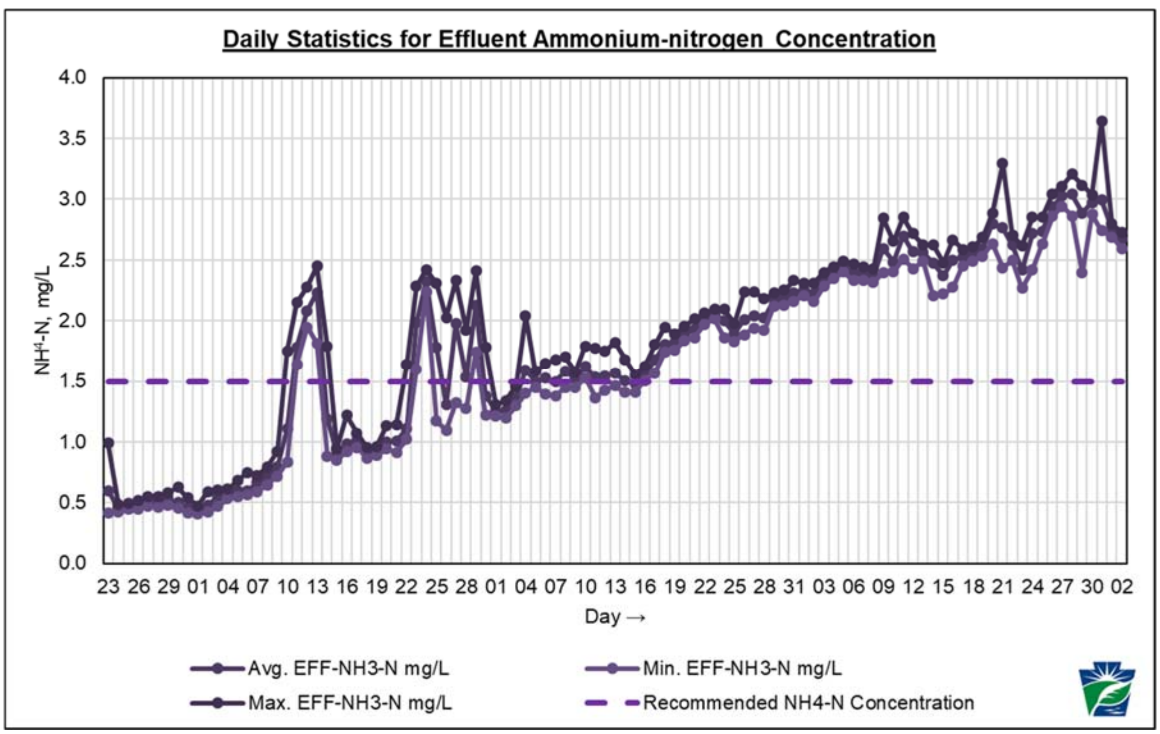

Daily Statistics for Bioreactor Dissolved Oxygen Residual Concentration
DO, mg/L:
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. AT-DO mg/L
Min. Eff-DO mg/L
Max. AT-DO mg/L
DO low
ORP higl

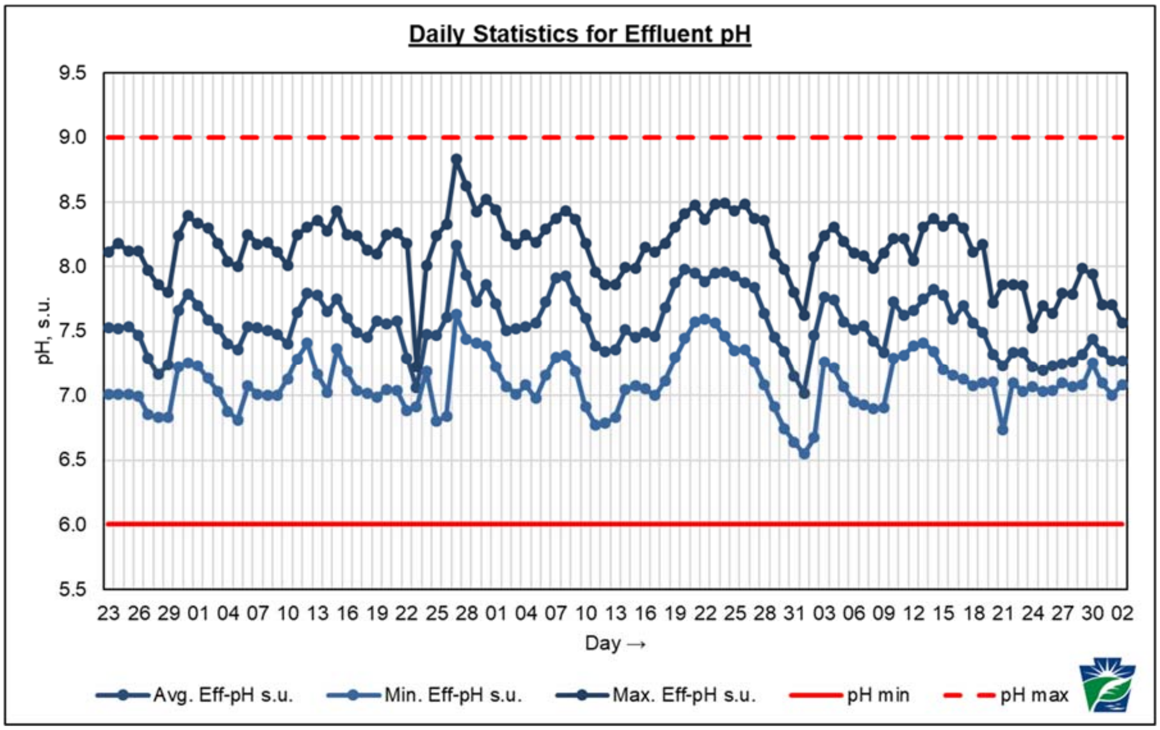

Daily Statistics for Bioreactor Oxidation / Reduction Potential
ORP, +/- mV
600
500
400
300
200
100
0
-100
-200
-300
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. AT-ORP mV
Min. AT-ORP mV
Max. AT-ORP mV
ORP low
ORP high

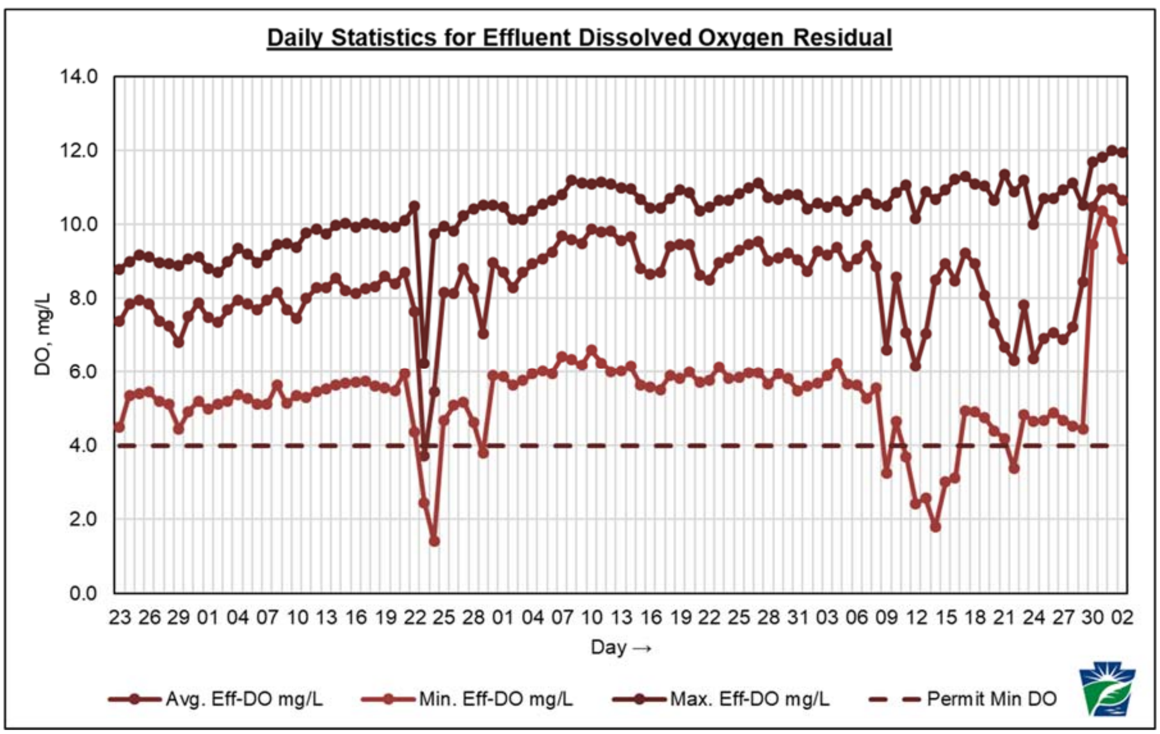

Daily Statistics for Mixed Liquor Suspended Solids Concentration
MLSS, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. AT-MLSS mg/L
Min. AT-MLSS mg/L
Max. AT-MLSS mg/L
Avg Aerated MLSS

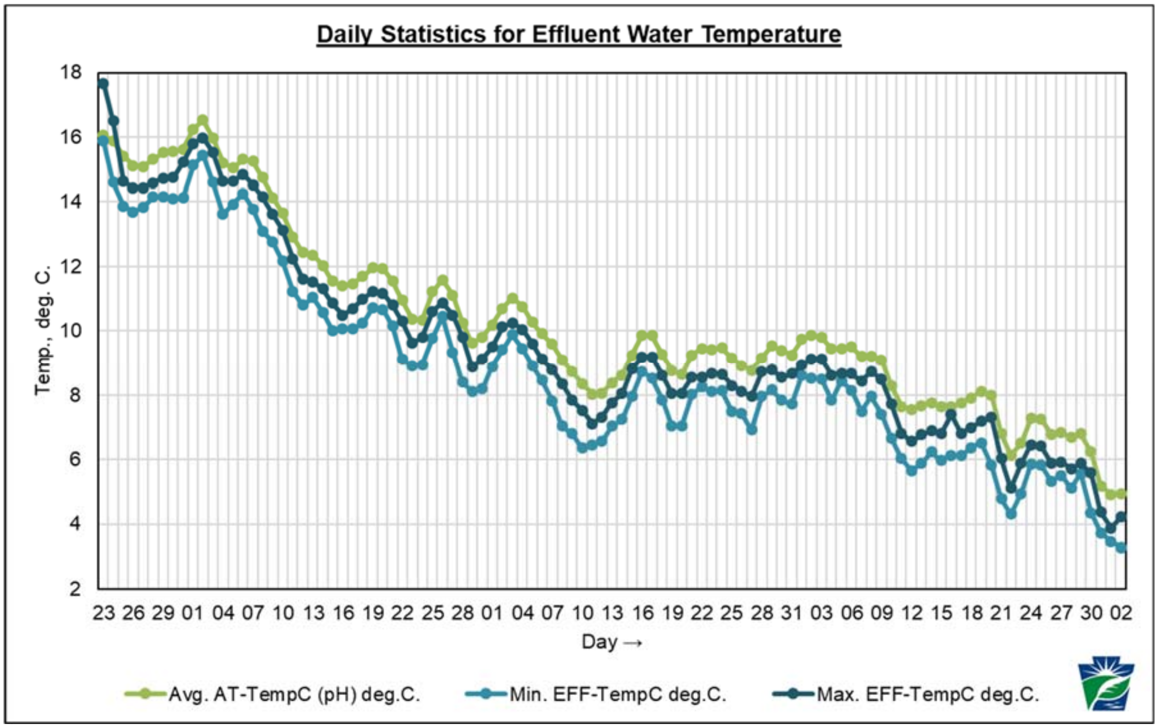

Daily Statistics for Bioreactor Water Temperature
Temp., deg.C.
18
16
14
12
10
8
6
4
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. AT-TempC (pH) deg.C.
Min. AT-TempC (pH) deg.C.
Max. AT-TempC (pH) deg.C.
Min Temp for Efficient Nitrification


Daily Statistics for Effluent Nitrate-nitrogen Concentration
NO3-N, mg/L
50
45
40
35
30
25
20
15
10
5
0
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. Eff-NO3-N mg/L
Min. Eff-NO3-N mg/L
Max. Eff-NO3-N mg/L
Recommended NO3-N Concentration

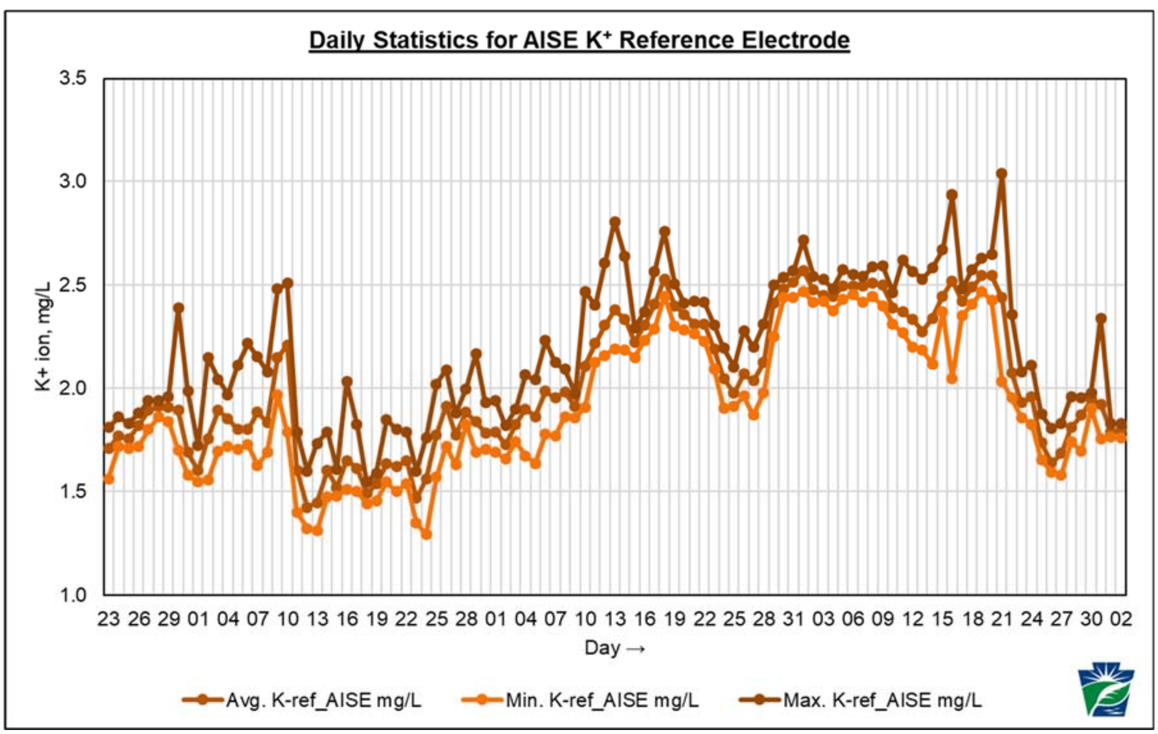

Daily Statistics for Effluent Ammonium-nitrogen Concentration
NH4-N, mg/L
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. EFF-NH3-N mg/L
Min. EFF-NH3-N mg/L
Max. EFF-NH3-N mg/L
Recommended NH4-N Concentration


Daily Statistics for Effluent pH
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
pH, s.u.
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. Eff-pH s.u.
Min. Eff-pH s.u.
Max. Eff-pH s.u.
pH min
pH max


Daily Statistics for Effluent Dissolved Oxygen Residual
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
DO, mg/L
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. Eff-DO mg/L
Min. Eff-DO mg/L
Max. Eff-DO mg/L
Permit Min DO



Daily Statistics for Effluent Water Temperature
18
16
14
12
10
8
6
4
2
Temp., deg. C.
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. AT-TempC (pH) deg.C.
Min. EFF-TempC deg.C.
Max. EFF-TempC deg.C.



Daily Statistics for AISE K⁺ Reference Electrode
3.5
3.0
2.5
2.0
1.5
1.0
K+ ion, mg/L
23 26 29 01 04 07 10 13 16 19 22 25 28 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21 24 27 30 02
Day →
Avg. K-ref_AISE mg/L
Min. K-ref_AISE mg/L
Max. K-ref_AISE mg/L

ATTACHMENT D: RECORD PHOTOGRAPHS

Equalization Tank & Bar Rack: equalization tank level should be maintained high enough to provide flow and load attenuation without endangering its capacity limit. The bar rack is not suited for a BNR facility, although it was adequate for extended aeration.

Aeration Tank with DO Sensor Probe at Upper Right and WTE probes at left. The DO sensor controls aeration blower valves to regulate oxygen content.

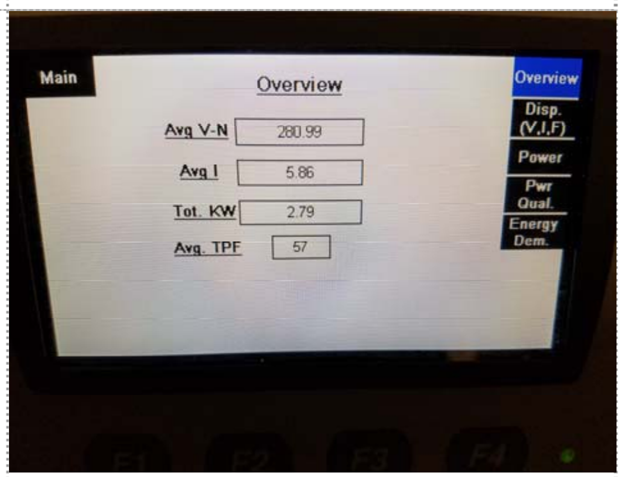
DEP Rail-mounted Immersion Probes: pH, DO, ORP, and MLSS

Centrifugal Blowers & DEP Monitoring Network. At left are the chemical feed system, with a work area in the far right corner.

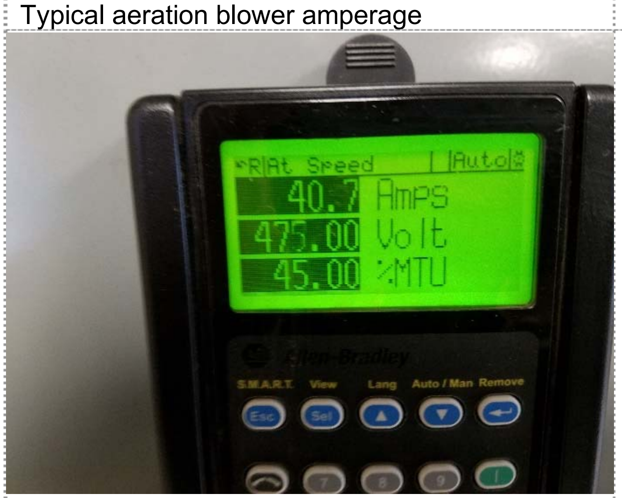
Effluent Balance Tank w/ Nutrient Probes : DEP had installed NO3-N and Ammonium ISE probes and added pH and DO for continuous monitoring. Shortly later, facility staff installed DO and pH monitoring probes that are tied to the facility SCADA system.

Intake valve regulator on centrifugal blower: Because centrifugal blowers are incompatible with variable frequency drives and operate at constant rpm, the intake valve is throttled to regulate air flow, supervised by dissolved oxygen residual in the aeration tank.

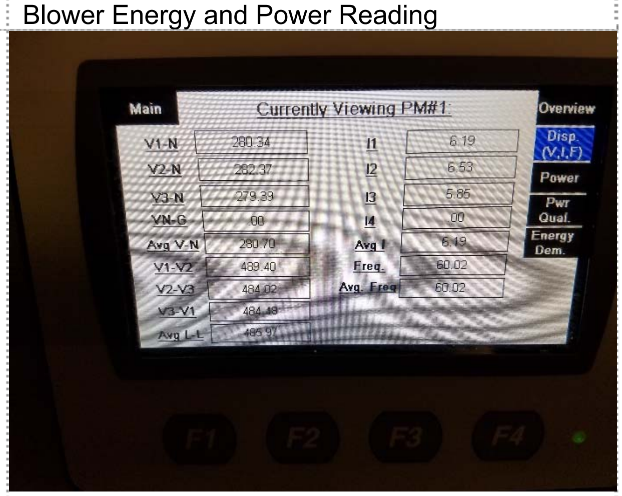
Typical aeration blower amperage



Blower Energy and Power Reading



Blower amperage and voltage



New Chemical Pump for Magnesia

Magnesia product used for alkalinity control

One of two new 230-volt grinder pumps used for anoxic mixing in the aeration tank. Alterations to the discharge end of the pump assured that current in the aeration tank would be in the form of a clockwise swirl instead of a geyser.

Detail of new pump model number and voltage.

New metering pump used to feed $Mg(OH)_2$ slurry

Equalization tank: view of wall penetration for to the equalization tank, shown at right.

chemical feed line. Operators threaded a polyflow tube through the broken chemical feed line to deliver the $Mg(OH)_2$, assuring they would never have to re-excavate this pipe.

Rag string clinging to solids probe is an example of why fine screening of trash and detritus is necessary for preliminary treatment: rag accumulation on the probe can damage the probe by making the mount too heavy to withstand current forces within the aeration tank.

View of aeration tank during anoxic mixing phase: two new grinder pumps were installed at opposite ends of the tank, creating a whirlpool swirl of mixing during anoxic periods. Doing this kept the facultative bacteria in contact with both food (organic carbon in the wastewater) and nitrate ion in solution, the backup source of oxygen for cellular respiration.

ATTACHMENT E: COST ESTIMATES FOR MONITORING PROBES

During the evaluation, the facility manager installed a DO and pH probes at the effluent reaeration tank for continuous monitoring of these compliance parameters. To increase the efficacy of biological nitrogen removal in the aeration tanks, using intermittent aeration, DEP staff recommends the inclusion of pH and ORP probes in the aeration tanks. The following table summarizes projected initial and ongoing costs that should be budgeted as part of the facility's maintenance budget.

Probe Installation and Maintenance Pricing:			
Hach.com	List price	Qty	Cost:
PHDsc pH Immersion Probe	$ 980	2	$ 2,098
pH/ORP Immersion Probe	$ 1,210	2	$ 2,238
Salt Bridge for pH & ORP Probe, annually	$ 81	4	$ 322
Std.Cell Solution for Salt Bridge, annually	$ 72	1	$ 72
200mV ORP Sol'n. 500 ml., annually	$ 63	2	$ 127
		Total:	$ 5,287

Repair/Replacement Recommendations:

1. The cost for an SC1000 controller base with full capability is $2,586 but it also requires a universal display module for another $2,520. Total SC1000 cost would be: $5,106.
2. The SC200 controller price new is $1,965.
3. ORP and pH probes: the sub-total cost for 2 pH and 2 ORP probes is $4,336.
4. The cost for sensor end caps for the LDO probes is $215 each. These must be replaced annually and should be budgeted as recurring expense. Sub-total cost: $430.

Automation Improvements:

1. Cost of probes to automate the final effluent compliance testing, as recommended in the evaluation, includes the following:
   1 Chlorine analyzer & accessories: $5,300
   Costs do not include installation and electrical work that is done in-house.
2. The operators desired to have digital recording of probe output on the computer used in their control building, which would require connecting all SC200 to one another and a digital converter for the lab computer, with software. The digital converter is about $140, but the software may cost up to $1,200. This would provide continuous data recording and display, and data could be graphed and displayed as done by DEP's evaluator. A full, remote SCADA system would probably require significant custom programming and cost much more.

Nutrient Probes:

BNR treatment facilities generally require a higher standard of process monitoring, including monitoring of ammonium and nitrate nitrogen in addition to process alkalinity and nitrite-nitrate, nitrite nitrogen, total Kjeldahl (organic nitrogen + ammonium,) and orthophosphate. While considered "luxury" items in smaller treatment facilities, pricing information for ammonium and nitrate probes are here provided for possible consideration in budget planning:

1. Cost of probes to automate monitoring of ammonium and nitrate, exclusive of a probe

controller (the facility may employ one of eight repaired SC200 with these):

1 Ammonium + Nitrate ISE Probe	$10,114
1 Rail Mount Kit	453
1 Air-blast Cleaning Harness	301
1 Air-blast 120vac Compressor	2,003
2 Probe heads per year	2,056
1 Nitrate Standard solution for calibration	$ 61
Total these items:	$14,988

-or-

1 Ammonium ISE Probe	$ 7,428
1 Rail Mount Kit	453
1 Air-blast Cleaning Harness	301
1 Air-blast 120vac Compressor	2,003
2 Probe heads per year	2,056
1 Nitratax Plus SC Probe, 2mm:	18,251
1 Wall-mount Kit	522
1 Replacement wipers for Nitratax	314
1 Nitrate Standard solution for calibration	61
Total these items:	$31,389

2. Like all immersion probes, these probes require regularly scheduled maintenance, and the ISE probe requires replacement of the sensor head every six months. Parts and bench calibration should be budgeted as recurring costs.

2 AN-ISE or AISE probe heads	$ 2,056 w/o annual svc.
AN-ISE or AISE annual bench service includes 2 new probe heads per year	$ 3,050 w/ annual svc.
Nitratax Plus SC annual bench service	$ 870

3. These probes are usually installed post-secondary treatment, usually in the effluent stream or following secondary clarifiers.

Suspended Solids Probe:

DEP employed a suspended solids probe in the aeration tank to monitor the concentration of mixed liquor suspended solids (MLSS.) While laboratory process monitoring tests are adequate for this facility, the solids probe has been eminently useful for reducing laboratory time, provided it is regularly calibrated with laboratory test results. The pricing is provided here for planning purposes.

Solitax sc Probe	$4,539
Rail Mount Kit	519
Annual bench service	450
Total these items:	$5,508

ATTACHMENT F: RECOMMENDED MONITORING TESTS & FREQUENCIES

PROCESS CONTROL TESTS FOR DOMESTIC WASTEWATER TREATMENT FACILITIES

Activated Sludge Facility: Conventional, Complete Mix, Step Feed, or Extended Air
Less than and including 1.0 MGD (Page1 of 1)

SAMPLE PARAMETER	SAMPLE LOCATION	SAMPLE TYPE	3/WEEK	1/WEEK	2/MONTH
Raw Influent*					
BOD_5 and/or COD	Influent	Grab			X
TSS/VSS, NH_3-N, and pH	Influent	Grab			X
* Frequency of sampling may need to be increased or decreased depending on plant size or conditions.					
Aeration Basin					
MLSS/MLVSS (or centrifuge, with correlated data from periodic MLVSS values)	RAS line and effluent	Grab			X
Dissolved oxygen	Effluent	In situ		X	
Settleability (SV30)	Effluent	Grab	X		
pH	Effluent	Grab		X	
Microscopic examination	Effluent	Grab			X
Computation of SVI, F/M ratio, sludge age, and/or MCRT, as desired	Effluent	—	As data collected		
Secondary Clarifier					
Sludge blanket depth	As appropriate	In situ		X	
Final Effluent					
Parameters, sample types, and frequencies as required by permits.					

The table reproduced above lists suggested sampling frequencies for facilities of capacity up to 1.0 MGD. This represents the minimum monitoring requirements; however, experience suggests that process monitoring tests be performed more frequently when a facility is experiencing any changes. These changes include any process changes made by the operators and any changes due to unavoidable circumstances, such as slug loading, hydraulic overloads (“storm mode”,) or equipment service interruptions. Generally, the higher the level of treatment, the more process control testing is necessary. For example, denitrification operations require additional process monitoring when compared to nitrification operations.

The gravimetric solids test is the gold standard for solids testing. The DEP portable laboratory included a solids-by-volume centrifuge test that does in 15 minute what otherwise takes up to four hours. If used, centrifuge solids tests are done daily and are backed up with gravimetric solids tests about twice per month to maintain centrifuge calibration (Weight-to-Concentration Ratio, or WCR.) Microscopy, Settleability, and water chemistry should be done on the mixed liquor at least twice per week until the operators have reasonable understanding of a 4-season set of reference data to which they may refer in future years. Whenever process or treatment methods change, the test data set would need to be reproduced. Also, whenever the facility experiences plant upset conditions more frequent process-monitoring and control testing should be performed by the operators, until conditions stabilize.

Process Monitoring testing is often not the same as those performed by contract laboratories in that approved test methods are not utilized. Compliance testing refers to those analyses used by certified laboratories for reporting parameters required by the NPDES permit and the daily required effluent testing for dissolved oxygen (DO,) pH, and total residual chlorine (TRC.) Over the years, many small treatment facilities began to contract compliance testing to certified environmental laboratories. This eased the burden on operators, and it saved the facility owner the cost of maintaining certification of its own laboratory. However, over time, many facilities ceased to perform regular process monitoring tests, as well. It is important for operators to know the condition of their facilities, the sludge solids inventory, and the qualities of the treatment solids (i.e., quantity and quality of "bugs") to effectively optimize operations.

DEP's WWTAP has adopted the process monitoring tests recommended by US-EPA and the professional trade organization, Water Environment Federation (WEF.) These tests include the following:

- Centrifuge solids test: percent volume/volume measurement of activated sludge solids for activated sludge-type plants: Calculations stemming from this data include solids inventory (expressed as "sludge units" (SLU).)
- Clarifier blanket level: a core-sampling of the clarifier contents provides a proportional quantity of mixed liquor and supernatant that can be analyzed for percent suspended solids (TSS) using the centrifuge. Test results are used for developing awareness of how much mixed liquor is detained in the effluent clarifier, representing part of the overall sludge inventory.
- Settleometry test: 30- and 60- minute activated sludge settling rates in wide half-gallon or 1-liter, calibrated vessels: Settled sludge volume (SSV) is expressed in standard 30-minute intervals and used to calculate Settled Sludge Concentration (SSC) which is a qualitative measure of how well the activated sludge settles in the clarifier, mimicking clarifier performance in terms of supernatant quality as well. Using WCR, it is also possible to calculate and track Sludge Volume Index (SVI).
- Oxygen Uptake Rate (a.k.a. Soluble Oxygen Uptake Rate): By measuring the rate of dissolved oxygen depletion in a sample of mixed liquor, one may demonstrate the relative effect of BOD loading on the biomass, how quickly this material will be metabolized by the activated sludge organisms. Expressed in "milligrams Oxygen per hour," when mixed liquor volatile suspended solids concentration is known or can be extrapolated, then one may determine the actual Respiration Rate, in mg. Oxygen per hour per gram of activated sludge. OUR and RR are also useful for comparing the relative health of the biomass under toxic conditions, should there be undesirable contaminants in the raw wastewater, or anoxic conditions, should the aeration be insufficient to treat the incoming waste load using the available amount of oxygen.
- Raw Wastewater and Effluent Chemical Oxygen Demand (COD): an analog of the 5-day Biochemical Oxygen Demand test, COD can be determined in about three hours and give operators a quick assessment of relative strength of wastewater and/or the amount of material remaining in treated effluent, thereby providing an analog of treatment efficiency.
- Nutrient Tests: A portable wastewater laboratory provided during the WTE consists of materials for conducting various colorimetric analyses for nutrients such as ammonia-nitrogen, nitrite, nitrate, organic nitrogen, phosphorus, etc. to determine whether the facility is removing or treating nutrients. For process monitoring purposes, nutrient test strips provide ample, low-cost, low-trouble test results. They are available in most supplier catalogs (USA Blue Book, Hach, Grainger, et al.)

- Various other tests included in the portable wastewater laboratory include alkalinity testing (the buffering capacity of the mixed liquor or the clarified supernatant to resist changes in pH,) chlorides, sulfides, halogens such as Total Residual Chlorine and Free Chlorine, and metals including aluminum and iron, known contaminants to downstream aquatic life.

The objective of all this testing is to develop a unique profile for the facility useful in creating visual graphs of operational trends, showing conditions that become predictive of how the facility responds to various beneficial or adverse conditions that could affect effluent quality and treatment efficiency. Once sufficient data exists, operators should have a cogent understanding of how the facility responds to process adjustments and what they must do to maintain it in good condition.

Typically, operators of activated sludge treatment facilities should determine an overall treatment strategy for their facility, using standard industry calculations for constant:

- Food to Mass Ratio (F/M)
- Mean Cell Residence Time (MCRT)
- Sludge Age or Dynamic Sludge Age

These values can be determined using the equipment described above. These calculations provide set-points unique to the facility that can be adjusted either through changes in sludge wasting rates or aeration capacity, assuming that the concentration of waste in the wastewater is a variable that operators cannot control.

Since operators have the most control over sludge wasting rates, adjusting any of these process control strategies can be done successfully by adjusting the concentration (or load) of suspended solids (biomass) under aeration.

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ATTACHMENT G: CALCULATING ALKALINITY DEMAND

Typically, alkalinity in effluent should be 50 mg/L or match that of the receiving stream; however, because of bioavailability of alkalinity at the pH range needed by nitrifying bacteria, this concentration should be higher in the Aeration Tanks, 100 mg/L up to 220 mg/L.

Alkalinity demand should be calculated. Since each 1 mg/L of ammonium in the secondary influent requires 7.14 mg/L alkalinity as $CaCO_3$[10], multiply the influent (or raw) TKN (total Kjeldahl nitrogen, which is organic nitrogen and ammonium nitrogen, combined)[11] concentration in mg/L X 7.14 mg/L alkalinity to determine a minimum amount of alkalinity needed for ammonia removal through nitrification. Then determine the influent alkalinity concentration already present and subtract this from the alkalinity demand you just calculated for your influent ammonium.

Example:
32 mg/L Influent TKN x 7.14 mg/L alkalinity per 1 mg/L TKN = 228 mg/L alkalinity required

If the secondary influent already has 56 mg/L of alkalinity, then the net alkalinity demand is:

228 mg/L alkalinity needed to treat – 56 mg/L alkalinity in Influent = 172 mg/L alkalinity demand

To convert this to an actual chemical dose, you will have to multiply the net demand concentration by the Influent flow rate:

If the average flow is <u>0.035 MGD</u>, then the amount of alkalinity required would be

172 mg/L x 0.035 MGD x 8.34 lb./gal = 50 lb./day.

To convert this to a chemical dose, you will have to determine the available alkalinity in the chemical. For example, 1 lb. hydrated lime has 0.74 lb. alkalinity[12]. This means that to provide 50 lb./day alkalinity as $CaCO_3$, you need to divide this by the ratio of chemical to alkalinity:

50 ÷ 0.74 = 68 lb./day of hydrated lime

Figure adding 1-½ fifty-pound bags added over 24 hours, not all at once. Using the 100-gallon day tank, the feed rate would be

75 lb./day ÷ 24 hours = 3-1/8 lb./hr. (100 gal. per day = c. 4.2 gal./hr.)

Keeping track of the alkalinity demand over time should help when determining the size and capacity of the chemical feed pump and the size of the line needed.

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[10] To account for bioavailability of alkalinity at the desired MLSS pH of 7.2 to 7.5, substitute 8 mg/L for 7.14 mg/L. This increased the alkalinity required but is also more realistic, since 7.14 mg/L is the **minimum** required.
[11] If you can't test for TKN, substitute a test for ammonia-nitrogen and multiply the result by 1.25 to approximate the combination of organic nitrogen and ammonium nitrogen, together.
[12] See the table on the next page.

Supplemental Alkalinity Buffering Compounds

Compounds	Alkalinity-Ratio, ppm/ppm $CaCO_3$
Soda Ash	1.06
Acetate	0.82
Hydrated Lime	0.74
Quick Lime	0.56
Bicarbonate	1.68
Caustic soda	0.80
Magnesium hydroxide	0.50

ATTACHMENT H: NPDES PERMIT REPORTING PARAMETERS

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. A. For Outfall 001 , **Latitude** 40° 16' 27.90" , **Longitude** 79° 18' 12.40" , **River Mile Index** 32.68 , **Stream Code** 43255
Receiving Waters: Loyalhanna Creek

Type of Effluent: Sewage Effluent

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lb./day)		Concentrations (mg/L)					
	Average Monthly	Weekly Average	Instantaneous Minimum	Average Monthly	Weekly Average	Instant. Maximum	Minimum Measure-ment Frequency	Required Sample Type
Flow (MGD)	Report	Report Daily Max	XXX	XXX	XXX	XXX	Continuous	Recorded
pH (S.U.)	XXX	XXX	6.0 Min	XXX	9.0 Max	XXX	1/day	Grab
Dissolved Oxygen	XXX	XXX	4.0 Min	XXX	XXX	XXX	1/day	Grab
Carbonaceous Biochemical Oxygen Demand (CBOD5)	32.1	48.2	XXX	25	37.5	50	1/week	8-Hr Composite
Biochemical Oxygen Demand (BOD5) Raw Sewage Influent	Report	Report Daily Max	XXX	Report	Report Daily Max	XXX	2/month	8-Hr Composite
Total Suspended Solids Raw Sewage Influent	Report	Report Daily Max	XXX	Report	Report Daily Max	XXX	2/month	8-Hr Composite
Total Suspended Solids	38.6	57.8	XXX	30	45	60	1/week	8-Hr Composite
Fecal Coliform (No./100 ml) Oct 1 - Apr 30	XXX	XXX	XXX	2,000 Geo Mean	XXX	10,000	1/week	Grab
Fecal Coliform (No./100 ml) May 1 - Sep 30	XXX	XXX	XXX	200 Geo Mean	XXX	1,000	1/week	Grab
Ultraviolet light transmittance (mW/cm^2)	XXX	XXX	Report	Report	XXX	XXX	1/day	Measured
Total Nitrogen	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	8-Hr Composite
Ammonia-Nitrogen	XXX	XXX	XXX	Report	XXX	Report	2/month	8-Hr Composite
Total Phosphorus	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	8-Hr Composite
Aluminum, Total	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	8-Hr Composite
Iron, Total	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	8-Hr Composite
Manganese, Total	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	8-Hr Composite

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