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**WASTEWATER TREATMENT EVALUATION**  
**SCHUYLKILL HAVEN AREA MUNICIPAL AUTHORITY**  
SEWAGE TREATMENT FACILITY  
SCHUYLKILL COUNTY, PENNSYLVANIA  
NPDES Permit No. PA0029017



—prepared by—  
Marc Austin Neville, WPS  
PA Dept. of Environmental Protection  
Bureau of Clean Water  
POB 8774  
Harrisburg, PA 171050-8774



**October 2018**

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**Disclaimers:**

The mention or use of a brand of equipment is not an endorsement for any manufacturer or vendor. The Department urges the permittee to research available products and select those which are the most applicable for its situation and compatible with existing equipment. The goal of the Department's Wastewater Optimization Program is to improve receiving water quality through training, trouble-shooting, and monitoring. Permittees will be encouraged to achieve effluent quality above and beyond current permit requirements.



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### **Executive Summary:**

During the summer of 2018, staff from Pennsylvania Department of Environmental Protection (DEP) and U.S. Environmental Protection Agency Region III (EPA) conducted an Enhanced Technical Assistance Evaluation (ETA) at Schuylkill Haven Wastewater Treatment Facility (SHSTP) located along the Schuylkill River evaluating denitrification using intermittent aeration. DEP was invited to do so by the facility's superintendent, who has been seeking ways to minimize energy costs at his facility. Although the scope of this demonstration was limited by availability and age of existing equipment, DEP and EPA staff were able to show that the facility would reap a combined benefit of energy and nutrient reduction if it pursues a program of denitrification when upgrading obsolete equipment. The facility is planning to replace its aeration blowers and diffusers used in secondary activated sludge treatment and to replace existing aeration facilities in its aerobic digesters, a project proposed by the facility engineer, Entech, in a report dated March 2, 2018

EPA Staff had been working with SHSTP regarding its energy options, and they recommended that DEP deploy its collection of in-line, continuous monitoring immersion probes to assist facility operators in visualizing intermittent aeration and denitrification as a vehicle to increased energy savings. This report covers the demonstration and evaluation, with the accompanying recommendations.

### **Recommendations:**

While working on site, EPA and DEP staff offered suggestions for ways to improve performance of the treatment process, some of which follow in the body of the report.

The principal recommendation supported by this study is that no proposed modifications to this facility should be made without first considering the incorporation of controlled biological nutrient removal (BNR) into the operations and process control strategy as identified in the facility wastewater treatment plant feasibility study.

Other considerations include:

1. Using treatment chemicals to boost the alkalinity of mixed liquor during aeration and nitrification. Adding alkalinity in the forms of bicarbonate or hydroxide will help to maintain treatment pH within a range more optimal for nitrifying bacteria;
2. Reducing the concentration of activated sludge solids during the summer months. Doing so will remove inert mass from the system while promoting a more active, younger biomass to more efficiently remove carbon and ammonia wastes, but it may also require operating all three of the aeration basins. At present, one of these basins has been idle for a long time;
3. Installing pH probes in the aeration tanks to use with a proposed chemical alkalinity feed system. Lime, if used, should be mixed with service water and metered into the facility to achieve a working pH range of 7.0 to 8.5 s.u. in the aeration tanks. Alternative chemical feed systems, such as use of magnesium hydroxide [Mg(OH)<sub>2</sub>] should be investigated and priced for feasibility.
4. Pursue the engineers' recommendations to upgrade the aeration facilities, replacing obsolete blower-motor combinations with more energy-efficient models that are controlled by dissolved oxygen probes located in secondary aeration, through variable frequency drives for the blower motors.
5. Install ORP Probes and subsurface anoxic mixers to control and optimize anoxic denitrification in the existing footprint of aeration tanks. A sophisticated SCADA system would incorporate aeration/anoxic timing controls, but it may also be possible to achieve this using simple NO/NC secondary timers.

6. The facility's secondary clarifiers should be evaluated for short-circuiting and potential adverse currents;
7. Evaluate the grease-removal system for upgrades or repairs to eliminate the accumulation of rotting organic material on the surface of the primary clarifiers.
8. Installation of total suspended solids (TSS/MLSS) probes in the aeration tanks may enhance solids management in conjunction with a robust solids inventory program; however, this is not considered essential. Likewise, installation of effluent nitrate and ammonium ion probes, employed usefully during the evaluation, may not be essential if nutrient testing is routinely performed as part of an overall process monitoring program.
9. In the wastewater laboratory, consider modernizing the existing analytical equipment. To complete the recommended nutrient monitoring, a multi-parameter spectrophotometer should be acquired along with a digester block used with the total nitrogen and phosphorus tests;
10. Pursue the engineers' recommendations to replace and upgrade the control switchboard for the facility with a modern supervisory data acquisition and control system (SCADA.) The extent of the SCADA proposed in the referenced Entech report may be too expensive for immediate rollout, but a smaller SCADA can be built and added to as time and funding permits. Most importantly, EPA and DEP staff recommend that the SCADA include dissolved oxygen controls for any upgraded aeration facilities, installation of pH probes at the aeration tanks, with accompanying feedback to alkalinity chemical feed system, and automate the required final effluent testing through the use of pH and DO probes at the final effluent testing location;
11. If the opportunity for BNR arises, consider adding oxidation / reduction potential probes to the secondary process to optimize the use of anoxic treatment for the denitrification of treated wastewater. These probes may be used to regulate the duration of anoxic treatment;
12. Consider automating all in-house recordkeeping for routine and reactive maintenance tasks, process monitoring laboratory, and process control logging. Though this evaluation did not examine the superintendent's computer equipment used for administration, automation of the laboratory and recordkeeping functions at the sub-management level may reduce the Superintendent's keyboarding workload while automating many routine tasks. Regarding solids testing in the lab, a successful solids inventory program would account for treatment of sludge solids from cradle-to-grave, generating efficiencies that enhance both biosolids quality and energy reduction;
13. Continue cross-training personnel in all aspects of operating the wastewater treatment facility, inasmuch as work rules may allow. Since new technology will be added to the treatment system, requiring increased specialization for power controls, process instrumentation, and SCADA, plant staff should all pursue training and expertise to upgrade their skills.

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## Introduction

The Borough of Schuylkill Haven, NPDES Permit No. PA0029017, owns and operates a sewage treatment facility located between St. Charles and St. James Streets within borough limits. The facility discharges treated wastewater to the Schuylkill River nearby. The general design limits of the plant are for 2.8 MGD and 1,549 lb./day organic loading (as BOD<sub>5</sub>.) In 2017, the annual average daily flow and loading were 0.963 MGD and 2,400 lb./day, respectively.

The facility is presently operated as a conventional, activated sludge secondary treatment system. A labelled aerial photo of the site is found in Attachment C. Treatment processes include preliminary screening and inert solids removal, primary clarifiers, secondary aeration with nitrification, secondary clarifiers, tertiary media filters, and disinfection facilities employing gas chlorine. Solids are managed using three aerobic digesters, sludge thickening, a belt-filter sludge press, with sludge solids disposal as Class C biosolids. (The facility recently began land-applying its biosolids after having previously disposed of them in landfill.)

The treatment facility is showing its age. In-ground treatment units have some deterioration of concrete, and steel pipe and fittings show corrosion and, in some cases, ongoing damage. For example, the primary clarifier scum removal system no longer works as designed, and the operators are required to occasionally contract for a vacuum truck to remove the surface scum that, in summer, is a rotting mass of fats, oils, and greases congealed with plastics and rags.

The existing secondary aeration treatment units have ceramic disk diffusers that many not have been adequately maintained over the years. The diffuser manufacturer noted that ceramic disks must be regularly cleaned using gaseous acid to remove biological growth and scale deposits that clog the pores in the disks. Thus, it is anticipated that oxygen transfer efficiency of these aerators has been compromised over time, and the diffusers may not be amenable to rehabilitation.

Similarly, the sludge digesters that were originally designed and operated as anaerobic digesters have an aeration system that is relatively unsuited for use with thickened waste sludge. Newer technologies, such as the use of draft-tube aerators, provide for more efficient digester mixing and for greater destruction of volatile solids content in digested biomass.

## Biological Nitrogen Removal via Intermittent Aeration

In June 2018, representatives of USEPA Region III Outreach and PA DEP met with the facility manager to discuss ongoing efforts to reduce energy consumption, pursuant to completion of an analysis by the facility engineer that recommended upgrading the aeration system and blower technology, installation of a SCADA system, improved control of aerobic digesters, and management of idle process units. EPA staff recommended installing equipment to study the effects of intermittent aeration on overall energy consumption and to determine if marginal, voluntary improvements in effluent quality, through nutrient reduction, were practicable and justifiable.

PA DEP staff installed a small array of in-line digital probes at secondary activated sludge process units and nitrogen/nutrient probes in the treated effluent. Following a fourteen-day collection of background or baseline data, the plant operators began a series of timed aeration / settling cycles whereby the secondary aeration tank contents could go anoxic for two to four hours per day. This was to see if the process would naturally reduce effluent nitrogen, converting nitrate ion to molecular nitrogen, while at the same time regenerating process alkalinity and improving effluent pH.

Concurrently, DEP staff had a power logger installed at the power supply for one of the four aeration blowers regularly used at the facility. The aeration blower is a 100 h.p. centrifugal blower that the facility engineer has proposed to replace with more-easily controlled positive displacement blowers, controlling blower output using variable frequency drives (VFD) that are regulated through use of dissolved oxygen probes located in the secondary aeration tanks.

Plant staff noted several limitations on the ability to conduct a full-scale trial of intermittent aeration:

1. Chiefly, because the centrifugal blower is uncontrolled by automatic valves on its inlet side, it could not be set to operate according to a timed schedule using automatic timers.
2. The aeration grid in the secondary reactor tanks is subject to backfilling with water during the anoxic period, requiring the plant operators to open two or three blow-off valves in each tank when the aeration is restored, in order to purge water from the grid.
3. Further complicating matters, operational schedules for sludge thickening and dewatering took precedence over shutting down the centrifugal blower for several hours during the workday, and blower operation could not be interrupted overnight when the facility was unsupervised, because several manual processes must be completed to successfully restart the blowers.
4. Lastly, anoxic mixing is not available at this site, naturally, because it wasn't designed for it. The difficulty of securing and installing temporary grinder pumps in the aeration tanks for analogous anoxic mixing was beyond the facility's budget for this analysis.

Despite all this, the evaluation data showed that intermittent aeration had resulted in some reductions of nitrate-nitrogen in the effluent, although pH improvements, due to release of 3.5 lb. alkalinity (as CaCO<sub>3</sub>) for every pound of nitrate ion converted to nitrogen gas, were negligible. Energy savings were limited due to time constraints; however, evidence infers that operating this main blower for anything less than 24/7/365 would naturally reduce electricity consumption.

Following six weeks of data collection, the probe output was graphed and studied for trends and outputs relative to biological nutrient (nitrogen) reduction. The findings are summarized below:

1. Generally, the evaluation showed that BNR is achievable at this facility, despite the technology limitations imposed by centrifugal blowers and the limited time schedule for operating in intermittent aeration.
2. Low mixed liquor pH, averaging 6.3 s.u. during data collection, is a hindrance to optimal oxidation of ammonium wastes by nitrifying bacteria. The facility is equipped to add lime to the activated sludge process, but this is not typically practiced because the raw wastewater is naturally low pH and the cost to treat it is high. The ideal pH range for nitrification is often quoted at "above 7.0 s.u. and no higher than 8.5."
3. When viewing graphs of parameters such as dissolved oxygen and oxidation / reduction potential, it is important to keep in mind the locations of the probes: they are approximately eighteen inches below the surface of the mixed liquor. During anoxic settling periods, much of the denitrification biochemistry is occurring within the sludge blanket that forms. Therefore, the anoxic ORP values are less conclusive than they would be were anoxic mixing available. Even so, they do show that denitrification is occurring, and as a confirmation of this, EPA staff deployed a portable ORP probe into the sludge blanket and recorded ORP values well within the anoxic region, better values than observed near the surface of the aeration tanks. A brief illustration of this is included in the discussion in Attachment B.
4. During the evaluation, effluent nitrogen concentration dropped to 4.8 mg/L<sup>1</sup> following the third of three anoxic cycles during the day shift. This represents the lowest nitrate concentration that occurred while the facility was cycling aeration and which could be proved by the data to not have been an anomaly.
5. The maximum nitrate value determined during the evaluation was 31.9 mg/L, during the morning of July 15, although non-BNR effluent nitrate values tended to be in the low-to-mid

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<sup>1</sup> Lower values occurred during probe-cleaning events, the August flooding, and when the effluent disinfectant contact tank was emptied for cleaning. Probe reliability faded near the end of data collection, when the probe required bench recalibration.

20s mg/L. The average nitrate concentration for the entire period was 17.0 mg/L, but this number is statistically meaningless and cannot be used in analysis.

6. Effluent ammonium concentration averaged 0.4 mg/L. For most of the time, ammonium was well-oxidized, with most of the values logged below 0.5 mg/L. The only exceptions were following the flooding event around August 12, when the maximum effluent value reached 6.8 mg/L. The minimum effluent ammonium concentrations were below the method detection limit for the bench test.<sup>2</sup>
7. Mixed liquor concentrations at this facility are considerably higher than those found at similar facilities. Values between 5,000 and 6,000 mg/L were not atypical. This is an operator preference: A high solids inventory is a buffer against solids washout due to influent surging, and the maximized populations of bacillus and nitrifiers are very forgiving to upsets. There is a drawback, though, in decreased clarifier performance, where there were always some solids going forward, but the tertiary filters relieve that, and the facility was never out of compliance on effluent solids.
8. Clarifier performance may benefit from an evaluation of currents for short-circuiting. The remedy is usually to add baffles that promote settling. The facility's consulting engineer can offer information on such services.

### Energy Analysis:

One of the benefits of denitrifying effluent that has been nitrified is in the energy savings. Schuylkill Haven has four centrifugal aeration blowers, two with 100 h.p. motors and two with 50 h.p. motors. For the digesters, separate rotary lobe blowers are located in the basement of the control building. The operators vary the use of the blowers based on oxygen demand and loading, sometimes using the 50 h.p. blowers instead of the larger ones.

1. Operation of these centrifugal blowers is a labor-intensive task when attempting to cycle intermittent aeration.
  - a. A timer on the motor starter would be of little use, because the blower valves must be monitored to prevent the blower motor from overloading during re-starts; and,
  - b. the aeration grid must be air-purged of water following any blower down-time.
2. In an aeration upgrade, rotary lobe blowers would probably work better for cycled oxic/anoxic treatment. In such an arrangement, the aeration blower motors are regulated using dissolved oxygen probes in the aeration tanks and variable frequency motor drives. Frequent valve adjustments would not be necessary, and the blowers could be regulated by simple timers or by a SCADA system.
3. From April 10 to May 10, DEP and Borough staff installed a power logger at the motor starter for one of two centrifugal blowers used for aeration.
  - a. The average power consumption for the blower was 50 kW.
  - b. During the evaluation, the aeration was off for up to four hours during an eight-hour shift, meaning blower consumption dropped only 200 kWh from the usual 24/7 run-time of 1,200 kWh/day (17% reduction.) This would save only \$19 per day.
  - c. If the facility operated as an engineered BNR system, aeration would likely occur only twelve to eighteen hours per day. In those operating conditions, the savings would vary from \$10,500 to \$21,000 per year. This is modest when considering the overall operating budget for the facility; however, this is a potential revenue diversion that could pay for instrumentation and blower control within about five years.



<sup>2</sup> Hach TNT Plus 830, Ammonium-N, Ultra-Low Range

**Observations:**

Incorporation of controlled denitrification into the operations and process control strategy should improve effluent quality. Nitrification to eliminate ammonia-nitrogen is an energy-intensive practice. This study demonstrated that, even in the limited application of intermittent cycling during the weekday work shift, and excluding days when the sludge thickener was operating, reductions in effluent total nitrogen are possible and would yield energy- and cost-saving benefits:

- 3.7 lb. of BOD<sub>5</sub> is consumed for every 1.0 lb. nitrate-nitrogen destroyed =  
Reduction of primary clarifiers in operation =  
Some energy savings
- 3.57 lb. of alkalinity recovered for every 1.0 lb. of nitrate-nitrogen destroyed =  
Reduction of required chemical usage for pH buffering =  
Some chemical cost reduction
- 2.86 lb. of molecular oxygen recovered for every 1.0 lb. of nitrate-nitrogen destroyed =  
Slight reduction of oxygen demand satisfied by mechanical aeration =  
Some energy savings / reduction of equipment wear and tear

The facility has long experienced low pH values in its raw wastewater and in the mixed liquor, prior to acidification that occurs during nitrification. It is equipped for lime addition, although this is not used regularly enough to change either the pH or alkalinity in the aeration tanks where it matters most. Therefore, it is suggested that alkalinity modification be restarted and budgeted for. The Entech report and the EPA/DEP evaluators both point to the efficacy and safety of using magnesium hydroxide solution to raise alkalinity; however, at NPDES major discharger facilities, this proves to be an expensive proposition. It may be more economical to add alkalinity using caustic soda (sodium hydroxide, soda ash, lye) for gross alkalinity changes and employ magnesium hydroxide for fine-tuning alkalinity. The recommendations for mixed liquor alkalinity in nitrifying activated sludge plants is "over 100 mg/L, to as high as 220 mg/L." These values are for nitrification in aeration tanks. Generally, effluent alkalinity levels should not drop below 80 mg/L.

The consulting engineers have suggested replacing the ceramic aeration diffusers and the centrifugal blowers at this facility. This evaluation supports those recommendations. Following many years of use without prescribed maintenance,<sup>3</sup> the diffusers may be too damaged by scale and inert matter to be redeemable. The modern prescription for the aeration blowers is to regulate them using dissolved oxygen concentration as a controlling feedback to adjust blower output. The ideal blower type for this is the positive displacement blower over centrifugal blower, because the output of the former may be throttled more easily to meet DO demand, using variable frequency drives (VFD) on the blower motors. Centrifugal blowers cannot be easily throttled: it is done by regulating the air intake, but the blower vanes must turn at a prescribed RPM to compress the air. Too little air intake results in the blower operating in its "surge zone," resulting in overheating of the motor. Any aeration blower should be controlled by a DO feedback loop with the mixed liquor under aeration, as this will maintain energy efficiency. As the dissolved oxygen graphs have demonstrated, this facility tends to operate in the "wasted energy" range of DO residual.

Since energy conservation is important to the future of this facility, it follows that ORP probes should be used to regulate and optimize a proposed denitrification cycle. It is obvious that the mixed liquor need not be under aeration 24/7/365; rather, the total run time for aeration blowers in a facility that denitrifies may be between a total of nine (9) to twelve (12) hours per day. EPA staff have estimated that the energy savings on the existing 100 h.p. centrifugal blowers, if reduced from 24 hr./day to 12 hr./day, would be \$12,000 per year. That is money available for other uses, such as provision of adequate alkalinity to promote healthy biomass and denitrified effluent.

<sup>3</sup> The diffuser manufacturer provided for cleaning the ceramic diffusers using gaseous hydrochloric acid; however, this practice evidently was either never done to schedule or, in any case, abandoned decades ago.

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The Authority's engineers recently had suggested installation of a supervisory control and data acquisition (SCADA) system to replace the existing analog control panel. This evaluation also supports those recommendations, because modernization of process monitoring and control will provide for optimizing the treatment process, resulting in process efficiencies that will save money and labor while promoting higher quality treated effluent. Naturally, such a system should include at the minimum, pH/temperature, dissolved oxygen, and oxidation/reduction potential probes. Further, if the facility wishes to recoup operating costs through denitrification, the owners should consider installing nitrate and ammonium probes to monitor and optimize the effluent total nitrogen. As chlorine continues to be an economical and efficient method of disinfection and is essential to maintaining operation of the polishing filters at this facility, the evaluators suggest that installation of a chlorine residual ISE probe as a component of the SCADA system may provide valuable effluent monitoring. Indeed, installation of pH/temperature and DO probes at the effluent discharge, alongside a chlorine ISE probe, may eliminate the need for overtime work required to monitor the effluent discharge on weekends and holidays, provided they are properly maintained and connected to an alarm/notification system that will require operator presence should permit excursions occur.<sup>4</sup>

Lastly, the evaluation monitored solids/turbidity to measure mixed liquor suspended solids concentration (MLSS) during this project. Schuylkill Haven tends to operate with MLSS concentrations more than the usual recommended levels for conventional activated sludge treatment. While this has been the practice for some time, the maintenance of high activated sludge concentrations may make the facility more difficult to operate, since pin floc or solids ashing at the secondary clarifiers will introduce unwanted biological growth into the polishing filters. It should be possible to operate the secondary treatment tanks at a lower concentration of biomass while achieving the same quality of treatment; however, a lower concentration may be less forgiving of organic and hydraulic slug loads. It may also happen, though unlikely, that the third aeration tank would be needed as treatment volume if concentration is to be reduced.

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<sup>4</sup> Reliance on such probes as a replacement for physical presence at the facility to conduct effluent compliance tests, as required by the NPDES Permit, may first require that the facility conduct a side-by-side parameter testing study to compare probe output with that of laboratory bench testing. The existing regulations require that pH and DO probes be calibrated before each daily use and the actions be logged and retained for five years. Therefore, a side-by-side study is warranted. The results would be presented to the DEP Regional Office in advance of written approval to rely on continuous immersion testing.



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**ATTACHMENT A: EVALUATION TEAM**

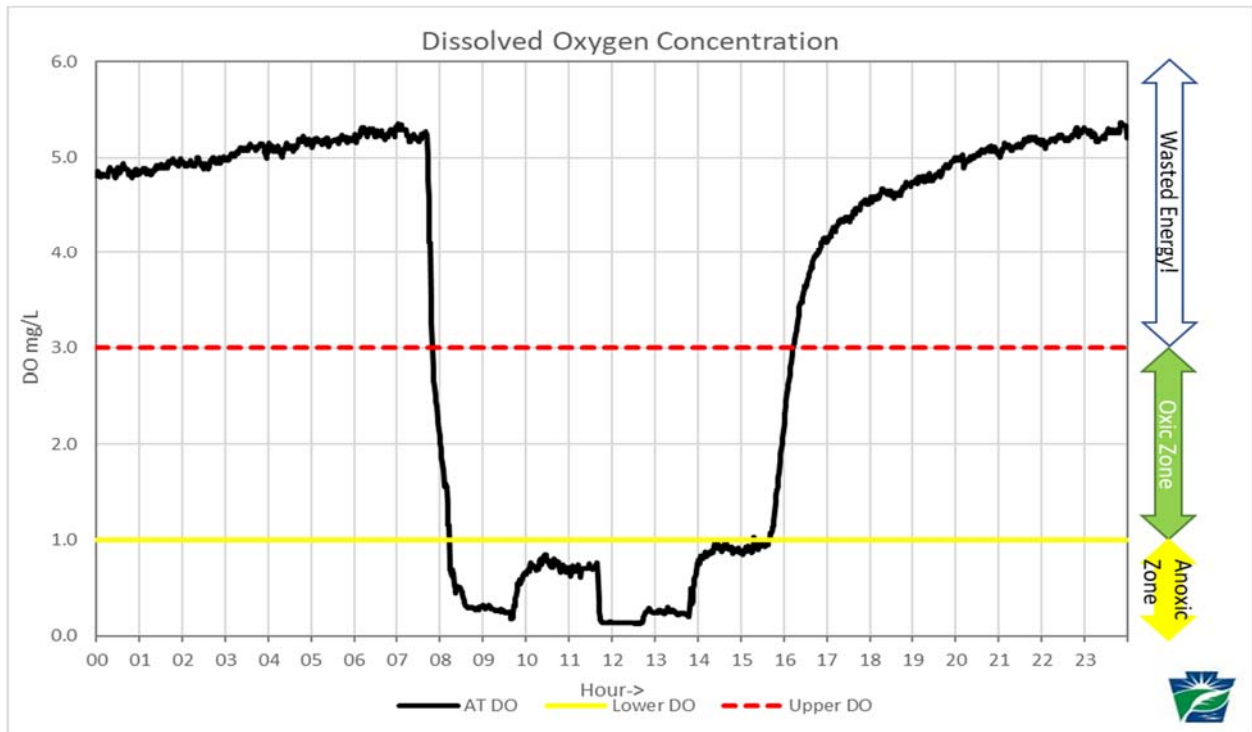
<b>PA Dept. of Environmental Protection</b>	<b>U.S. Environmental Protection Agency</b>
<p>Marc Neville, Water Program Specialist Bureau of Clean Water—Operations Div. Rachel Carson State Office Bldg. 400 Market St; POB 8774 Harrisburg, PA 17105-8774</p> <p>email: <a href="mailto:mneville@pa.gov">mneville@pa.gov</a> phone: (717) 772-4019</p>	<p>Walter Higgins EPA Region III Water Protection Division Office of Infrastructure and Assistance (3WP50) 1650 Arch Street Philadelphia, PA 19103-2029</p> <p>email: <a href="mailto:higgins.walter@epa.gov">higgins.walter@epa.gov</a> phone: (215) 814-5476</p>
<b>Borough of Schuylkill Haven</b>	
<p>Ron Schultz, Superintendent Borough of Schuylkill Haven WWTF St. Charles &amp; Liberty Streets Schuylkill Haven, PA 17972</p> <p>phone: (570) 385-2841 email: <a href="mailto:rschultz@schuylkillhaven.org">rschultz@schuylkillhaven.org</a></p>	



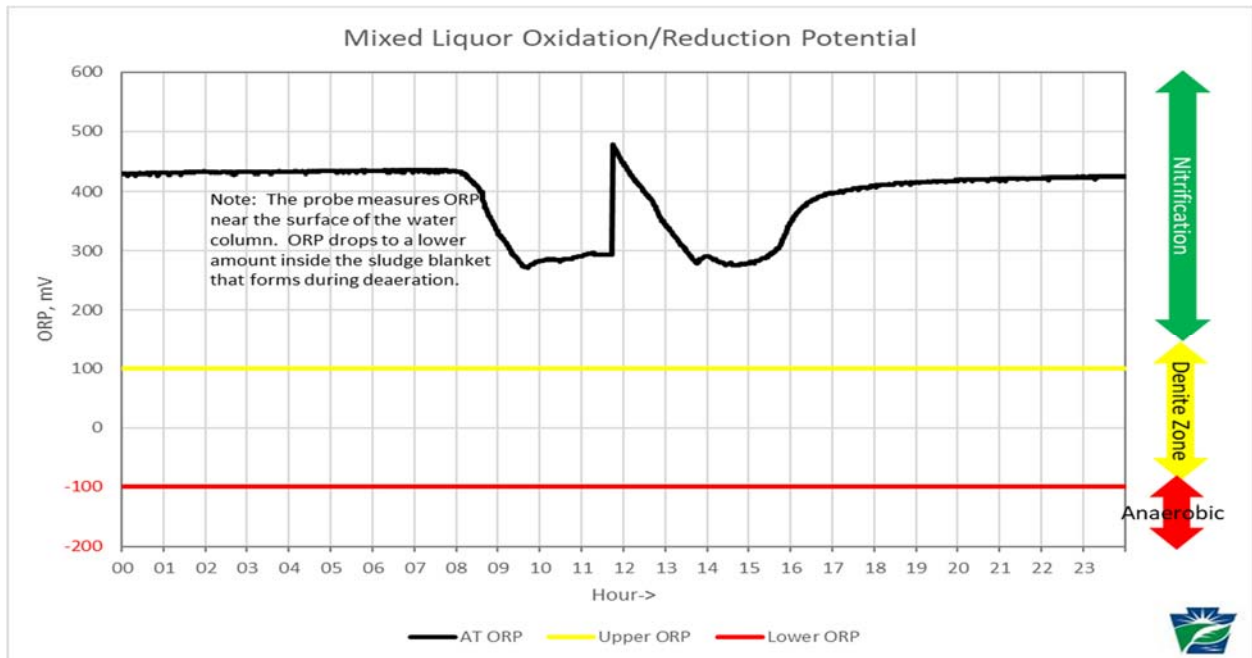
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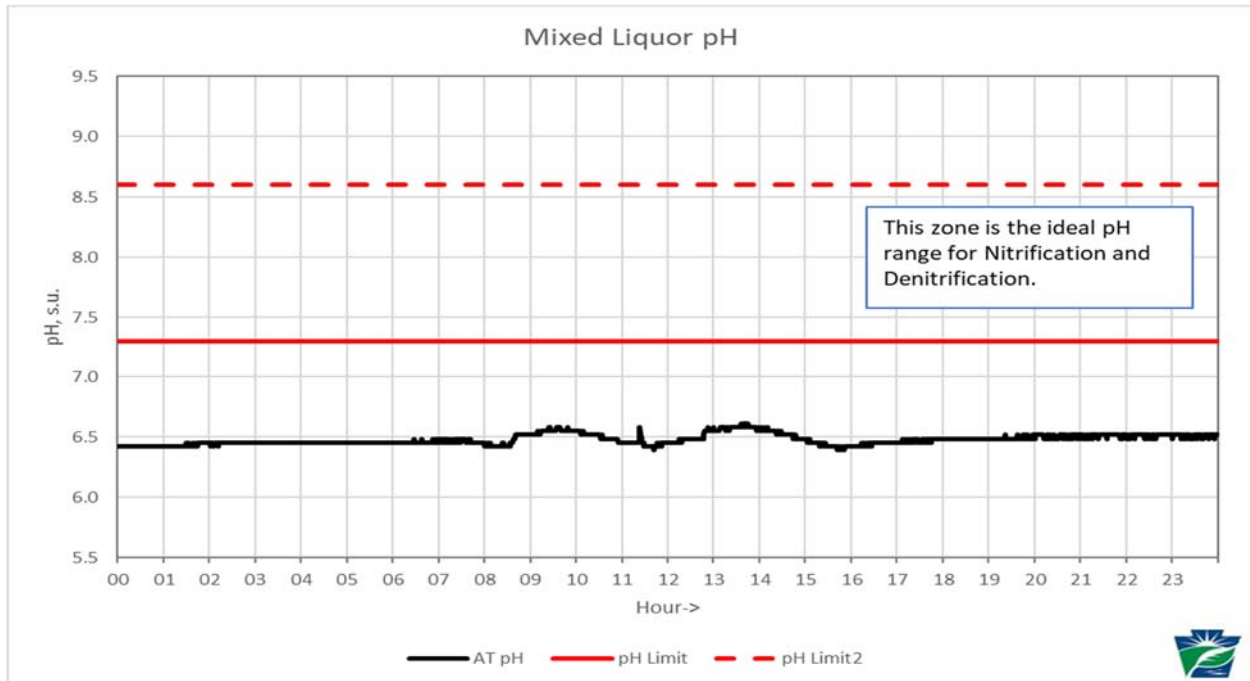
**ATTACHMENT B: GRAPH INTERPRETATIONS:**



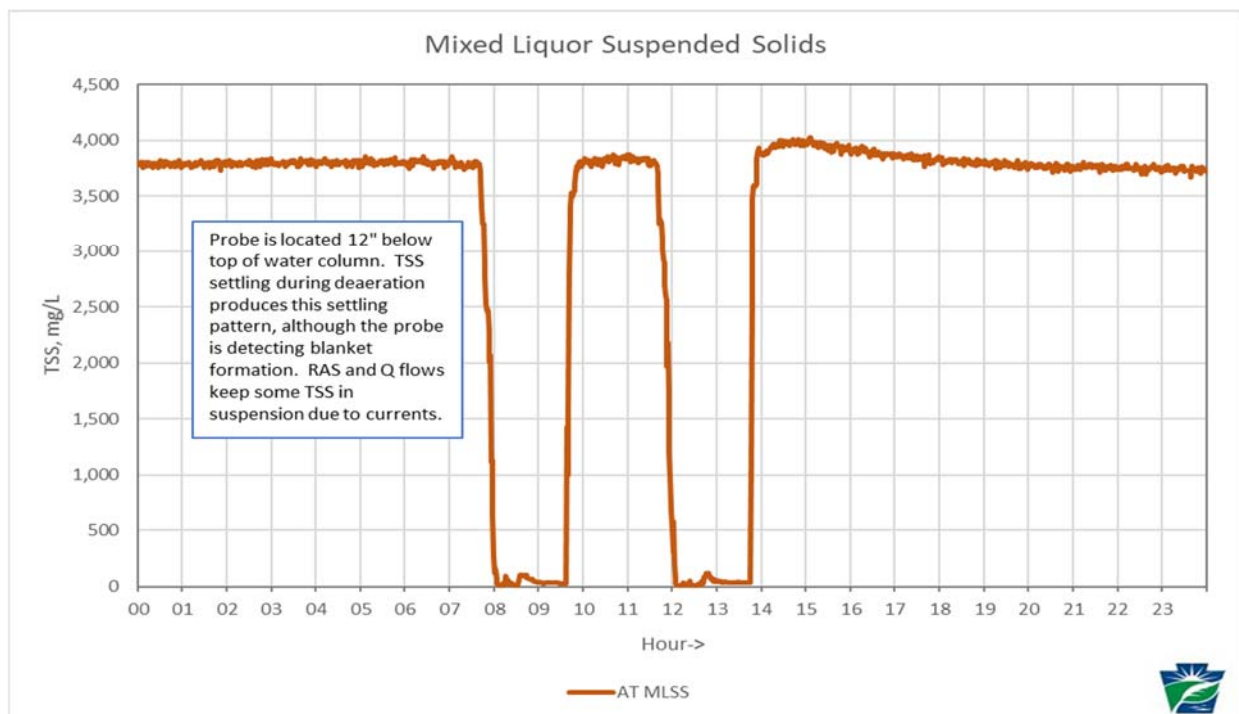
08/29/2018 DO profile showing two day-shift anoxic intervals. DO recovery between intervals was not as robust as expected but may be due to open purge valves on the diffuser system.



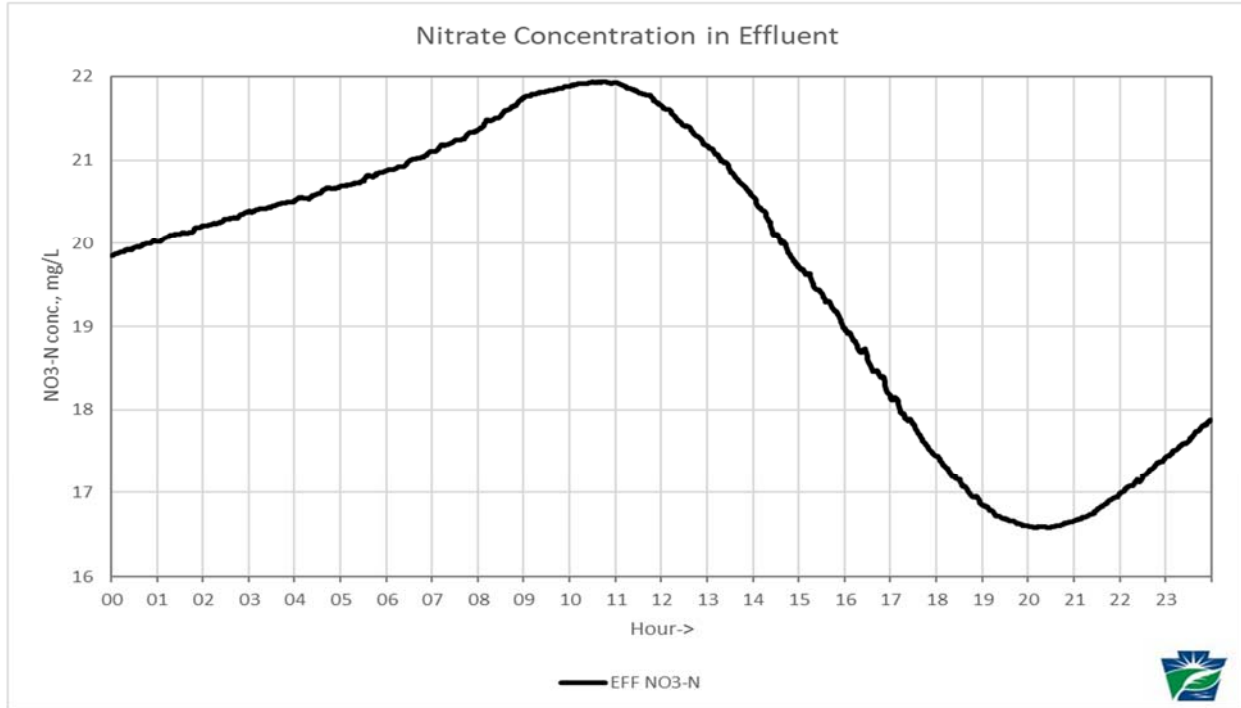
08/29/2018 ORP Profile: two dips in surface ORP indicate that anoxic activity was occurring in the sludge blanket that formed in the aeration tanks.



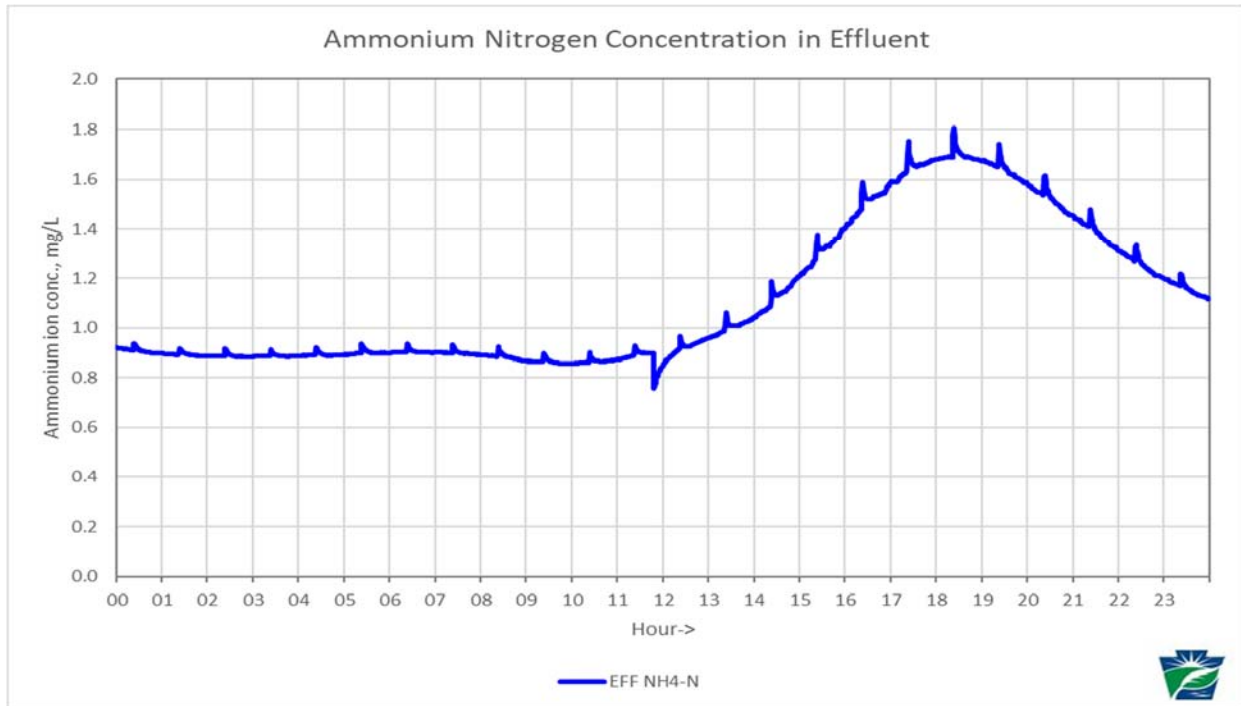
08/29/2018 pH profile shows the near-imperceptible rise in pH during the anoxic periods, showing that some alkalinity was being formed from the denitrification byproducts. It wasn't enough to substantially affect the volume of water, and (again) without anoxic mixing, most of the chemical activity was occurring in the sludge blanket. This chart shows pH rising slightly during the anoxic period.



08/29/2018 MLSS profile displays the two anoxic cycles during day- shift, each about 120 minutes long.

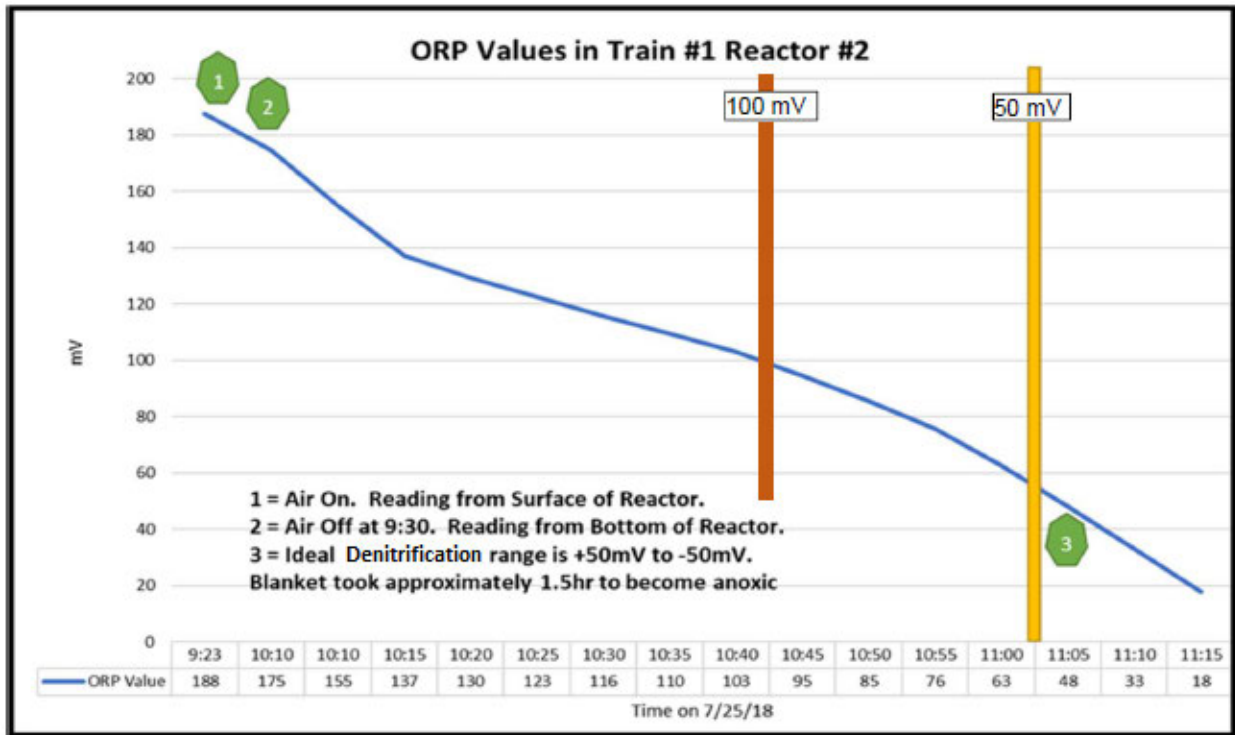


08/29/2018: Effluent Nitrate concentration showed a dip from c. 22 mg/L to 16.7 mg/L because of two anoxic cycles.



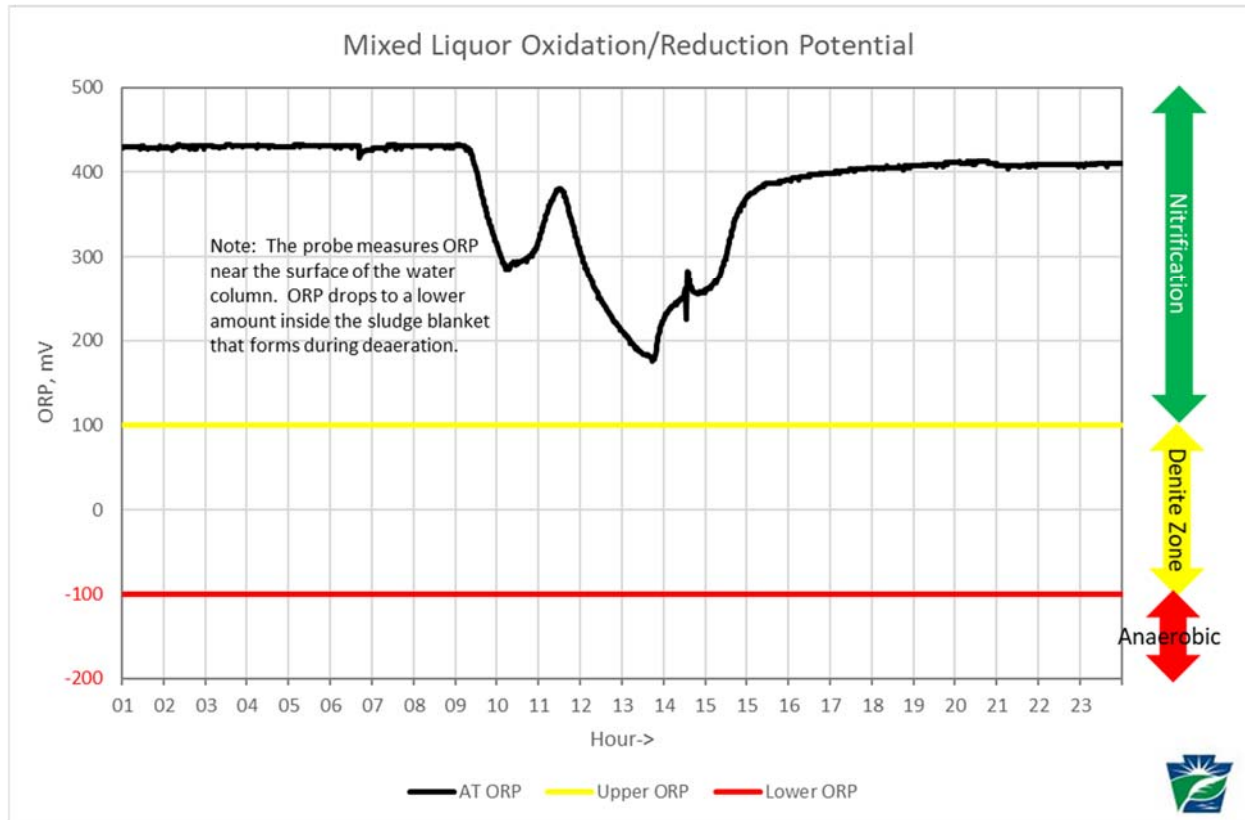
08/29/2018: Ammonium ion concentration x 10: Following anoxic treatment, the effluent ammonium briefly showed an 80% increase. The concentration is negligible, but, again, it is important to complete the chemical balance (anoxic mixing, carbon availability, alkalinity adjustment) with the physical factors (treatment volume, detention time) to assure that nitrification does not suffer from attention to total nitrogen removal.

**OXIDATION / REDUCTION POTENTIAL VARIATION**



Due to the absence of anoxic mixing in the Schuylkill Haven aeration tanks, anoxic ORP readings reported by the DEP HachNet SCADA system have appeared higher than expected or observed during past projects. This chart depicts concurrent ORP readings from a portable probe inserted into the sludge blanket that formed during the OFF-cycle for the blower. The ORP values within the forming sludge blanket dropped to well within the desired ORP range for denitrification, proving that the denitrification reaction had been occurring as expected.

Nitrate-nitrogen reduction to molecular nitrogen gas will occur even in the absence of anoxic mixing, although it is often a less-efficient process than expected.



The SCADA probe output for July 25, 2018, is shown in the chart above. The probe tip is located approximately eighteen inches below the surface of the aeration tank. ORP values during the anoxic cycles occur in two valleys shown between 0900 and 1400 hrs, corresponding with the portable probe values shown at the top. When the surface probe registered less than +300 mV, the actual ORP within the sludge blanket was below +50 mV. That's within the range for effective denitrification to occur.



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**ATTACHMENT C: FACILITY LAYOUT**





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**ATTACHMENT D: RECORD PHOTOGRAPHS**



Aeration Tank Probes (DO, pH, ORP, TSS)



Mini-SCADA Housing for Aeration Probes



SC1000 & Wireless Data Server



Effluent SC1000 & Cleaning System



Ammonium & Nitrate Probes at Effluent



Power Logger for Centrifugal Blower Motor



Power Log Display: Power & Power Factor



Rotary Screen Preliminary Treatment



Primary Clarifiers & Scum Removal System



Aeration Tank during Anoxic Settling Period



Biomass Under Aeration



Secondary Clarifier Ashing