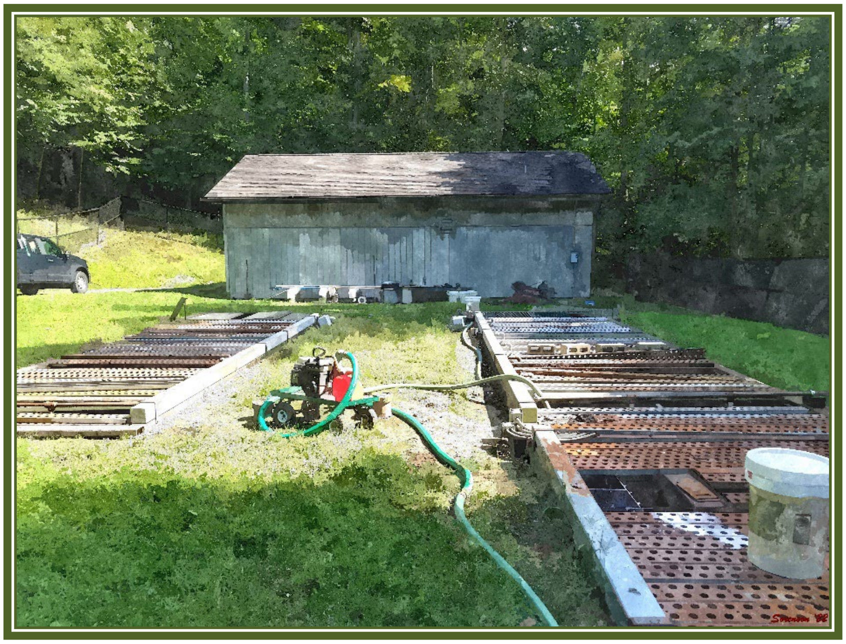
KENTUCK CAMPGROUND STP
DCNR OHIOPYLE STATE PARK
STEWART TOWNSHIP, FAYETTE COUNTY, PENNSYLVANIA

NPDES Permit PA0032425



WASTEWATER TREATMENT EVALUATION

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

2022

Disclaimers:
The mention of a brand of equipment is in no way an endorsement for any specific company. 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 troubleshooting, training, and monitoring. Permittees may be encouraged to achieve effluent quality above and beyond current permit requirements.

Executive Summary

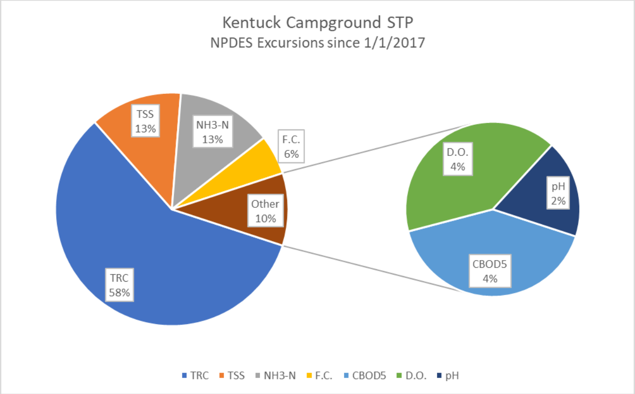
Technical Assistance staff from the Pennsylvania Department of Environmental Protection (DEP) have worked with the Department of Conservation and Natural Resources (DCNR) to evaluate and improve wastewater treatment performance at several facilities operated by its Bureau of State Parks. Over the past several years, DEP and park staff have worked cooperatively to resolve compliance excursions at the Ohiopyle State Park in Stewart Township of Fayette County. This work has included operator training in process monitoring and control, as well as process improvements such as replacement of aeration diffusers. DEP staff returned to Ohiopyle during the summer of 2022 to perform an instrument-based diagnostic of the wastewater treatment process at the park's Kentuck Campground STP. A wastewater treatment evaluation (WTE) using a combination of in-line, continuous immersion probes and enhanced onsite laboratory analyses has given both DEP and the facility operators clearer understanding of the challenges facing the park's wastewater treatment facilities. This report discusses the DEP's evaluation and provides recommendations for both process control and structural improvements.

Background:

The PA Department of Conservation and Natural Resources, Bureau of State Parks, holds four active National Pollutant Discharge Elimination (NPDES) permits for facilities. Of these three are for actively operating facilities, and one is for a facility that has not operated for over ten years. The four facilities are:

- Kentuck Campground STP, PA0032425
- Boaters' Change House STP, PA0096521
- Falls Visitors' Center STP, WQM2611402
- Ridge STP, PA0046116

Within the past five years, park staff have reported numerous total residual chlorine (TRC) excursions in the Kentuck Campground STP's discharge monitoring reports (DMR). These constituted 58% of all non-administrative permit excursions since the beginning of 2017. The NPDES permit limits for TRC are very low because plant effluent dominates the receiving stream's dry weather flow. These limits are 0.1 mg/L as a monthly average and 0.2 mg/L as an instantaneous maximum. This facility, rated for 40,000 gallons per day (gpd), has been averaging about 8,500 gpd since the beginning of 2021. Flow peaks of fifteen to twenty-four thousand gpd are not uncommon during peak campground patronage, especially holiday weekends. The secondary treatment system consists of two 20,000-gallon prefabricated aeration tanks, having 3,333-gallon clarifiers, a 15,000-gallon wastewater surge tank, and 3,000-gallon sludge holding tank. An unused combination lamellar and sand filter follows for tertiary filtration, but the filter was reported to never have worked well due to solids loading and biological growth, resulting in constant automatic backwashing that hydraulically overloaded the secondary activated sludge process. Today, flow from the secondary clarifiers passes through two serial wet wells, one for erosion-type chlorine disinfection, the other for sulfonation and ultrasonic flow metering. The flow meter is presently nonfunctional. Aeration is provided by rotary lobe blowers, and while the influent lift pumps are electromechanical, air lift pumps in the clarifiers transfer solids from the clarifiers back to aeration (RAS) or to sludge holding (WAS.) The control building houses the unused tertiary filter and an unused waste sludge



bagging system, chemical metering tanks, and a small process monitoring laboratory. Presently, domestic water service to the facility is inoperable.

At the Boaters' Change House facility, staff noted that ammonia-nitrogen appeared to be increasing within the sand filtration units that follow nitrification in secondary treatment, even when nitrification in the activated sludge process appears to be complete. This treatment facility is rated for ten thousand gpd, but staff reported that it more likely averages only five hundred gpd during most of the park's tourist season. One of the two PureStream treatment trains is idle, while the other serves to treat waste from shower houses, comfort facilities, and small concessions nearby. The design is similar to the package plant at the campground, although it uses a simpler type of sand filtration following secondary treatment.

Staff also noted that the Falls Visitors' Center demonstration treatment facility had experienced some problems due to high demand on the center's comfort facilities. Flows were reported to average two thousand gallons per day (gpd) and five thousand gpd on weekends and holidays. This facility is part of an overall LEED-certified design that recycles water from the comfort facilities through a series of tanks and wetlands. Solids are stored in septic tanks and hauled off site, while treated water is reused. Presently, a tank used to maintain water pressure in the comfort facilities is not working properly, so the visitors' center is using potable water for make-up and discharging wastewater to the municipal treatment facility off-site.

The fourth treatment facility, a small package plant at the former Pressley School on Ridge Road in Henry Clay Township, has been shut down since at least 2012 and is no longer in operable condition. The NPDES permit is still active, although it expired in 2021. Recent inspection reports have noted that this permit should be voluntarily terminated if there are no plans to use the site of the former school, which has fallen into significant disrepair.

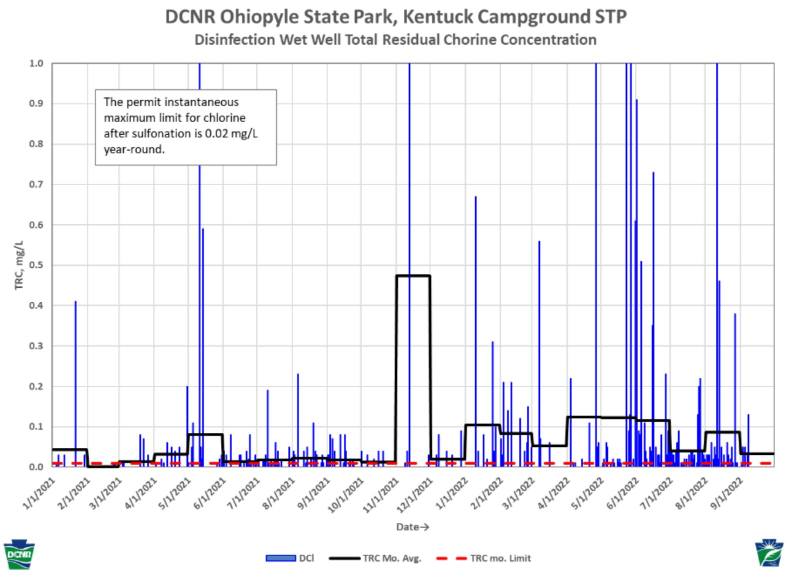
While DEP staff's work for this WTE centered on the campground treatment facility, they also considered issues raised concerning the other two, active, permitted facilities. Following are recommendations offered for consideration by the park's facilities management staff and their engineers.

Recommendations regarding Kentuck Campground STP:

Based on the results of the field evaluation, the following recommendations are offered for short-, medium-, and long-term improvements to facility operation and, where applicable, process improvements:

Short-term:

1. The facility requires a working effluent flow meter that is calibrated annually. It is important to have reliable flow measurement for calculating pollutant loading and operational process control values for managing the plant.
2. Potable water to the facility should be placed back into service. This is primarily a worker safety and hygiene matter. Successful operation of the laboratory and maintenance of the activated sludge facility also benefit from having this service restored. A suggested alternative had been to use a portable tanker on a truck, with a pressure washer, to maintain the treatment tanks. Life experience suggests, though, that the more cumbersome a task becomes, the less likely it is to be regularly completed.
3. The emergency generator requires additional service work, perhaps replacement of its head gasket: it may be cheaper to buy a replacement generator through the federal surplus sales at the state's Department of General Services surplus depot.



4. Replace the existing chlorine disinfection and sulfonation process at the effluent wet wells with ultraviolet light (UV) disinfection, eliminating the use of chlorine and sulfide pucks for erosion-style disinfection. 58% of the 195 effluent quality failures since January 1, 2017, have been related to total residual chlorine (TRC) problems.[1]
5. The influent pumps may have to be "right sized" for the variability in flow that we observed; that is, to use a smaller capacity lead pump for low-flow times and a larger capacity lag pump for times of higher flow rates. This idea is to ensure more constant raw wastewater feed rate for the biological processes rather than allowing the biomass to be "starved into auto-digestion" for long periods throughout the day.
6. Replace the existing comminutor with a rotary fine screen to eliminate plastics and reknitting of cloth fibers downstream. This is important for the preservation of pumps, valves, probes, and other downstream process equipment.
7. While the PureStream steel tanks appear to be in serviceable condition, it may be useful to check the cathodic protection system to assure it is functional. The sacrificial anodes for the tanks may need to be replaced, eventually. Also the buildup of sludge on parts of the tanks will produce organic acids that could deteriorate the finish on the steel, adding to corrosion; therefore, such buildups should be more regularly cleaned by simply hosing off the material or using a pressure washer.
8. Aeration controls that use dissolved oxygen (D.O.) probes to control blower output by way of variable frequency motor drives should be added to the air compressors. This not only saves energy, but it maintains the activated sludge biomass within an adequate D.O. range for nitrification while allowing for quick depletion should denitrification be required to reduce excessive nitrate pollution of the effluent.
9. Chemical addition such as alkalinity should be done using dissolved chemicals and metering pumps. The unused day tanks and LMI pumps could be adapted to this use. The recent switch from pellet to granular soda ash means that the chemical is now being dosed as a slug load when the dose should be attenuated over the course of the day.
10. Sludge wasting should be done more regularly and in a measured fashion. The current practice is to waste the clarifier sludge blankets when necessary, but during the evaluation, the mixed liquor suspended solids (MLSS) concentration seemed elevated for summer operations. Previous inspection reports noted that sludge wasting should be more frequent. It should be more quantifiable, as well. The facility's operating budget may need to include

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[1] These TRC excursions were exceedances of the permit limit rather than absence of an effective chlorine residual. This occurs with tablet erosion disinfection systems when flow is interrupted but the tablets continue to shed hypochlorite into standing water; when flow resumes, an overdose of hypochlorite happens.

more funding to cover hauling and disposal of waste sludge, as well, to maintain activated sludge concentrations according to more frequent process control recommendations.

11. Install a fan or cooling system in the motor control panel for the blower relays. During hot, humid weather, the relays overheated and tripped. The operators were working on such a solution to the problem, but it had not been completed by the end of the on-site evaluation.
12. The operators should regularly clear solids from the walls and hoppers of the existing clarifiers. The manufacturer recommends using squee-gee-type tools to sweep adhered solids toward the air-lift withdrawal pipes in the hoppers, and I suggest that such material should be wasted to the sludge holding tank. Continue to use biocide when necessary to control midge larvae.
13. Some additional laboratory testing equipment is recommended for monitoring suspended solids and nutrients in the water, for process control rather than simply for NPDES permit compliance. At present, the operators conduct regular settleometer tests and occasional centrifuge tests of the activated sludge biomass. Other process monitoring and control tests should become routine as part of an overall strategy to improve plant performance. These include regular tests for nutrients, alkalinity, and chemical oxygen demand (COD). While effluent compliance testing is done frequently, parameters such as D.O. and pH should also be tested at the aeration tanks. Wasted sludge should be tested for percent total solids to keep track of the weight of solids removed by sludge haulers, as volume shipped is not sufficient to quantify sludge wasting. The facility has a drying oven that has never been used. DEP can provide a list of additional equipment that would be needed for conducting gravimetric solids tests. Volumetric centrifuge testing is also possible, provided that occasional calibration samples are quantified by a vendor laboratory that would be conducting the gravimetric test perhaps once every three or four months. A list of recommended process control tests and their frequencies is provided in one of the attachments to the report.

Medium-term:

1. Construction of a flow equalization tank of larger capacity than the existing surge tank, especially considering the campground expansion. Flow equalization attenuates hydraulic and organic loading and would be beneficial considering the planned full-service campground construction and our recommendations to consider a pump and haul management strategy for the Boaters' Change House STP.
2. Noise reduction should be considered. The rotary lobe, positive displacement (PD) blowers can be enclosed in small noise-resistant housing to reduce the noise occurring near the treatment facility. (It was most noticeable at the nearby camp sites during the late-night hours.) Operating the PD blowers on variable frequency motor drives as recommended above in the D.O. control comment, may also reduce the noise effect of these blowers running at top speed.
3. The facility should be operated using intermittent ("on/off") aeration to denitrify some of the dissolved nitrate that is a product oxidizing ammonia and organic nitrogen. During the evaluation, this was done on a trial basis. Experience has shown that aeration of the activated sludge need not be constant and that periods of de-aeration while maintaining anoxic mixing in the tanks will not only denitrify nitrate, but the anoxic biological process that ensues will also return 60% of the oxygen consumed by nitrification and 50% of the alkalinity consumed. This results in savings on energy and chemical costs.
    1. It is important to consider the influent wastewater when doing this: ammonia-nitrogen concentration appears to be significant at this treatment plant, likely due in large part to the two dumping stations for caravan and motorhome septage. Efficient nitrification should not be sacrificed to achieve some measure of denitrification; however, some reduction of nitrate loading to the receiving stream is better than no reduction at all.
    2. Adding a denitrification step to this facility would require addition of subsurface mixers to keep the biomass in suspension during the off cycle. Also, the air lift pumps required

for return activated sludge (RAS) flow should be plumbed to a separate compressed air source, such as a "jockey blower," to assure they remain functional when the denitrification cycle occurs.

4. As an alternative to the use of air lift pumps, which are very difficult to regulate, consider replacing the Return Activated Sludge (RAS) air lifts with electro-mechanical, submersible pumps in the clarifiers. This will give plant operators more control over RAS and sludge wasting rates, permitting a more quantifiable accounting of sludge being removed from the system.

Long-term:

1. Phosphorus present in the raw wastewater is not removed at this facility. The permit does not require it, but consideration should be given to treating excess total phosphorus in the finished effluent. This would require an additional chemical metering assembly to deliver chemicals such as polyaluminum chloride (PAC) or aluminum sulfate at the effluent end of the aeration tanks. The phosphorus would be bound by the aluminum and wasted from the treatment system with the waste activated sludge (WAS). One of the additional benefits of this is better floc formation results in more efficient clarification of secondary effluent.
2. Have the facility engineer evaluate the potential to convert the existing PureStream treatment system to sequencing batch reactors, which may allow for reduction of suspended solids losses from the hopper-style clarifiers while providing a set denitrification "mixed fill" cycle to reduce nitrate-nitrogen;
3. Have the facility engineer evaluate replacing the hopper-style clarifiers with a small cylindrical and mechanical clarifier for use by both treatment trains. This was successfully done at a facility in Mapleton Depot[2], Huntingdon County, to resolve operational problems with passive, hopper-style clarifiers.

Recommendations for Boaters' Change House STP:

One of the initial concerns about the Boaters' Change House STP that attracted our interest was that the operators stated ammonia nitrogen appeared to rise as secondary effluent passed through the sand filters. It is possible that the filters harbor dead spots where flow is restricted and where anaerobic activity can occur. Anaerobic activity could reduce nitrogen and further interrupt the nitrogen cycle. (Nitrate in the absence of favorable biological conditions—anaerobic instead of anoxic—may be converted by certain bacteria to reduced forms, ammonia and organic nitrogen.) Given the filters' age, a simple remedy may be to remove and replace the filter media. During the mid-to-late summer, the boaters' change house washrooms and showers, and the commercial facilities associated with them, did not appear to be producing enough wastewater to adequately maintain healthy biomass in this treatment facility.

1. If this facility is to remain productively in service, it is recommended that the media in the sand filters be excavated and replaced. Over the course of the year, it is also important to remove weeds and other vegetative growth from the filter beds when it occurs. This is also a requirement of the NPDES Permit, for maintenance of the facility, Part B.1.E, et seq.[3]
2. Have the facility engineer follow through on connecting the Park's Dinner Bell Road maintenance facility to this plant.

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[2] Mapleton Area Joint Sewer Authority, Mapleton Wastewater Treatment Facility, Wastewater Treatment Evaluation, PA Dept. of Environmental Protection, Harrisburg, 2018. *Link*

[3] 40 CFR 122.41(e)

3. The facility engineer should evaluate this facility with an eye to “right sizing” its treatment capacity for the waste stream it receives, as it presently appears to be operating well below its design capacity to the detriment of effectively managing its biological treatment process.
4. If loading to this facility remains at only five to ten percent of its design capacity, it may be more economical to use the existing tanks for holding wastewater and then regularly pump and haul it to the Kentuck Campground STP for treatment. Were a larger equalization tank built at the campground, there could be sufficient storage capacity to sustain a pump and haul management scheme for Boaters’ Change House STP that would also benefit the campground plant by providing more consistent flow and loading there.
    a. However, park staff did not know the projected additional flow and loading expected if the maintenance buildings on Dinner Bell Road are connected to this facility. This would be a factor in any decision to improve the existing facility or to mothball it and use the tanks for storage as part of a pump and haul program supplementing loading to the campground facility.

Recommendations for the Falls Visitors’ Center STP:

The demonstration water recycling and waste treatment facility is an integral part of the LEED-certified design of the visitors’ center. Plant operators report that its treatment capacity is limited and that, by design, excess wastewater flows to the Borough of Ohiopyle’s 0.030 MGD municipal wastewater treatment works nearby. Evidence of organic overloading was observed in the form of biosolids on the surface of the polishing wetland. During the most recent inspection, it was observed that the pressure tank for recycling water to the comfort facilities was inoperable and that all wastewater was going to the municipal treatment plant.

1. Repair or replace the pressure tank.
2. Consider installing a flow metering device on the wastewater bypass from the visitors’ center to the municipal treatment facility, and regularly report the quantity of wastewater bypassed.

Recommendations for the Pressley Ridge School STP

The NPDES Permit for Pressley Ridge STP, though expired, is still listed as “active.” Since after ten or more years of abandonment the treatment facility is all but destroyed, DEP’s recommendation has been for DCNR to formally vacate the facility, eliminating its collection system connections and its final effluent outfall. Once the facility has been properly abandoned by DCNR, certified by their engineer, and inspected by DEP, a request to cancel the NPDES permit (PA0046116) should be submitted to the Department. A link to the appropriate Notice of Termination form can be found on DEP’s website by navigating to the line provided here:

http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=5892.

Wastewater Treatment Evaluation:

The DEP offers an array of compliance assistance and process improvement services to operators of wastewater treatment plants in the Commonwealth. Funding for this is provided through grants from the U.S. Environmental Protection Agency under a program to primarily reduce nutrient nitrogen and phosphorus in treated effluents. In 2008, DEP built upon an existing operator compliance assistance program by starting an instrument-based analyses that provided continuous monitoring data with which to improve process control through adjustments and water treatments. The program also provided a portable wastewater laboratory to assist operators in improving their process monitoring skills. Initially, the funding grant sought to reduce certain pathogens in treated wastewater effluents, but with the advancing technology for biological nutrient removal[4] (BNR) and more stringent technology-based pollutant limits in waterways of the Commonwealth and the Delaware and Chesapeake bays, the program shifted to BNR.

Nutrient Reduction Goals:

Small flow wastewater treatment facilities are generally exempt from nutrient management regulations unless called for by local, stream-based limits such as TMDLs. The NPDES Permits for the Ohiopyle plants at best require only “monitor and report” permit conditions, so there is no statutory requirement for these facilities to meet effluent nutrient limits. However, there are many benefits that accrue to facilities that are able to manipulate biological process to reduce nitrogen in their effluents. These include:

- Reduction of energy consumed in aerating activated sludge systems;
- Improved effluent quality by removal of nitrate and nitrite;
- Recovery of alkalinity consumed during required nitrification of ammonia waste;
- Reduction of rising sludge in secondary clarifiers, reducing potential for suspended solids violations in effluent discharges;
- Improved disinfection by reduction of suspended solids;
- Improved compaction of biomass sludges;
- Modest reductions in quantity of waste sludges to be disposed of.

Any facility that is required to nitrify should also consider denitrifying, because of these benefits.

Further, one of the missions of the technical assistance program is to improve effluent quality through application of biological nutrient removal.

Watershed 19-E includes the Youghiogheny River drainage, a portion of the larger Ohio and Mississippi River basins. Whilst efforts to reduce nutrient pollution in tributaries of the Chesapeake and Delaware bays have led to nutrient limits written into National Pollutant Discharge Elimination Permits (NPDES) in central and eastern Pennsylvania, imposing stricter treatment standards on point-source discharges like wastewater treatment plants, the western counties of the Commonwealth have thus far escaped more stringent permitting. However, the continuing development of local total maximum daily pollutant loads (TMDL) for smaller waterways and drainage areas has engendered regulatory interest in improving effluent quality for permittees discharging to the Ohio River Basin. Many facilities that have new “monitor and report” permit conditions covering soluble nutrients may have firm discharge limits as permitees within the next four or five permit cycles.

Since most treatment facilities are now required to nitrify toxic dissolved ammonia in their waste streams, which is an energy and cost-intensive process, it makes sense financially and practically for such facilities to also denitrify their facility effluents. Doing so has been found to return approximately

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[4] The subject is also called “biological nutrient reduction,” as 100% removal is still technologically unattainable.

half the oxygen and sixty percent of the alkalinity consumed during nitrification of ammonia wastes. Nitrate dissolved in treated wastewater can be reduced to natural nitrogen gas that leaves the water and returns to the atmosphere that is eighty percent (80%) molecular nitrogen to begin with. There are financial and operational benefits to denitrification: reduced energy consumption, lower chemical and power costs, fewer effluent violations for suspended solids and fecal coliform bacteria, inhibition of cumbersome filamentous organisms in the activated sludge treatment process, and some modest reductions in sludge generation. The benefits of nitrogen removal are discussed in Attachment H, following.

Phosphorus reduction is also important. The small treatment facilities operated in Ohiopyle State Park do not have phosphorus limits in their NPDES permits. That does not mean that the discharges of phosphorus, a plant nutrient that causes algal blooms in small streams, rivers, and lakes, is insignificant locally. While some phosphorus is consumed by the bacteria of the activated sludge process, most of it passes through treatment plants where there is no existing regulation. Thus, the evaluation included testing for phosphorus, as well.

Ohiopyle State Park and its Wastewater Treatment Facilities:

Ohiopyle State Park holds three NPDES Permits and one Water Quality Management Permit, and it operates three wastewater treatment facilities. Two are small extended aeration secondary sewage treatment facilities, and the other is a pilot water recycling system set up in the park's visitor center. Some wastewater generated at the state park also enters the municipal treatment plant operated by the Borough of Ohiopyle at its Meadow Run treatment facility. A fourth permitted treatment plant at a former school site on Pressley Ridge Road had been transferred to the park when it acquired the defunct school property in 2010. Its wastewater treatment facility had been shut down in 2012, although the permit continues to remain active. The four park facilities are:

- Kentuck Campground, PA0032425,
- Boater's Change House, PA0096521
- Park Visitor Center, WQM2611402
- Pressley Ridge, PA0046116

Because the fourth facility has been abandoned for a decade and has deteriorated and been vandalized, its operation was not evaluated. Past inspection records show that the Pressley Ridge School ceased operations in 2010, with the treatment facility being shut down about two years later. Over time, the buildings were stripped by scrappers and vandals, and the treatment facility fell into abandonment. The NPDES Permit, though expired, is still listed as "active." Since after ten or more years of abandonment the treatment facility is all but destroyed, DEP's recommendation has been for DCNR to formally vacate the facility, eliminating its collection system connections and its final effluent outfall. Once the facility has been properly abandoned and inspected, a request to cancel the NPDES permit (PA0046116) should be submitted to the Department. A link to the appropriate Notice of Termination form can be found on DEP's website by navigating to the line provided here: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=5892.

Of the three actively permitted facilities, the Kentuck Campground treatment facility (Campground) is the main focus of this evaluation, because it has the largest permitted flow capacity and is expected to see increases in wastewater loading as the park operator advances plans to add up to several hundred new campsites, some of which will have direct sanitary sewer connections for recreational vehicles and caravans.[5] Kentuck has also experienced spates of discharge violations in the past, events that the park owners and operators would be happy to curtail entirely.

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[5] That is, no more need for some park visitors to use the septage dumping station near the entrance to the campground. Caravans and motor homes will have direct connection to utilities, including water and sewer.

The village of Ohiopyle, itself, owns and operates a wastewater treatment facility to treat wastes from the many businesses and some residential users in its boundaries. This is the Meadow Run STP, PA0028258, located near the riverbank at the confluence of Meadow Run with the Youghiogheny River. This facility is similar to the Kentuck Campground and Boaters' Washroom facilities, and it is rated for 30,000 gpd and a design organic load of 60.05 lb./day. When the tourist trade is booming, and when the park visitor center treatment facility becomes overwhelmed, the Meadow Run plant experiences organic overloading and subsequent effluent violations. This facility discharges to Meadow Run, a cold-water fishery, immediately upstream of its confluence with the Youghiogheny River that is the very focus of the tourist trade at both Ohiopyle and Ohiopyle State Park. While not in the current scope of this evaluation, DEP may return one day to evaluate that plant for possible improvement.

The park's wastewater collection system (map shown in Attachment B, following) collects conventional sewage from several comfort stations throughout the park, year-round office and maintenance facilities, and small food concession stands. There is also a septage facility for receiving waste from recreational vehicles and travel trailers. Altogether, the waste stream comprises about 12,000 gallons per day on average at Kentuck Campground, while only about 500-to-1,200 gpd is conveyed to the Boaters Change House facility. Kentuck and Boaters Change House have permitted flows of 40,000 gpd and 10,000 gpd, respectively. From a strictly water flow standpoint, both facilities appear to be drastically underloaded most of the time. Complicating this is that Kentuck experiences peak hydraulic and organic loadings during the busiest times of the tourist season, requiring operators to maintain biomass well in excess of that needed for treating the average flow. Meanwhile, Boaters Change House STP is simply underloaded all of the time. It functions less as a wastewater treatment facility than it does a septage holding tank, where the common condition has led to breakthroughs of ammonia nitrogen in its treated effluent, small in quantity though it may be.

The two plants described here consist of dual secondary treatment tanks where mechanically aerated suspended growth (activated sludge) consumes waste elements. Both are often oversized to the average wastewater load, so only one of two trains is operated at Boaters Change House while Kentuck experiences occasional surges of potent wastewater.

At Kentuck, each aeration tank holds about twenty-thousand gallons capacity. Flow from the treatment tanks is clarified in dual hopper-style gravity clarifiers, operated using air-lift pumps. The plant headworks consists of a small comminutor and back-up bar rack. Secondary effluent flows to series of disinfection and dechlorination wet wells where erosion-style (tablet-form) calcium hypochlorite disinfection is followed by sulfide dechlorination to quench any remaining chlorine residual. The aerators in the bioreactor tanks are coarse bubble, providing a rolling current that maintains solids in suspension while mixing biomass with food source. Aeration is provided by small positive displacement blowers.

As originally configured, this secondary treatment system was intended to remove carbonaceous biochemical oxygen demand ($CBOD_5$) and provide for some nitrification of ammonia waste. Its design is not necessarily conducive to denitrification or to phosphorus removal.

Park visits have been especially strong coming out of the Covid pandemic, although attendance at park facilities falls off after schools reopen in September. By November, the wastewater treatment facilities shut down. Kentuck Campground is locked and off limits to the public after the park closes in late-Autumn. Sewage flow diminishes but for mild inflow and infiltration of water into the collection system. Such flow is insufficient for maintaining secondary treatment.

DEP staff performed routine process monitoring once per week during July and August to assure calibration of the nutrient probes. As the graphs here demonstrate, ammonia and nitrite were usually nondetectable, indicating thorough nitrification. Nitrate, though, is another matter: with influent ammonia concentrations as high as 120 mg/L, correspondingly, nitrate ion present in the effluent was almost equally as high.

The Ohiopyle treatment facilities, for the most part, were not designed to treat nitrate and phosphorus. At present, the Ohio River watershed into which the Youghiogheny River drains is not considered overly threatened. The Campground and Boater's Change House STPs are minor-flow, extended aeration package plants. They are chiefly designed to eliminate solids, organic, and ammonia waste. Through nitrification, organic nitrogen and ammonia are oxidized into nitrate. The effluent nitrate concentrations are approximately as high as the ammonia entering the plants.

From process management and cost-to-treat standpoint, when facilities nitrify ammonia wastes, it is beneficial and economical to consider denitrifying the nitrate that is produced. In facilities such as the Campground and Boaters' Change House plants, this can be achieved through a treatment strategy called intermittent, or "on / off," aeration. Research has shown that extended aeration plants need not run the aeration blowers continuously. Instead, by cycling the blowers on and off over the course of the day, and with addition of anoxic mixing during the "off" periods, facility operators allow facultative, cBOD-consuming bacteria to use influent organic carbon to reduce dissolved nitrate in the mixed liquor to molecular nitrogen gas (N_2)that leaves the water and returns to the atmosphere, which is about eighty percent molecular nitrogen to begin with.

<u>Observations:</u>

1. From the time of the initial site scoping meeting in June, through the evaluation that ran until September 8, Kentuck had no running, potable water. In addition, during the evaluation, there was no working effluent flow meter, and the lack of internal weirs meant that reported flows are, at best, an educated guess on the part of the operators. Both conditions are clearly in violation of the NPDES permit's clause on operation and maintenance, 40 CFR 122.41(e). Although sewage plants with maximum daily flow less than 100,000 gpd are not required to have flow totalizers with recording charts, the requirement of the Permit to
2. The facility was built with an accompanying lamellar filter system for the effluent; however, park staff maintained that the filter never worked properly. Due mainly to biologically active suspended solids carrying over from the hopper-style secondary clarifiers, bacteria seeded into the filter media led to growth that resulted in almost-constant automatic filter backwashing. This filter backwash water, combined with normal influent flows, hydraulically overloaded the secondary treatment system. The filters have remained bypassed for years.
3. While during the evaluation, DEP staff were able to haul in potable water for equipment washing and for laboratory work (this is, after all, a campground,) lack of easily accessible potable water for washing down treatment units, mixing chemical solutions, operating the onsite comfort facilities[6], etc., leads to more violations of the operations and maintenance clause. Fortunately, in July the park installed a portable safety eye-wash station to resolve concerns about the non-operational permanent safety fixture.

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[6] Granted, one can just as easily hop into a vehicle and drive to the nearby campers' washroom to access comfort facilities and hot water for hygiene purposes, but given the nature of the work in the treatment facility, where exposure to pathogens is possible, it behooves the operators to have working sanitary facilities and hand-wash station within quick reach.

4. The secondary treatment system is oversized compared to its collection system's organic loading for most of the year. When organic loading is sufficient, it nitrifies well.
5. Denitrification was occurring in the clarifiers most of the time. This produced a "lava lamp" effect of rising solids that results in loss of biomass to the chlorine contact wet well, where the solids interfere with disinfection. During the evaluation, DEP monitored oxidation / reduction potential in the aeration tank to see if the biomass ever reached an anoxic state that might promote denitrification in the bioreactor tank instead of in the clarifiers: it rarely did, even during experimental intermittent aeration, and ORP was frequently measured over 300 millivolts when denitrification occurs best at -50 mv. Only during a power outage around August 14 did the ORP remain in the anoxic zone. Nitrate concentration dipped, but it did so only because ammonia wasn't being converted to nitrate while dissolved oxygen was absent.

   Under the right conditions, where continuous mixing is provided during "anoxic" conditions, nitrate provides oxygen for certain bacteria when the aeration blower is not operating. Nitrate may be converted to nitrogen gas in the bioreactor, and the clarifiers will not experience rising biosolids.
6. The diffusers in the bioreactor had been upgraded recently. The bioreactors do a good enough job oxidizing waste and ammonia, but the influent ammonia concentration is often very high on weekends and holidays. While trying to see if some denitrification was possible, it was more important to operate the aeration blowers at full capacity to keep up with the ammonia loading, negating any benefit that denitrification could bring.
7. Air lift pumps are economical to operate, but they are inefficient and virtually impossible to regulate. D.O. concentration over 3.5 mg/L represents "wasted energy." To treat organic and ammonia waste, one needs only to maintain bioreactor D.O. between 1.5 mg/L and 3.5 mg/L. It works out to this: too little D.O. = high ammonia in effluent / too much D.O. = high nitrate in effluent.
8. It appears that Ohiopyle State Park has some continuous I/I flow that cannot be easily eliminated without relining the collection system pipes and re-grouting the manholes. If inflow and infiltration cannot be controlled by doing that, then it stands to reason that one bioreactor should remain in minimal service during the winter months.
9. Alternatively, the wastewater treatment plant could be "right sized" to treat the waste it receives, not the waste that people thought it may receive decades ago when the plan for the state park was very different from the reality it is today. There are different ways to do this, and DEP would recommend that a proper engineering evaluation study be done to recommend alternatives. Such alternatives include:
   a. Reconfigure the existing plant to support engineered biological nutrient removal (BNR) by converting the existing tankage to sequencing batch reactors (SBRs) that include a denitrification cycle.
   b. Control aeration blower output using D.O. probes in a feedback loop with variable frequency motor drives (VFD.)
   c. Add anoxic mixers to provide for denitrification treatment, along with supplemental carbon sources, when needed, to assure that denitrification happens in the bioreactor tank and not the clarifiers.
   d. Eliminate the use of air lift pumps for mixed liquor transfer, return and waste activated sludge pumping. Instead, use electrical pumps that are also controlled using VFD to provide for efficient operation over a range of flow. Ideally, internal pump discharges should be extended below surface, with vacuum breaks also provided, to eliminate splashing at the surface of the secondary bioreactors that introduces unwanted oxygen when denitrification is a treatment goal. Air lift pumps are notoriously difficult to regulate: they are either fully on or fully off. Internal return sludge rates and, when considered, internal mixed liquor recycle rates, have critical limits based on the flow

rate of influent wastewater. To quick, and the bioreactor becomes hydraulically overloaded; too slow, and the biological treatment process suffers.

e. Because rags, “disposable” wipes, and plastics pass through the existing comminutor / bar rack headworks, consider installing a fine-screen trash removal system up front to prevent damage to downstream pumps, aerators, mixers, and control instrumentation. Such devices prevent hosts of downstream problems with fouling of pumps, damage to aerators, trash carryover into the effluent, and damage to instrumentation. Ideally, fine screening systems also provide a wash function that serves to rinse useful BOD_5 from the trash.

f. At the disinfection process, consider substituting flow-paced sodium hypochlorite (“bleach”) solution instead of calcium hypochlorite “pucks” that are not well regulated when flow is either too low or too high. And to preserve the cold-water fishery quality of the receiving waters, add efficient dechlorination using flow-metered sodium bisulfite or even a high-quality erosion tablet dispenser. If the discharge chlorine residual limits in the Permit become too stringent, it may be better to replace chlorine disinfection altogether with ultraviolet light disinfection and eliminate the chlorine hazard altogether. Given the size of these facilities, it may be possible to incorporate UV disinfection systems into existing wet wells or structures, minimizing installation costs.

g. Pump-and-treat is a viable option for dealing with the low-flow conditions at the Boaters’ Change House treatment plant, where daily flows appear to belie the need for a 10,000 gpd treatment works. Pump-and-treat is also an option for the off-season, as is the use of community septic and fee-only pump and treat disposal of trailer and motorhome waste.

h. Lastly, if money were no object, there is membrane technology in the form of “mini-MBR” (membrane bioreactor) that produces high quality recycled water from wastewater while employing un-needed, existing tankage for flow equalization and load attenuation. Membrane treatment plants have been used in other state parks, such as Gifford Pinchot in York County, for drinking water purification. In wastewater treatment facilities, membrane treatment eliminates the need for secondary clarifiers and their associated operational problems. A higher concentration mixed liquor suspended solid may be held in a smaller footprint bioreactor than is currently in use. Depending on projected average and maximum, flows, MBR-style treatment can be scaled to employ existing tankage as flow equalization capacity. For Kentuck Campground, an MBR would probably fit into the existing control building.

Process Monitoring during Evaluation:

During the evaluation, DEP staff conducted routine process monitoring tests on-site. The facility operators routinely perform the Permit-mandated effluent testing for total chlorine residual, dissolved oxygen, and pH. In addition, they perform daily Settleometry tests on mixed liquor from both bioreactors and ammonia testing using the Chem-Mets® kit. DEP staff, when on site, performed basic process monitoring tests and tests used to confirm in-line probe calibration. A list of recommended routine process monitoring tests is included in Attachment E.

DEP’s on-site nutrient and chemical oxygen demand test results are tabulated below. Alkalinity test results for most of the test dates show that soda ash had already been added to the influent wastewater before the test samples were drawn.

The test results show generally that the raw wastewater tends to be highly concentrated at low volumes. Frequently, the tops of the influent lift pumps were exposed at the bottom of the surge tank when the samples were drawn about mid-morning. More precise nutrient testing would be done using flow-paced composite samples, but in this case, one may reliably assert that the nutrient concentrations for phosphorus and nitrate tend to be high at Kentuck Campground. This is because these nutrients are not currently regulated by the Permit.

DCNR Ohiopyle State Park 2022 WTE Lab Results
Kentuck Campground Plant

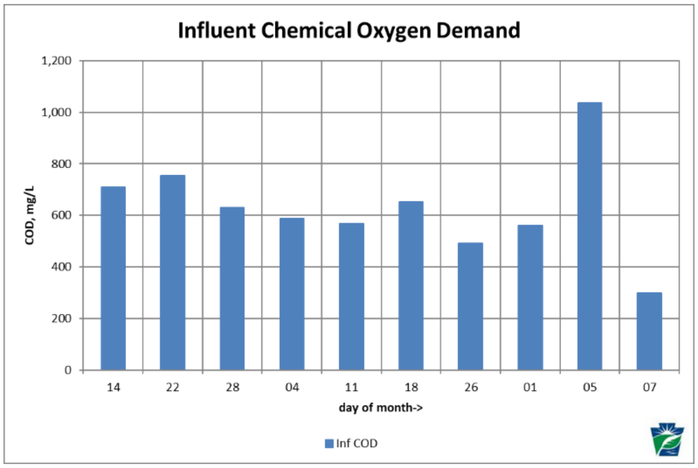
		Surge Tank			Clarifier Effluent							Surge Tank	
Loc/Test Conc.	Inf COD mg/L	Inf NH3-N mg/L	Inf Alk. mg/L	Inf PO4-P mg/L	Eff NH3-N mg/L	Eff Alk. mg/L	Eff PO4-P mg/L	Eff NO3-N mg/L	Eff NO2-N mg/L	Eff Tot. N mg/L	Loc/Test Conc.	Inf COD mg/L	Inf PO4-P mg/L
Average	584	79	477	14.0	0.044	293	12	77	0.021	106	Average	629	13.4
7/8/22		105	400	15	0.066	26	12.564			80	7/8/22		15
7/14/22	710	110	640	11.876	0.023	53	17.887	138.98		120.86	7/14/22	710	11.876
7/22/22	754	207	682	17.719	0.170	549				200	7/22/22	754	17.719
7/28/22	631	76	421	6.261	0.016	183	10.281	86.6	0.017	110.21	7/28/22	631	6.261
8/4/22	589	12	218	11.585	0.036	245	7.265	51.33	0.030	61.03	8/4/22	589	11.585
8/11/22	569	55	400	12.748	0.050	174	5.349	51.36	0.019	93.98	8/11/22	569	12.748
8/18/22	652	49	710	11.447	0.004	729	8.438	64.53	0.016	78.76	8/18/22	652	11.447
8/26/22	493	60	422	11.637	0.015	380	8.76	71.21	0.028	104.29	8/26/22	493	11.637
9/1/22	561	35	400	35.55	0.015	298	26.69	75.88	0.018	102.85	9/1/22	561	35.55
9/7/22	298			6.02			8.856				9/5/22	1035	7.525
											9/7/22	298	6.02

Meadow Run Plant

		Surge Tank			Clarifier Effluent					
Loc/Test Conc.	Inf COD mg/L	Inf NH3-N mg/L	Inf Alk. mg/L	Inf PO4-P mg/L	Eff NH3-N mg/L	Eff Alk. mg/L	Eff PO4-P mg/L	Eff NO3-N mg/L	Eff NO2-N mg/L	Eff Tot. N mg/L
8/4/22	205	34	231.9	4.52	0.026	255.2	> 25	49	0.028	71.49

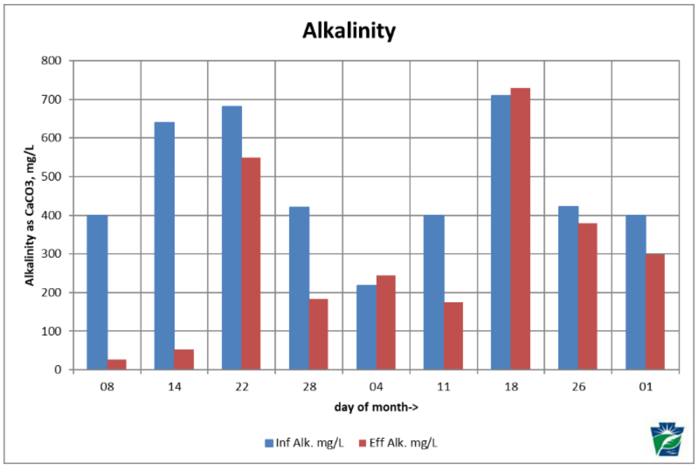
(Non-detects are indicated in **red**, and results over the test limit are indicated in **blue**.)

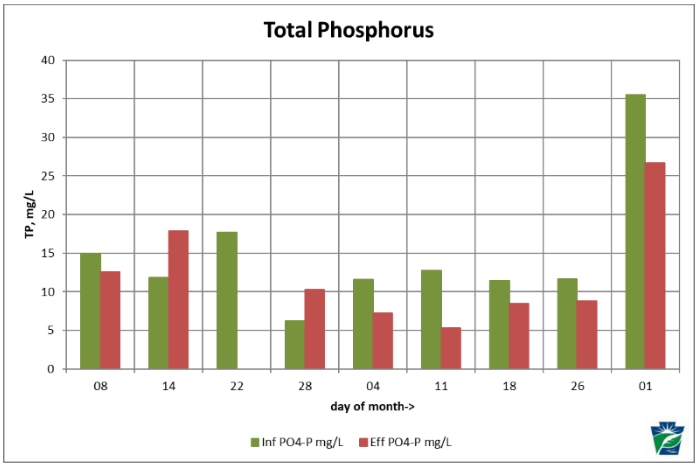
The following charts show the concentration of wastewater strength (chemical oxygen demand) and nutrients on the days when DEP staff conducted testing. Chemical oxygen demand (COD) is a useful process monitoring indicator of wastewater strength, because the test takes only two hours of digestion time compared to a five-day incubation time required for biological oxygen demand. It is recommended that operators routinely check the strength of influent wastewater so they can adjust treatment to meet demand and to avoid slug loads of high-strength waste. The test is more typically used in industrial wastewater treatment but has its uses at facilities such as Kentuck Campground.



COD generally averaged about 580 mg/L. For domestic wastewater, the BOD5 concentration is about 50% of COD, suggesting that BOD averaged 290 mg/L. An influent sample taken on Labor Day weekend (September 5) had a COD of 1,035 mg/L, suggesting that the BOD concentration that day was 175% of the routine average.

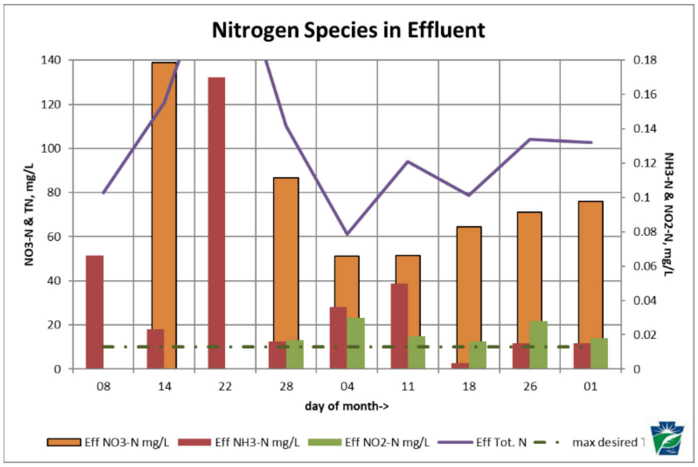
Alkalinity concentration at Kentuck Campground was generally good when soda ash is routinely added as a supplement. Attachment I explains how to calculate alkalinity demand based on influent ammonia or Kjeldahl nitrogen concentrations. The main point is that for each unit of ammonia-nitrogen present, 7.2 units of alkalinity are required by activated sludge bacteria to fully convert that ammonia to nitrate. If the average ammonia concentration is 80 mg/L in the influent, the concentration of alkalinity in the bioreactor has to be about 570 mg/L for efficient oxidation.





Phosphorus is not treated at the Kentuck Campground or Boaters' Change House treatment plants. Most of it simply passes through the treatment process; some is used by the bacteria for growth and metabolism. The average phosphorus concentrations of 14 mg/L in the influent and 12 mg/L in the effluent are not remarkable; however, when considering phosphorus loading to the effluent-dominated receiving stream, "un-named tributary of Youghiogheny River," in combination with planned expansion of the campground, phosphorus reduction may eventually be required for a higher quality effluent. Phosphorus is usually treated using aluminum sulfate or with polyaluminum chloride. The aluminum combines with phosphate as a precipitate that is wasted with excess activated sludge from the treatment system.

The graph of nitrogen species in the effluent shows concentrations of nitrite- and nitrate-nitrogen, ammonia-nitrogen, and total nitrogen. Total nitrogen is the combination of oxidized nitrogen (nitrite-nitrate) and reduced nitrogen (organic nitrogen and ammonia-nitrogen.) As the graph indicates, most of the nitrogen in the effluent is in nitrate form. This demonstrates that ammonia oxidation is complete at Kentuck Campground, very good, considering that the facility receives concentrated ammonia waste.



(This graph is truncated to eliminate an unrealistically high total nitrogen test result that was discarded as being improbable and likely in error.)

With an average daily flow of about 15,000 gallons, the effluent loading is low in comparison with larger-capacity treatment plants. Thus, total nitrogen is not regulated by the Permit. However, a case can be made that the benefits of denitrifying nitrate from the effluent outweigh the costs of doing nothing. Attachment H has a discussion of biological nitrogen removal. The bottom line is that by removing nitrate from the effluent, not only is water quality improved, but treatment costs will be somewhat lower. This is because

- less supplemental alkalinity is required,
- the oxygen bound to nitrate becomes available to bacteria, reducing aeration requirements,
- less electricity is consumed when aeration blowers do not have to be run constantly,
- filamentous organisms that interfere with clarifier performance are more likely to be eliminated,
- sludges settle more compactly.

Any facility that nitrifies ammonia should consider denitrifying nitrate.

During the evaluation, the operators and DEP staff adjusted the aeration timers to provide periods of anoxic conditions in hopes of promoting denitrification; however, the attempt was not altogether successful due to the lack of anoxic mixing required to maintain the activated sludge biomass in constant contact with dissolved nitrate and influent organic waste material. Denitrification is a problem with the hopper-style clarifiers used at Kentuck Campground: rising sludge carries over the weirs to interfere with disinfection downstream. Total suspended solids in the disinfection tank consume chlorine and also shield fecal coliform bacteria from the effects of dissolved chlorine in the water. This contributes to fecal coliform violations.

Because the influent ammonia concentrations are relatively high, the operators had more of a concern to treat ammonia than to attempt removing nitrate. As a result, the attempted denitrification by intermittent (“on/off”) aeration was restricted to weekdays so that the higher ammonia loading on weekends and the Monday following could be completely nitrified.

Collection System Tests:

On October 20 and 21, 2021, personnel from US EPA’s Region 3 Office of Water Management assisted the plant operator in performing a smoke study of the campground’s collection system. This testing revealed some defects around potable water drains that could become problematic during wet weather events and when water tables are high. The report recommended that park staff conduct further investigation during wet weather, including the following:

- Each manhole should be inventoried and geo-located on a map, during which the manhole is inspected for damage or infiltration.
- Sewer and manhole rehabilitation may be required if infiltration and inflow is significant. Both manholes and pipes can be re-lined during the off-season, if necessary.

The report noted that further evaluation during wet weather is recommended. Use of in-pipe flow metering devices is available through EPA’s outreach program.

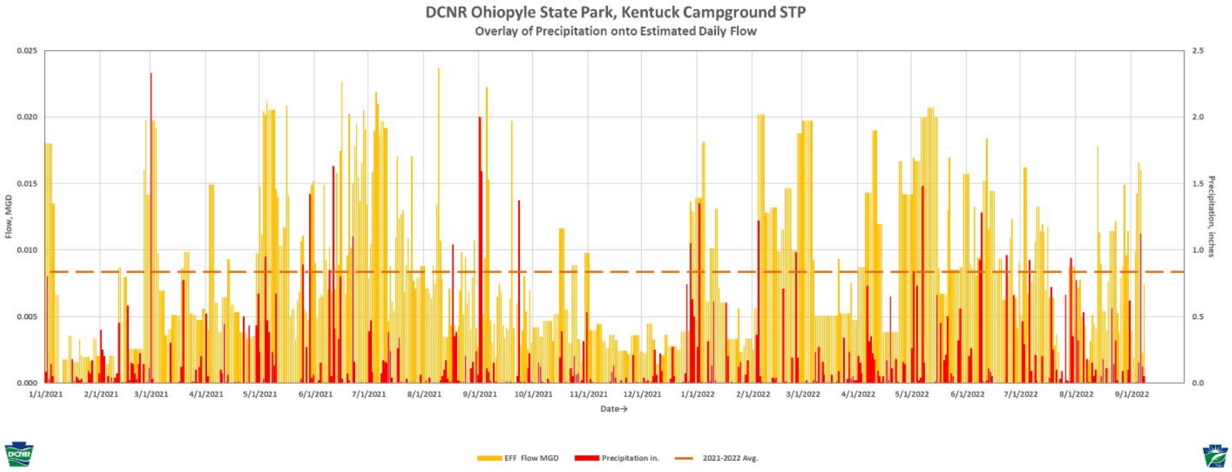
Lastly, the report noted that, as an option, park staff could employ inflatable plugs within the manholes during the off-season to isolate areas of inflow and infiltration and temporarily eliminate flow to the treatment facility. This would require a plan be submitted to DEP and approved prior to taking action, but it has been offered as an option for curtailing treatment plant use during the winter months.

Smoke machine in process and smoke seen coming from building vent.

Potable water station with drainage pit below ground. Smoke was seen around concrete base.

Comparison of Precipitation with Estimated Effluent Flow

To determine if inflow or infiltration is potentially a problem with the existing campground collection system, a comparison of daily precipitation was made, overlaying precipitation onto a bar graph of the estimated or reported plant effluent flows. The graph below shows that when precipitation was recorded at a weather station in Confluence, there had been a corresponding increase in throughput at the Kentuck facility.



Graph: Comparison of Precipitation with plant effluent flows at Kentuck Campground STP

The peaks of precipitation shown in red correspond with some of the measured plant flows, indicating that the collection system is adversely affected by inflow or infiltration. Because the graph employs two y-axes, the peaks of daily precipitation and daily plant flow are proportional and do not represent exact volumes: they do show correspondence. Other plant flow peaks may be due to increases in park attendance or to the way that plant flows are measured in the absence of a working flow meter. The main point is that the correspondence of peaks does validate findings of EPA's smoke testing, which looked for both infiltration, which is water seeping into pipes and manholes from the ground through worn joints or cracks, and inflow, which is precipitation water other than sewage entering pipes by way of intended connections such as roof drains or external collection areas, or through manhole lids where no inserts are present or through ponding over broken connection clean-outs.

As the park planners are intending to build more campsites, some of which will have direct trailer sanitary connections, it is recommended that they consider phased rehabilitation of the existing collection system as part of this or similar expansion projects.

ATTACHMENT A: EVALUATION TEAM

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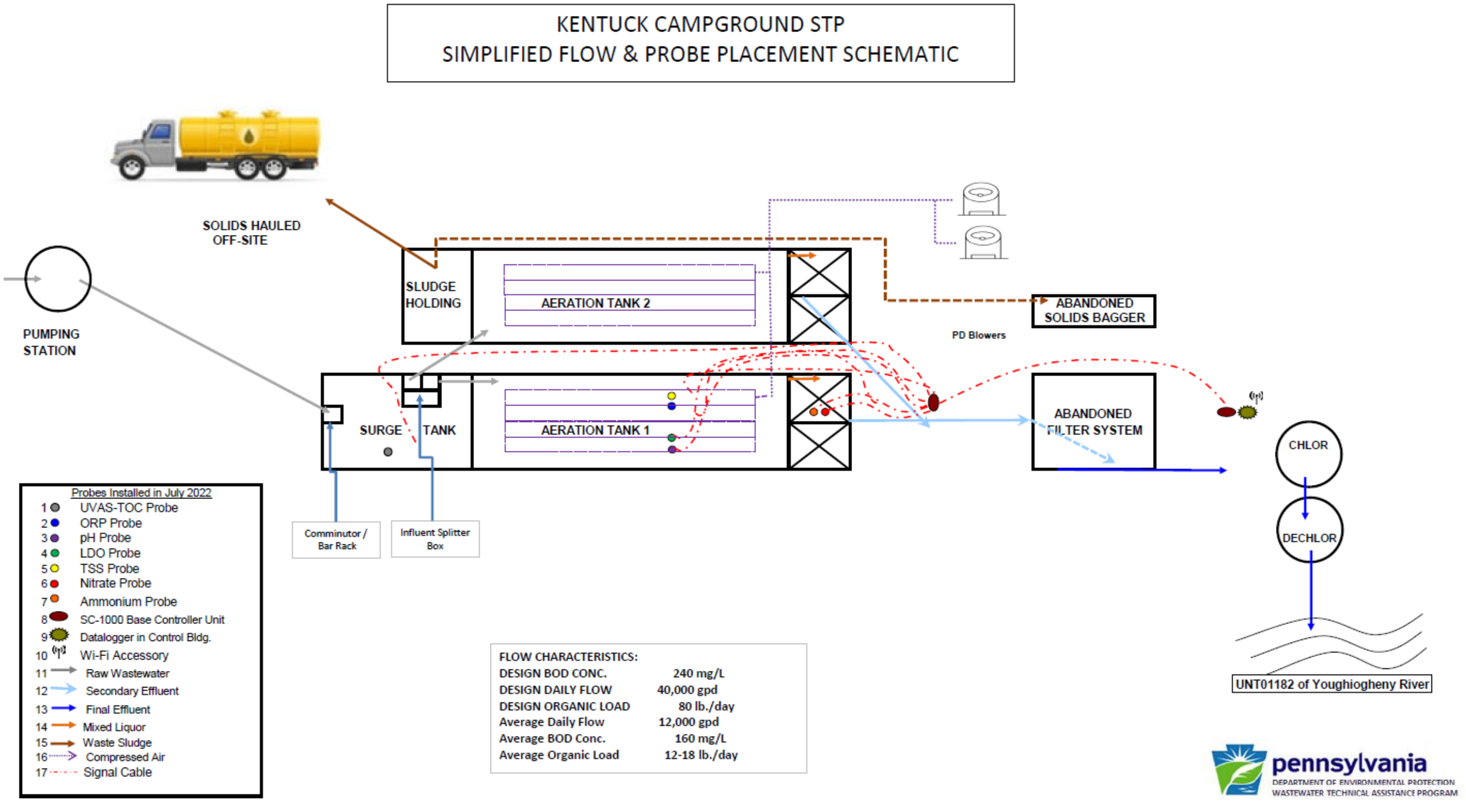
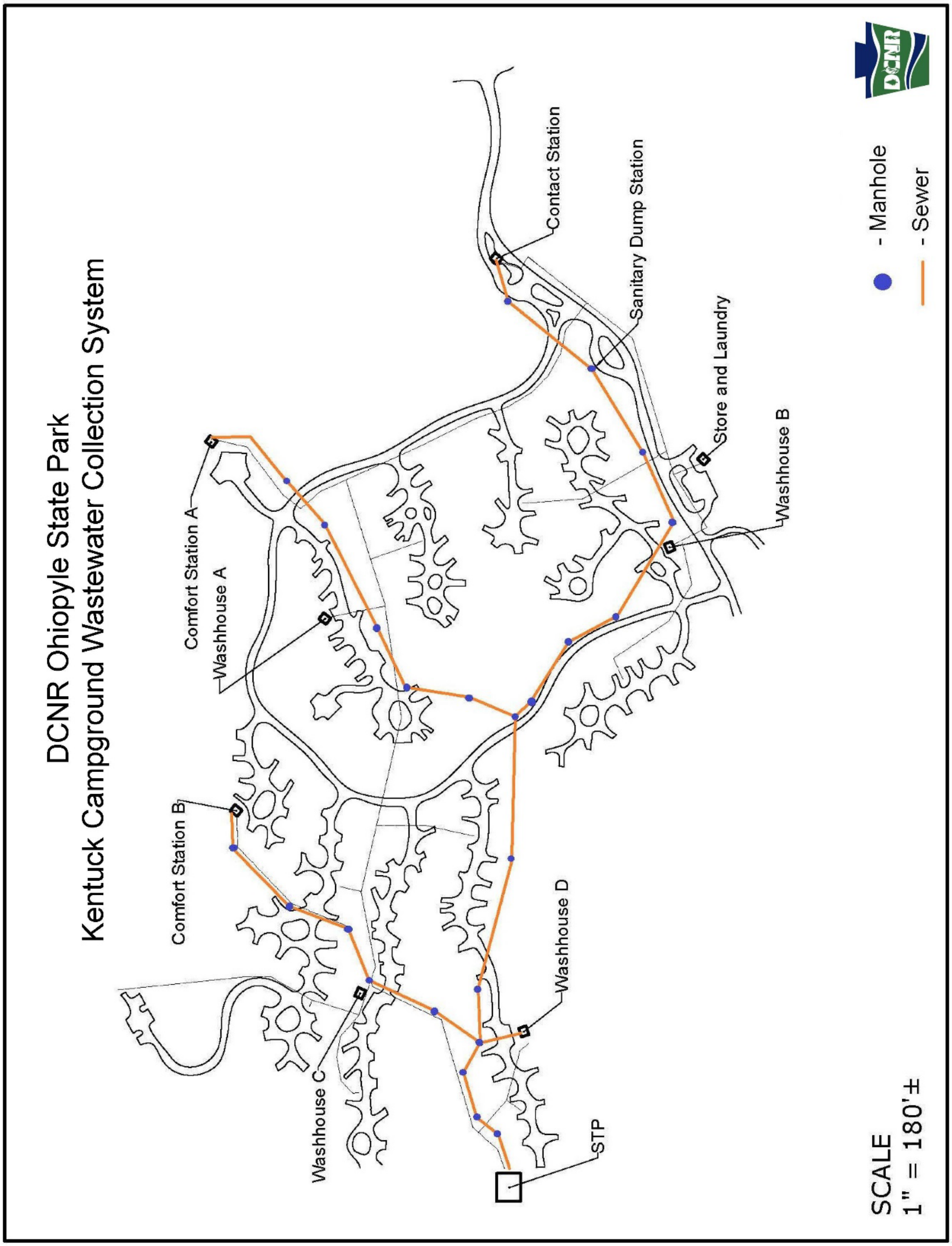
ATTACHMENT B: EQUIPMENT PLACEMENT SCHEMATIC





DCNR Ohiopyle State Park
Kentuck Campground Wastewater Collection System

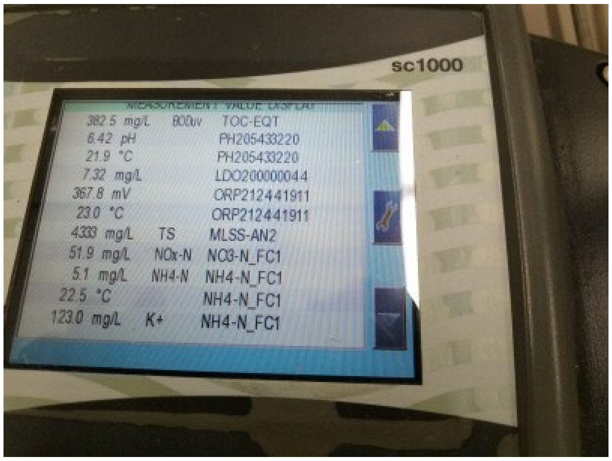
ATTACHMENT C: RECORD PHOTOGRAPHS

Kentuck Campground Wastewater Treatment Facility, PA0032425


Treatment unit 1 and Surge Tank with probes


External probe controller


Data logging system and probe controller



```
MEASUREMENT VALUE DISPLAY
 382.5 mg/L   BODuv   TOC-EQT
  6.42 pH             PH205433220
  21.9 °C             PH205433220
  7.32 mg/L           LDO200000044
 367.8 mV             ORP212441911
  23.0 °C             ORP212441911
  4333 mg/L   TS      MLSS-AN2
  51.9 mg/L   NOx-N   NO3-N_FC1
   5.1 mg/L   NH4-N   NH4-N_FC1
  22.5 °C             NH4-N_FC1
 123.0 mg/L   K+      NH4-N_FC1
```

Programmable display unit for probe controller


View of Process Monitoring Lab

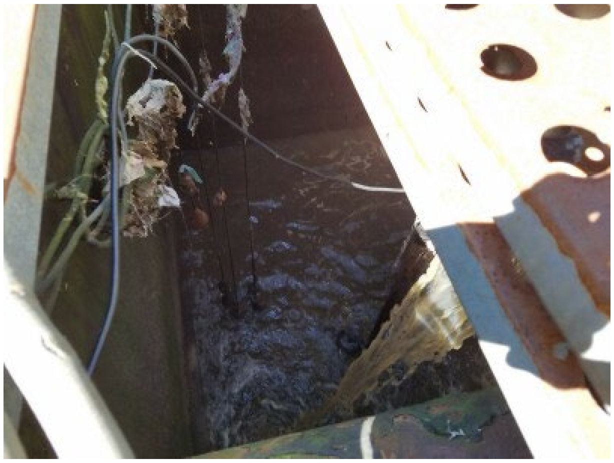

No potable water for running laboratory


Centrifuge and other lab equipment at left


View of PureStream Secondary Treatment Plant


Clarifier


Comminutor and Bar Rack


View into Surge Tank, with rag accumulation

PD blowers for aeration and pumping

Disinfection & Sulfonation Wet Wells

Tablet Erosion Chlorinator

Sulfonator and Broken Ultrasonic Meter

Outfall 001

Secondary treatment plant control panel
with temporary cooling fan

Type of new diffusers installed during last upgrade

Filter control panel

Biosolids bagging system

Generator needs another head gasket

Pumping Station outside fence

One of two caravan dump stations

Temporary eye wash station next to nonfunctional eye wash station (due to water line break)

Polymer Settling Agent, in neat frm

Chemical Day Tanks, unused

Solids accumulation on aeration tank

Rags destroyed this influent lift pump

Material removed from pump impeller

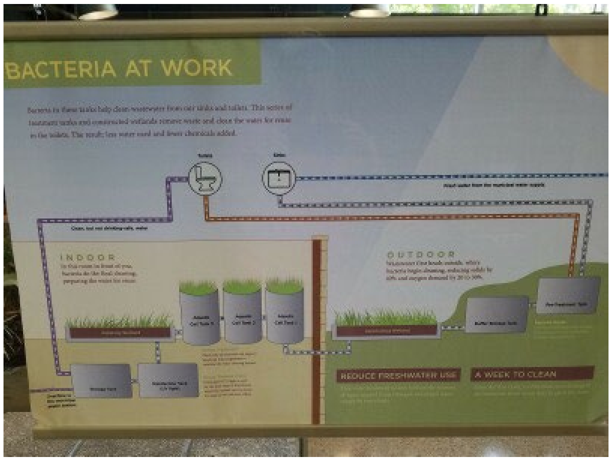
Inactivated bacteria prep mixture

Boaters' Change House Wastewater Treatment Facility, PA0096521


Purestream
DANGER

Falls Visitors' Center Wastewater Treatment Facility, WQM2611402

View of LEED designed Falls Visitors' Centre



Schematic of Treatment System

Rainwater Collection Zone

Constructed Wetland

Location of Septic Tanks for Solids

Valve box

Aquatic Cells

Polishing Wetland

Filter pads

Air compressors for facility

UV disinfection system

Pump and Filter

Turbidimeter

Controller for Turbidimeter

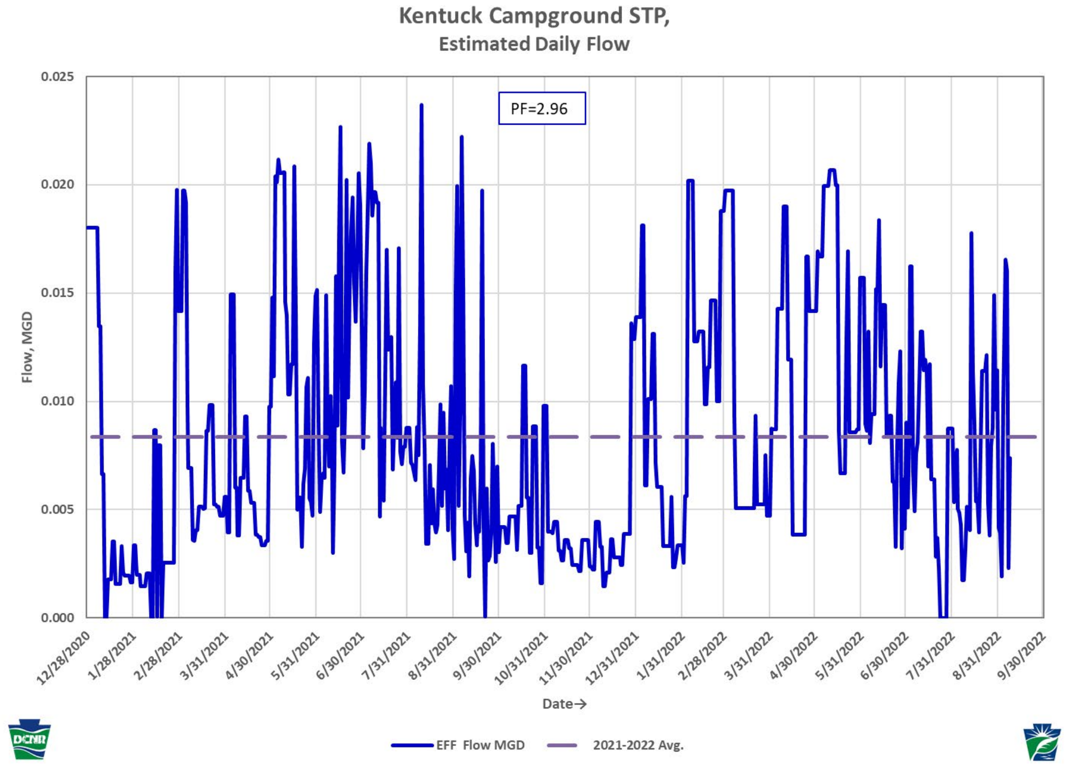
System Control

Level controller

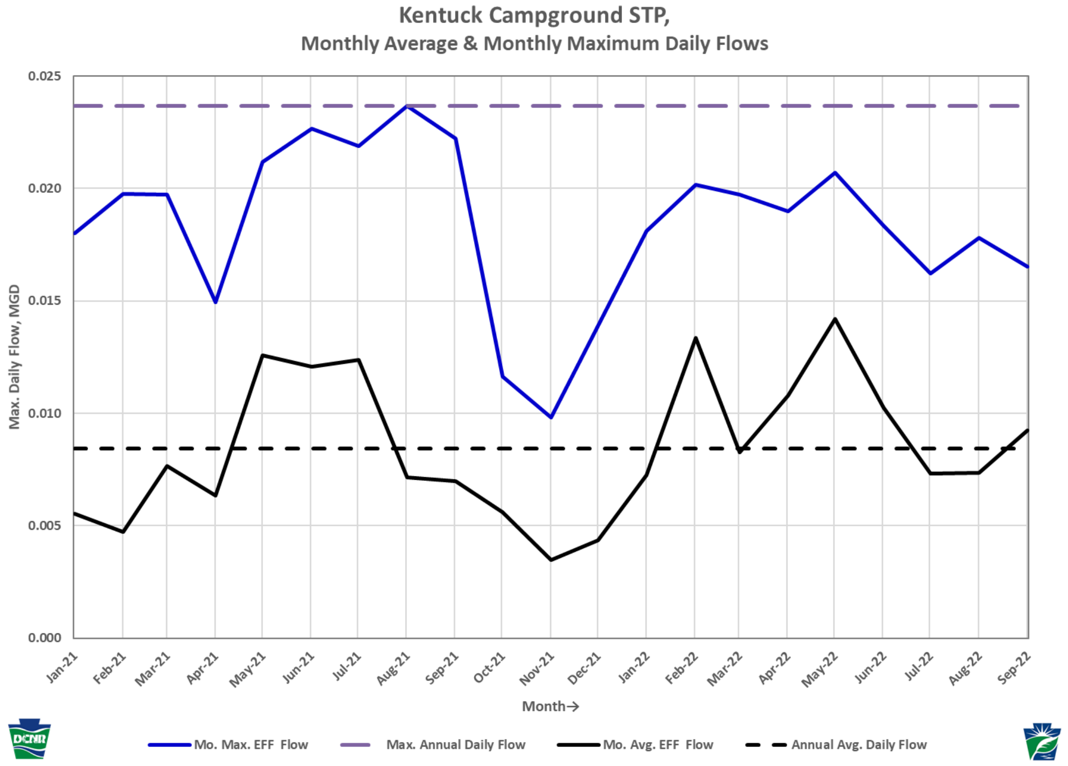
Sludge accumulation in polishing wetland

Unsecured electrical connections in wet well

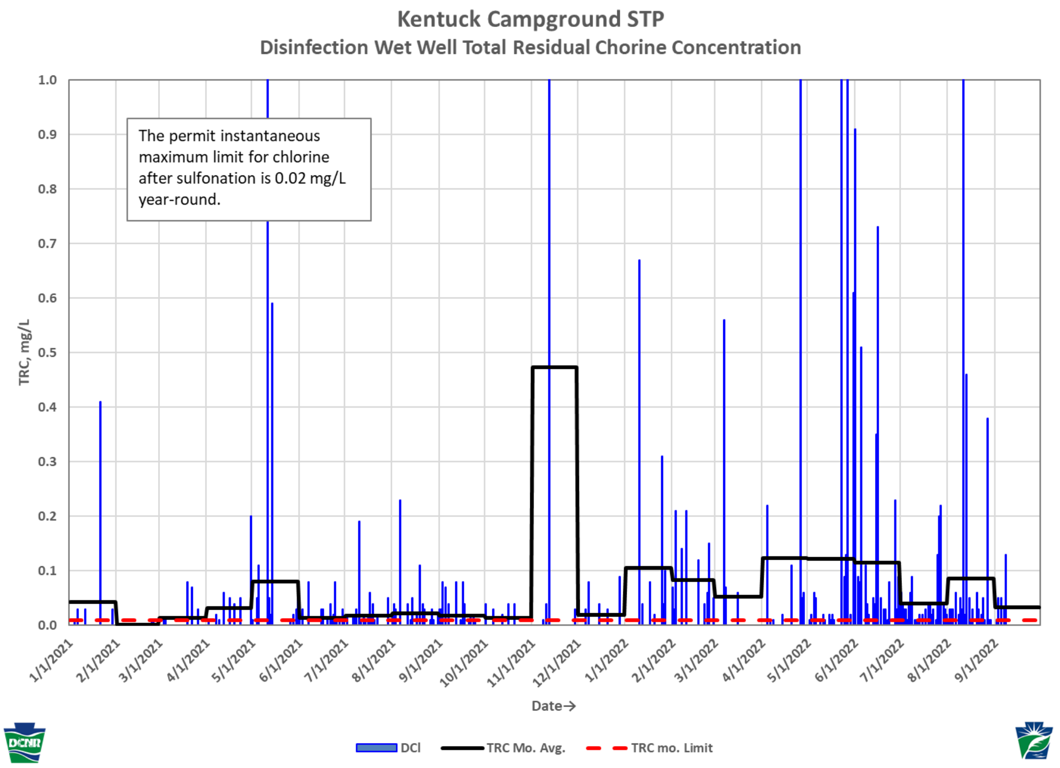
ATTACHMENT D: EXAMPLE TRENDS CHARTS



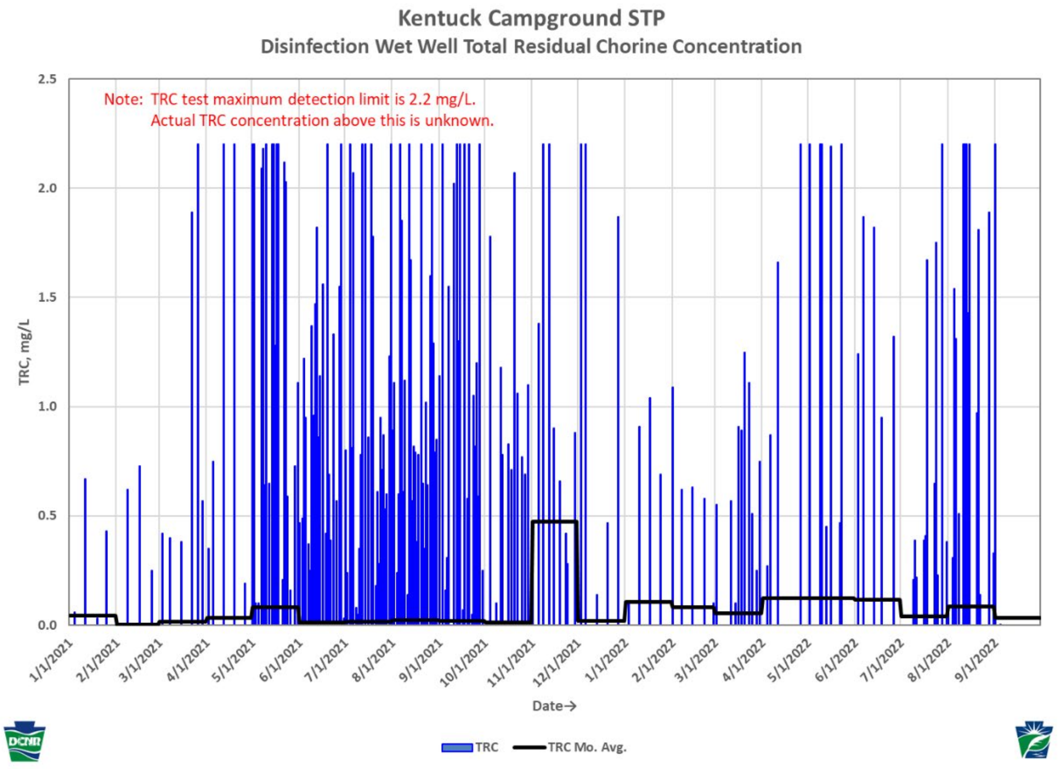
1/1/2021-9/8/2022 Kentuck Campground STP Daily Flow: estimated for 14.2 gpm, based on operator disclosure



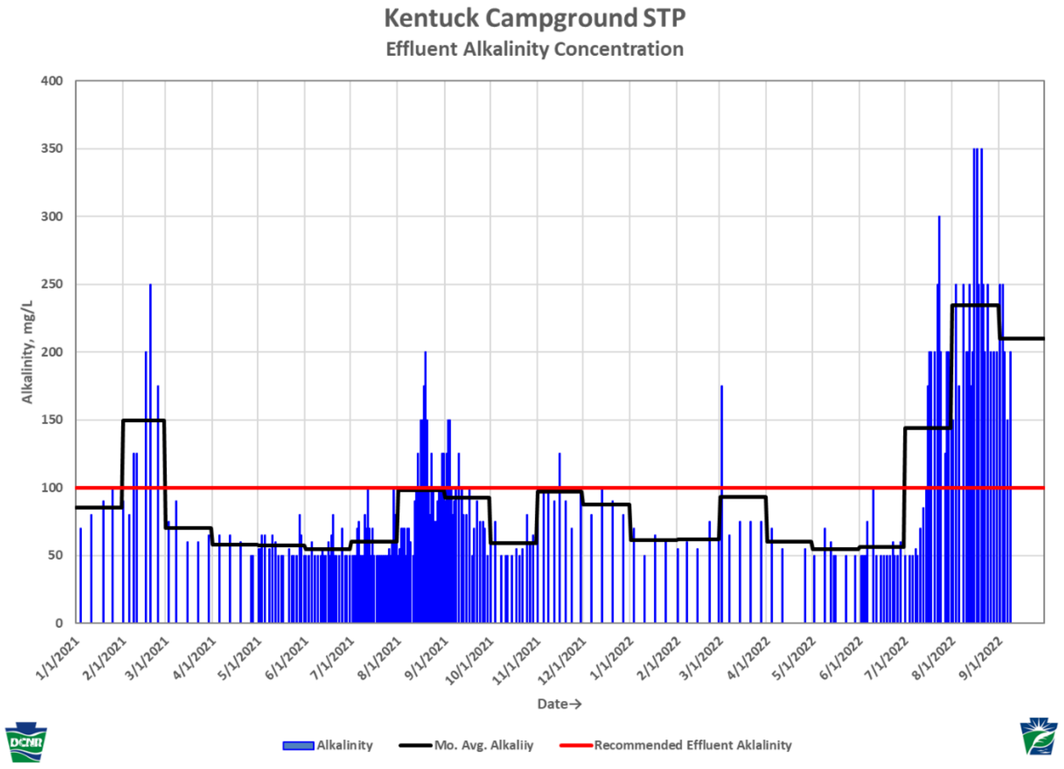
1/1/2021-9/8/2022 Monthly Average and Monthly Maximum Daily Flows, estimated for 14.2 gpm

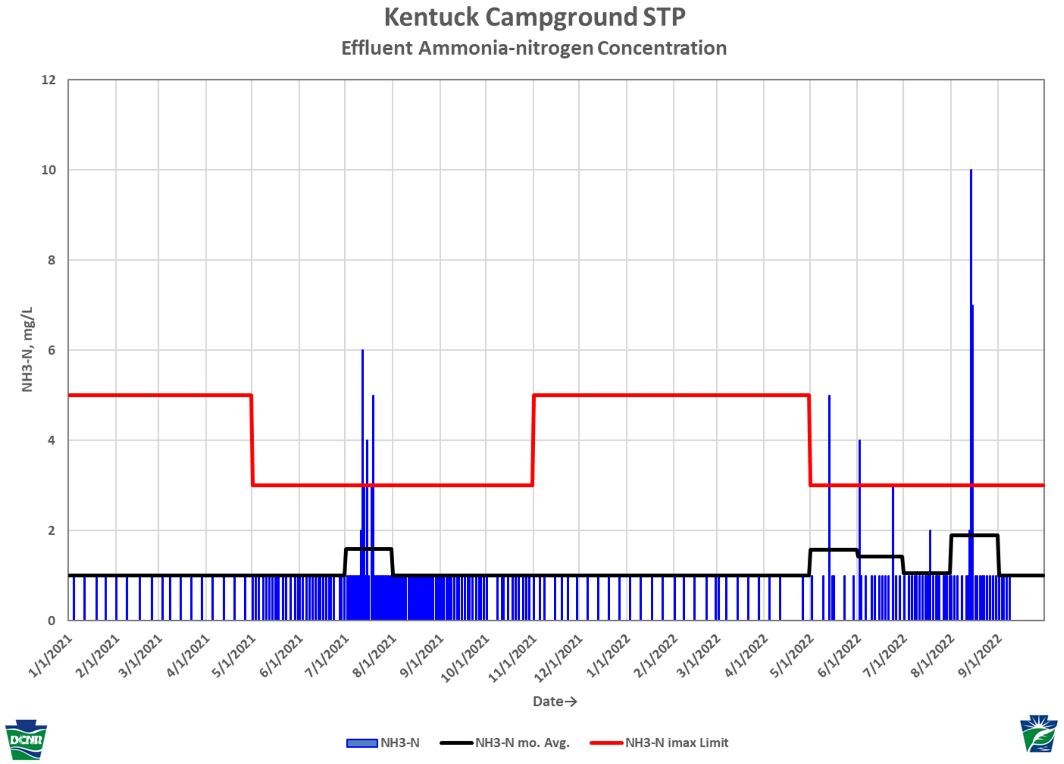


2021-2022 Effluent post-sulfonation TRC values



2021-2022 Secondary Effluent Disinfection TRC, prior to Sulfonation


Kentuck Campground STP
Effluent Alkalinity Concentration
Alkalinity, mg/L
400
350
300
250
200
150
100
50
0
1/1/2021
2/1/2021
3/1/2021
4/1/2021
5/1/2021
6/1/2021
7/1/2021
8/1/2021
9/1/2021
10/1/2021
11/1/2021
12/1/2021
1/1/2022
2/1/2022
3/1/2022
4/1/2022
5/1/2022
6/1/2022
7/1/2022
8/1/2022
9/1/2022
Date→
Alkalinity
Mo. Avg. Alkaliiy
Recommended Effluent Aklalinity


Kentuck Campground STP
Effluent Ammonia-nitrogen Concentration
NH3-N, mg/L
12
10
8
6
4
2
0
1/1/2021
2/1/2021
3/1/2021
4/1/2021
5/1/2021
6/1/2021
7/1/2021
8/1/2021
9/1/2021
10/1/2021
11/1/2021
12/1/2021
1/1/2022
2/1/2022
3/1/2022
4/1/2022
5/1/2022
6/1/2022
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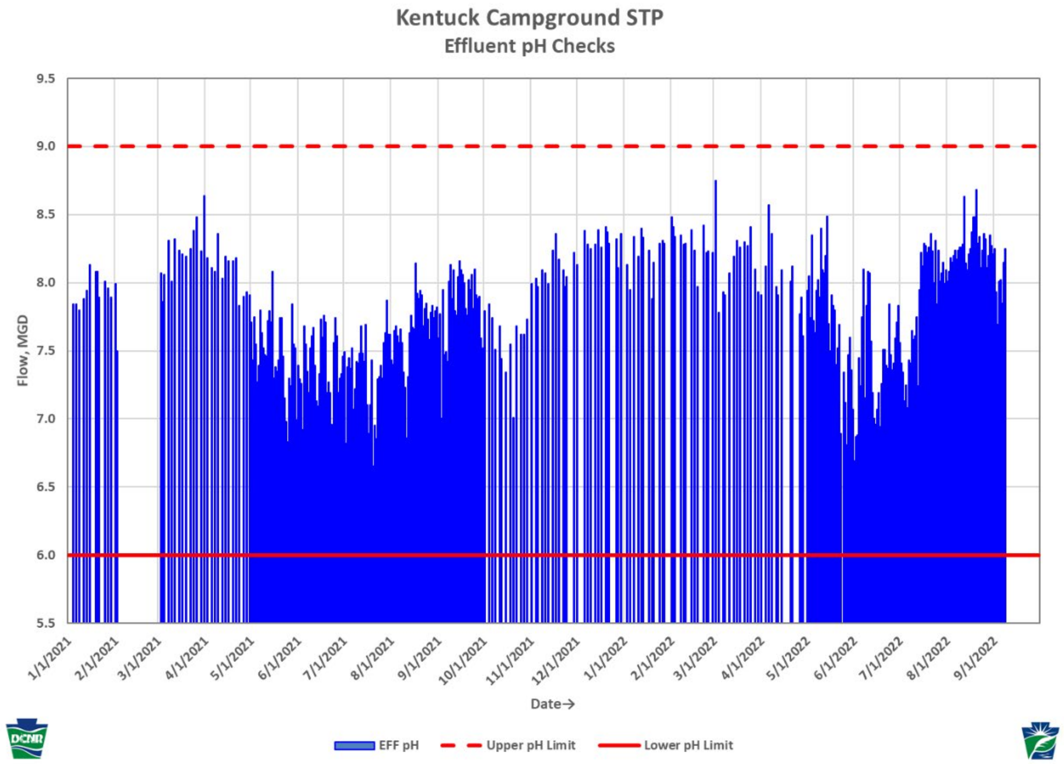
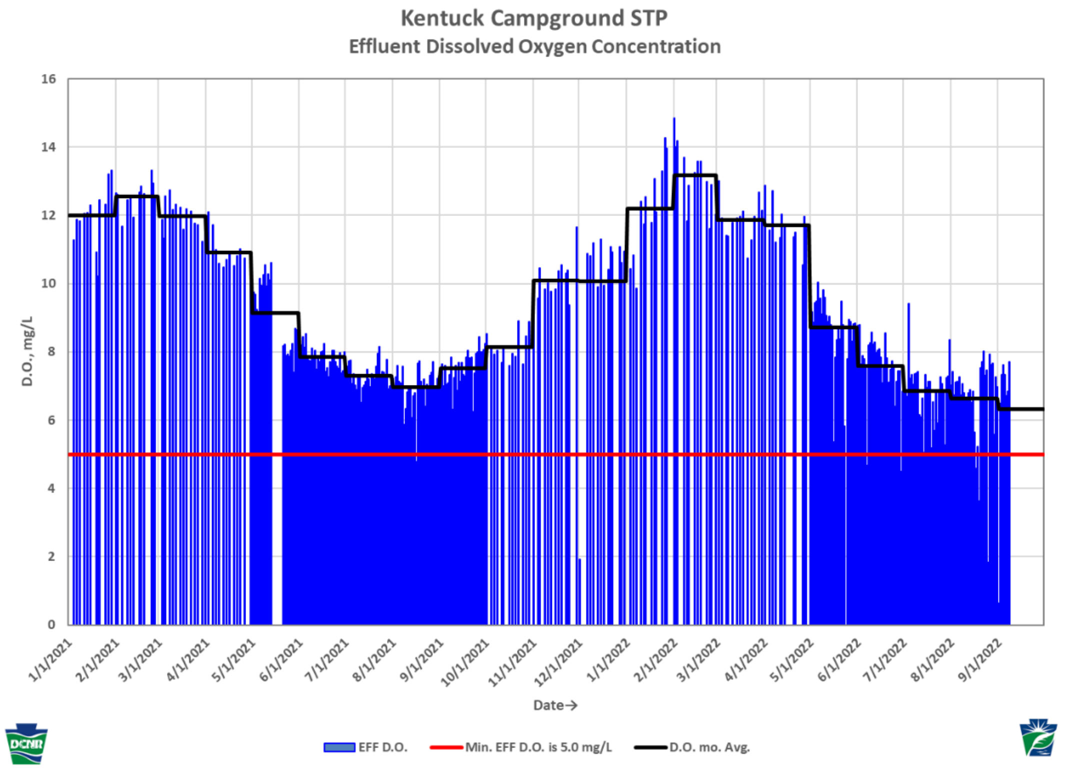
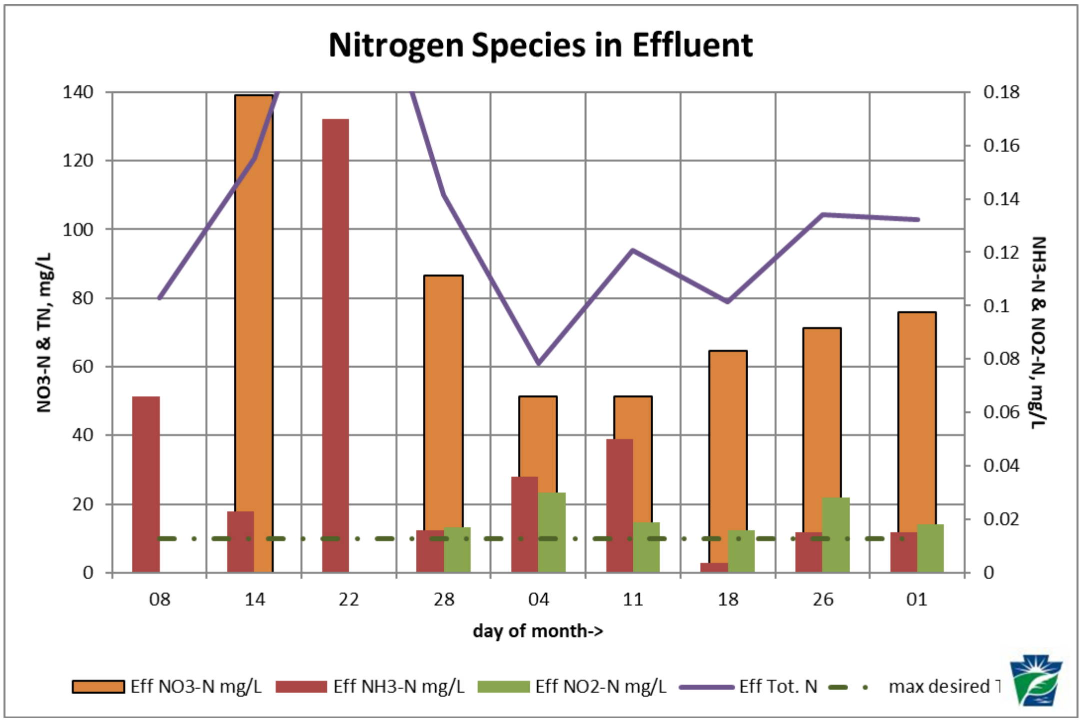
8/1/2022
9/1/2022
Date→
NH3-N
NH3-N mo. Avg.
NH3-N imax Limit



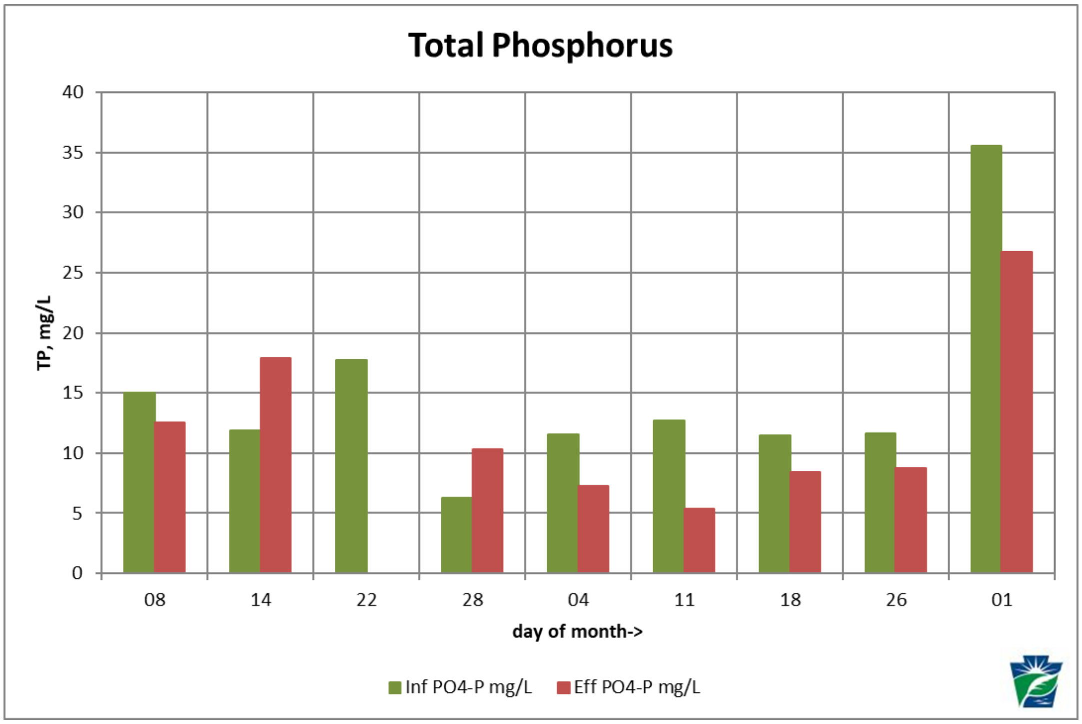
Data based on facility operating records



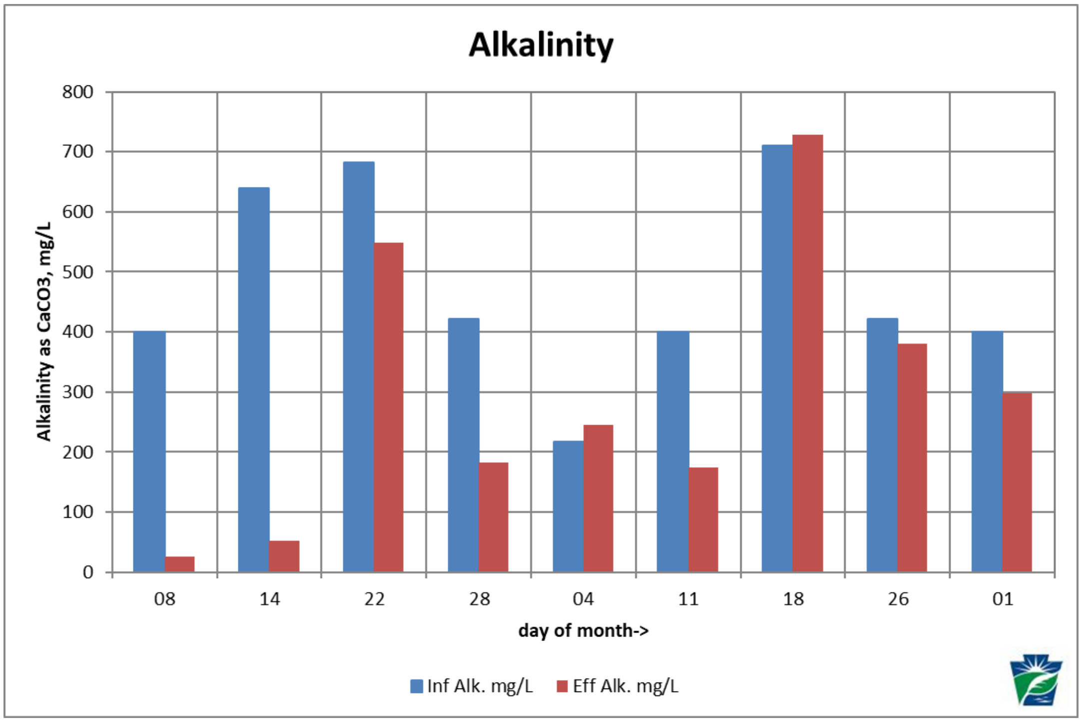
Data based on facility operating records



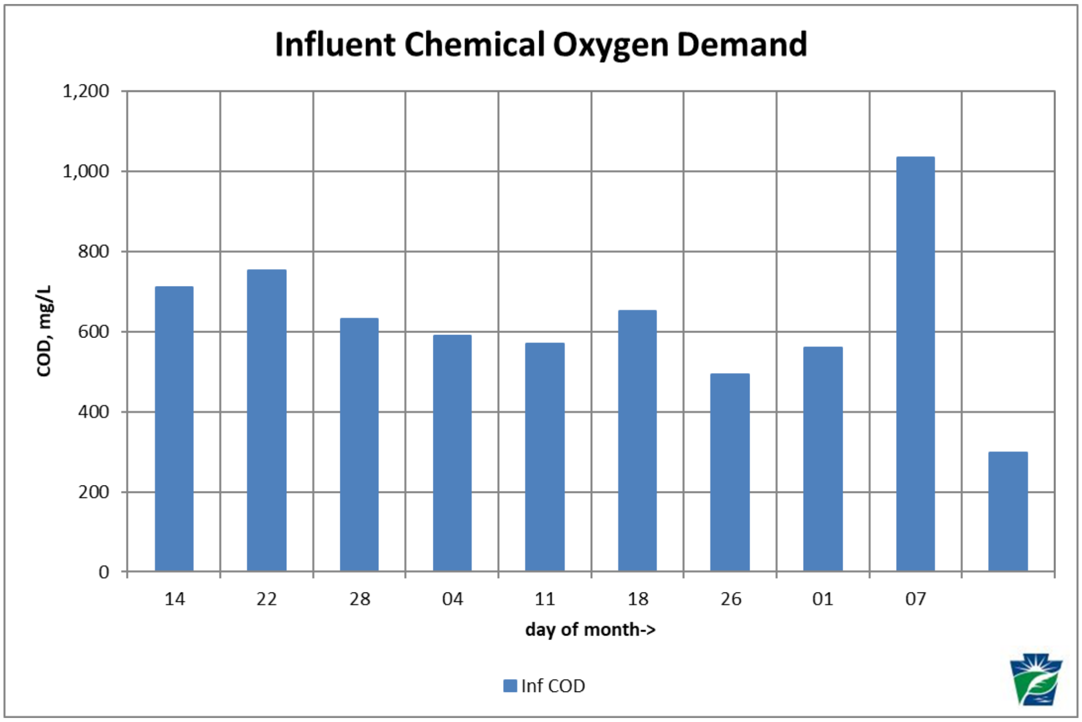
Effluent nitrate is comparatively high because influent ammonia and TKN tend to be high. Effluent ammonia and nitrite values show good, complete nitrification.



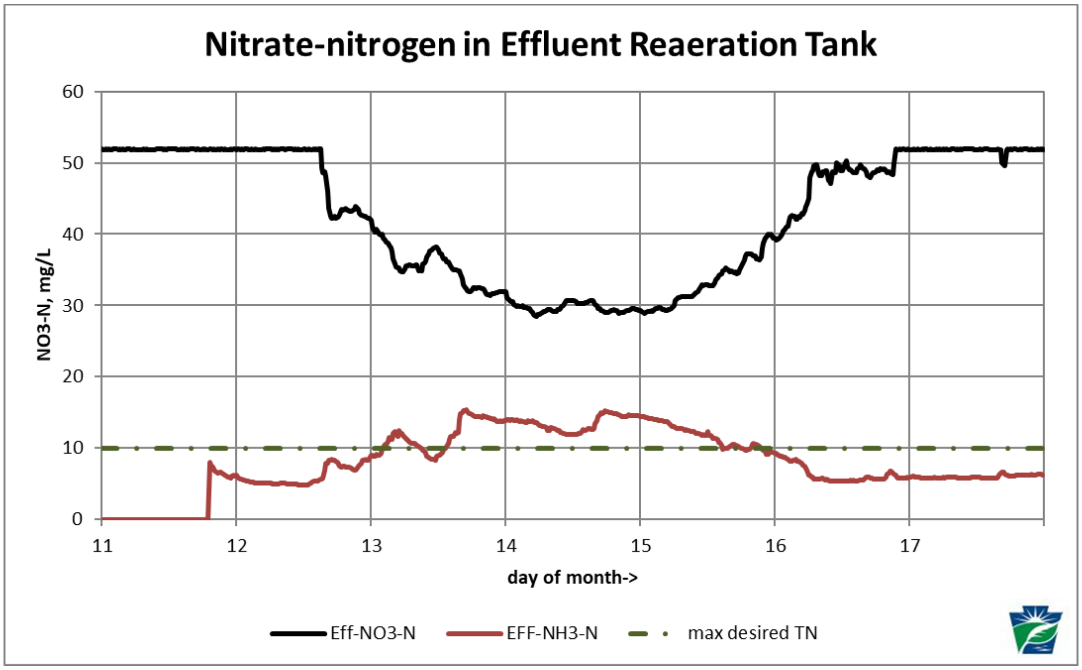
Phosphorus is not treated for removal at this facility. The differences between concentrations of influent and effluent phosphorus usually indicate the amount of phosphorus used by the biomass for metabolic processes.



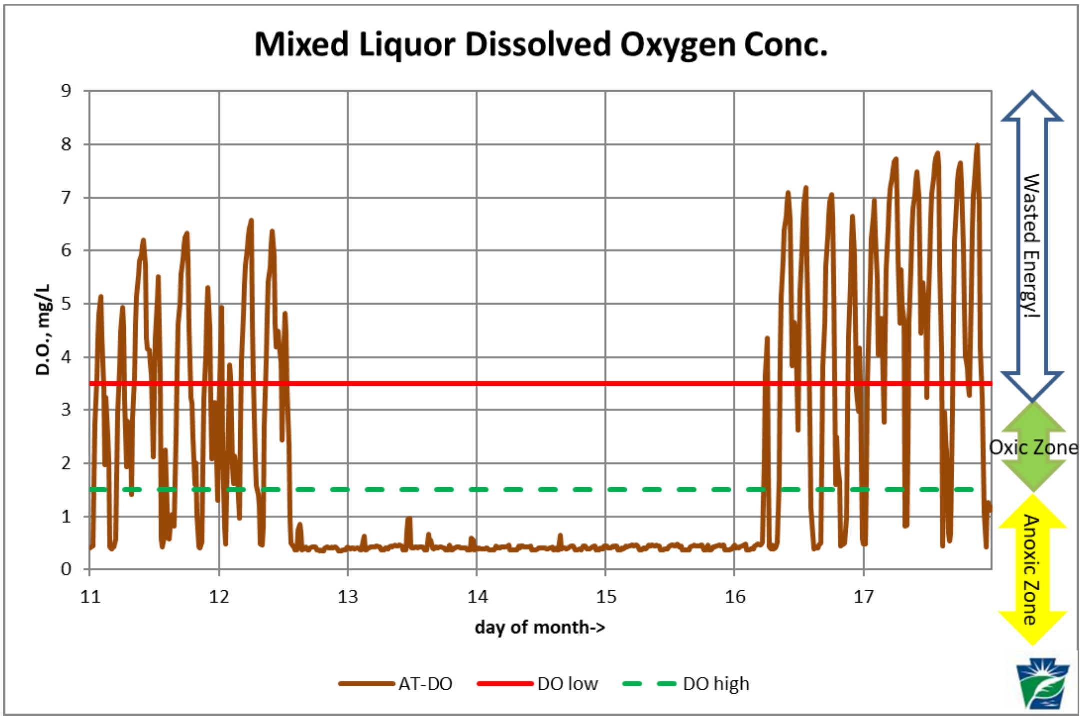
Alkalinity is supplemented using soda ash dosed as a daily bulk load. Attachment I lists a method for "right-sizing" the supplemental alkalinity dose, to prevent wasting money on chemical treatments.



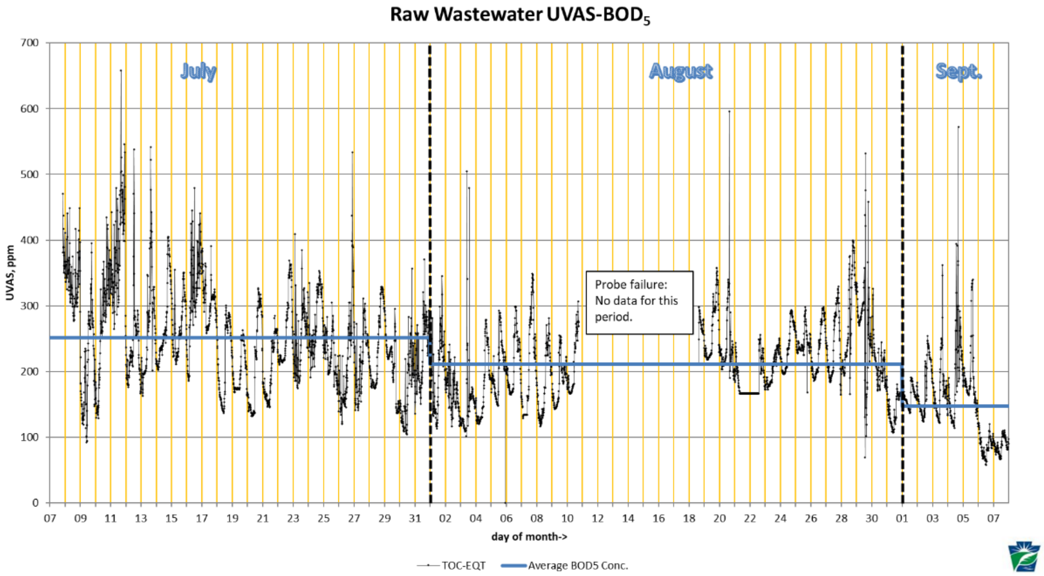
Domestic biochemical oxygen demand concentration is estimated to be fifty percent of chemical oxygen demand. These values were used for calibrating the UVAS probe placed in the surge tank.



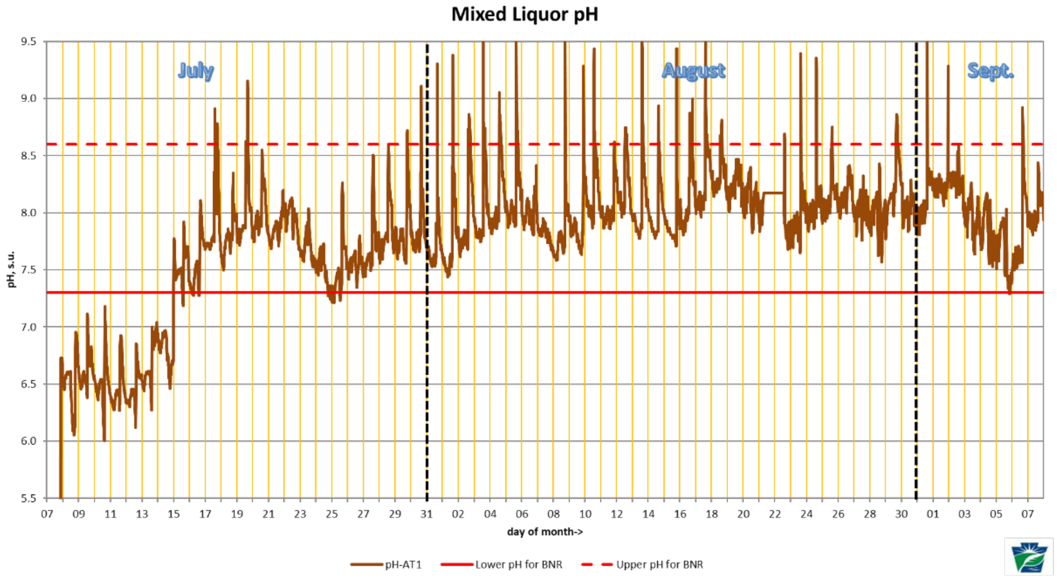
This dip in the nitrate concentration at the clarifier supernatant occurred during a power failure at the facility, where ammonium was not nitrified during an extended period without air. Some denitrification may have occurred, although without the organic carbon loading from influent raw wastewater and the mixing required to maintain bacteria in suspension, any denitrification would have been minimal and short-lived.



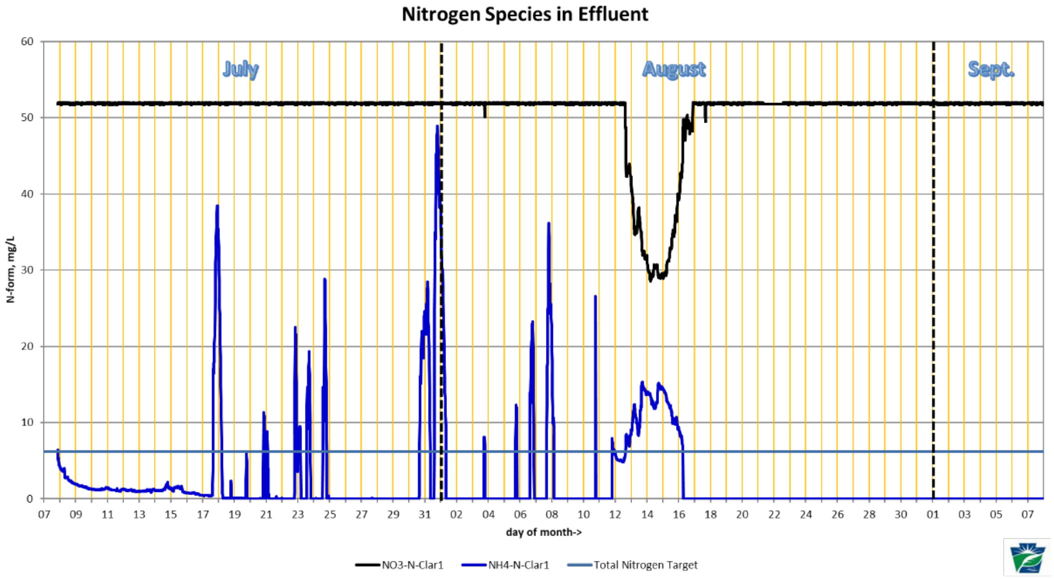
This corresponding graph of MLSS concentration shows the accompanying loss of mixing, and subsequent settling, of biomass during the power failure. When D.O. exceeds 3.5 mg/L concentration, the aeration system is delivering more oxygen than is necessary for nitrification. This may be made more efficient by installing variable frequency drives on the PD blower motors and controlling them through the use D.O. feedback.



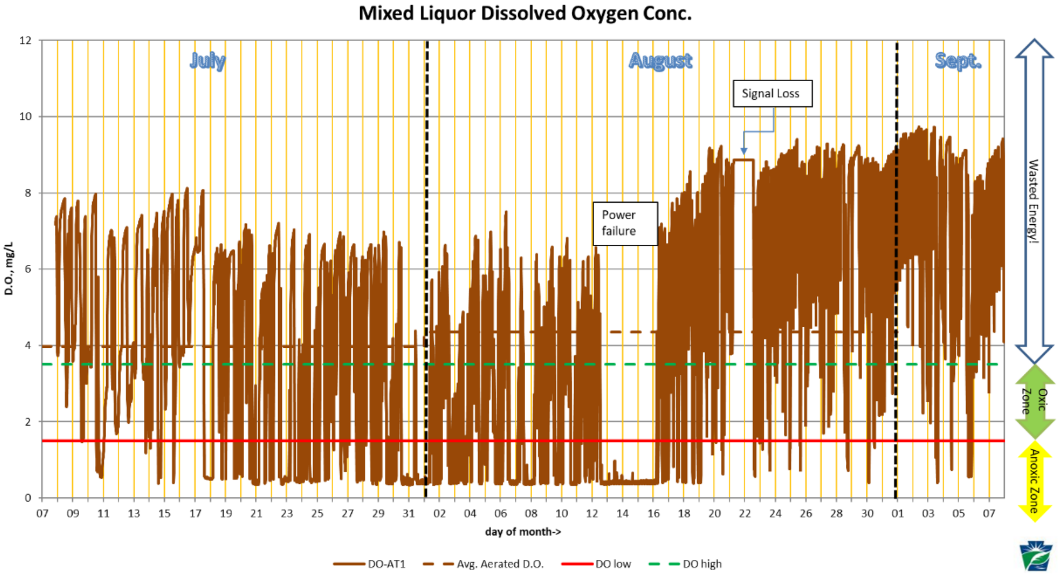
Influent organic concentration: Excessive peaks in the graph are likely caused by trash or detritus obscuring the instrument's lens, because the facility lacks an efficient screening and grit removal process.



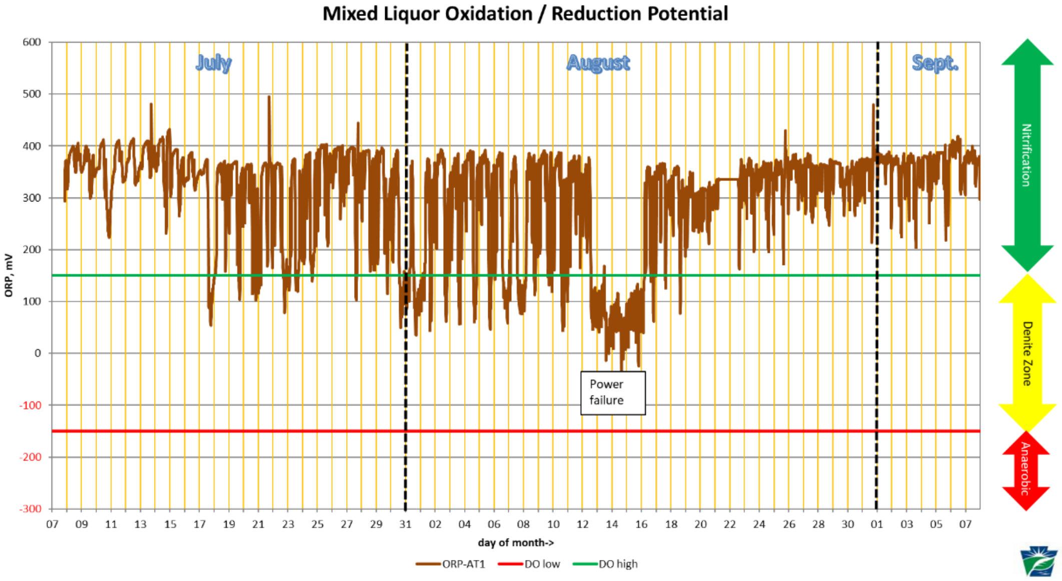
Observed peaks in pH of the mixed liquor occurred when soda ash was delivered in bulk to the aeration tank. These spikes can be problematic if the high pH is sustained; however, there were no adverse effects noted.



This graph depicts the overall recording of ammonium and nitrate during the WTE. Effluent ammonia spikes were likely due to periods of high occupancy at the campground.

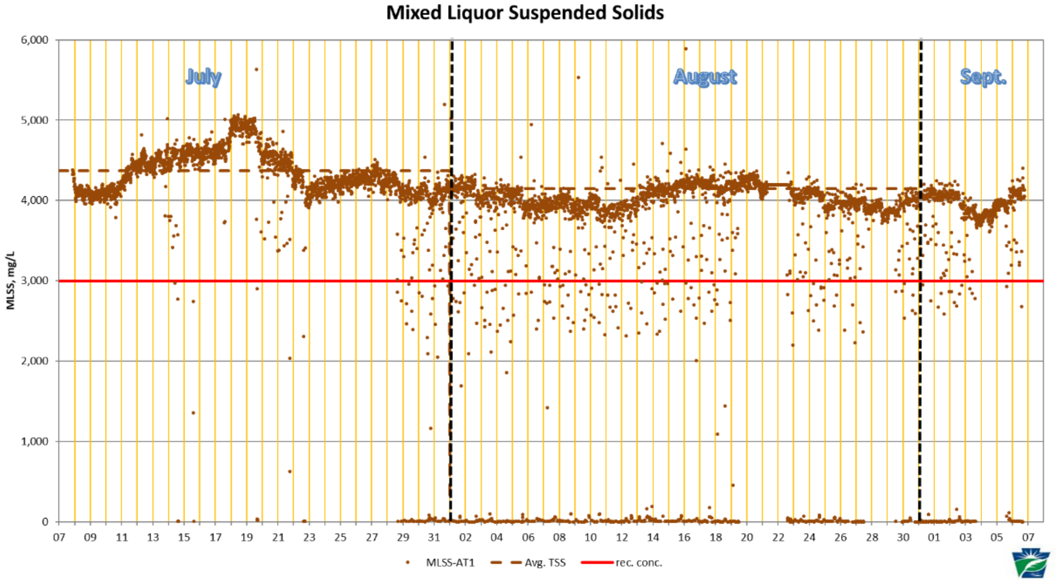


D.O. during nitrification exceeds the amount required by the biomass for effective nitrification. As stated above, this could be remedied by installing controls on the system. Such controls would save on energy costs during aeration, and were intermittent aeration used to promote denitrification in the bioreactor, having the D.O. concentration controlled would permit the bioreactor to achieve anoxic conditions more rapidly, increasing the effectiveness of biological nitrate reduction.



Mixed Liquor Oxidation / Reduction Potential

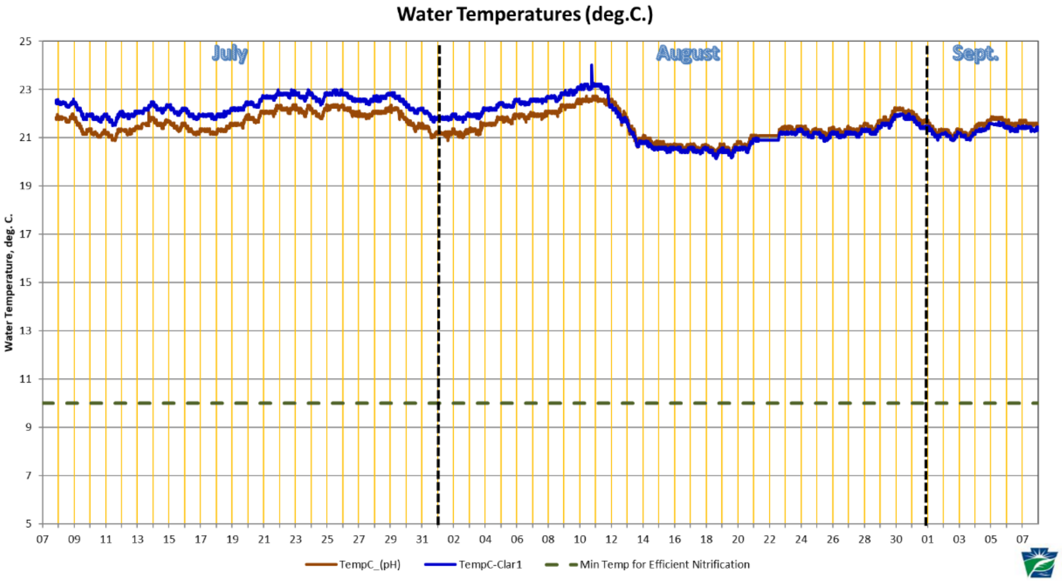
Oxidation / Reduction Potential is used to optimize denitrification in anoxic treatment processes where dissolved oxygen content is expected to be 0.3 mg/L or less. At the Kentuck Campground facility, where nitrification of high concentrations of dissolved ammonia is a priority, experiments for denitrification took reduced priority, so ORP values did not drop into the ideal denitrification zone of 0 mV to -50 mV. The facility, with its most recent upgrade to its aeration diffusers, did provide adequate and successful nitrification as required.



Mixed Liquor Suspended Solids

Mixed liquor suspended solids (MLSS) at Kentuck Campground were more concentrated than what is usually recommended for facilities of this type and size during warm weather months. While the technical assistance program usually recommends summer MLSS concentrations ranging between 1,800 and 2,200 mg/L, the operators of the facility said that their preferred concentration was 3,000 mg/L, noted by the red line.

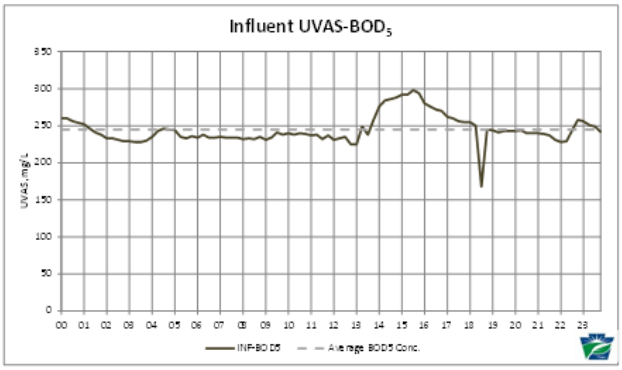
The appearance of data points on the x-axis of the graph represent periods when aeration blowers were turned off in a trial to encourage denitrification. This is “intermittent” or “ON/OFF” aeration, and in facilities where an organic carbon source and anoxic mixing is available, this practice has been very successful in reducing effluent nitrate concentrations to below the drinking water standard of 10 mg/L.

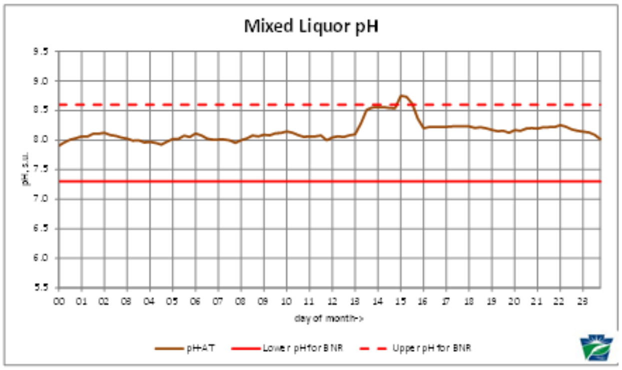


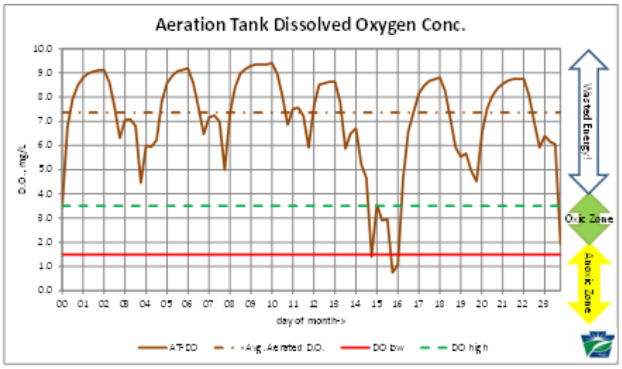
Water temperatures during the evaluation were favorable to rapid metabolism of organic and nitrogenous waste. The dotted line at ten degrees, Celsius, (50° F) represents a point at which nitrification becomes metabolically inefficient.

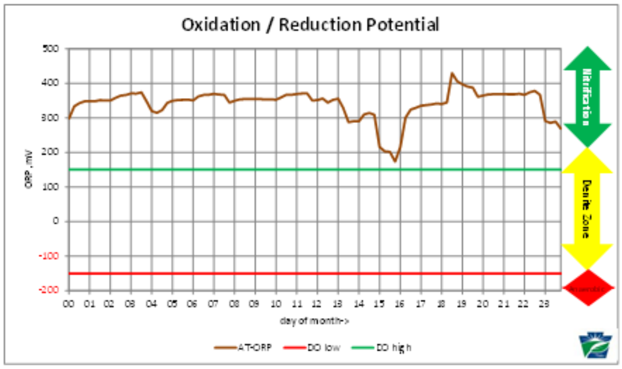
This is a typical display of the daily graphical monitoring of the treatment process during the WTE. Information was provided to the facility operators on a regular basis.

Thursday, August 25, 2022

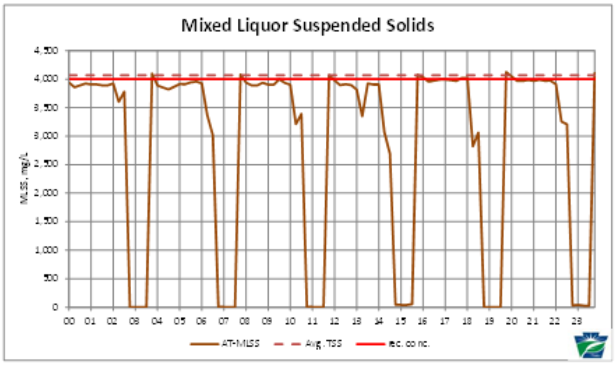

Influent UVAS-BOD$_5$

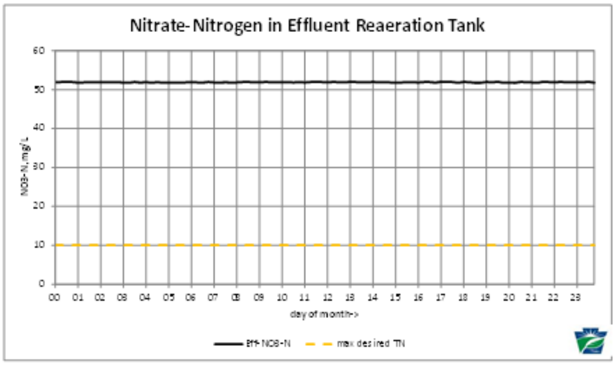

Mixed Liquor pH

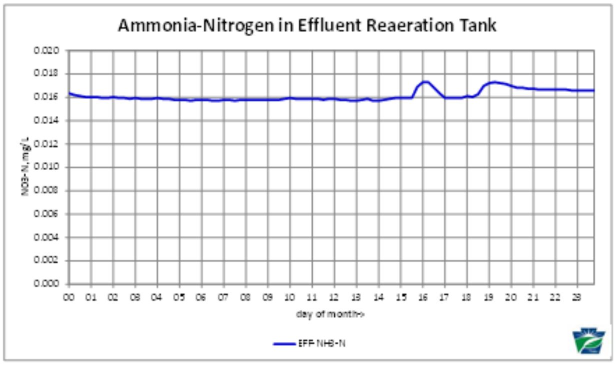

Aeration Tank Dissolved Oxygen Conc.

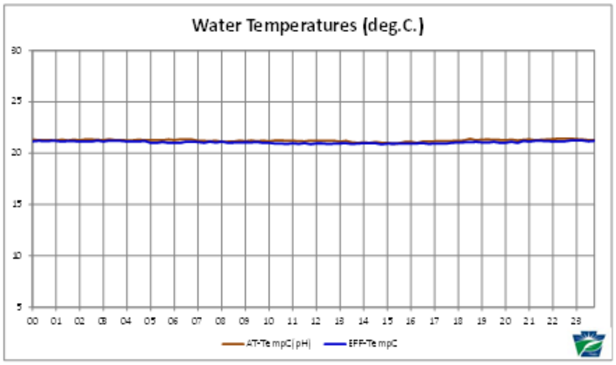

Oxidation / Reduction Potential

Thursday, August 25, 2022


Mixed Liquor Suspended Solids

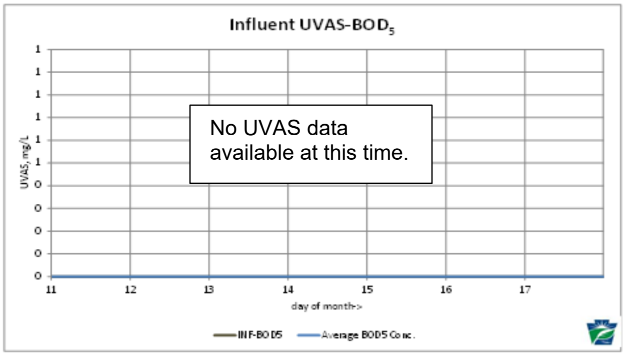

Nitrate-Nitrogen in Effluent Reaeration Tank

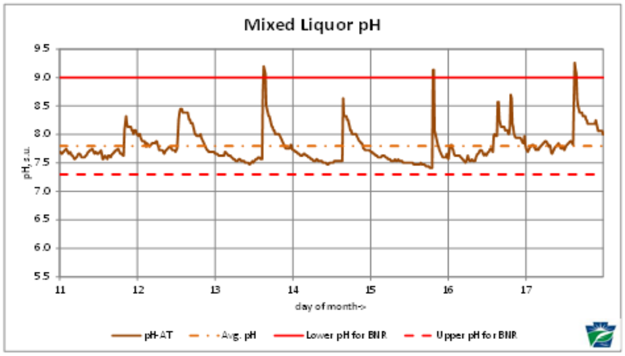

Ammonia-Nitrogen in Effluent Reaeration Tank

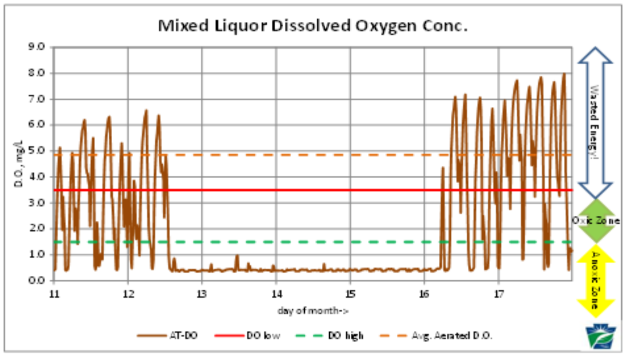

Water Temperatures (deg.C.)

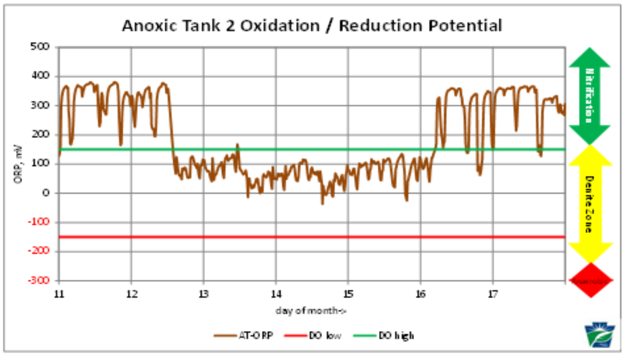
This is an example of the weekly monitoring graphs based on the probe data.

Week of August 11 to 17, 2022

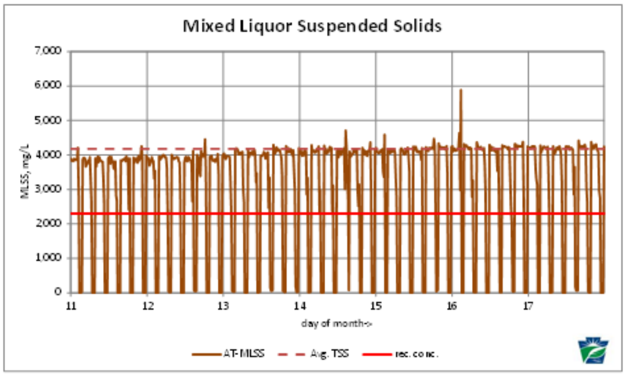


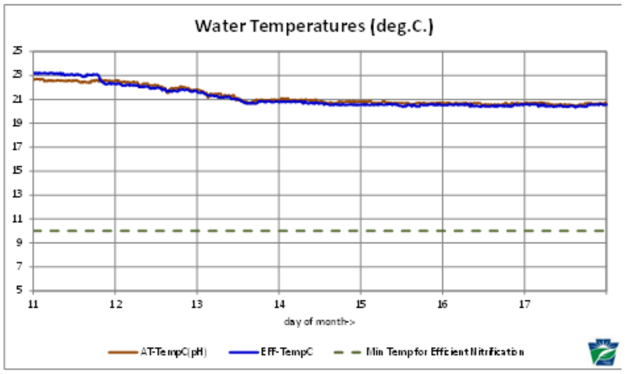


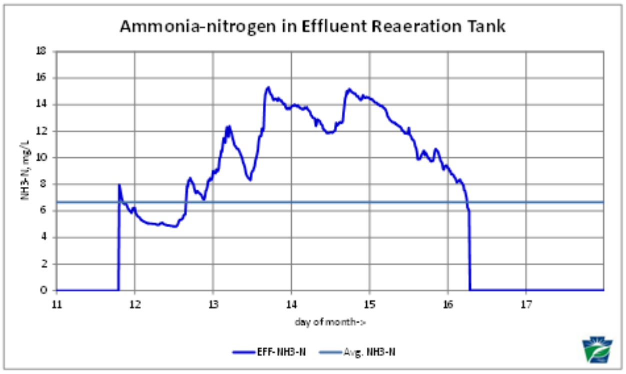


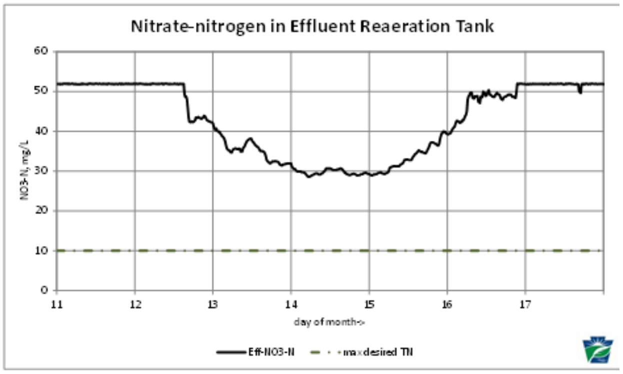


Week of August 11 to 17, 2022

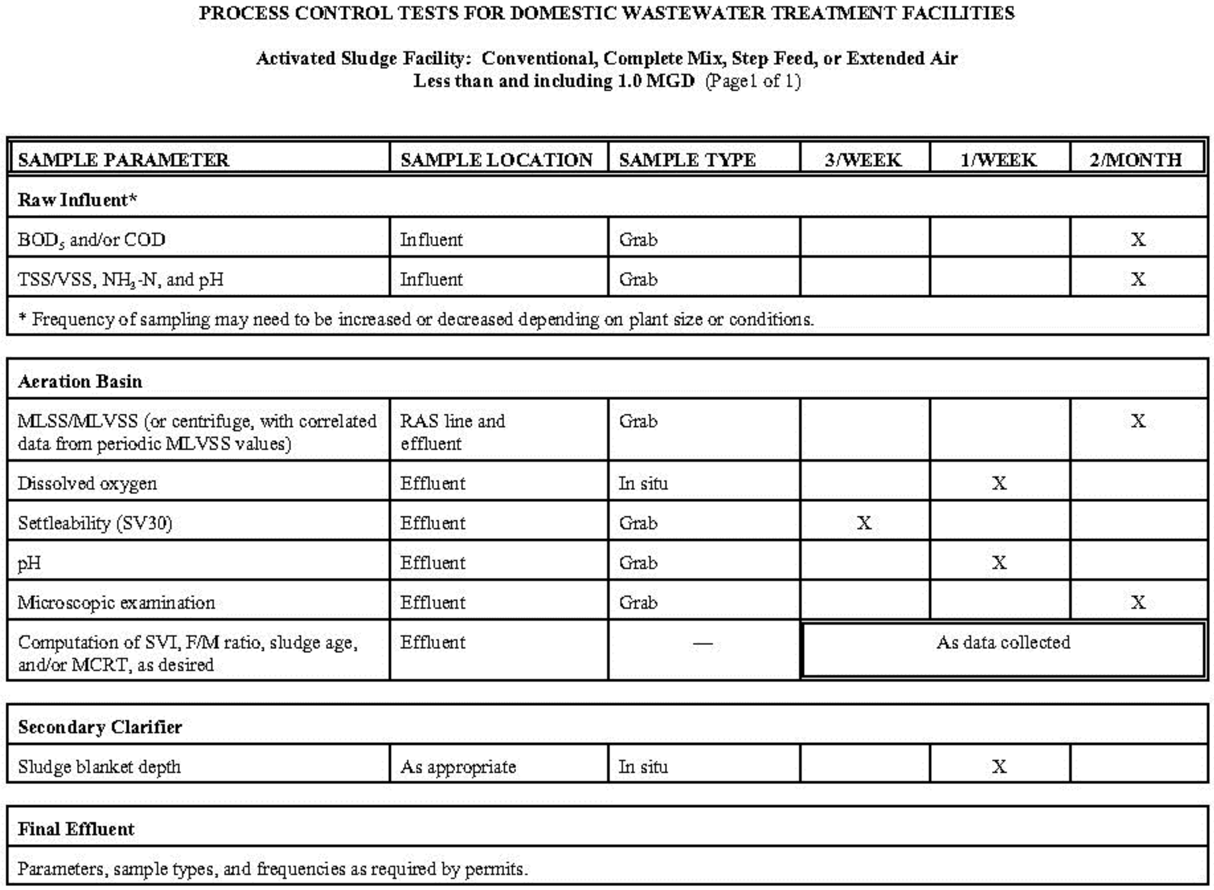








ATTACHMENT E: RECOMMENDED MONITORING TESTS & FREQUENCIES



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.					

Process monitoring is vital to maintaining a well-operated wastewater treatment facility. Engineers design wastewater treatment plants to meet steady-state operating conditions based on constant parameters such as Food-to-Mass ratio, Solids Retention Time, or Cell Residence Time. In the absence of large flow equalization and storage capacity, treatment operators maintain F/M, SRT, or MCRT by controlling the amount of active biosolids available to treat the incoming organic and nitrogenous load. They do this by regulating sludge wasting rates.

Every treatment facility should waste a little bit of its biomass on a consistent schedule. Wasting sludge every day is ideal, but in small package plants this may not always be practical. However, wasting should be done no less than every few days in such facilities, as sludge wasting promotes growth of new microorganisms while removing those that are endogenous.

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 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 facility routinely performs settled sludge volume testing and solids-by-volume centrifuge tests. It is recommended that centrifuge solids tests are done twice weekly at a minimum and backed up with gravimetric solids tests once or twice a month to maintain centrifuge calibration (Weight-to-Concentration Ratio, or WCR.) Microscopy and water chemistry should be done on the mixed liquor weekly until the operators have reasonable understanding of a 4-season set of reference data to which they may refer in future years, after which the testing may be done twice per month. 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. 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 dimensionless “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 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,) 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 developing operations 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 should determine an overall treatment strategy for their facility, using standard industry calculations for:

- 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, where possible, treatment capacity (by adding or subtracting additional treatment units,) assuming that the concentration of waste in the wastewater is a variable that operators cannot control.

ATTACHMENT F: PERMIT LIMITS FOR OHIOPYLE STATE PARK STPs

Kentuck Campground STP: PA0032425

For Outfall 001; Latitude 39º 52' 45", Longitude 79º 29' 32", Stewart Twp., Fayette County
River Mile Index 0.19 Stream Code 38474;
Receiving Waters: Unnamed Tributary to Youghiogheny River; Watershed 19-E

	Mass Units (lb./day) [1]		**Concentrations (mg/L)**				**Minimum [2] Measurement Frequency**	**Required Sample Type**
	Average Monthly	**Average Weekly**	**Minimum**	**Average Monthly**	**Maximum**	**Instant. Maximum**		
Flow (MGD)	**0.04**	XXX	XXX	XXX	XXX	XXX	**2/month**	**Measured**
pH (S.U.) Oct 1 - Apr 30	XXX	XXX	**6.0**	XXX	**9.0**	XXX	**3/week**	**Grab**
pH (S.U.) May 1 - Sep 30	XXX	XXX	**6.0**	XXX	**9.0**	XXX	**1/day**	**Grab**
Dissolved Oxygen Oct 1 - Apr 30	XXX	XXX	**5.0**	XXX	XXX	XXX	**3/week**	**Grab**
Dissolved Oxygen May 1 - Sep 30	XXX	XXX	**5.0**	XXX	XXX	XXX	**1/day**	**Grab**
Total Residual Chlorine (TRC) Oct 1 - Apr 30	XXX	XXX	XXX	**0.01**	XXX	**0.02**	**3/week**	**Grab**
Total Residual Chlorine (TRC) May 1 - Sep 30	XXX	XXX	XXX	**0.01**	XXX	**0.02**	**1/day**	**Grab**
Carbonaceous Biochemical Oxygen Demand (CBOD5)	XXX	XXX	XXX	**10.0**	XXX	**20.0**	**2/month**	**Grab**
Total Suspended Solids	XXX	XXX	XXX	**10.0**	XXX	**20.0**	**2/month**	**Grab**
Fecal Coliform (No./100 ml) Oct 1 - Apr 30	XXX	XXX	XXX	**2,000** Geo Mean	XXX	**10,000**	**2/month**	**Grab**
Fecal Coliform (No./100 ml) May 1 - Sep 30	XXX	XXX	XXX	**200** Geo Mean	XXX	**1,000**	**2/month**	**Grab**
Total Nitrogen	XXX	XXX	XXX	XXX	**Report Daily Max**	XXX	**1/year**	**Grab**
Ammonia-Nitrogen Nov 1 - Apr 30	XXX	XXX	XXX	**2.5**	XXX	**5.0**	**2/month**	**Grab**
Ammonia-Nitrogen May 1 - Oct 31	XXX	XXX	XXX	**1.5**	XXX	**3.0**	**2/month**	**Grab**
Total Phosphorus	XXX	XXX	XXX	XXX	**Report Daily Max**	XXX	**1/year**	**Grab**

Footnotes

(1) When sampling to determine compliance with mass effluent limitations, the discharge flow at the time of sampling must be measured and recorded.

(2) This is the minimum number of sampling events required. Permittees are encouraged, and it may be advantageous in demonstrating compliance, to perform more than the minimum number of sampling events.

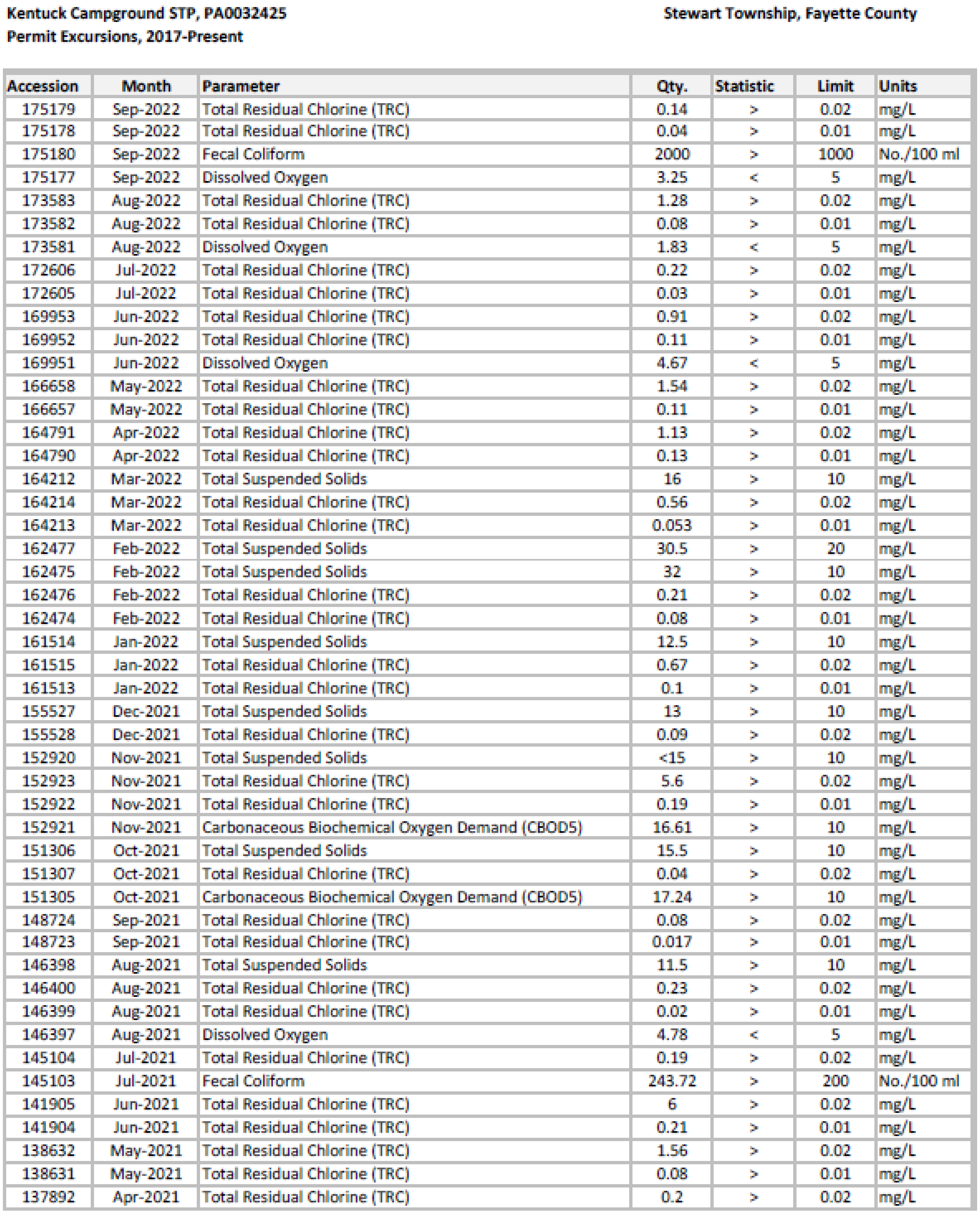
Boaters' Change House STP: PA0096521

For Outfall 001, Latitude 39º 51' 10"; Longitude 79º 30' 6", Stewart Twp., Fayette County
River Mile Index 2.0, Stream Code 38488; Receiving Waters: Meadow Run, Watershed 19-E

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lb./day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Average Weekly	Minimum	Average Monthly	Maximum	Instant. Maximum		
Flow (MGD)	0.01	XXX	XXX	XXX	XXX	XXX	2/month	Measured
pH (S.U.) Oct 1 - Apr 30	XXX	XXX	6.0	XXX	9.0	XXX	3/week	Grab
pH (S.U.) May 1 - Sep 30	XXX	XXX	6.0	XXX	9.0	XXX	1/day	Grab
Dissolved Oxygen Oct 1 - Apr 30	XXX	XXX	4.0	XXX	XXX	XXX	3/week	Grab
Dissolved Oxygen May 1 - Sep 30	XXX	XXX	4.0	XXX	XXX	XXX	1/day	Grab
Total Residual Chlorine (TRC) Oct 1 - Apr 30	XXX	XXX	XXX	0.5	XXX	1.6	3/week	Grab
Total Residual Chlorine (TRC) May 1 - Sep 30	XXX	XXX	XXX	0.5	XXX	1.6	1/day	Grab
Carbonaceous Biochemical Oxygen Demand (CBOD5)	XXX	XXX	XXX	15.0	XXX	30.0	2/month	Grab
Total Suspended Solids	XXX	XXX	XXX	10.0	XXX	20.0	2/month	Grab
Fecal Coliform (No./100 ml) Oct 1 - Apr 30	XXX	XXX	XXX	2,000 Geo Mean	XXX	10,000	2/month	Grab
Fecal Coliform (No./100 ml) May 1 - Sep 30	XXX	XXX	XXX	200 Geo Mean	XXX	1,000	2/month	Grab
Total Nitrogen	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	Grab
Ammonia-Nitrogen Nov 1 - Apr 30	XXX	XXX	XXX	4.5	XXX	9.0	2/month	Grab
Ammonia-Nitrogen May 1 - Oct 31	XXX	XXX	XXX	1.5	XXX	3.0	2/month	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report Daily Max	XXX	1/year	Grab

ATTACHMENT G: PERMIT EXCURSION HISTORY FOR CAMPGROUND STP

(Excludes administrative excursions)



Kentuck Campground STP, PA0032425 **Stewart Township, Fayette County**

Permit Excursions, 2017-Present

Accession	Month	Parameter	Qty.	Statistic	Limit	Units
175179	Sep-2022	Total Residual Chlorine (TRC)	0.14	>	0.02	mg/L
175178	Sep-2022	Total Residual Chlorine (TRC)	0.04	>	0.01	mg/L
175180	Sep-2022	Fecal Coliform	2000	>	1000	No./100 ml
175177	Sep-2022	Dissolved Oxygen	3.25	<	5	mg/L
173583	Aug-2022	Total Residual Chlorine (TRC)	1.28	>	0.02	mg/L
173582	Aug-2022	Total Residual Chlorine (TRC)	0.08	>	0.01	mg/L
173581	Aug-2022	Dissolved Oxygen	1.83	<	5	mg/L
172606	Jul-2022	Total Residual Chlorine (TRC)	0.22	>	0.02	mg/L
172605	Jul-2022	Total Residual Chlorine (TRC)	0.03	>	0.01	mg/L
169953	Jun-2022	Total Residual Chlorine (TRC)	0.91	>	0.02	mg/L
169952	Jun-2022	Total Residual Chlorine (TRC)	0.11	>	0.01	mg/L
169951	Jun-2022	Dissolved Oxygen	4.67	<	5	mg/L
166658	May-2022	Total Residual Chlorine (TRC)	1.54	>	0.02	mg/L
166657	May-2022	Total Residual Chlorine (TRC)	0.11	>	0.01	mg/L
164791	Apr-2022	Total Residual Chlorine (TRC)	1.13	>	0.02	mg/L
164790	Apr-2022	Total Residual Chlorine (TRC)	0.13	>	0.01	mg/L
164212	Mar-2022	Total Suspended Solids	16	>	10	mg/L
164214	Mar-2022	Total Residual Chlorine (TRC)	0.56	>	0.02	mg/L
164213	Mar-2022	Total Residual Chlorine (TRC)	0.053	>	0.01	mg/L
162477	Feb-2022	Total Suspended Solids	30.5	>	20	mg/L
162475	Feb-2022	Total Suspended Solids	32	>	10	mg/L
162476	Feb-2022	Total Residual Chlorine (TRC)	0.21	>	0.02	mg/L
162474	Feb-2022	Total Residual Chlorine (TRC)	0.08	>	0.01	mg/L
161514	Jan-2022	Total Suspended Solids	12.5	>	10	mg/L
161515	Jan-2022	Total Residual Chlorine (TRC)	0.67	>	0.02	mg/L
161513	Jan-2022	Total Residual Chlorine (TRC)	0.1	>	0.01	mg/L
155527	Dec-2021	Total Suspended Solids	13	>	10	mg/L
155528	Dec-2021	Total Residual Chlorine (TRC)	0.09	>	0.02	mg/L
152920	Nov-2021	Total Suspended Solids	<15	>	10	mg/L
152923	Nov-2021	Total Residual Chlorine (TRC)	5.6	>	0.02	mg/L
152922	Nov-2021	Total Residual Chlorine (TRC)	0.19	>	0.01	mg/L
152921	Nov-2021	Carbonaceous Biochemical Oxygen Demand (CBOD5)	16.61	>	10	mg/L
151306	Oct-2021	Total Suspended Solids	15.5	>	10	mg/L
151307	Oct-2021	Total Residual Chlorine (TRC)	0.04	>	0.02	mg/L
151305	Oct-2021	Carbonaceous Biochemical Oxygen Demand (CBOD5)	17.24	>	10	mg/L
148724	Sep-2021	Total Residual Chlorine (TRC)	0.08	>	0.02	mg/L
148723	Sep-2021	Total Residual Chlorine (TRC)	0.017	>	0.01	mg/L
146398	Aug-2021	Total Suspended Solids	11.5	>	10	mg/L
146400	Aug-2021	Total Residual Chlorine (TRC)	0.23	>	0.02	mg/L
146399	Aug-2021	Total Residual Chlorine (TRC)	0.02	>	0.01	mg/L
146397	Aug-2021	Dissolved Oxygen	4.78	<	5	mg/L
145104	Jul-2021	Total Residual Chlorine (TRC)	0.19	>	0.02	mg/L
145103	Jul-2021	Fecal Coliform	243.72	>	200	No./100 ml
141905	Jun-2021	Total Residual Chlorine (TRC)	6	>	0.02	mg/L
141904	Jun-2021	Total Residual Chlorine (TRC)	0.21	>	0.01	mg/L
138632	May-2021	Total Residual Chlorine (TRC)	1.56	>	0.02	mg/L
138631	May-2021	Total Residual Chlorine (TRC)	0.08	>	0.01	mg/L
137892	Apr-2021	Total Residual Chlorine (TRC)	0.2	>	0.02	mg/L

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Accession	Month	Parameter	Qty.	Statistic	Limit	Units
137891	Apr-2021	Total Residual Chlorine (TRC)	0.033	>	0.01	mg/L
136331	Mar-2021	Total Suspended Solids	21	>	20	mg/L
136329	Mar-2021	Total Suspended Solids	18.5	>	10	mg/L
136330	Mar-2021	Total Residual Chlorine (TRC)	0.08	>	0.02	mg/L
134040	Feb-2021	Total Suspended Solids	55	>	20	mg/L
134039	Feb-2021	Total Suspended Solids	47	>	10	mg/L
134038	Feb-2021	pH	3.8	<	6	S.U.
132317	Jan-2021	Total Suspended Solids	23	>	20	mg/L
132315	Jan-2021	Total Suspended Solids	23	>	10	mg/L
132316	Jan-2021	Total Residual Chlorine (TRC)	0.41	>	0.02	mg/L
132314	Jan-2021	Total Residual Chlorine (TRC)	0.04	>	0.01	mg/L
128852	Dec-2020	Total Residual Chlorine (TRC)	0.23	>	0.02	mg/L
128851	Dec-2020	Total Residual Chlorine (TRC)	0.03	>	0.01	mg/L
126709	Nov-2020	Total Residual Chlorine (TRC)	0.06	>	0.02	mg/L
125604	Oct-2020	Total Residual Chlorine (TRC)	1.07	>	0.02	mg/L
125603	Oct-2020	Total Residual Chlorine (TRC)	0.15	>	0.01	mg/L
124332	Sep-2020	Total Suspended Solids	16.5	>	10	mg/L
124335	Sep-2020	Total Residual Chlorine (TRC)	1.14	>	0.02	mg/L
124333	Sep-2020	Total Residual Chlorine (TRC)	0.11	>	0.01	mg/L
124330	Sep-2020	Dissolved Oxygen	4.7	<	5	mg/L
124334	Sep-2020	Ammonia-Nitrogen	3.7	>	3	mg/L
124331	Sep-2020	Ammonia-Nitrogen	2	>	1.5	mg/L
121796	Aug-2020	Total Residual Chlorine (TRC)	1.6	>	0.02	mg/L
121794	Aug-2020	Total Residual Chlorine (TRC)	0.08	>	0.01	mg/L
121795	Aug-2020	Fecal Coliform	225	>	200	No./100 ml
120105	Jul-2020	Total Residual Chlorine (TRC)	1.22	>	0.02	mg/L
120103	Jul-2020	Total Residual Chlorine (TRC)	0.06	>	0.01	mg/L
120104	Jul-2020	Fecal Coliform	607	>	200	No./100 ml
117704	Jun-2020	Total Suspended Solids	14	>	10	mg/L
117707	Jun-2020	Total Residual Chlorine (TRC)	7.6	>	0.02	mg/L
117706	Jun-2020	Total Residual Chlorine (TRC)	0.28	>	0.01	mg/L
117705	Jun-2020	Fecal Coliform	386	>	200	No./100 ml
114302	May-2020	Total Residual Chlorine (TRC)	3.7	>	0.02	mg/L
114301	May-2020	Total Residual Chlorine (TRC)	0.33	>	0.01	mg/L
113018	Apr-2020	Total Suspended Solids	13	>	10	mg/L
113020	Apr-2020	Total Residual Chlorine (TRC)	8.8	>	0.02	mg/L
113019	Apr-2020	Total Residual Chlorine (TRC)	0.72	>	0.01	mg/L
111547	Mar-2020	Total Residual Chlorine (TRC)	0.59	>	0.02	mg/L
111546	Mar-2020	Total Residual Chlorine (TRC)	0.1	>	0.01	mg/L
109608	Feb-2020	Total Residual Chlorine (TRC)	1.52	>	0.02	mg/L
109607	Feb-2020	Total Residual Chlorine (TRC)	0.22	>	0.01	mg/L
107565	Jan-2020	Total Residual Chlorine (TRC)	0.32	>	0.02	mg/L
107564	Jan-2020	Total Residual Chlorine (TRC)	0.05	>	0.01	mg/L
104793	Dec-2019	Total Residual Chlorine (TRC)	2.2	>	0.02	mg/L
104792	Dec-2019	Total Residual Chlorine (TRC)	0.21	>	0.01	mg/L
102725	Nov-2019	Total Residual Chlorine (TRC)	<8.8	>	0.02	mg/L
102724	Nov-2019	Total Residual Chlorine (TRC)	<1.21	>	0.01	mg/L
101563	Oct-2019	Total Residual Chlorine (TRC)	0.18	>	0.02	mg/L

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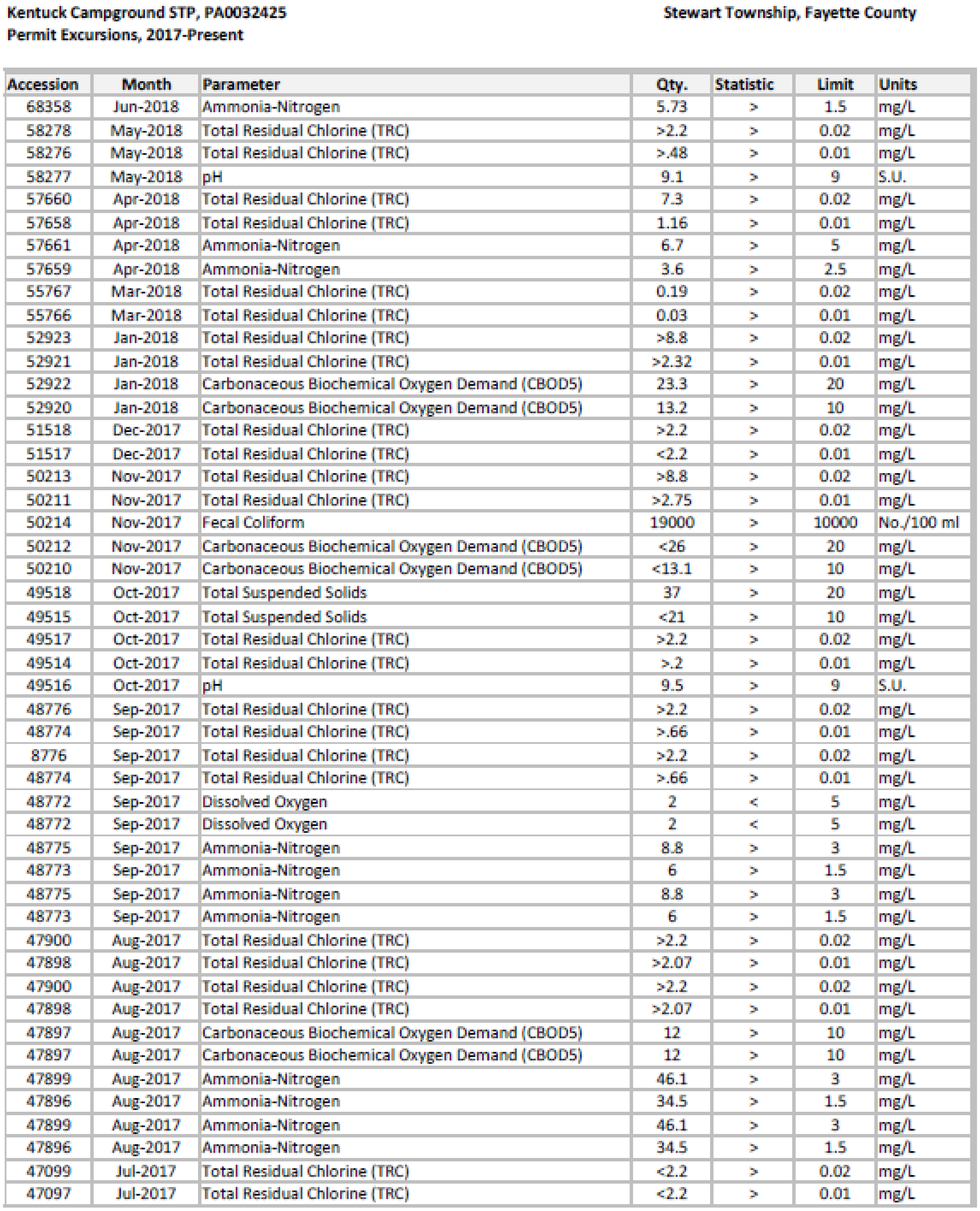
Accession	Month	Parameter	Qty.	Statistic	Limit	Units
101562	Oct-2019	Total Residual Chlorine (TRC)	0.04	>	0.01	mg/L
99792	Sep-2019	Total Residual Chlorine (TRC)	2.2	>	0.02	mg/L
99791	Sep-2019	Total Residual Chlorine (TRC)	0.13	>	0.01	mg/L
99790	Sep-2019	Fecal Coliform	435	>	200	No./100 ml
97403	Aug-2019	Total Residual Chlorine (TRC)	2.2	>	0.02	mg/L
97401	Aug-2019	Total Residual Chlorine (TRC)	0.22	>	0.01	mg/L
97404	Aug-2019	Fecal Coliform	3700	>	1000	No./100 ml
97402	Aug-2019	Ammonia-Nitrogen	15.1	>	3	mg/L
97400	Aug-2019	Ammonia-Nitrogen	8	>	1.5	mg/L
95963	Jul-2019	Total Residual Chlorine (TRC)	8.8	>	0.02	mg/L
95961	Jul-2019	Total Residual Chlorine (TRC)	1.48	>	0.01	mg/L
95964	Jul-2019	Ammonia-Nitrogen	21	>	3	mg/L
95962	Jul-2019	Ammonia-Nitrogen	20.4	>	1.5	mg/L
93515	Jun-2019	Total Suspended Solids	11	>	10	mg/L
93518	Jun-2019	Total Residual Chlorine (TRC)	8.8	>	0.02	mg/L
93516	Jun-2019	Total Residual Chlorine (TRC)	1.02	>	0.01	mg/L
93513	Jun-2019	Dissolved Oxygen	4.1	<	5	mg/L
93517	Jun-2019	Ammonia-Nitrogen	11.6	>	3	mg/L
93514	Jun-2019	Ammonia-Nitrogen	11	>	1.5	mg/L
90186	May-2019	Total Residual Chlorine (TRC)	8.8	>	0.02	mg/L
90183	May-2019	Total Residual Chlorine (TRC)	1.45	>	0.01	mg/L
90185	May-2019	Ammonia-Nitrogen	6.4	>	3	mg/L
90184	May-2019	Ammonia-Nitrogen	3.2	>	1.5	mg/L
88184	Apr-2019	Total Suspended Solids	12.5	>	10	mg/L
88187	Apr-2019	Total Residual Chlorine (TRC)	1.78	>	0.02	mg/L
88185	Apr-2019	Total Residual Chlorine (TRC)	0.29	>	0.01	mg/L
88186	Apr-2019	pH	9.4	>	9	S.U.
85751	Mar-2019	Total Suspended Solids	16	>	10	mg/L
85753	Mar-2019	Total Residual Chlorine (TRC)	0.4	>	0.02	mg/L
85752	Mar-2019	Total Residual Chlorine (TRC)	0.06	>	0.01	mg/L
84387	Feb-2019	Total Suspended Solids	21	>	20	mg/L
84385	Feb-2019	Total Suspended Solids	21	>	10	mg/L
84388	Feb-2019	Total Residual Chlorine (TRC)	0.87	>	0.02	mg/L
84386	Feb-2019	Total Residual Chlorine (TRC)	0.45	>	0.01	mg/L
83054	Jan-2019	Total Suspended Solids	22	>	20	mg/L
83052	Jan-2019	Total Suspended Solids	20.5	>	10	mg/L
83055	Jan-2019	Total Residual Chlorine (TRC)	6.63	>	0.02	mg/L
83053	Jan-2019	Total Residual Chlorine (TRC)	2.55	>	0.01	mg/L
78132	Nov-2018	Total Residual Chlorine (TRC)	2.05	>	0.02	mg/L
78131	Nov-2018	Total Residual Chlorine (TRC)	0.16	>	0.01	mg/L
72949	Sep-2018	Total Residual Chlorine (TRC)	0.72	>	0.02	mg/L
72947	Sep-2018	Fecal Coliform	5900	>	1000	No./100 ml
72946	Sep-2018	Fecal Coliform	3840	>	200	No./100 ml
72948	Sep-2018	Ammonia-Nitrogen	17.7	>	3	mg/L
70568	Jul-2018	Total Residual Chlorine (TRC)	>.49	>	0.01	mg/L
68361	Jun-2018	Total Residual Chlorine (TRC)	2.16	>	0.02	mg/L
68359	Jun-2018	Total Residual Chlorine (TRC)	0.26	>	0.01	mg/L
68360	Jun-2018	Ammonia-Nitrogen	11.16	>	3	mg/L



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Accession	Month	Parameter	Qty.	Statistic	Limit	Units
68358	Jun-2018	Ammonia-Nitrogen	5.73	>	1.5	mg/L
58278	May-2018	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
58276	May-2018	Total Residual Chlorine (TRC)	>.48	>	0.01	mg/L
58277	May-2018	pH	9.1	>	9	S.U.
57660	Apr-2018	Total Residual Chlorine (TRC)	7.3	>	0.02	mg/L
57658	Apr-2018	Total Residual Chlorine (TRC)	1.16	>	0.01	mg/L
57661	Apr-2018	Ammonia-Nitrogen	6.7	>	5	mg/L
57659	Apr-2018	Ammonia-Nitrogen	3.6	>	2.5	mg/L
55767	Mar-2018	Total Residual Chlorine (TRC)	0.19	>	0.02	mg/L
55766	Mar-2018	Total Residual Chlorine (TRC)	0.03	>	0.01	mg/L
52923	Jan-2018	Total Residual Chlorine (TRC)	>8.8	>	0.02	mg/L
52921	Jan-2018	Total Residual Chlorine (TRC)	>2.32	>	0.01	mg/L
52922	Jan-2018	Carbonaceous Biochemical Oxygen Demand (CBOD5)	23.3	>	20	mg/L
52920	Jan-2018	Carbonaceous Biochemical Oxygen Demand (CBOD5)	13.2	>	10	mg/L
51518	Dec-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
51517	Dec-2017	Total Residual Chlorine (TRC)	<2.2	>	0.01	mg/L
50213	Nov-2017	Total Residual Chlorine (TRC)	>8.8	>	0.02	mg/L
50211	Nov-2017	Total Residual Chlorine (TRC)	>2.75	>	0.01	mg/L
50214	Nov-2017	Fecal Coliform	19000	>	10000	No./100 ml
50212	Nov-2017	Carbonaceous Biochemical Oxygen Demand (CBOD5)	<26	>	20	mg/L
50210	Nov-2017	Carbonaceous Biochemical Oxygen Demand (CBOD5)	<13.1	>	10	mg/L
49518	Oct-2017	Total Suspended Solids	37	>	20	mg/L
49515	Oct-2017	Total Suspended Solids	<21	>	10	mg/L
49517	Oct-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
49514	Oct-2017	Total Residual Chlorine (TRC)	>.2	>	0.01	mg/L
49516	Oct-2017	pH	9.5	>	9	S.U.
48776	Sep-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
48774	Sep-2017	Total Residual Chlorine (TRC)	>.66	>	0.01	mg/L
8776	Sep-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
48774	Sep-2017	Total Residual Chlorine (TRC)	>.66	>	0.01	mg/L
48772	Sep-2017	Dissolved Oxygen	2	<	5	mg/L
48772	Sep-2017	Dissolved Oxygen	2	<	5	mg/L
48775	Sep-2017	Ammonia-Nitrogen	8.8	>	3	mg/L
48773	Sep-2017	Ammonia-Nitrogen	6	>	1.5	mg/L
48775	Sep-2017	Ammonia-Nitrogen	8.8	>	3	mg/L
48773	Sep-2017	Ammonia-Nitrogen	6	>	1.5	mg/L
47900	Aug-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
47898	Aug-2017	Total Residual Chlorine (TRC)	>2.07	>	0.01	mg/L
47900	Aug-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
47898	Aug-2017	Total Residual Chlorine (TRC)	>2.07	>	0.01	mg/L
47897	Aug-2017	Carbonaceous Biochemical Oxygen Demand (CBOD5)	12	>	10	mg/L
47897	Aug-2017	Carbonaceous Biochemical Oxygen Demand (CBOD5)	12	>	10	mg/L
47899	Aug-2017	Ammonia-Nitrogen	46.1	>	3	mg/L
47896	Aug-2017	Ammonia-Nitrogen	34.5	>	1.5	mg/L
47899	Aug-2017	Ammonia-Nitrogen	46.1	>	3	mg/L
47896	Aug-2017	Ammonia-Nitrogen	34.5	>	1.5	mg/L
47099	Jul-2017	Total Residual Chlorine (TRC)	<2.2	>	0.02	mg/L
47097	Jul-2017	Total Residual Chlorine (TRC)	<2.2	>	0.01	mg/L

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47100	Jul-2017	Ammonia-Nitrogen	17.2	>	3	mg/L
47098	Jul-2017	Ammonia-Nitrogen	13.3	>	1.5	mg/L
45741	Jun-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
45738	Jun-2017	Total Residual Chlorine (TRC)	>1.5	>	0.01	mg/L
45740	Jun-2017	Carbonaceous Biochemical Oxygen Demand (CBOD5)	14	>	10	mg/L
45742	Jun-2017	Ammonia-Nitrogen	30.8	>	3	mg/L
45739	Jun-2017	Ammonia-Nitrogen	21.2	>	1.5	mg/L
43588	May-2017	Total Residual Chlorine (TRC)	>2.2	>	0.02	mg/L
43587	May-2017	Total Residual Chlorine (TRC)	>2.11	>	0.01	mg/L
42639	Apr-2017	Total Residual Chlorine (TRC)	1.63	>	0.02	mg/L
42638	Apr-2017	Total Residual Chlorine (TRC)	0.4	>	0.01	mg/L
42640	Apr-2017	Ammonia-Nitrogen	6.3	>	5	mg/L
42637	Apr-2017	Ammonia-Nitrogen	3.8	>	2.5	mg/L
41547	Mar-2017	Total Residual Chlorine (TRC)	0.19	>	0.02	mg/L
40702	Feb-2017	Total Suspended Solids	55	>	20	mg/L
40701	Feb-2017	Total Suspended Solids	45	>	10	mg/L
39647	Jan-2017	Total Suspended Solids	27	>	20	mg/L
39646	Jan-2017	Total Suspended Solids	21	>	10	mg/L

Complaints

Accession	Month	Parameter	Qty.	Statistic	Limit	Units
72937	Sep-2018	Ammonia-Nitrogen	0.91	>	0.02	mg/L
72933	Sep-2018	Ammonia-Nitrogen	0.11	>	0.01	mg/L
169931	Jun-2022	Dissolved Oxygen	4.67	<	5	mg/L
72938	Sep-2018	Fecal Coliform	32	>	20	mg/L
72936	Sep-2018	Fecal Coliform	0.21	>	0.02	mg/L
169933	Jun-2022	Total Residual Chlorine (TRC)	32	>	10	mg/L
169932	Jun-2022	Total Residual Chlorine (TRC)	0.08	>	0.01	mg/L
162419	Feb-2022	Total Residual Chlorine (TRC)	0.67	>	0.02	mg/L
162417	Feb-2022	Total Residual Chlorine (TRC)	0.1	>	0.01	mg/L
159587	Jan-2022	Total Residual Chlorine (TRC)	0.72	>	0.02	mg/L
159586	Jan-2022	Total Residual Chlorine (TRC)	5900	>	1000	No./100 ml
72939	Sep-2018	Total Residual Chlorine (TRC)	17.7	>	3	mg/L
72935	Sep-2018	Total Residual Chlorine (TRC)	3840	>	200	No./100 ml
162420	Feb-2022	Total Suspended Solids	0.05	>	0.01	mg/L
162418	Feb-2022	Total Suspended Solids	11.5	>	10	mg/L
72934	Sep-2018	Total Suspended Solids	12.4	>	1.5	mg/L

ATTACHMENT H: DISCUSSION OF BIOLOGICAL NUTRIENT REMOVAL (BNR)

Why Nitrate in the Effluent is a Concern:

Dissolved nutrients in treated wastewater effluents create both environmental and health concerns. They cause over-fertilization of algae and plant growth that sets up a cycle of excessive growth followed by eutrophication and decay. The excessive growth robs the natural environment of its capacity to support local biota that are the source of food for aquatic organisms and displaces native plant species. Once eutrophication has been established, large algal die-offs result in decay that robs the aquatic environment of dissolved oxygen, causing entire aquatic populations to suffer and die. This degrades water quality for higher uses, as well, including withdrawals for drinking water filtration, swimming and recreation, angling, and other activities.

DEP has an operator training manual covering this topic, found here .

Nitrate is a pollutant of concern in surface waters filtered for human consumption and in groundwater sources for drinking water wells. EPA has set an enforceable standard called a maximum contaminant level (MCL) in potable drinking water for nitrates at 10 parts per million (ppm) (10 mg/L) and for nitrites at 1 ppm (1 mg/L). Many regulators are calling for similar limits for point-source and ground water discharges.

Human health concerns are a major factor in regulatory efforts to reduce nitrate in wastewater discharges. Exposure to nitrate also increases the risk of thyroid disease[7] and may lead to certain types of cancers of the colon and bladder[8], as well as a very specific birth defect called neural tube disorders caused early in pregnancies.[9] Nitrate acts on hemoglobin in red blood cells to form methemoglobin, reducing the oxygenation of organs and tissues.[10] Acquired methemoglobinemia in infants may occur when they consume nitrate in water used to mix infant formula or in nitrate-rich foods, medications such as benzocaine or dapsone, or through household exposure to naphthalene found in mothballs, toilet deodorants, plastics, and chemicals.[11] Nitrate may also be implicated in diabetes, miscarriages, and acute respiratory infections. The medical science on the effects of nitrates continues to develop.

Nitrification and Denitrification:

During the 1970s, treatment facilities were required to nitrify ammonia wastes to eliminate this pollutant that was killing aquatic life in receiving waters. Nitrification employs autotrophic bacteria in highly aerated conditions to convert ammonia to nitrate. The bacteria, normally found in topsoil, are found in activated sludge. During the past thirty years, microbiologists have discovered that there exist many genera of nitrifying bacteria, some of which are capable of completely nitrifying inorganic ammonia to

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[7] Epidemiology: May 2010 - Volume 21 - Issue 3 - p 389-395 (Nitrate converts to nitrite *in vitro* which becomes nitrosamines, leading to a host of health issues.)

[8] Schullehner J, Hansen B, Thygesen M, Pedersen CB, Sigsgaard T. Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study. Int J Cancer. 2018 Jul 1;143(1):73-79. doi: 10.1002/ijc.31306. Epub 2018 Feb 23. PMID: 29435982.

[9] Epidemiology: July 2004 - Volume 15 - Issue 4 - p S184; The Lancet, Volume 14, 100286, March 1, 2022

[10] Kross BC, Ayebo AD, Fuortes LJ. Methemoglobinemia: nitrate toxicity in rural America. Am Fam Physician. 1992 Jul;46(1):183-8. PMID: 1621630

[11] Wisconsin Dept. of Health Services website, Infant Methemoglobinemia (Blue Baby Syndrome) , (rev. 04/15/2021)

nitrate.[12] *Nitrospira* and *nitrococcus* come to mind. Traditional explanation of nitrification, prior to these discoveries, focused on a two-step process performed by two different genera of bacteria. These two genera of nitrifiers work in tandem: *nitrosomonas*, an ammonia-oxidizing bacteria (AOB), converts ammonium to nitrite, after which *nitrobacter*, a nitrite-oxidizing bacteria (NOB) converts nitrite to nitrate. The net reaction is shown below:

$$NH3 + O2 + H2O \rightarrow NO3- + 5H+ +4e \qquad (1)$$

The first step reaction by *nitrosomonas* is shown here:

$$NH_4^+ + 3/2\ O_2 \rightarrow NO_2^- + 2\ H_2O + 2\ H^{+\ 13} \qquad (2)$$

Additional oxygen and detention time are necessary to allow *nitrobacter* to oxidize the biologically active nitrite ion to chemically inert nitrate ion.[14]

$$NO_2^- + ½\ O_2 \rightarrow NO_3^- \qquad (3)$$

Nitrification requires several factors to complete the process. These include

- Sufficient detention time, 10 to 14 days: most of the cBOD must first be consumed by heterotrophic and facultative bacteria in the activated sludge.
- Dissolved oxygen residual between 1.5 mg/L and 3.5 mg/L in the bioreactor.
- 4.6 lb. of oxygen consumed per pound of ammonia converted to nitrate: this can double the amount of oxygen required, compared to only treating for cBOD.
- pH generally above 7.0 s.u., ideally between 7.3 and 8.6, but no lower than 6.5 s.u.
- 7.14 pounds of alkalinity is needed to convert every 1 lb. of ammonia.
- Alkalinity in the raw wastewater should be over 200 mg/L as CaCO3 or be supplemented to assure effluent alkalinity remains between 50 mg/L and 100 mg/L after treatment.
- Water temperature above 5 degrees Celsius (41 deg. Fahrenheit).

Nitrosomonas and nitrobacter are very sensitive to toxicity, as well, and one or the other can easily be suppressed by the presence of many household and commercial cleaners, excessive metals, and other contaminants.

Considering these factors, it is important for wastewater operators to regularly perform process control testing to determine whether the conditions are favorable for nitrification. If nitrification breaks down, these tests may help to determine what conditions are affecting the bacteria and which, *nitrosomonas* or *nitrobacter*, are most affected. Testing for pH, alkalinity, are dissolved oxygen residual are critical to maintaining effective nitrification.

Many wastewater treatment facilities built or upgraded in recent times have been equipped for biological nutrient removal (BNR). Denitrification is a process by which facultative, heterotrophic

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[12] van Kessel, M., Speth, D., Albertsen, M. et al. Complete nitrification by a single microorganism. Nature 528, 555–559 (2015). https://doi.org/10.1038/nature16459

[13] This is the first half of the reaction, converting ammonium to nitrite. The nitrite, in red, associates with the hydrogen, also in red, as nitrous acid, resulting in lower pH if alkalinity is inadequate.

[14] The chemical oxidation state of nitrate ion is such that it does not necessarily associate with hydronium to produce more acid. It more typically associates with metal ions and is inert.

bacteria in the activated sludge will reduce nitrate to nitrogen gas that leaves the water and returns to the atmosphere. The balanced chemical equations are shown below:

$$6\ NO_3^- + 2\ H_3COH \rightarrow 6\ NO_2^- + 2\ CO_2 + 4\ H_2O$$ [15]

$$6\ NO_2^- + 3\ H_3COH \rightarrow 3\ N_2\uparrow + 3\ CO_2 + 3\ H_2O + 6\ OH^-$$ [16]

For successful denitrification, the following conditions are necessary:

- anoxic treatment conditions, where no dissolved oxygen is present. Generally, dissolved oxygen should be below 0.3 mg/L for denitrification.
- nitrate-rich environment: nitrification should be complete to the best extent possible. Nitrate dissolved in the water will provide the oxygen needed by the bacteria for metabolism.
- Presence of organic carbon as a food-source for the bacteria: usually, this comes from the raw wastewater but sometimes is required as supplemental cBOD in for form of simple chemicals like methanol, citrate, or glycerol, or as food manufacturing wastes such as molasses sugar, fruit juice waste, or whey powder.

Denitrification is a rapid reaction under the right conditions. If a treatment facility can successfully nitrify, there should be little or no problems denitrifying. In fact, in conventional and extended aeration facilities, denitrification is sometimes observed occurring in secondary clarifiers when the sludge blanket there has been retained too long: fine bubbles form in the floc causing clumps of sludge to rise to the surface. This "lava lamp" effect, called "rising sludge," can cause effluent violations when solids are carried over the clarifier weirs to the outfall. Excessive solids carryover will also inhibit downstream disinfection processes by consuming available chlorine or by occluding the penetration of ultraviolet light.

Alkalinity is Critical

During nitrification, the nitrifying bacteria consume inorganic carbon in the form of dissolved carbonate / bicarbonate in the water. Alkalinity provides buffering against rapid and drastic pH changes, but it also provides a source of inorganic carbon. For every pound of ammonia oxidized, 7.14 pounds of alkalinity are consumed. (Given water chemistry and cellular metabolism, this amount is often rounded up to 7.2-to-7.5 lb. alkalinity per 1 lb. ammonia oxidized.)

If the biomass is deficient of alkalinity, the AOB conversion of ammonia to nitrite will lower the pH. This is because the nitrite released from the bacteria, as a waste product, is the anionic half of nitrous acid. The metabolism of ammonia produces hydronium ion that acidifies the water. To counteract this, supplemental alkalinity is often required in many parts of Pennsylvania where, excepting the limestone-rich geology of the Great Valley and similar areas, most of the geography is naturally deficient in alkalinity. Acid-mine drainage also contributes to lowering the pH of surface and ground waters.

While the rule-of-thumb holds that a facility is in good stead if effluent alkalinity is 100 mg/L and influent alkalinity is over 200 mg/L, experience has demonstrated that facility operators should calculate

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[15] In this equation, H_3COH represents methyl alcohol, a simple organic carbon most often used in denite filters.

[16] The carbon dioxide and hydroxyl ion combine in water to produce carbonate alkalinity. Almost half of the alkalinity consumed by nitrification is returned to the treatment process by denitrification, resulting in reductions of alkalinity needed up front as well as energy consumed in oxygenating the water.

alkalinity demand in the course of their routine process monitoring and control tests. DEP has developed alkalinity calculator spreadsheet tools to aid in this, found at this website .

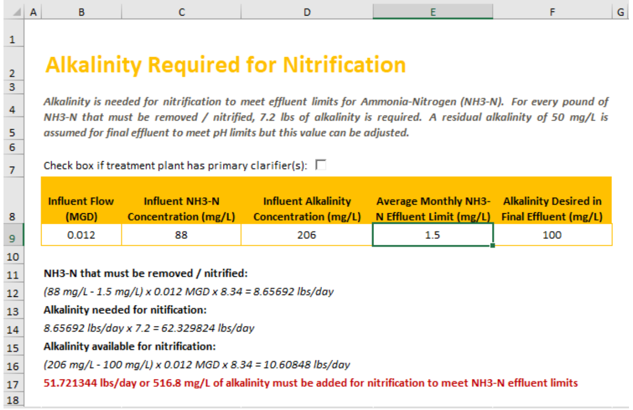
Using the calculator, operators enter test value for influent ammonia concentration and for influent alkalinity. Entering the estimated flow in million-gallons-per-day (MGD) calculates the ammonia and alkalinity loads present, the alkalinity required to oxidize the ammonia, and the equation produces a net result of how much additional alkalinity to add to the process.

It should be noted that conversion factors should be applied, based on the type of alkalinity chemical being deployed. These are found in a table on the following page. To use this table, select the ratio for the chemical being used and divide this into the estimated amount required to treat the ammonia to meet the ammonia effluent limit.

E.G., from the calculator and table:

$$51.7 \text{ lb./day as } CaCO_3 \div 1.06 = 48.8 \text{ lb./day as Soda Ash}$$

For practical purposes, the operator could round this example result up to 50 lb./day, since the Soda Ash is provided in 50 lb. sacks.



Alkalinity Required for Nitrification

Alkalinity is needed for nitrification to meet effluent limits for Ammonia-Nitrogen (NH3-N). For every pound of NH3-N that must be removed / nitrified, 7.2 lbs of alkalinity is required. A residual alkalinity of 50 mg/L is assumed for final effluent to meet pH limits but this value can be adjusted.

Check box if treatment plant has primary clarifier(s): ☐

Influent Flow (MGD)	Influent NH3-N Concentration (mg/L)	Influent Alkalinity Concentration (mg/L)	Average Monthly NH3-N Effluent Limit (mg/L)	Alkalinity Desired in Final Effluent (mg/L)
0.012	88	206	1.5	100

NH3-N that must be removed / nitrified:

(88 mg/L - 1.5 mg/L) x 0.012 MGD x 8.34 = 8.65692 lbs/day

Alkalinity needed for nitification:

8.65692 lbs/day x 7.2 = 62.329824 lbs/day

Alkalinity available for nitrification:

(206 mg/L - 100 mg/L) x 0.012 MGD x 8.34 = 10.60848 lbs/day

51.721344 lbs/day or 516.8 mg/L of alkalinity must be added for nitrification to meet NH3-N effluent limits

Example alkalinity calculator

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	0.8
Magnesium hydroxide	0.5

Alkalinity ratios to use in converting alkalinity doses

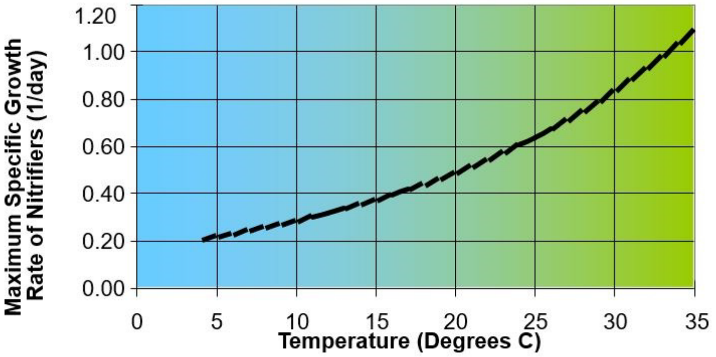
When adding any chemical to a biological treatment process, it helps if the chemical is dosed over the course of the day rather than dumped as a bulk or slug load. Therefore, it is beneficial to mix powders with water as a diluted solution and use metering pumps to deliver the chemical dose in a twenty-four-hour period. For example, if a 50 lb. sack of Calcium carbonate is dissolved into 100 gallons of water in a day tank, the metering pump should be set to deliver 4.2 gallons per hour.

PA DEP has a training manual for chemical feed systems, found here .

Inhibition of Nitrification

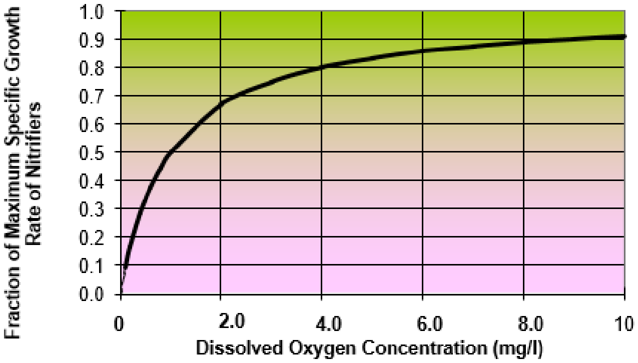
Many factors may lead to inhibition of nitrification. These include:

- pH out of range for the biomass, causing nitrifiers to stop reproducing and get washed out of the system.
- Low water temperature: Below 5 degrees Celsius, the biological reaction slows considerably, as see in this graph:



Growth of nitrifiers is dependent on temperature, and at colder temperatures, they do not replicate quickly enough to be effective

- Dissolved oxygen:



- Mean Cell Residence Time:
- Alkalinity concentration should be sufficient to maintain pH within a range from 7.0 s.u. to 8.6 s.u., and the effluent alkalinity residual should remain between 50 and 100 mg/L.
- cBOD removal:
- Toxic compounds in the wastewater will inhibit the metabolism and reproduction of nitrifying bacteria that are more sensitive to environmental changes than are the facultative heterotrophs that consume cBOD and denitrify nitrate.
- Facility design affects nitrification because of detention time, limits on hydraulic loading, quality of aeration and mixing, removal of trash and detritus, and capacity of waste sludge holding.
- Wet weather operation and inflow/infiltration affects nitrifiers because they reproduce slowly and are easily washed out of the system by hydraulic surges and overloads.

Effect of Partial Nitrification on Chlorine Disinfection

If conditions are unfavorable for complete nitrification, nitrite level will rise and exert a chlorine demand by reacting with both free chlorine and chloramines. This is called “nitrite lock.” Low D.O., insufficient alkalinity, or acidic pH; high temperature or pH; and toxic or inhibitory substances will inhibit the final oxidation step from nitrite to nitrate. Nitrite lock also may occur during facility startup or during seasonal transitions, because *nitrobacter* grow more slowly than *nitrosomonas*. For example, in the seasonal temperature transition range from 10° C to 17° C, the rate of nitrite formation is slower than the rate of nitrite disappearance. 1 mg/L of nitrite will consume 5 mg/L of chlorine as Cl_2. When the nitrite concentration in the clarified effluent exceeds 1 mg/L, nitrite lock makes it seem like operators cannot add enough chlorine to their disinfection process; total chlorine residual (TRC) becomes non-detectable even at high chlorine doses, and fecal coliform counts exceed permit limits.

Since nitrite lock has many potential causes, the remedies for it are also variable. Maintaining desirable pH and alkalinity in the mixed liquor is important. Eliminating toxic or inhibitory substances in the waste stream will help, too. Sometimes these substances may be generated internally, too. For example, using small doses of liquid bleach to control filamentous growth in the biomass will likely inhibit *nitrobacter* before it affects *nitrosomonas*, resulting in higher nitrite concentrations. While water temperature cannot be easily controlled, low water temperatures generally call for longer MCRT, and this may be achieved by building up the concentration of biomass by reducing the sludge wasting rate.

For more immediate remedies to nitrite lock, if a treatment process has more than one treatment train and both are independent of one another, it may be possible to blend low-nitrite effluent with the problematic high-nitrite effluent to dilute the nitrite. Also, if the facility permit allows it, increasing the concentration of ammonia in the effluent above that of the nitrite concentration may solve the problem, because chloramines forming in the disinfection process appear to be less prone to nitrite lock than free chlorine.

Most treatment facilities test for nitrite and nitrate together. From a process control standpoint, though, it may be better to test the two separately. That way, the operators can be alert to rising nitrite concentration in time to avert problems.

Nitrogen Removal Without Major Process Changes

In modern treatment facility design, biological nutrient removal (BNR) has become common. Many process designs exist to support both nitrification and denitrification. However, it is not necessary for older treatment facilities to be radically redesigned to achieve nitrogen removal. The simplest method is called “intermittent” or “on / off” aeration, where the aeration blowers are cycled to provide either full-on aeration for oxidation of organic and ammonia waste, or turned off to provide periods of anoxic treatment where denitrification reduces nitrate to nitrogen gas in the bioreactor, preventing rising sludge from occurring in the clarifier.

Intermittent aeration requires some minor modifications to make it work successfully:

- Dissolved oxygen control: Ideally, D.O. during oxidative periods should range from 1.5 mg/L to 3.5 mg/L to achieve complete nitrification.
- Anoxic, subsurface mixing: During air “off” period, denitrification will be optimal if mechanical mixing is present in the bioreactor to maintain the bacteria, cBOD, and dissolved nitrate all in contact with one another. Without anoxic mixing, the denitrification reaction will occur mostly at the top of the sludge blanket that forms, although rising sludge (as in a clarifier) does occur, showing that denitrification will occur, albeit inefficiently, throughout the sludge blanket.
- Organic carbon: Facultative, heterotrophic bacteria that denitrify require a carbon source for cellular metabolism and reproduction. Usually, this organic carbon comes from raw wastewater continuing to enter the bioreactor while it is in the “off” period. If necessary, supplemental carbon in the form of commercially prepared additives or otherwise as simple food processing wastes, sugar, rabbit or fish food, may be substituted.

Operational Benefits of Biological Nitrogen Removal

It is said that if a facility is required to nitrify ammonia wastes as part of its NPDES permit, it should denitrify the nitrate, as well, because of the economic benefit of doing so. Nitrification is energy intensive, and there are costs associated with power consumption, maintenance costs for aeration systems, chemical expenses associated with alkalinity addition, and use of polymer for sludge settling aids that counteract rising sludge in clarifiers.

Denitrification reduces the overall amount of power and chemicals consumed. These may be quantified as follows:

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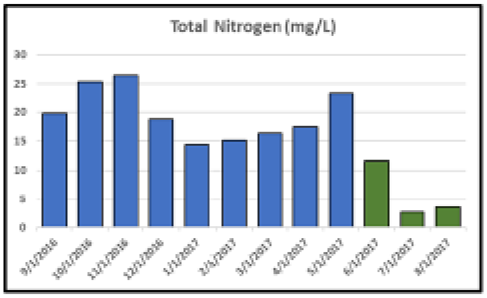
Case History

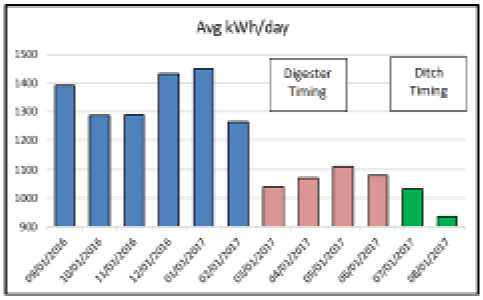
Intermittent aeration was tried at the Adamstown, Lancaster County, wastewater treatment facility to reduce effluent total nitrogen—mostly nitrate—so that the facility operators could save money by avoiding annual purchase of nitrogen credits to meet their Chesapeake Bay nutrient reduction goals. The facility includes two secondary bioreactors as oxidation ditches, aerated through surface mechanical aerators.

Using instrumentation to monitor dissolved oxygen, pH, and oxidation / reduction potential (ORP), and installing simple timers on the aerators' motor controls, the operators were able to reduce aeration time from 24/7/365 to 2 hours "on" and 3 hours "off" for every five-hour cycle.

Based on feedback from the instrumentation, the operator manipulated the timing regime from 24hr/day ON to 9.6 hours/day ON to optimize denitrification (TN removal). At the close of the project, effluent Total Nitrogen (TN) and energy consumption were reduced by 74% and 30%, respectively.



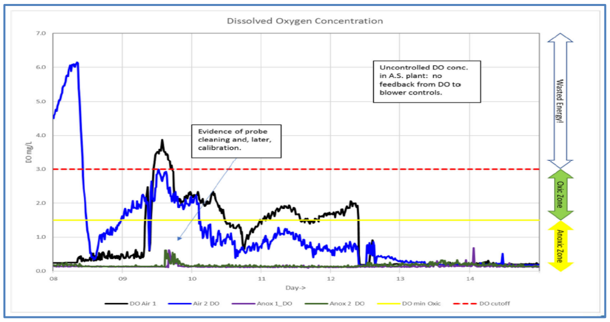
Figures: Effluent Nitrogen Reduction



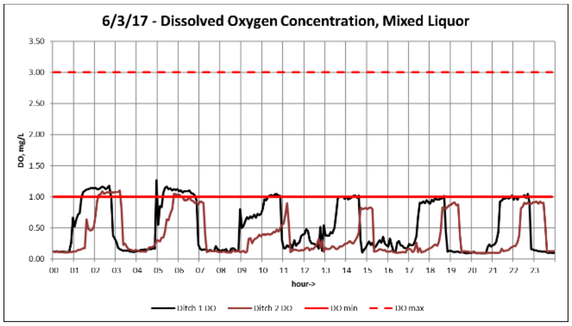
Electrical Consumption

Instrumentation and Automation

Excessive dissolved oxygen residual in bioreactors could be controlled by using variable frequency motor drives (VFD) to regulate the motors driving aeration blowers. The principle is to install continuous monitoring dissolved oxygen probes in the bioreactors and using a 4-to-20 milliamp signal from the probe controller to signal the VFD to maintain blower speed that maintains D.O. residual between 1.5 mg/L and 3.5 mg/L. The graphs below compare unregulated D.O. residual to controlled residual within aeration tanks:



Unregulated D.O. residual in bioreactor



Controlled D.O. residual via VFD feedback loop

The technology of the dissolved oxygen probes is limited at the lower end of the scale, where any reading below 0.3 mg/L may be considered to be zero. To better understand the effective ranges for denitrification, oxidation / reduction potential (ORP) probes are used, where anoxic process is favorable between 150 mV and -150 mV. In practice, the denitrification “sweet spot” occurs between 0 mV and -50 mV, although experience may be different among differing treatment technologies. ORP probes are installed in the same bioreactor in the cases of intermittent aeration, sequencing batch reactors (SBR), oxidation ditches, Orbals, Schreiber process tanks, membrane bioreactors (MBR), and the like. Where anoxic processes occur in separate tanks, the ORP probes are placed in anoxic (denitrification) tanks or in anaerobic selectors. Process automation may use ORP probes to regulate the addition of supplemental carbon or to control the nitrate recycle rate as ways to optimize denitrification.

Because nitrifier bacteria are very sensitive to pH changes, and because the action of AOB to oxidize ammonia to nitrite produces acidification of the biomass, it is important to monitor pH in the aeration tank. Automation may use pH set points to regulate the addition of alkalinity to control pH.

wastewater. BNR treatment facilities require adequate attention be given to assuring that alkalinity and pH, often using supplemental alkalinity addition added as lime, quicklime, calcium carbonate, sodium bicarbonate, caustic soda, or magnesia.

This is where insufficient D.O. in the bioreactor may lead to the complete reaction from ammonium to nitrate to break down, resulting in a prevalence of nitrite-nitrogen.

nitrite often combines with chlorine disinfectants at other facilities, reducing disinfection efficiency and causing effluent coliform violations.

Likewise, the anoxic treatment zone processes require effective absence of D.O. to force certain bacteria to strip oxygen from the aqueous nitrate produced by nitrification. Since D.O. probes are inadequate for measuring this, it is recommended that oxidation/reduction potential (ORP) probes be deployed in the anoxic tanks to measure the relative positive or negative charge and optimize to the most effective range where denitrification becomes most efficient. This is typically within a range from 0 mV to -50 mV, although an overall range from +100 mV to -100 mV is often adequate.

ATTACHMENT I: METHOD FOR ALKALINITY DOSING CALCULATION

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 $CaCO_3$[17], multiply the influent (or raw) TKN (total Kjeldahl nitrogen, which is organic nitrogen and ammonium nitrogen, combined)[18] 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:

88 mg/L Influent Ammonia-nitrogen in Raw Wastewater
(Estimated that Ammonia-nitrogen is 70% of TKN in domestic wastewater)
(88 x 100%) ÷ 70% = 126 mg/L TKN estimated

126 mg/L Influent TKN x 7.2 mg/L alkalinity per 1 mg/L TKN = 905.1 mg/L alkalinity required

If the secondary influent already has 403 mg/L of alkalinity, then the net alkalinity demand is:

915.2 mg/L alkalinity needed to treat: 403 mg/L alkalinity in Influent = 502.1 mg/L alk. 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 0.0122 MGD, then the amount of alkalinity required would be

502.1 mg/L x 0.0122 MGD x 8.34 lb./gal = 51.1 lb./day.

To convert this to a chemical dose, you will have to determine the available alkalinity in the chemical. For example, 1 lb. Soda Ash has 1.06 lb. alkalinity[19]. This means that to provide 52 lb./day alkalinity as $CaCO_3$, you need to divide this by the ratio of chemical to alkalinity:

51.1 lb./day ÷ 1.06 = 47.3 lb./day of Soda Ash (round up to 50 lb.)

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

50 lb./day ÷ 24 hours = 2 lb., 1⅓ oz. per hour (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

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[17] 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.

[18] 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.

[19] See the table on the next page.

of the chemical feed pump and the size of the line needed. When using this dosing method, it doesn't hurt to round up to easier quantities to work with; for example, 47.3 pounds of demand rounds up to 50 pounds.

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 J: IMPROVING DISINFECTION

In small flow wastewater treatment systems, it is not uncommon to see erosion chlorinators that employ calcium hypochlorite tablets as a source of chlorine for disinfection. The material is durable in storage and provides an accessible source for disinfection when flow is present, provided that they are not continually immersed in water. Water to be disinfected flows through the chlorinator box, contacting tablets at the bottom of a stack. The chlorinated water then flows into a larger holding space calculated to provide adequate contact time for the chlorine to destroy pathogenic bacteria and viruses.

Where the method breaks down, leading to fecal coliform violations or to excess chlorine violations, is when the tablets are applied improperly. Some operators simply place the tablets in a perforated bucket or inside socks that are in constant contact with water. When effluent flow stops, the tablets continue to dissolve in a remaining puddle or column of water, overdosing hypochlorite into solution. If flow becomes excessive, there is not enough contact time with the tablets or within the holding tank for effective disinfection to occur. In addition, excess suspended solids that may be in the effluent will consume chlorine while reducing exposure of pathogens to its effects.

Alternatives to the use of erosion chlorination in small flow treatment systems include the use of liquid sodium hypochlorite solution or the use of ultraviolet lighting.

“Liquid Bleach” Disinfection

Using sodium hypochlorite as a halogen source is fairly common. Liquid bleach solutions at 12.5% are metered into a disinfection system on a flow-proportioned basis, assuring that the chlorine dose matches the volume of water being treated. This provides assurance that the pathogens will be effectively neutralized. The bleach may be delivered or stored in 55-gallon drums or 300-gallon totes. Metering pumps may be equipped to receive a 4-to-20 milliamp signal from a flow meter, or they may be operated simply based on a dose/time relationship.

Where chlorine residuals are stringent, dechlorination using liquid sulfite solutions are employed to quench any remaining chlorine residual following sufficient contact time. This is sometimes called sulfonation. Dechlorination is a rapid chemical reaction that does not require much contact time, so insertion of the chemical at the outflow weir of a chlorine contact time is usually sufficient.

Using liquid sulfite solution in place of erosion tablets allows the dose to be flow-paced, reducing the chances of overdosing sulfite into the effluent and artificially depleting dissolved oxygen in the water.

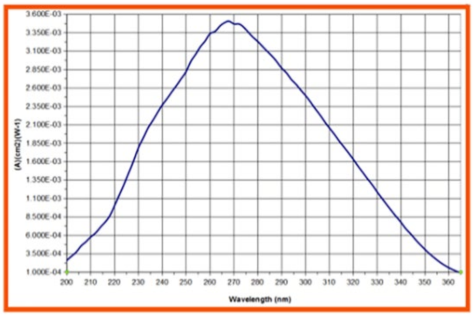
Ultra-Low Total Chlorine Residual Testing

When NPDES Permits require dechlorination, the total residual chlorine (TRC) limits for the effluent may be very low, effectively “zero” concentration at the outfall. To effectively demonstrate that excess TRC has been quenched by dechlorination, a more accurate chlorine residual test is required. It is not enough for an operator to simply report a zero concentration or a concentration value less than the method detection limit if that limit is greater than the requirement listed in the permit. Some post-dechlorination limits are in the range of 40 parts per billion. To demonstrate effective dechlorination, it is necessary to upgrade laboratory test methods and equipment to attain a method detection limit lower than the permit limit. This can require investment in new lab equipment and training in using more accurate detection methods. For such reasons, it is sometimes more effective for a facility to adopt a different disinfection technology, such as the use of ultraviolet light irradiation to disinfect facility effluents.

UV Disinfection Systems

Facility owners and operators whose permits have very stringent effluent residual chlorine limits may consider converting from chlorine-based disinfection to ultraviolet light disinfection treatment. While dechlorination can eliminate chlorine residual, excessive dechlorination may lead to other effluent limit violations, such as those for insufficient dissolved oxygen. The testing requirements for facilities that dechlorinate have become more stringent, also, requiring use of ultra-low chlorine testing to determine total residual chlorine in the parts per billion.

Use of erosion-type chlorinators and similar devices for dechlorination using sulfites can be unreliable when flows are variable or when they diminish throughout the day. Calcium hypochlorite tablets that are allowed to "stew" in standing water will release excessive amounts of chemical into the water, so that when moderate flow resumes, chlorine violations can occur. The same thing happens to dechlorinating sulfite tablets, but these do not necessarily cancel out the chlorine residual. Effluent TRC violations will happen.



Graph of UV light detected within UVC Range for wastewater disinfection

Treatment facilities using ultraviolet light radiation produce no chlorine residual. The mechanism is to irradiate fecal coliform bacteria to cause intracellular disruption of DNA and RNA, breaking down biological reactions that sustain cellular life. Once spent, the energy of UV light is harmless to the effluent and to the environment.

For design and proper sizing of a UV disinfection system, it is recommended that the facility owner work with its consulting engineer to explore available options and properly size the equipment to meet expected average and peak hydraulic flows. Training of facility operators and maintenance workers is essential to maintaining the equipment in good working order, especially when working with hard waters.

The U.S. EPA, in its document wastewater technology fact sheet "Ultraviolet Disinfection,"[20] discusses the science and the advantages and disadvantages of ultraviolet light disinfection in wastewater treatment.

About UV Transmittance (UVT)

UV transmittance, UV transmission or UVT is a measurement of the amount of ultraviolet light (commonly at 254 nm due to its germicidal effect) that passes through a water sample compared to the amount of light that passes through a pure water sample. The measurement is expressed as a percentage, % UVT.

WHY IS IT IMPORTANT?

Measurement of UV Transmittance is important for ultraviolet (UV) disinfection of drinking water, wastewater and process water. Low-pressure UV disinfection systems disinfect water using monochromatic UV light at the 254 nm wavelength. The effectiveness of a UV disinfection system is determined by the dose that the system is able to deliver to the target microorganisms in the water. The effective UV dose is dependent primarily on the combined effects of the UV light intensity, the exposure time and the UVT.

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[20] U.S. Environmental Protection Agency Office of Water Programs, "Ultraviolet Disinfection", EPA 832-F-99-064, Washington D.C., September 1999

UV Transmission varies over time and from site to site as it is related to the quantity of organics, colloidal solids and other material in the water which absorb and scatter the UV light as it passes through the water column. In a UV disinfection system, if the UVT of the water is low, then the UV light is not able to penetrate the water as effectively, thereby reducing the potency of the dose. For this reason, it is very important to monitor UVT and ensure its levels are maintained above the manufacturer's minimum for proper disinfection to occur.

LABORATORY UVT

Ultraviolet light (commonly at 254 nm) is passed through a 10 mm quartz cell containing the sample water. The intensity of attenuated light is measured with a sensor and compared to that of a pure water sample. The instrument then reports the UVT value as a percentage. A universal laboratory spectrophotometer would be used, but there may be other field-testing equipment designed for only this wavelength. In addition, UVC light meters are available on the market for about $2,000.

1UVC light meter and detector