WESTERN WESTMORELAND MUNICIPAL AUTHORITY
BRUSH CREEK WASTEWATER TREATMENT FACILITY

IRWIN, WESTMORELAND COUNTY, PA
NPDES #PA0027570

WASTEWATER TREATMENT EVALUATION

Prepared by:
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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

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Executive Summary:

The Western Westmoreland Municipal Authority (WWMA) owns and operates a wastewater treatment facility in North Huntingdon Township that serves the boroughs and townships of western Westmoreland County, located at the southeastern extent of the Pittsburgh standard metropolitan statistical area, near the Borough of Irwin. This contact/stabilization treatment works was constructed in 1977 along the banks of Brush Creek, an acid-mine drainage-impacted waterway of the Commonwealth.[1] The facility is rated for 4.4 MGD annual average daily flow and 7,490 lb./day of organic loading. The facility is presently undergoing an upgrade of its preliminary treatment systems, including construction of a 7.5 MG equalization tank, a 16 MGD preliminary pumping station, two rotary fine-screen units, and a grit removal system. The WWMA is also in the early stages of replacing the primary interceptor that it owns, with contracts to be let in September or October of this year.

The facility has a history of interactions with the Department of Environmental Protection's South West Regional Office, but the secondary treatment process remains relatively unchanged from the time of its construction.[2] The facility has a primary clarifier that feeds a 1.6 MG secondary treatment system which is partitioned into two trains each having three tanks of equal capacity. The contact/stabilization method of secondary treatment has been an adequate hedge against solids washout due to heavy inflow/infiltration in the contributing collection systems that are owned and operated by their respective municipalities. It is implicated, though, in causing fecal coliform violations due to inadequate detention time, causing formation of nitrites that consume available chlorine at the disinfection process. In addition, with the construction of the new preliminary treatment systems and plant headworks, Mr. Kevin Fisher, the WWMA General Manager, and plant staff are considering treatment alternatives that would improve process efficiency and reduce the amount of untreated ammonia-nitrogen which concentrates within the process. High effluent ammonium may impact Whole Effluent Toxicity Tests (WET) scheduled to begin later this year. In addition, ammonia-nitrogen is readily evident within the treatment facility and concentrates in side stream processes including sludge thickener, anaerobic digesters, and sludge centrifuge.[3]

Staff from PA DEP's Bureau of Clean Water, Operations Section, had been working with Mr. Fisher and with Mr. Stan Goreski, assistant general manager, to consider process changes including conventional secondary treatment with nitrification and the potential for denitrification, using the existing secondary tank footprint. Essential to converting from contact/stabilization to conventional aeration had been the provision of alkalinity enhancement, and 62% magnesium hydroxide was tried. Mixed liquor pH should be neutral for nitrification and between 7.0 and 8.5 for denitrification.

[1] Irwin's Tinker's Run AMD discharge is estimated at 7,700 gpm, or 11 MGD, shortly upstream from Brush Creek Outfall 001. The TMDL is for metals (Iron, Manganese, and Aluminum,) and for acidity. Brush Creek runs orange from Iron discharges for a considerable distance beyond the confluence of Tinker's Run. (Brush Creek Watershed TMDL, PA DEP, Jan. 28, 2005.)

[2] The current headworks improvements and flow equalization tank are part of a Consent Order and Agreement (COA).

[3] 55,000 gallons from a typical centrifuge run returns an estimated 300 lb. of ammonia-nitrogen to the headworks.

In late June, DEP staff from the Wastewater Technical Assistance Program (WWTAP) installed continuous monitoring equipment for wastewater treatment focused on the secondary treatment system. The purpose of the equipment was to provide monitoring of key chemical indicators of treatment efficiency during the conventional treatment and magnesium hydroxide trials. Continuous monitoring also allows plant operators to observe common changes in treatment parameters such as diurnal variation of organic loading. Because of the ongoing construction, the data collection had to be wireless to minimize disruption of construction traffic while preserving round-the-clock monitoring. To this end, two separate SCADA systems would be deployed on site: one to monitor effluent nutrients, and the other to monitor secondary treatment parameters. Attachment 2 provides a listing and location of monitoring equipment.

Data was collected and graphed by DEP staff to identify trends and variations of secondary treatment process. While being operated in a conventional treatment mode, staff were able to effectively nitrify ammonia wastes; however, alkalinity adjustments was necessary to cope with side stream flows and variations in raw influent. The nitrified activated sludge tended to denitrify at the secondary clarifiers and in the sludge thickener. Unintended denitrification at the clarifiers caused solids carryover to the disinfection process, where effluent violations for fecal coliform and for suspended solids occurred.

Operating in an ON/OFF aeration mode, with continuous feed of primary effluent and return activated sludge, to promote denitrification within the reactor tanks yielded mixed results due to the lack of anoxic mixing during the anoxic periods. It was suggested that the operators might maintain much thinner clarifier blankets and employ the use of polymer flocculants in an attempt to reduce problems with the secondary clarifiers.

For the month of June, the average raw wastewater alkalinity was approximately 200 mg/L, meaning that sufficient alkalinity should have been present for nitrification. However, it was quickly determined that side stream flows added more ammonia-nitrogen than could be biologically processed, given the raw alkalinity. The facility employs anaerobic digesters to reduce the volatile content of its primary sludge and its waste secondary sludge. Centrifuge runs typically add about 300 lb/day of ammonia-nitrogen, boosting the requirement for additional alkalinity by way of sodium or magnesium hydroxide, lime, or sodium carbonate.[4]

During the course of the WTE there were at least two washouts or other secondary treatment failures due to storms and / or stormwater surges. The Brush Creek facility is currently undergoing an overhaul and upgrade of its preliminary treatment system, wherein a new equalization basin is being built to attenuate surge flows. This will relieve the facility of similar events going forward, but their effect on the evaluation

[4] It also may be possible to destroy some of this ammonia load using inorganic chemicals, such as hypochlorous acid. Prior to the use of biological methods, excess effluent ammonia-nitrogen was destroyed using increased dosage of chlorine in the disinfection process.

required that additional time be spent at the facility to find and maintain process equilibrium.

The evaluation included an attempt in July and August to denitrify at the secondary aeration tanks by operating the aeration system intermittently, called ON/OFF aeration. Unfortunately, an important element was missing. To denitrify efficiently, the activated sludge must mix with soluble nitrate and a carbon source, typically raw wastewater. At Brush Creek, DEP staff had recommended temporarily installing submersible grinder pumps into the aeration tanks to provide anoxic mixing, but it could not be done in the time permitting. Building on the successes gaining denitrification at a smaller facility earlier this year, it was hoped that forward flow could provide enough mixing, but this was not to be. Another factor inhibiting denitrification in the reactor tanks was likely that too much carbon (organic loading) had been removed at the primary clarifiers, leaving insufficient carbon to drive facultative denitrification.

Recommendations:

Based on the results of trials during the WTE, the following recommendations are put forth for consideration:

- The facility owners should engage their consulting engineer to evaluate the primary, secondary, and disinfection treatment systems for adaptation or upgrades to meet more stringent permitting requirements that include imposition of WET testing and consult with DEP regional permitting staff regarding future permit expectations.
  - Depending on level of treatment required by NPDES and other requirements, many options may be considered:
    - Do nothing option: Continue operating Contact/Stabilization mode with primary clarification and chlorine disinfection until new NPDES permit requires improvement;
    - Process nitrification to reduce ammonia-nitrogen: Operate secondary treatment in conventional mode, extending detention time, and treat downstream denitrification through process adjustments and chemical flocculants;
      - This will require use of alkalinity adjustment in secondary aeration to control acidification of biomass;
      - Evaluate alkalinity chemicals to determine most effective and economical combination;
    - Biological Nutrient Removal: Adapt existing configuration to MLE with minimum of retrofitting;
      - Will require boosting carbon source by eliminating primary clarifier, but the tankage may be used to provide capacity for oxic and anoxic phases;
      - Alkalinity enhancement will be required to maintain nitrification and to support facultative denitrification at higher operational pH;

- Eliminate chlorine disinfection and replace disinfection method with ultra-violet light arrays:
  - WWMA's website lists many "pros" and "cons" regarding this option. Please see: http://wwmaweb.com/disinfection.htm for details;
  - Capital and operational costs must be considered;
  - Maintenance of UV array and lamps may be intensive;
  - Not improving secondary treatment will continue to cause ammonia-nitrogen problems in facility (e.g. WET failures, malodors.)

- When the headworks and flow equalization construction has been completed, the facility operators should consider changing the method of secondary treatment from contact/stabilization to conventional treatment with nitrification. This will require that the facility provide for alkalinity enhancement.

- Alkalinity supplement was provided during the WTE using Magnesium hydroxide solution. While there are many favorable reasons to employ this chemical, one major adverse consideration is the cost of this chemical. Alkalinity supplement is determined from the raw wastewater organic and inorganic nitrogen ("total Kjeldahl nitrogen" or TKN.) At daily throughputs of two to four MGD, the amount of chemical required to counteract the acidification of the biomass caused by nitrifying bacteria can be cost-prohibitive. In such cases, it may be useful for the operators to consider using a cheaper alternative, such as caustic soda (NaOH solution) that is hazardous to work with but could be used for rough alkalinity supplement while $Mg(OH)_2$ may be used for polishing the alkalinity content.

- Because denitrification is likely to occur in the secondary clarifiers, as it had during the evaluation, there exists potential for solids carryover to the disinfection process, where it will consume chlorine and cause fecal violations. WMMA should investigate the use of polymer flocculants to assist in settling in the clarifiers and to maintain thinner clarifier blankets especially in warm weather.

Wastewater Treatment Evaluation, June--August 2017:

NOTE: The observations and remarks below will be formalized in report form, with amendment as necessary. These are presented for discussion purposes.

1. Average influent raw wastewater alkalinity is about 180 – 220 mg/L. Variations notwithstanding, alkalinity addition is chiefly for ammonia-N coming from centrate, thickener, and leachate.
   a. **Average** raw influent alkalinity seems sufficient to treat the collection system flow of TKN, but there are wide swings in native alkalinity, plus leachate and side stream flows
   b. Mitigation of alkalinity deficits is critical to maintaining suitable pH range 7.0 – 8.5 for nitrification.

2. In the facility configuration at the time, with construction of a headworks and flow equalization, the facility continued to experience problems due to variable flows (solids washout, rags) that would interfere with BNR.
    a. Flow equalization coming on-line should attenuate storm-related surges
    b. New fine-screen headworks should end the rag problem
    c. Downstream processes likely must be purged of existing rags and detritus
3. The “do-nothing” option:
    a. Failure of Whole Effluent Toxicity (WET) test due to high ammonia (notwithstanding failures due to unknown metals or toxicants otherwise in the system!)
    b. Wait until NPDES Permits begin requiring timetable for ammonium (or nitrogen) reduction, generally.
4. The “inexpensive” option:
    a. Replace chlorine-based disinfection with ultra violet light (UV) disinfection
        i. Benefits: no chlorine; no chloramines in effluent; no need for sulfonation (dechlorination); reduction of disinfection process footprint; no risk management associated with cylinders or tank cars
        ii. Argument against: energy and maintenance costs for UV process (e.g. Trojan); chlorine is still cheapest, most bang-for-buck; NPDES may eventually require ammonia or total nitrogen limits
5. Existing Contact / Stabilization: lack of nitrification; partial nitrification causes nitrite-lock at chlorine-based disinfection system w/ fecal coliform violations
    a. Nitrite-lock at disinfection tank: alternative to consider: UV-disinfection system is currently NO GO due to energy cost and maintenance, but should be considered in lieu of capital outlay required to reconfigure secondary treatment for conventional treatment or modified Ludzack-Ettinger (MLE)
    b. Consider: receiving stream AMD-impacted
    c. Consider: excess ammonia in effluent was traditionally destroyed using excess chlorine in disinfection processes; doing this today would require installation of dechlorination system downstream of disinfection tanks, probably using hydrogen sulfide gas at these high flow volumes
6. Conventional Aeration: nitrification of ammonia waste to reduce effluent ammonia and also reduce malodors leaving the site
    a. Ammonia dropped from average highs of c. 25 mg/L to less than 1 mg/L, at best, during nitrification trials
    b. Ammonia sources: Raw Wastewater; Leachate; Centrate
        i. Centrate side stream flow appears to be proximal cause of high ammonia in plant
        ii. Centrate may contribute about 300 lb. NH4-N per 50,000 gallon centrifuge run
    c. Acidification of biomass if process alkalinity falls below absolute minimum 100 mg/L
        i. Magnesium hydroxide alkalinity addition this summer
            1. Cost to treat on continual basis

            2. Permanent delivery system must be installed
        ii. Cheaper alternatives:
            1. soda ash/ NaOH for hydroxide alkalinity (less safe to handle, doesn't provide same level of hydroxide alkalinity per pound);
            2. Lime requires construction of silo and delivery system, best delivered as continual slurry to aeration tanks
    d. Nitrification at secondary treatment caused excessive denitrification to occur in secondary clarifiers
        i. Effluent violations for Fecal Coliform and Solids (?) due to solids carryover from clarifiers
        ii. Remedies:
            1. Tried reducing clarifier blanket thickness, to little effect
            2. Recommended use of polymers/settling agents to help clear solids from clarifiers
                a. This wasn't operative during the WTE but may have helped
    e. Denitrification occurring in sludge thickener was problematic from an operations/maintenance standpoint; also recycling solids to head of plant
    f. Recommend engineering evaluation to consider modification to conventional treatment, with nitrification, to reduce impacts of high ammonium concentration, whether or not required by NPDES permit or by AMD-impaired receiving stream
        i. This is a long-term project that would offset expected failure of pending Whole Effluent Toxicity Testing;
        ii. Treatment of ammonium reduces chance of nitrite-lock on disinfection process;
        iii. Reduce on- and off-site malodors related to high ammonium concentrations.

7. Denitrification using ON/OFF Aeration during WTE:
    a. Denitrification is possible using ON/OFF aeration cycles within the existing secondary treatment tanks; however,
        i. Subsurface anoxic mixing is essential to making this succeed;
        ii. Primary clarifiers remove carbon that is best used to drive denitrification process
            1. Primary clarifier volume could be diverted for use as MLE anoxic and (possibly) Bardenpho-type anoxic selector volume
            2. Using this BOD for denitrification instead of sending it to anaerobic digesters will impact digester performance
    b. NH4-N removal overall was less efficient without anoxic mixing and extra carbon:
        i. Effluent NH4-N increase from <1 mg/L to c. 10 mg/L during attempts to denitrify without use of subsurface mixing during anoxic periods of varying lengths

c. Recommend engineering evaluation to consider MLE or Bardenpho-type process employing existing primary clarifiers and secondary aeration tanks, if BNR is truly a goal in this Region

Summary

The testing this summer proved that nitrification will work if additional alkalinity and detention time are provided, but a key component of flow equalization, needed to attenuate hydraulic surges in secondary treatment, was not available at the time of the study and led to mixed results. Likewise, denitrification would benefit the operation, reducing net alkalinity consumption and energy costs, and producing a cleaner effluent.

Unfortunately, the short-term does not appear to offer a remedy unless the facility is willing to immediately reinstate conventional treatment and alkalinity addition, with the added feature of controlling sludge coagulation and blanket levels in secondary clarifiers, to prevent solids loss downstream.

ATTACHMENT A: EVALUATION TEAM

--for the Western Westmoreland Municipal Authority	
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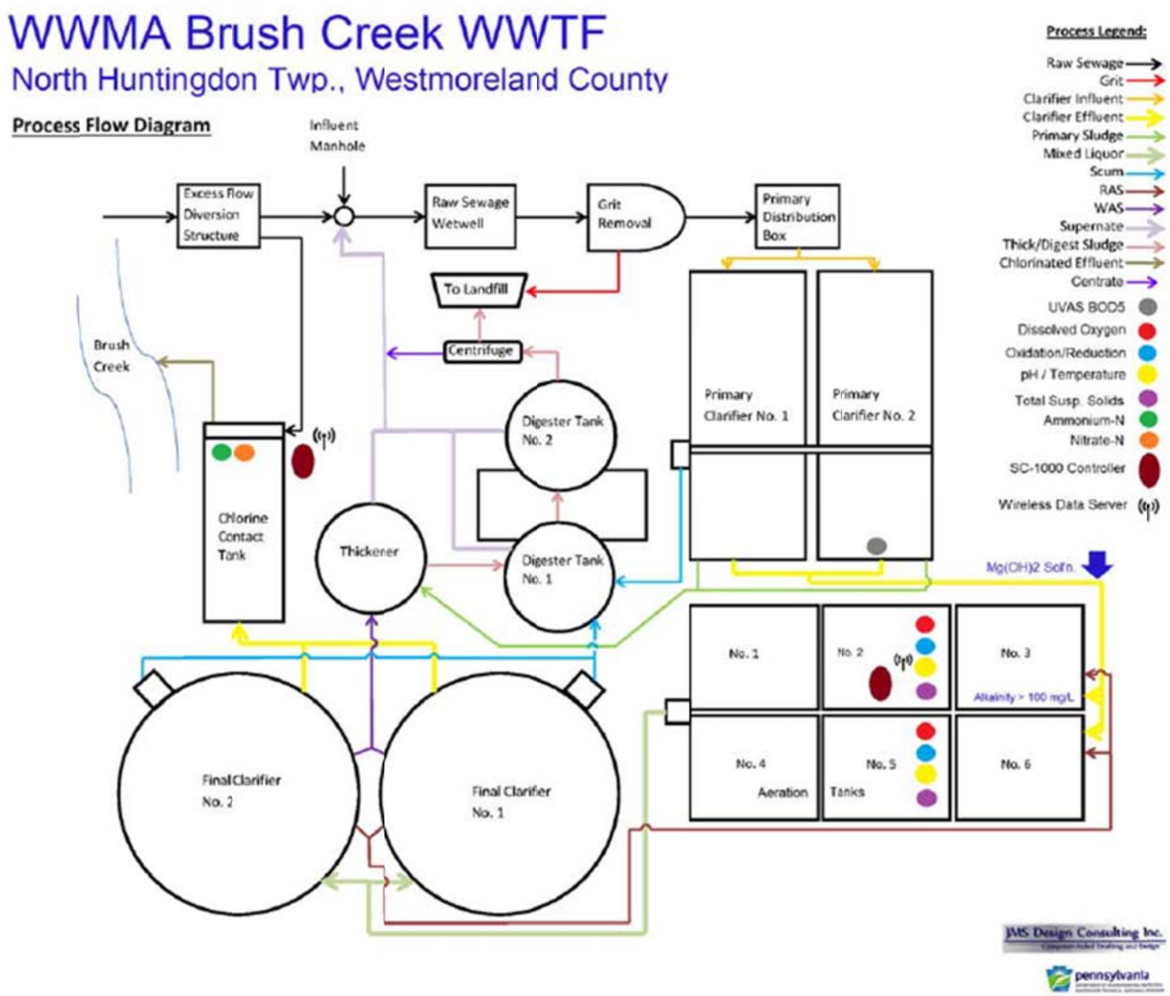
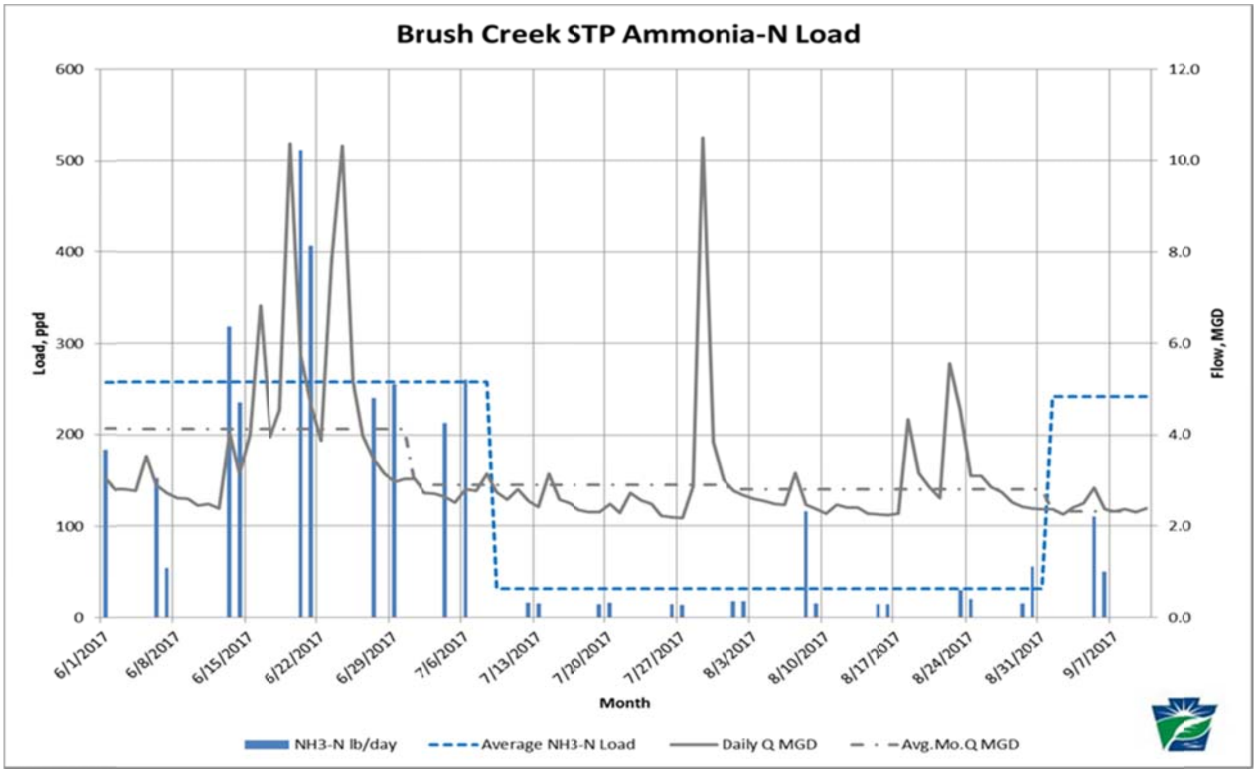
ATTACHMENT B: INSTRUMENT PLACEMENT



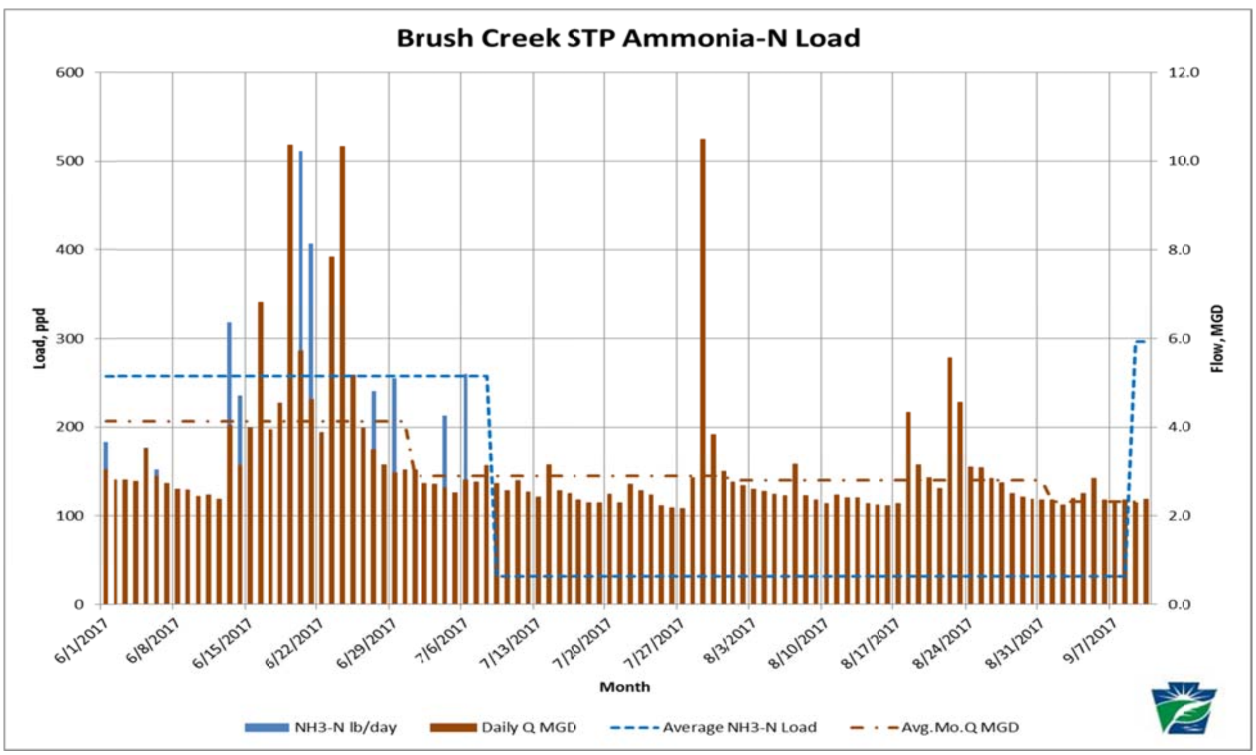
Equipment Listing for WTE:

2 Hach DPD-1P1 digital pH probes
2 Hach DRD-1P5 digital ORP probes
2 Hach Solitax sc TSS probes
2 Hach LDO2 Dissolved Oxygen probes
1 Hach UVAS sc 2mm digital BOD5 probe
1 Hach AISE sc digital ammonium probe
1 Hach Nitratax sc 2mm digital nitrate probe
2 Hach SC-1000 digital controllers
1 Hach SC-100 digital controller
2 eWON Wireless Integrated Data Servers
2 Verizon Mi-Fi Wireless Web Routers

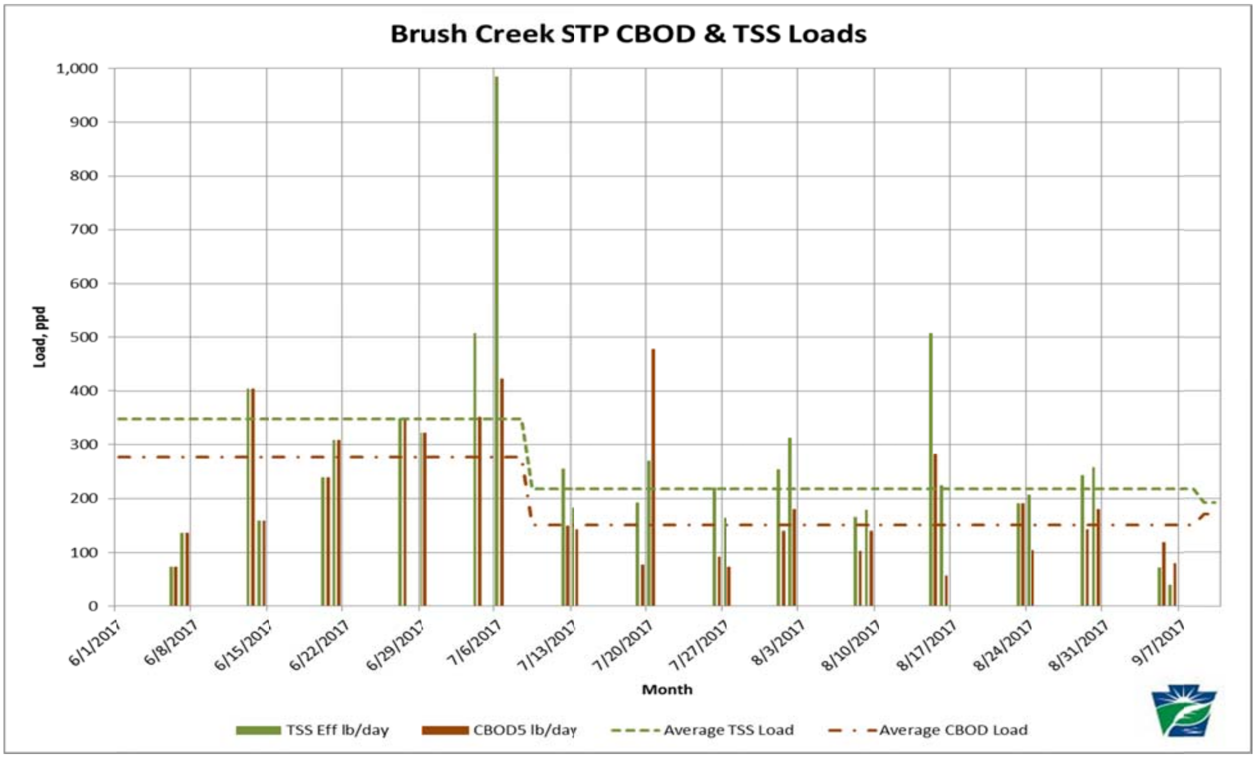
ATTACHMENT C: TREND CHARTS



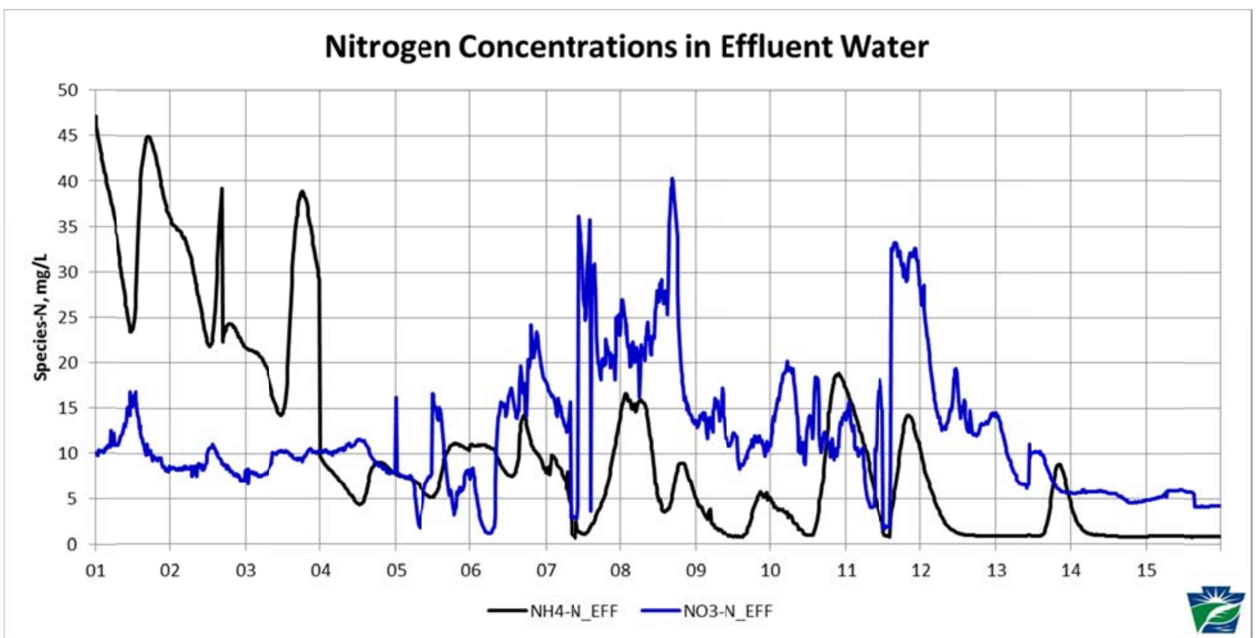
Graph 1: Comparison of Effluent Ammonium Loading Before, During, & After Nitrification Study



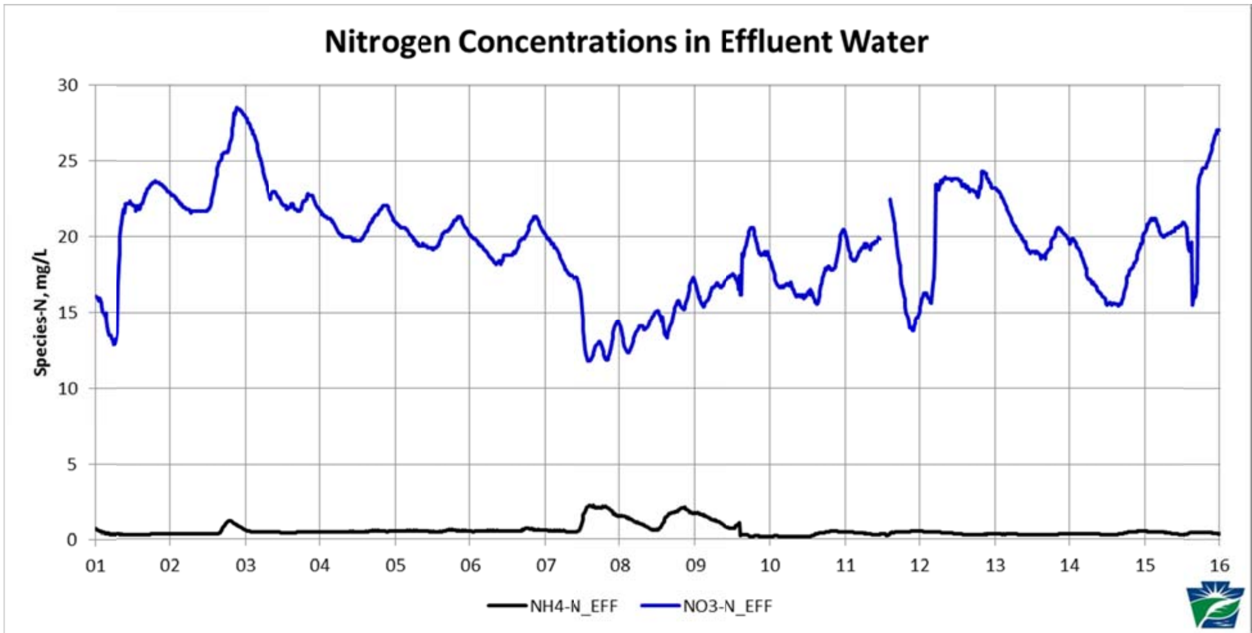
Graph 2: Effluent Flow and Ammonia-nitrogen Load to Brush Creek, before WTE, during, and afterward: Average before and after was >250 lb./day; during WTE, NH3-N load dropped to average 32 lb./day



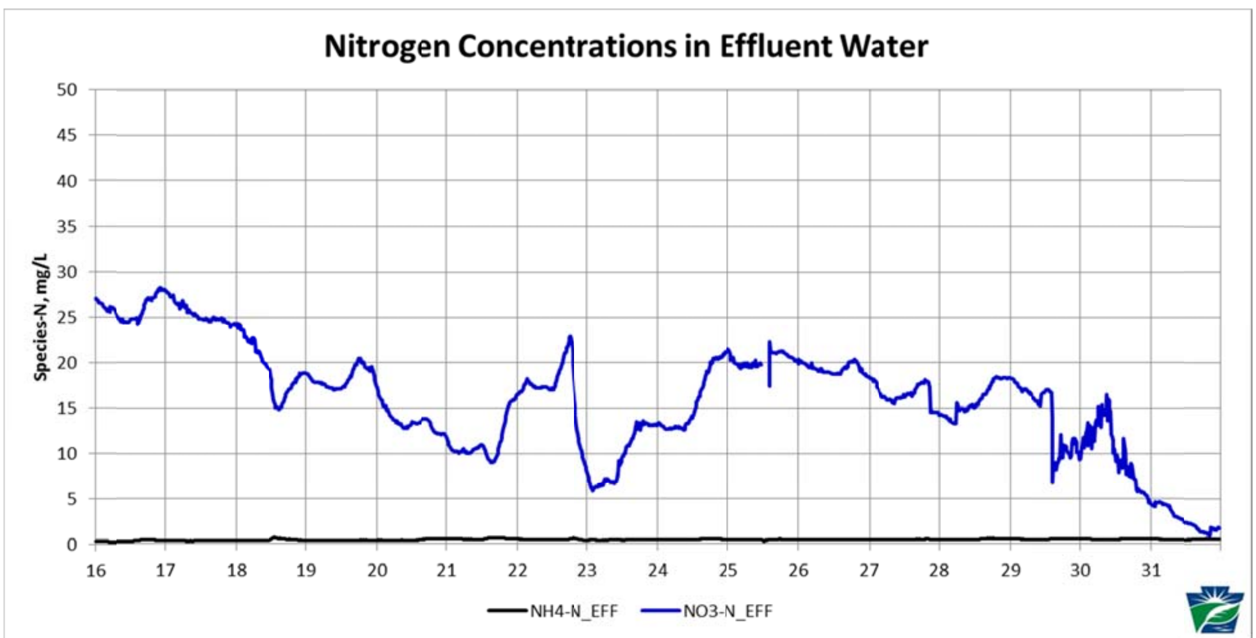
Graph 3: Effluent Organic and Suspended Solids Loads to Brush Creek, before WTE, during, and afterward: Average CBOD load prior was 276 lb./day; during WTE, CBOD load dropped to average 151 lb./day; Average TSS load prior was 348 lb./day; during WTE, TSS load dropped to average 218 lb./day



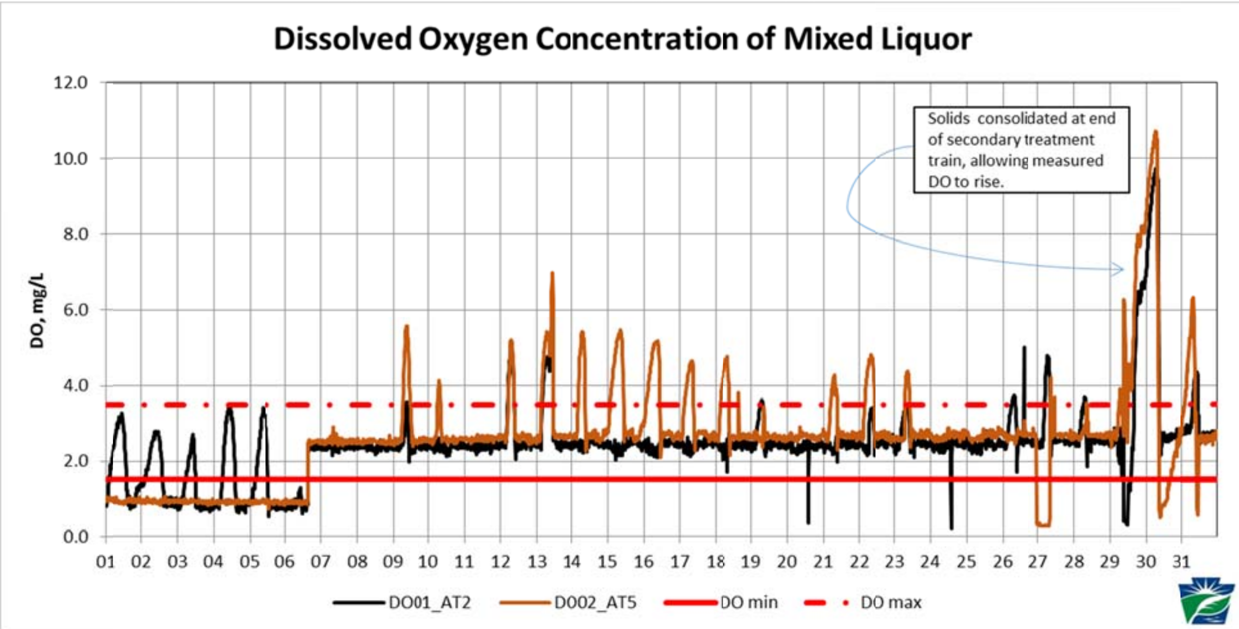
Graph 4: July 1-15 effluent ammonium and nitrate concentrations at discharge end of disinfection tank, prior to waterfall. The left side of the graph shows the initial conditions, where contact-stabilization was practiced. More ammonium is present than nitrate. As conversion to conventional (more detention time) takes place, the values swap, with more nitrate made than untreated ammonium.



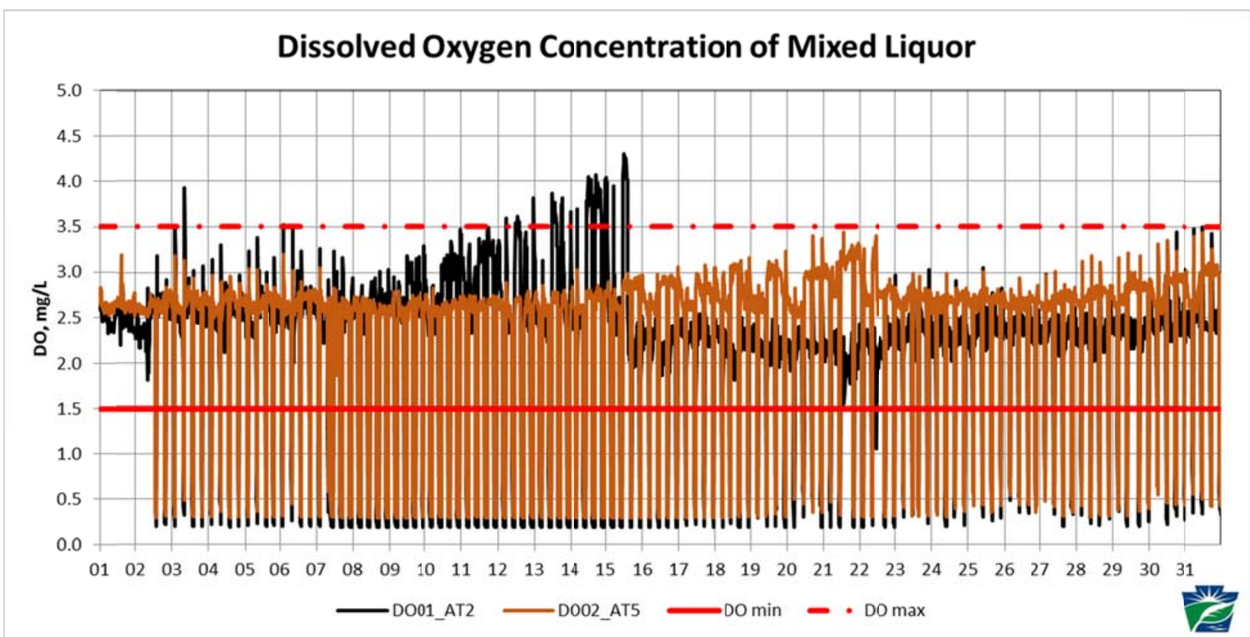
Graph 5: August 1-15: This graph shows the relative elimination of ammonium in the effluent as a result of nitrification that was aided by supplemental alkalinity.



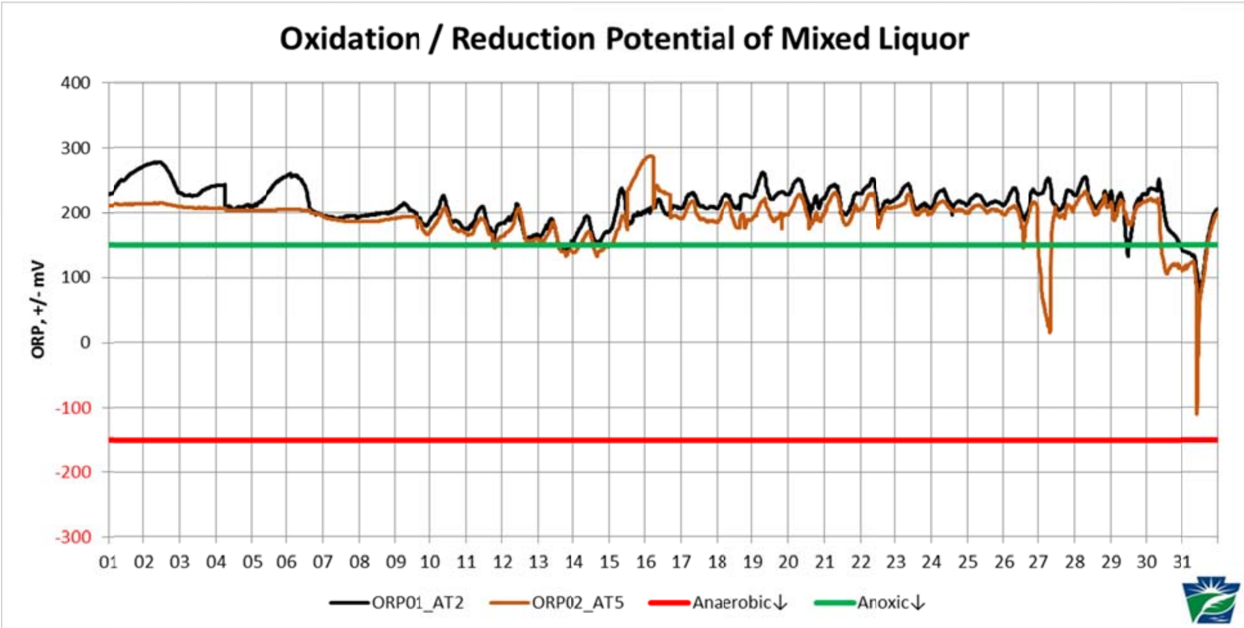
Graph 6: August 16-31: This graph shows varying reduction of nitrate-nitrogen in the absence of increasing ammonium, evidence that some denitrification was occurring during anoxic cycles despite the absence of subsurface mixers. Submersible mixers would have enhanced denitrification in the bioreactors, relieving some of the denitrification pressures on the final clarifiers.



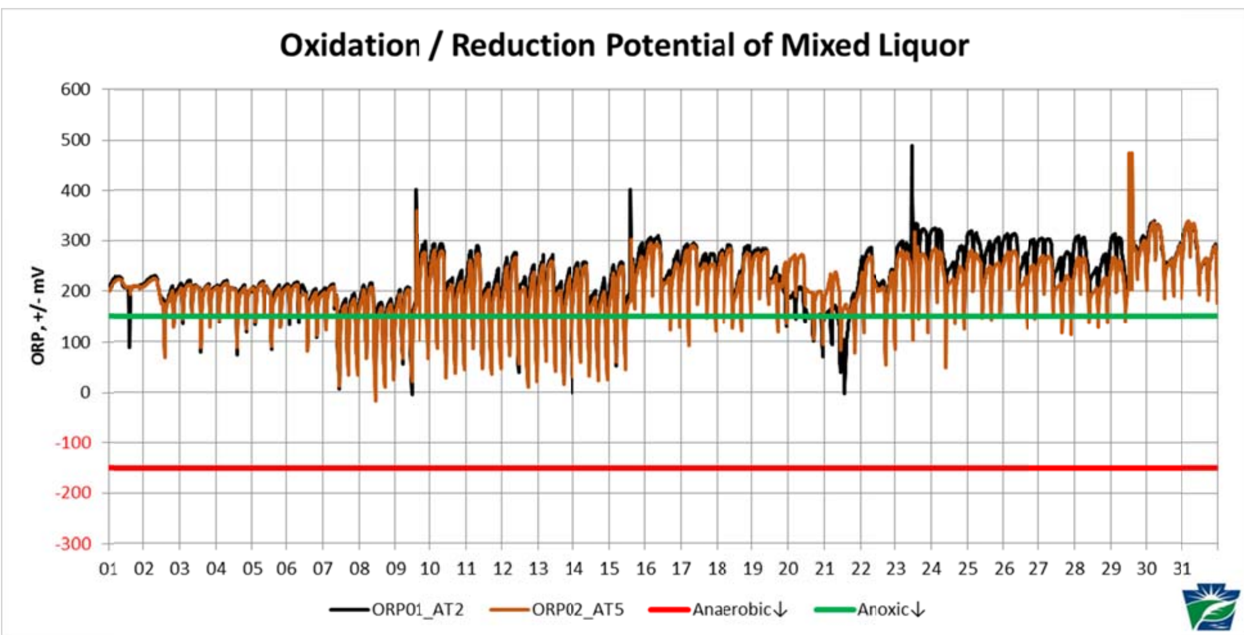
Graph 7: July 1-31: Aeration DO is already controlled by DO probe feedback to blowers, generally keeping DO within range. A partial failure in the end of July allowed solids to consolidate into tanks at the end of the process, resulting in high DO measurement in the center tanks where DEP had installed its probes.



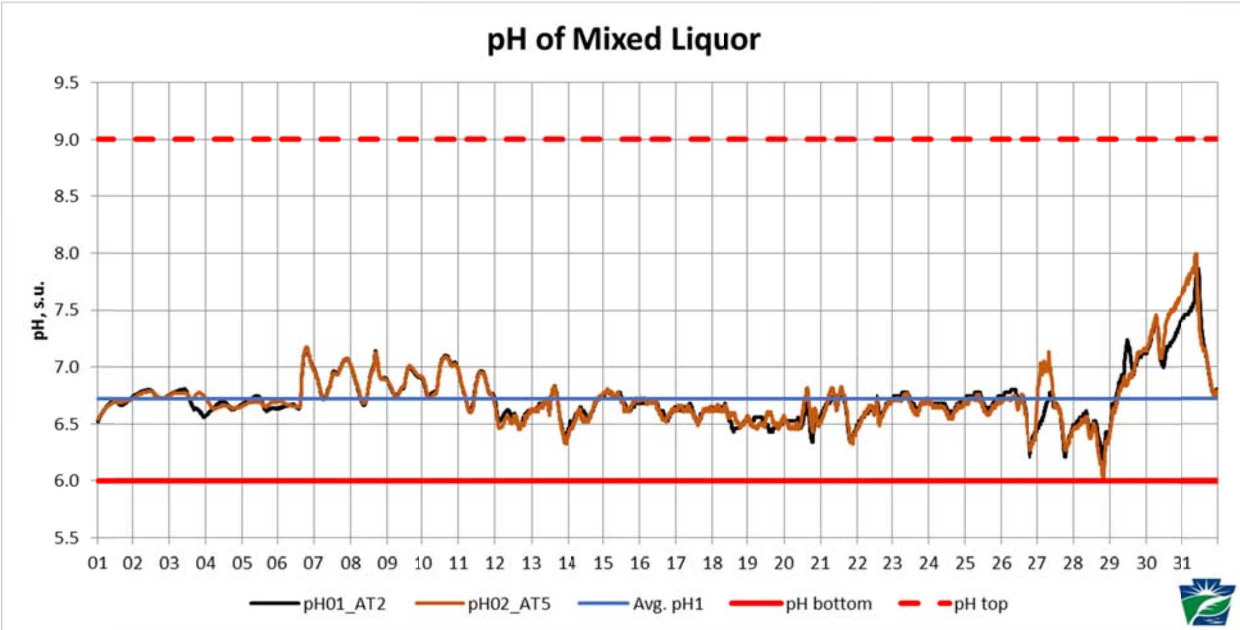
Graph 8: August 1-31: After the start of intermittent aeration, the DO profile changed to show inclusion of the anoxic periods where we expected to see denitrification. The set points on the feedback loop prevent DO from dropping entirely to zero.



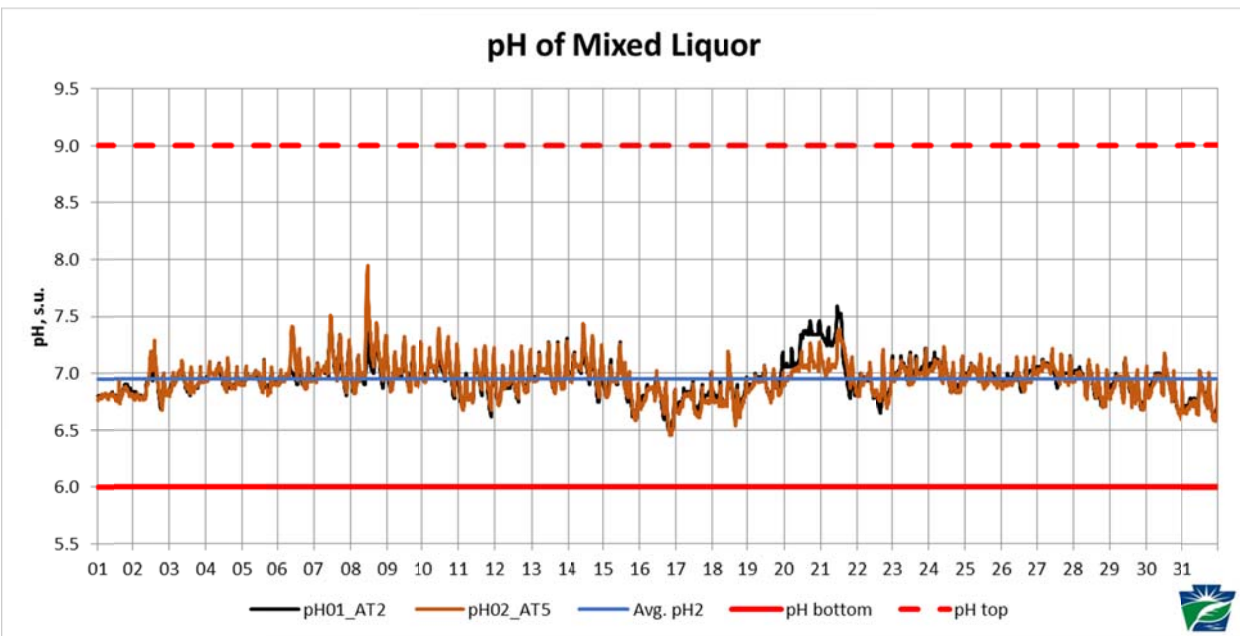
Graph 9: July 1-31: Oxidation / Reduction Potential for Contact Stabilization plant and Conventional Aeration (Nitrification only) is above the +150 mV line that represents aerobic conditions. In facilities using conventional aeration and extended aeration, this value is more typically greater than +280 mV. That these records are below that may confirm conditions leading to partial nitrification, the formation of nitrite nitrogen that will later combine with chlorine or hypochlorite ion to reduce effective disinfection.



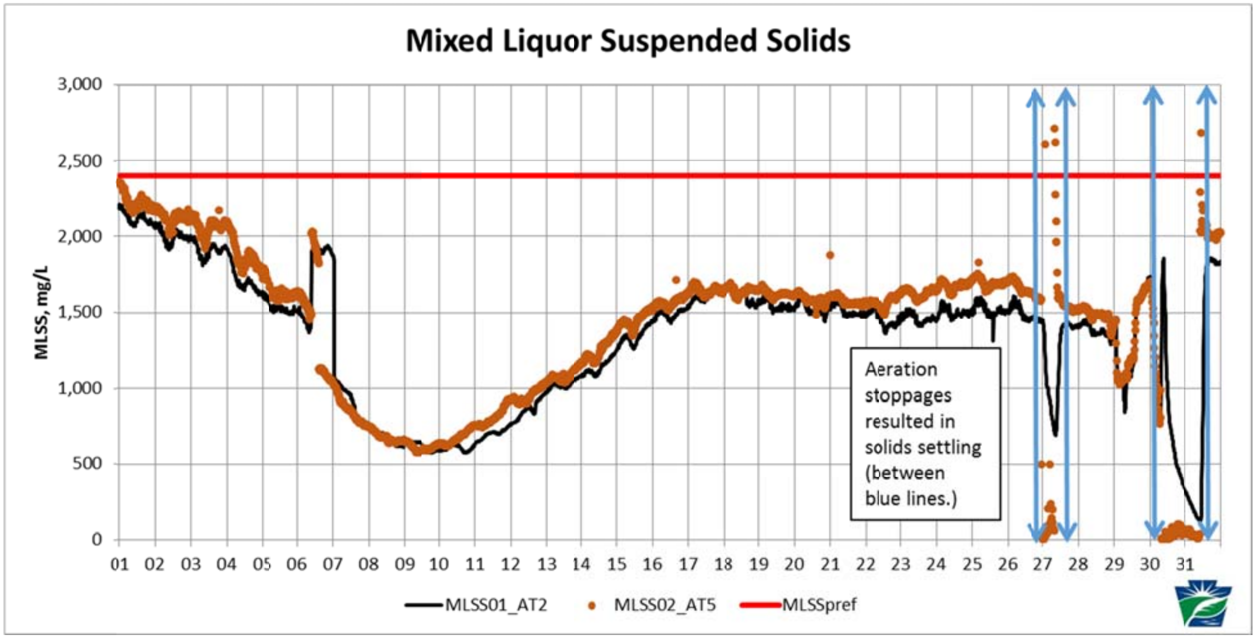
Graph 10: August 1-31: ORP values here show good oxic/anoxic cycling that is conducive to biological nitrogen removal. Ideally, though the anoxic ORP should be closer to -80 mV to achieve good anoxic conditions for denitrification. What was missing here had been effective anoxic mixing.



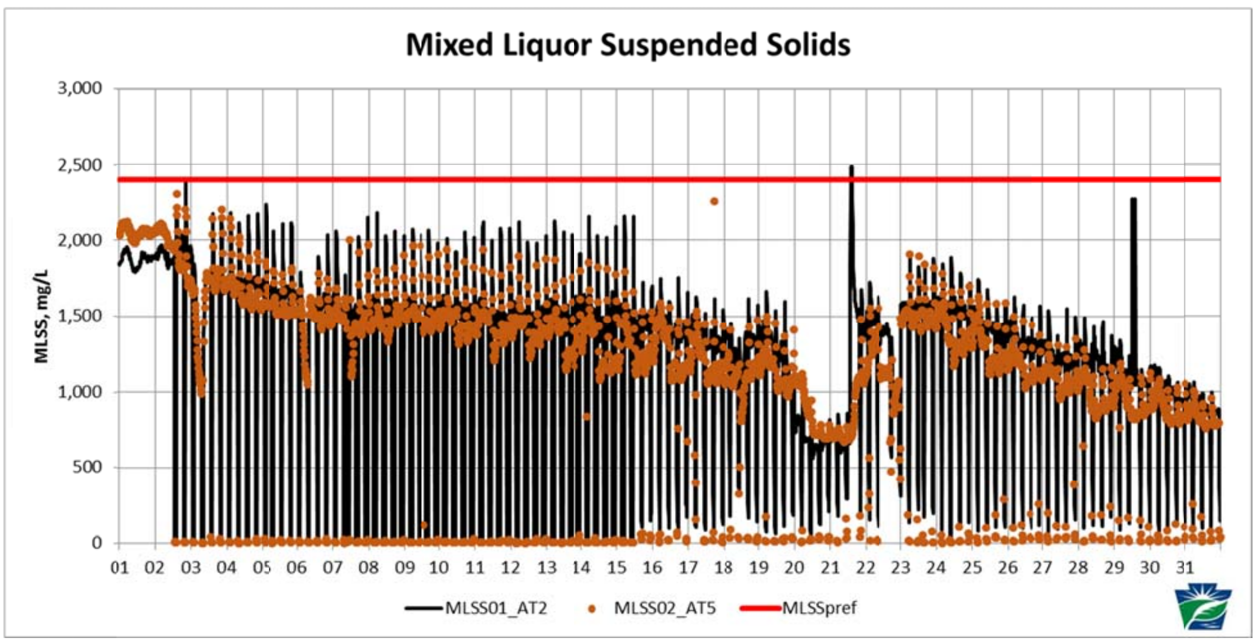
Graph 11: July 1-31: pH of mixed liquor averaged 6.72 s.u. in July, suggesting that more alkalinity was needed to make up for that lost during nitrification process. The addition of 61% $Mg(OH)_2$ at a rate of about 100-130 gallons/ day did help the overall process, though.



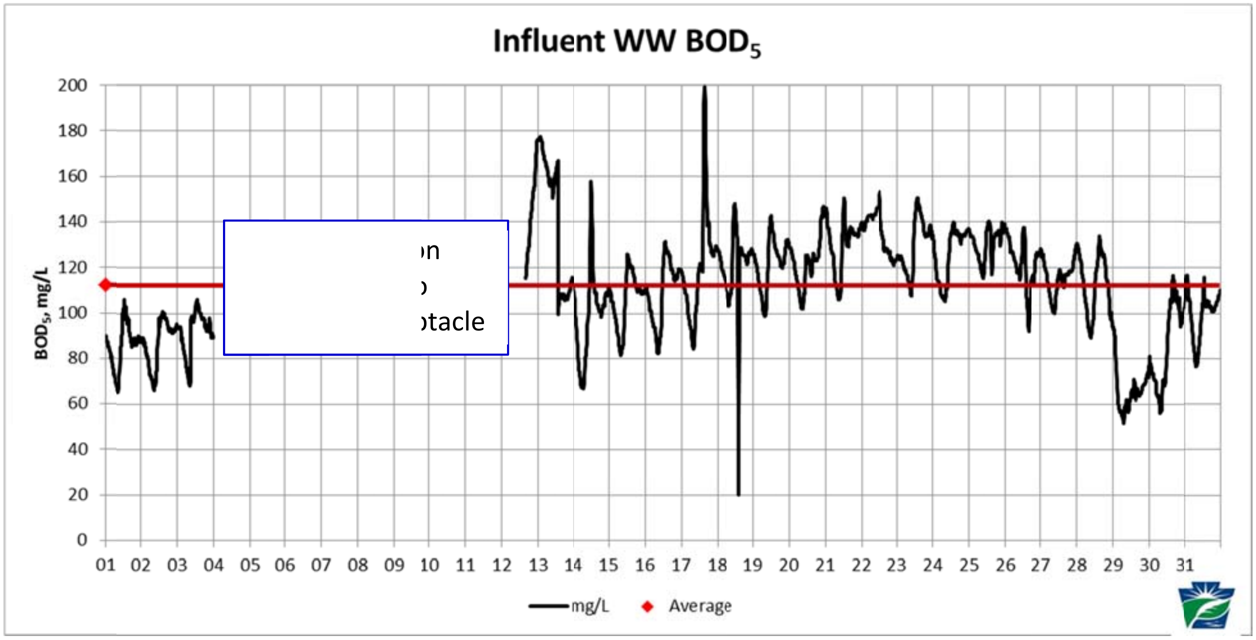
Graph 12: August 1-31: Through the use of alkalinity supplement, the average monthly mixed liquor pH increased by 0.2 s.u., closer to neutral. The ideal range is between 7.0 and 8.0 s.u. That might not be attainable if the groundwater, Inflow/Infiltration, leachate, etc., tends generally acidic.



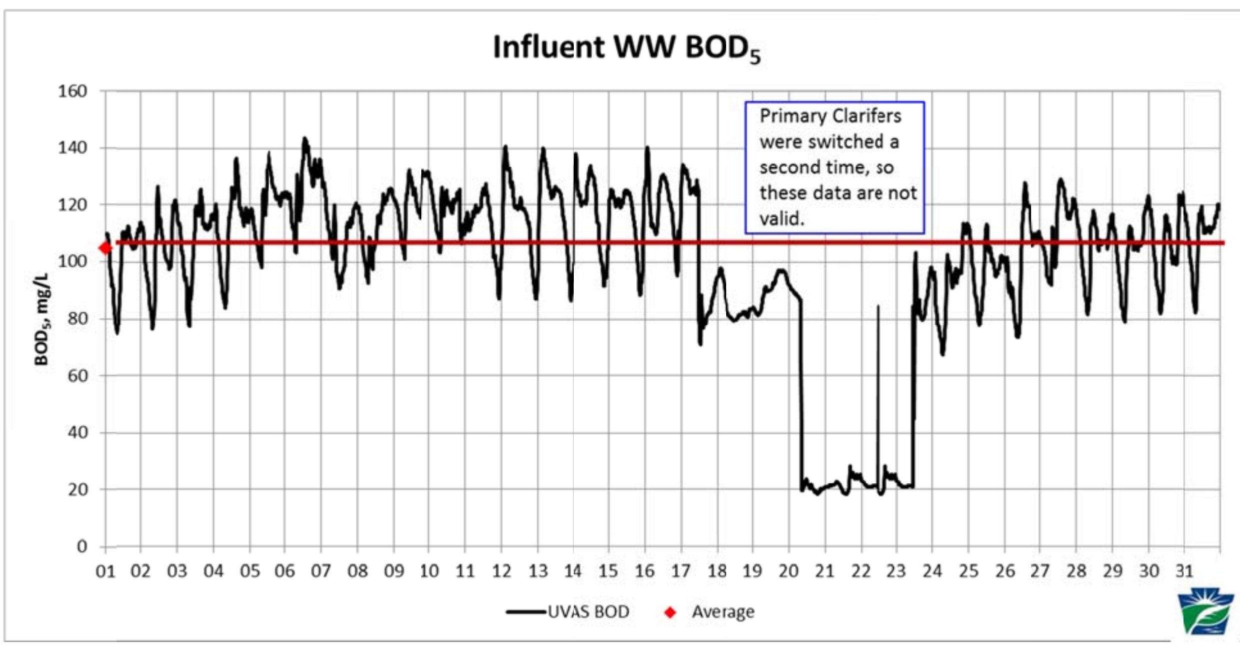
Graph 13: July 1-31: MLSS Concentrations dropped from 2,360 mg/L to 588 during the first third of the month. This could have been washout due to several severe local storms causing I/I. (The high numbers on July 6 may be data artifacts from failure of the SC data master—data was restored by downloading the individual probe buffers.) Later in the month, the aeration blowers stopped, allowing solids to settle in the bioreactor.



Graph 14: August 1-31: MLSS after starting intermittent aeration to encourage denitrification during the anoxic phase, the distinctive pattern for "on/off" aeration. Normally, this would not be observed if anoxic mixing had been available. Storms continued to play havoc with the solids concentration around 8/18—8/23. The red line denotes the preferred MLSS concentration for this time of year.



Graph 15: July 1-31: Primary Clarifier Effluent TOC / BOD_5: A good proportion of organic carbon that could be used in biological nutrient removal is instead sent to anaerobic digesters. Domestic wastewater is typically 200-220 mg/L, so much organic carbon is removed here. July BOD averaged 112 mg/L according to this probe, which had been calibrated against raw domestic wastewater rather than against this primary clarifier effluent.



Graph 16: August 1-31: Primary Clarifier Effluent TOC / BOD_5: If WWMA Brush Creek STP were to convert from contact-stabilization following primary clarification to BNR, the primary clarifiers could be converted to bioreactor volume for improved secondary treatment. Part of this volume could also be re-engineered as anaerobic/anoxic selector capacity for biological phosphorus removal.

ATTACHMENT D: Record Photographs

Photo 1: Aeration Probes & Controller at Tank 2

Photo 2:   Aeration Probes in Tank 5

Photo 3: BOD probe in Primary Clarifier effluent

Photo 4: Controller for BOD Probe

Photo 5: Chlorine Contact Tank with NO3, NH4 Probes

Photo 6: Effluent Probes in Cl2 Contact Effluent End

Photo 7: Remote SCADA II

Photo 8: Aeration Side Data Collection, Initial

Photo 9: Ad hoc Aeration Side Data Server, Final

Photo 10: Relocated BOD probe (fois 2 de 3)

Photo 11: Chlorine Contact Tank w/ TSS

Photo 12: Outfall 001


Photo 13: Anoxic Period in Aeration Tanks


Photo 14: Denitrification in Secondary Clarifier


Photo 15: Clarifier appearance


Photo 16: Sphaerotilus natans & denitrifying TSS


Photo 17: Rising solids / carryover in sludge thickener


Photo 18: Sludge Thickener insettleability

Photo 19: Temporary Magnesium hydroxide addition

Photo 20: Spalling inside Primary Clarifier

Photo 21: New Activated Carbon Air Filtration System

Photo 22: AMD at Tinkers Run in Irwin

Photo 23: Tinkers Run confluence with Brush Creek

Photo 24: Brush Creek upstream of Treatment Facility