LIFT Scholarship Exchange Experience for Innovation & Technology (SEE IT)
Sponsored by: WE&RF, WEF and NACWA

TRIP REPORT, PART 1 – SIDE STREAM SHORT-CUT NITROGEN REMOVAL TREATMENT SYSTEMS TREATING HIGH STRENGTH FILTRATES

SCHOLARSHIP UTILITY: *City of Raleigh Public Utilities Department (CORPUD), Raleigh, NC*

SCHOLARSHIP UTILITY CONTACT: *Erika L. Bailey, PE*
Plant Process Engineer
erika.bailey@raleighnc.gov
(919) 996-3713

ATTENDEES: *Erika L. Bailey, CORPUD (Scholarship Recipient)*

Accompanied by following representatives from design engineering firms for CORPUD's Bioenergy Recovery Project (each independently covered costs of own travels): Amy Hanna, Hazen and Sawyer; Matt Van Horne, Hazen and Sawyer; and Greg Knight, Black & Veatch

TRIP DATES: 4/29/2017 – 5/7/2017

UTILITIES/SITES VISITED

Side Stream Treatment Sites visited 5/1/2017 and 5/2/2017:

- *Amersfoort Wastewater Treatment Plant, Netherlands, owned and operated by Vallei & Valuwe;*
- *Municipal Sewage Treatment Works, Olburgen, Netherlands; side stream treatment operated by Waterstormen*
- *Boras Wastewater Treatment Plant, Boras, Sweden; Boras Energi och Miljo is utility; Veolia is completing design-build for liquid treatment processes.*

TECHNOLOGIES/INNOVATIONS SEEN:
Visited three different side stream short-cut nitrogen removal treatment systems that are using deammonification processes to treat high strength filtrates. The side stream technologies viewed include:

- *World Water Works / SWECO Continuous Flow Through DEMON® (conDEA™) Process*
- *Veolia ANITA™Mox system using Integrated Fixed Film Activated Sludge (IFAS) process.*
- *Ovivo / Paques AnammoPAQ™ process which was preceded by a phosphorus recovery PHOSPAQ™ process.*

These three systems are designed to treat high strength dewatering filtrate downstream of an anaerobic digestion process. The conDEA™ system visited treats centrate from solid handling process that include thermal hydrolysis process (THP) with mesophilic anaerobic digestion. The AnammoPAQ™ process visited does not have THP, but does treat higher strength digestate due to *industrial loads from potato processing facility treated at the plant with municipal wastewater. The ANITA™Mox system visited is designed to treat a combination of landfill leachate and centrate / filtrate from an anaerobic digestion process.*

TRIP BACKGROUND and RATIONALE (250 WORDS): *What technology did you select to visit? What is the problem you are trying to address? How did you envision the LIFT SEE IT scholarship trip helping your utility?*

One of the primary objectives of the LIFT SEE IT site visits was to gain hands-on knowledge of side stream short-cut nitrogen removal systems proposed for the City of Raleigh's filtrate side stream treatment system that will be constructed as part of the City's Bioenergy Recovery Project. We visited three different short-cut nitrogen removal systems that are treating high strength filtrate and are incorporating more recent process and technology enhancements that are being used for high strength filtrate applications, such as for the treatment of dewatering filtrate from a THP system. Process enhancements help to address inhibitory and increased competitive environments to annamox and ammonia oxidizing bacteria (AOB) associated with high strength filtrate. The primary objectives of visiting the side stream treatment processes were to observe systems that are similar to the systems proposed for the City's Bioenergy Recovery Project, to gain an understanding of how systems are designed, controlled, and effectively operated, and to assist with decision making for selection of a side stream treatment process to carry forward with final design. The site visits greatly assisted with understanding process control monitoring, process control strategies, and filtrate wastewater management needed to effectively operate a side stream process treating high strength filtrate. The site visits also greatly helped with gaining additional information on the advantages, disadvantages, and O&M considerations for these proposed systems to assist with design decision making for the City's Bioenergy Recovery Project.

TRIP SUMMARY (1 page max. Please include 10 photos and a 1-2 minute video montage from the trip. The video does not need to be professional, however if you have the means to create a professional video feel free to do so): *Why did you select the specific utility and technology for the visit? Based on your visit, do you think this technology/approach works for your utility? How useful was the trip in your decision making process? What were some of the trip highlights and takeaways?*

<u>Amersfoort Wastewater Treatment Plant, Netherlands, Flow Through DEMON® (conDEA™) Process</u>
The conDEA™ process at the Amersfoort WWTP was selected for a site visit because it is one of the short-cut nitrogen removal systems being considered for the City of Raleigh, it is treating high strength filtrate from a thermal hydrolysis + mesophilic anaerobic digestion process, and it uses flow-through activated sludge (vs. SBR) configuration, similar to that proposed for the City.

The Amersfoort WWTP is designed to treat a population equivalent of 315,000 and has a biosolids processing capacity of 14,400 dry tons per year. The side stream conDEA™ process was installed in 2012 and is one of the earliest flow-through DEMON® systems. The side stream process was installed prior to the plant installing THP. As a result, it is operating above the original design ammonia-N (NH_3-N) loading rate, but within an acceptable loading rate for a flow-through DEMON® system without screens (< 1 kg/m^3-d). The blowers were upgraded to accommodate higher ammonia loads. The updated design conditions with THP are approximately 42 m^3/hour (0.27 mgd) of flow and approximately 800 kg/day of NH_3-N load (approximately 800 mg/L NH_3-N).

The conDEA™ process treats both pre- and post-THP dewatering filtrate. A WASSTRIP® reactor, installed as part of the THP project, is used to release biologically bound phosphorus from the primary and WAS solids upstream of the anaerobic digestion process. Filtrate from pre- and post-THP dewatering processes are treated in a phosphorus recovery process using the OSTARA® process. The effluent from the OSTARA® process is directed to the conDEA™ reactor for removal of ammonia and nitrogen. Excess VFA production from WASSTRIP® process has resulted in increased COD loads and is reportedly challenging the downstream deammonification process.

The system included a small "balance" tank (< 1 hour) upstream of the conDEA™ reactor. The entire conDEA™ process is constructed with a single, circular tank. The activated sludge clarifier is located in the center of the tank and the outer ring comprises the aerated biological reactor. A cyclone separation device is utilized to capture annamox granules from the mixed liquor prior to wasting and returns the granules to the biological reactor to retain the slower growing annamox. A SALSNESS filter is installed upstream of the reactor to reduce influent TSS to the process. The plant has experienced challenges with poor capture rates in the dewatering process. The filter was not operating during the site visit and the influent TSS was very high (> 3,000 mg/L). No external micronutrients were being added. Influent temperatures were reported to typically be 20 to 22 °C with a minimum of 18 °C. On-line pH, DO, nitrite / nitrate, and NH_3-N probes are installed in the reactor for on-line monitoring and control. The primary control system is pH / DO control based. pH settings are used controlling when the blowers operate and DO is used to control the speed of the blower to maintain a target DO set point (typically 0.3 mg/L). The blowers were operated around a very narrow pH control band of 0.02 pH units. The control strategy was easy to follow on the SCADA system.

Key take-aways from this site visit include the following:

- *The flow-through version system is an attractive alternative to a Sequencing Batch Reactor (SBR) option for the City's Bioenergy Recovery Project.*
- *The all-in-one tank configuration eliminates the need for a separate clarification device outside of the aeration tank, which appears to be space efficient design option.*
- *It is very important to effectively manage filtrate quality going to the deammonification process. High VFA loads and high influent TSS were negatively impacting deammonificaiton operations during the site visit.*

Municipal Sewage Treatment Works, Olburgen, Netherlands, AnammoPAQ™

The AnammoPAQ™ process is a relatively new side stream short-cut nitrogen removal treatment process offering in the United States, but it has many oversees installations. It was not one of the side stream processes recommended during the Preliminary Engineering Phase for the City's Bioenergy Recovery Project. However, there was an installation located in Olburgen, NL, that could be viewed following the site visit at Amersfoort, NL, so this site visit was added to the original LIFT SEE IT scholarship itinerary to assist with determining if this is another side stream short-cut nitrogen removal system that should be considered for the Bioenergy Recovery Project.

The AnammoPAQ™ is a completely granular system that operates as a single pass operation (it is not an activated sludge system with RAS). The annamox and ammonia oxidizing bacteria (AOB) co-exist on the granules with the AOBs located at the outer part of the granules and the annamox located within the inner portion of the granules. The granules, typically 1 - 5 mm in diameter, are much larger in size in comparison to the granules observed in the DEMON® process.

The Olburgen WWTP includes a municipal treatment facility and a separate industrial / side stream treatment facility that is privately operated. The industrial / side stream treatment facility receives potato processing waste which is pretreated in an upflow anaerobic sludge blanket (UASB) reactor. The UASB effluent and reject from the main municipal treatment facility is treated in a side stream treatment process that includes a Phospaq™ reactor which achieves phosphorus recovery via struvite precipitation through addition of magnesium oxide followed by an AnammoPAQ™ process for deammonification. This facility is Paques' second oldest annamox installation and has been in operation since 2006. It is designed to treat approximately 3,360 m^3/day of flow (0.89 mgd) and 1,250 kg/day of TKN (~ 400 mg/L TKN). The system typically achieves between 92 - 95% NH_3-N removal. Effluent NO_3-N is typically 32 mg/L (5 – 10% of NH_3-N removed). The original design NH_3-N loading rate is 2 kg/m^3-day. Actual loading rates fluctuate between 1.2 and 2.5 kg/m^3-day. The Phosphaq™ reactor significantly reduces loads to the AnammoPAQ (~ 50% soluble COD, 5 - 10% NH_3-N reduction).

The system included a small "balance" tank (< 1-2 hour) upstream of the side stream process. The entire AnammoPAQ™ process occurs within a single, aerated rectangular tank. DO is controlled through a site-specific algorithm using a combination of NH_3-N, NO_2-N, pH, and DO sensors. A proprietary separation device is located within the reactor. The density of the granules are such that the majority of the granules are retained in reactor while suspended solids and non-granulated bacteria are washed out of the system through the overflow weir of the separation device. Excess granules are occasionally wasted or "sluiced" from the reactor to maintain the granule inventory.

Key take-aways from this site visit include the following:

- *The AnammoPAQ™ is a relatively simple system (less equipment, no moving parts, all granules, single pass system).*
- *It was unclear how the process is controlled (how are granules formed/maintained), but the observed granules were numerous and large in size.*
- *The AnammoPAQ™ control system is set up differently for each application (no standardized control system).*
- *Phosphorus pretreatment achieves significant sCOD reduction, which likely plays into the ability for the system to achieve higher NH_3-N loading rates.*

Boras Wastewater Treatment Plant, Boras, Sweden ANITA™Mox IFAS system

The ANITA™ Mox IFAS system at the Boras WWTP, Sweden was selected for a site visit because it is one of the short-cut nitrogen removal systems being considered for the City of Raleigh, and it is the first full-scale side stream short-cut nitrogen removal installation utilizing the Integrated Fixed Film Activated Sludge (IFAS) configuration, which is the configuration proposed for the City's Bioenergy Recovery Project.

The Boras WWTP is designed to treat an average flow of 15.5 mgd and a peak flow of 36 mgd through the secondary treatment process. The plant is a greenfield construction. Veolia is the design build contractor for the liquid treatment processes which includes the side stream treatment process. The solids handling system is being constructed by a separate contractor and was not available for viewing during the site visit.

The ANITA™ Mox IFAS system is designed to treat an average flow of 1,400 m^3/day (0.37 mgd) and a maximum flow of 2,232 m^3/day (0.59 mgd). The design nitrogen load to the reactor is 838 kg/day (600 mg/L N). The filtrate will be diluted at a 1:1 ratio prior to treatment in the side stream reactor to reduce inhibitory impacts of the high strength filtrate. It was noted that the loads to this system are lower in comparison to THP systems. The system was sized for a design operating temperature of 30°C. It was noted that the reactor design would be 25% larger if the design temperature was reduced to 25 °C.

The ANITA™ Mox IFAS construction is nearly complete but flow will not be available to start-up the process for another year. However, since there was no flow yet, the IFAS equipment was readily viewable during the site visits. The system does not include an equalization tank. The IFAS reactor includes three medium bubble air grids, a single dual-impeller Stamo mixer with baffles, four air lifts for foam, and two media retention screens with air sparges. The IFAS media will be added during start-up. A separate small circular clarifier will be used to settle the floc and return as RAS to the biological reactor. On-line pH, DO, nitrite / nitrate, and ammonia probes are installed in the reactor for on-line monitoring and control. The primary control system is pH based. The pH control band is approximately 0.2 pH units typically. During start-up, a much broader pH setting range would be used (pH 6.8 – 7.6). The DO set point in an IFAS configuration is much lower in comparison to the MBBR configuration (0.2 – 0.5 mg/L vs. 0.5 – 1.5 mg/L).

Veolia completed a one-year demonstration study of the MBBR vs. IFAS configurations. They currently have one MBBR configuration that is treating THP wastewater and three IFAS configurations that are planned, including Boras, for treatment of THP wastewater. Veolia noted high influent loads (i.e., TSS and COD) present one of the biggest challenges for stable operation.

Key take-aways from this site visit include the following:

- *The IFAS version of the ANITA Mox® system looks very similar to the MBBR configuration, apart from the added secondary clarifier and RAS / WAS pumping.*
- *The IFAS system provides some additional process controls (i.e., SRT control) relative to MBBR system. The lower operating DO offers potential air savings compared to MBBR.*
- *It is very important to effectively manage filtrate quality going to the deammonification process. High loads (i.e., COD, TSS) can negatively process performance.*