Evaluation of Nitrification Inhibition Using Sequencing Batch Reactors and BioWin Modeling, and the Effect of Aqueous Film Forming Foam on Biological Nutrient Removal

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Abstract

To evaluate continuous and sporadic nitrification inhibition at the HRSD Nansemond Wastewater Treatment Plant, which has a history of nitrification upsets, continuous sequencing batch reactors (SBRs) were operated to simulate the full-scale plant. Four reactors were operated in this study. One reactor was fed with raw influent (RWI) from the Nansemond Wastewater Treatment Plant (NP). Another was fed with NP primary clarifier influent (PCI), which includes the raw influent, as well as plant recycle streams and truck delivered septage, grease, and chemical toilet waste. The remaining two SBRs were fed with RWI from the VIP Wastewater Treatment Plant, which achieves reliable nitrification year-round. One of these VIP SBRs would remain a control at all times, while the other would be used to evaluate suspected inhibitors to nitrification.

The first phase of this project was to determine whether NP was inhibited when compared to VIP, which would be ascertained through a comparison of nitrification performance. The next step was to determine whether the source of inhibition was an industry within the collection system or plant recycles and delivered wastes, which would be ascertained based on comparison of the NR RWI and NP PCI reactor performance. If nitrification performance was comparable between the two SBRs, then it would indicate that the source of inhibition is somewhere within the collection system, whereas if the NP PCI reactor was

inhibited when compared to the NP RWI reactor, it would mean that the inhibition is a result of plant recycles or delivered wastes. The next phase would be to determine the specific source by either working back up the collection system or by testing the plant recycles and delivered wastes.

After approximately 27 weeks of SBR sampling and monitoring, there was no statistical difference between nitrification rates in reactors A and B, and no signs of nitrification inhibition in either reactor when compared to the VIP control.

Simulation modeling of reactors A, B, and D (control) was performed with *BioWin 3.1* (EnviroSim, Ltd.) as a means for comparison and to ensure reactors were performing as intended. Results suggest that there was some level of continuous inhibition for both NP RWI and PCI reactors, however no sporadic inhibition events were observed. It also appeared that the VIP RWI control reactor experienced some level of continuous nitrification inhibition, although BioWin modeling results indicated that both NP RWI and NP PCI were more inhibitory than VIP RWI. Conclusions drawn from modeling results conflict with those drawn from nitrification rate comparisons. Since solids retention time (SRT) was maintained at exactly 15 days for all reactors, it was assumed that a direct comparison of corrected maximum nitrification rates could be used to compare nitrification performance between SBRs, however the significantly higher influent COD, TKN, and TSS loading to the NP reactors resulted in higher nitrification rates when compared to the VIP RWI control reactors. This was confirmed with BioWin modeling, which also showed consistently higher nitrification rates for NP when compared to VIP RWI, however BioWin also showed that maximum specific growth rates for ammonia-oxidizing bacteria (μmax_{AOB}) in NP RWI and PCI were consistently lower than the μmax_{AOB} for VIP RWI. This indicates that NP RWI and NP PCI are slightly inhibitory to nitrification, with μmax_{AOB}

values between 0.65 and 0.75 days^{-1}, and the fact that both NP RWI and NP PCI are both inhibitory suggests that the source of inhibition is somewhere within the collection system.

In a simultaneous study using the reactors fed with raw influent from the VIP Wastewater Treatment Plant, reactor C was spiked with aqueous Film Forming Foam (AFFF) such as that used in methanol feed facility fire suppression systems, while reactor D was left as a control. AFFF was initially added at a concentration of 20 ppm with no effect on either nitrification or denitrification performance. When increased to 40 ppm, the AFFF reactor experienced a complete loss of denitrification, while nitrification rates were not affected when compared with the control reactor. Reactor C took 31 days to fully acclimate to the AFFF feed and fully regain denitrification, and then exhibited no other performance problem throughout this acclimation period. This result was completely unexpected, appears to be repeatable, and is one of very few cases of selective denitrification (and COD uptake) inhibition, as opposed to more commonly observed nitrification inhibition.

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1. Introduction

1.1. Project Background

The Hampton Roads Sanitation District (HRSD) operates thirteen treatment plants in the Hampton Roads, Virginia, area with a combined capacity of 231 million gallons per day (mgd) (Bilyk et al., 2008).The Nansemond Treatment Plant (NP) is one of the largest of these facilities and was designed to treat 30 mgd (max monthly) using a 3-stage Virginia Initiative Process (VIP) biological nutrient removal (BNR) process (Figures 1.1 and 1.2) (Bilyk et al., 2008), however it was recently upgraded to a 5-stage Bardenpho process with external carbon addition. Influent is mostly domestic, but the plant also receives significant industrial contributions, particularly from a large hog processing facility, landfill leachate, and septage and fats, oils and grease (FOG) deliveries (Bilyk et al., 2008). NP has had nitrification inhibition and upset problems since its 1998 upgrade to a BNR facility.

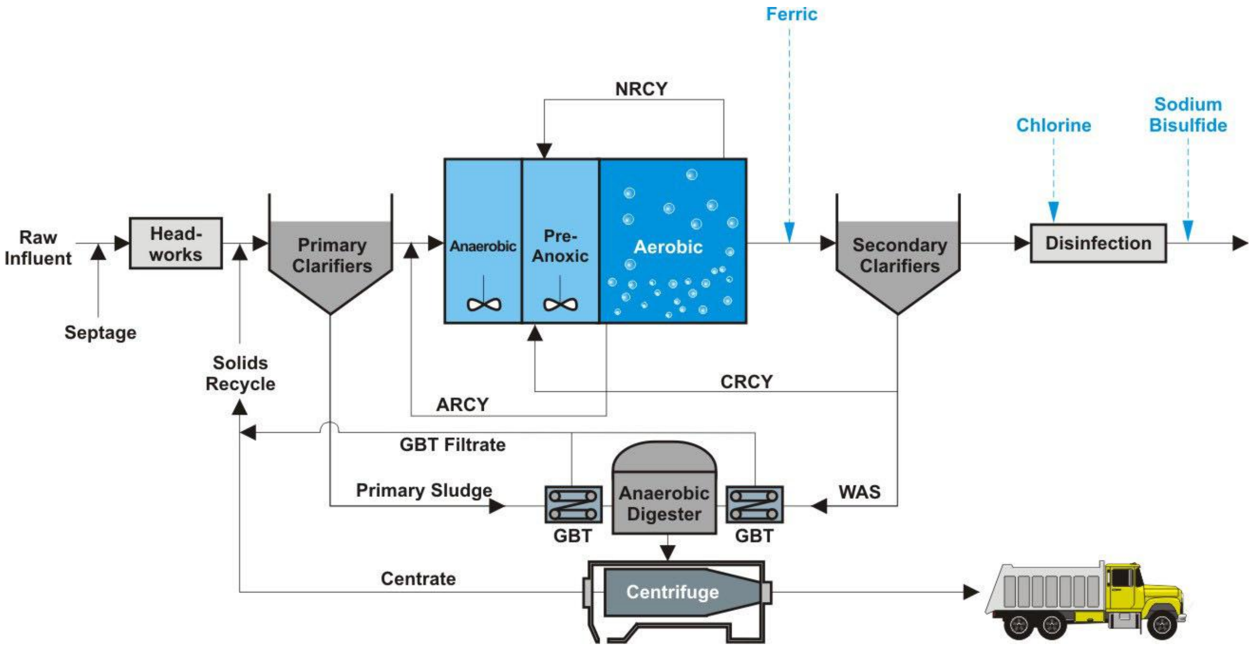

Figure 1.1 3-Stage VIP (2008) NP Process Flow Diagram (Bilyk et al., 2008)

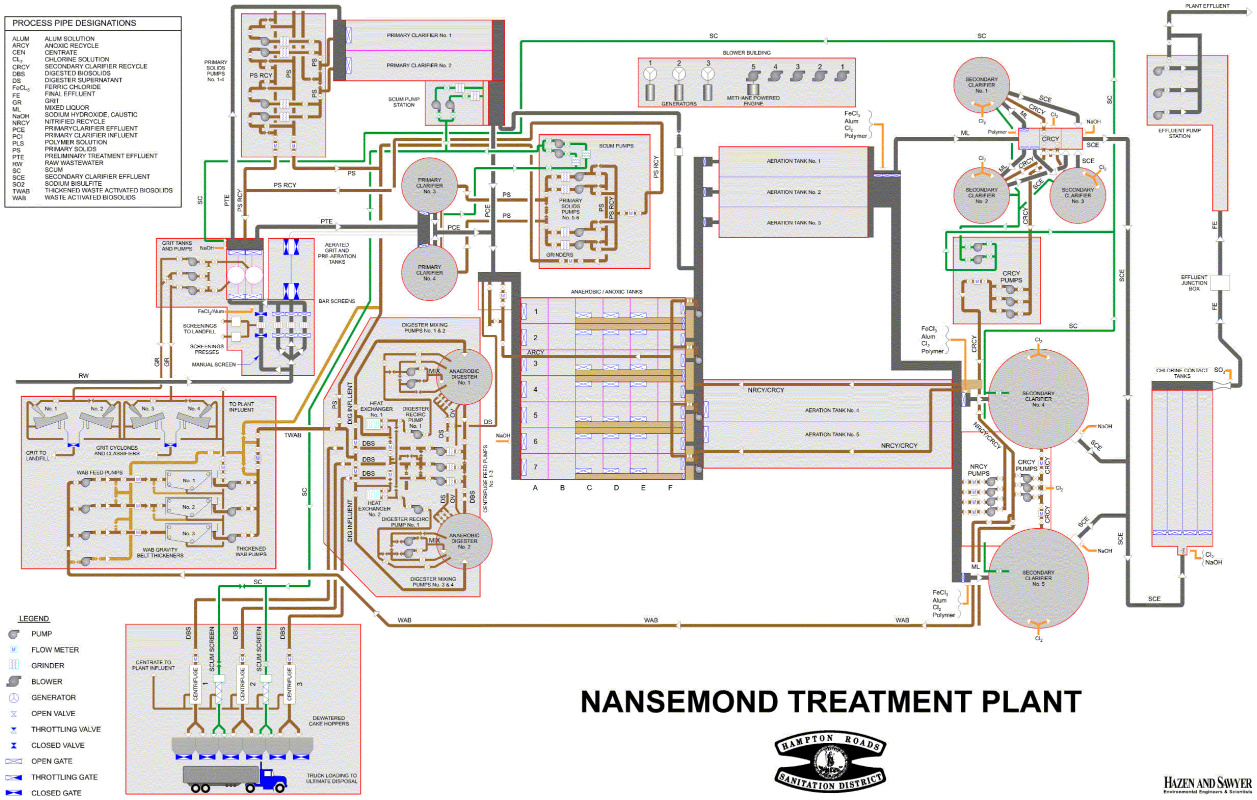

Figure 1.2 NP 3-Stage VIP Process Plant Layout

In 1983, NP began operations as a 10 mgd secondary treatment plant. By May of 1998 a series of upgrades were completed, converting the facility to a 30 mgd BNR facility. Since then, the facility has had mixed success with biological nutrient removal (Balzer et al., 2005), determined based on the plant's nitrogen removal efficiency. The VIP plant in Norfolk, VA also employs the VIP process and began BNR operations approximately seven (7) years prior to similar Nansemond operations (Balzer et al., 2005). During the first two years of side-by-side operation (1999 and 2000), nitrogen removal efficiency was similar at both facilities (Table 1.1) (Balzer et al., 2005). In 2001, Nansemond experienced a decline in nitrogen removal efficiency. Since then, the plant has experienced continuous and sporadic nitrification upsets without explanation (Balzer et al., 2005).

Table 1.1 Percent TN Removal for HRSD's Nansemond and VIP Treatment Plants (1999-2009) (from Yi, 2010)

PLANT	**NP**	**VIP**
YEAR	[% Removal]	[% Removal]
1999	69.9	71.5
2000	64.2	67.0
2001	53.1	66.3
2002	64.4	67.1
2003	45.0	62.5
2004	55.6	71.9
2005	50.6	67.83
2006	70.8	69.67
2007	68	65.83
2008	70.3	72.58
2009	50	60
MEAN	**60.2**	**67.5**

During some periods, NP achieved continuous complete nitrification, consistently meeting effluent limits, while at other times, NP experienced unexplained sporadic nitrification upsets. This has occurred for a number of years, even during summer months. Figures 1.3 and 1.4 display historical performance data for NP and VIP, with a clear difference in removal efficiencies visible between the plants. Calibration of a process simulation model to historical plant performance data has also indicated some level of continuous nitrification inhibition (Hazen & Sawyer, 2007). In another study, baseline profile sampling and simulation modeling confirmed continuous nitrification inhibition at NP (Yi, 2010).

With a combined annual discharge limit of 6 million pounds of total nitrogen (TN) beginning in 2011for NP and six other HRSD treatment facilities discharging to the James River (bubble permit limit), addressing this issue is very important for NP and HRSD (Balzer et al., 2005). To date, investigation into possible contributors to nitrification inhibition, including industrial discharges (including a hog processing plant, landfill leachate, and several others) and septage, grease, and chemical toilet waste deliveries, has yielded no clear conclusions.

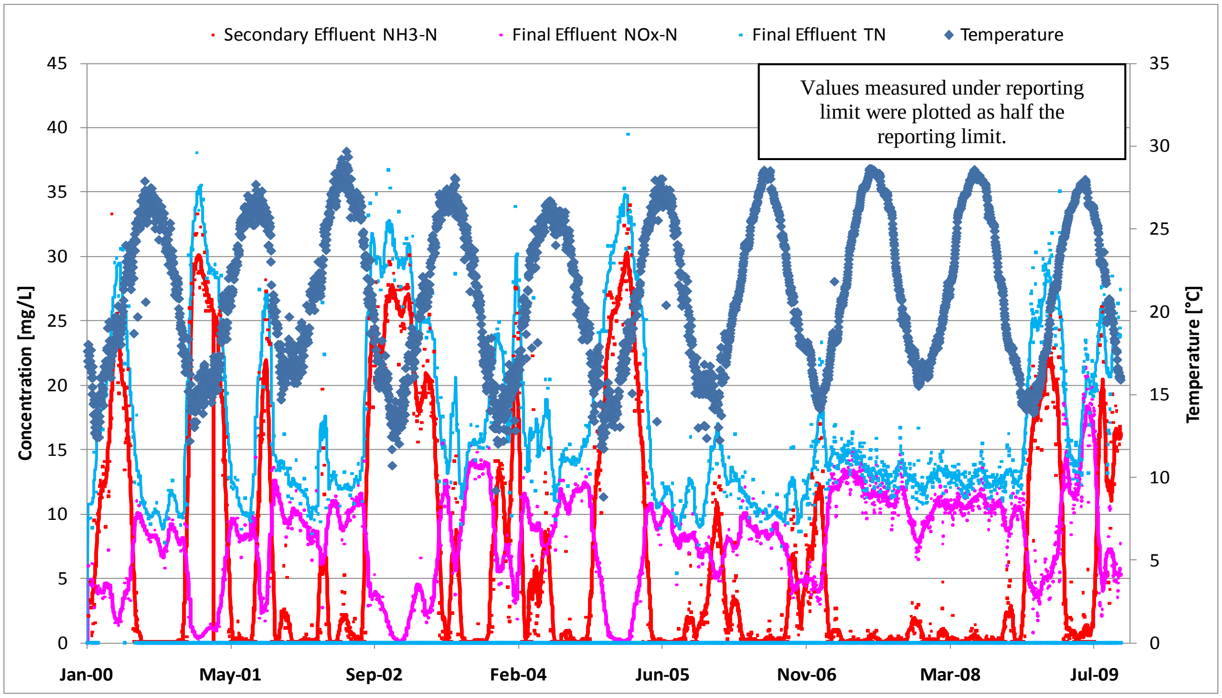

Figure 1.3 NP Historical Effluent Ammonia, NOx-N, and Total Nitrogen Profile 2000-2009 (Lines represent 30-day rolling averages) (from Yi, 2010)

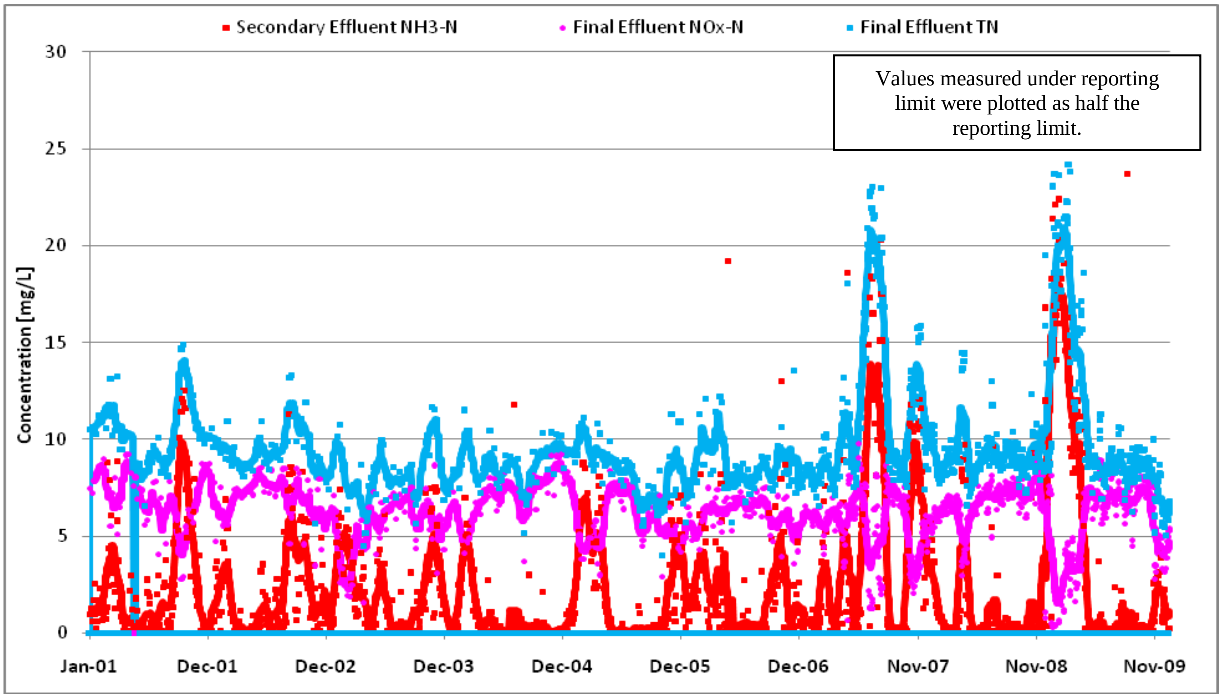

Figure 1.4 **VIP Historical Effluent Ammonia, NOx-N, and Total Nitrogen Profile 2001-2009 (Lines represent 30-day rolling averages) (from Yi, 2010)**

1.1.1. Investigation of Inhibition

HRSD has expended considerable time and effort to determine the source(s) of nitrification inhibition. It was originally suspected that contributions from industrial loads, either from a hog processing facility or landfill leachate, were the culprits for sporadic failure in nitrification and bio-P upsets, however plant recycles and FOG deliveries could also be responsible.

1.1.2. Facility Upgrades

In order to meet future permit limits, NP has recently upgraded to a 5-stage Bardenpho process (Figures 1.5 and 1.6). This upgrade has increased aeration capacity to enhance both nitrification and biological phosphorus removal. The upgrades also include a full-scale proprietary technology developed by Ostara that uses a fluidized bed reactor to recover phosphorus and ammonia through struvite precipitation from the centrate being generated at NP. The harvested struvite is then utilized as a slow release fertilizer (Ostara, 2007).

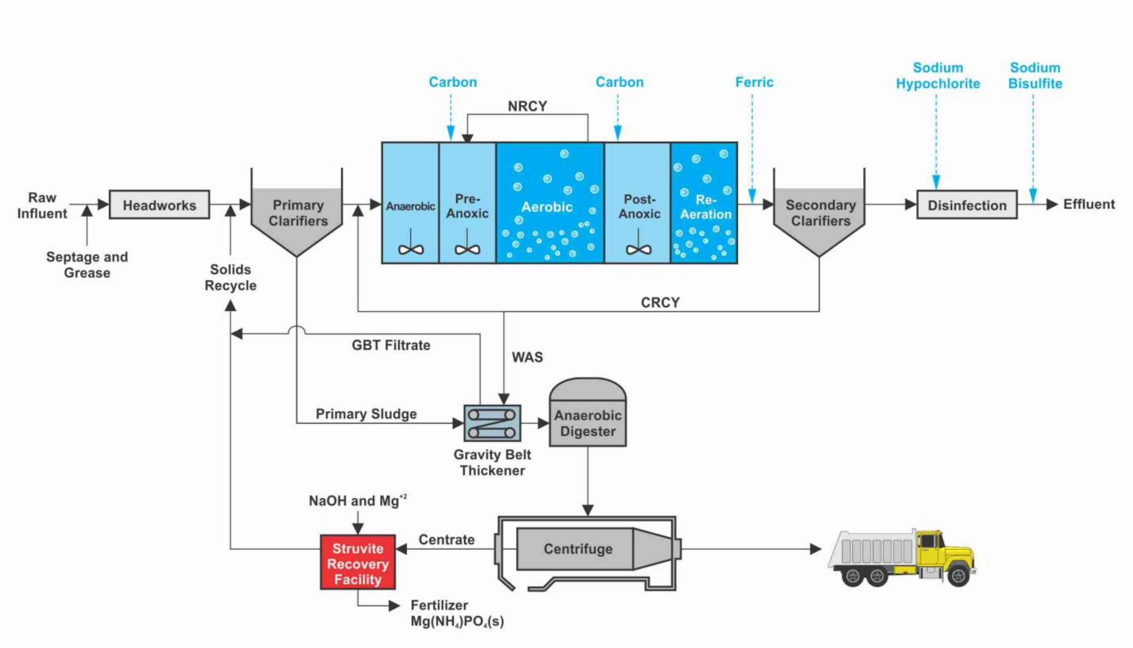

Figure 1.5 5-stage Bardenpho Process NP Process Flow Diagram

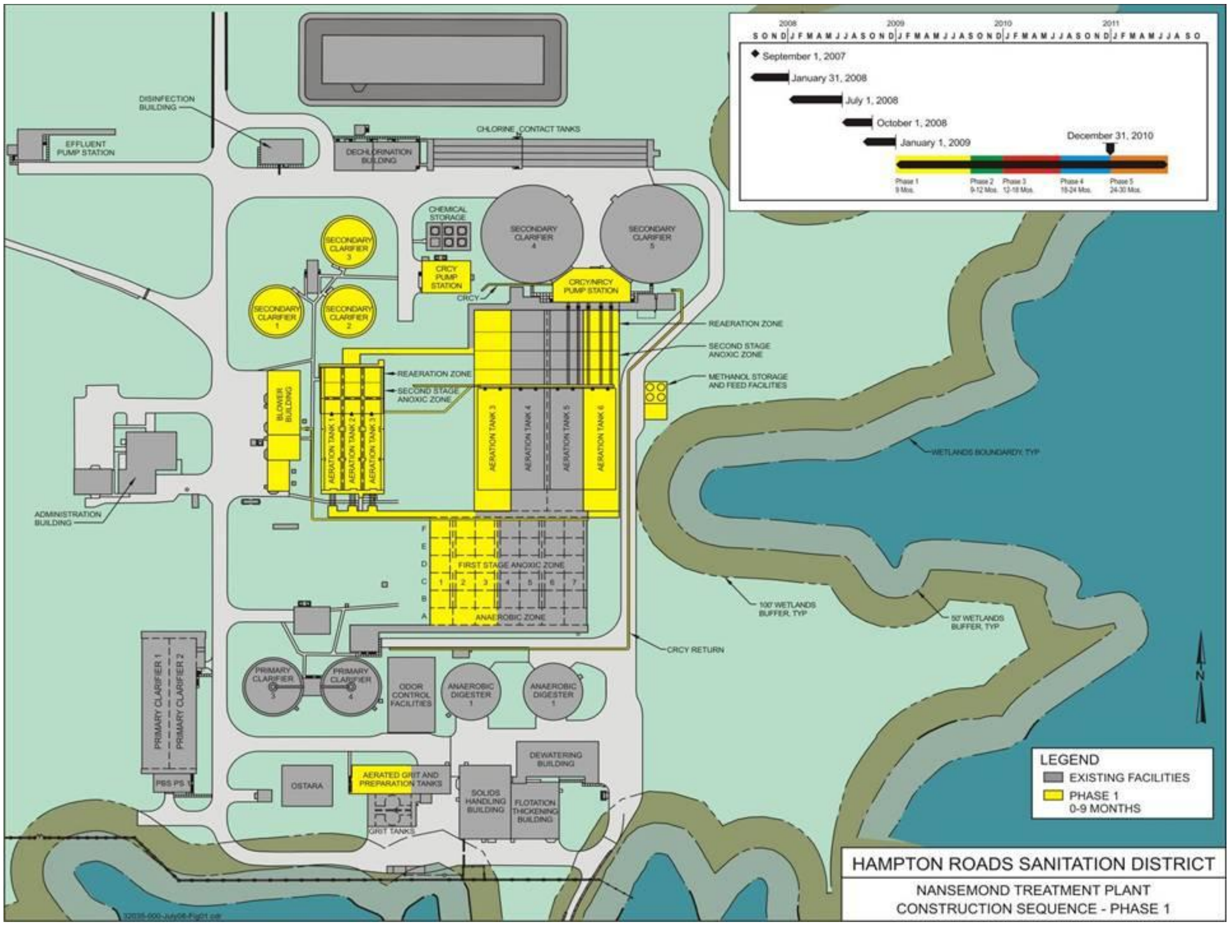

Figure 1.6 NP with Upgrades to 5-stage Bardenpho Process.

For the current nutrient removal upgrade, Hazen and Sawyer, P.C. prepared a preliminary engineering report, suggesting that the ammonia-oxidizing bacteria (AOB) maximum specific growth rate ($\mu_{max,\ AOB}$) be lowered from the default value of 0.90 days^{-1} to 0.57 days^{-1} as a result of high effluent ammonia data during the calibration period (Hazen & Sawyer, 2007). This reduction resulted in a significant increase in the aeration volume required for the plant upgrade in order to consistently achieve nitrification at cold temperatures. If NP were able to determine the source of nitrification inhibition, it would help to ensure that NP and the other James River HRSD facilities would meet the TN bubble permit limit.

1.2. Research Objectives

The objectives of this study were as follows:

- Establish the inhibitory characteristics of NP raw wastewater influent (RWI) and NP primary clarifier influent (PCI) (which includes raw influent, as well as plant recycle streams and truck delivered septage, FOG, and chemical toilet waste) compared to VIP RWI through bench-scale SBR experimentation
- Determine source of continuous and sporadic nitrification inhibition at the Nansemond Wastewater Treatment Plant
- Model nitrification kinetics and compare these values to previously determined kinetic values.
- Evaluate nitrification and denitrification inhibition potential of Aqueous Film-Forming Foam (AFFF).

1.2.1. Sequencing Batch Reactor Experimentation

The initial objectives of this research were to evaluate the inhibitory characteristics of either NP RWI or NP PCI, and then to determine the specific source of inhibition. One SBR was operated with NP RWI as the feed source, and another was operated with NP PCI as the feed source. NP PCI includes the raw influent, as well as plant recycle streams and truck delivered septage, FOG, and chemical toilet waste. Two more SBRs were operated with VIP RWI as the feed source. VIP RWI was used as the control as it achieves reliable nitrification year-round. SBRs were configured to simulate an MLE process with anoxic feeding and pre-denitrification using nitrate remaining in the reactor from the preceding cycle followed by an aerobic nitrification period.

The first stage of the project involved a comparison of nitrification performance of the SBRs fed with NP RWI and PCI, and both NP reactors were compared to the VIP RWI control reactor. Through this comparison, it would be possible to determine whether NP was experiencing inhibition when compared to the VIP RWI control. Then, through comparison of the NP reactors, it would be determined whether a source within the collection system is responsible for nitrification inhibition, or whether delivered waste or plant recycles are responsible. If both NP reactors experienced similar levels of inhibition, it would indicate that the source is somewhere within the collection system. If NP PCI were to experience higher levels of inhibition, then the inhibition would be considered a result of plant recycle streams or septage, grease, and chemical toilet waste deliveries.

With the collection system having been deemed responsible, the next step would have been to determine the source by back-tracking through the collection system and finally to the specific source. This would be performed by collecting composite samples from different pump stations in the NP collection system. This composite sample would be fed to one of the VIP RWI SBRs, while the other SBR would continue operation with VIP RWI as the feed source, to serve as the control. Once one of these feed sources resulted in nitrification inhibition in the test reactor, the source of inhibition would be determined by back-tracking up the collection system using the same method. NP RWI and NP PCI reactors would remain in operation and be profiled regularly to monitor performance and capture any sporadic nitrification inhibition events.

Over the course of the project, significant efforts were made to ensure that all SBRs were maintained at the same SRT. As nitrification performance is highly dependent on SRT, it was important to make sure the reactors were operated as closely as possible to the same SRT. By maintaining the same SRT for all SBRs, accurate comparisons could be made with respect to reactor performance without the need to normalize the rates to the Mixed Liquor Volatile Suspended Solids (MLVSS). With this study, normalizing to MLVSS would not be accurate, given the significantly higher BOD and TSS loads for the NP reactors. By operating at the same SRT, the growth rate for nitrifying bacteria should be the same between the reactors, and thus measurements of maximum corrected NR (see equation 8 in section 3.1.3.1), not specific NR, through reactor profiling should be the same. SRT adjustments included compensating for variability in waste activated sludge (WAS) pumping, effluent total suspended solids (TSS), and volume removed for sample analysis.

1.2.2. BioWin Simulation Modeling

The profile sampling data were modeled using *BioWin 3.1* (EnviroSim, Ltd.). Profile sampling occurred regularly between 8-18-10 and 1-19-11. A calibrated simulation was then generated over the entire period of profile samples. These simulations were compared to data collected during the profile sampling to better understand the level of continuous nitrification inhibition experienced at Nansemond.

1.2.3. AFFF Study

AFFF is a synthetic foam consisting of a mix of fluorochemical and hydrocarbon surfactants, combined with high boiling point solvents and water. The surfactants alter the surface properties of water, resulting in a thin aqueous film that can cover a hydrocarbon fuel, preventing or stopping ignition (Cheung, 1997). AFFF is used and a waste stream is generated whenever fire suppression systems are tested and as part of fire fighter training programs. A specific example is in fire suppression systems associated with WWTP carbon feed facilities using methanol or ethanol. When these systems are tested, AFFF waste is generated and must be disposed of properly. There are several concerns with the disposal and treatment of AFFF, particularly its effect on biological processes in wastewater treatment plants and pass-through toxicity which may be discharged to the environment. This work focuses on the potential inhibition of nitrification and denitrification processes at wastewater treatment facilities.

1.3. Thesis Organization

- Chapter two is dedicated to providing literature reviews of biological nutrient removal, nitrification inhibition, and general information and previous studies on Aqueous Film-Forming Foam.
- Chapter three provides methodologies for SBR setup and operation, reactor sampling, sample analysis, and simulation modeling.
- Results and discussion covers SBR testing for nitrification inhibition and denitrification inhibition and simulation modeling of the SBRs over the course of the project.

2. Literature Review

2.1. Biological Nutrient Removal

In wastewater treatment, the removal of nitrogen is achieved biologically through nitrification and denitrification. The form of nitrogen in raw municipal sewage is principally ammonia and organic nitrogen, most of which is converted to ammonia through standard biological treatment processes. The nitrification process is the aerobic oxidation of ammonia to nitrate by two different types of bacteria, ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) (Tchobanoglous et al., 2003). This conversion occurs in the following reactions:

1st Reaction – *Nitroso*-bacteria (AOB)

$$NH_4^+ + 1.5\ O_2 \longrightarrow NO_2^- + 2H^+ + H_2O \qquad (1)$$

2nd Reaction – *Nitro*-bacteria (NOB)

$$NO_2^- + 0.5\ O_2 \longrightarrow NO_3^- \qquad (2)$$

Resulting in the complete reaction:

$$NH_4^+ + 2O_2 \longrightarrow NO_3^- + 2H^+ + H_2O \qquad (3)$$

Autotrophic nitrifying bacteria that drive these reactions have slow growth kinetics and low yield (Tchobanoglous et al., 2003). The low yield of nitrifying bacteria results in a negligible contribution to biomass in the activated sludge process. Because of the slow growth kinetics, the aerobic activated sludge process requires a high solids retention time (SRT); at least 6 days at 12°C, and the requirement to maintain stable and consistent nitrification typically governs biological process design (Tchobanoglous et al., 2003). The minimum allowable SRT for operation of a nitrifying activated sludge process is controlled by the following design equations to take into account nitrification kinetics:

$$\frac{1}{SRT_{\min}} = \mu_a \tag{4}$$

$$\mu_a = \left(\frac{\mu_{\max,a} N}{K_N + N}\right)\left(\frac{DO}{K_o + DO}\right) + b_a \tag{5}$$

where μ_a is the nitrifier specific growth rate, $\mu_{max,a}$ is the nitrifier maximum specific growth rate, N is the target effluent ammonia-N concentration, K_N is the nitrifier Monod half-saturation coefficient for ammonia, DO is the aeration basin dissolved oxygen concentration, K_o is the nitrifier Monod half-saturation coefficient for oxygen, and b_a is the autotrophic decay rate (Tchobanoglous et al., 2003).

The final SRT used for process design is determined by multiplying the minimum SRT required for nitrification by a factor of safety, which can range from 1.5 to 5.0 (for extended aeration). Chemical inhibitors can result in reduced nitrifier maximum specific growth rate, $\mu_{max,a}$, but can also increase the nitrifier half-saturation coefficient for ammonia, K_N. When under the influence of chemical inhibitors, the SRT_{min} can approach the design SRT, which may not immediately affect process performance with respect to effluent ammonia-N, but will make the system much more susceptible to nitrification problems due to changes in temperature or peak ammonia loading events. As a result, it is important to investigate the effect of chemical inhibitors on nitrification performance (Kelly et al., 2004; Daigger and Sadick, 1998; Hockenbury and Grady, 1977).

Nitrification is well recognized as the most sensitive process in biological nutrient removal (BNR) systems and is very sensitive to stressors including pH, temperature, substrate concentrations, dissolved oxygen (DO) concentrations, and toxins (Juliastuti et al., 2003a). The optimum pH range for nitrification is between 7.5 and 8. At pH values below 6.8, nitrification rates decline considerably, and at a pH of approximately 6, nitrification rates can be as low as 20% of those obtained at a pH of 7 (Tchobanoglous et al., 2003). Nitrifying bacteria are inhibited by a wide range of toxins at concentrations well below those that would affect aerobic heterotrophic bacteria that remove biodegradable organic matter, in some cases at concentrations an order of magnitude lower (Daigger and Sadick, 1998). Inadequate aeration results in incomplete nitrification, which can result in increased nitrite (NO_2^-) concentrations in the effluent (Tchobanoglous et al., 2003). The importance of nitrification in wastewater treatment is based on the following water quality concerns:

- Effect of ammonia on receiving water with respect to DO concentrations,
- Toxicity of ammonia to aquatic and marine life in receiving waters
- Prevention of eutrophication
- Providing nitrogen control for water-reuse applications, including groundwater infiltration (Tchobanoglous et al., 2003).

Nitrification is also commonly used in combination with denitrification processes for total nitrogen removal. Except when using methanol, the same heterotrophs responsible for aerobic oxidation of organic materials can use nitrate as an electron acceptor when oxygen is not present. So, the combination of heterotrophic bacteria, nitrate and/or nitrite, and an electron donor (carbon source) results in denitrification, which is the oxidation of the carbon and reduction of the NO_3^- and/or NO_2^- to N_2. Denitrification can be performed in two different ways: pre-denitrification or post-denitrification, depending on the source of the carbon or electron donor. Pre-denitrification uses the carbon present in raw sewage (BOD or COD) as the electron donor, and is represented with the following equation:

$$NO_3^- + \text{BOD (org C)} \longrightarrow CO_2 + N_2 + \text{Alk} + \text{Biomass} \qquad (6)$$

With typical municipal wastewater characteristics, pre-denitrification can achieve final effluent concentrations around 7-10 mg/L TN. The modified Ludzack-Ettinger (MLE) process shown in Figure 2.1 uses a pre-denitrification process, accomplishing denitrification in an anoxic tank for BOD removal, from which point, the mixed liquor enters an aerobic tank where nitrification occurs along with residual BOD removal. The nitrate created in the aerobic zone is then recycled back to the front of the process to be used for denitrification and BOD removal.

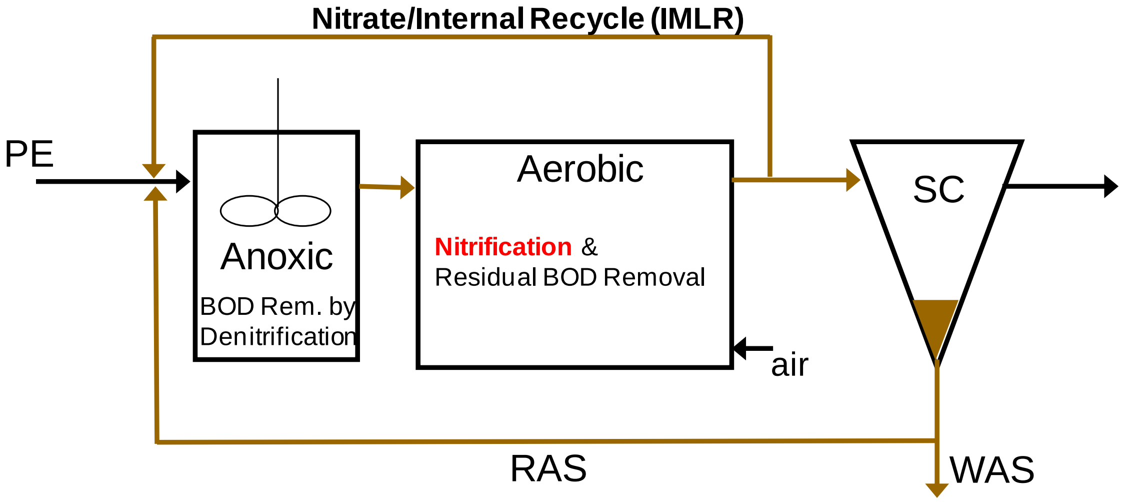

Figure 2.1 Pre-denitrification in an MLE process

Instead of raw sewage, post-denitrification uses an external carbon source to drive denitrification. The following equation represents the reaction that takes place in this process:

$$NO_3^- + CH_3OH \text{ (methanol)} \longrightarrow CO_2 + N_2 + \text{Alk} + \text{Biomass} \quad (7)$$

A 4-stage Bardenpho process, shown in Figure 2.2, is an example of a process that uses post-denitrification. This process is similar to the MLE process in that it employs pre-denitrification, but also utilizes an additional aerobic and anoxic tank for further denitrification, only the second set of tanks use an external carbon source, such as methanol, to drive denitrification. This type of process is needed in order to achieve effluent TN in the range of 3-5 mg/L (Tchobanoglous et al., 2003).

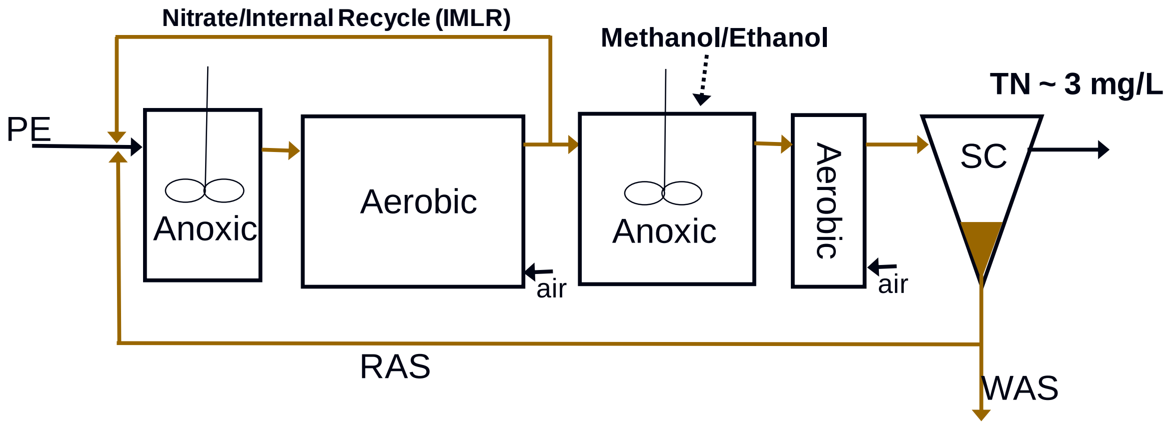

Figure 2.2 Post-denitrification in a 4-stage Bardenpho process

The denitrification process is less sensitive to changes in pH, temperature, and other factors than the nitrification process, so it is practical to investigate the more sensitive nitrification process (Pagga et al., 2006).

By adding an anaerobic zone prior to the first anoxic zone, the 4-stage Bardenpho process can be converted to a 5-stage Bardenpho process, which, in addition to N-removal, will also achieve biological phosphorus (Bio-P) removal. Under the conditions created in the anaerobic tank, a group of heterotrophic bacteria called polyphosphate-accumulating organisms (PAO) are selectively enriched within the activated sludge. These bacteria are able to accumulate large quantities of polyphosphate, enhancing the removal of phosphorus (Tchobanoglous et al., 2003).

2.2. Nitrification Inhibition

In 2000, a WERF Report survey of 110 wastewater treatment facilities revealed that nitrification inhibition was one of the most common causes of upsets to biological treatment processes, second only to inhibited COD/BOD removal (Love and Bott, 2000). This survey demonstrates that nitrification inhibition has become an important issue for treatment facilities everywhere, particularly in regions with increasingly strict effluent limits.

It is important to know the inhibition potential of substances on nitrification to prevent unexpected disturbances (Pagga et al., 2006). To determine the presence, or the severity, of a chemical's inhibitory effects, there are a number of experiments which can be conducted (Pagga et al., 2006). Experiments can use continuously stirred tank reactors, batch reactors, or nitrifying bioreactors in bench, pilot, and full scale studies (Hu et al., 2004). Nitrification inhibition can be measured through measuring oxygen uptake rates (respirometry) or nitrate and nitrite generation and ammonia uptake rates (NGR or AUR). These experiments typically use nitrifying biomass and add suspected or known inhibitors to the reactors to examine oxygen, ammonia, nitrate, and nitrite uptake and generation rates. The remainder of this section addresses some of the many causes and effects of nitrification inhibition.

2.2.1. Impact of Heavy Metals on Biological Treatment

Wastewaters can contain high levels of metals, particularly at treatment facilities that receive industrial wastewater. The contributions from these industrial sources are suspected to be one of the main causes of nitrification inhibition issues (Hu et al., 2002). In recent years, the discharge of industrial effluent to publicly owned treatment works has become increasingly common. This practice is likely to increase the concentrations of metal ions entering treatment facilities, thus increasing the chances of nitrification upsets as a result of heavy metal inhibition (Stasinakis et al., 2003). However, the institution and improvement of industrial pretreatment programs has dramatically decreased the impact of industrial discharges and heavy metals on municipal POTWs.

Although studies have shown that the microbes responsible for biological processes are typically unaffected by constant low-level exposure to metals, as a result of biomass acclimation, sudden introduction of metals can result in a total upset of these biological processes (Hu et al., 2004). Many studies have been conducted to investigate the effects of heavy metals on biological systems, evaluating the effects of individual metals, as well as combinations of different metals.

As a result of varying operational parameters in the different studies that have been conducted to determine the inhibitory concentrations of different metals, there is a high level of variability in the reported values (Semerci et al., 2007). Furthermore, different studies also interpret their results based on different metal species (i.e. total, labile, free or biosorbed), making it difficult to compare the inhibitory concentration ranges (Semerci et al., 2007). Of the different metal species measured, the aqueous free metal cation concentration appears to correlate best with nitrification inhibition (Hu et al., 2004). Of the varying metals found in wastewater, the widespread industrial use of nickel, cadmium, copper, and zinc has made their presence more common in wastewater influents (Hu et al., 2004). Inhibition of nitrifying biomass is clear for heavy metals such as cadmium, zinc, and copper when exposed to higher shock load (24-hour period) concentrations (0.2 – 0.65 mg/L Cd^{2+}, 0.5 – 3 mg/L Zn^{2+}, 0.1 – 12.5 mg/L Cu^{2+}) based on the results of several studies (Hu et al., 2002; Kelly et al., 2004b; Semerci et al., 2007; Madoni et al., 1999; Juliastuti et al., 2003a).

2.2.2. Chemical Inhibition

Shock loads of toxic chemicals are known causes of sporadic upsets at treatment plants, proven to hinder every essential process within an activated sludge system (Henriques et al., 2007). In addition to the effects of heavy metals from industrial sources, toxins discharged from industries have also been shown to inhibit nitrification processes (Anthonisen et al., 1976; Blum and Speece, 1991; Grunditz and Dalhammar, 2001), and are often responsible for sporadic upsets at full-scale plants, which can affect performance for weeks at a time (Hu et al., 2002; Nowak and Svardal, 1993). There is also evidence that some types of solids processing can produce inhibitory chemicals (Daigger and Sadick, 1998). Several facilities within the Hampton Roads Sanitation District incinerate biosolids, and the in-plant recycle of the flue-gas scrubber water was shown to inhibit nitrification (Daigger and Sadick, 1998). It was determined that hydrocyanic acid (HCN) in the scrubber water was the inhibitor, with concentrations around 0.1 or 0.2 mg/L resulting in a 50% reduction in the nitrifier maximum specific growth rate (Daigger and Sadick, 1998). Side-stream nitrification enhancement facilities (NEFs) were implemented to treat the flue-gas scrubber water to prevent upsets to nitrification as a result of HCN. Even after the inhibitory chemical is no longer entering the process, it can take some time to fully regain nitrification (Stasinakis et al., 2003). This slow recovery stage can result in permit violations for the treatment facility, in addition to the environmental consequences of poor nutrient removal (Kelly et al., 2004a).

2.2.3. Impact of Nitrification Inhibition on Biological Nutrient Removal (BNR)

For ammonia-oxidizing bacteria (AOB), an uninhibited maximum specific growth rate is typically between 0.80 and 1.0 d^{-1}, while inhibited values can fall well below this range. For process design, the minimum SRT is typically controlled by the maximum specific growth rate for AOB. As a result of an increased minimum SRT, the required capacity for aeration can increase dramatically, resulting in significant capital costs for treatment facilities.

An additional consequence of nitrification inhibition is its effect on other BNR processes. As a result of incomplete nitrification, nitrite can accumulate, affecting biological phosphorus removal (Bio-P) (Meinhold et al., 1999). High concentrations of nitrite interfere with the metabolism of phosphate-accumulating organisms causing PHA utilization and anoxic phosphate uptake to stop (Meinhold et al., 1999).

Denitrification can also be affected by nitrification inhibition, as a result of reduced nitrate production by nitrite-oxidizing bacteria. Since nitrate serves as the primary electron acceptor in denitrification, reduced levels of nitrate could impact performance of denitrifying bacteria.

2.3. Bench-Rate Measurements

To fully evaluate a wastewater treatment facility's nitrification performance, it is important to determine AOB and NOB rates. Based on these rates and other plant data (influent characteristics, etc.), it is possible to predict important kinetic parameters, such as maximum specific growth rates, which are important when evaluating a plant's performance.

The two most common methods for determining nitrification rates are respirometry and nitrate/nitrite generation rates (NGR) (Kelly et al., 2004b), which are described below:

- Respirometry involves measuring the oxygen uptake rate (OUR) of microbes associated with biological treatment. A sample of mixed liquor is acquired from either a full, pilot, or bench scale process, and. To evaluate nitrification kinetics, a sample of mixed liquor is added to a temperature-controlled respirometer reactor with and without (control) a chemical stressor. The mixed liquor is typically spiked with some source of ammonia or nitrite to ensure that the nitrification rate remains high enough to prevent ammonia limitation of the reaction for the duration of the respirometry. These experiments can be run with and without nitrification inhibitor in order to differentiate between heterotrophic and autotrophic oxygen uptake. Using the specific oxygen uptake rate (SOUR) (defined as the OUR normalized to the biomass concentration), it is possible to calculate nitrification kinetic parameters.

- Nitrate/nitrite generation rates (NGR) or ammonia uptake rates (AUR) are used to evaluate nitrification fully independent of heterotrophic activity. Using this method, kinetic rates directly related to the consumption or production of reactants and products of the nitrification process are measured. For these experiments, the sample must be mixed and well aerated and can be performed with batch tests or with continuously operated reactors, such as sequencing batch reactors. With either setup, at least one reactor should serve as a control, while the other(s) are subjected to a known or suspected inhibitor. Ammonia or nitrite is spiked into the reactor, and the nitrate, nitrite, and ammonia concentrations are monitored over time using typical analytical methods (APHA, 1998).

Although respirometry is an effective method for determining nitrification inhibition in that it is quick and avoids the need for extensive sample analyses, it also has several drawbacks (Kelly et al., 2004b). Since respirometry measures the total oxygen uptake rate of a biomass, it requires several iterations of tests to determine the respiration rate of the nitrifying bacteria alone. This is because, in a mixed community like mixed liquor, the nitrifying bacteria must be specifically inhibited to distinguish them from other species. As a result, a total respirometry must be performed as well as a respirometry where nitrification has been completely inhibited, using a known inhibitor (Kelly et al., 2004b). NGR provides a direct measure of the nitrification rate by measuring the generation of nitrate and nitrite, the product of two-stage nitrification (Kelly et al., 2004b). NGR can be used to calculate both AOB and NOB rates based on NOx-N generation or

NO_3-N generation, respectively. The disadvantage is that, although it provides a direct measure, it requires more time to complete than respirometry.

One particular study measured the resulting nitrification rates caused by two different chemical compounds to compare the use of respirometry to NGR measurement (Kelly et al., 2004b). Results from the study suggested that NGR is the more accurate method for determining the level of nitrification inhibition, as it provides a direct measurement of the nitrification final product in the reaction, while respirometry can only provide an indirect measurement (Kelly et al., 2004b). Another important discovery was that NGR tests returned much more comparable results for duplicate reactors (Kelly et al., 2004b).

2.4. Aqueous Film-Forming Foam

2.4.1. Overview

AFFF utilizes fluorochemical and hydrocarbon surfactants, combined with high boiling point solvents and water, to alter water's surface properties so that a film can coat hydrocarbon fuels to prevent or stop ignition (Cheung, 1997).

Foam solutions are produced by diluting AFFF concentrates with water through proportioning valves or eductors. AFFF is available in three common concentrated forms – 1%, 3%, and 6%. The dilution ratio for the 3% concentrate is 3 parts concentrated AFFF to 97 parts water. Thus, as the named concentration decreases (i.e. from 6% to 1%), the AFFF solution strength increases. The concentration of chemicals in the final foam solution is intended to be roughly the same for all three concentrates, meaning that the chemical content of a 1% concentrate is roughly six times that of a 6% concentrate and three times that of a 3% concentrate (Cheung, 1997).

The key ingredients in most AFFF concentrates are fluorochemical surfactants. There is no other known class of materials as effective at producing solutions with a surface tension low enough to allow the formation of an aqueous film on hydrocarbon fuels. As a result of this low surface tension, an aqueous film seals the surface of the fuel, extinguishing flames and preventing evaporation of the flammable liquids. No other surfactant can do this as effectively as a fluorochemical surfactant. Fire fighting agents containing fluorochemical surfactants can extinguish flammable liquid fires more quickly with less agent volume use than fire fighting agents lacking fluorochemical surfactants. The downside to fluorochemical surfactants is that they are mobile aquatic systems and resistant to biodegradation in the environment. Eventually, fluorochemical surfactants may reach groundwater sources or surface waters, resulting in foaming and other issues (Cheung, 1997).

The actual percentage of manufactured foam that is used to fight fires is relatively low, at about 5% to 10% (Scheffey, 2002). The remaining 90%-95% is used for firefighting training programs, fire suppression system testing, accidental discharge, replacement of contaminated or obsolete stock, or storage in new systems (Scheffey, 2002). Discharges from some of these systems can produce thousands of gallons of foam solution (Cheung, 1997). A specific example is in fire suppression systems associated with WWTP carbon feed facilities using methanol or ethanol. When these systems are tested, AFFF waste is generated and must be disposed of properly. There are several concerns with the disposal and treatment of AFFF, particularly its biodegradability, pass-through toxicity, and its effect on biological processes in wastewater treatment plants.

The biodegradability of a foam is measured by how readily it is broken down by microorganisms in the environment. Biodegradability of wastewater constituents are often assessed by measuring the biochemical oxygen demand (BOD) and expressing as a percentage of the chemical oxygen demand (COD). Foams with a BOD5:COD ratio greater than 50% are typically considered to be biodegradable. Data reported in AFFF manufacturer's material safety data sheets provide ratios that range from 0.60 to 0.99, classifying AFFF solutions as biodegradable (Cheung, 1997). However, several of these manufacturers use BOD20:COD ratios to determine biodegradability as opposed to BOD5:COD ratios, resulting in an improved value for biodegradability (Table 2.1). It is also important to note that the fluoro chemicals are present at concentrations of ~10% in AFFF (this is an estimate, since the exact fluoro chemical and how much is added are proprietary and not disclosed in the MSDS, see Table 2.2), resulting in the AFFF concentrate as a whole being considered biodegradable, even though the fluoro chemical portion is likely to persist in the environment.

Table 2.1 Ecological Information for ChemGuard 6% AFFF

	CONCENTRATE	SOLUTION AS USED
Chemical Oxygen Demand:	348,750 mg/l	20,925 mg/l
Biological Oxygen Demand (20 day):	279,000 mg/l	16,740 mg/l
Biodegradability (B.O.D./C.O.D.)	80%	80%
Total Organic Carbon:	not determined	not determined
LC50 96 day (fundulus heteroclitus)	1134 mg/l	18,900 mg/l

Table 2.2 Composition/Information on Ingredients for ChemGuard 6% AFFF

CAS NO.	Common Name	% by wt
7732-18-5	water	70%-80%
112-34-5	diethylene glycol monobutyl ether	4% - 7%
7487-88-9	magnesium sulfate	0.25 - 0.75%
64-02-8	ethylenediaminetetraacetic acid tetrasodium salt	0.25 - 0.75%
proprietary	proprietary hydrocarbon surfactant	proprietary
proprietary	proprietary fluorosurfactant	proprietary

The foaming agent in AFFF is a hydrocarbon surfactant, also known as synthetic detergent, and is the most important ingredient (Angus Fire, 2004). It is also the most acutely toxic of the main foam constituents, with LC50 values less than 20 mg/L for algae, mollusks, crustaceans, insects, and fish (Angus Fire, 2004). LC50 is defined as the lethal concentration in a test solution that kills 50% of a test batch of animals within a given period of time. Glycol ether, specifically Diethylene Glycol Butyl Ether (DGBE), is also present in most AFFF foams. It is currently under review by the US Environmental Protection Agency (EPA) (Angus Fire, 2004). Some low molecular weight glycol ethers are associated with adverse reproductive and developmental effects in humans. Glycol ether is also toxic to aquatic organisms with LC50 values of about 1,500 mg/L (Angus Fire, 2004).

Of the different options available for treatment of AFFF solutions, the most common method is through regulated flow to wastewater treatment plants (Cheung, 1997). Based upon the maximum allowable concentration specified by the facility and the size and capacity of the treatment plant, a maximum flow rate to the plant can be determined (Cheung, 1997).

AFFF has also been blamed for solubilizing and preventing the removal of toxic hydrocarbons in oil-water separators, as a result of the presence of synthetic detergents from AFFF (Angus Fire, 2004). The detergent prevents the oil and water from separating fully, effectively acting as an emulsifier. When the seemingly pure water is discharged from oil separators, harmful oil may find its way into rivers, lakes, stream, reservoirs, etc. (Angus Fire, 2004). At military installations, oil-water separators are commonly used as part of hangar drainage systems. They are installed to intercept oil or fuel spilled on the floor before it is discharged to the wastewater treatment plant. Oil in the influent to treatment plants can upset the treatment process and, for this reason, low threshold limits are enforced by treatment plant authorities. An oil-water separator is sized for a specific flow rate, based on the maximum anticipated spill. If not contained, the deployment of AFFF would result in significant volumes of oil and AFFF bypassing the oil-water separator and entering the treatment plant (Cheung, 1997).

2.4.2. Treatability

There have been several treatability studies conducted with AFFF, or similar surfactants, to determine inhibitory concentrations to biological processes, pass-through toxicity, and other performance issues that may arise as a result of their addition.

Treatability studies have been conducted using a high-purity oxygen activated sludge system, which showed that acceptable levels of biological treatment could be reached with untreated firefighting waste containing 3% AFFF, diluted by a factor of 100. Using dissolved air flotation (DAF), it was possible to further reduce the necessary dilution to reach the desired effluent quality (EG&G, 1978, Union Carbide, 1978).

The use of coagulants such as alum, ferric chloride, calcium chloride and cationic polymers has been observed to be capable of reducing the organic content of AFFF (Chan, 1978, Chan and Bingham, 1988). Through the use of chemical pretreatment and DAF, it was possible to consistently remove BOD, COD, TSS, and firefighting surfactants, producing effluent fit for discharge to a BNR process, without excessive foaming (Engineering-Science Inc., 1986). With chemical pretreatment and the use of aerobic and anaerobic SBRs, it was determined that it was possible to achieve effluent quality acceptable for direct environmental release (Saam and Rakowski, 1979, Saam et al., 1979, Thomas and Lefebvre, 1973).

The biodegradability of other surfactants, similar to AFFF, was evaluated with bench-scale, continuous-feed activated sludge processes. The reactors were fed initially at concentrations of 100 ppm, but raised to 250 ppm by the end of the experiment. Excellent BOD and COD removals were achieved throughout, but nitrification inhibition increased with surfactant concentrations (Lefebvre and Inmand, 1975, Lefebvre and Inmand 1974, Lefebvre and Thomas, 1973).

Another series of studies conducted in 1998 was aimed specifically at determining the effects of AFFF addition to the VIP BNR process (Erten-Unal et al., 1997, Erten-Unal et al., 1998, Erten-Unal and Schafran, 1998). This study used 1% AFFF concentrate (the strongest available); 1% AFFF requires 1 part AFFF concentrate for every 100 parts AFFF solution. Results of the study suggested that nitrification inhibition occurred at concentrations of 1% AFFF concentrate greater than 60 ppm. There was significant foaming evident in reactors at concentrations of 10 ppm and up. Also observed was a reduction in the percent COD removal as AFFF concentrations increased, though this could be attributed to the significant increase in the initial COD concentrations as a result of AFFF addition. Overall, this study suggests that 1% AFFF at concentrations less than 60 ppm will not affect nitrification performance (Erten-Unal et al., 1997, Erten-Unal et al., 1998). However, this study based nitrification performance on percent NH4-N removal between the end of the feed cycle to the end of the aerobic period, which makes actual comparison between the test and control reactors difficult. Furthermore, the two-hour feed cycle was aerobic, so a substantial amount of NH4-N had already been oxidized by the time the initial ammonia-N concentration was measured. In some cases, the initial NH4-N concentrations were already less than 1 mg/L, making any comparison based on percent removal meaningless. One pattern seen throughout the study was that, in spite of all reactors being fed with the same stock feed solution, NH4-N concentrations for the control reactors at the end of the feed cycle were consistently less than those measured for the AFFF-spiked reactors. Although it is difficult to state with any certainty without actual rate measurements, this suggests that the AFFF-spiked reactors may in fact have been experiencing some level of nitrification inhibition. Denitrification performance could not be determined from this study since, as previously mentioned, there were no rate measurements collected, however, decrease in COD removal efficiency could be attributed to some level of denitrification inhibition.

3. Methodology

3.1. Sequencing Batch Reactor Experimentation

3.1.1. Sequencing Batch Reactor Construction and Setup

3.1.1.1. SBR Setup

Four 22-liter SBRs were operated in parallel at the same hydraulic residence time (HRT) and solids retention time (SRT). The SBRs were operated in the Garrett configuration (wasting at the end of each react period), and provided feed collected from two wastewater treatment plants in the Hampton Roads area, Nansemond and VIP. The SBRs were configured to simulate an MLE process with anoxic fill and react period prior to an aeration period (Figure 2.1). Figures 3.1 and 3.2 show actual images of the SBRs used, and a detailed schematic of a single SBR.

Reactors A and B were operated with Nansemond raw wastewater and primary clarifier influent (PCI), respectively, as the feed source. Reactors C and D were operated with VIP raw wastewater as the feed source.

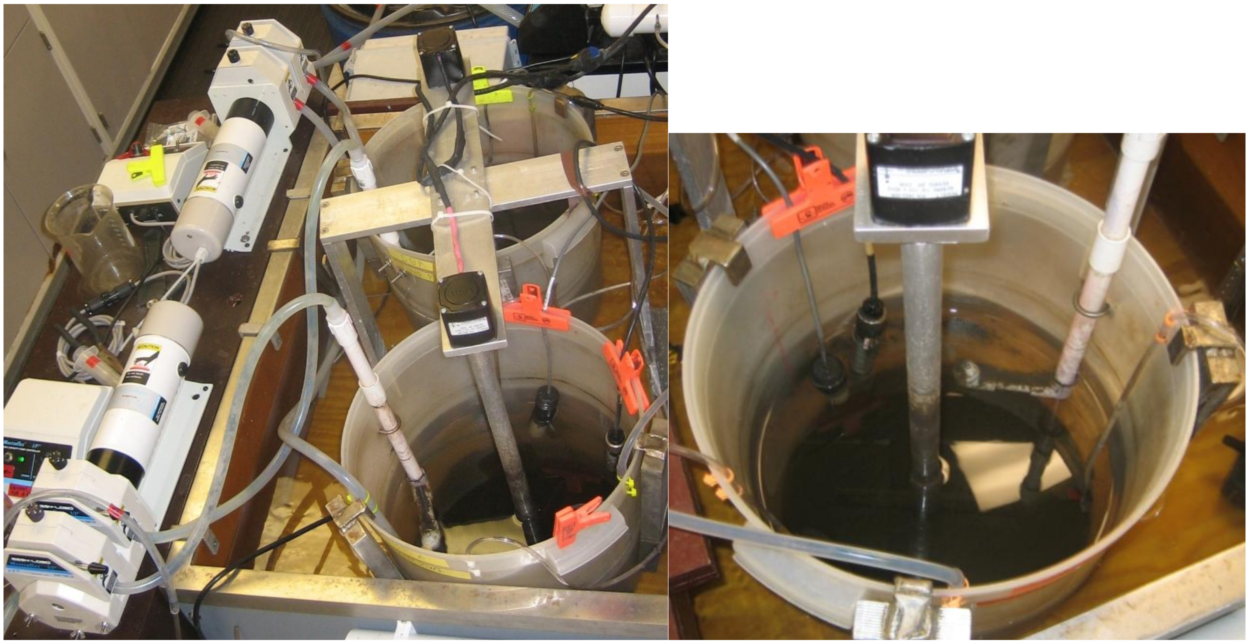

Figure 3.1 **Sequencing Batch Reactors**

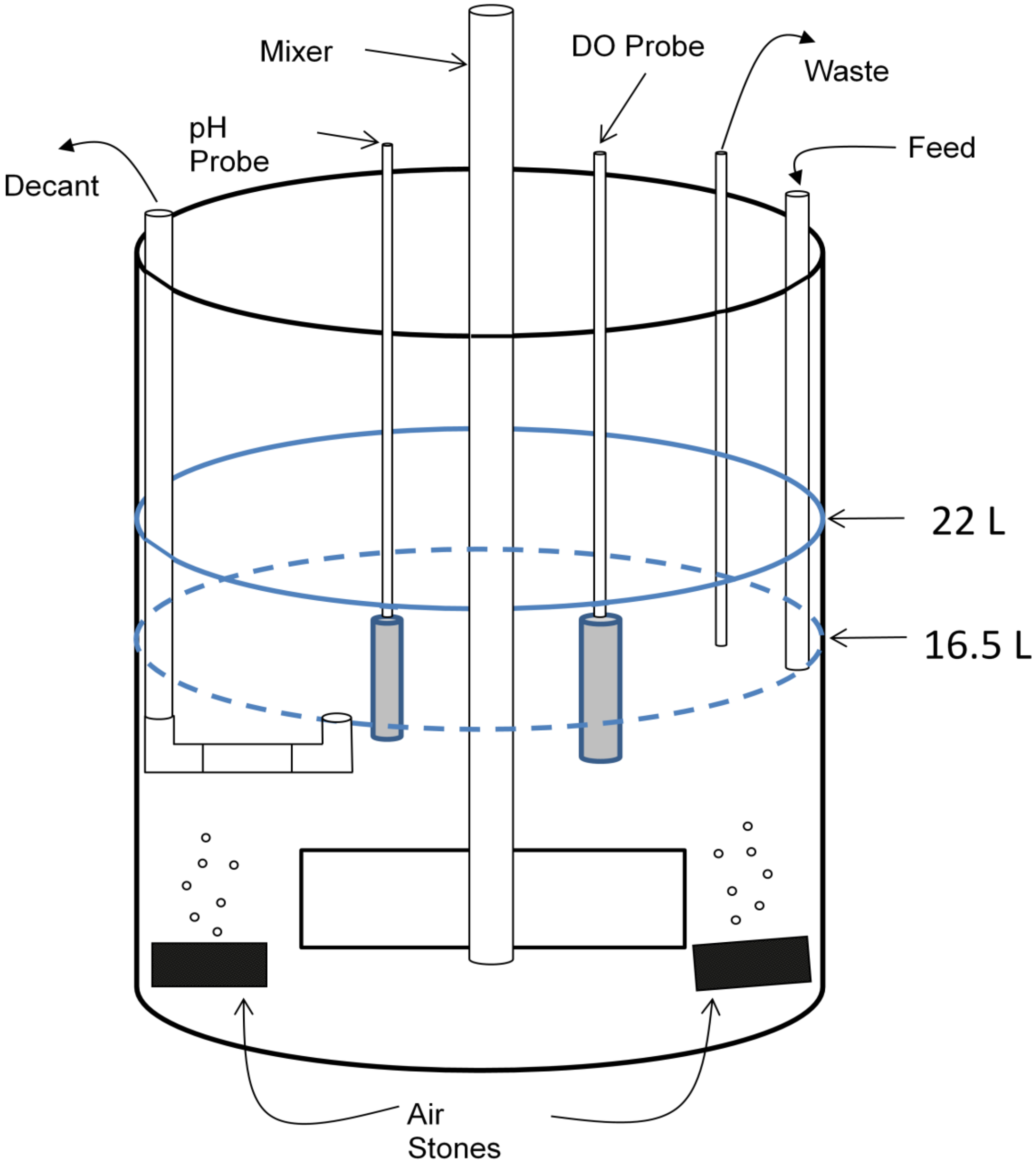

Figure 3.2 **Sequencing Batch Reactor Schematic**

3.1.1.2. Sequence Schedule

Each SBR cycle was 6 hours long with a 90 minute anoxic fill/feed and react period, a 210 minute aerobic react period, a 55 minute settling period, and a 5 minute decant period. There were four (4) cycles per day, and SBR cycles were automatically controlled via a programmable timer. Figure 3.3 shows the SBR sequence schedule, accompanied by a schematic of the MLE process to which it closely relates.

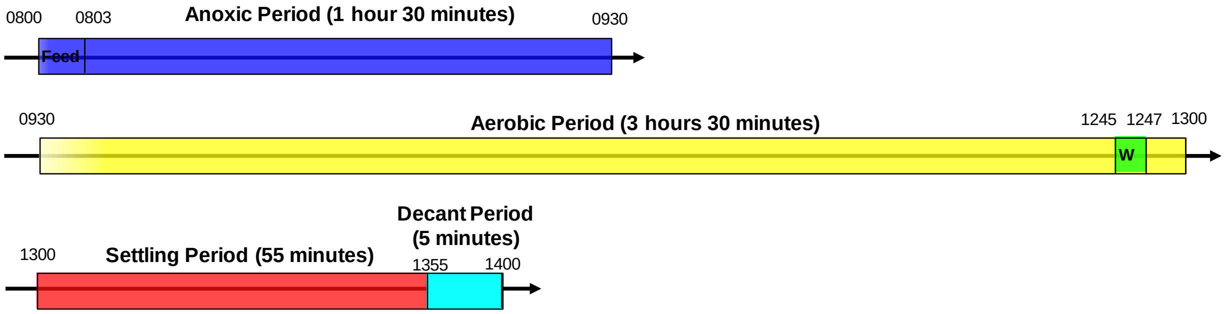

Figure 3.3 **Sequence Schedule**

3.1.1.3. Chiller Setup

The desired temperature in the reactors was 12° C. In order to reach this temperature, the reactors were submerged in a cold water bath maintained at 12° C using a chiller. The Nansemond and VIP feed containers (55 gallon containers) were initially at temperatures as high as 26° C during the summer months. With feed temperatures this high, the reactors would reach temperatures as high as 19° C immediately following the feed cycle and would require the entire 6 hour cycle to cool to 12° C. Therefore, it was imperative to cool the feed prior to the feed cycle. This was achieved by installing 15 feet of ¾-inch diameter vinyl coiled coated copper tubing in each drum and connecting them in series. The thermostat was placed in the last barrel in the series and a chiller was used to circulate cold water through the system until the desired temperature was reached. Coated copper tubing was used because of its heat transfer properties, but also to prevent any interference from copper corrosion and solubilization in the feed, particularly since copper is a known inhibitor to nitrification at levels as low as 0.1 mg/L (Juliastuti et al., 2003a). Figure 3.4 shows the coated copper chiller coil installed in each feed drum. Once this setup was completed, temperatures in the reactors remained at a constant temperature of 12° C ± 0.5° C throughout the entire reactor cycle. In the event that the reactor temperature dropped too low, immersion heaters were located in the water bath to raise temperature back to the desired level. Temperature data were measured and uploaded to a server by the data logger every two minutes. Average temperatures of each reactor over the project period varied slightly (~0.3°C, see Table 4.1) this is most likely a result of two factors:

(1) Location of each reactor in the water bath, with the chiller outflow closest to reactor B (NP PCI) (refer to Figure 3.6), which resulted in a consistently lower temperature, with the other three SBRs maintaining similar temperatures. Three submersible pumps were used in the water bath on a continuous basis to maintain mixing and create a uniform temperature as closely as possible.

(2) Chiller system for the feed containers is also likely to have affected temperatures in the SBRs directly following the feed cycle. With the NP PCI feed drum located first in the series of chiller coils installed in each drum, it was measured to be consistently colder that the other three feed containers. This is also likely to have played a role in the lower temperature in reactor B (NP PCI).

Figures 3.5 and 3.6 show an image of the entire SBR system setup, and a detailed system schematic showing the chiller, feed, waste, and decant setup.

Figure 3.4 **Coated-copper coil setup in feed drum to maintain feed temperatures at 12±0.5° C**

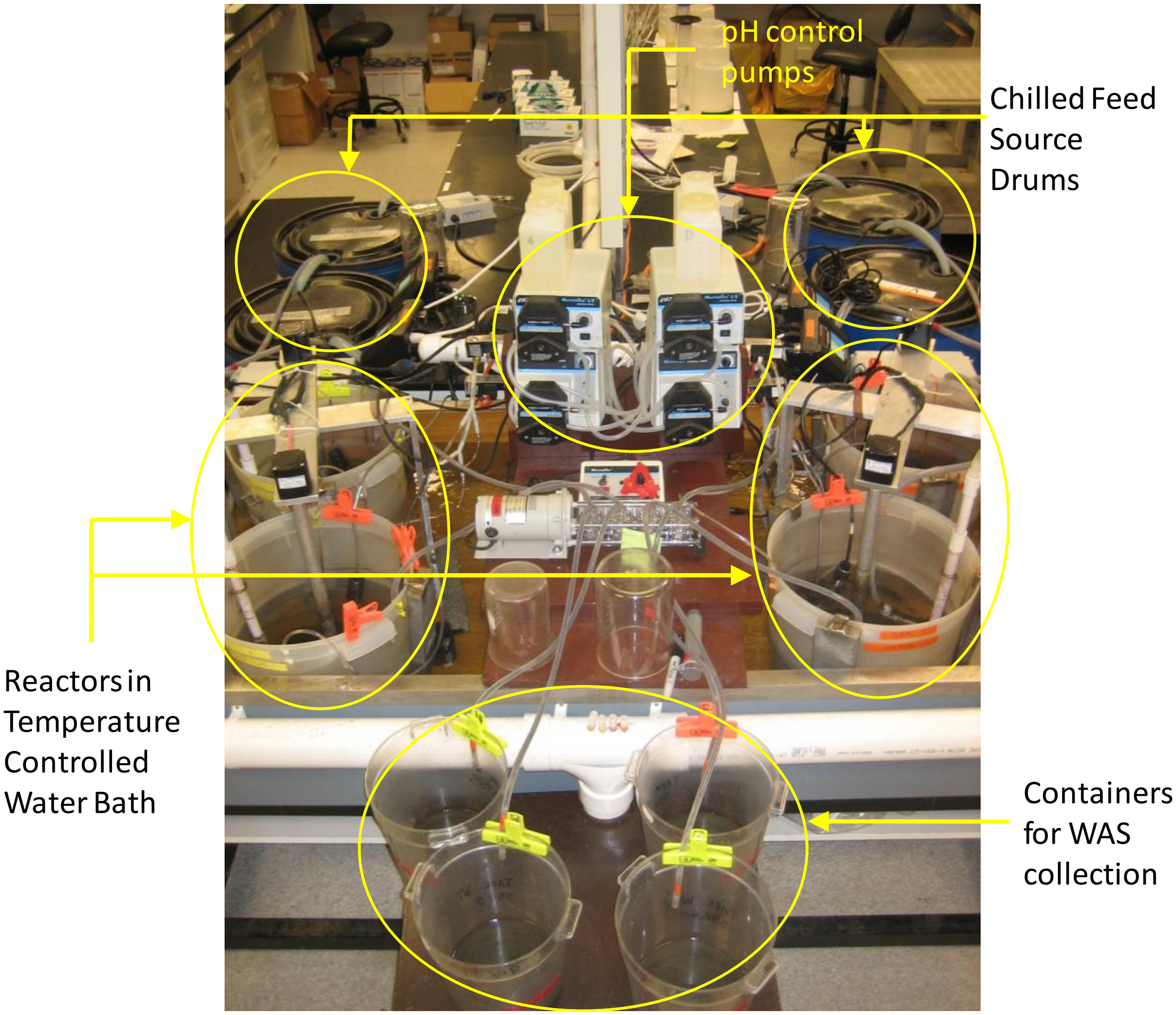

Figure 3.5 **SBR setup in water bath**

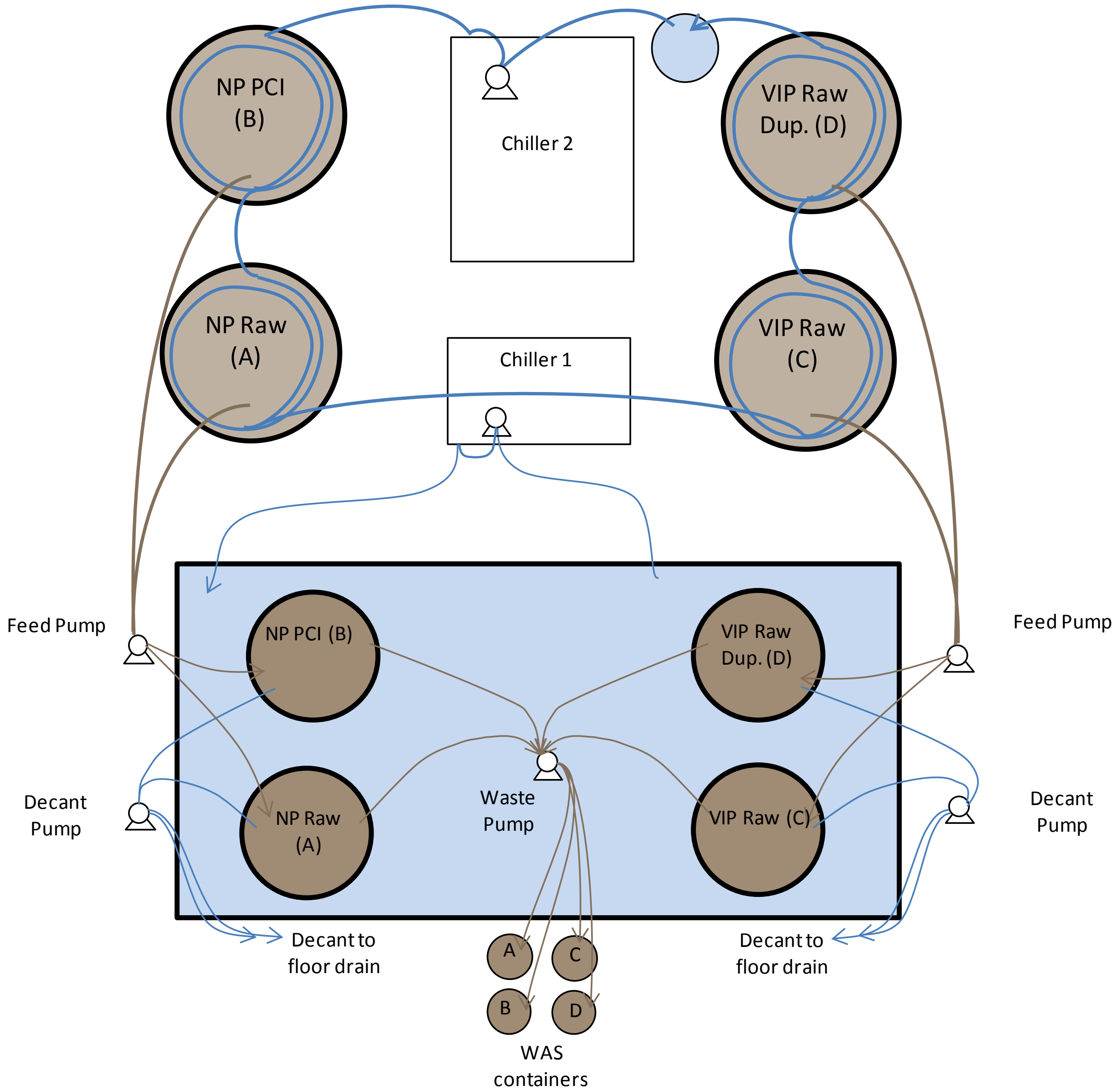

Figure 3.6 **Complete System Schematic**

3.1.2. Sequencing Batch Reactor Startup and Operation

3.1.2.1. Composite Feed Collection

In order to attain the most representative feed sample for the SBRs, a time-paced composite sampling system was set up at each feed collection point (Nansemond and VIP treatment plants). At each location, one liter of wastewater was drawn every 30 minutes and stored in an onsite 50-gallon feed drum. By doing so, it was expected that the SBRs would be able to capture any agent responsible for sporadic loss or inhibition of nitrification. With this setup, the SBR's were essentially operating on the same influent as the plants, with a 2-3 day time lag behind the plant. The time period during which each composite sample was collected, and the subsequent days in which they were fed to the SBRs were as follows:

- Monday afternoon thru Wednesday morning – SBR feed represents plant influent from Friday morning thru Monday morning.
- Wednesday afternoon thru Friday morning - SBR feed represents plant influent from Monday morning thru Wednesday morning.
- Friday afternoon thru Monday morning - SBR feed represents plant influent from Wednesday morning thru Friday morning.

An advantage of this setup was that if the plant noticed any issues with nitrification, there was ample time to request a SBR profile that would reflect that day's influent characteristics. Every Monday, Wednesday, and Friday, the Technical Services Division (TSD) of HRSD arranged to transfer the contents of each storage container at the feed collection points to the SBR lab. Container contents at each site were pumped from the storage containers, to empty containers in the back of a truck. Once feed containers were transported to the lab, the stationary feed containers were emptied, rinsed, and refilled with fresh feed samples. Fresh feed was typically transferred immediately following a feed cycle, particularly during the summer months, to allow the wastewater sufficient time to cool to 12°C before the next feed cycle. Every two weeks, stationary feed containers were washed with bleach and rinsed thoroughly, and feed tubing was replaced to prevent growth of filamentous bacteria, which would cause poor settling in the reactors. If bulking of sludge or poor settling was observed before two weeks had passed, this practice was performed as needed. Each stationary feed drum also contained a submersible pump which was programmed to cut on 15 minutes before each feed cycle to ensure that the influent feed was well-mixed before being fed to the reactors.

3.1.2.2. Reactor Seeding

The seed biomass for the VIP SBRs was collected directly from the VIP Wastewater Treatment Plant (Norfolk, VA). Nansemond Raw and PCI reactors were seeded using biomass collected from the Nansemond Wastewater Treatment Plant (Suffolk, VA).

After seeding, the reactors were initially started at 12° C, with a 12 day SRT and a 12 hour HRT. After 28 days, complete nitrification had not yet been achieved in any of the reactors, and mixed liquor concentrations had steadily increased and not yet stabilized, with the Nansemond PCI-fed reactor exceeding 4,500 mg/L. At this point, the reactor temperatures were raised to 20° C, the SRTs were raised to 15 days, and the HRTs were raised to 24 hours. Within 3 days, all four reactors were fully nitrifying and mixed liquor concentrations began to decrease.

Reactor temperatures were then slowly decreased to 12 °C over an 8 day period. Full nitrification was maintained in all reactors and MLSS concentrations stabilized between 2,000 and 3,000 mg/L for all reactors. The last sampling event was conducted 194 days after the initial seeding with reactors operating stably since August 18, 2010 (154 days).

3.1.2.3. Solids Retention Time

The SRT of the SBRs were maintained by wasting biomass at the end of the aerobic phase, just prior to the settling phase, to maintain a target 12 or 15 day SRT. The waste pump was calibrated as accurately as possible, but identical wastage rates were not able to be achieved. To monitor this, the waste activated sludge (WAS) was collected in storage containers, and these containers were weighed every 2 to 3 days and the exact volume wasted per cycle was determined. With this data, as well as the effluent total suspended solids (TSS) data and mixed liquor suspended solids (MLSS) data for each reactor, the actual SRT could be determined. To maintain the desired 12 or 15 day SRT as closely as possible, the appropriate volume of biomass was returned from each WAS container to its respective reactor during one cycle 3 days per week. By monitoring the wastage and effluent characteristics so closely, the SRT for all reactors was maintained as closely as possible to 15 days. During sampling events, the volume of mixed liquor removed from each reactor for data analysis was recorded and this volume was returned to each reactor from the designated waste container to maintain the desired SRT. For the purposes of modeling, it could therefore be assumed that the SBRs were maintained at exactly 15 days SRT.

3.1.3. SBR Profile Sampling

Profile sampling was conducted regularly to collect data which would be used to determine rates of nitrification and denitrification, as well as monitor nutrients and other parameters over the course of a reactor cycle. Figure 3.7 details the sample schedule on a typical profile day.

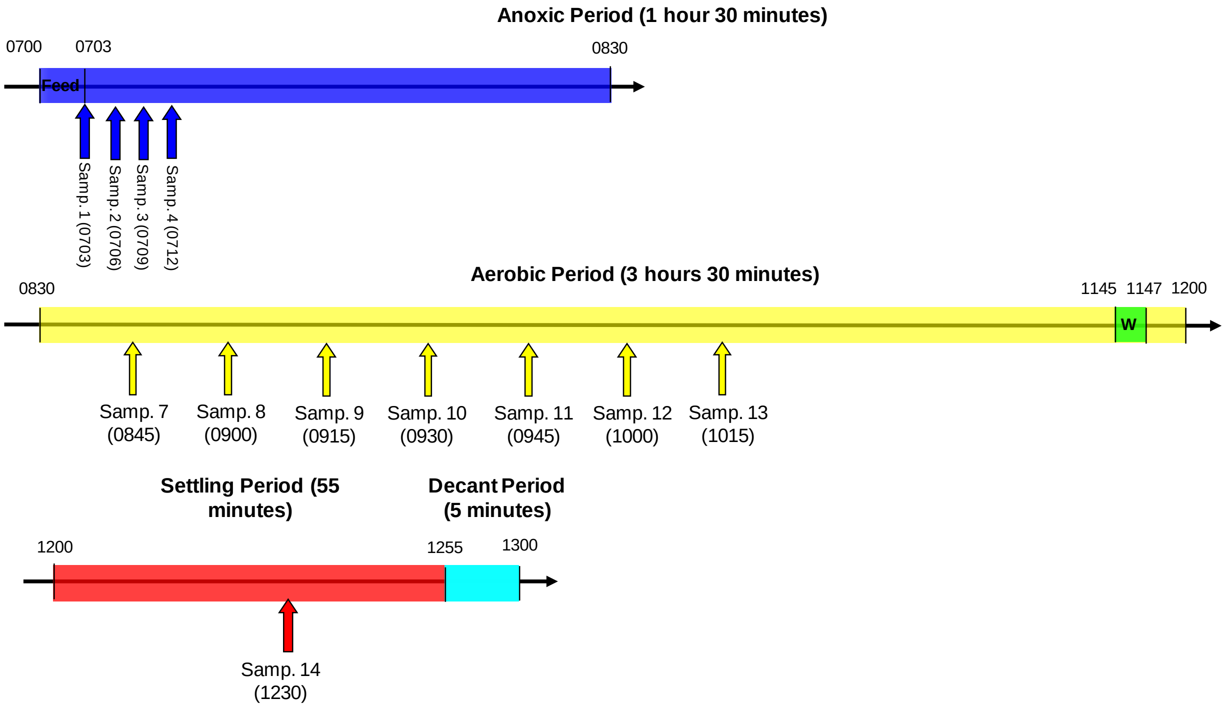

Figure 3.7 **Sampling Schedule (*Note: Samp. = Sample)**

Samples 1-13 represent 15 mL aliquots taken from each reactor at the designated times. Upon extraction, aliquots were immediately vacuum filtered using 0.45 µm filters and stored at approximately 4° C until analysis. For sample 14, 240 mL aliquots were collected from each reactor to be analyzed for MLSS and MLVSS. Sample 15 was used to monitor the final effluent quality. One liter of effluent was siphoned from each reactor using a J-tube decanter (to avoid stirring up any settled sludge) and 15 ml of sample was extracted and filtered. Since denitrification began immediately after the feed cycle, it was necessary to sample intensely during that time frame in order to attain sufficient data for analysis and comparison. With nitrification occurring at a slower rate, samples were collected beginning 15 minutes after aeration began to ensure that the dissolved oxygen (DO) concentration had reached at least 3 mg/L in all reactors prior to sample collection. The next 6 samples were collected in 15 minute intervals after the first aerobic sample.

Beginning November 3, 2010 and continuing to the last sampling event, each reactor was spiked with a solution of ammonium chloride immediately prior to the start of the aerobic phase to raise the initial ammonia concentration to approximately 10 mg/L for reactor profile sampling. By doing so, ammonia concentrations were maintained at a high enough concentration throughout aerobic cycling that nitrification would not become ammonia-limited. Prior to spiking, typical starting NH4-N values for NP RWI and NP PCI reactors were around 7 mg/L, while VIP RWI SBRs typically started around 5 mg/L.

Influent COD, TKN, TSS, VSS, NH4-N, MLSS, MLVSS, and Effluent TSS, NH4-N, NO3-N, and NO2-N data was collected every Monday, Wednesday, and Friday, excluding certain holiday and weather related closings.

3.1.3.1. Bench-Rate Measurements

Nitrification rates and denitrification rates were determined using NOx-N generation or depletion rates, respectively, and normalized to MLVSS to get specific rates. In order to get the corrected maximum nitrification rate (NR or SNR), the following Monod expression was used to adjust measured and modeled rates to the maximum nitrification rate assuming no ammonia limitations. The ammonia concentration used in this Monod expression was the average over the course of the rate measurement sampling:

$$\frac{\qquad}{\qquad} \tag{8}$$

where K_{NH4} = half saturation coefficient for ammonia = 0.7 mg/L (from BioWin default value)

3.1.3.2. Dissolved Oxygen Control

DO was maintained between 3 and 4 mg/L using Royce Technologies conventional galvanic membrane probes and meters and a solid state controller. When each reactor reached 4 mg/L, the air supply would be turned off. When the reactors reached 3 mg/L, the air supply would automatically be turned back on until the concentration once again reached 4 mg/L, and this pattern continued throughout the entire aerobic phase. When air was turned off, mixers remained on to keep solids and associated nitrifying bacteria in suspension. The DO concentration was recorded at 20-second intervals using a data logger. The rates at which the DO concentration dropped from 4 to 3 mg/L during the aerobic phase was used to create a profile of oxygen uptake rates (OUR) for each reactor over the course of the aerobic phase of each reactor cycle. When normalized with respect to the mixed liquor volatile suspended solids (MLVSS) concentration, the specific oxygen uptake rate (SOUR) was determined.

All pH and temperature data were also uploaded to a server by the data logger every two minutes. The pH of the SBR's were monitored, but not controlled, and temperature was maintained at approximately 12±0.5° C.

Figure 3.8 **DO meters, solid state DO controller and data logger.**

3.1.4. Analytical Methods

Samples were analyzed for COD (mg/L COD), TKN, ammonium (mg/L as N), nitrate (mg/L as N), nitrite (mg/L as N), Ortho-phosphate (mg/L as P), MLSS (mg/L), MLVSS (mg/L), TSS (mg/L), and VSS (mg/L). DO was measured throughout the sampling period using the permanently mounted probes to ensure that aerobic and anoxic periods were indeed at the required levels, and also to attain Oxygen Uptake Rates. DO levels were also checked regularly with handheld probes to ensure that permanently mounted probes were still calibrated. Temperature and pH measurements were also confirmed with handheld instruments regularly. The sludge volume index (SVI) was also measured in the reactors during each sampling period (APHA, 1998).

Mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) samples were analyzed by the Central Environmental Laboratory (CEL) of the Hampton Roads Sanitation District (HRSD). Total suspended solids (TSS) and volatile suspended solids (VSS) were also analyzed for feed samples, and only TSS data was collected for effluent samples. COD and TKN samples for the feed sources were also analyzed by CEL. All procedures and tests performed by CEL were carried out according to the guidelines set forth by *Standard Methods* (APHA, 1998). The sludge volume index (SVI) was measured by noting the sludge blanket height 30 minutes into the settling period using Nalgene settlometers and normalizing with respect to MLSS concentrations.

3.1.4.1. Ammonia (NH4-N) HACH Test Kit

Ammonia was analyzed using HACH Test N' Tube (TNT) 830 (ultra low range) or 831 (low range) kits and a HACH DR2800 spectrophotometer. This method uses the salicylate method, whereby ammonium ions react with hypochlorite and salicylate ions in the presence of sodium nitroprusside as a catalyst to form indophenol. The amount of color formed is directly proportional to the NH4-N present.

3.1.4.2. Nitrate (NO3-N) HACH Test Kit

Nitrate was analyzed using HACH TNT 835 (low range) or 836 (high range) kits. These kits incorporate the dimethylphenol method where nitrate ions in solution with sulfuric and phosphoric acids react with 2,6-dimethyphenol to form 4-nitro-2,6-dimethyphenol.

3.1.4.3. Nitrite (NO2-N) HACH Test Kit

Nitrite was analyzed using Test N' Tube NitriVer3 Nitrite Reagent sets. This kit uses the diazotization method where nitrite in the sample reacts with sulfanilic acid to form an intermediate diazonium salt. This salt combined with chromotropic acid forms a pink color which is directly proportional to the amount of nitrite present.

3.1.4.4. Ortho-Phosphate (PO4-P) HACH Test Kit

Ortho-Phosphate was analyzed using the HACH Reactive Phosphate TNT Reagent Kit. This test kit uses the USEPA-approved PhosVer3 method where orthophosphate reacts with molybdate in an acid to produce a mixed complex. Ascorbic acid then reduces this complex, producing an intense blue color.

3.1.5. Intensive Sampling

For two weeks, an intensive sampling period was conducted, which included 5 individual intensive sampling days. On these days, in addition to the regularly collected data, the following parameters were also measured:

- Influent and Effluent COD_{GF} (glass fiber (1.5 µm nominal) filtered COD)
- Influent and Effluent ffCOD (flocculated-filtered COD per Melcer et al.)

- Influent and Effluent BOD
- Influent and Effluent BOD_{GF} (glass-fiber (1.5 µm nominal) filtered BOD)
- Influent and Effluent TKN_{MF} (0.45 µm membrane-filtered TKN)
- Influent and Effluent TP
- Effluent COD
- Effluent TKN
- Effluent VSS
- Mixed Liquor TKN
- Mixed Liquor TP

These data were collected for use with BioWin modeling, in order to predict wastewater fractionations. This will be discussed further in the next section.

3.2. BioWin Modeling

Modeling was performed using BioWin version 3.1, a biological wastewater treatment simulation package developed by EnviroSim Ltd (Flamborough, Ontario, Canada) and based on the IWA activated sludge models. BioWin was utilized for this work as a way to compare predicted reactor performance to actual reactor performance. Based on the data collected during the aforementioned intensive sampling period, the various wastewater fractions in Table 3.1 were determined using the BioWin influent specifier. Influent data itineraries were prepared for the course of the experiment period based on COD, TKN, and inorganic suspended solids (ISS) data collected since project startup. Influent data itineraries also reflected feed and waste cycles over the course of the project. Other values required for influent feed characteristics and fractionation were assumed constant at the concentrations listed in Table 3.2. For each BioWin simulation, the following model modules were selected:

- “Use BioWin integrate AS/AD model” (Note: AS/AD = Activated Sludge/Anaerobic Digestion)
- “Use oxygen modeling (assumes immediate response to DO setpoint changes when not selected)”
- “Include pH calculations (otherwise pH of 7.0 assumed)”

Initially, the only modifications made to the BioWin parameters were those provided by the BioWin influent specifier. For the SBR model, non-reactive settling was used. With this setup, a reactive settling model was not necessary because all solids were artificially maintained in the reactors using a clarifier with 100% removal efficiency, with the solids returned to the reactor (see Figure 3.9). Using the influent data itineraries prepared from influent feed characteristics (TSS, COD, and TKN), all three SBR models were simulated for the project period. Each was simulated several times to ensure that steady state had been reached. Once steady state had been reached, model data was exported for comparison to actual data over the course of the project. Based on comparison of measured and model data, the need for changes to model parameters was evaluated. Initially, no changes were made to the models for both NP RWI and NP PCI reactors. However, the model VIP RWI control reactor consistently over-predicted MLSS concentrations and for this reason, aerobic and anoxic yield values were adjusted slightly to create a closer fit. The aerobic yield was reduced from 0.666 to 0.610, and anoxic yield was reduced from 0.54 to 0.52. Since yield is defined as the mass of biomass produced per mass of substrate used, these minor adjustments reduced the model MLSS concentrations to match the measured concentrations. Next, the corrected maximum nitrification rates were compared over the course of the project. Upon comparison, it was observed that the model consistently achieved higher nitrification rates over the course of the project. In order to find the best fit, several different maximum specific growth rates for AOB (μmax, AOB) were simulated in BioWin. The adjustment of this parameter resulted in significant changes for nitrification rate data, as well as effluent nutrient concentrations, all of which were compared to measured data to determine the μmax, AOB which most accurately reflected reactor performance.

Table 3.1: BioWin Wastewater fractionation

Name	Default	NP RWI	NP PCI	VIP RWI
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.160	0.198	0.132	0.212
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.150	0.200	0.197	0.153
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.750	0.730	0.730	0.694
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.050	0.103	0.086	0.159
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.130	0.206	0.206	0.312
Fna - Ammonia [gNH3-N/gTKN]	0.660	0.657	0.638	0.665
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.500	0.500	0.500	0.500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.020	0.020	0.020	0.020
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.035	0.035	0.035	0.035
Fpo4 - Phosphate [gPO4-P/gTP]	0.500	0.713	0.641	0.688
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.011	0.011	0.011	0.011
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZbp - PAOs [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZbpa - Propionic acetogens [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Particulate substrate COD:VSS ratio	1.600	2.660	2.940	2.330
Particulate inert COD:VSS ratio	1.600	2.660	2.940	2.330
Yield (aerobic)	0.666	0.666	0.666	0.610
Yield (anoxic)	0.540	0.540	0.540	0.520

Table 3.2: Influent Feed Parameters

Parameter	Value
Nitrate-N (mg N/L)	0.0
Alkalinity (mmol/L)	6.0
Calcium (mg/L)	80.0
Magnesium (mg/L)	15.0
Dissolved Oxygen (mg/L)	0.0

Figure 3.9 shows an image of one of the BioWin SBR models. This layout was used for each SBR model. The layout includes a COD influent (labeled “NP RWI” in Figure 3.9), an SBR, a waste effluent, a decant effluent, and a point clarifier. Wastewater fractions for the COD influent were determined using the BioWin influent specifier for each reactor. Data itineraries were also prepared for each reactor and the COD influent data reflected the influent characteristics of the actual reactors; waste and feed schedules also reflected actual operational conditions. An important feature to note about the model is the use of a point clarifier between the SBR and decant. The function of this point clarifier was to reduce effluent TSS to 0 mg/L, resulting in an SRT controlled by reactor volume and wastage rates alone. This is important for this project, as SRT for the actual SBRs was corrected to keep it as close as possible to 15 days, as discussed in section 3.1.2.3.

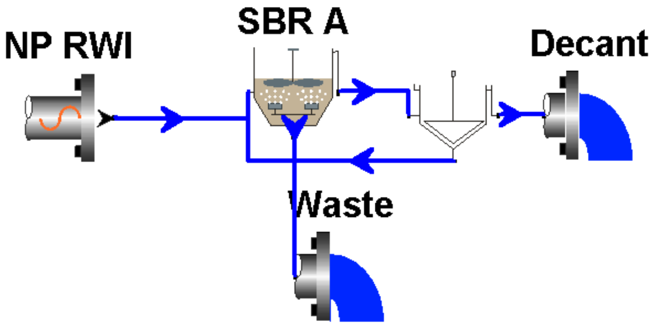

Figure 3.9 **BioWin SBR model**

4. Results and Discussion

4.1. Evaluation of Nitrification Inhibition Using SBRs

4.1.1. Reactor Operation

From the time that reactor operation stabilized at the desired operating conditions (SRT=15 days, HRT =24 hours, and T=12°C) on August 18, 2010, samples for influent TSS, VSS, COD, TKN, NH4-N, MLSS, MLVSS, SVI, effluent NH4-N, NO3-N, NO2-N, and TSS were collected every Monday, Wednesday, and Friday, with a few exceptions. These data were compiled and plotted versus time in Figures 4.1 – 4.10. Table 4.1 provides average values over the experimental period with standard deviations for each reactor. Effluent nutrient data collected on profile sampling days where reactors received a spike of ammonium chloride were not included in the effluent data reports, as these values were not representative of actual reactor performance. That is because a byproduct of the ammonia spike was an increase in effluent nitrogen species.

Influent TSS, COD, TKN, and NH4-N data are shown in Figures 4.1 – 4.4. From these figures, several observations can be made. First, Nansemond RWI and PCI influent were consistently higher in TSS, COD, TKN and NH4-N than VIP RWI. NP PCI typically had higher TSS, TKN and NH4-N than NP RWI as a result of internal plant recycle stream input, although total COD tended to switch back and forth between the two sources. NP PCI experienced a sudden drop-off in TSS and COD at the beginning of January, which may have had something to do with plant operations. There was a significant rainfall event in the Hampton Roads area at the end of September and into early October. This is most obvious in the influent NH4-N and TKN plots, although some effect can be seen in the TSS and COD plots.

Table 4.1 **Average values over the experimental period with standard deviations for all reactors**

			NP RWI (A)		NP PCI (B)		VIP RWI (C)		VIP RWI (D)	
			Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Influent	NH4-N	mg/L	31.6	3.7	32.2	4.4	22.0	4.1	22.2	4.0
	TSS	mg/L	129	33	141	45	115	56	104	36
	VSS	mg/L	114	31	123	40	95	47	87	30
	COD	mg/L	523	132	524	152	407	136	395	124
	TKN	mg/L	48	6	50	6	34	6	34	6
Effluent	NH4-N	mg/L	0.2	0.3	0.1	0.0	0.1	0.2	0.1	0.1
	NO3-N	mg/L	10.8	4.0	12.0	2.9	8.8	3.7	8.5	4.1
	NO2-N	mg/L	0.1	0.2	0.1	0.6	0.0	0.1	0.0	0.1
	TN	mg/L	11.0	4.1	12.2	3.0	9.0	3.7	8.7	4.1
	TSS	mg/L	12	5	10	5	9	4	7	3
Reactor	MLSS	mg/L	2138	276	2320	458	1796	305	1753	290
	MLVSS	mg/L	1800	217	1920	334	1472	206	1436	206
	SVI	mL/g	124	32	116	19	110	41	118	48
	Temp.	° C	12.3	0.1	11.8	0.1	12.2	0.1	12.1	0.1

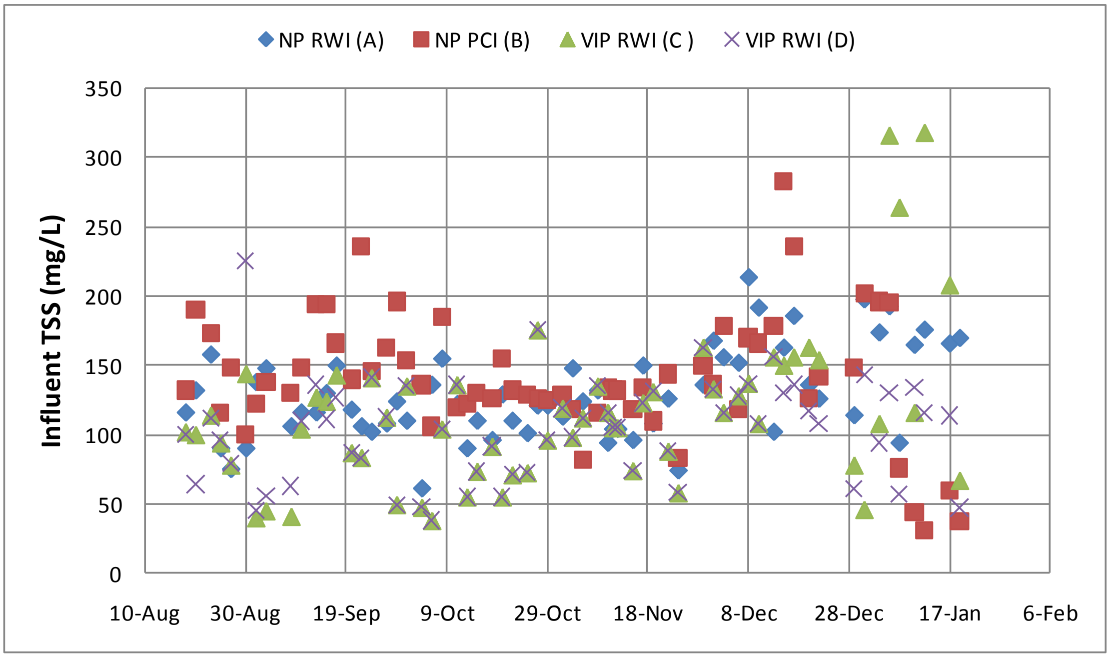

Figure 4.1 **Influent TSS data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

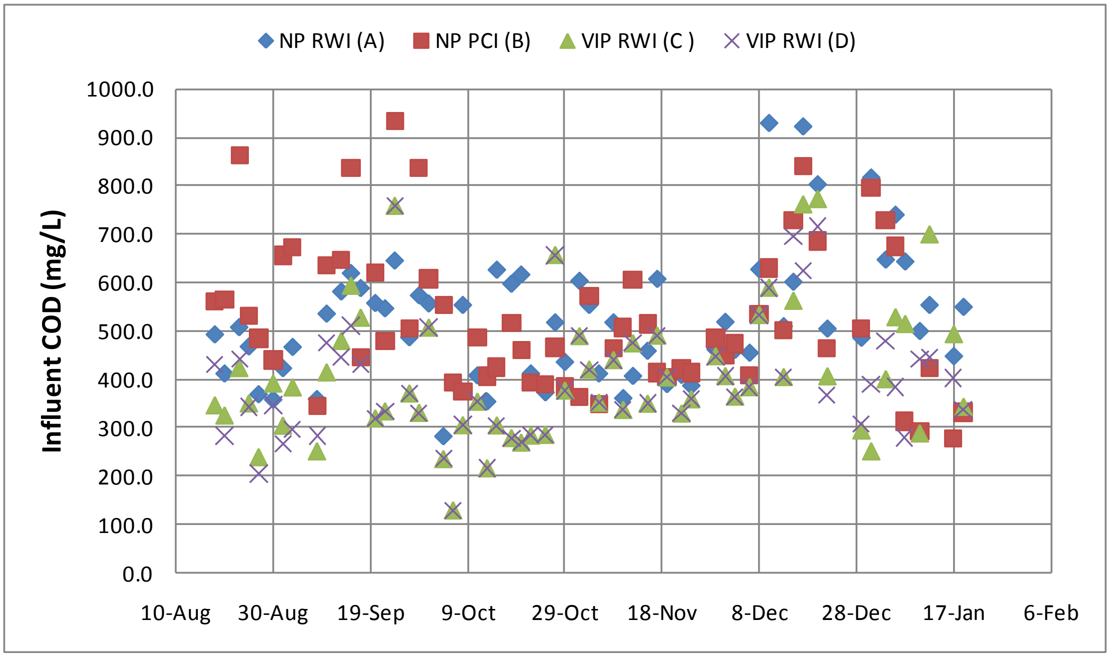

Figure 4.2 **Influent COD data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

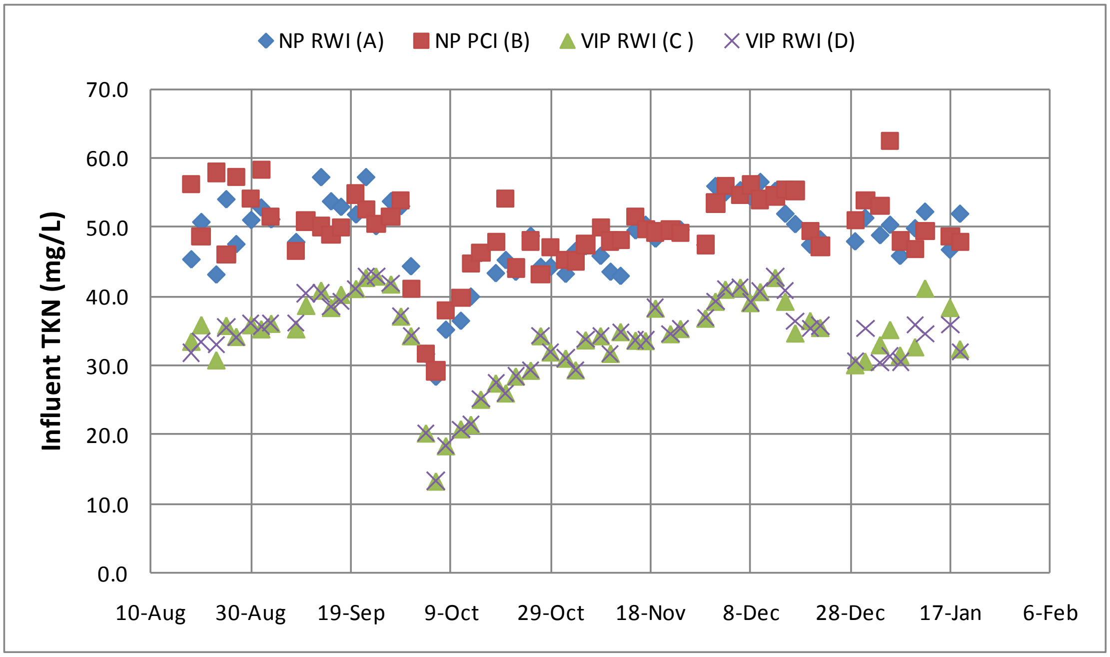

Figure 4.3 **Influent TKN data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

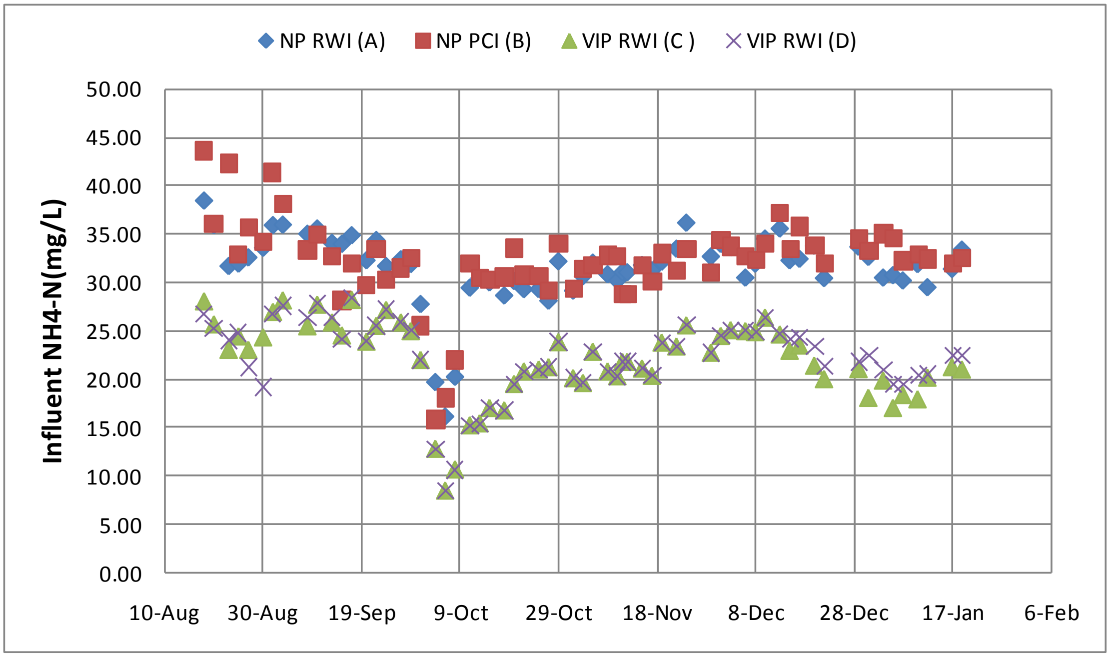

Figure 4.4 **Influent NH4-N data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

Figures 4.5 and 4.6 show MLSS and SVI data over the course of the project. As with the influent data, NP RWI and PCI had consistently higher MLSS concentrations than the VIP RWI SBRs (C and D), with NP PCI typically higher than NP RWI. Based on the influent data this comes as no surprise, as it is also not surprising that all four reactors experienced a drop in MLSS concentrations immediately following the rainfall event in late September. SVI data varied over the course of the project, although a few peaks could be seen. When these peaks were observed, feed containers were immediately washed with bleach and rinsed thoroughly, and feed tubing was replaced. Since these SVI peaks are typically a result of filamentous bacteria, thorough cleaning/replacement of these typically solved the problems and SVI values immediately fell to more typical values.

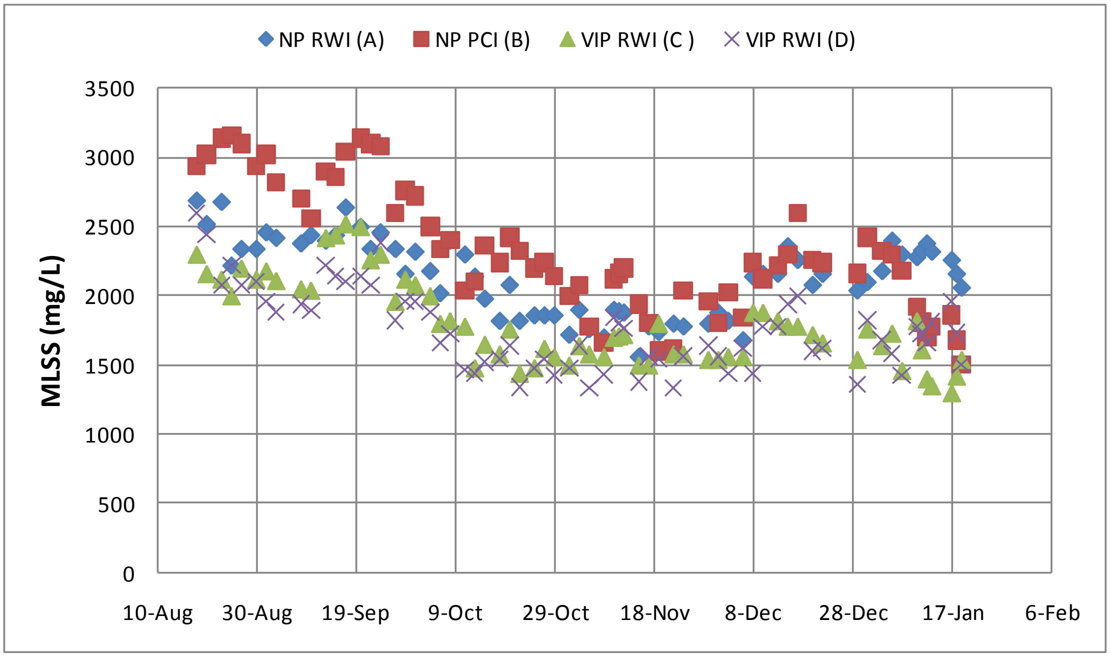

Figure 4.5 **MLSS data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

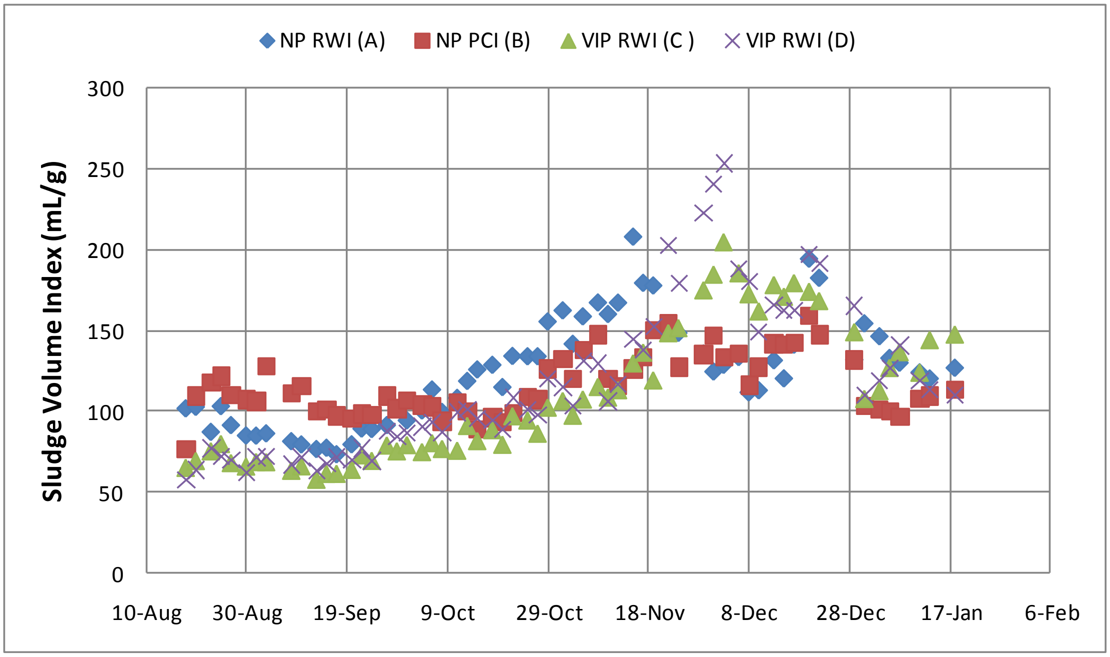

Figure 4.6 **SVI data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

Effluent data collected during the project are presented in Figures 4.7-4.10. Effluent NH4-N concentrations were consistently below 1 mg/L, which is typical, considering the temperature was maintained at 12±0.5°C. Effluent NO2-N is also consistently low over the course of the project. The consistently low effluent concentrations for both NH4-N and NO2-N indicate complete nitrification. Effluent NO3-N concentrations are directly affected by influent TKN and this impacts total nitrogen (TN) removal. Effluent NO3-N varied over the course of the project for all reactors, but NP PCI regularly reaches the highest concentrations, which is a result of having the highest influent TKN. Effluent TSS concentrations varied throughout the project for all four reactors with NP RWI and PCI seeing the highest values. At their peaks, effluent TSS reached values around 25 mg/L which were fairly high for these SBRs. However, since SRT was adjusted to 15 days by adding back wasted solids three times weekly, taking into account the effluent TSS, there was little concern with solids washout during these periods.

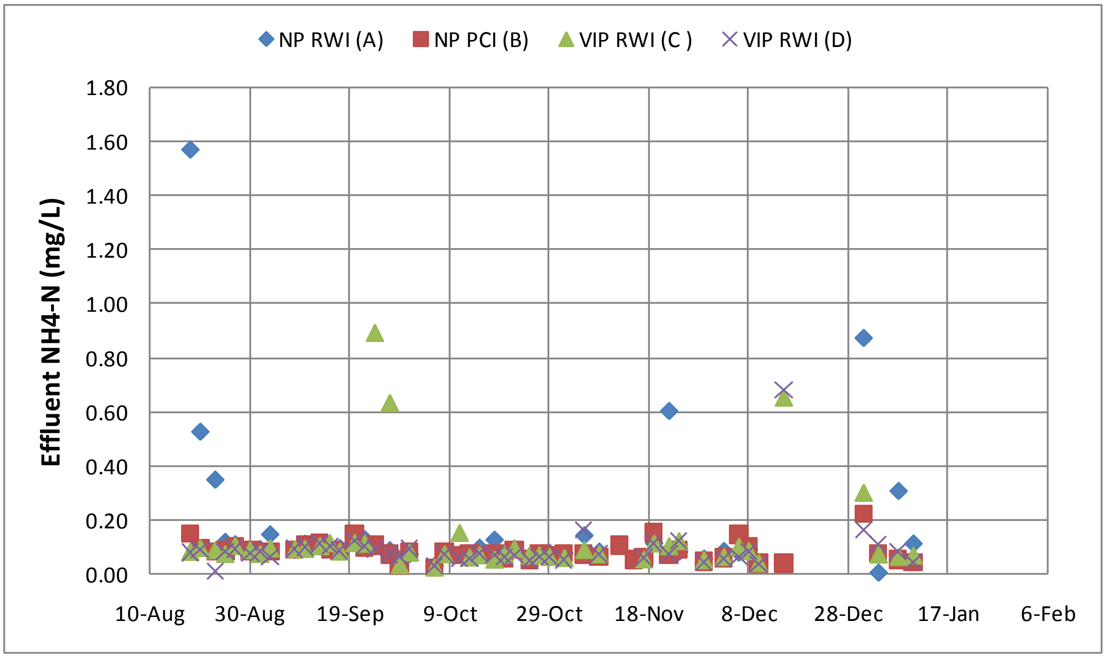

Figure 4.7 **Effluent NH4-Ndata for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

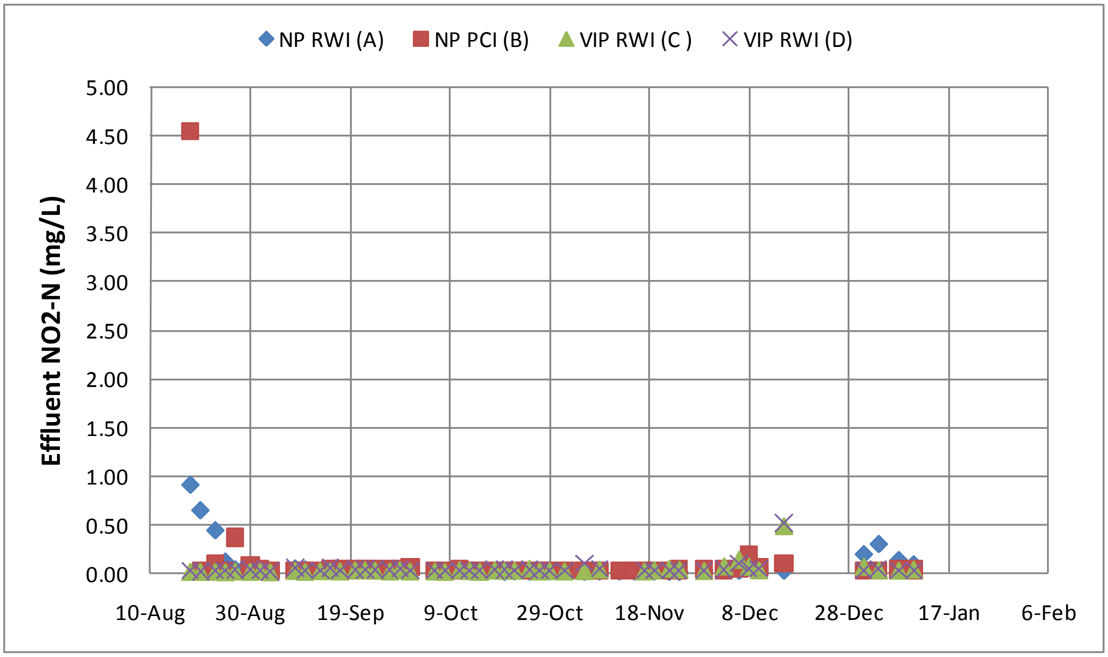

Figure 4.8 **Effluent NO2-N data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

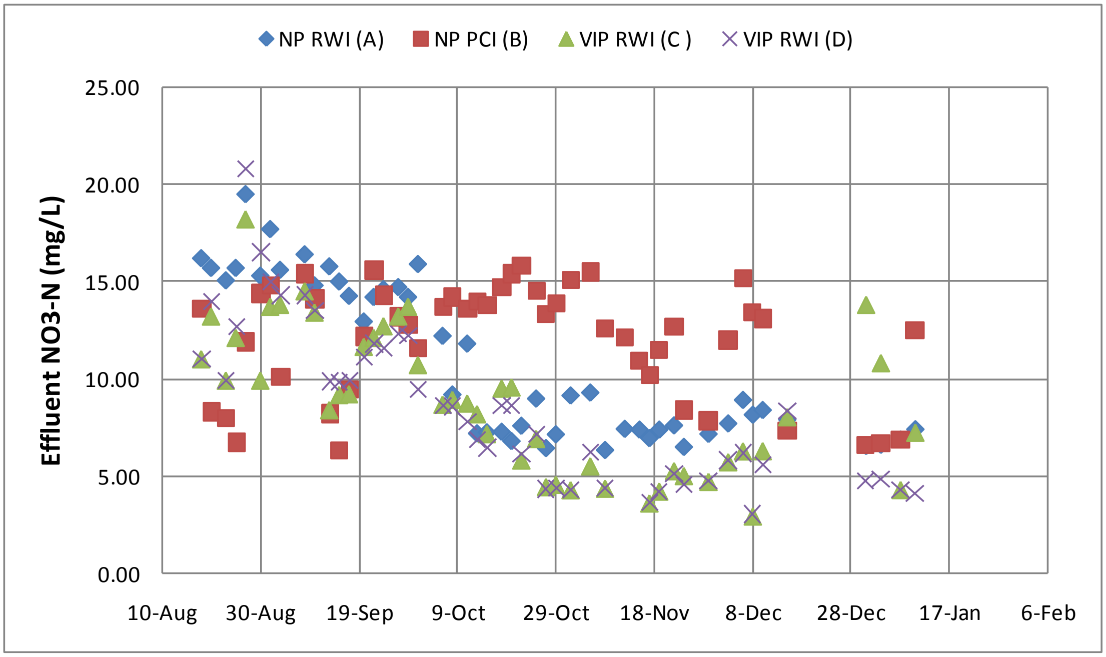

Figure 4.9 **Effluent NO3-N data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

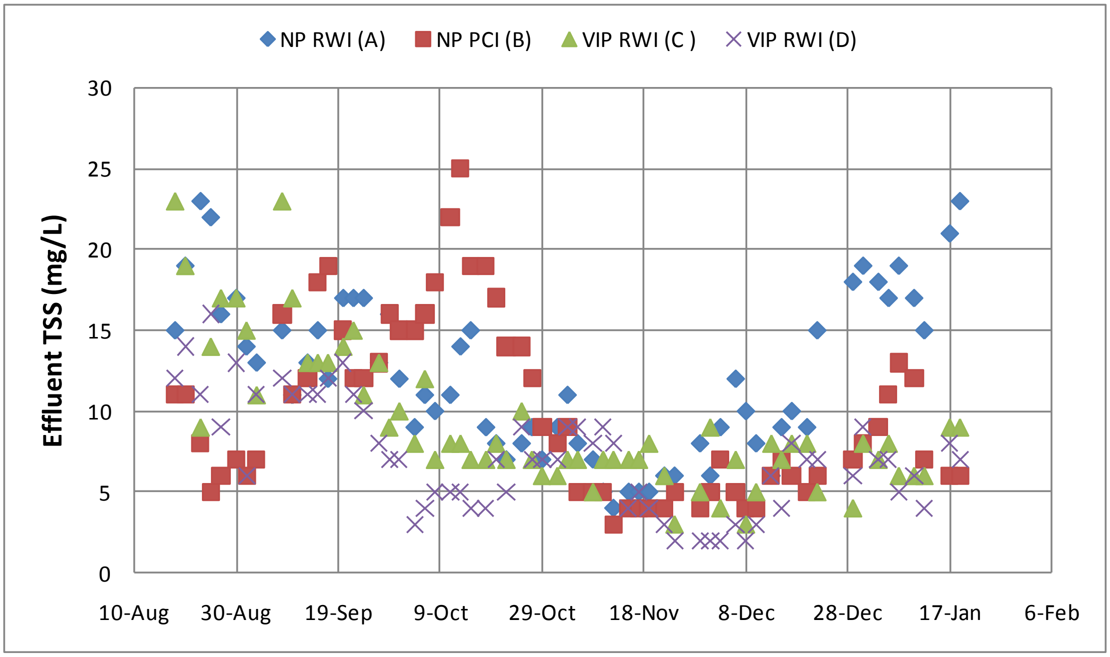

Figure 4.10 **Effluent TSS data for all four reactors from the onset of stable operation (August 18, 2010) until project completion (January 19, 2011)**

4.1.2. Reactor Comparison

Profile sampling events were conducted regularly to measure nitrification and denitrification rates. Nitrification rates (AOB) were determined using NOx-N generation rates. In order to get the corrected maximum nitrification rates (unlimited by NH4 concentrations during rate measurement), Equation 8 (section 3.1.3.1) was used to adjust rates so there were no effects from ammonia limitations. The ammonia concentration used in this expression was the average over the course of the rate measurement sampling. Figures 4.11 and 4.12 show the nitrification rates measured for each profile sampling event over the course of this project.

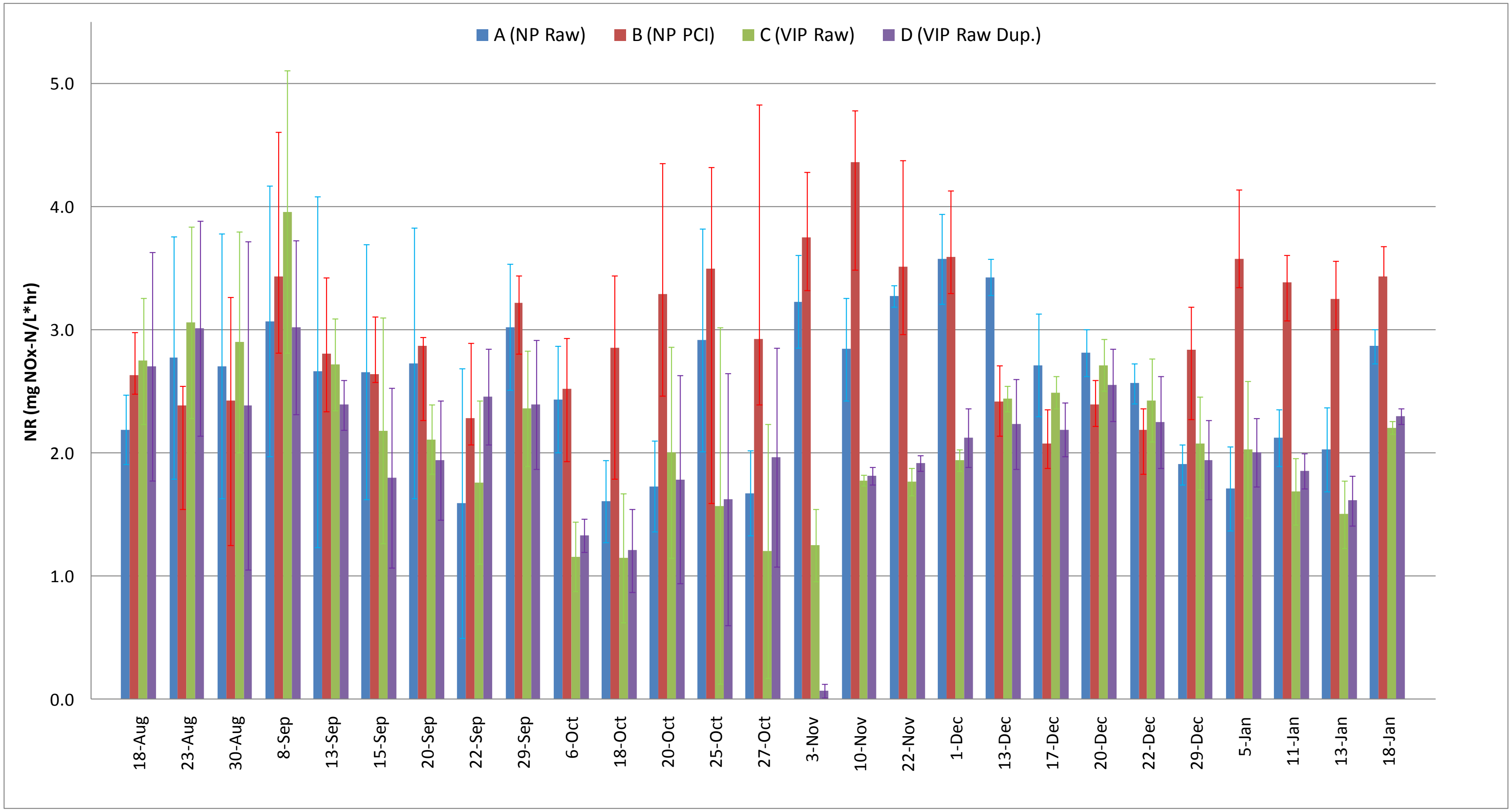

Figure 4.11 **Nitrification Rates (NR) from SBR profiling with 95% confidence interval based on the regression slope (Note: NR for VIP reactor D on November 3, 2010 is a result of a brief ATU test, discussed in detail in section 4.1.3)**

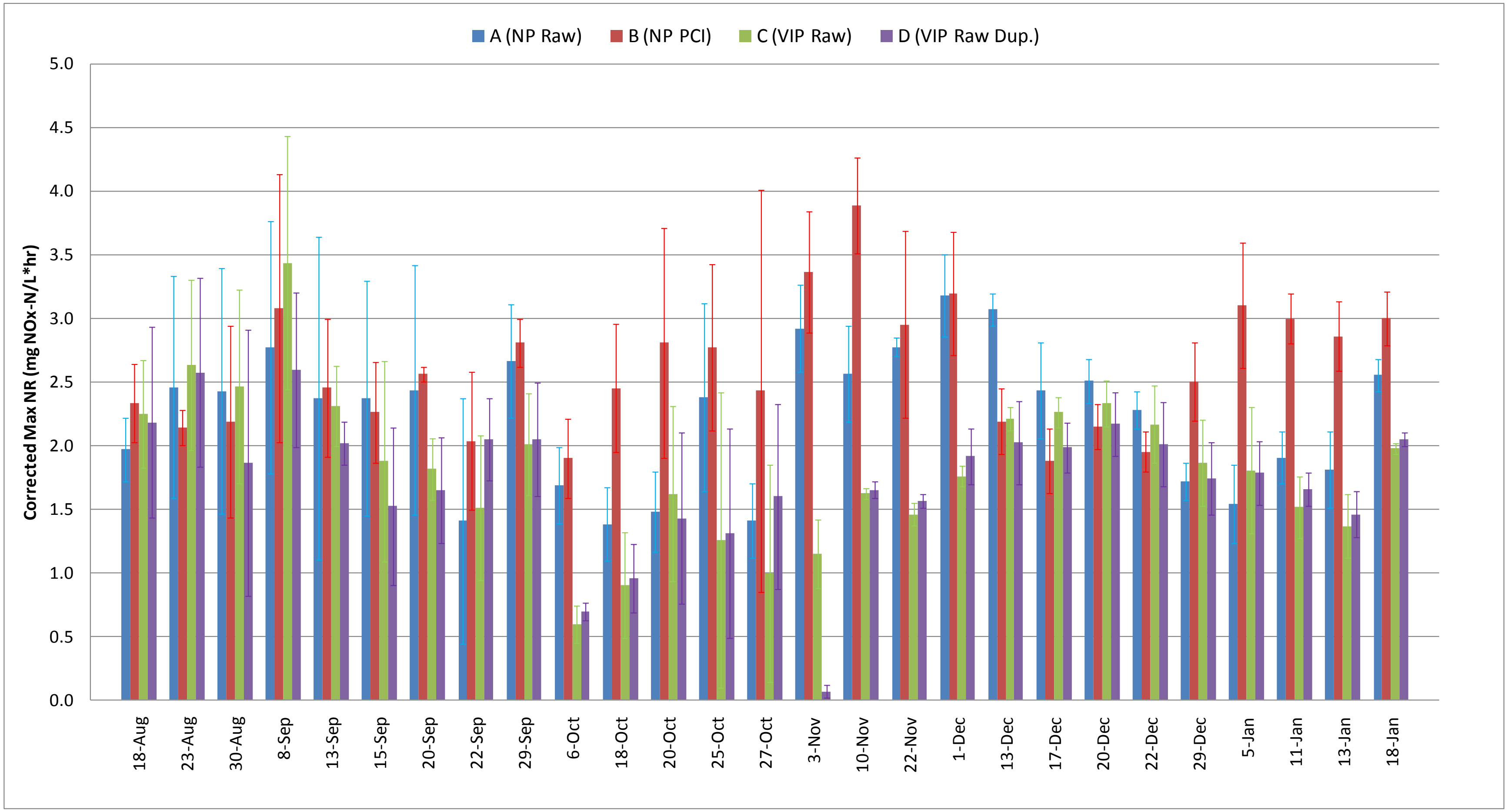

Figure 4.12 **Corrected Maximum Nitrification Rates for all Four Sequencing Batch Reactors Since August 18, 2010 with 95% confidence interval based on the regression slope (Note: NR for VIP reactor D on November 3, 2010 is a result of a brief ATU test, discussed in detail in section 4.1.3)**

With such a large amount of data, it was difficult to compare nitrification performance between the reactors from Figures 4.11 and 4.12. To better compare reactor performance between NP RWI and NP PCI, nitrification rates were normalized to those of the VIP control reactors, as seen in Figures 4.13 and 4.14. Which VIP reactor selected for comparison was based upon whether any experimental work was being conducted with the VIP reactors. From August 18, 2010 until December 13, 2010, VIP reactor C served as the control; this was because during this time, VIP reactor D performance was affected by addition of ATU and AFFF. From December 15, 2010 until project completion, VIP reactor D served as the control, as VIP reactor C was being used for AFFF experimental work. In order retain the error associated with the regression slope calculation, propagation of error (see equation 9) was used to generate Figures 4.13 and 4.14. These graphs show that NP PCI and NP RWI follow one another fairly closely over the course of this project. There was only one occasion where NP RWI outperformed NP PCI, on December 14, 2010. The three sampling events that followed produced a similar outcome, but these were statistically insignificant differences. The remainder of the time, NP PCI consistently matches or outperforms NP RWI. This suggests that if nitrification at Nansemond is inhibited, then the source is the collection system.

NP wastewater sources also demonstrated higher nitrification rates than VIP RWI (based on the NP/VIP ratio being greater than one). There are several NP/VIP points that are less than one, but the error bars (representing the 95% confidence interval based on the regression slopes) always extend to or beyond that point. These data suggest that NP experiences minimal or no continuous nitrification inhibition when compared to VIP.

$$- \qquad - \qquad \overline{\frac{\;}{\;} \qquad \frac{\;}{\;}} \tag{9}$$

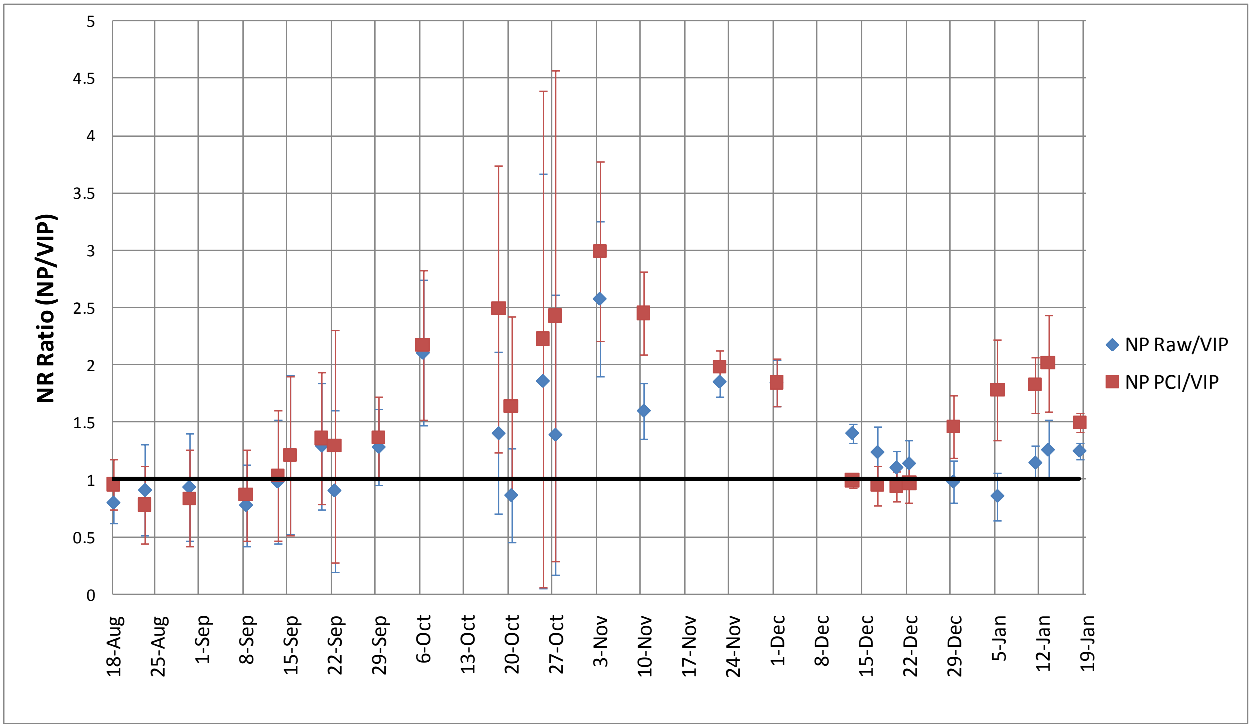

Figure 4.13 **Nitrification Rates for Nansemond RWI and PCI normalized to the VIP RWI Control Reactor**

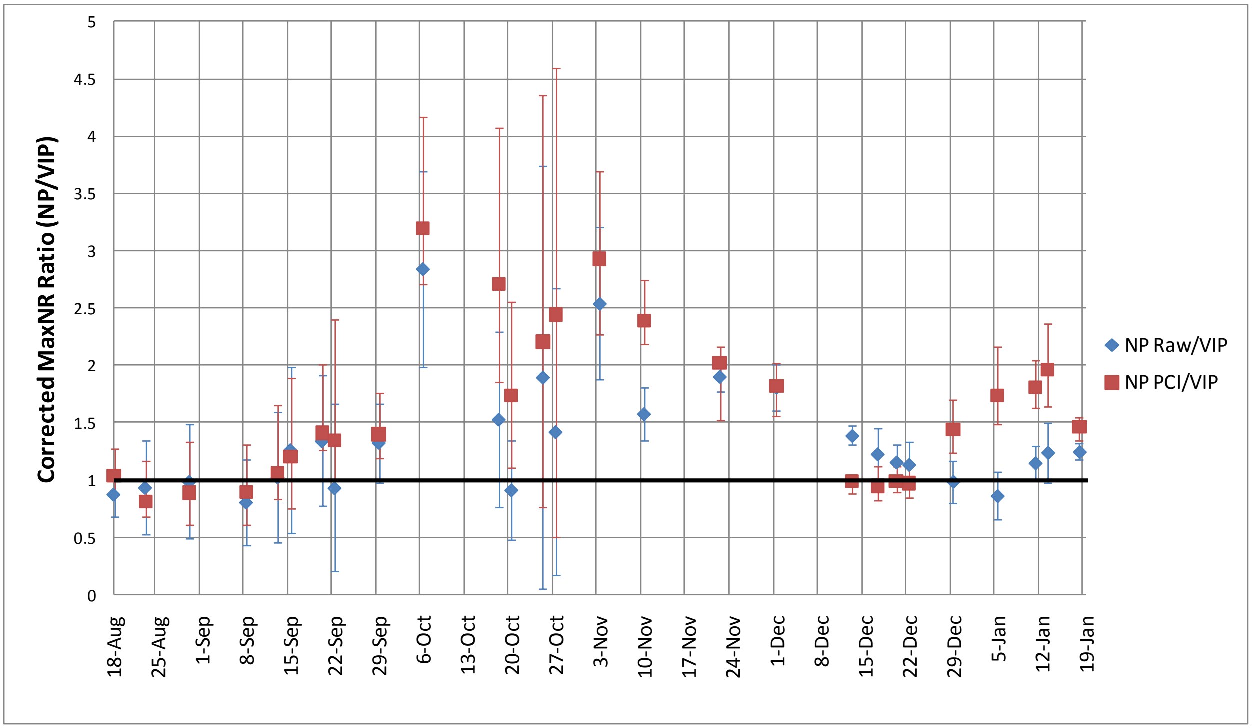

Figure 4.14 **Corrected Maximum Nitrification Rates for Nansemond RWI and PCI normalized to the VIP RWI Control Reactor**

4.1.3. ATU Test

In order to test the sensitivity of the reactors to a sporadic source of nitrification inhibition, one of the VIP reactor feed containers (D) was spiked with 1 mg/L ATU (allylthiourea), a known inhibitor of ammonia oxidizing bacteria (Hooper and Terry, 1973). The test VIP reactor was profiled during the third cycle after ATU addition began, resulting in an approximate ATU concentration in the reactor of 0.58 mg/L, assuming no losses from the reactor over time due to biodegradation, volatilization, or sorption. The result was a total loss of nitrification in the ATU fed reactor (Figures 4.15 and 4.16). This experiment confirmed that the SBRs were in fact sensitive to sources of sporadic nitrification inhibition.

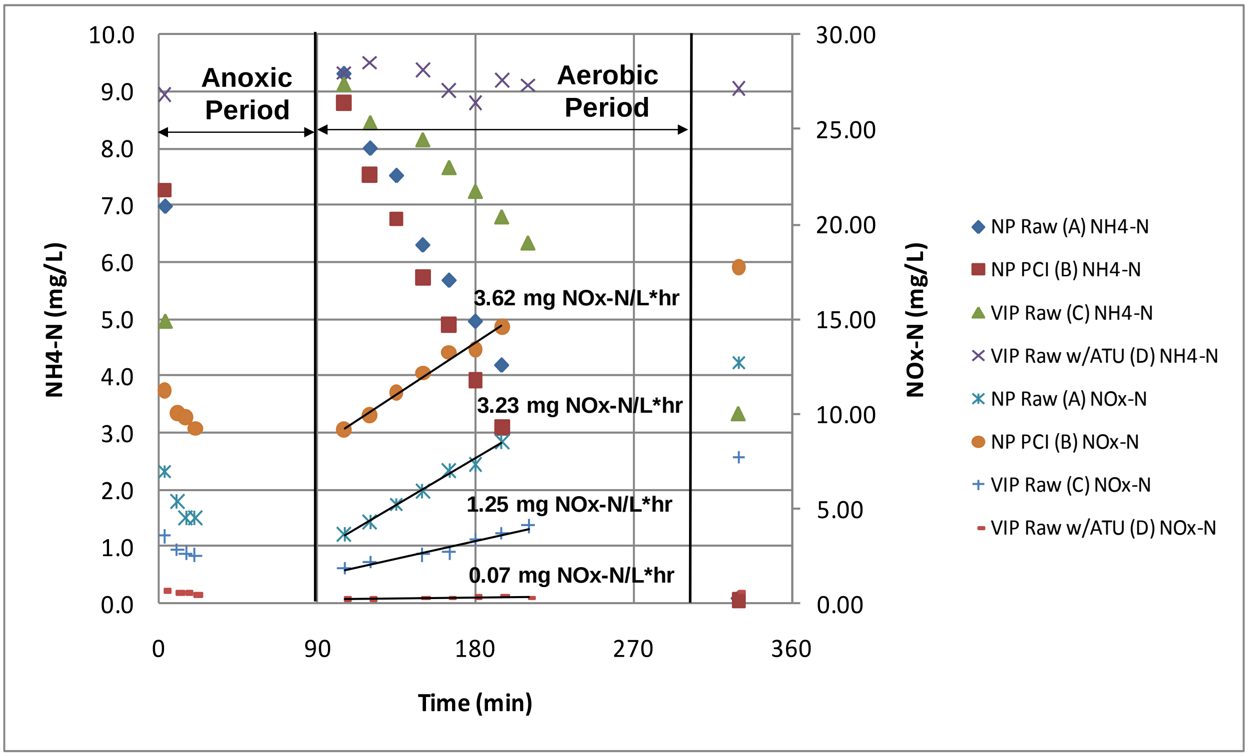

Figure 4.15 **Ammonia and NOx-N Profile over Reactor Cycle After ATU Addition to VIP Reactor (D)**

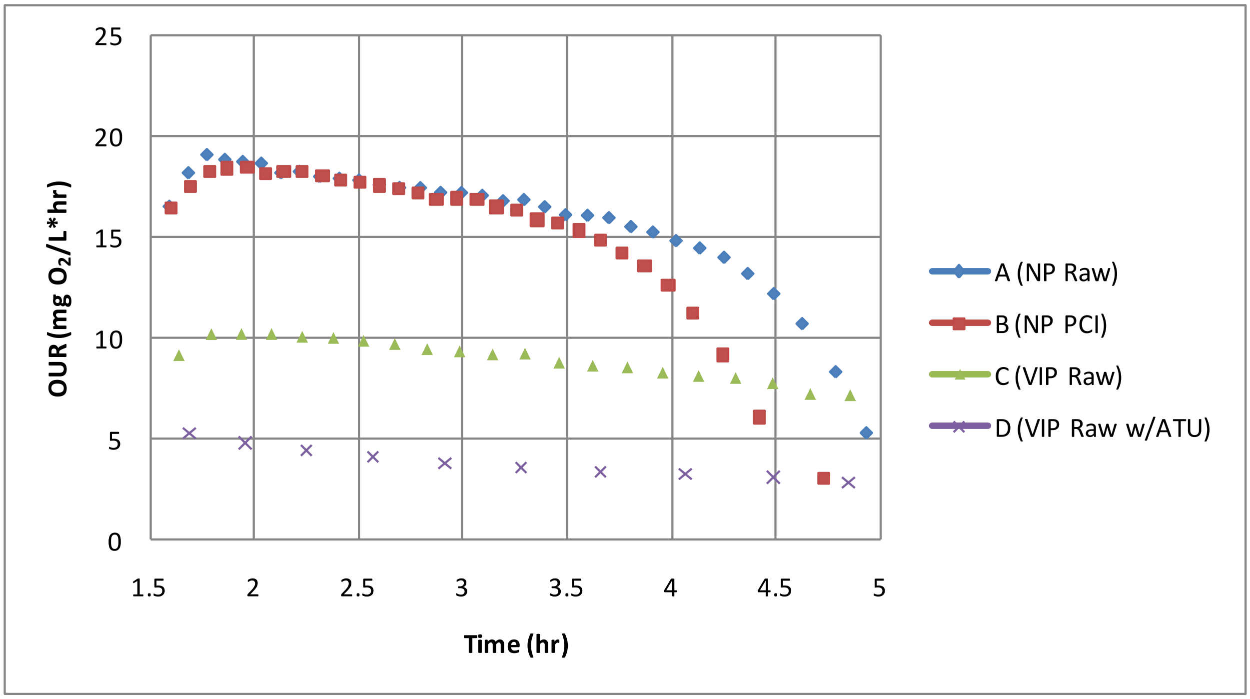

Figure 4.16 **Oxygen Uptake Rate Profile over Reactor Cycle After ATU Addition to VIP Reactor (D)**

4.1.4. BioWin Modeling

BioWin was utilized for this work as a means to compare predicted reactor performance to actual reactor performance and as a means of further scrutinizing the measured NRs and SNRs. Based on the data collected in the intensive sampling period described in Section 3.1.5, wastewater fractionation in Table 3.1 was determined using the BioWin influent specifier. Influent data itineraries were prepared for the course of the experiment period based on COD, TKN, and inorganic suspended solids (ISS) data collected since project startup. Other values required for influent feed characteristics and fractionation were assumed constant at the concentrations listed in Table 3.2.

After BioWin simulation of each reactor, the generated data were compared to the data collected over the course of the project. Each reactor was simulated with a range of maximum specific growth rates for ammonia-oxidizing bacteria (μmax, AOB) to determine which value best matched actual reactor performance. For the VIP control reactor, MLSS data consistently over-predicted MLSS concentrations and for this reason, aerobic and anoxic yield values were adjusted slightly to create a closer fit. The aerobic yield was reduced from 0.666 to 0.610, and anoxic yield was reduced from 0.54 to 0.52. For "Measured" data shown in the figures in this section, use the following legend:

◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)

4.1.4.1. Influent Characteristics

Over the course of this project, one VIP RWI reactor always served as a control, to use for comparison. Which reactor was used as the control varied, so measured data displayed in this section are a combination of the two VIP reactors, based upon which served as the control at any given point.

Based on comparison of BioWin-predicted influent data to actual data collected during the project, wastewater fractionation provided by the BioWin influent specifier accurately predicted influent TSS, VSS, and NH4-N for all three reactors based on constant wastewater fractionation determined by the influent specifier (Figures 4.17, 4.18, and 4.21). COD and TKN values were provided in the influent data itineraries so are a perfect fit, but are displayed here in Figures 4.19 and 4.20 to show influent characteristics over the course of the project.

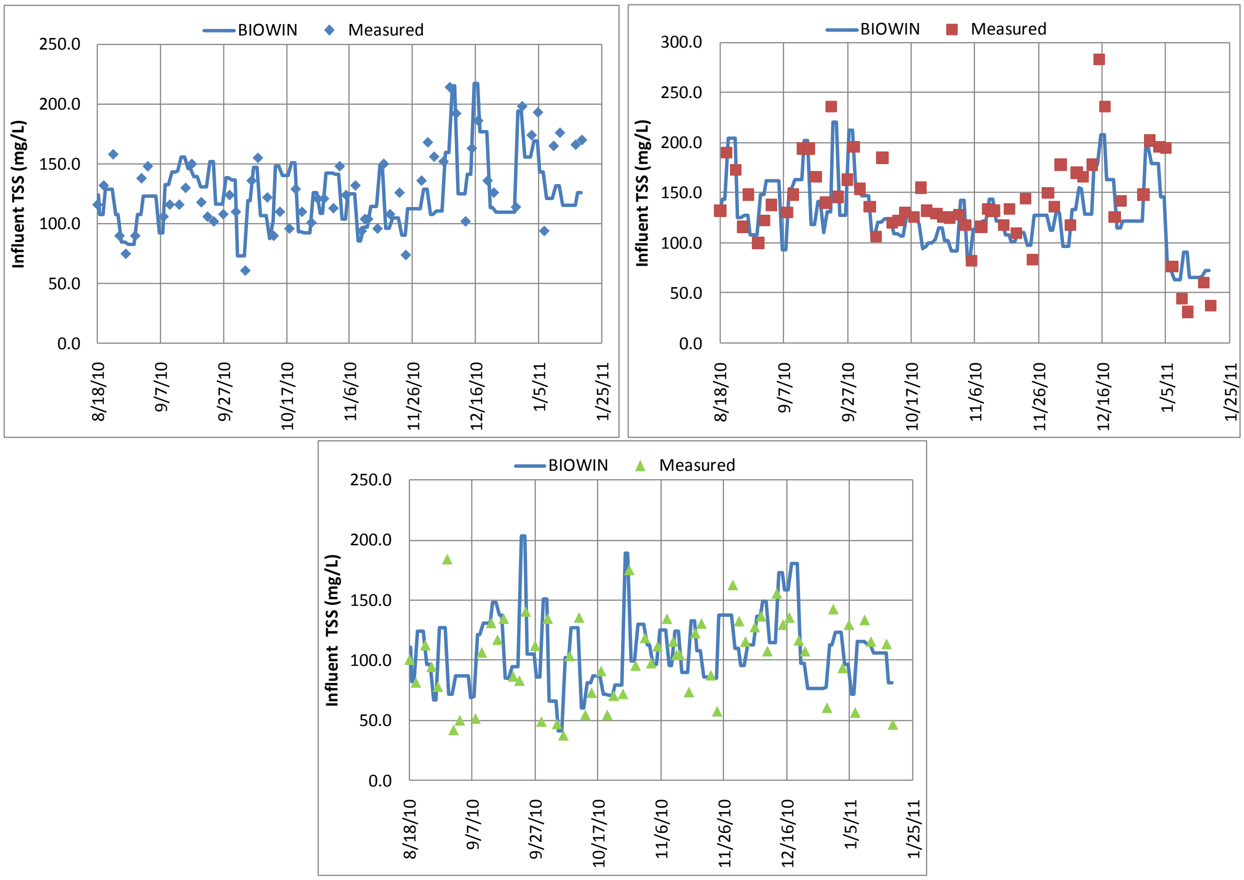

Figure 4.17 **Influent Total Suspended Solids to Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

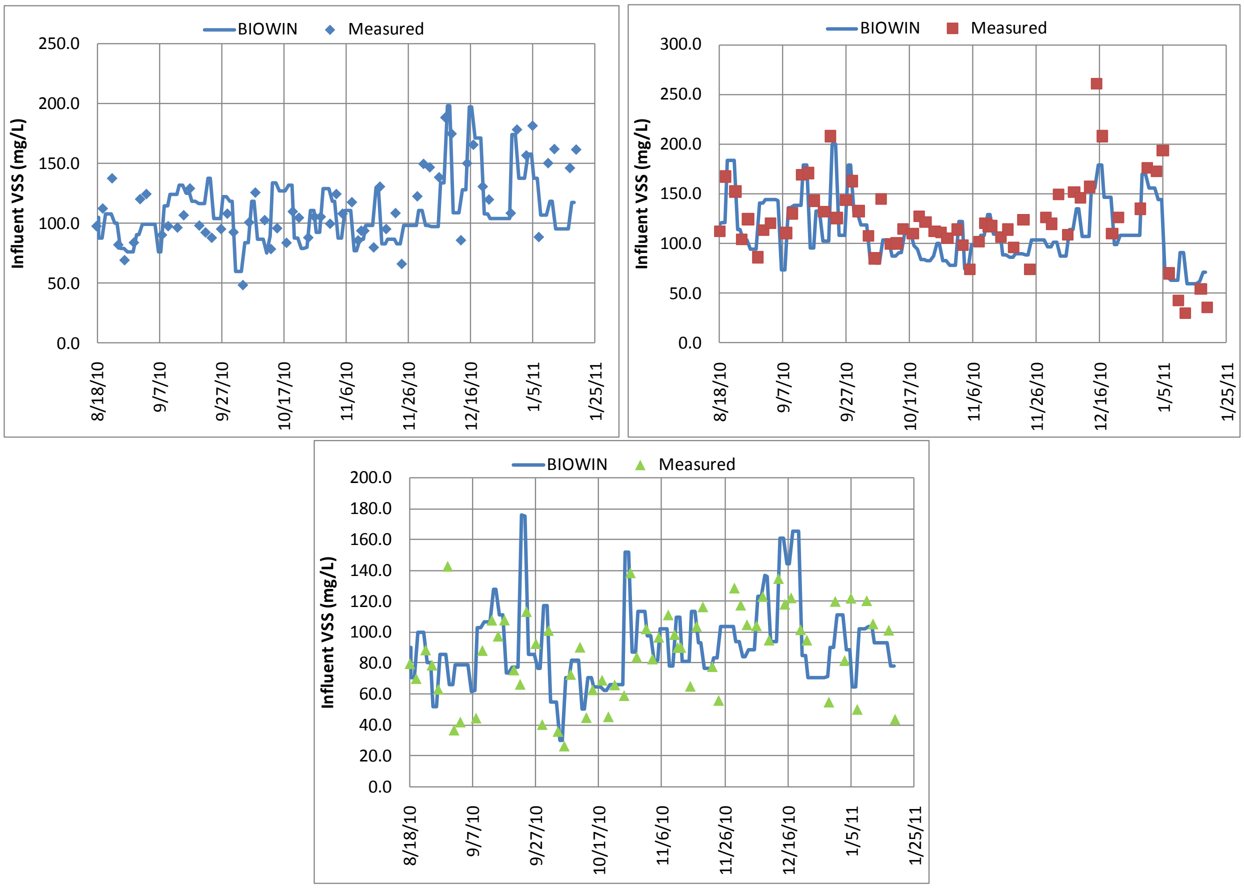

Figure 4.18 **Influent Volatile Suspended Solids to Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

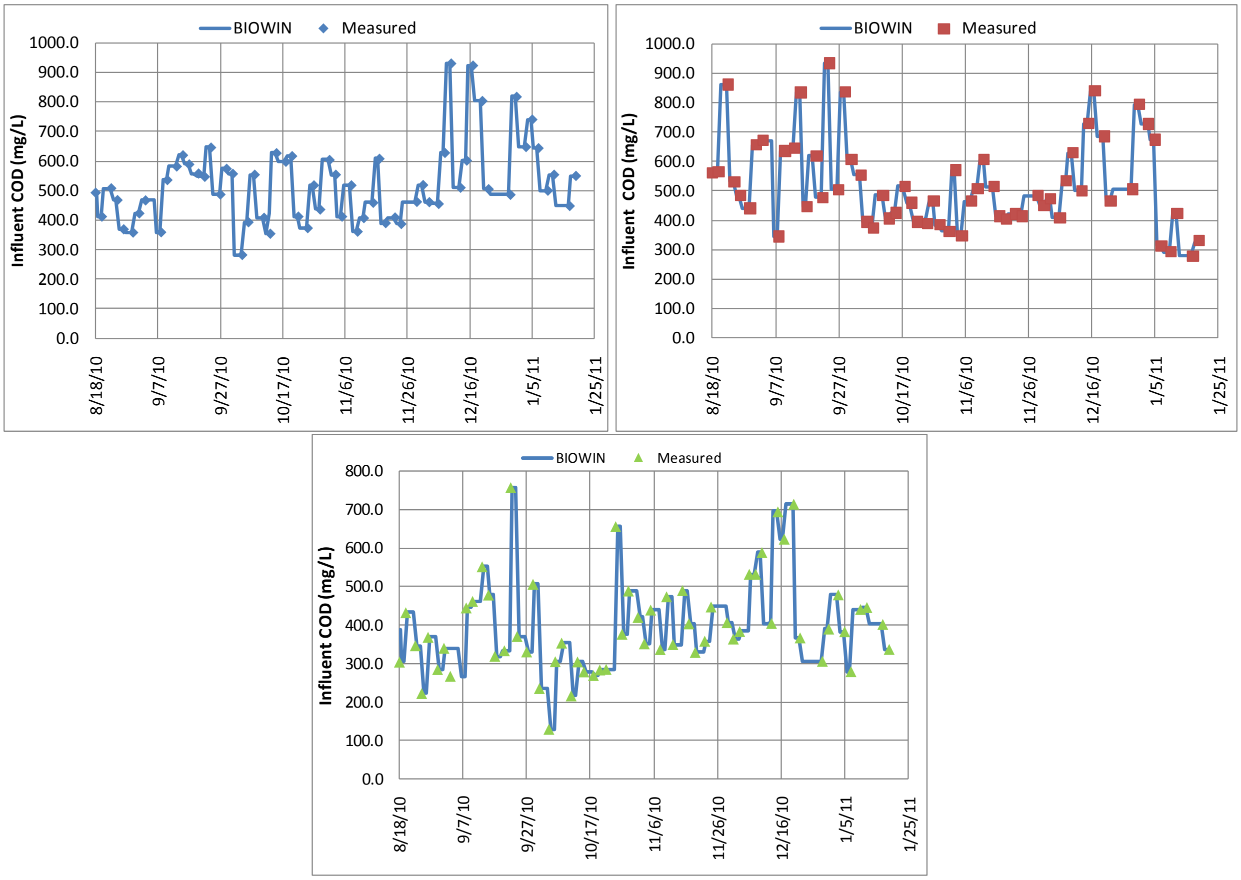

Figure 4.19 **Influent COD to Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

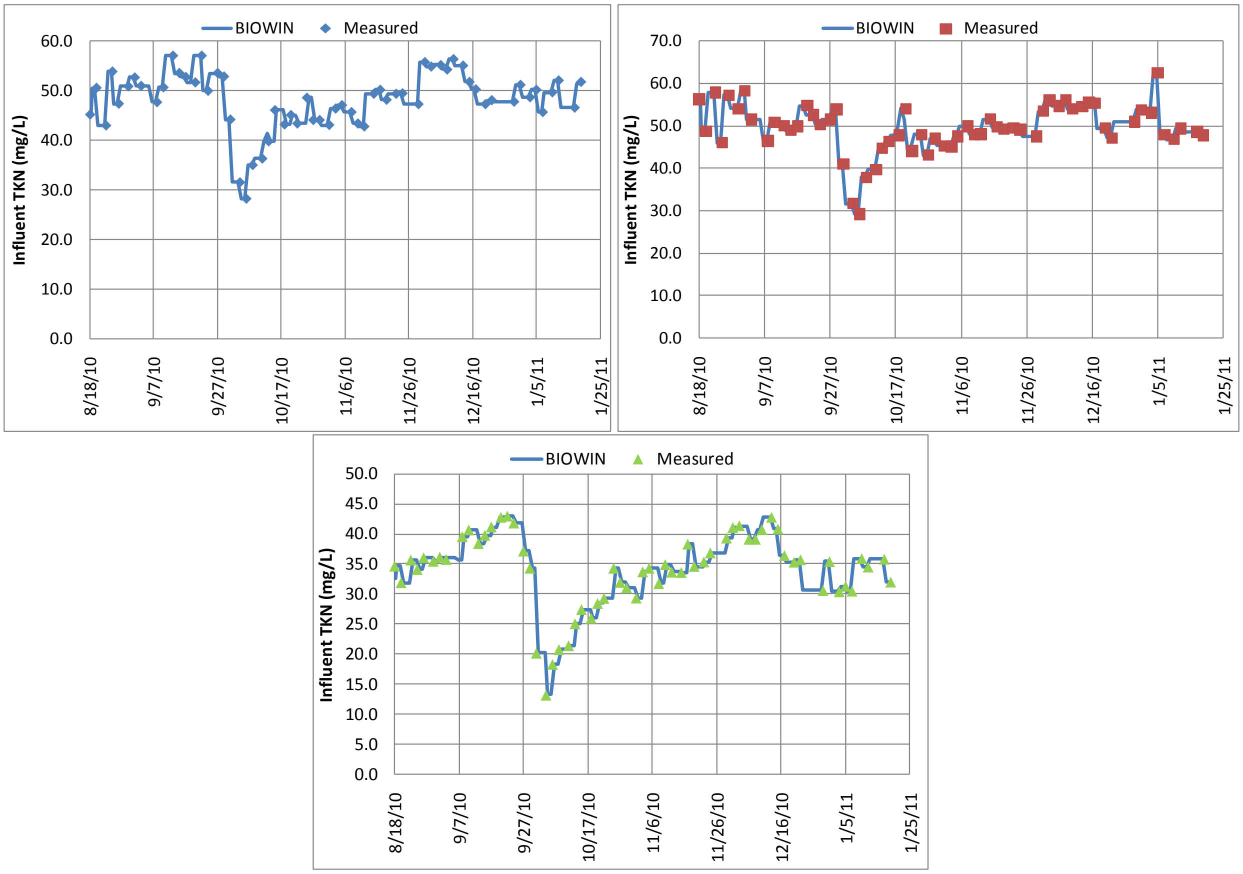

Figure 4.20 **Influent TKN to Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

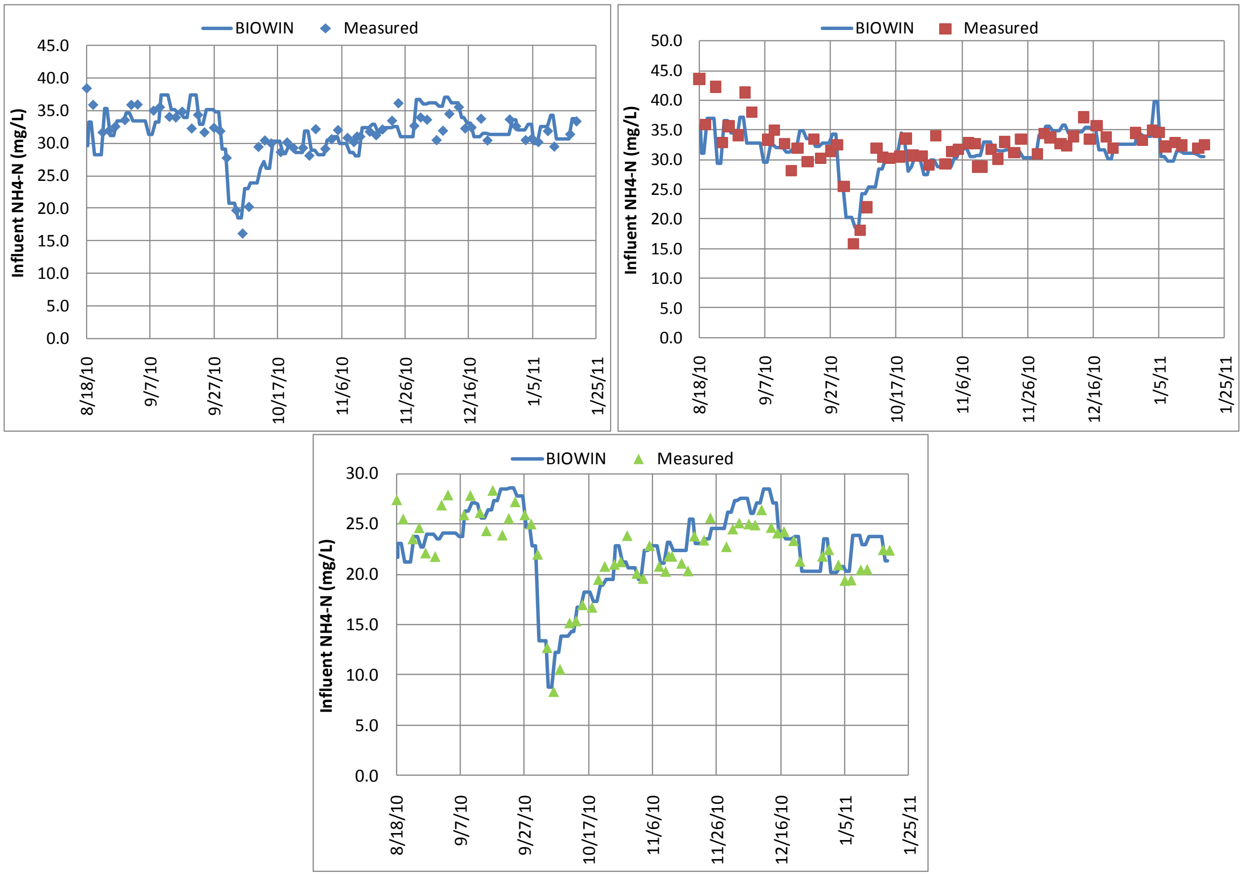

Figure 4.21 **Influent Ammonia to Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

4.1.4.2. Reactor Characteristics

Measured and BioWin-predicted MLSS and MLVSS data are shown in Figures 4.22 and 4.23. Starting in mid-September, there was a close fit between the actual and predicted values for NP RWI and NP PCI, which continued for the duration of the project. The first month of data where there was a poor correlation is most likely a result of the SBRs approaching a quasi steady-state condition both in the laboratory and in the model. There were no adjustments necessary to any BioWin kinetic or stoichiometric parameters to achieve this fit.

Although these figures show a close correlation between modeled and measured data for VIP RWI, initial plots showed the model consistently over-predicting mixed liquor concentrations. To correct this, aerobic and anoxic yields were adjusted slightly in the BioWin stoichiometric parameters. The aerobic yield was reduced from 0.666 to 0.610, and anoxic yield was reduced from 0.54 to 0.52. Since yield is the mass of biomass produced per mass of substrate used, these minor adjustments reduced the model MLSS concentrations to match the measured concentrations. After these changes, the MLSS and MLVSS concentrations matched well beginning in late September and continuing until project completion. Again, the first month and a half of data where there is a poor fit is most likely due to the model approaching a quasi steady-state condition.

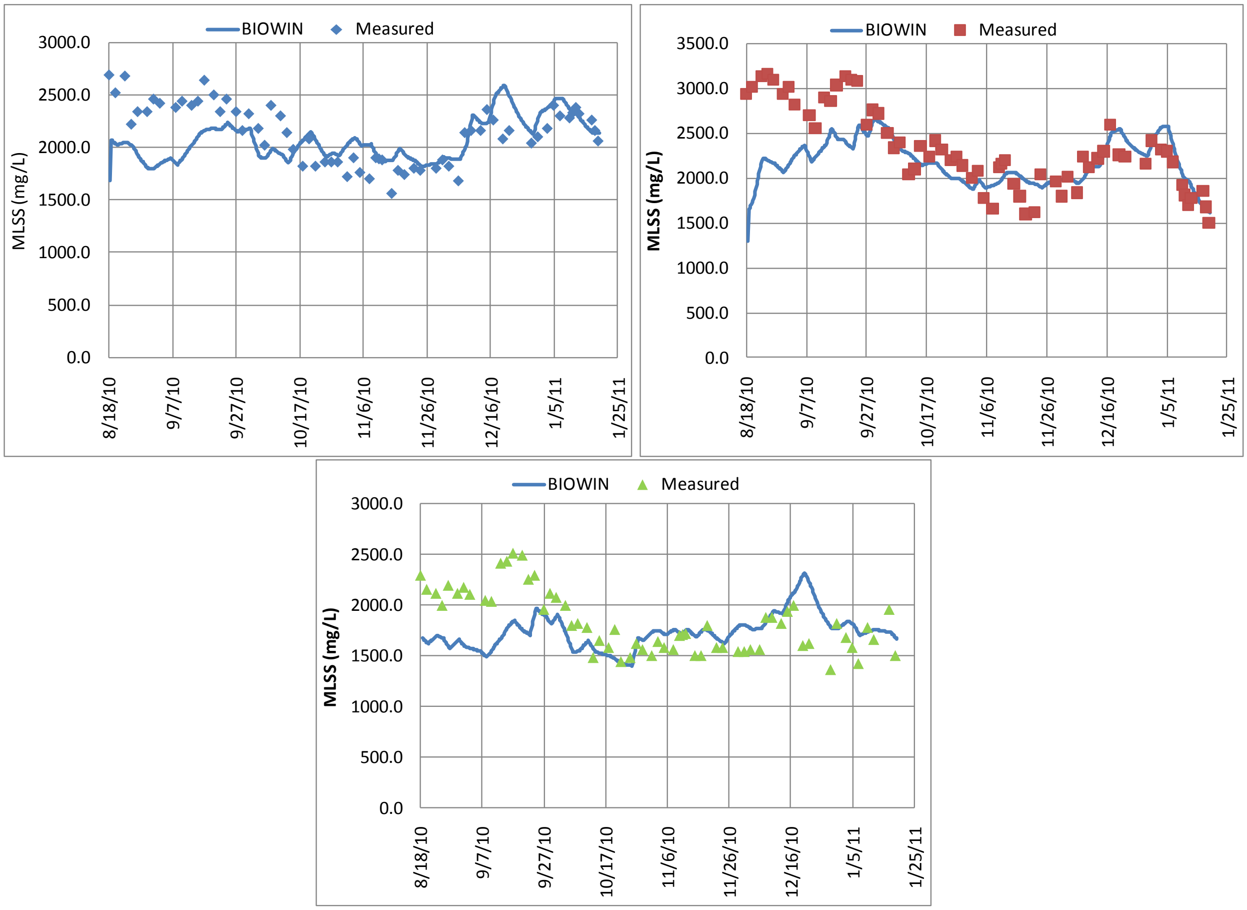

Figure 4.22 **Mixed Liquor Suspended Solids for Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

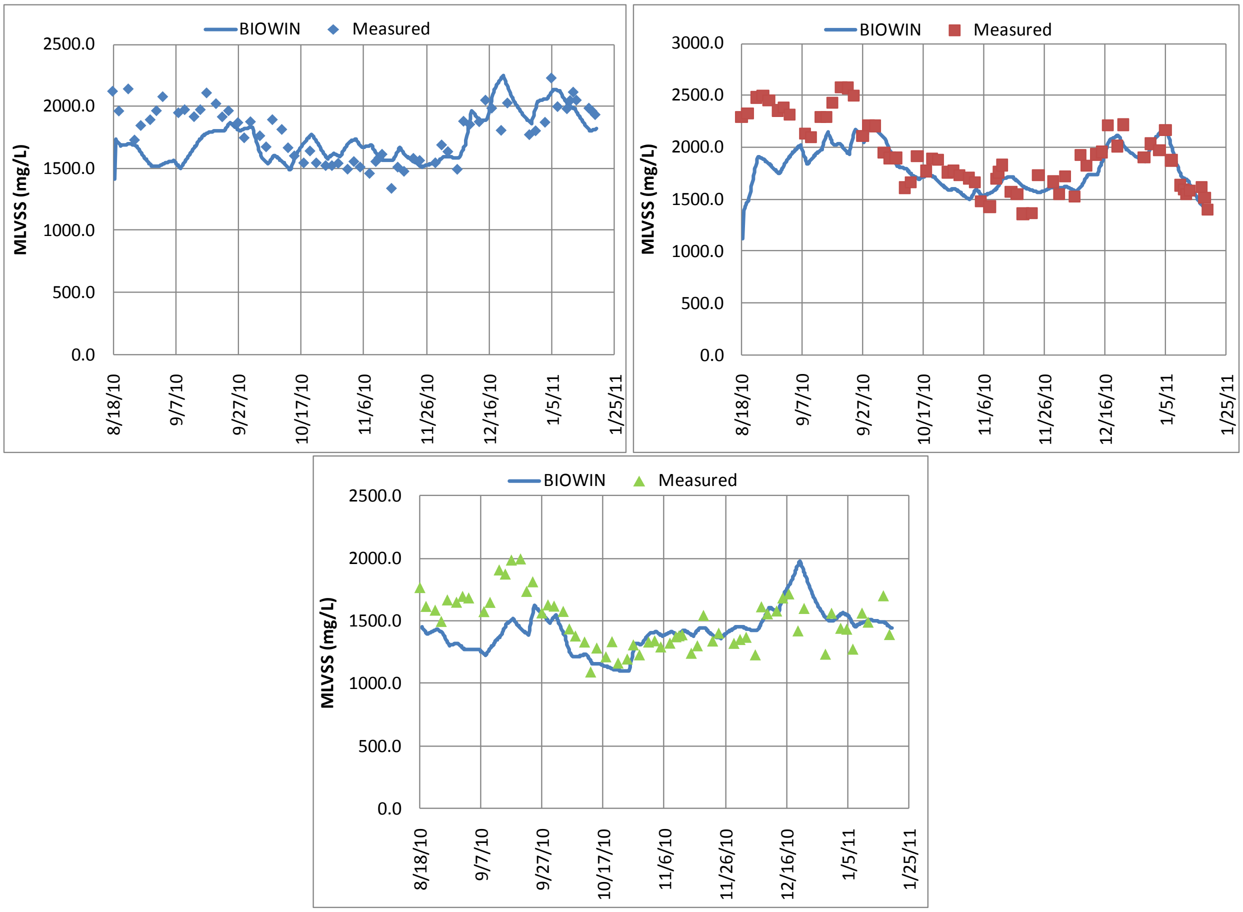

Figure 4.23 **Mixed Liquor Volatile Suspended Solids for Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

4.1.4.3. Effluent Characteristics

Effluent nitrogen data are displayed in Figures 4.24 – 4.27 for all three reactors. As shown in Figure 3.9, the use of a point clarifier between the SBR and decant, designed with 100% efficiency, results in an effluent TSS of 0 mg/L for the duration of the project. This maintains the modeled reactor SRT at exactly 15 days to reflect the efforts that were made to keep the actual reactors operating at a 15 day SRT. For this reason, there was no need to include effluent TSS data output by the model. Each plot displays the predicted effluent nutrient concentrations based on μmax$_{AOB}$ values of 0.9, 0.8, 0.7, and 0.6 days^{-1}. Measured effluent data points do not include profile days on which reactors received an ammonium chloride spike to increase initial ammonia-N concentrations.

Based on Figure 4.24, effluent ammonia-N data suggest a μmax_{AOB} value in the range of 0.9 and 0.7 $days^{-1}$ for NP RWI. Effluent nitrite-N data (Figure 4.25) show similar results, with a μmax_{AOB} value of 0.6 $days^{-1}$ consistently over-predicting concentrations. This is a direct result of the default μmax_{NOB} value of 0.7 $days^{-1}$, which remained constant throughout all modeling simulations. When the μmax_{AOB} dropped to 0.6 $days^{-1}$, below the default value for μmax_{NOB} of 0.7 $days^{-1}$, the result was nitrite accumulation in the model. Predicted effluent nitrate-N data (Figure 4.26) were essentially the same for μmax_{AOB} values of 0.7-0.9 $days^{-1}$, with an obvious distinction seen at a μmax_{AOB} value of 0.6 $days^{-1}$, which is most likely caused by the model predicted NO2 accumulation. BioWin predicts several peaks over the course of the project that do not match actual data, but for the most part, the predicted data correlates well with measured data. Modeled effluent NOx-N data (Figure 4.27) show a similar trend to modeled effluent nitrate-N, which is expected, due to the low concentrations of nitrite-N in the effluent. Based on the predicted effluent data generated by BioWin for μmax_{AOB} values of 0.9, 0.8, 0.7, and 0.6 $days^{-1}$ and their relation to actual data, it is clear that the actual value is most likely between 0.7 and 0.9 $days^{-1}$ for NP RWI.

For NP PCI, effluent ammonia-N data suggest a μmax_{AOB} value somewhere between 0.9 and 0.7 $days^{-1}$. Effluent nitrite-N data show similar results, with a μmax_{AOB} of 0.6 $days^{-1}$ consistently over-predicting concentrations. Again, this is a result of the default μmax_{NOB} value of 0.7 $days^{-1}$, which, being higher than the μmax_{AOB} value of 0.6 $days^{-1}$, resulted in nitrite accumulation in the model. As expected, predicted effluent nitrate-N data are similar for μmax_{AOB} values of 0.7-0.9 $days^{-1}$, with a μmax_{AOB} value of 0.6 $days^{-1}$ noticeably higher, which, again, is likely a result of model predicted NO2-N accumulation. BioWin predicts several peaks over the course of the project that do not match measured data, but for the most part, the modeled data approximately match the measured data. Effluent NOx-N data show a similar trend to effluent nitrate-N. Based on the predicted effluent data generated by BioWin for $\mu\text{max}_{\text{AOB}}$ values of 0.9, 0.8, 0.7, and 0.6 days^{-1} and their relation to actual data, it is clear that the actual value is most likely between 0.7 and 0.9 days^{-1} for NP PCI.

Effluent ammonia-N data suggest a $\mu\text{max}_{\text{AOB}}$ value between 0.9 and 0.8 days^{-1} for VIP RWI. Effluent nitrite-N data show similar results, with $\mu\text{max}_{\text{AOB}}$ values of 0.6 and 0.7 days^{-1} consistently over-predicting concentrations. Again, this is a direct result of the default $\mu\text{max}_{\text{NOB}}$ value of 0.7 days^{-1}, which, being higher than the $\mu\text{max}_{\text{AOB}}$ value of 0.6 days^{-1}, resulted in nitrite accumulation in the model. Predicted effluent nitrate-N data are similar for $\mu\text{max}_{\text{AOB}}$ values of 0.7-0.9 days^{-1}, with an obvious distinction seen at a $\mu\text{max}_{\text{AOB}}$ value of 0.6 days^{-1}, which is likely a result of the model predicted NO2-N accumulation. BioWin predicts several peaks over the course of the project that do not match actual data, but for the most part, the modeled data approximately matches the measured data. Effluent NOx-N data show a similar trend to modeled effluent nitrate-N. Based on the predicted effluent data generated by BioWin for $\mu\text{max}_{\text{AOB}}$ values of 0.9, 0.8, 0.7, and 0.6 days^{-1} and their relation to actual data, the actual value is most likely between 0.8 and 0.9 days^{-1} for VIP RWI.

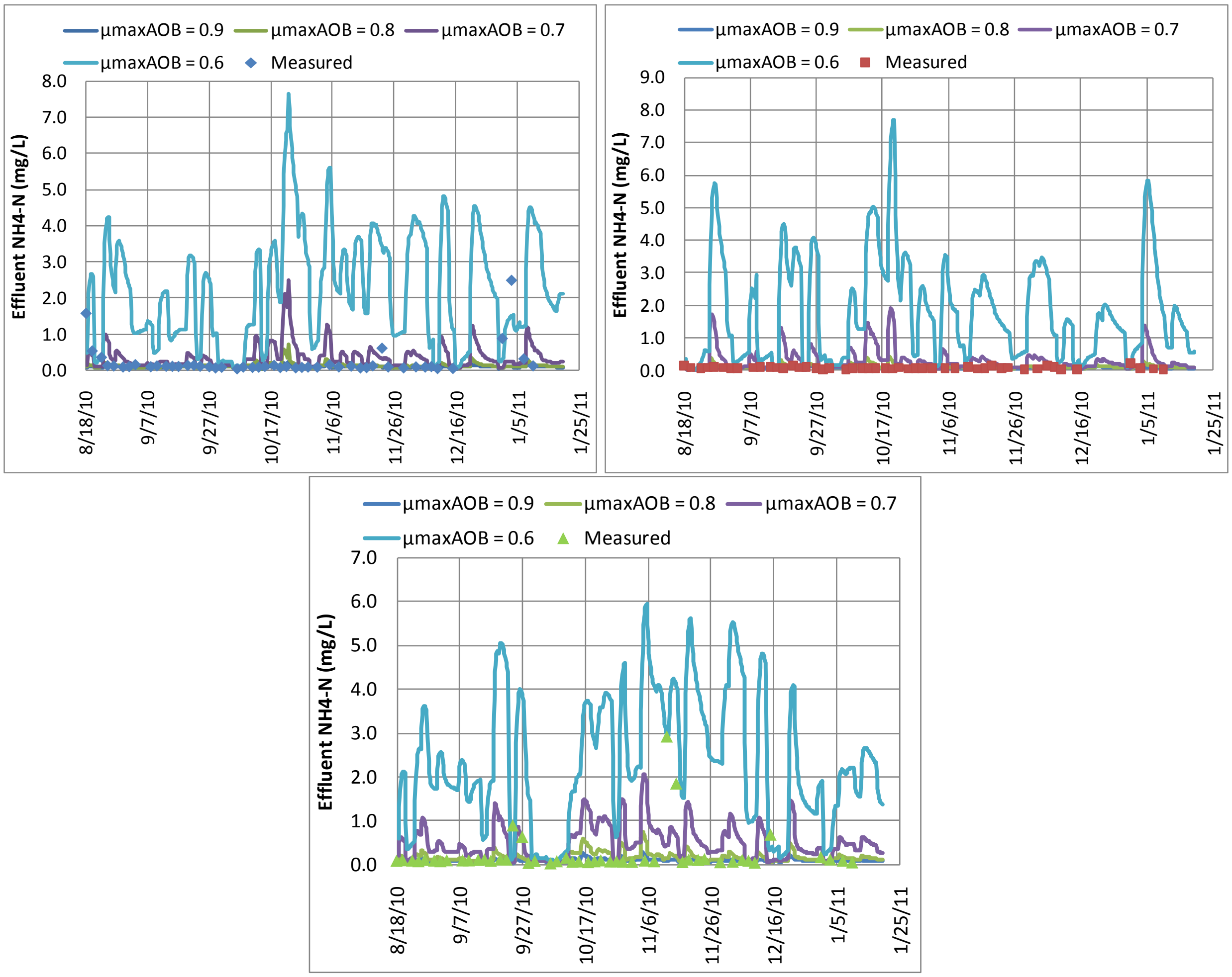

Figure 4.24 **Effluent Ammonia from Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

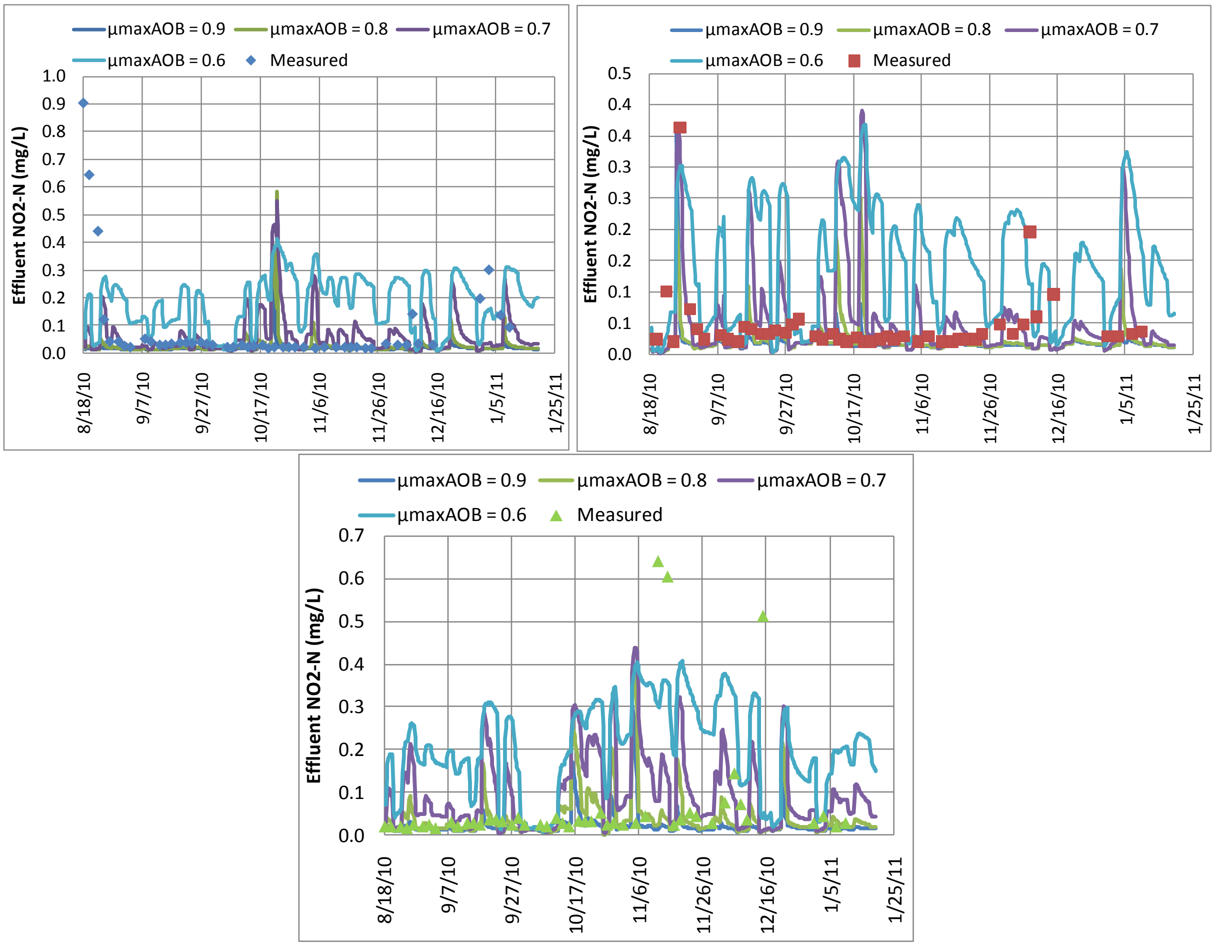

Figure 4.25 **Effluent Nitrite from Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

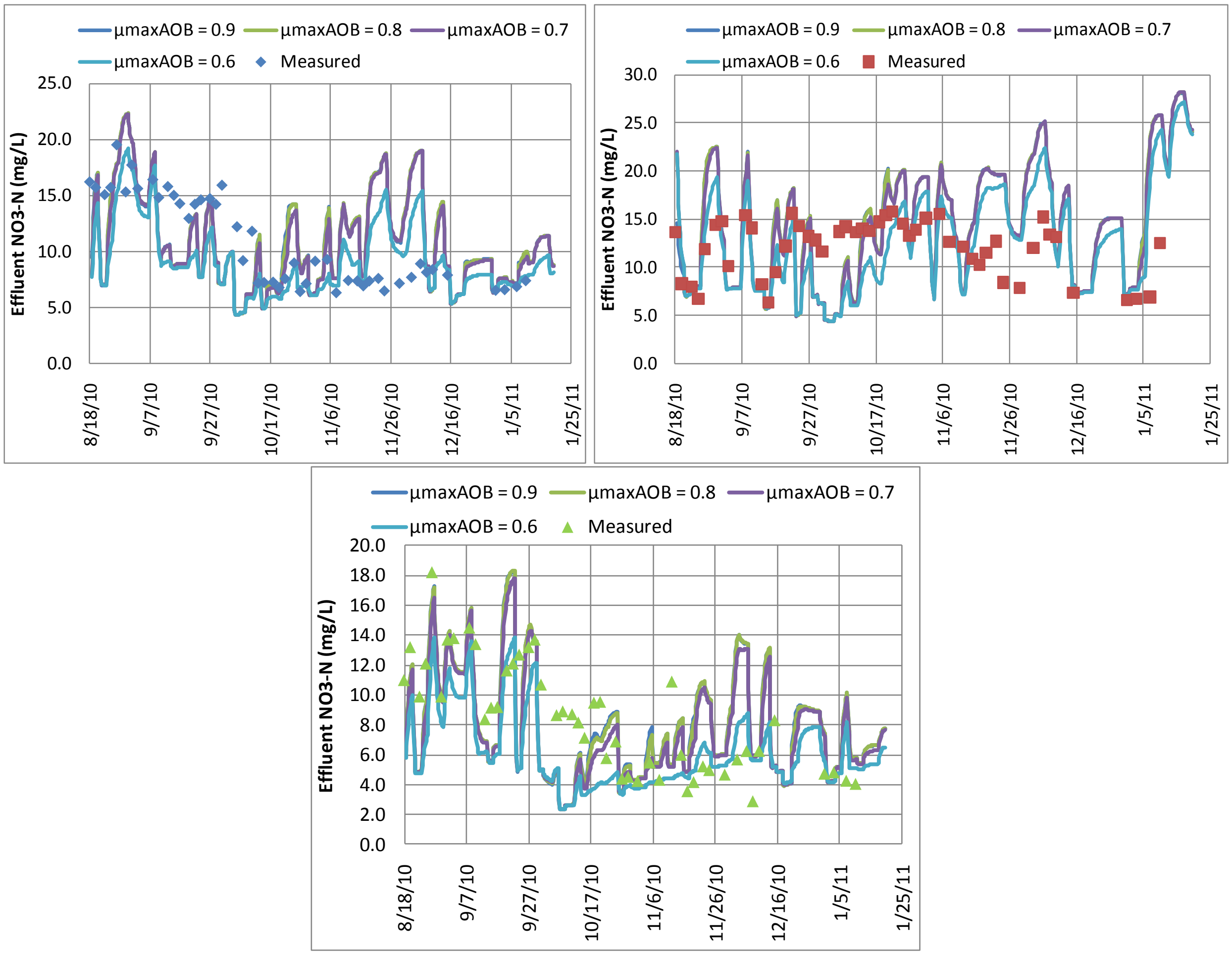

Figure 4.26 **Effluent Nitrate from Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

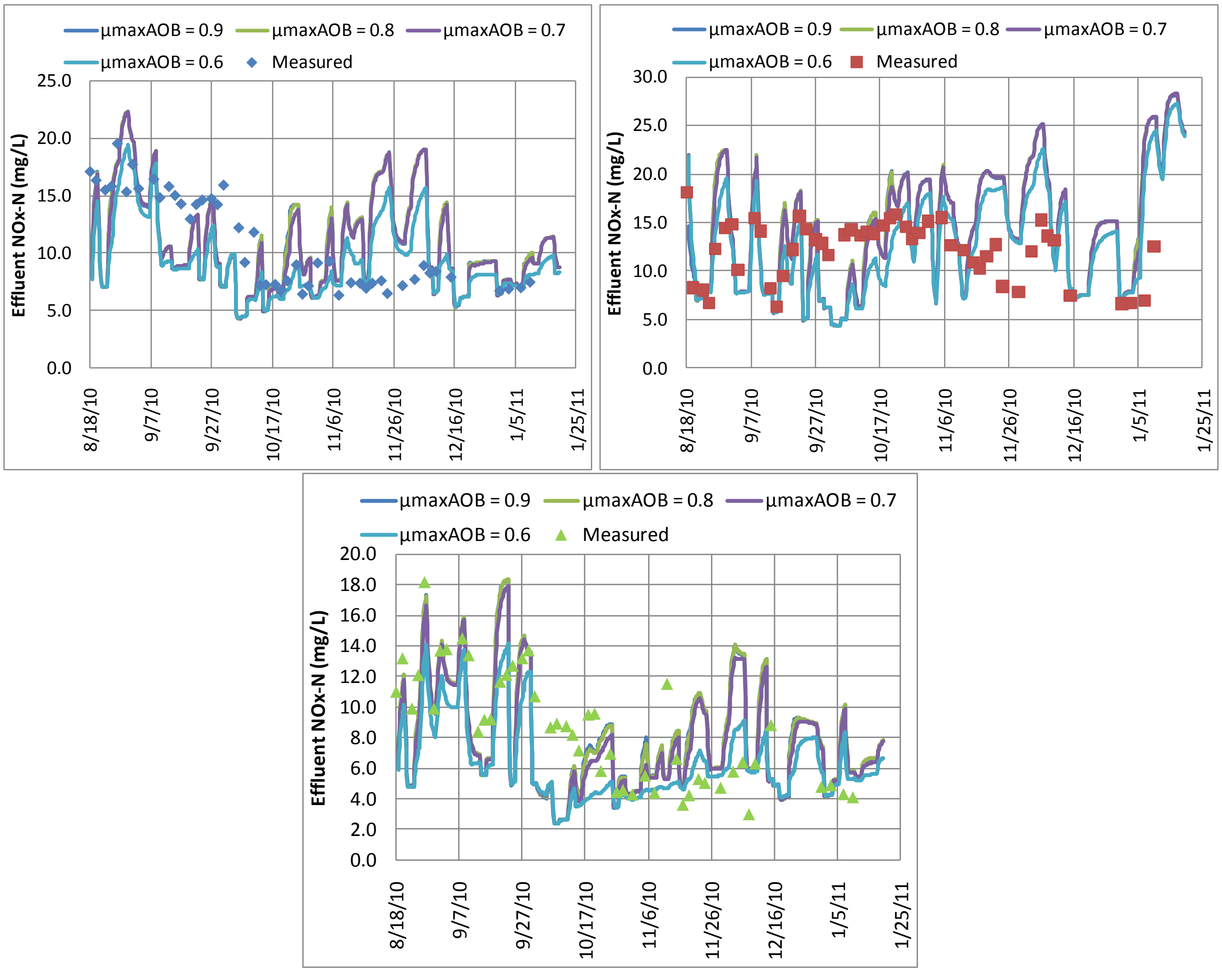

Figure 4.27 **Effluent NOx-N (Nitrate + Nitrite) from Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

4.1.4.4. Reaction Rates

Nitrification rates from BioWin model output were calculated in the same manner as actual nitrification rates, using NOx-N generation rates over time. The first NOx-N data point used for rate calculations was measured 0.25 hours into the aerobic period, ensuring that DO concentration in the reactor had reached a minimum concentration of 3 mg O_2/L. The last NOx-N data point used for rate calculations was measured 1.75 hours into the aerobic period to ensure that nitrification had not become ammonia-limited. The calculated rates plotted over the duration of the project are shown in Figure 4.28. The figure includes BioWin-generated nitrification rates for μmax_{AOB} values of 0.9, 0.8, 0.7, and 0.6 days^{-1}.

Based on comparison of these rates to actual rates, the μmax_{AOB} value for NP RWI seems to fit best somewhere between 0.75 days^{-1} and slightly below 0.6 days^{-1}. When taking into consideration the evaluation of BioWin-generated effluent ammonia-N and nitrite-N to actual data, a basic comparison of nitrification rates would suggest a μmax_{AOB} value of approximately 0.7 days^{-1}. However, simply comparing nitrification rates does not address a key issue, which is ammonia limitation during reactor profiling. To account for this equation 3.1 was used to calculate the corrected maximum nitrification rate for both modeled and measured data in order to get an accurate comparison of nitrification rates. The ammonia concentration used for each rate calculation was the average over the course of the rate measurement sampling period for both model output and measured values. The results can be seen in Figure 4.29. Although, the result is similar, comparison of Figure 4.29 to Figure 4.28 shows that the corrected maximum nitrification rates show modeled rates that create a similar trend to measured rates over the course of the project. Still, the resulting μmax_{AOB} value seems to fit best somewhere between 0.75 days^{-1} and just below 0.6 days^{-1}. Again taking into consideration the effluent data, this would suggest a μmax_{AOB} value of approximately 0.7 days^{-1}.

For NP PCI, the μmax_{AOB} value seems to fit best somewhere between 0.8 days^{-1} and slightly below 0.6 days^{-1}. When taking into account the BioWin-generated effluent ammonia-N and nitrite-N data, a basic comparison of nitrification rates would suggest a μmax_{AOB} value of approximately 0.7 days^{-1}. To take into account the effects of ammonia limitation, corrected maximum nitrification rates were calculated and plotted in Figure 4.29. In this case, there is very little change as a result of using the corrected maximum nitrification rate. Both figures show a slight relation between modeled and measured data, but it is difficult to select a μmax_{AOB} value based on such a poor fit. Considering the comparison of nitrification rates and effluent nutrient data, μmax_{AOB} for NP PCI appears similar to NP RWI at a value of approximately 0.7 $days^{-1}$.

Although for VIP RWI the nitrification rates follow the same general pattern over the course of the project, there is a significant amount of scatter making it difficult to select a μmax_{AOB}. Even after the use of corrected maximum nitrification rates for comparison (Figure 4.29), there is little improvement. Though, taking into consideration the model-generated effluent ammonia-N and nitrite-N data and comparing closely the nitrification rates, the μmax_{AOB} value is most likely around 0.75 or 0.8 $days^{-1}$. This suggests a somewhat depressed AOB growth rate at VIP which was not expected at the outset of the project

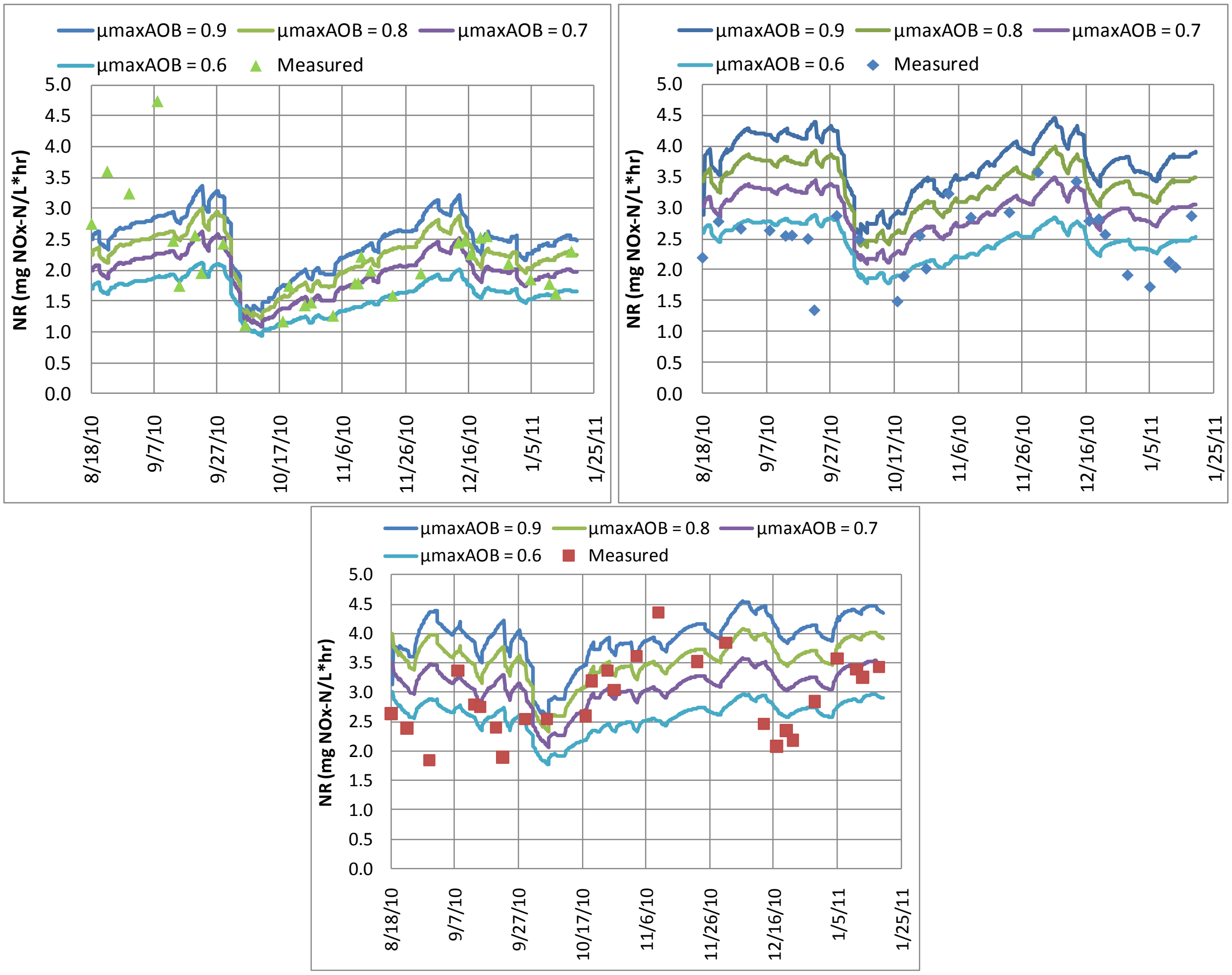

Figure 4.28 **Nitrification Rates for Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

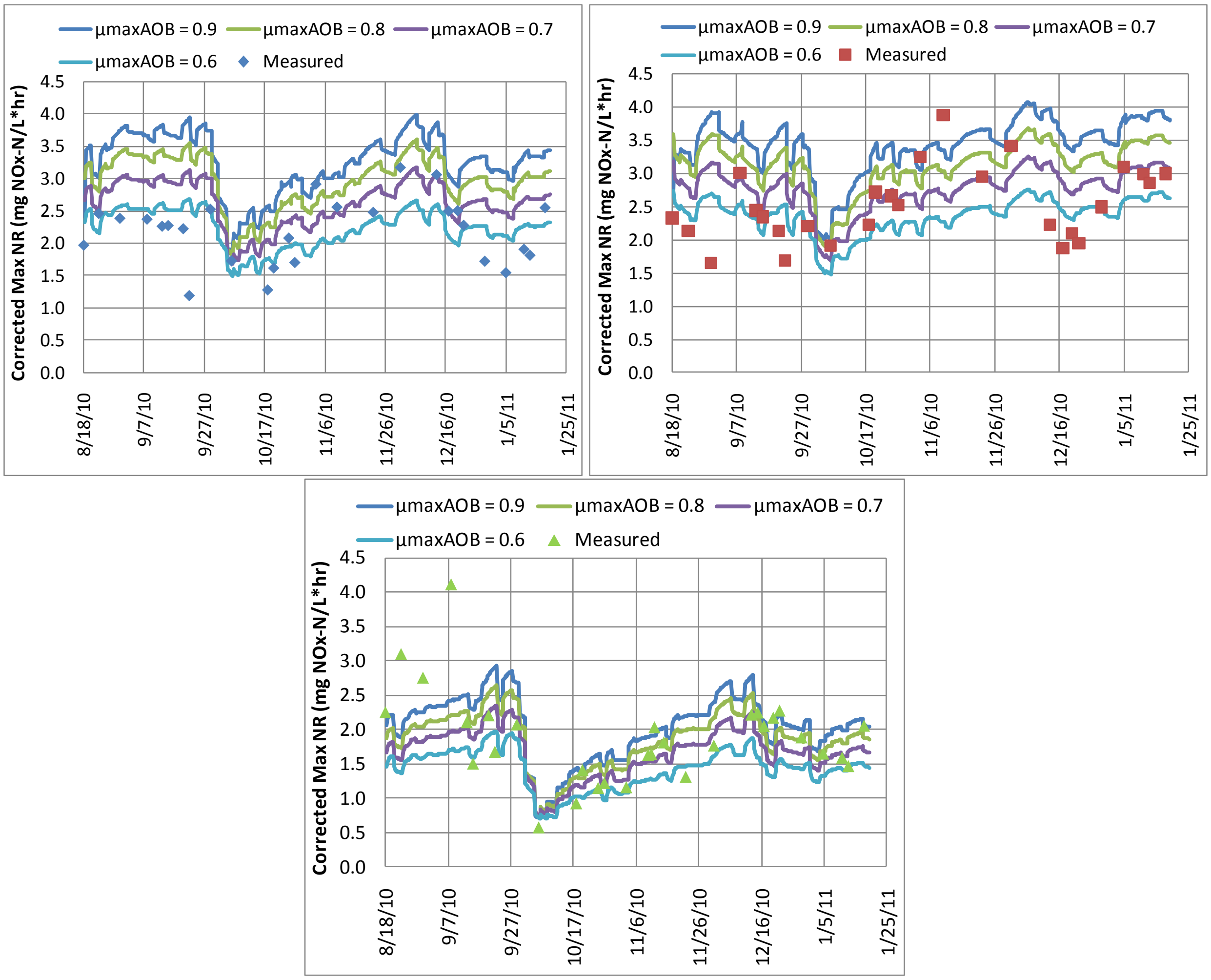

Figure 4.29 **Corrected Maximum Nitrification Rates for Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

Denitrification rates (DNRs) for BioWin models were calculated in the same manner as actual denitrification rates, using NOx-N depletion rates over time. The first NOx-N data point used for rate calculations was measured immediately following the feed cycle, and the last point was measured 18 minutes into the anoxic period, before denitrification slowed down. Modeled and measured denitrification rates are shown in Figure 4.30. For the first several months, there is a poor correlation between measured and modeled rates, after which point the measured and modeled rates track each other closely for all three reactors. This could be attributed to a more thorough sampling protocol that was initiated for the anoxic cycle, to include several more points taken at 3 minute intervals. This resulted in DNRs that more closely matched the BioWin predicted data.

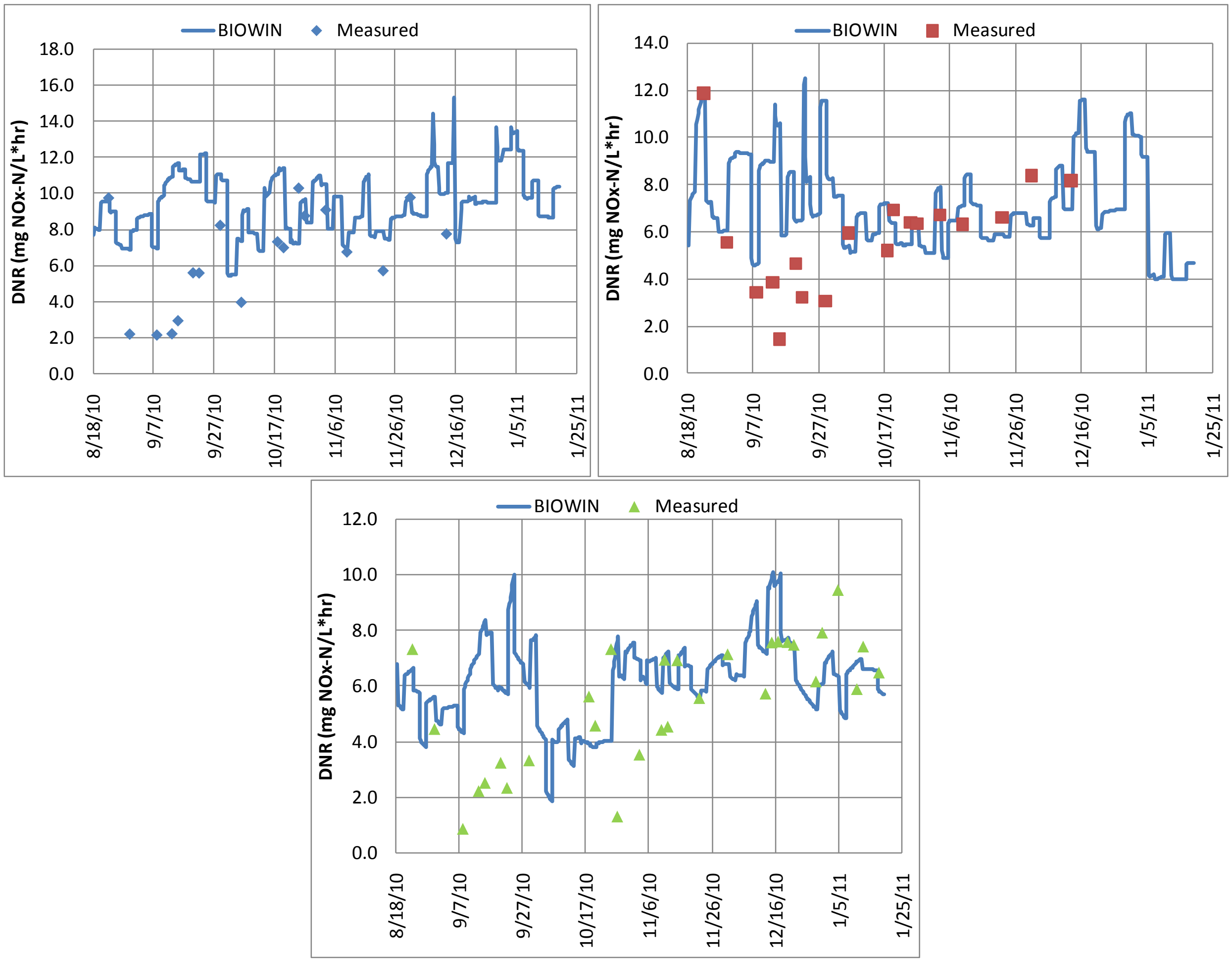

Figure 4.30 **Denitrification Rates for Nansemond RWI Reactor (A) , Nansemond PCI Reactor (B), and VIP RWI Control Reactor (C/D)**

4.1.4.5. Full Cycle Profiles Compared to BioWin-Generated Profile Data

For further comparison of BioWin generated data to actual data, two individual profile sampling days were selected and analyzed. The days selected for analysis were September 29, 2010 and November 22, 2010. BioWin data for these days were generated, and again, included results for μmax_{AOB} values of 0.9, 0.8, 0.7, and 0.6 days^{-1}.

4.1.4.5.1. September 29, 2010

4.1.4.5.1.1. NP Raw Wastewater Influent

Figure 4.31 shows the ammonia-N profile, the NOx-N profile and the OUR profile for NP RWI over the reactor cycle for measured values, as well as the different μmax$_{AOB}$ values for comparison. On this particular day, plots indicate a μmax$_{AOB}$ value of approximately 0.75 days^{-1} for the NP RWI reactor.

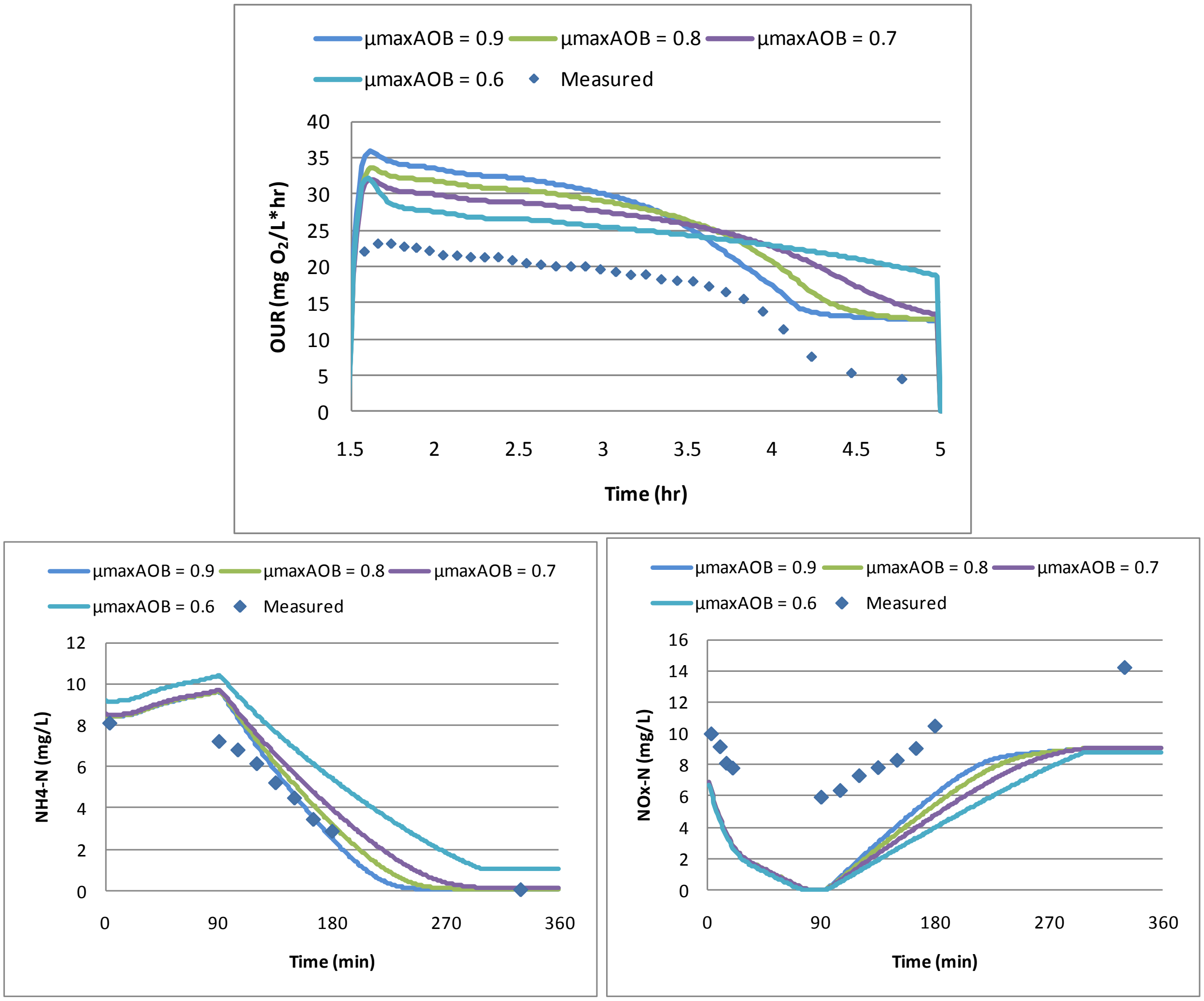

Figure 4.31 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for Nansemond RWI Reactor (A)**

4.1.4.5.1.2. NP Primary Clarifier Influent

Figure 4.32 shows the ammonia-N profile, the NOx-N profile and the OUR profile for NP PCI over the reactor cycle for measured values, as well as the different μmax_{AOB} values for comparison. On this particular day, plots indicate a μmax_{AOB} value of 0.75 days^{-1} for the NP PCI reactor.

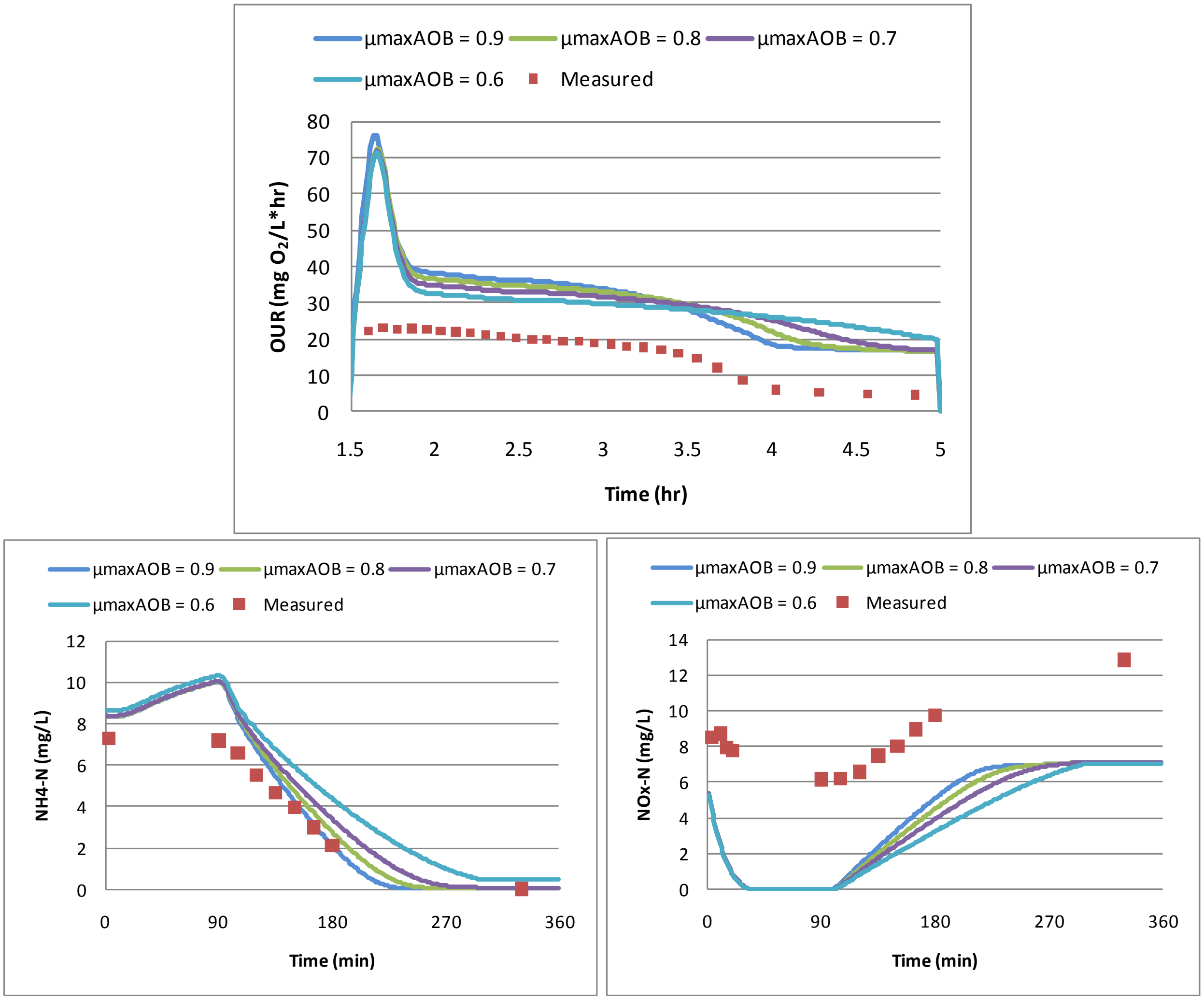

Figure 4.32 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for Nansemond PCI Reactor (B)**

4.1.4.5.1.3. VIP Raw Wastewater Influent

Figure 4.33 shows the ammonia-N profile, the NOx-N profile and the OUR profile for VIP RWI over the reactor cycle for measured values, as well as the different $\mu\text{max}_{\text{AOB}}$ values for comparison. On this particular day, plots seem to indicate a $\mu\text{max}_{\text{AOB}}$ value of approximately 0.7 days^{-1}.

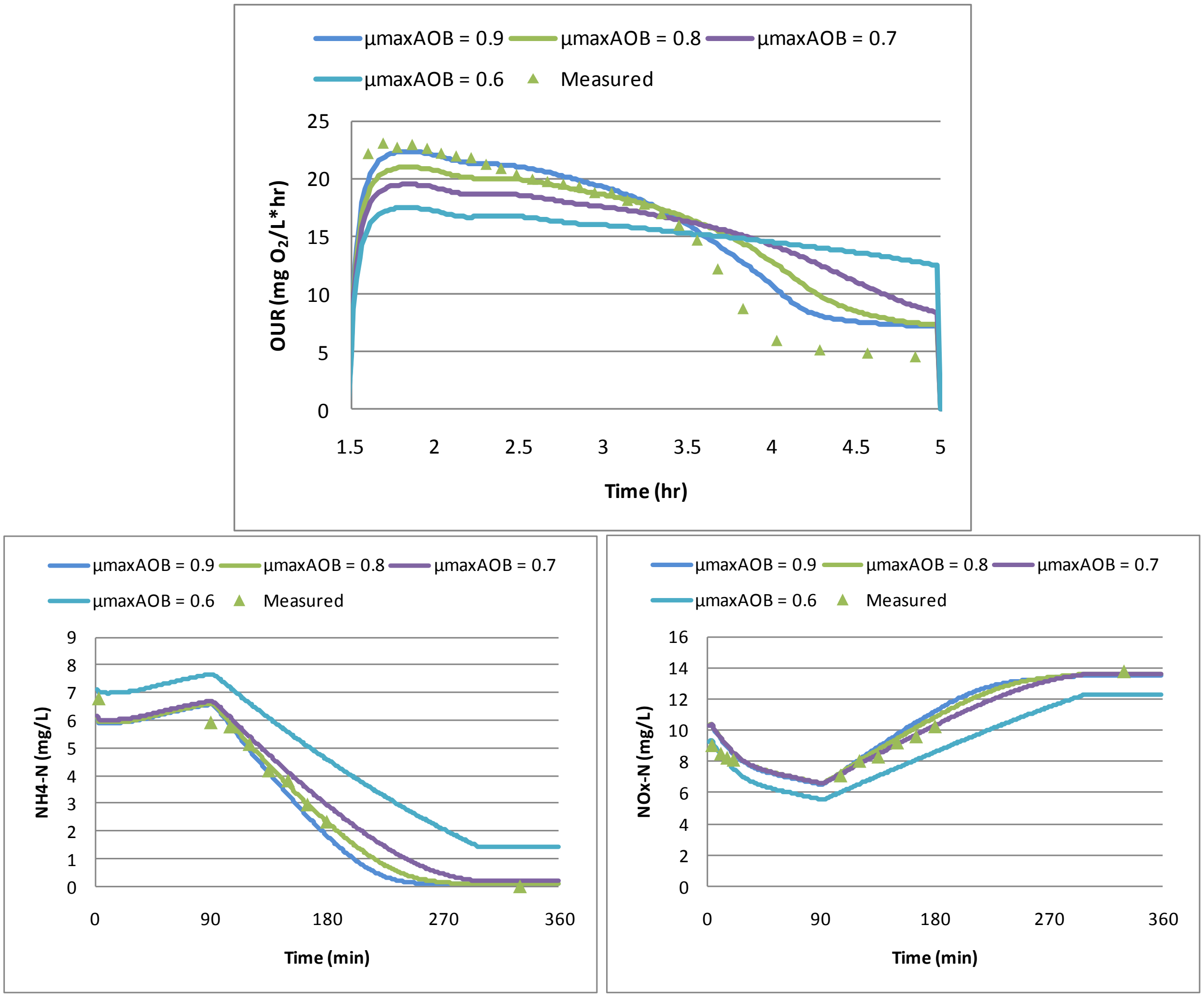

Figure 4.33 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for VIP RWI Control Reactor (C/D)**

4.1.4.5.2. November 22, 2010

4.1.4.5.2.1. NP Raw Wastewater Influent

Figure 4.34 shows the ammonia-N profile, the NOx-N profile and the OUR profile for NP RWI over the reactor cycle for measured values, as well as the different μmax_{AOB} values for comparison. On this particular day, plots indicate a μmax_{AOB} value of approximately 0.75 days^{-1} for the NP RWI reactor.

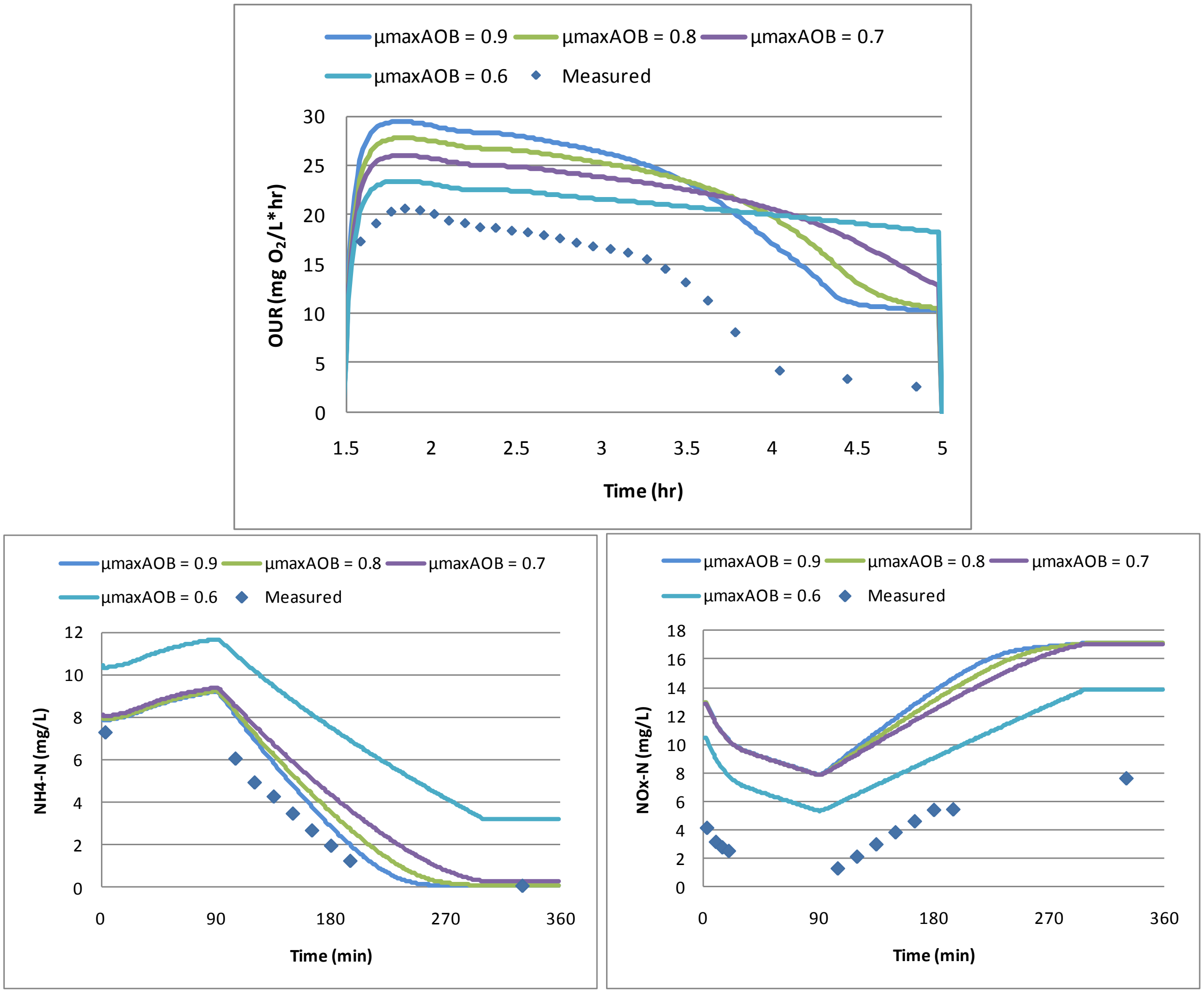

Figure 4.34 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for Nansemond RWI Reactor (A)**

4.1.4.5.2.2. NP Primary Clarifier Influent

Figure 4.35 shows the ammonia-N profile, the NOx-N profile and the OUR profile for NP PCI over the reactor cycle for measured values, as well as the different μmax$_{AOB}$ values for comparison. On this particular day, plots indicate a μmax$_{AOB}$ value of 0.7 days^{-1} for the NP PCI reactor.

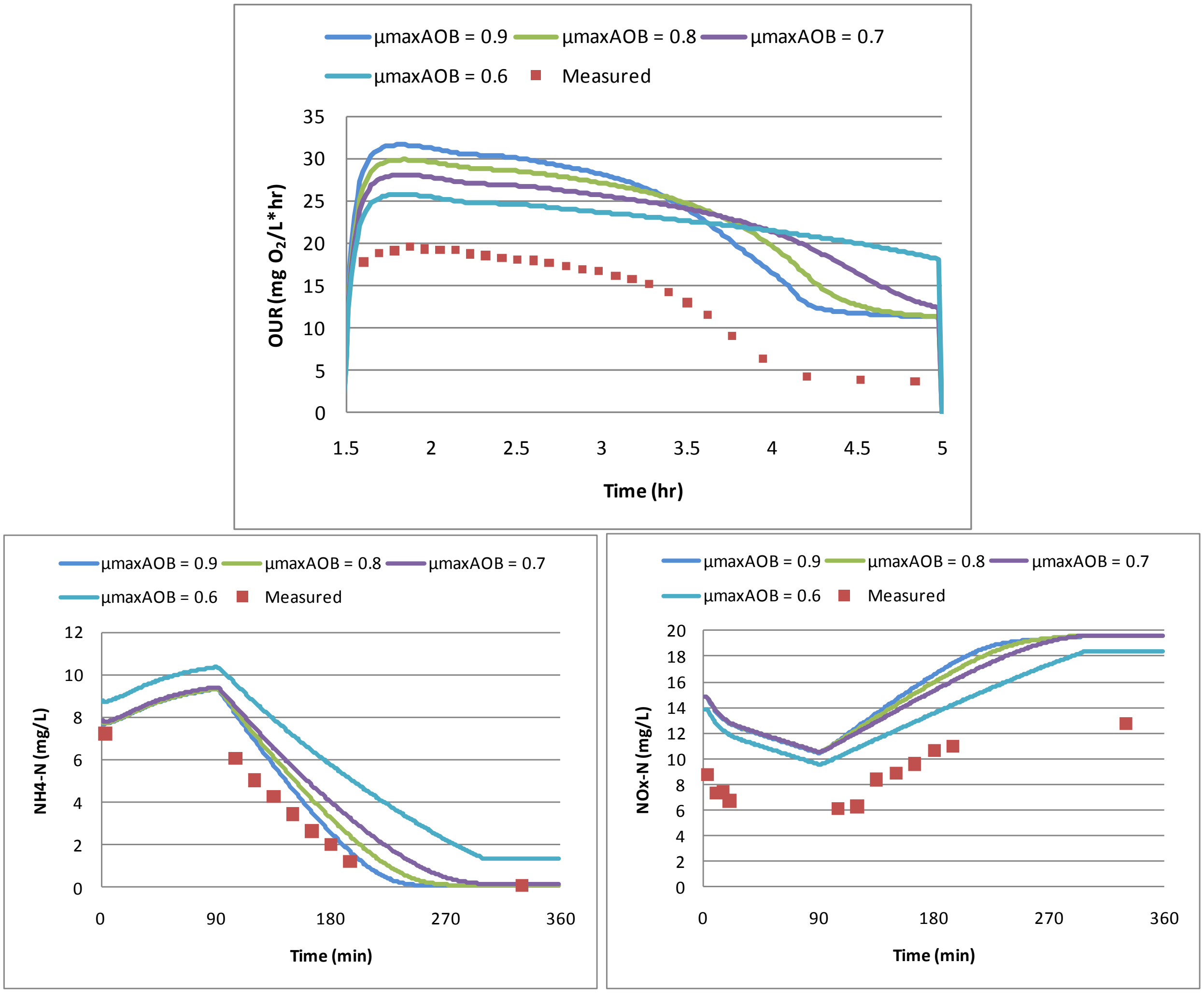

Figure 4.35 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for Nansemond PCI Reactor (B)**

4.1.4.5.2.3. VIP Raw Wastewater Influent

Figure 4.36 shows the ammonia-N profile, the NOx-N profile and the OUR profile for VIP RWI over the reactor cycle for measured values, as well as the different μmax_{AOB} values for comparison. On this particular day, plots indicate a μmax_{AOB} value of approximately 0.7 days^{-1}.

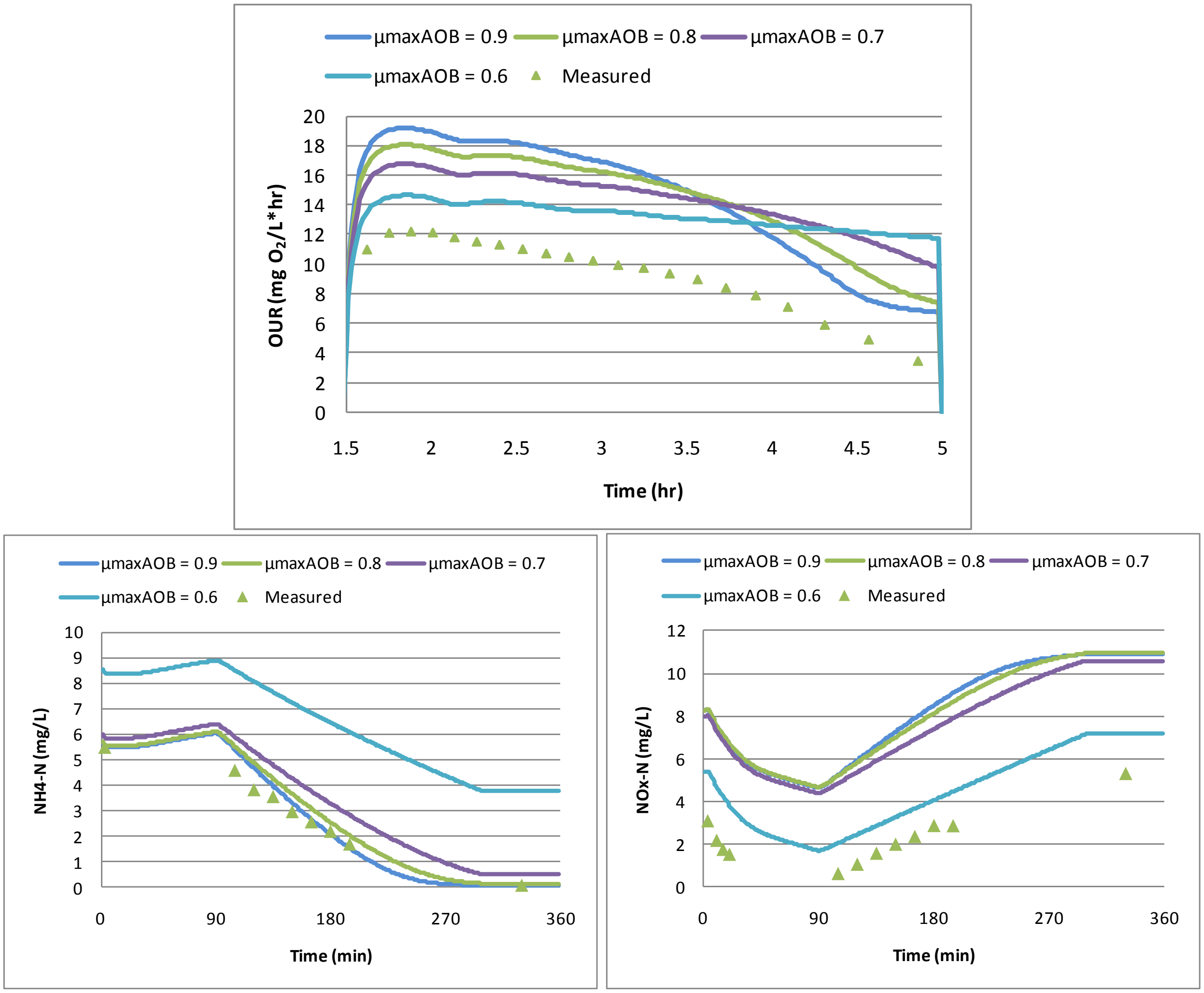

Figure 4.36 **Ammonia, NOx-N (Nitrate + Nitrite), and Oxygen Uptake Rate (OUR) profiles over reactor cycle for VIP RWI Control Reactor (C/D)**

4.2. Results and Discussion for the Effect of AFFF on BNR Processes

To evaluate the potential effects of AFFF on nitrification and denitrification, two experiments were conducted. The first utilized an AFFF sample of an approximate concentration contained at the HRSD York River Treatment Plant, while the second used a specified concentration from an AFFF solution purchased directly from a manufacturer.

4.2.1. Preliminary AFFF Test (AFFF feed of unknown concentration)

The first AFFF test performed with the SBRs utilized the waste material of uncertain concentration contained at the HRSD York River Treatment Plant as a result of testing the methanol facility fire suppression system. Based on the mixing ratio required for AFFF with water for use in the fire fighting suppression system, the volume released, and the dilution as a result of mixing with non-potable plant water, an approximate concentration of the solution can be predicted. Assuming the use of 6% AFFF (mixed at a proportion of 6 parts water to 94 parts water), a release of 1,000 gallons of this mixture, diluted by 100,000 gallons of non-potable water, the approximate concentration of concentrated AFFF in the solution was 600 ppm. When mixed with SBR influent feed at percentages of 0.1% and 1.0%, the approximate concentrations added were 0.6 ppm and 6.0 ppm of concentrated AFFF, respectively.

The AFFF solution was added to the SBR influent feed on a volume/volume percentage basis, at the aforementioned values of 0.6 ppm and 6.0 ppm. The resulting concentrations in the VIP test reactor (D) over time are displayed in Figure 4.37. By the time the first profile was performed at 0700 on November 11, the resulting concentration of AFFF in reactor D was approximately 0.3 ppm, assuming no losses from the reactor. When the next profile was performed at 0700 on November 12, the resulting level of AFFF in reactor D had risen to approximately 3.6 ppm, again assuming no losses. This feed concentration was maintained until November 15, 2010, resulting in an AFFF concentration of approximately 6.0 ppm in the test reactor. At this point, the reactor appeared to have fully acclimated to the AFFF feed. The VIP raw spiked with AFFF was compared to reactor C, which served as a control fed only VIP raw wastewater.

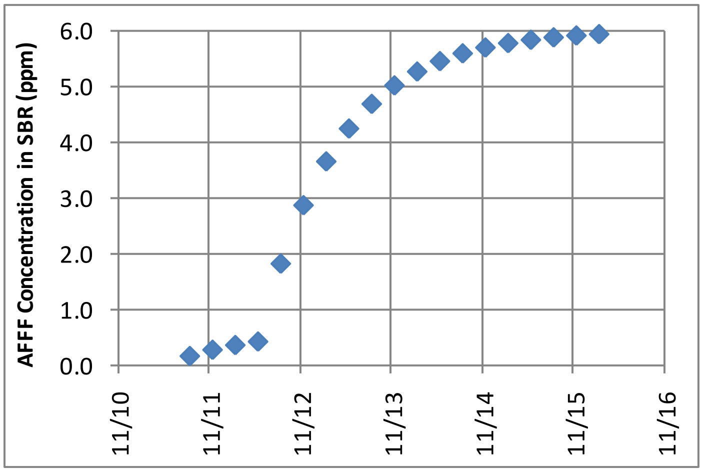

Figure 4.37 **Percentage AFFF solution contained in VIP RWI test reactor**

Feed characteristics for the control feed drum can be seen in Figure 4.38. Feed characteristics for the AFFF-spiked feed drum would have most likely been slightly different, but still comparable to these values.

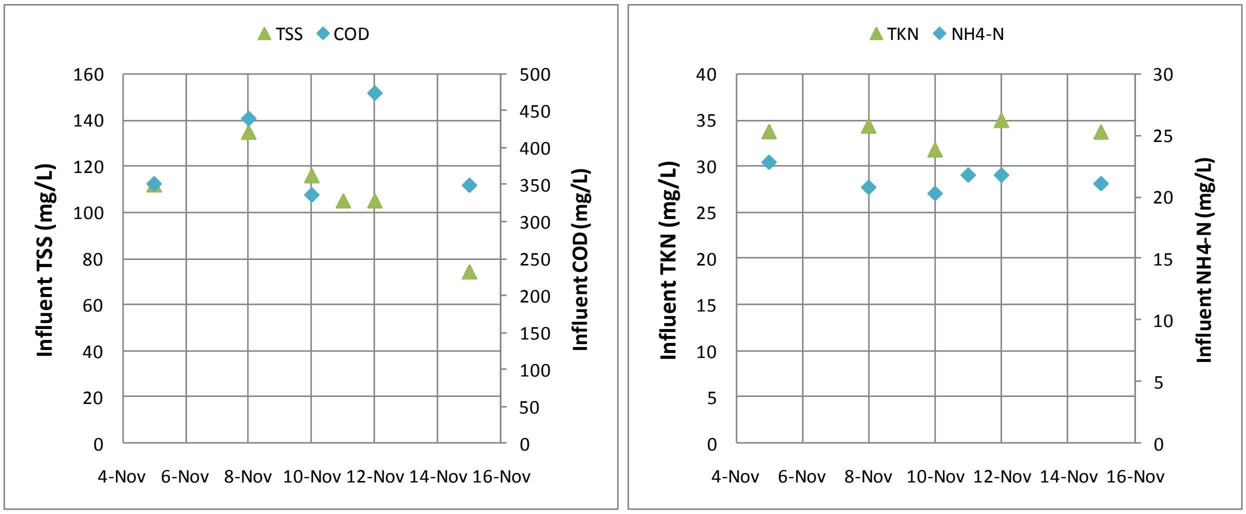

Figure 4.38 **VIP RWI characteristics**

Over this experimental period, MLSS, MLVSS and SVI data were collected to monitor effects of AFFF on settling characteristics, solids washout, etc. These data are presented in Figure 4.39. Based on comparison of the AFFF-spiked reactor to the control reactor and to data collected prior to AFFF addition, there were no significant changes in the test reactor for MLSS, MLVSS, SVI, or effluent TSS. Also, the AFFF-spiked reactor was checked regularly for the presence of foam, but it never differed from the control reactor. Although mixed liquor concentrations appear to drop beginning November 10, this is seen in both reactors and can be attributed to a decrease in the influent TSS concentrations. MLVSS data show a similar pattern, indicating that the volatile fraction experienced little/no change as a result of AFFF addition. The SVI data collected over this experimental period also show little change. Although the AFFF-spiked reactor shows a slight increase by November 15, it was insignificant, as these small discrepancies were noted regularly even before addition of AFFF. Effluent TSS data show no signs of solids washout as a result of AFFF addition, and in fact shows a modest though likely insignificant reduction in effluent TSS for the AFFF-spiked reactor.

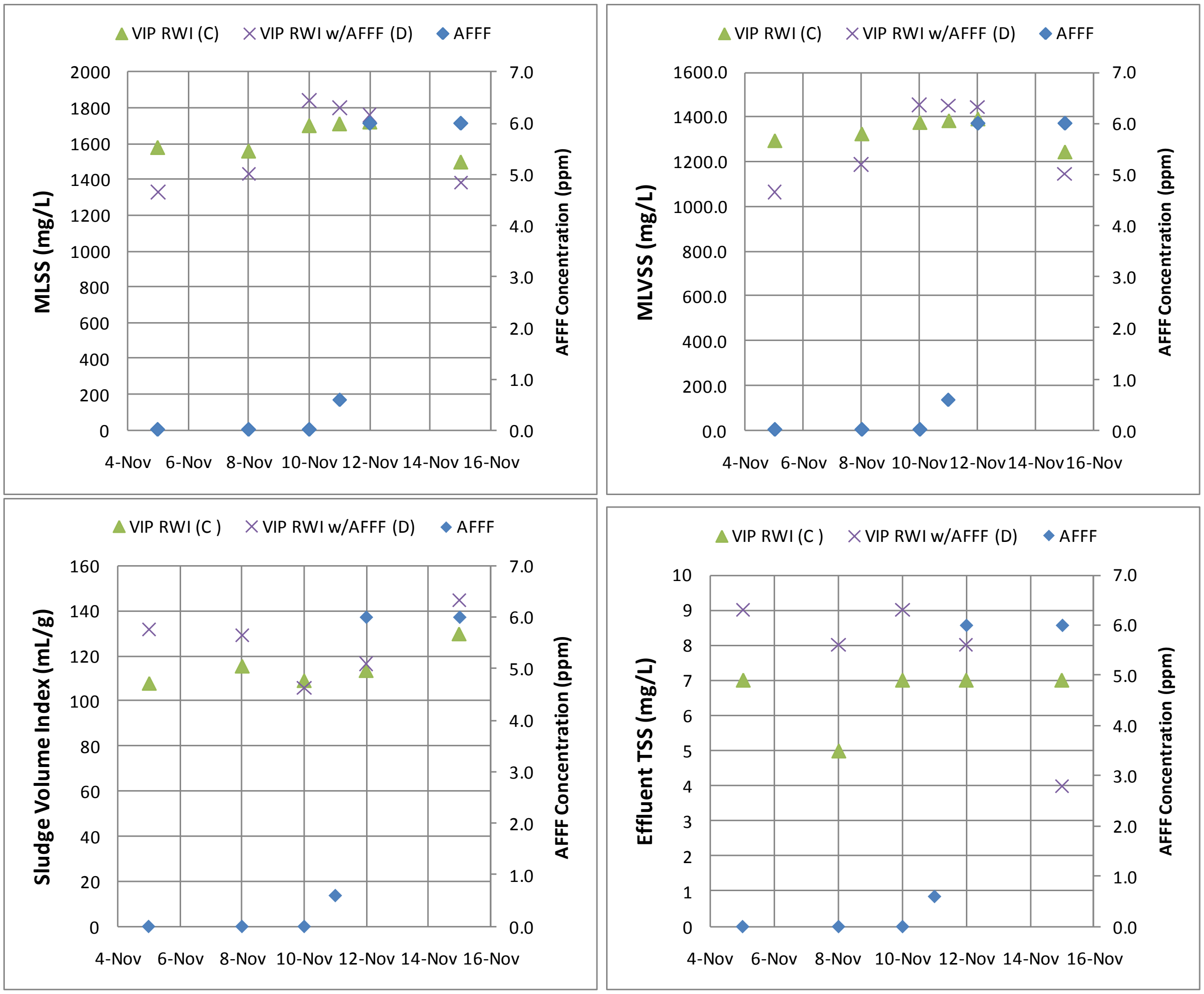

Figure 4.39 **VIP SBR characteristics with AFFF feed concentrations in test reactor (D) over experimental period**

Effluent nutrients, specifically nitrogen species, were of particular importance for this experiment. For these profiles, each SBR was spiked with a solution of Ammonium chloride to raise the ammonia-N concentration to approximately 10 mg N/L at the start of the aerobic phase to avoid NH4-N limitation of nitrification. A byproduct of the ammonia spike was an increase in effluent nitrogen species. This is evident from data collected on November 10, 11, 12, and 15, which show an obvious boost in the nitrogen species in the effluent (Figure 4.40). Although both VIP reactors experience this issue, comparison of the effluent data shows some important similarities and differences. With respect to the effluent NH4-N and NO2-N concentrations, there were slight differences, but no obvious pattern was seen, suggesting that nitrification performance was comparable between the two reactors over the course of the experiment, with no inhibition of ammonia-oxidizing bacteria (AOB) or nitrite-oxidizing bacteria (NOB). Effluent nitrate-N data, on the other hand, show significant disparity beginning immediately following AFFF addition on November 11, and continuing until November 15. This suggests that the AFFF-spiked reactor experienced some level of denitrification inhibition. Effluent total nitrogen concentrations reflected this same pattern, which was expected since effluent NH4-N and NO2-N concentrations were similar between the two reactors.

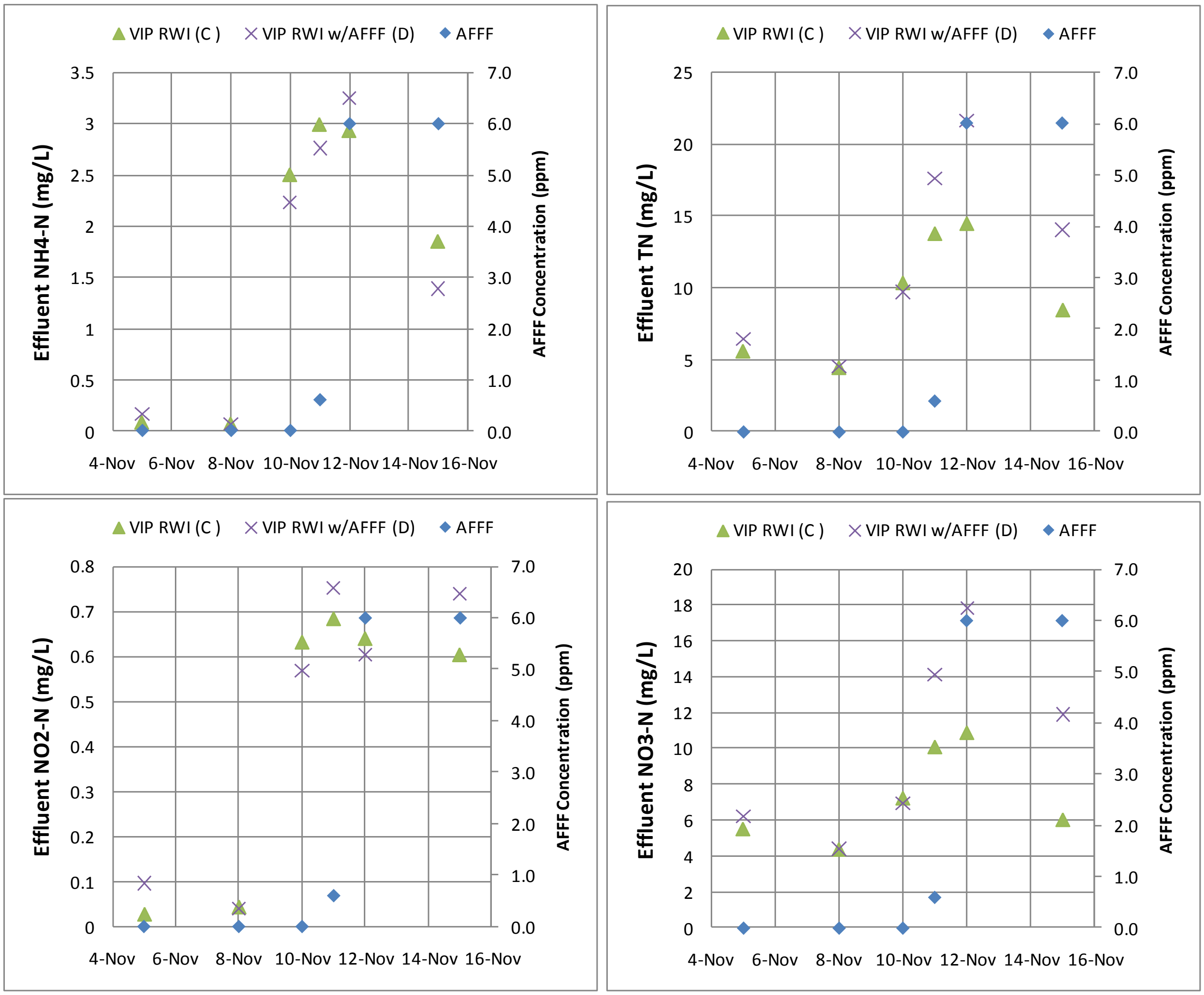

Figure 4.40 **VIP SBR effluent nutrient data with AFFF feed concentrations in test reactor (D) over experimental period**

A profile sampling event was conducted during the cycle immediately prior to AFFF addition to ensure similar reactor performance. From this, it can be observed in Figure 4.41 that nitrification rates between the two reactors were very similar, with no statistically significant difference based on the 95% confidence intervals between the regression slopes. With the AFFF solution added at 0.6 ppm of the feed volume, little change was seen from the preceding day with no AFFF addition. By the next day, with AFFF solution added at 6.0 ppm of the feed volume, the nitrification rate of the AFFF-spiked reactor actually appears to be slightly higher than that of the control, but the difference was not statistically significant. AFFF feed continued at this concentration until November 15 when the next profile was performed. This profile showed a slight reversal, with the control reactor nitrification rate surpassing that of the AFFF-spiked reactor, but again, not at a level that was statistically significant. The nitrification rates over the course of this experiment confirmed that this AFFF solution had no significant impact on nitrification performance if mixed at a percentage less than or equal to 6.0 ppm.

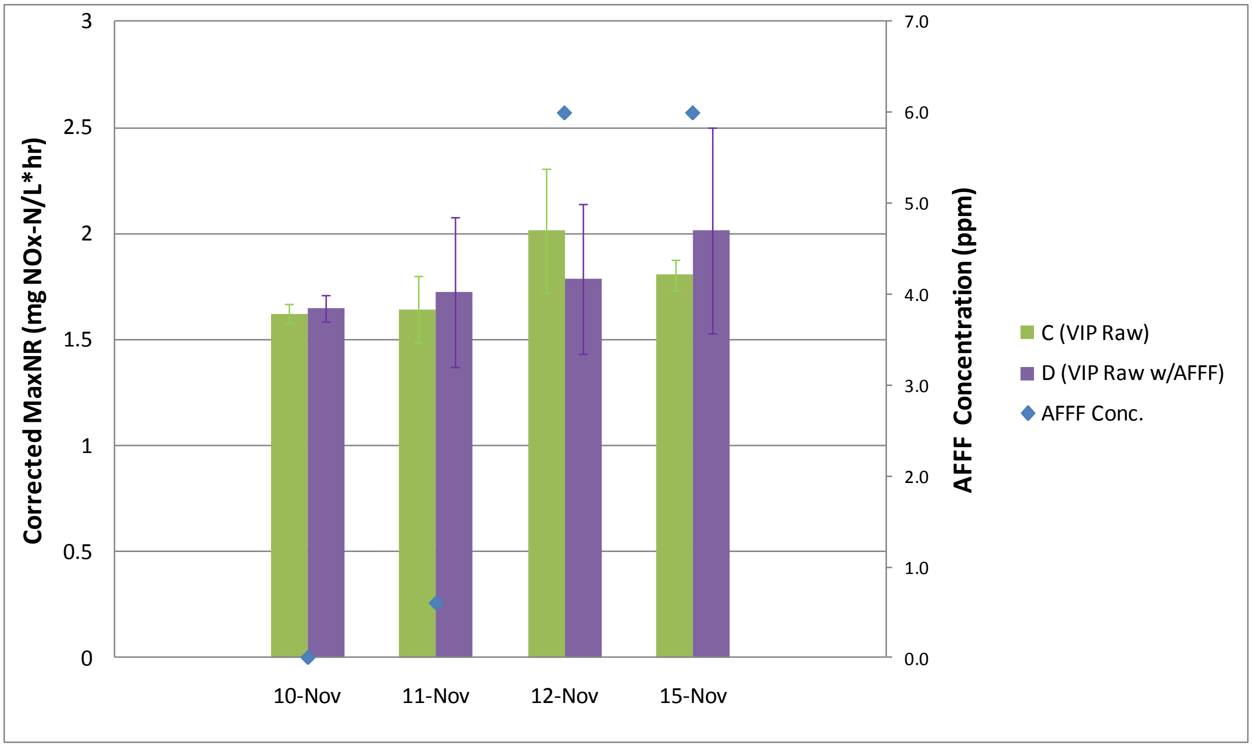

Figure 4.41 **Corrected Maximum Nitrification Rates with 95% Confidence Interval for VIP Reactor C (control) and VIP Reactor D (spiked with Aqueous Film Forming Foam solution), with the AFFF concentration in Reactor D shown over experimental period**

At the outset of this test, the focus had been to observe inhibitory effects of AFFF on nitrification, while closely monitoring other performance issues. For this reason, only four samples were collected during the anoxic phase to monitor denitrification performance, and were spread through the first 20 minutes. This is reflected in the large error bars in Figure 4.42 which initially covered a range so wide that there was no way to draw any conclusions on the statistical significance of the denitrification rate reduction. By November 12, the sampling protocol was changed to collect 6 samples over the first 18 minutes of the anoxic period to provide a more accurate estimate of denitrification rates. This is reflected in the size of the error bar on this date for the control reactor compared to the error bars calculated for November 10 (no error bar is shown for the AFFF-fed reactor on November 12, as denitrification had stopped completely).

On November 11, with the AFFF concentration at 0.6 ppm in the feed container, the denitrification rate for the control reactor remained close to the rate measured on the preceding day with no AFFF addition. However, the AFFF-spiked reactor experienced a sudden decrease in denitrification rate, at a level that was statistically significant based on the 95% confidence intervals between the regression slopes of the control and AFFF-spiked reactors. By the next day, with AFFF added at 6.0 ppm in the feed volume, the denitrification rate of the control reactor again experienced little change, while denitrification in the AFFF-spiked reactor had stopped completely. This was confirmed with an additional profile sampling of the anoxic zone at the start of the next reactor cycle, which also indicated a total loss of denitrification in reactor D. By the next profile sampling period conducted three days later, the AFFF-fed reactor had totally recovered with a denitrification rate slightly exceeding that of the control reactor, though not statistically significant. The denitrification rates measured over the course of this experiment confirmed that this AFFF had a significant impact on denitrification performance when mixed with influent feed concentrations as low as 0.6 ppm, but acclimation was possible and in this case achieved within 4 days of initial AFFF addition.

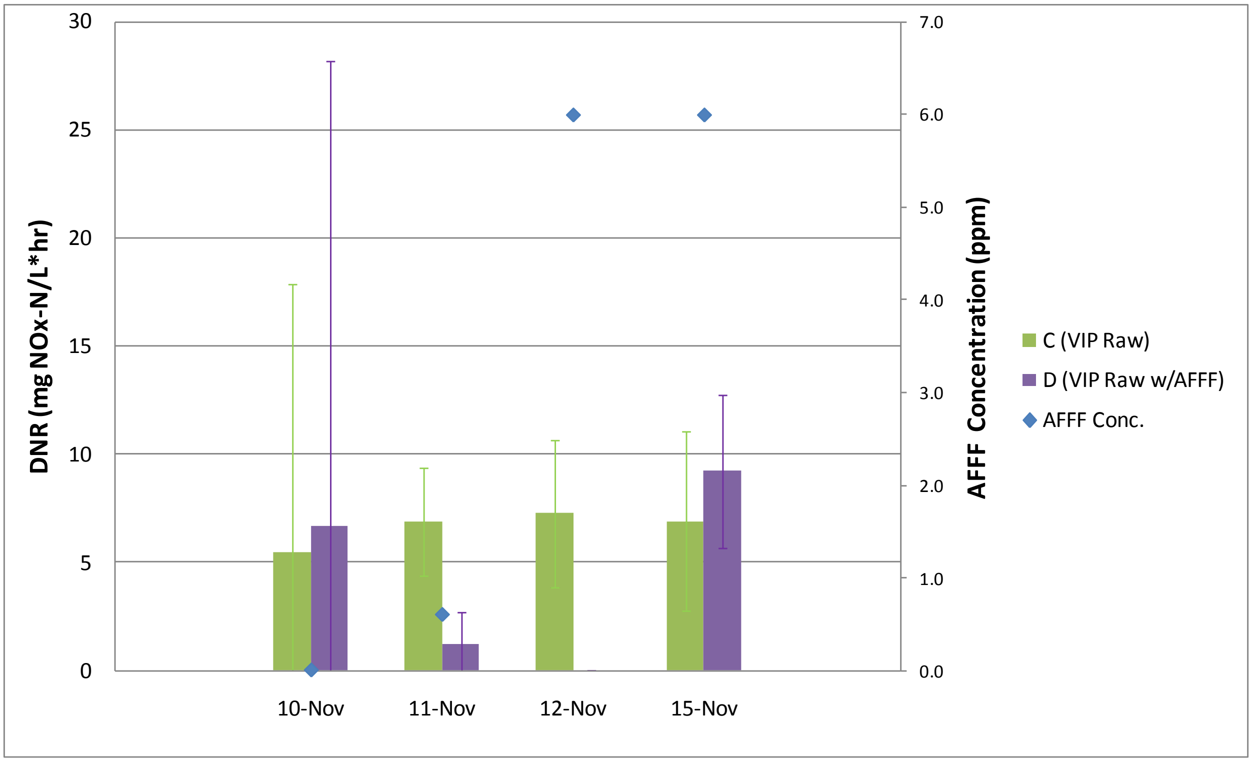

Figure 4.42 **Denitrification Rates with 95% Confidence Interval for VIP Reactor C (control) and VIP Reactor D (spiked with Aqueous Film Forming Foam solution), with the AFFF concentration in Reactor D shown over experimental period**

The results of this study were completely unexpected, and if confirmed, would be one of very few cases of selective denitrification (and COD uptake) inhibition where nitrification continues unaffected. Based on this study and its findings, further investigation of AFFF and its effect on selective denitrification inhibition was coordinated to determine whether these results were repeatable.

4.2.2. Final AFFF Test (AFFF feed of known concentrations)

After reviewing the results from the initial AFFF study, it was decided to conduct an additional AFFF test, this time using an AFFF stock solution added at known concentrations. The stock solution ordered was Chemguard® 6% Military Specification AFFF. The designation of “6% AFFF” represents the intended mixing proportions for the concentrated AFFF for use as a fire suppressant. So, 6% AFFF signifies that 6 parts concentrated AFFF is designed to enter solution with 94 parts water. Addition of AFFF to the feed source was initiated at 20 ppm, and was gradually increased until denitrification in the test reactor was affected. Concentrations expressed in parts per million are based on dilution directly from the purchased AFFF container. Prior to beginning this AFFF test, the AFFF-spiked reactor from the previous experiment was allowed nearly one month for recovery, with several profiles carried out during that time to monitor the reactors. For this experiment, AFFF was added to reactor C, which had previously been the control, to determine whether both reactors would have the same reaction to AFFF addition.

The resulting concentrations in the VIP test reactor (C) over time are displayed in Figure 4.43, based on simple dilution calculations assuming no other losses. Figure 4.43 shows only the first 8 days following addition of AFFF to the reactor, as AFFF feed concentration was maintained at 40 ppm for the duration of the project. AFFF-spiked feed addition began at 20 ppm in VIP reactor C at 1900 on December 14, 2010. By the time the first profile was performed at 0700 on December 15, the resulting concentration of AFFF in reactor C was approximately 9.3 ppm. AFFF-spiked feed was then added at 40 ppm to VIP reactor D beginning at 1900 on December 16, 2010. By the time the next profile was performed at 0700 on December 17, the resulting level of AFFF solution in reactor D was approximately 30.5 ppm. This feed concentration was maintained until January 18, 2011, at which point the test reactor had been fed with AFFF-spiked feed at 40 ppm for 32 days, with the AFFF concentration in the reactor at approximately 40 ppm for the last 27 of those days. By the final profile sampling event, the test reactor appeared to have fully acclimated to the AFFF feed.

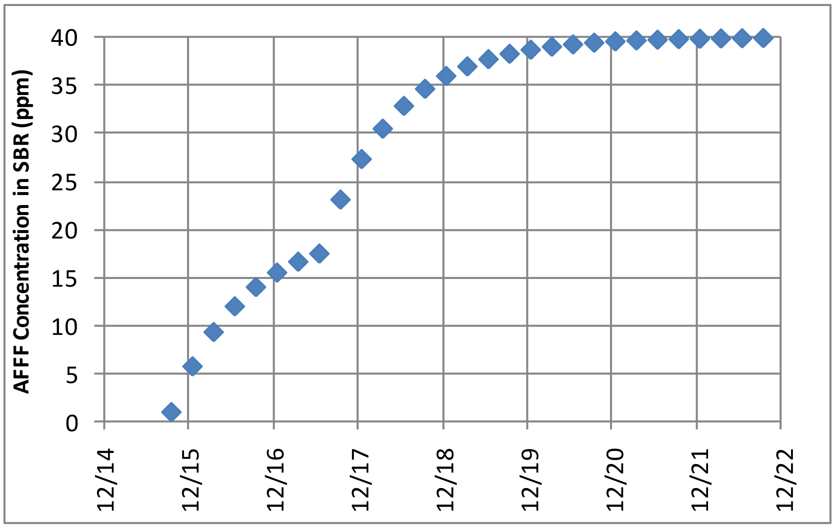

Figure 4.43 **Percentage AFFF solution contained in VIP RWI test reactor**

Although the two VIP SBRs were fed with the same influent composite sample, it is important to note the feed characteristics during the sampling period when comparing reactor performance data. For this experiment, as with the initial AFFF test, it was necessary to use a second feed drum, filled with a specified volume of feed, so that the AFFF could be added at the proper concentration. For this test, individual samples were analyzed from the control feed drum and the AFFF-spiked feed drum for COD, TKN, TSS, and VSS. Feed characteristics for the feed sources can be seen in Figure 4.44. There are some important differences to note between the two feed sources. First, there were several days on which the influent TSS values differ widely between the two feed sources, with the AFFF-spiked feed consistently higher, with the exception of December 31. To ensure that both feed containers started with the exact same feed, the control feed container was filled fully with VIP raw. At this point, a submersible pump was used to transfer a specific volume to the test feed container to be spiked with the AFFF. Although the control feed container was being mixed during the transfer, it is possible that it was not sufficiently mixed, resulting in a higher concentration of solids at the bottom of the container where the submersible pump was drawing from, thus leading to a higher TSS value in the AFFF-spiked feed container. A similar pattern was seen with influent COD data, possibly resulting from the same circumstances. Influent TKN and NH4-N were comparable throughout the experimental period.

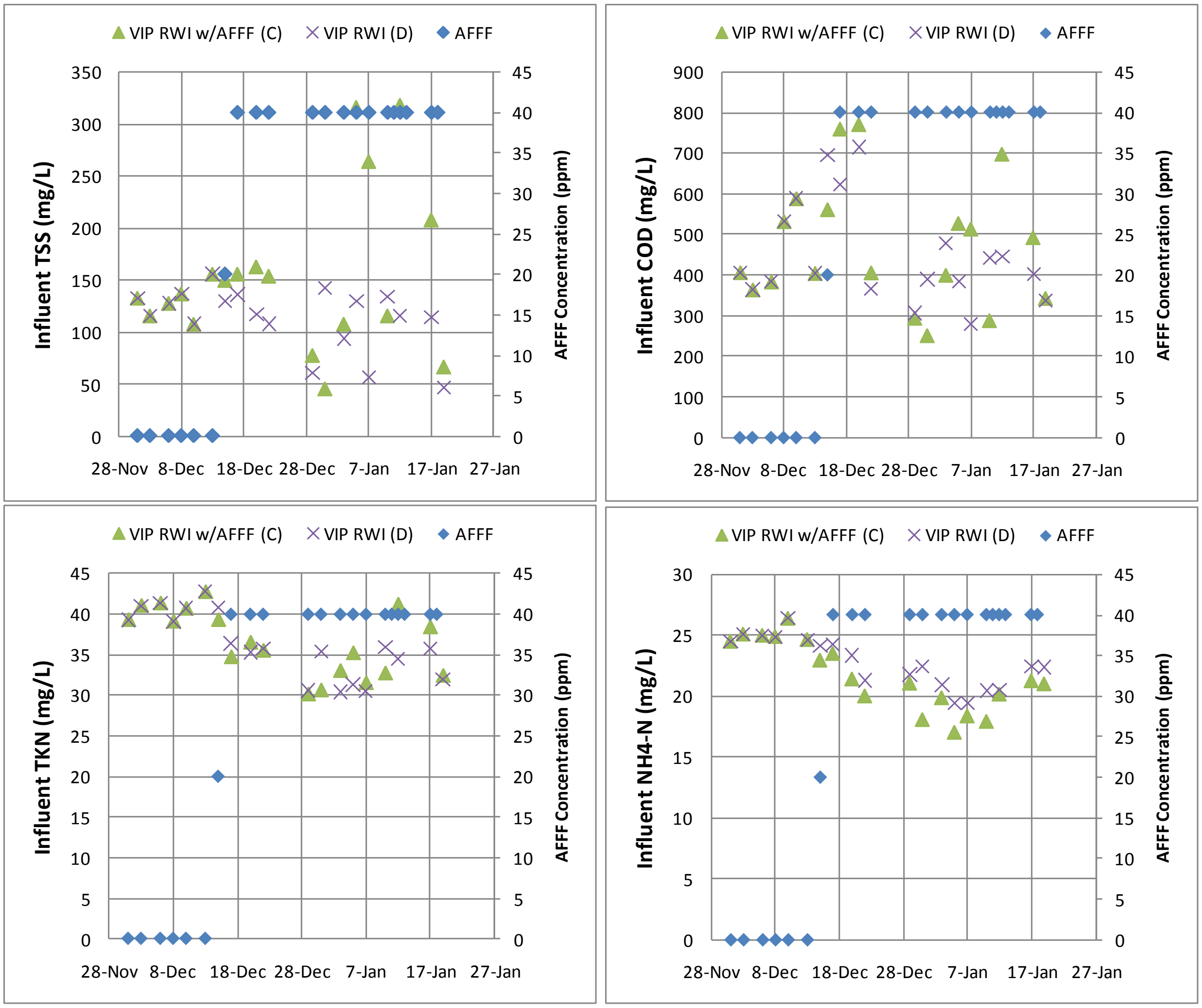

Figure 4.44 **VIP RWI characteristics with AFFF feed concentrations in test reactor (C) over experimental period**

Over this test period, MLSS, MLVSS and SVI data were collected to monitor any effects of AFFF on settling characteristics, solids washout, etc. These data are presented in Figure 4.45. Based on comparison of the AFFF-spiked reactor to the control reactor and to data collected prior to AFFF addition, there were no significant changes in the test reactor as a result of AFFF addition. Although mixed liquor concentrations drop in the AFFF-spiked reactor beginning January12, there was no significant increase in effluent TSS, eliminating the possibility that solids were being washed out due to AFFF addition. This drop in MLSS for the AFFF-spiked reactor is even more unusual when the influent TSS data are considered, which showed a steady increase when compared to the control feed drum; the reason for this is uncertain. MLVSS data show a similar pattern, indicating that the volatile fraction experiences little/no change as a result of AFFF addition. The SVI data collected over this experimental period also show little change. Although the AFFF-spiked reactor shows a slight increase around January 14, it was insignificant, as similar discrepancies were noted regularly even before addition of AFFF. Effluent TSS data show no signs of solids washout, and neither reactor consistently achieves lower effluent TSS concentrations than the other. Again, signs of foaming were monitored, but never became an issue.

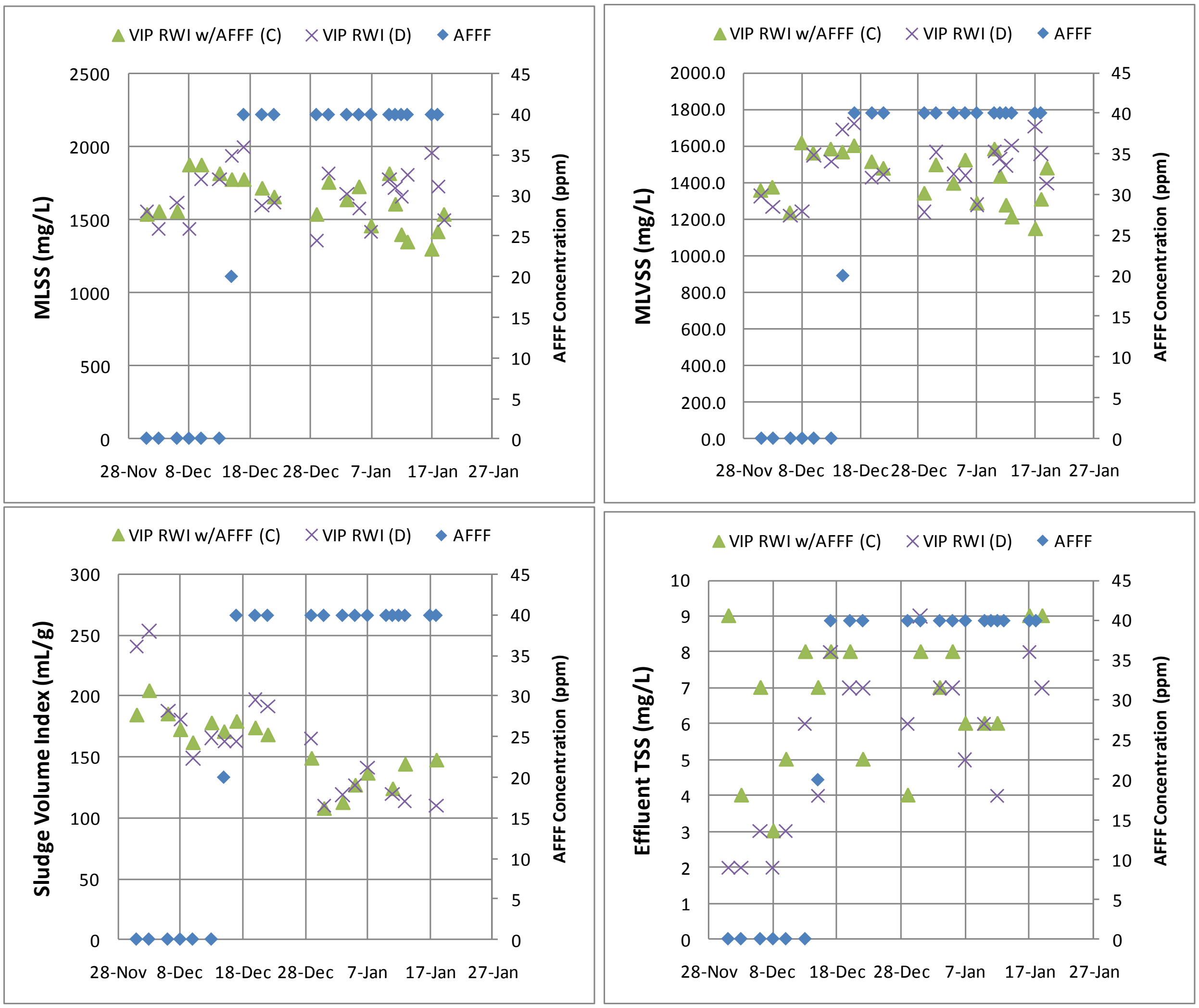

Figure 4.45 **VIP SBR characteristics with AFFF feed concentrations in test reactor (C) over experimental period**

As with the previous AFFF test, effluent nutrients, specifically nitrogen species, were of particular importance. As with all other profile sampling events, each SBR was spiked with a solution of ammonium chloride to raise the ammonia-N concentration to approximately 10 mg - N/L at the start of the aerobic phase to avoid NH4-N limitation of nitrification. A byproduct of the ammonia spike was an increase in effluent nitrogen species. This was evident from the obvious increase in the effluent nitrogen species concentrations in the effluent, as seen in Figure 4.46. Although both VIP reactors experienced this, there was some discrepancy between effluent NH4-N concentrations from the two reactors, but these were quite minor and can be attributed to slight differences between the starting ammonia concentrations. Effluent nitrite-N data also show no obvious pattern. The similarity between the concentrations of effluent NH4-N and NO2-N would suggest that nitrification performance between the two reactors was similar over the course of the experiment, with no inhibition of AOB or NOB. Effluent nitrate-N data differed significantly between the test and control reactors throughout the experimental period. Although several dates show effluent NO3-N values that match closely, the significant differences between them on other sampling days suggest that the AFFF-spiked reactor experienced some level of denitrification inhibition. Effluent total nitrogen concentrations reflect this same pattern, which is to be expected since effluent NH4-N and NO2-N concentrations were similar between the two reactors.

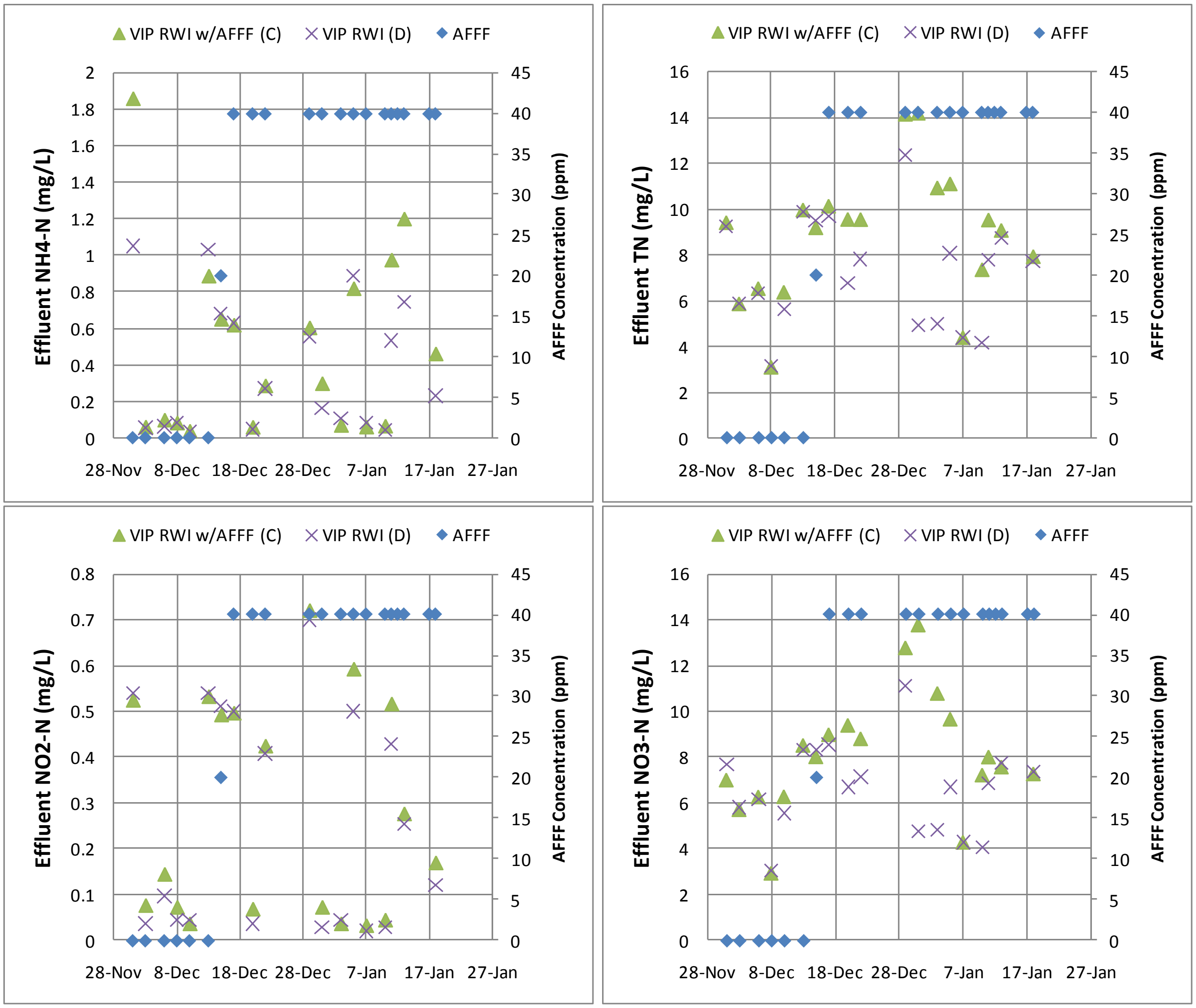

Figure 4.46 **VIP SBR effluent nutrient data with AFFF feed concentrations in test reactor (C) over experimental period**

A profile sampling event was conducted during the cycle immediately prior to AFFF addition. From this, it can be observed in Figure 4.47 that nitrification rates between the two reactors were very similar, with no statistically significant difference based on the 95% confidence intervals between the regression slopes. On December 15, with the AFFF solution added at a concentration of 20 ppm to the influent feed, little change was observed from the preceding day, which had no AFFF addition. Also, rates between the control and test reactor were nearly identical. By the next day, with AFFF solution added at 40 ppm to the influent feed, the nitrification rate of the AFFF-spiked reactor drops slightly, but not at a level that was statistically significant when compared to the control. AFFF feed continued at this concentration until January 18. Profiles up until January 5, 2011 continued this pattern, with slightly higher nitrification rates in the control reactor, but again, not at a statistically significant level. By the next profile on January 11 and continuing until the last profile on January 18, the pattern seemed to reverse, and the AFFF-spiked reactor experienced slightly higher rates of nitrification than the control reactor, although these differences were also statistically insignificant. The nitrification rates over the course of this experiment confirmed that 6% AFFF had no significant impact on nitrification performance if mixed at a concentration less than or equal to 40 ppm.

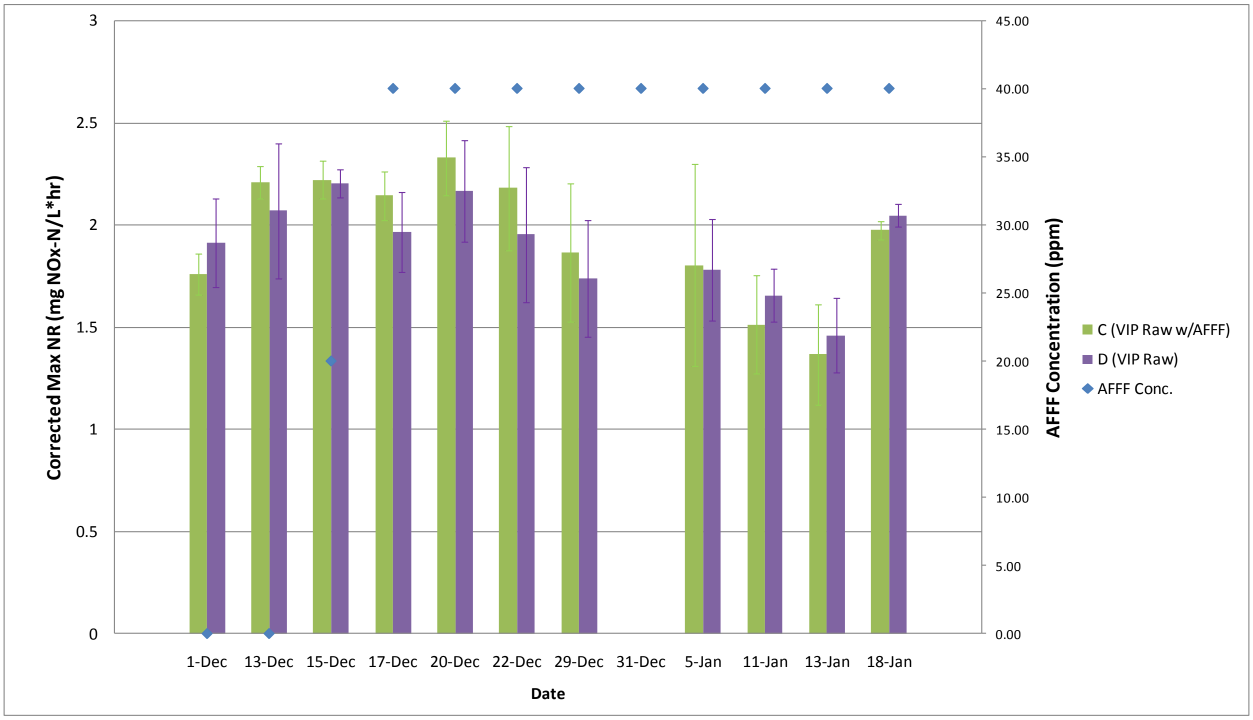

Figure 4.47 **Corrected Maximum Nitrification Rates with 95% Confidence Interval for VIP Reactor C (spiked with AFFF) and VIP Reactor D (control), with the AFFF concentration in Reactor C over experimental period**

On December 15, with the AFFF added at 20 ppm to the influent feed, the denitrification rates for both reactors remained relatively close to the rate measured on the preceding day with no AFFF addition (Figure 4.48). However, the denitrification rate for the AFFF-spiked reactor appeared slightly lower than that of the control, but not at a level that was statistically significant based on the 95% confidence intervals between the regression slopes. By the next profile conducted 2 days later, with AFFF solution added at 40 ppm to the influent feed, the denitrification rate of the control reactor experienced little change, while denitrification in the AFFF-spiked reactor had slowed to a rate that was significantly lower than that of the control. Profiles conducted both 3 and 5 days later showed similar results, with denitrification significantly inhibited when compared to the control reactor. By the next profile sampling event on December 29, 12 days following initial addition of AFFF at 40 ppm, the test reactor had fully regained denitrification, with rates very close to the control reactor. AFFF-spiked feed at 40 ppm continued in order to confirm that the test reactor had fully acclimated, but within 2 days of what had appeared to be full acclimation, the denitrification rate in the test reactor again dropped to a level significantly lower than the control. Another profile was conducted 5 days later, this time indicating a total loss of denitrification in the AFFF-spiked reactor. By the next profile on January 11, 6 days later, the test reactor had regained denitrification, with a rate similar to that of the control reactor. AFFF feed continued at 40 ppm until January 18, with two additional profile samples performed, both showing full recovery of denitrification of the AFFF-spiked reactor and rates similar to the control. The denitrification rates measured over the course of this experiment confirmed the findings of the initial AFFF study, showing that 6% AFFF had a significant impact on denitrification performance when added to influent feed at a concentration of 40 ppm.

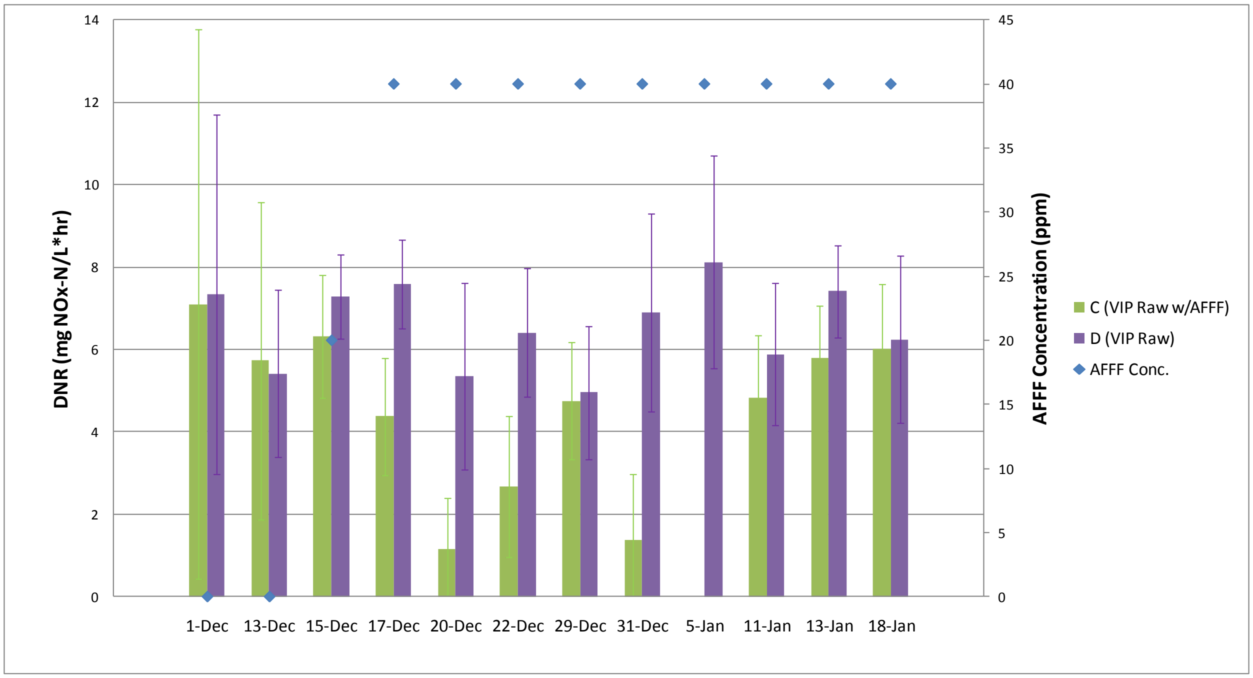

Figure 4.48 **Denitrification Rates with 95% Confidence Interval for VIP Reactor C (spiked with Aqueous Film Forming Foam) and VIP Reactor D (control), with the AFFF concentration in Reactor C over experimental period**

The results of this study indicate that AFFF is a selective inhibitor of denitrification (and COD uptake), without affecting nitrification performance. This is one of very few cases where this has been observed. Typically nitrifying bacteria are much more susceptible to chemical inhibitors of all types as compared to heterotrophs (Juliastuti et al., 2003a; Tchobanoglous et al., 2003). Although these results appear repeatable, several factors should be considered for any future studies investigating AFFF. First, these reactors were configured to simulate the MLE process, where denitrification occurs prior to nitrification. With the anoxic period first, it is possible that the heterotrophic denitrifiers were more impacted than nitrifiers. Although batch tests indicate that nitrification was unaffected by AFFF addition, it cannot be stated for certain that nitrification would not be inhibited based on the results of these SBRs, as it is possible that the AFFF had been fully degraded by the start of the aerobic period. In order to confirm the findings of this study, it is recommended that a similar study be performed with fully aerobic nitrifying SBRs or a system with post-denitrification.

5. Conclusions

The purpose of this project was to investigate continuous and sporadic nitrification inhibition experienced at the Nansemond wastewater treatment plant. The first objective was to determine whether the source of inhibition was an industry or other source within the collection system, or plant recycle streams and truck delivered septage/FOG/chemical toilet waste. This was determined based on comparison of an SBR fed with NP RWI and another fed with NP PCI (which included the recycle streams and delivered wastes), both of which were compared to a control reactor fed with VIP RWI. VIP RWI SBR C was used for comparison as the control reactor from August 18, 2010 until December 13, 2010, at which point VIP RWI reactor D became the control. Control reactor selection was based on which SBR was being used to test ATU or AFFF at the time, making the unaffected SBR the obvious choice for comparison as a control.

Since SRT was maintained at exactly 15 days for all reactors, it was assumed that a direct comparison of corrected maximum nitrification rates could be used to compare nitrification performance between the SBRs. By operating at the same SRT, the growth rate for nitrifying bacteria should have been the same between the reactors, and thus measurements of maximum corrected NR through reactor profiling should be the same (if uninhibited). Based on the SBR experiments, no specific source was identified as the cause of nitrification inhibition problems at NP. SBR operation did show that there was no significant difference in nitrification performance between NP RWI and NP PCI, based on comparison of maximum corrected NRs, indicating that the source of continuous nitrification inhibition is somewhere within the collection system, and not a result of plant recycle streams or delivered wastes. However, since there were no observed incidents of sporadic nitrification inhibition, plant recycles and delivered wastes cannot be eliminated as a source of these upsets. Over the course of the project, both NP reactors achieved either similar or higher nitrification rates as the VIP control reactor, suggesting that NP was not experiencing any level of continuous nitrification inhibition.

However, BioWin modeling suggested that there was some level of continuous inhibition for both NP RWI and PCI reactors, but no sporadic inhibition events were observed. It also appeared that the VIP RWI control reactor experienced some level of continuous nitrification inhibition, although results indicated that both NP reactors were more inhibited than the VIP control. This was determined based on comparison of measured effluent ammonia concentrations and maximum corrected nitrification rates, to the same parameters predicted by BioWin for μmax_{AOB} values of 0.6, 0.7, 0.8, and 0.9 $days^{-1}$. From this comparison, μmax_{AOB} values were predicted for each SBR. Individual profile sampling events were also used to compare actual data to BioWin-predicted data with different μmax_{AOB} values. The model data closely matched actual data for all reactors with respect to influent characteristics. BioWin-predicted MLSS and MLVSS concentrations for NP RWI and NP PCI were also a close fit to actual data. However, to achieve a good fit for VIP RWI MLSS and MLVSS data, minor adjustments were required for aerobic and anoxic yield values in BioWin (aerobic yield reduced from 0.666 to 0.610, and anoxic yield reduced from 0.54 to 0.52).

Based on comparison of effluent data, nitrification rates, and several representative profile sampling events, a range of μmax_{AOB} values were determined for NP RWI, NP PCI, and VIP RWI. The range of μmax_{AOB} values determined to provide the best fit for NP RWI was 0.65-0.75 $days^{-1}$. The range for NP PCI was also 0.65-0.75 $days^{-1}$. The range of μmax_{AOB} values that provided the best fit for VIP RWI was 0.75-0.80 $days^{-1}$. These results indicated that μmax_{AOB} values for all three reactors were lower than the typical default value of 0.90 $days^{-1}$.

The similar range of μmax_{AOB} values for NP RWI and NP PCI confirms SBR NR and effluent experimental results showing comparable performance between the two reactors. This further supports the conclusion that the source of continuous nitrification inhibition is somewhere within the collection system. Comparison of NP RWI and PCI μmax_{AOB} values to the VIP RWI μmax_{AOB} values illustrates that VIP RWI is somewhat less inhibitory to nitrifiers, but that the nitrifier growth rate even for VIP wastewater is somewhat depressed compared to typically default values.

Modeling results seem to contradict the results of SBR maximum corrected nitrification rate comparisons, however the significantly higher influent COD, TKN, and TSS loading to the NP reactors is the reason for higher nitrification rates when compared to the VIP RWI control reactors. This was also observed in the BioWin models, which showed consistently higher nitrification rates for NP when compared to VIP RWI, however BioWin also showed that maximum specific growth rates for μmax_{AOB} in NP RWI and PCI were consistently lower than the μmax_{AOB} for VIP RWI. This indicates that NP RWI and NP PCI are slightly inhibitory to nitrification, with μmax_{AOB} values between 0.65 and 0.75 $days^{-1}$, and the fact that both NP RWI and NP PCI are both inhibitory suggests that the source of inhibition is somewhere within the collection system.

When compared to the original design value of 0.57 $days^{-1}$ and previous plant profiling which suggested a μmax_{AOB} in the range of 0.50 – 0.60 $days^{-1}$ (Yi, 2010), this work suggests a slightly higher μmax_{AOB} for NP RWI and PCI, though still significantly lower than the typical μmax_{AOB} value of 0.90 $days^{-1}$. Over the course of this project, there were no observed sporadic upsets of nitrification. Although composite sampling was used for feed collection at the plants to capture any sources of inhibition entering the plant, it is possible that a 2-3 day composite sample diluted any inhibitory compound that would have resulted in a sporadic nitrification upset event in the reactors. SBR sensitivity to sporadic upsets of nitrification was confirmed with a spike of 1 mg/L ATU (allylthiourea), which resulted in a total loss of nitrification.

The purpose of the AFFF project was to evaluate the potential for nitrification inhibition as a result of AFFF addition, since AFFF waste is generated whenever fire suppression systems are tested and also as part of fire fighter training programs. In order for the waste must to be disposed of properly, it is important to understand its effect on biological wastewater treatment processes. AFFF was tested using the VIP fed SBRs, leaving one to serve as a control at all times. Based on SBR reactor profiling, it was determined that 6% AFFF at a concentration of 40 ppm in the influent feed (based on dilution directly from the purchased AFFF material) resulted in significant inhibition of denitrification, with no noticeable effects on nitrification performance. The results of this study indicate that AFFF may selectively inhibit denitrification (and COD uptake), without affecting nitrification. This was completely unexpected and is one of very few cases where this has been observed. However, although these results appear repeatable, it should be recognized that these reactors were configured to simulate the MLE process, where denitrification occurs prior to nitrification. With the anoxic period occurring first, it is possible that the heterotrophic denitrifiers were more impacted than nitrifiers, though unlikely. Although batch tests indicated that nitrification was unaffected by AFFF addition, it cannot be stated for certain that nitrification would not be inhibited solely based on the results of these SBRs, as it is possible that the AFFF had been fully degraded by the start of the aerobic period. In order to confirm the findings of this study, it is recommended that a similar study be performed with fully aerobic nitrifying SBRs or a system with post-denitrification.

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Appendices

7.1 Appendix A – Reactor Profiling Data

18-Aug-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	38.5	116	84%	97.44	493	45.2
B (NP PCI)	43.6	132	85%	112.2	560	56.3
C (VIP Raw)	28.1	102	78%	79.56	346	33.5
D (Vip Raw Dup.)	26.7	100	80%	80	430	31.8

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.13	2.29	1.77	2.00
NR (mg NOx-N/L*hr)	2.19	2.63	2.75	2.71
DNR (mg NOx-N/L*hr)				
SNR (mg NOx-N/g MLVSS*hr)	1.03	1.15	1.55	1.35
SDNR (mg NOx-N/g MLVSS*hr)				

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	9.73	7.91	2.080
B (NP PCI)	9.57	3.72	6.280
C (VIP Raw)	5.58	3.58	3.140
D (Vip Raw Dup.)	5.34	4.38	3.220

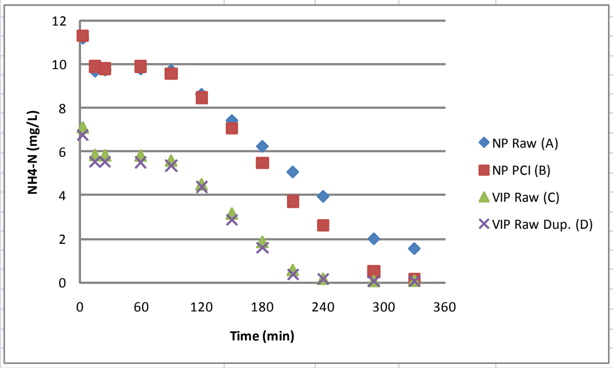
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2690	79%	2125.1
B (NP PCI)	2940	78%	2293.2
C (VIP Raw)	2300	77%	1771
D (Vip Raw Dup.)	2600	77%	2002

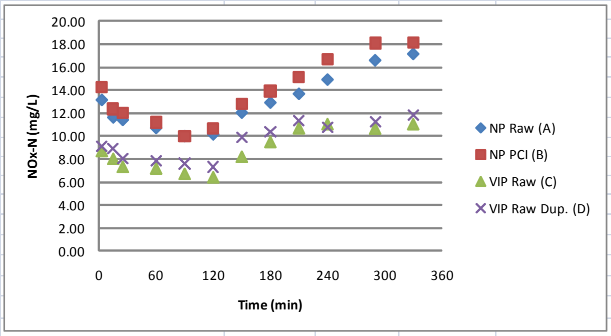
Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	1.570	16.2	0.904	15	8.42
B (NP PCI)	0.148	13.6	4.55	11	8.74
C (VIP Raw)	0.078	11	0.02	23	14.4
D (Vip Raw Dup.)	0.073	11.8	0.016	12	6.46

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	500	275	102.2
B (NP PCI)	580	225	76.5
C (VIP Raw)	260	150	65.2
D (Vip Raw Dup.)	270	150	57.7

	A	B	C	D
OUR (mg O_2/L*hr)	13.73	15.63	11.31	13.08
MLVSS (g/L)	2.13	2.29	1.77	2.00
SOUR (mg O_2/g MLVSS*hr)	6.46	6.82	6.39	6.53

Avg. Temp. (° C)	
A (NP Raw)	12.20
B (NP PCI)	11.76
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.09





NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	11.2	11.90	1.22	13.12	12.3
15	9.69	9.38	2.23	11.61	24.65
25	9.74	9.05	2.34	11.39	25.8
60	9.79	8.39	2.30	10.69	27.3
90	9.73	7.91	2.08	9.99	27.5
120	8.63	8.80	1.34	10.14	21.1
150	7.43	10.90	1.12	12.02	16.25
180	6.25	11.90	0.99	12.89	14.1
210	5.08	12.70	0.95	13.65	10.9
240	3.96	13.90	0.98	14.88	9.2
290	2.02	15.60	0.95	16.55	7.22
330	1.57	16.20	0.90	17.10	6.37

NP PCI (B)

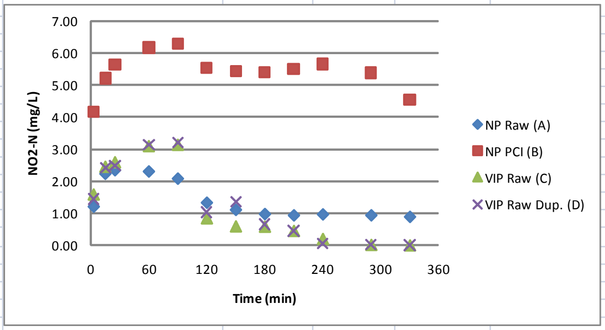
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	11.3	10.10	4.17	14.27	11.35
15	9.89	7.16	5.21	12.37	32.6
25	9.79	6.41	5.64	12.05	35.5
60	9.89	5.05	6.16	11.21	36.4
90	9.57	3.72	6.28	10.00	35.9
120	8.46	5.10	5.54	10.64	23.8
150	7.07	7.40	5.43	12.83	15.2
180	5.49	8.51	5.40	13.91	9.4
210	3.72	9.66	5.50	15.16	4.82
240	2.63	11.00	5.65	16.65	1.6
290	0.49	12.70	5.38	18.08	0.36
330	0.148	13.60	4.55	18.15	0.64

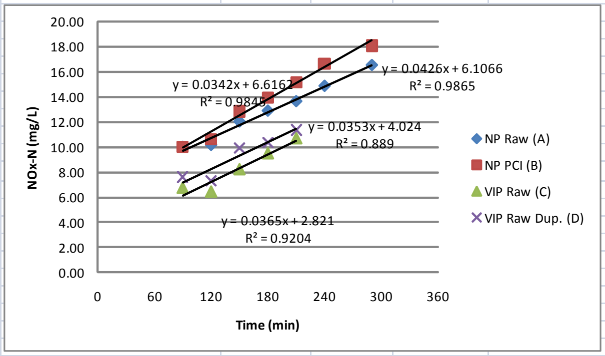
VIP Raw (C)

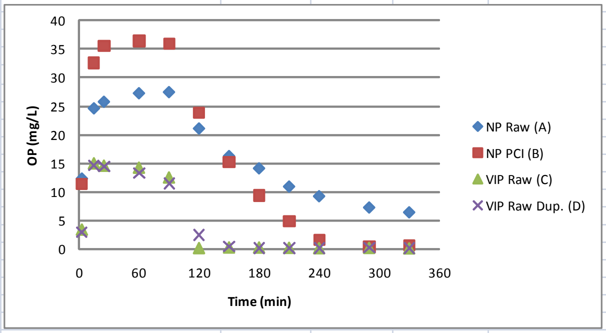
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.1	7.09	1.60	8.69	3.45
15	5.84	5.56	2.46	8.02	14.95
25	5.82	4.72	2.60	7.32	14.55
60	5.81	4.08	3.10	7.18	14.2
90	5.58	3.58	3.14	6.72	12.5
120	4.49	5.56	0.86	6.42	0.24
150	3.15	7.59	0.61	8.20	0.35
180	1.85	8.87	0.60	9.47	0.34
210	0.566	10.20	0.47	10.67	0.29
240	0.166	10.80	0.22	11.02	0.23
290	0.063	10.60	0.04	10.64	0.28
330	0.078	11.00	0.02	11.02	0.19

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.75	7.67	1.450	9.12	2.95
15	5.54	6.52	2.430	8.95	14.7
25	5.54	5.52	2.500	8.02	14.4
60	5.5	4.74	3.140	7.88	13.3
90	5.34	4.38	3.220	7.60	11.5
120	4.37	6.28	1.040	7.32	2.5
150	2.86	8.55	1.360	9.91	0.45
180	1.58	9.72	0.660	10.38	0.2
210	0.38	10.90	0.460	11.36	0.19
240	0.168	10.70	0.070	10.77	0.19
290	0.068	11.20	0.028	11.23	0.28
330	0.073	11.80	0.016	11.82	0.19







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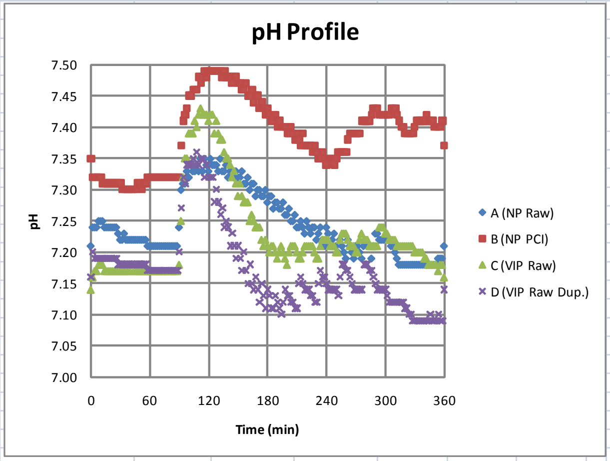
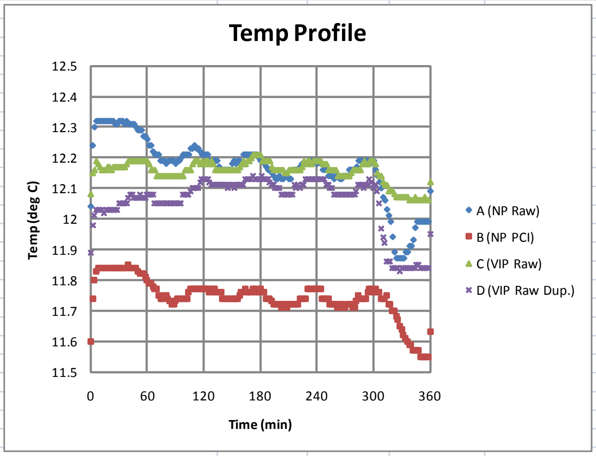




20-Aug-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	35.95	132	85%	112.2	412	50.6
B (NP PCl)	36	190	88%	167.2	565	48.7
C (VIP Raw)	25.7	100	82%	82	325	35.9
D (Vip Raw Dup.)	25.3	64	91%	58.24	283	33.4

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	8.49	6.26	2.020
B (NP PCl)	7.63	0.68	2.220
C (VIP Raw)	6.40	5.40	2.280
D (Vip Raw Dup.)	6.05	6.47	1.980

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2520	78%	1965.6
B (NP PCl)	3020	77%	2325.4
C (VIP Raw)	2160	75%	1620
D (Vip Raw Dup.)	2440	76%	1854

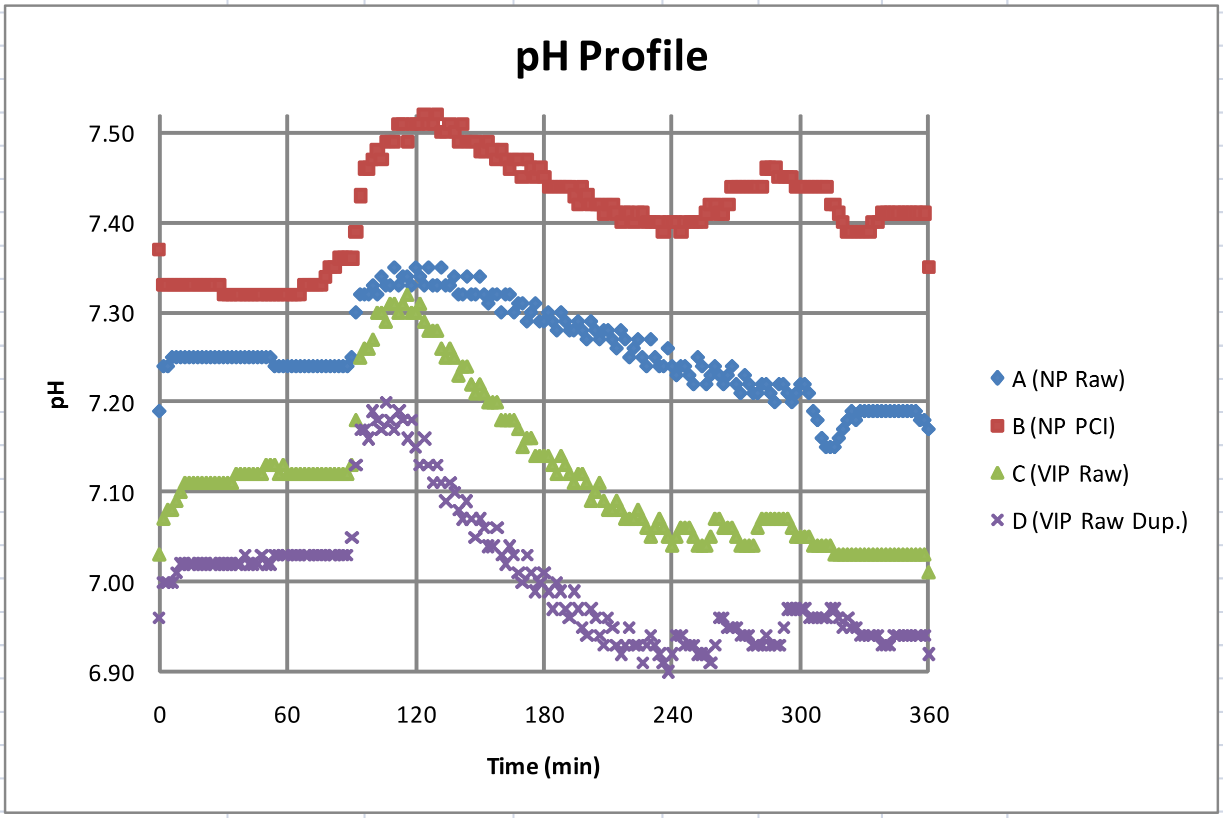
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.523	15.7	0.644	19	10.5
B (NP PCl)	0.094	8.3	0.024	11	6.41
C (VIP Raw)	0.092	13.2	0.02	19	11.5
D (Vip Raw Dup.)	0.088	14.0	0.016	14	6.8

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	470	260	103.2
B (NP PCl)	620	330	109.3
C (VIP Raw)	255	150	69.4
D (Vip Raw Dup.)	270	155	63.5

	A	B	C	D
OUR (mg O_2/L*hr)	15.60	10.93	12.13	0.00
MLVSS (g/L)	1.97	2.33	1.62	1.85
SOUR (mg O_2/g MLVSS*hr)	7.94	4.70	7.49	0.00

Avg. Temp. (° C)	
A (NP Raw)	12.18
B (NP PCl)	11.77
C (VIP Raw)	12.14
D (Vip Raw Dup.)	12.09

20-Aug-10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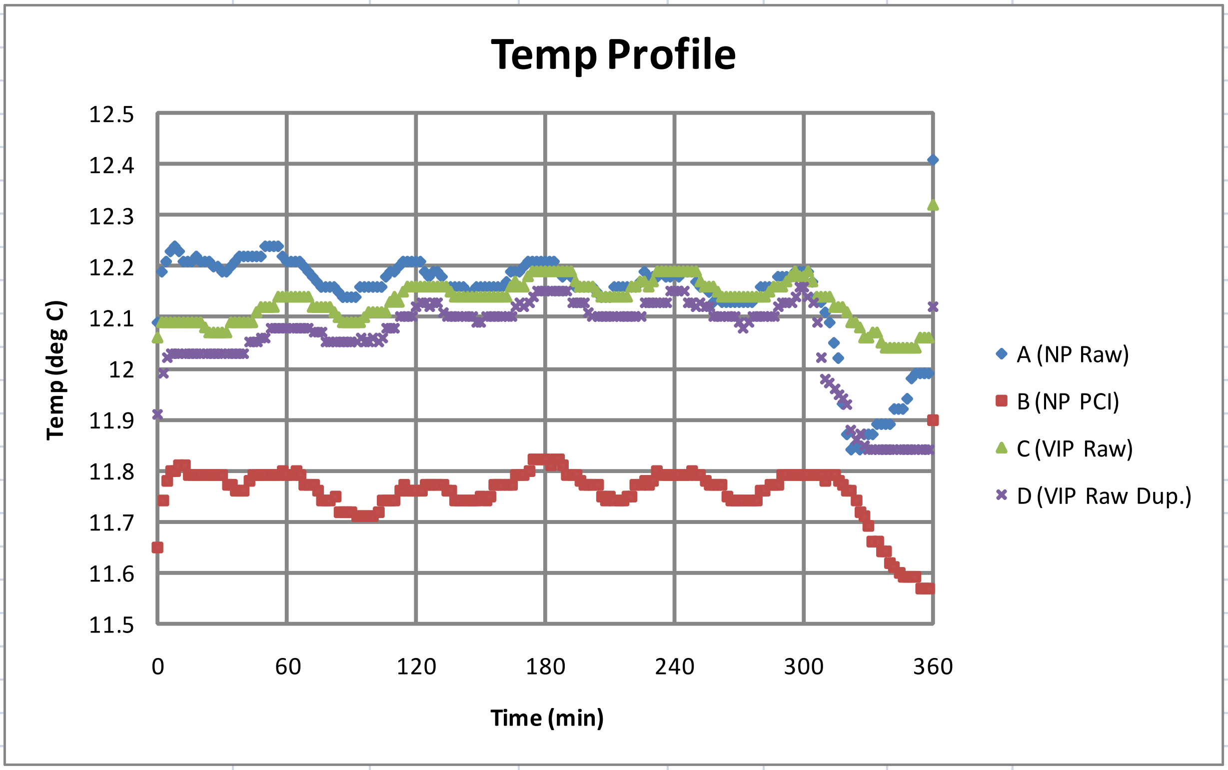
C (VIP Raw)
D (VIP Raw Dup.)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300
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Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

23-Aug-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.7	158	87%	137.46	508	43
B (NP PCI)	42.3	173	88%	152.24	862	57.9
C (VIP Raw)	23.05	114	75%	85.5	423	30.8
D (Vip Raw Dup.)	24	112	82%	91.84	442	33

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.45	5.62	1.300
B (NP PCI)	6.06	0.39	0.040
C (VIP Raw)	4.92	3.58	1.900
D (Vip Raw Dup.)	4.72	3.60	2.540

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2680	80%	2144
B (NP PCI)	3140	79%	2480.6
C (VIP Raw)	2120	75%	1590
D (Vip Raw Dup.)	2080	81%	1685

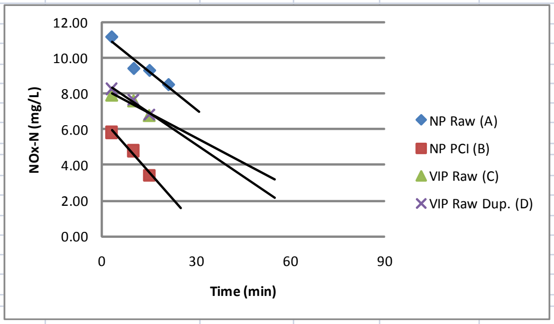
Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.345	15.06	0.44	23	10.6
B (NP PCI)	0.084	7.94	0.1	8	3.8
C (VIP Raw)	0.084	9.9	0.02	9	6.39
D (Vip Raw Dup.)	0.008	9.88	0.03	11	6.87

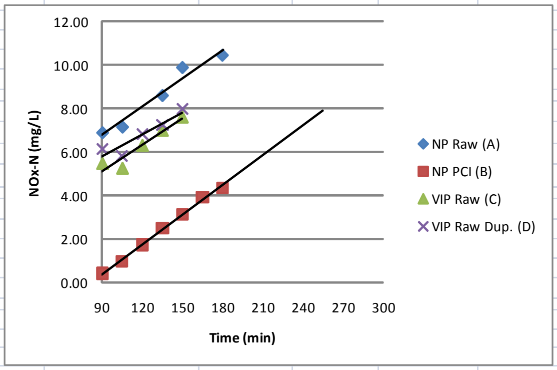
Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	430	235	87.7
B (NP PCI)	740	370	117.8
C (VIP Raw)	265	160	75.5
D (Vip Raw Dup.)	270	160	76.9

	A	B	C	D
OUR (mg O_2/L*hr)	14.19	17.23	10.42	12.59
MLVSS (g/L)	2.14	2.48	1.59	1.68
SOUR (mg O_2/g MLVSS*hr)	6.62	6.95	6.55	7.47

Avg. Temp. (° C)	
A (NP Raw)	12.18
B (NP PCI)	11.81
C (VIP Raw)	12.15
D (Vip Raw Dup.)	12.10

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.14	2.48	1.59	1.68
NR (mg NOx-N/L*hr)	2.78	2.39	3.06	3.01
DNR (mg NOx-N/L*hr)	9.72	11.88	7.32	8.99
SNR (mg NOx-N/g MLVSS*hr)	1.30	0.96	1.92	1.79
SDNR (mg NOx-N/g MLVSS*hr)	4.53	4.79	4.60	5.34





NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.29	10.60	0.57	11.17	48.25
10		8.26	1.15	9.41	
15		7.90	1.40	9.30	
21		7.17	1.34	8.51	
90	6.45	5.62	1.30	6.92	37.3
105	6.06	6.26	0.92	7.18	
120	6.51	8.33	0.85		
135	6.09	7.83	0.79	8.62	26.05
150	4.43	9.18	0.72	9.90	
165	4.66	7.16	0.70		
180	4.05	9.78	0.68	10.46	21.25
255			0.00		18.45
330	0.345	15.06	0.44	15.50	17.4

NP PCI (B)

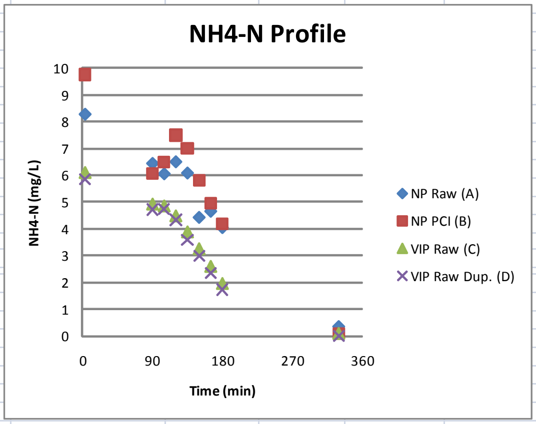
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	9.76	4.12	1.70	5.82	48.6
10		2.48	2.31	4.79	
15		1.75	1.68	3.43	
21		1.39	2.80	4.19	
90	6.06	0.39	0.04	0.43	36.2
105	6.5	0.71	0.28	0.99	
120	7.5	1.19	0.56	1.75	
135	6.99	1.74	0.76	2.50	24.2
150	5.81	2.28	0.86	3.14	
165	4.95	2.94	0.98	3.92	
180	4.18	3.32	1.05	4.37	15.9
255			0.00		10.5
330	0.084	7.94	0.09	8.03	8.65

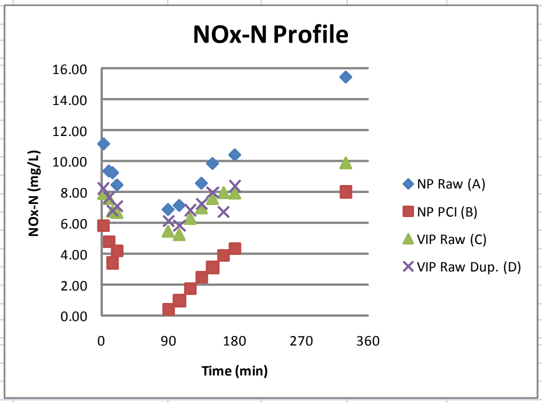
VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.1	7.00	0.93	7.93	40.7
10		6.14	1.47	7.61	
15		5.16	1.62	6.78	
21		5.02	1.68	6.70	
90	4.92	3.58	1.90	5.48	26.4
105	4.85	4.58	0.68	5.26	
120	4.48	5.87	0.44	6.31	
135	3.88	6.59	0.41	7.00	7.25
150	3.25	7.23	0.38	7.61	
165	2.59	7.62	0.37	7.99	
180	1.95	7.60	0.36	7.96	7.25
255			0.00		7.1
330	0.084	9.90	0.02	9.92	7.15

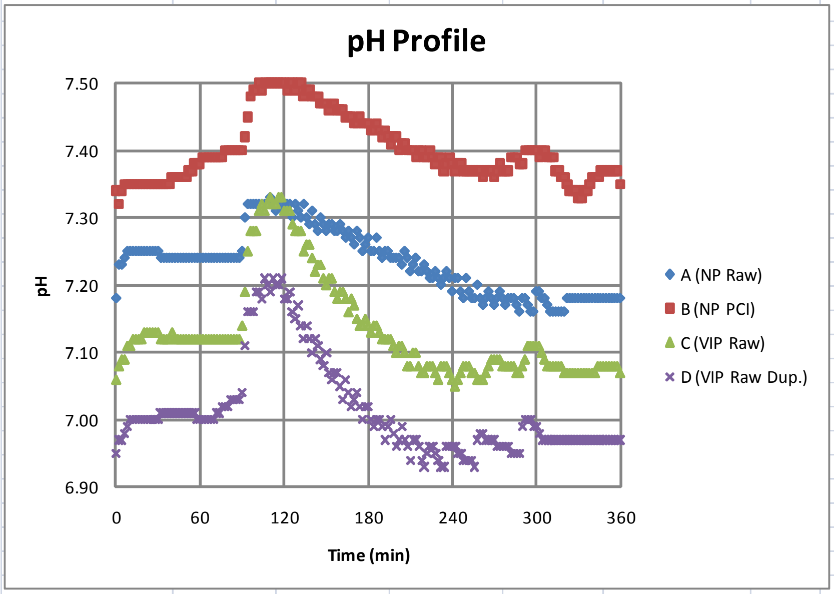
VIP Raw Dup. (D)

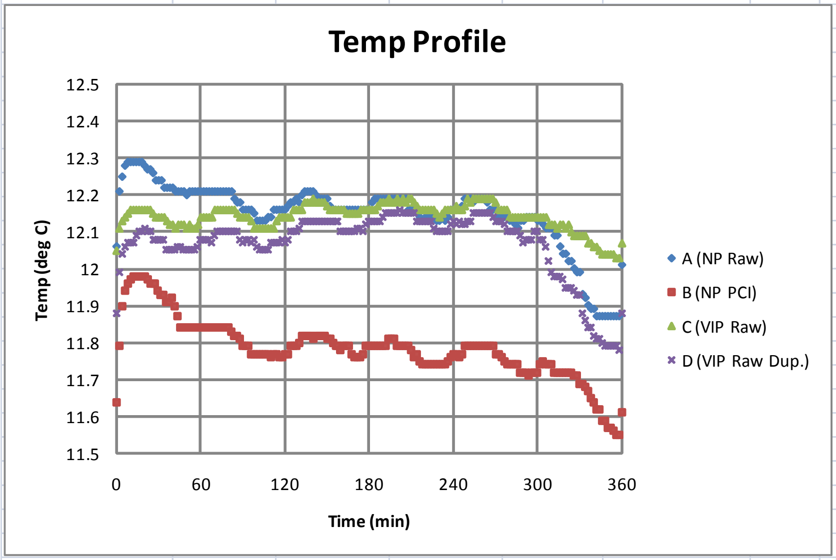
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.85	7.15	1.110	8.26	40.85
10		5.96	1.690	7.65	
15		4.96	1.860	6.82	
21		5.00	2.100	7.10	
90	4.72	3.60	2.540	6.14	26.0
105	4.73	4.74	1.080	5.82	
120	4.34	6.25	0.590	6.84	
135	3.6	6.77	0.470	7.24	6.95
150	2.98	7.57	0.410	7.98	
165	2.34	6.32	0.400	6.72	
180	1.73	8.04	0.370	8.41	7
255			0.000		7.05
330	0.008	9.88	0.030	9.91	7.05

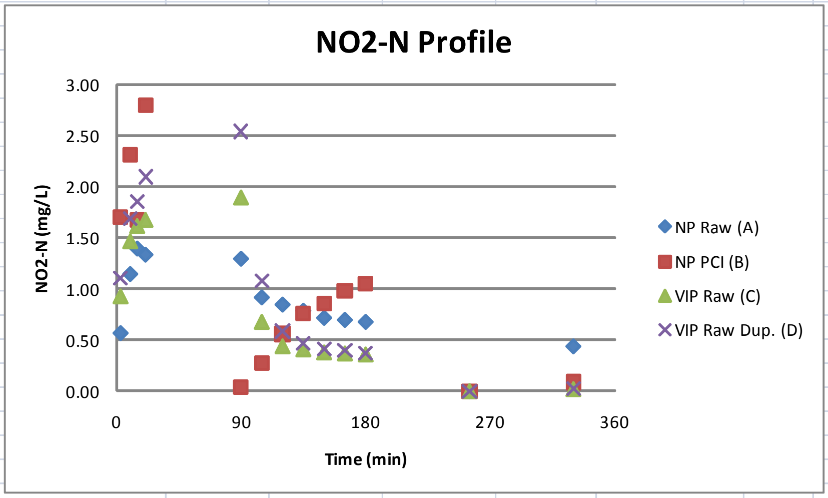


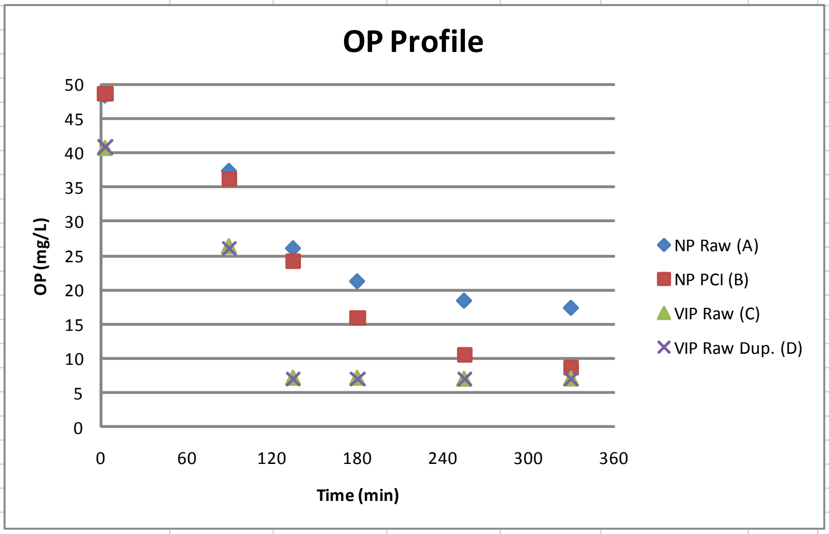


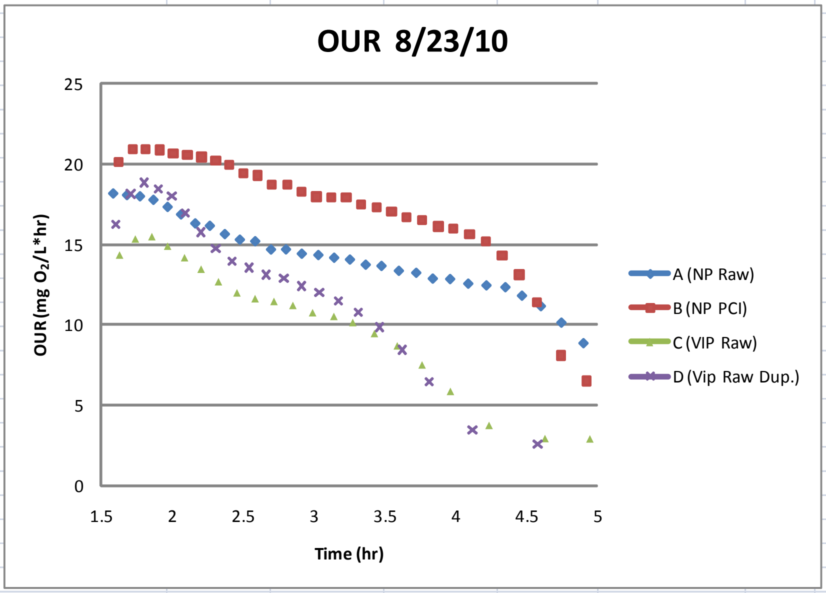
23-Aug-10

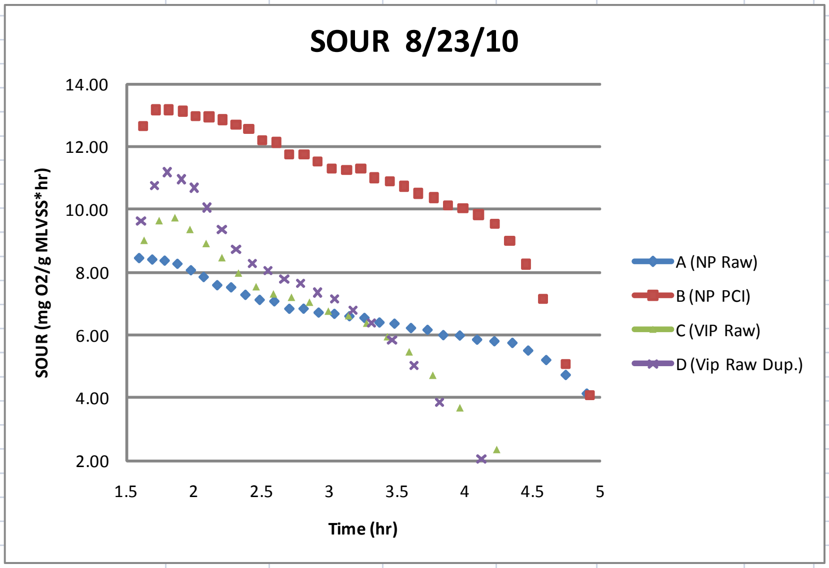

pH Profile
pH
7.50
7.40
7.30
7.20
7.10
7.00
6.90
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


NO2-N Profile
NO2-N (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
50
45
40
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR 8/23/10
OUR (mg O$_2$/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR 8/23/10
SOUR (mg O2/g MLVSS*hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

25-Aug-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.95	90	91%	81.9	468	53.9
B (NP PCl)	32.9	116	90%	104.4	531	46
C (VIP Raw)	24.45	94	83%	78.02	350	35.8
D (Vip Raw Dup.)	24.8	96	83%	79.68	343	35.5

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.65	7.09	1.58
B (NP PCl)	7.07	0.33	0.04
C (VIP Raw)	6.13	5.11	2.36
D (Vip Raw Dup.)	5.75	5.85	2.28

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2220	78%	1731.6
B (NP PCl)	3160	79%	2496.4
C (VIP Raw)	2000	75%	1500
D (Vip Raw Dup.)	2220	75%	1665

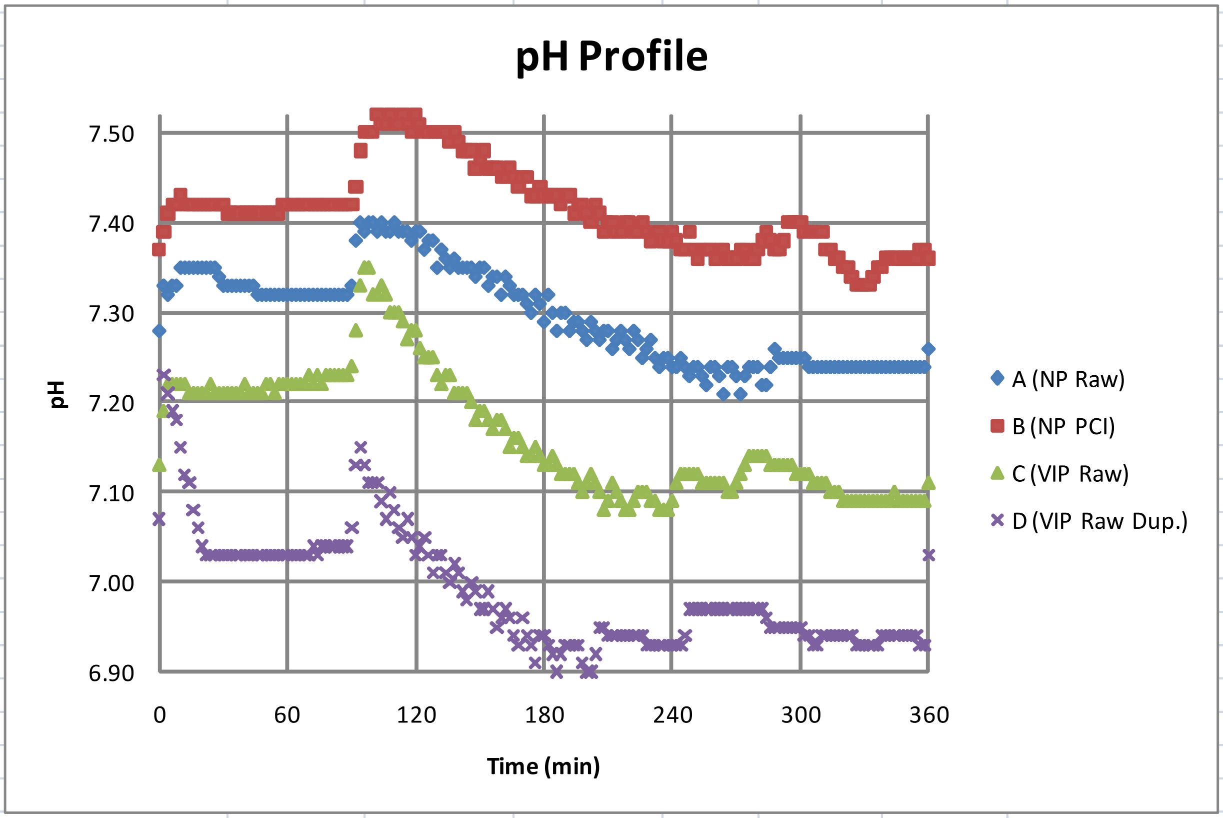
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.114	15.7	0.12	22	10.5
B (NP PCl)	0.086	6.7	0.02	5	3.1
C (VIP Raw)	0.070	12.1	0.016	14	7.93
D (Vip Raw Dup.)	0.082	12.7	0.02	16	8.98

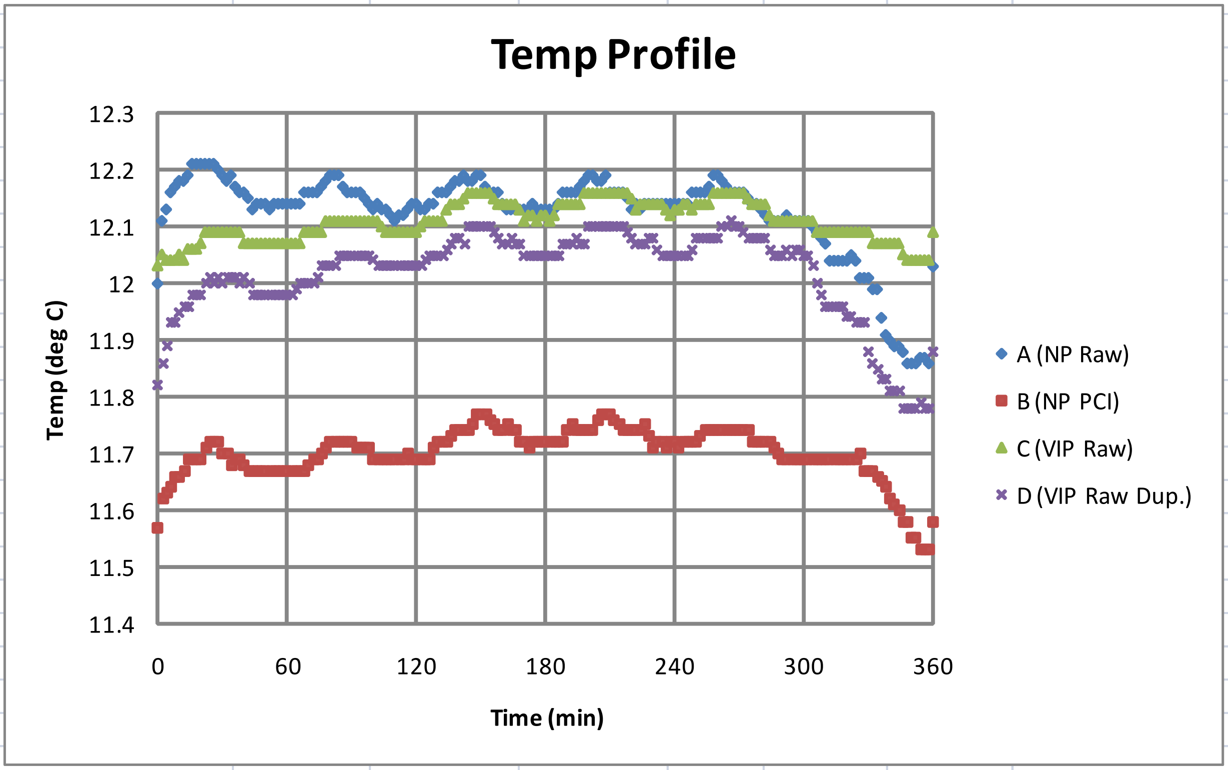
Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	410	230	103.6
B (NP PCl)	780	385	121.8
C (VIP Raw)	255	160	80.0
D (Vip Raw Dup.)	260	160	72.1

	A	B	C	D
OUR (mg O_2/L*hr)	15.10	9.49	9.91	0.00
MLVSS (g/L)	1.73	2.50	1.50	1.67
SOUR (mg O_2/g MLVSS*hr)	8.72	3.80	6.61	0.00

Avg. Temp. (° C)	
A (NP Raw)	12.15
B (NP PCl)	11.71
C (VIP Raw)	12.12
D (Vip Raw Dup.)	12.05

25-Aug-10


pH Profile
pH
7.50
7.40
7.30
7.20
7.10
7.00
6.90
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
11.4
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

27-Aug-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	32.6	74	92%	68.08	369	47.4
B (NP PCI)	35.65	148	84%	124.32	484	57.3
C (VIP Raw)	23.05	78	81%	63.18	239	34.2
D (Vip Raw Dup.)	21.2	79	80%	63.2	205	34

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	8.26	7.53	1.18
B (NP PCI)	9.02	0.85	1.48
C (VIP Raw)	5.87	8.24	0.58
D (Vip Raw Dup.)	4.64	11.10	0.60

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2340	79%	1848.6
B (NP PCI)	3100	79%	2449
C (VIP Raw)	2200	76%	1672
D (Vip Raw Dup.)	2080	75%	1560

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.105	19.5	0.04	16	8.6
B (NP PCI)	0.104	11.9	0.364	6	4.17
C (VIP Raw)	0.100	18.2	0.024	17	11
D (Vip Raw Dup.)	0.092	20.8	0.032	9	4.72

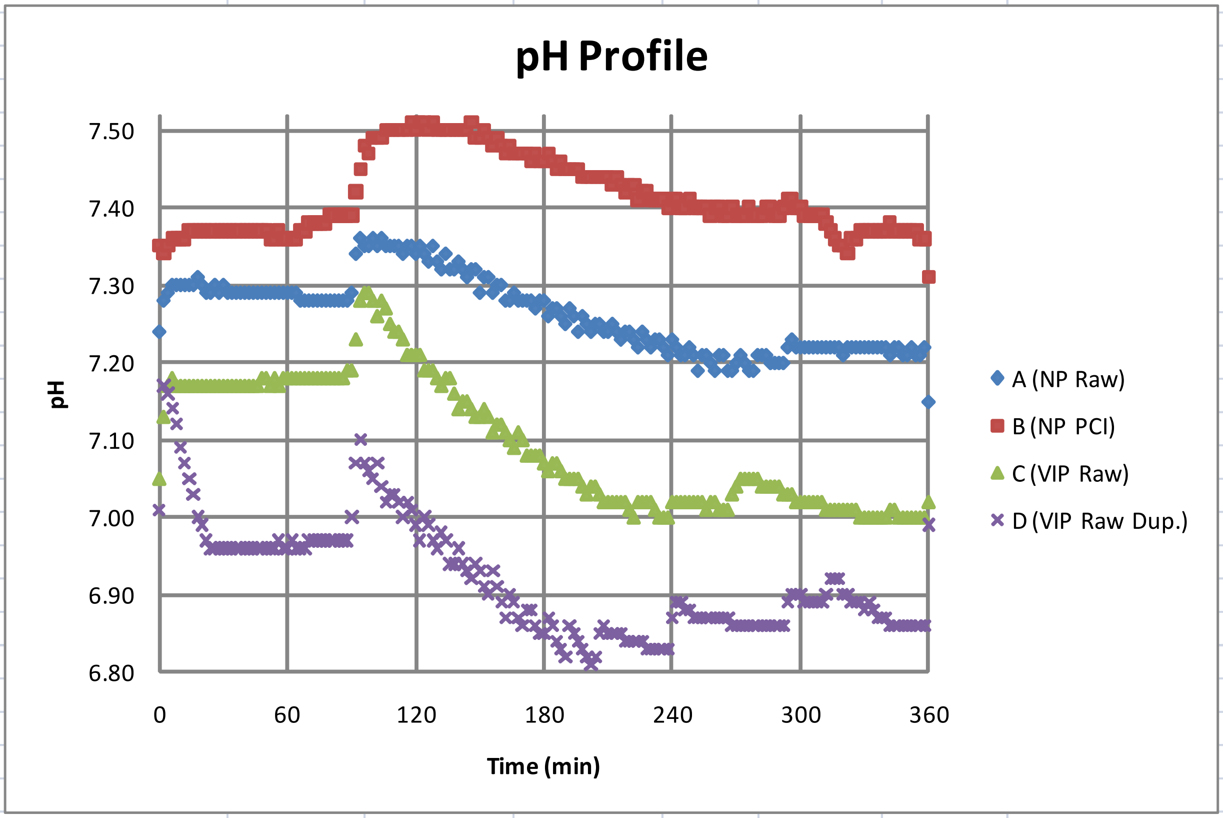
Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	400	215
B (NP PCI)	700	340
C (VIP Raw)	235	150
D (Vip Raw Dup.)	225	145

SVI (mL/g)
91.9
109.7
68.2
69.7

	A	B	C	D
OUR (mg O_2/L*hr)	16.77	9.31	9.65	0.00
MLVSS (g/L)	1.85	2.45	1.67	1.56
SOUR (mg O_2/g MLVSS*hr)	9.07	3.80	5.77	0.00

Avg. Temp. (° C)	
A (NP Raw)	12.16
B (NP PCI)	11.75
C (VIP Raw)	12.15
D (Vip Raw Dup.)	12.09

27-Aug-10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pH
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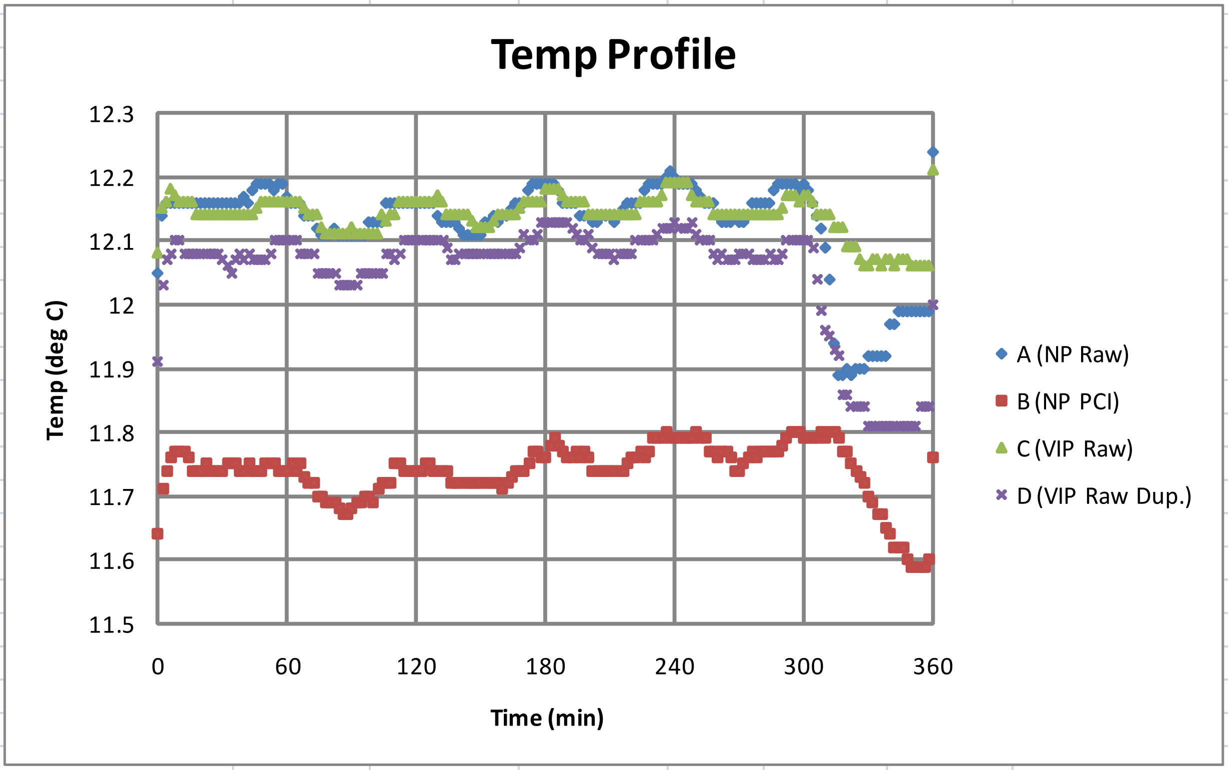
7.40
7.30
7.20
7.10
7.00
6.90
6.80
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

30-Aug-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	33.6	90	93%	83.7	358	50.9
B (NP PCI)	34.15	100	86%	86	440	54.1
C (VIP Raw)	24.35	144	75%	108	391	35.9
D (Vip Raw Dup.)	19.2	225	79%	177.75	346	36.2

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.85	8.20	1.220
B (NP PCI)	8.23	5.47	2.480
C (VIP Raw)	5.79	8.45	0.700
D (Vip Raw Dup.)	4.84	13.50	0.600

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2340	81%	1895.4
B (NP PCI)	2940	80%	2352
C (VIP Raw)	2120	78%	1653.6
D (Vip Raw Dup.)	2100	76%	1596

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.076	15.3	0.04	17	6.2
B (NP PCI)	0.085	14.4	0.072	7	4.2
C (VIP Raw)	0.084	9.9	0.02	17	9.28
D (Vip Raw Dup.)	0.076	16.5	0.036	13	6.94

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	370	200	85.5
B (NP PCI)	605	315	107.1
C (VIP Raw)	215	140	66.0
D (Vip Raw Dup.)	190	130	61.9

	A	B	C	D
OUR (mg O_2/L*hr)	14.73	15.10	9.49	9.91
MLVSS (g/L)	1.90	2.35	1.65	1.60
SOUR (mg O_2/g MLVSS*hr)	7.77	6.42	5.74	6.21

Avg. Temp. (° C)	
A (NP Raw)	12.15
B (NP PCI)	11.71
C (VIP Raw)	12.12
D (Vip Raw Dup.)	12.05

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.90	2.35	1.65	1.60
NR (mg NOx-N/L*hr)	2.66	1.84	3.24	2.53
DNR (mg NOx-N/L*hr)	2.19	5.54	4.45	3.30
SNR (mg NOx-N/g MLVSS*hr)	1.40	0.78	1.96	1.59
SDNR (mg NOx-N/g MLVSS*hr)	1.16	2.35	2.69	2.07

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.47	10.60	0.64	11.24	
10		9.90	1.50	11.40	
18		9.09	1.62	10.71	
90	7.85	8.20	1.22	9.42	
105	7.3	8.30	0.84	9.14	
120	6.46	8.90	0.72	9.62	
135	6.18	10.40	0.72	11.12	
150	5.21	16.10	1.04		
165	4.68	11.80	0.98	12.78	
180	3.84	11.70	0.86	12.56	
255					
330	0.076	15.30	0.04	15.34	

NP PCI (B)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.62	9.18	1.24	10.42	
10		7.82	2.06	9.88	
18		6.94	2.10	9.04	
90	8.23	5.47	2.48	7.95	
105	7.84	5.90	2.00	7.90	
120	6.6	6.44	1.76	8.20	
135	6.4	8.08	1.70	9.78	
150	5.67	10.90	0.84		
165	4.79	9.11	0.74	9.85	
180	4.04	9.73	0.76	10.49	
255					
330	0.085	14.40	0.07	14.47	

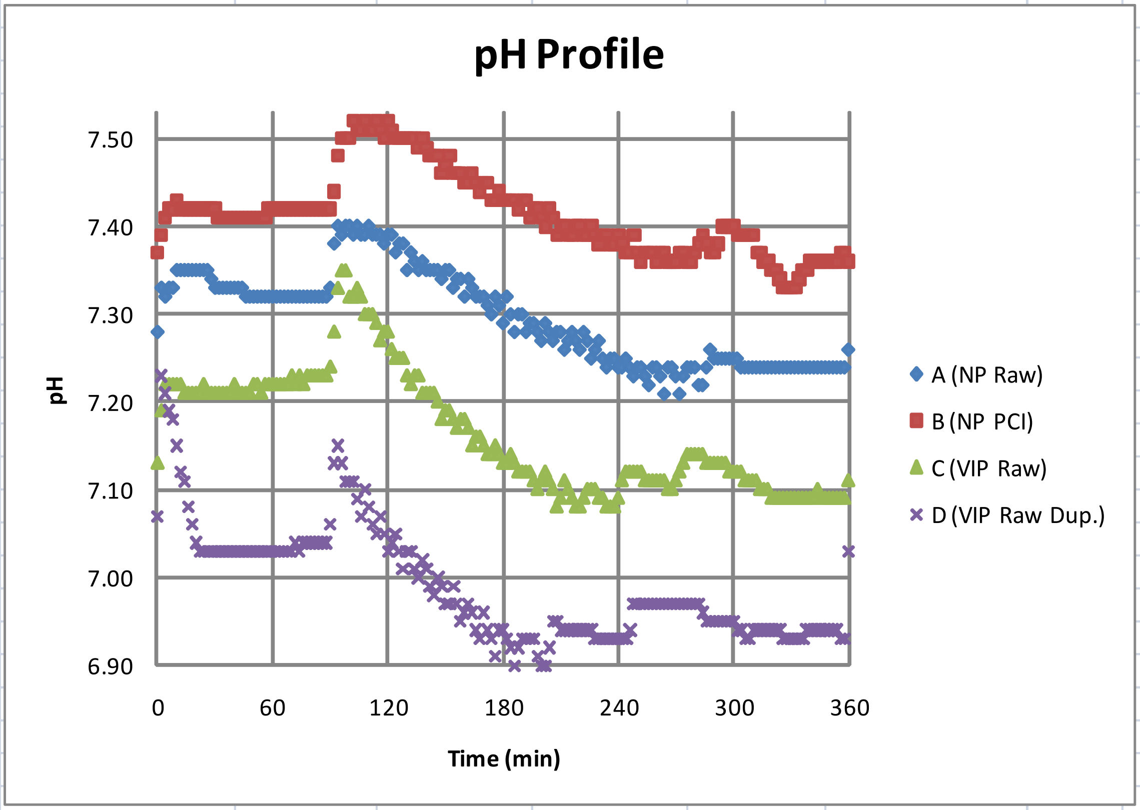
VIP Raw (C)

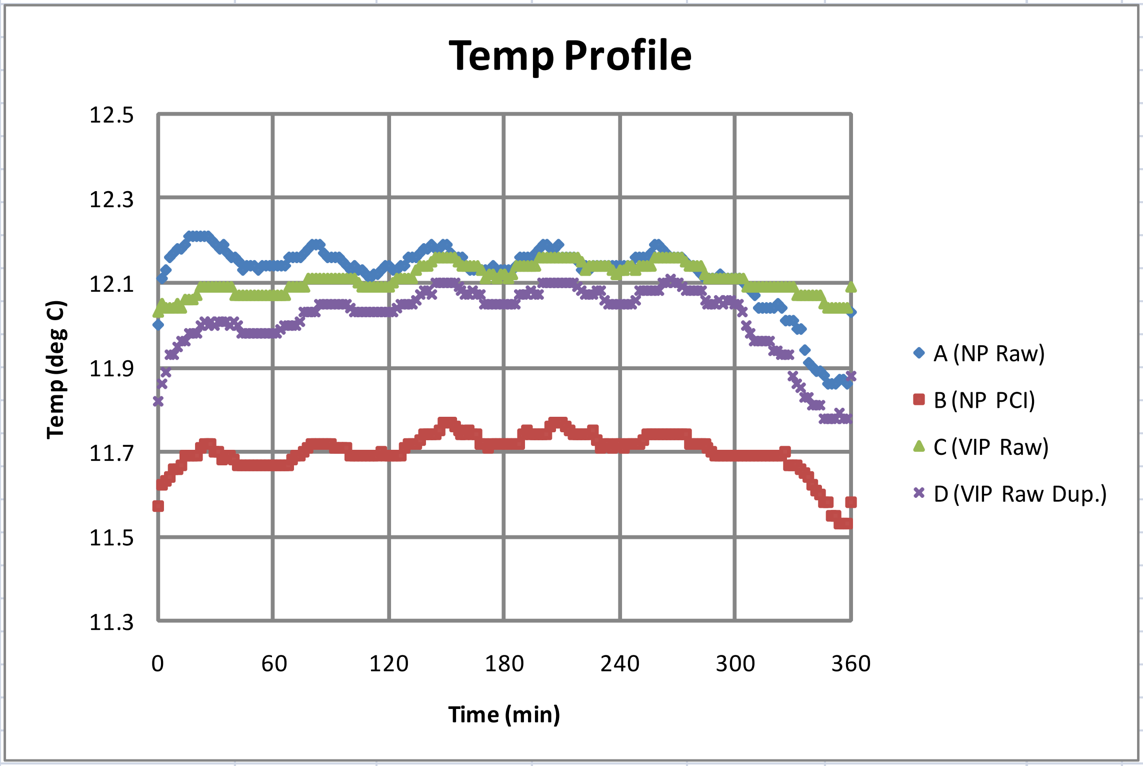
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.17	9.91	0.32	10.23	
10		9.39	0.38	9.77	
18		8.72	0.40	9.12	
90	5.79	8.45	0.70	9.15	
105	5.36	8.40	0.56	8.96	
120	4.45	8.94	0.72	9.66	
135	3.8	10.30	0.80	11.10	
150	3.05	8.73	1.62		
165	2.33	11.50	1.42	12.92	
180	1.71	11.80	1.56	13.36	
255					
330	0.083	13.60	0.02	13.62	

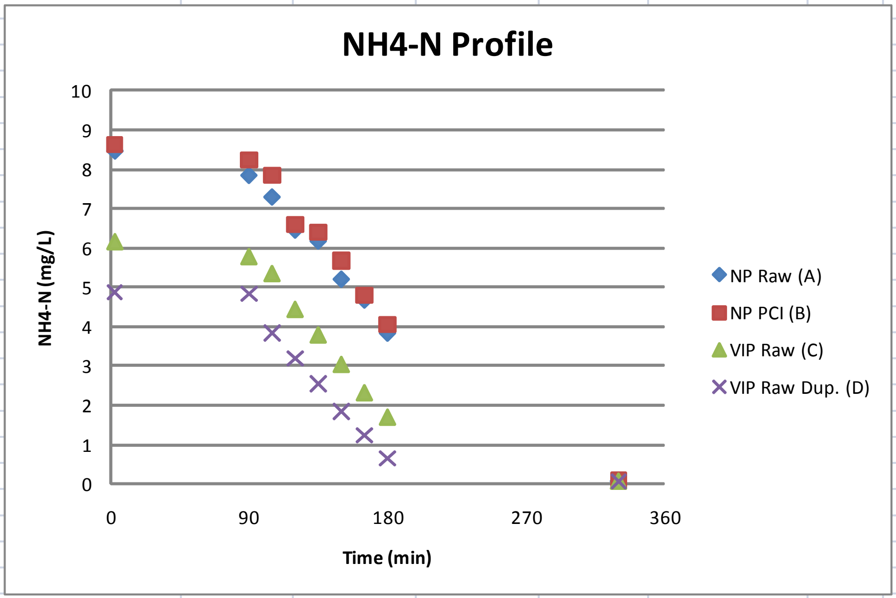
VIP Raw Dup. (D)

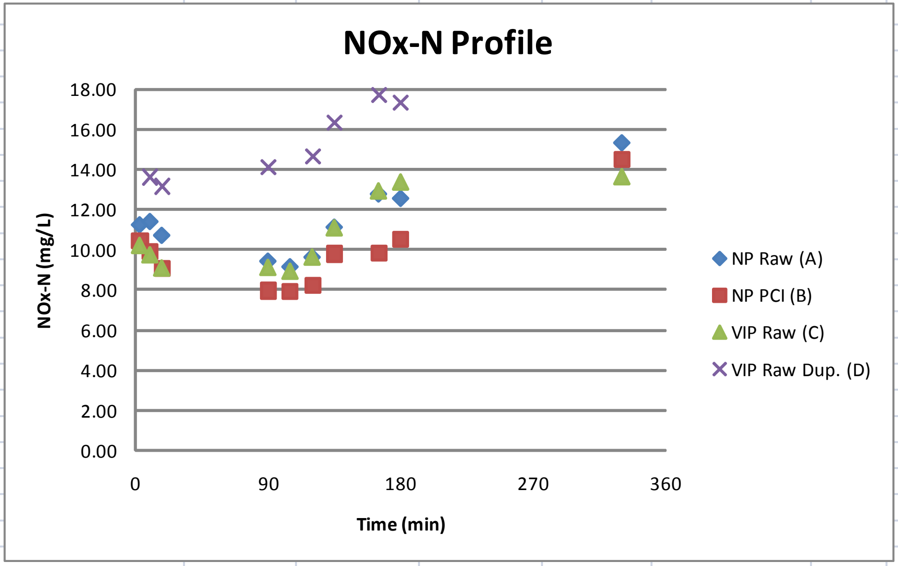
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.87	12.90	0.200		
10		13.20	0.400	13.60	
18		12.50	0.660	13.16	
90	4.84	13.50	0.600	14.10	
105	3.84	12.60	0.780		
120	3.18	13.68	0.960	14.64	
135	2.55	15.30	1.020	16.32	
150	1.84	11.90	0.720		
165	1.23	16.10	1.580	17.68	
180	0.647	16.60	0.740	17.34	
255					
330	0.076	16.50	0.036	16.54	

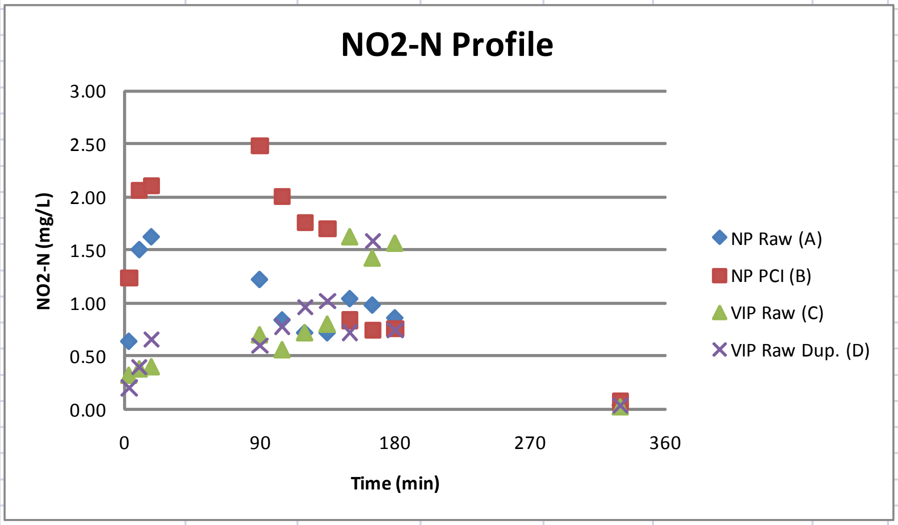
30-Aug-10

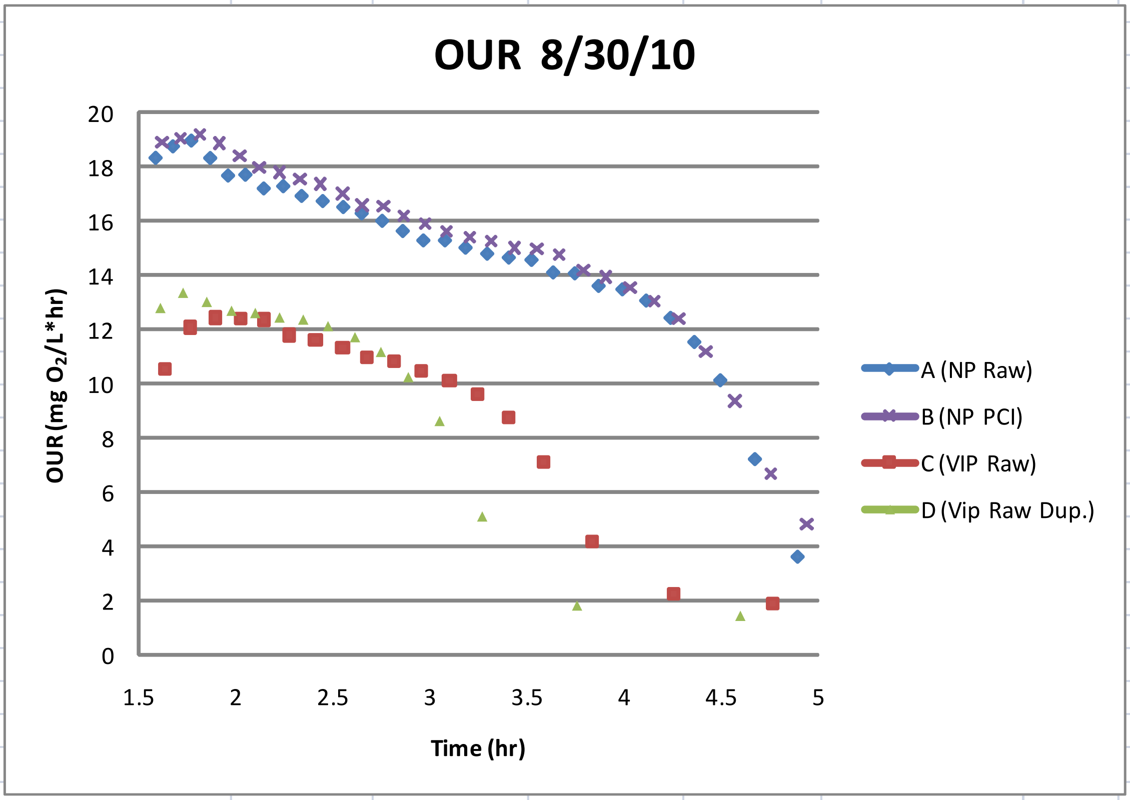

pH Profile
pH
7.50
7.40
7.30
7.20
7.10
7.00
6.90
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

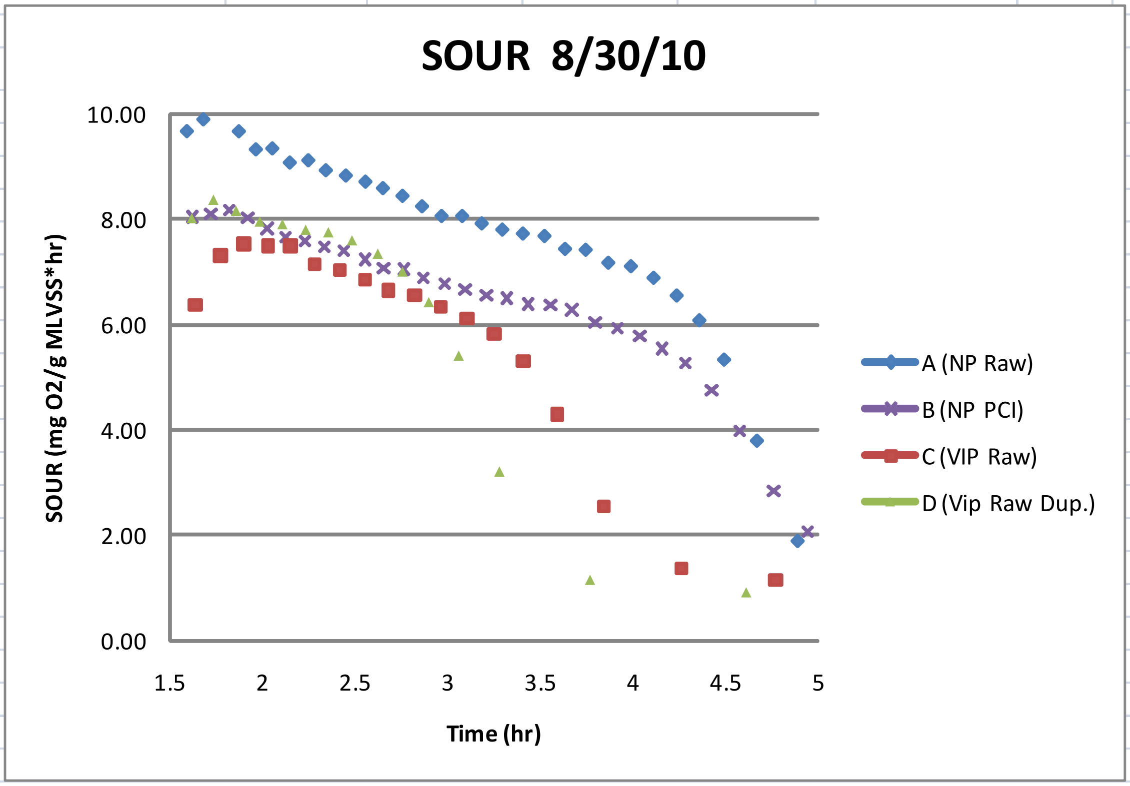

Temp Profile
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR 8/30/10
OUR (mg O₂/L*hr)
20
18
16
14
12
10
8
6
4
2
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR 8/30/10
SOUR (mg O2/g MLVSS*hr)
10.00
8.00
6.00
4.00
2.00
0.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)

1-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	35.95	138	87%	120.06	423	52.7
B (NP PCI)	41.35	122	93%	113.46	656	58.3
C (VIP Raw)	27	40	87%	34.8	304	35.3
D (Vip Raw Dup.)	26.75	45	86%	38.7	265	35.6

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	8.12	9.60	0.96
B (NP PCI)	8.98	5.39	3.12
C (VIP Raw)	6.49	7.35	1.82
D (Vip Raw Dup.)	6.03	8.75	2.26

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2460	80%	1968
B (NP PCI)	3020	79%	2385.8
C (VIP Raw)	2180	78%	1700.4
D (Vip Raw Dup.)	1960	78%	1529

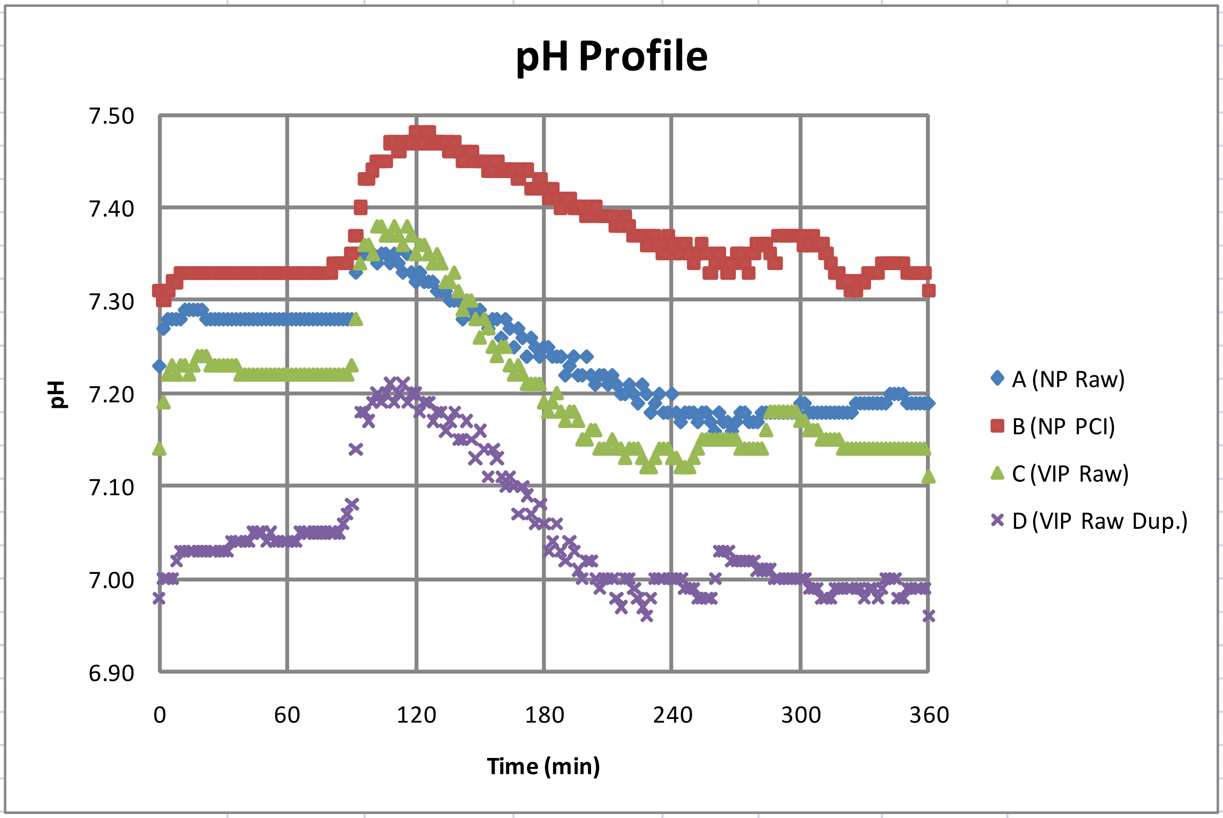
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.087	17.7	0.024	14	5.56
B (NP PCI)	0.075	14.8	0.04	6	3.56
C (VIP Raw)	0.070	13.7	0.024	15	9.28
D (Vip Raw Dup.)	0.081	15.0	0.02	6	4.14

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	390	210	85.4
B (NP PCI)	650	320	106.0
C (VIP Raw)	210	150	68.8
D (Vip Raw Dup.)	195	140	71.4

	A	B	C	D
OUR (mg O_2/L*hr)	15.20	15.83	10.71	12.96
MLVSS (g/L)	1.97	2.39	1.70	1.53
SOUR (mg O_2/g MLVSS*hr)	7.73	6.63	6.30	8.48

Avg. Temp. (° C)	
A (NP Raw)	12.33
B (NP PCI)	11.83
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.17

1-Sep-10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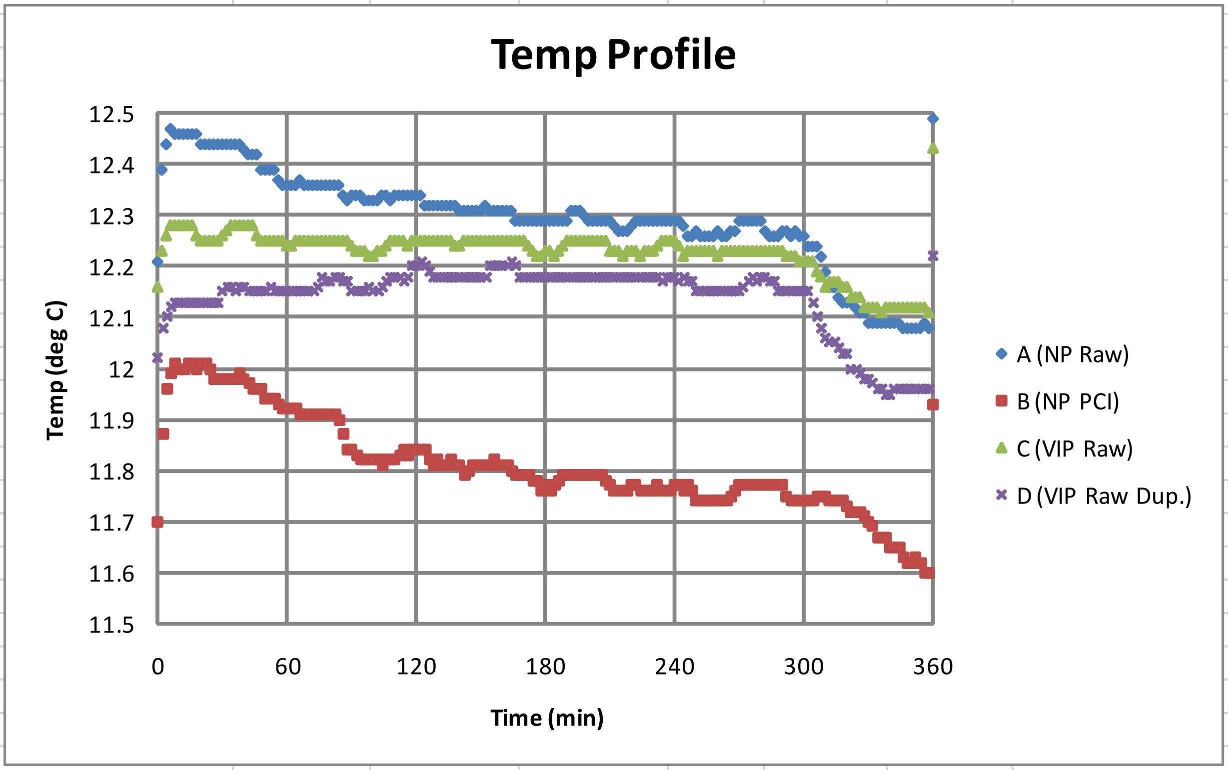
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

3-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	36	148	84%	124.32	467	51
B (NP PCI)	38.05	138	87%	120.06	672	51.5
C (VIP Raw)	28.2	45	87%	39.15	383	36.1
D (Vip Raw Dup.)	27.55	56	80%	44.8	297	36.2

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.99	7.54	1.34
B (NP PCI)	8.19	1.27	3.20
C (VIP Raw)	6.82	6.37	2.26
D (Vip Raw Dup.)	6.03	8.00	1.74

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2420	86%	2081.2
B (NP PCI)	2820	82%	2312.4
C (VIP Raw)	2110	80%	1688
D (Vip Raw Dup.)	1880	78%	1466

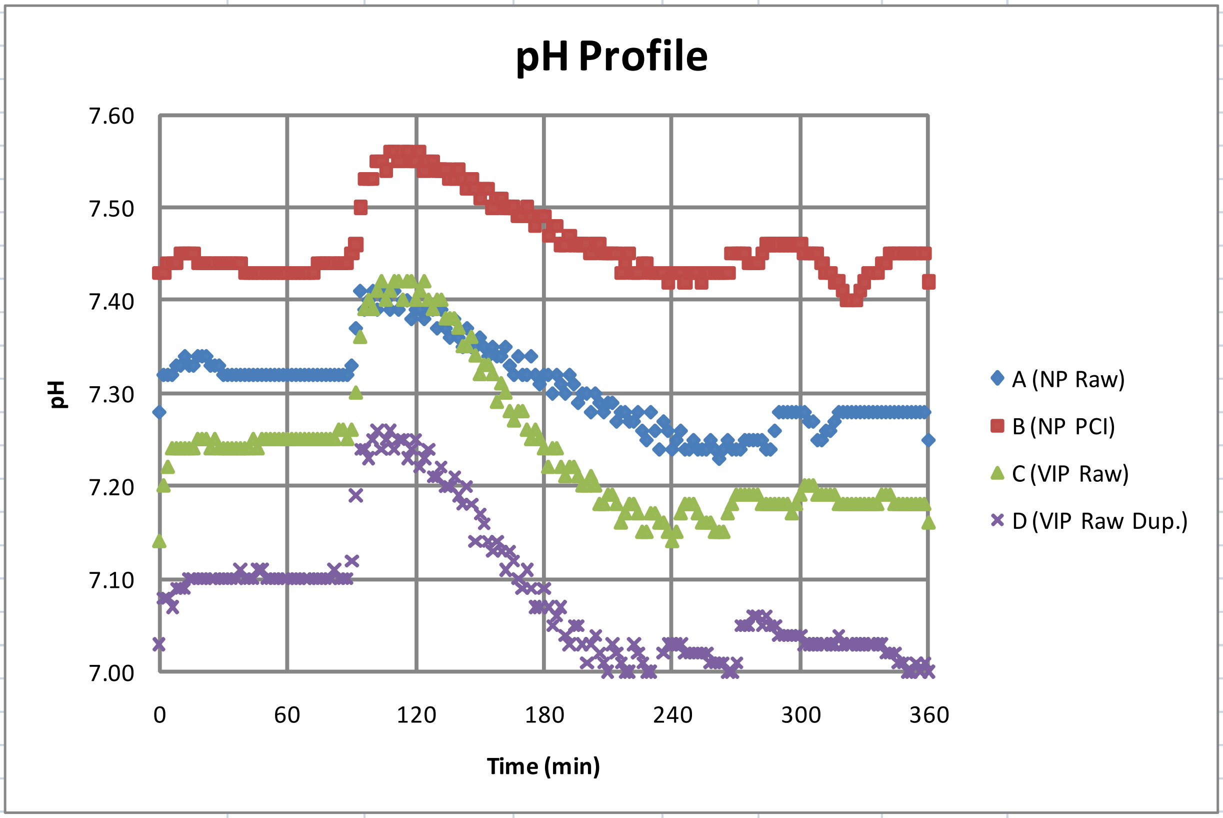
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.142	15.6	0.02	13	5.3
B (NP PCI)	0.080	10.1	0.024	7	3.78
C (VIP Raw)	0.091	13.8	0.016	11	7.38
D (Vip Raw Dup.)	0.061	14.3	0.016	11	6.83

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	370	210	86.8
B (NP PCI)	640	360	127.7
C (VIP Raw)	215	145	68.7
D (Vip Raw Dup.)	210	135	71.8

	A	B	C	D
OUR (mg O_2/L*hr)	15.78	15.92	11.38	12.53
MLVSS (g/L)	2.08	2.31	1.69	1.47
SOUR (mg O_2/g MLVSS*hr)	7.58	6.89	6.74	8.55

Avg. Temp. (° C)	
A (NP Raw)	12.31
B (NP PCI)	11.82
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.21

3-Sep-10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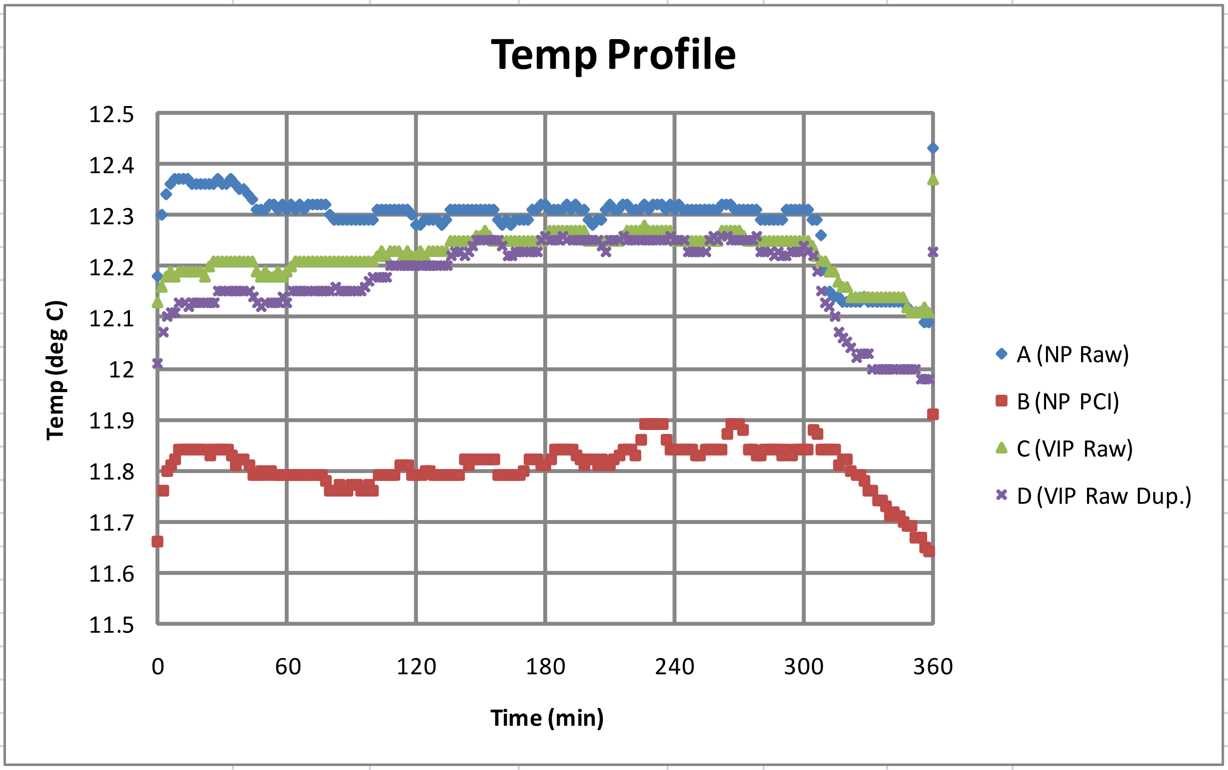
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

8-Sep-10

Feed					
Parameter	**units**	**A (NP Raw)**	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
NH4-N	**mg/L**	35.05	33.35	25.5	26.3
TSS	**mg/L**	106	130	41	63
Voltl. Frac.		85%	85%	85%	86%
VSS	**mg/L**	90.1	110.5	34.85	54.18
COD	**mg/L**	359	344	251	283
$sCOD_{GF}$	**mg/L**	214	191	181	191
ffCOD	**mg/L**	141	127	144	151
cBOD	**mg/L**	126	114	79	87
$cBOD_{GF}$	**mg/L**	58	50	46	46
TKN	**mg/L**	47.7	46.5	35.3	36.2
TKN_{MF}	**mg/L**	42.1	42	31.7	31.9
TP	**mg/L**	7.93	11	4.27	4.68
OP	**mg/L**	17.4	21.9	11.0	11.1

Aerobic Start (0930)					
Parameter	**units**	**A (NP Raw)**	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
NH3-N	**mg/L**	7.92	7.88	6.17	5.90
NO3-N	**mg/L**	7.98	7.36	8.32	8.40
NO2-N	**mg/L**	1.940	1.400	0.660	0.860

Mixed Liquor					
Parameter	**units**	**A (NP Raw)**	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
MLSS	**mg/L**	2380	2700	2050	1940
Voltl. Frac.		82%	79%	77%	77%
MLVSS	**mg/L**	1951.6	2133	1578.5	1493.8
TKN	**mg/L**	172	185	123	110
TP	**mg/L**	77.3	114	80.9	69.2

Effluent					
Parameter	**units**	**A (NP Raw)**	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
NH3-N	**mg/L**	0.084	0.088	0.088	0.091
NO3-N	**mg/L**	16.4	15.4	14.5	14.3
NO2-N	**mg/L**	0.05	0.03	0.03	0.05
TSS	**mg/L**	15	16	23	12
Voltl. Frac.		89%	90%	80%	82%
VSS	**mg/L**	13.35	14.4	18.4	9.84
COD	**mg/L**	80	93	111	79
$sCOD_{GF}$	**mg/L**	51	59	68	72
ffCOD	**mg/L**	51	39	60	72
cBOD	**mg/L**	6	5	4	4
$cBOD_{GF}$	**mg/L**	<2	<2	<2	<2
TKN	**mg/L**	3.58	2.83	2.83	1.78
TKN_{MF}	**mg/L**	1.95	1.71	1.21	1.26
TP	**mg/L**	3.48	5.92	0.78	0.37
OP	**mg/L**	9.2	16.3	0.28	0.18
Turb.	**NTU**	6.02	4.63	6.64	4.8

Settled Sludge Volume					
		A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
@ 5 min	**mL/L**	340	570	200	195
@ 30 min	**mL/L**	195	300	130	130

SVI	**(mL/g)**	81.9	111.1	63.4	67.0

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
OUR (mg O_2/L*hr)	14.69	13.33	9.13	11.37
MLVSS (g/L)	1.95	2.13	1.58	1.49
SOUR (mg O_2/g MLVSS*hr)	7.53	6.25	5.78	7.61

Avg. Temp. (° C)	
A (NP Raw)	12.33
B (NP PCI)	11.81
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.22

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.95	2.13	1.58	1.49
NR (mg NOx-N/L*hr)	2.63	3.36	4.07	3.09
DNR (mg NOx-N/L*hr)	2.14	3.44	0.87	1.96
SNR (mg NOx-N/g MLVSS*hr)	1.35	1.58	2.58	2.07
SDNR (mg NOx-N/g MLVSS*hr)	1.10	1.61	0.55	1.31

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.63	10.80	0.68	11.48	13.2
10		10.40	1.60	12.00	
15		9.16	1.96	11.12	
20		9.10	1.94	11.04	
90	7.92	7.98	1.94	9.92	23.7
105	7.32	8.52	1.16	9.68	
120	6.84	9.59	0.82	10.41	
135	5.94	10.00	0.72	10.72	16.6
150	5.5	11.10	0.72	11.82	
165	4.78	12.50	0.68	13.18	
180	4.09	12.40	0.68	13.08	13.7
255					10.55
330	0.084	16.40	0.05	16.45	9.2

NP PCI (B)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.3	10.60	0.70	11.30	21.3
10		9.31	1.66	10.97	
15		8.81	1.68	10.49	
20		8.71	1.68	10.39	
90	7.88	7.36	1.40	8.76	29.9
105	7.16	8.35	1.08	9.43	
120	6.28	8.66	0.92	9.58	
135	5.8	9.37	1.00	10.37	22.7
150	5.04	10.60	1.04	11.64	
165	4.25	12.00	1.16	13.16	
180	3.54	12.20	1.12	13.32	20.4
255					18.1
330	0.088	15.40	0.03	15.43	16.3

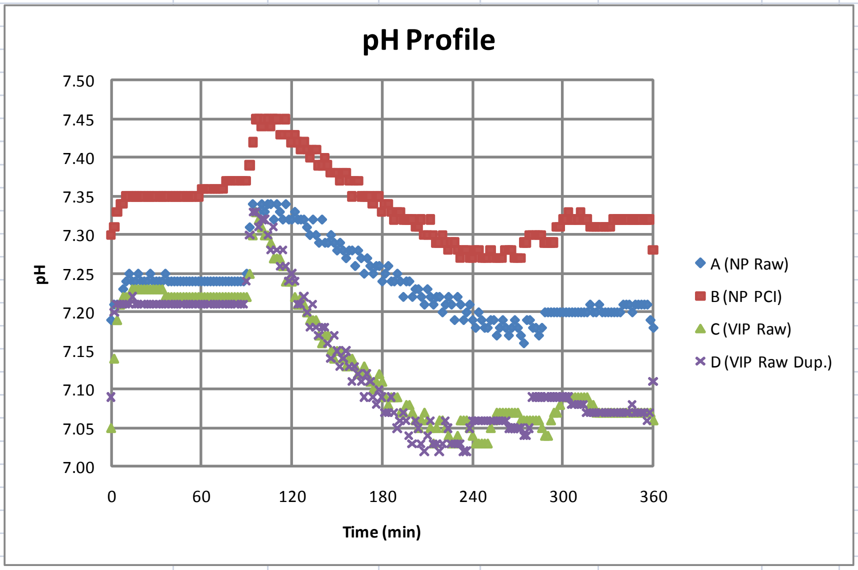
VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.9	10.40	0.20	10.60	3.7
10		8.58	0.36		
15		9.87	0.44	10.31	
20		9.85	0.54	10.39	
90	6.17	8.32	0.66	8.98	2.1
105	5.78	9.43	0.58	10.01	
120	5.01	9.92	0.74	10.66	
135	4.16	10.70	0.86	11.56	1.0
150	3.45	11.60	0.86	12.46	
165	2.79	13.60	0.86	14.46	
180	2.08	13.20	0.86	14.06	1.3
255					0.24
330	0.088	14.50	0.03	14.53	0.28

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.38	10.50	0.200	10.70	3.5
10		9.90	0.500	10.40	
15		9.51	0.600	10.11	
20		9.52	0.680	10.20	
90	5.9	8.40	0.860	9.26	4.6
105	5.53	9.72	0.680	10.40	
120	4.52	10.00	0.760	10.76	
135	3.91	10.60	0.900	11.50	0.7
150	3.2	11.30	0.900	12.20	
165	2.5	12.50	0.940	13.44	
180	1.89	13.00	0.920	13.92	0.7
255					0.22
330	0.091	14.30	0.050	14.35	0.18

8-Sep-10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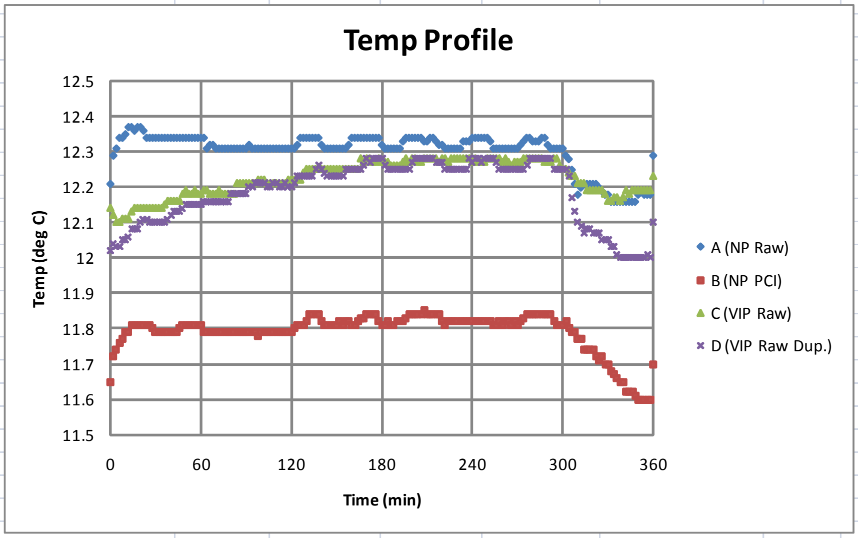
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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Time (min)
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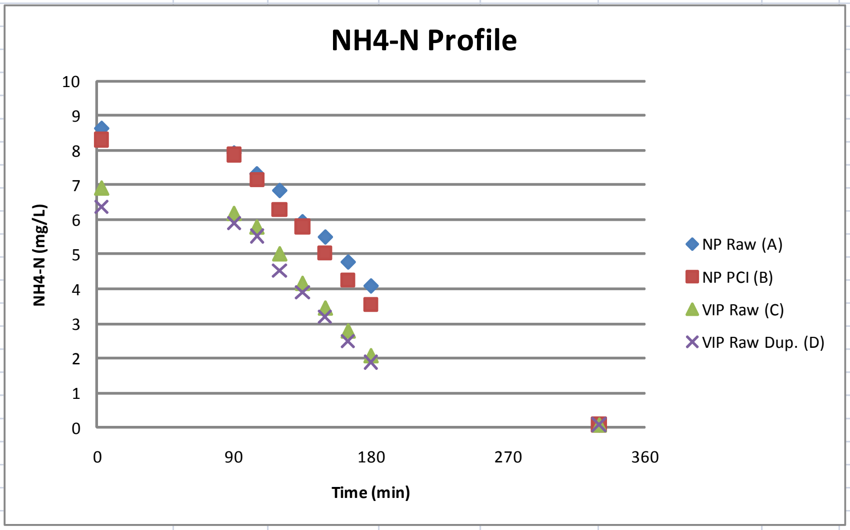
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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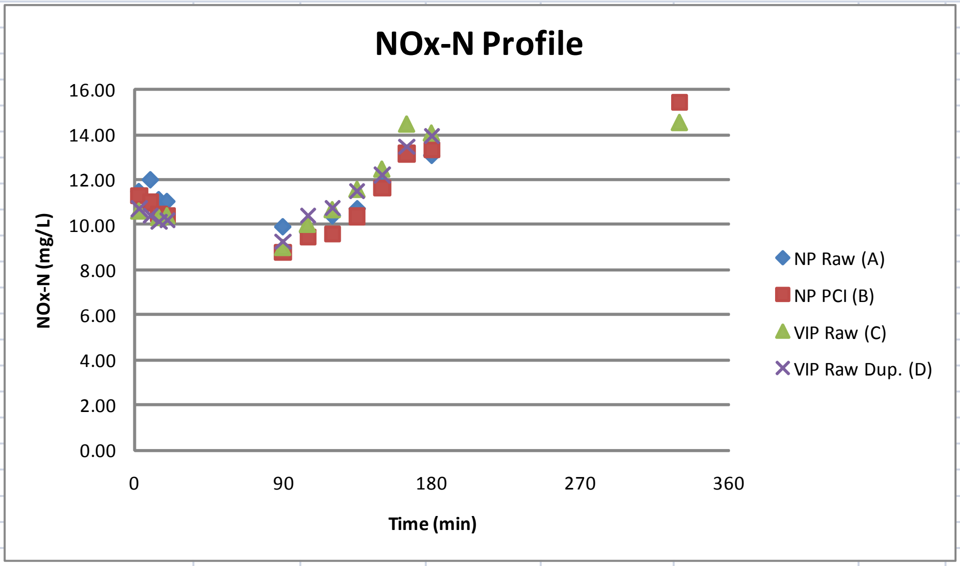
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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270
360
Time (min)
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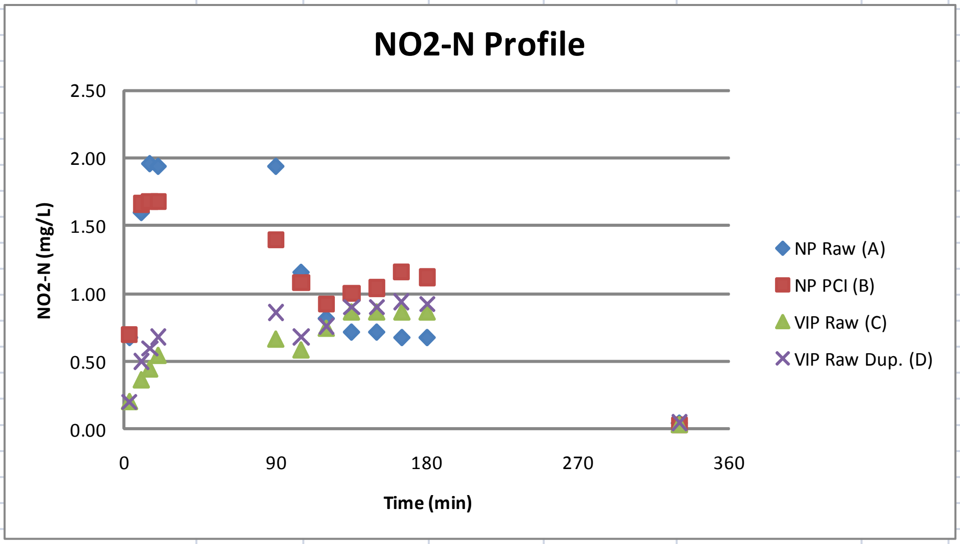
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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NO2-N (mg/L)
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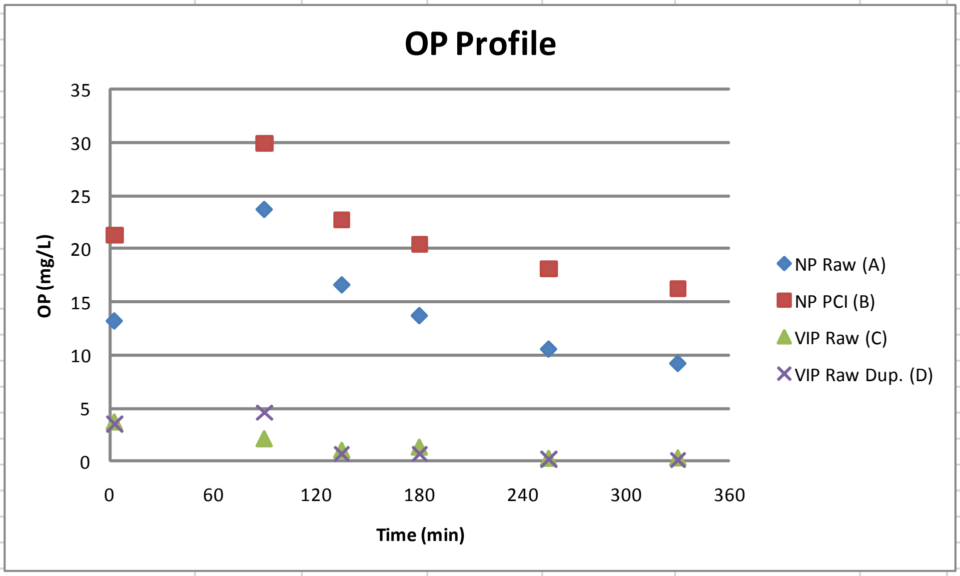
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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10
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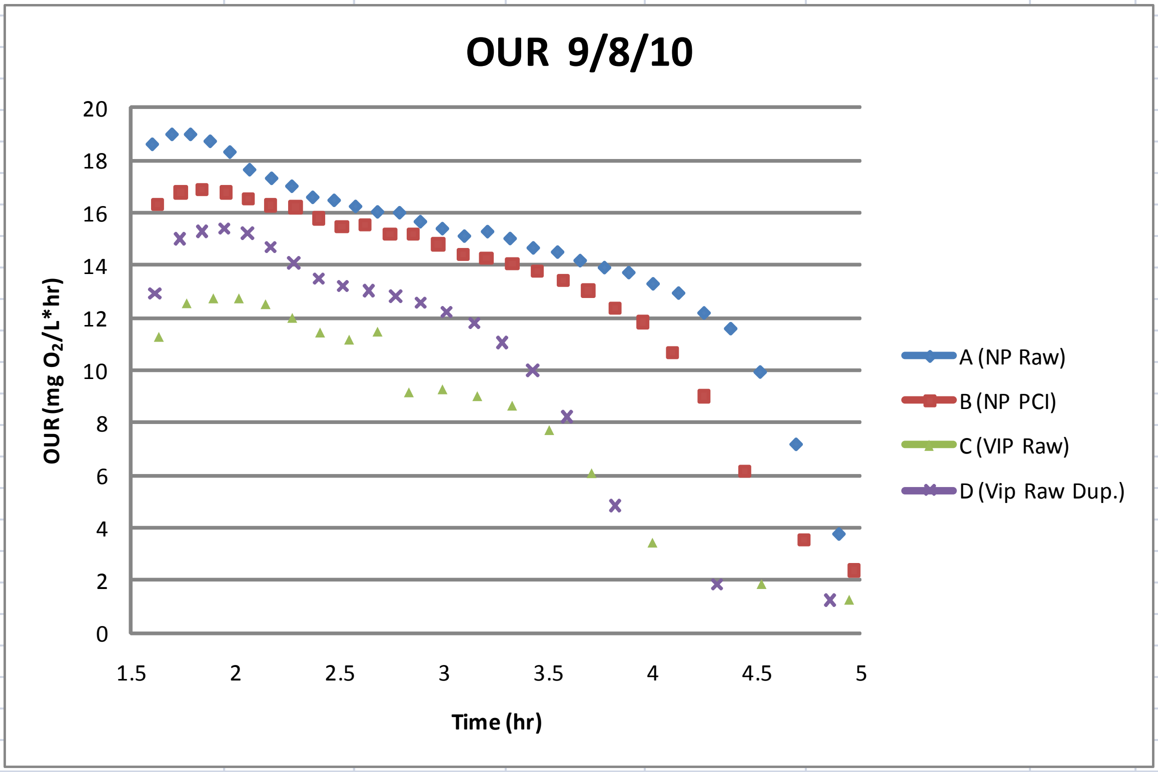
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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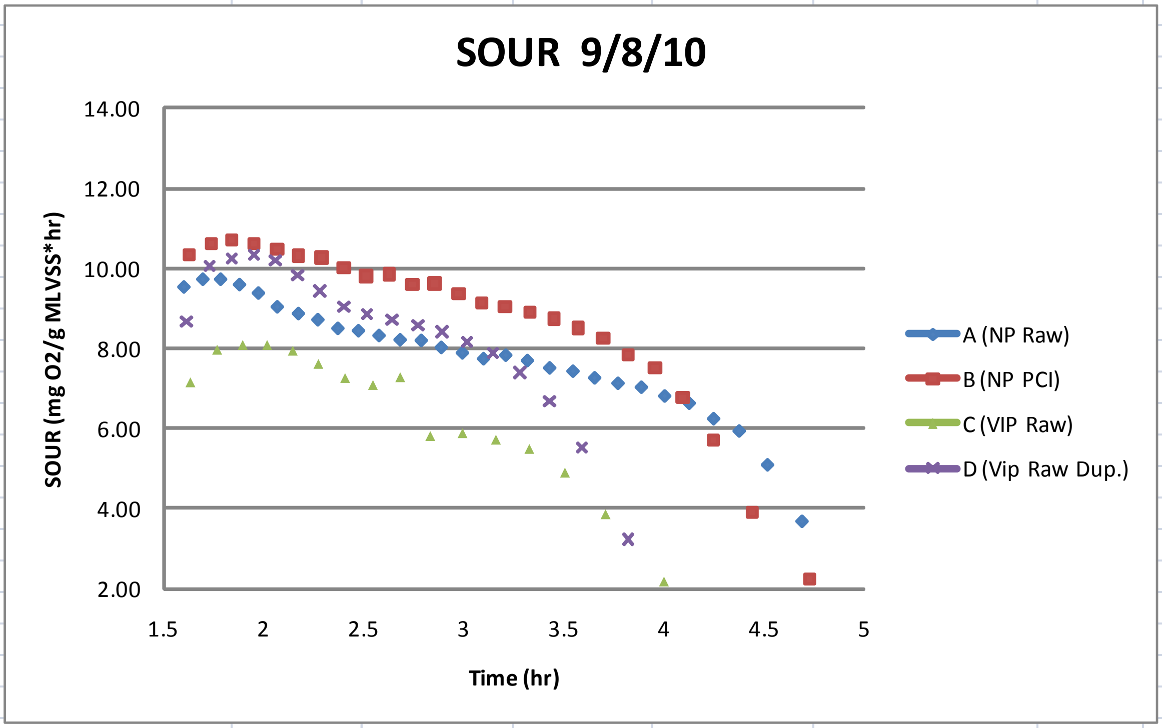
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)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3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

10-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	35.6	116	84%	97.44	536	50.7
B (NP PCI)	35	148	88%	130.24	636	50.9
C (VIP Raw)	27.75	104	82%	85.28	414	38.7
D (Vip Raw Dup.)	27.9	110	83%	91.3	476	40.4

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.89	6.64	2.48
B (NP PCI)	7.64	6.89	1.24
C (VIP Raw)	6.57	6.35	2.60
D (Vip Raw Dup.)	6.04	7.28	1.84

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2440	81%	1976.4
B (NP PCI)	2560	82%	2099.2
C (VIP Raw)	2040	81%	1652.4
D (Vip Raw Dup.)	1890	80%	1512

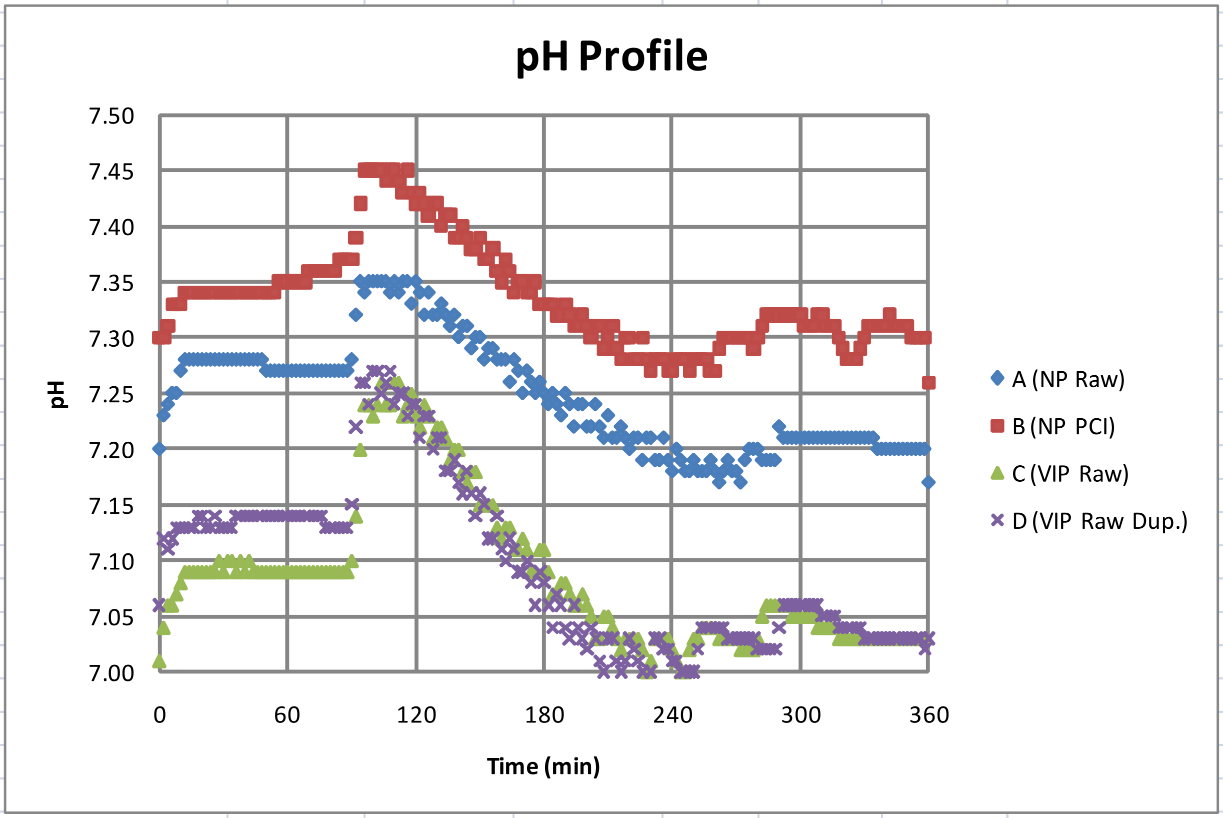
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.107	14.8	0.04	11	6.98
B (NP PCI)	0.110	14.1	0.024	11	4.89
C (VIP Raw)	0.089	13.4	0.02	17	11.7
D (Vip Raw Dup.)	0.098	13.5	0.02	11	8.51

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	340	195	79.9
B (NP PCI)	570	295	115.2
C (VIP Raw)	215	135	66.2
D (Vip Raw Dup.)	220	135	71.4

	A	B	C	D
OUR (mg O_2/L*hr)	15.89	13.87	10.55	12.31
MLVSS (g/L)	1.98	2.10	1.65	1.51
SOUR (mg O_2/g MLVSS*hr)	8.04	6.61	6.38	8.14

Avg. Temp. (° C)	
A (NP Raw)	12.29
B (NP PCI)	11.75
C (VIP Raw)	12.21
D (Vip Raw Dup.)	12.13

10-Sep-10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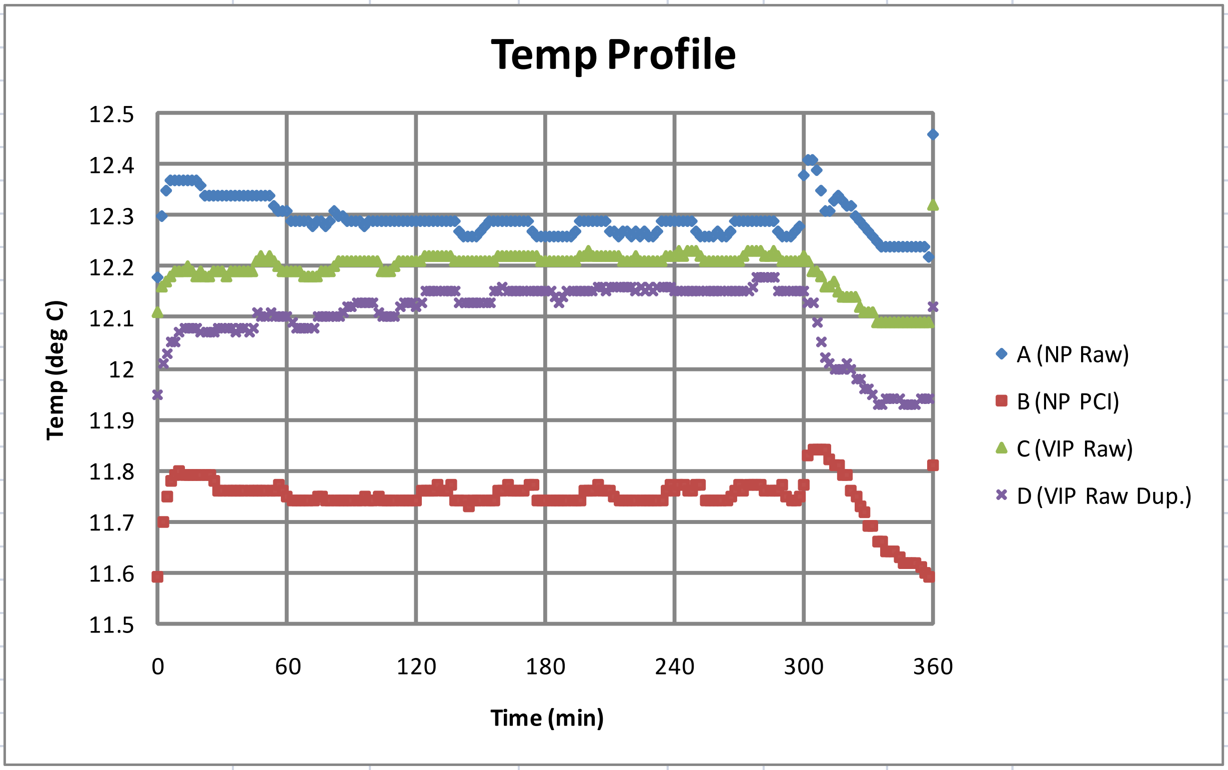
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

13-Sep-10

Feed

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH4-N	mg/L	34.1	32.7	25.9	26.35
TSS	mg/L	116	194	127	136
Voltl. Frac.		83%	87%	79%	85%
VSS	mg/L	96.28	168.78	100.33	115.6
COD	mg/L	582	646	479	445
sCOD$_{GF}$	mg/L	201	211	211	191
ffCOD	mg/L	130	145	148	147
cBOD	mg/L	127	205	139	102
cBOD$_{GF}$	mg/L	54	60	60	54
TKN	mg/L	57.1	50.1	40.9	40.4
TKN$_{MF}$	mg/L	40.6	37.6	31.1	32.1
TP	mg/L	8.84	9.29	5.19	5.28
OP	mg/L	18.9	22.1	11.1	10.0

Aerobic Start (0930)

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	8	7.44	6.37	5.88
NO3-N	mg/L	7.78	1.52	1.76	4.74
NO2-N	mg/L	1.64	1.58	3.14	1.280

Mixed Liquor

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLSS	mg/L	2400	2900	2420	2220
Voltl. Frac.		80%	79%	79%	78%
MLVSS	mg/L	1920	2291	1911.8	1731.6
TKN	mg/L	176	219	158	133
TP	mg/L	76.3	108	78.9	68.1

Effluent

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	0.097	0.115	0.099	0.111
NO3-N	mg/L	15.78	8.20	8.38	9.86
NO2-N	mg/L	0.03	0.02	0.03	0.024
TSS	mg/L	13	12	13	11
Voltl. Frac.		89%	94%	82%	78%
VSS	mg/L	11.57	11.28	10.66	8.58
COD	mg/L	71	60	78	76
sCOD$_{GF}$	mg/L	47	45	69	65
ffCOD	mg/L	39	39	58	65
cBOD	mg/L	4	6	4	5
cBOD$_{GF}$	mg/L	<2	<2	<2	<2
TKN	mg/L	3.31	3.22	2.03	1.9
TKN$_{MF}$	mg/L	1.92	1.47	0.83	1.35
TP	mg/L	3.7	2.67	0.32	0.45
OP	mg/L	10.35	7.22	0.24	0.22
Turb.	NTU	3.87	4.18	2.21	1.59

Settled Sludge Volume					
		A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
@ 5 min	**mL/L**	350	575	230	230
@ 30 min	**mL/L**	195	290	140	140

SVI	**(mL/g)**	81.3	100.0	57.9	63.1

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
OUR (mg O_2/L*hr)	15.46	14.56	11.64	12.95
MLVSS (g/L)	1.92	2.29	1.91	1.73
SOUR (mg O_2/g MLVSS*hr)	8.05	6.36	6.09	7.48

Avg. Temp. (° C)	
A (NP Raw)	12.31
B (NP PCI)	11.78
C (VIP Raw)	12.22
D (Vip Raw Dup.)	12.17

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.92	2.29	1.91	1.73
NR (mg NOx-N/L*hr)	2.54	2.79	2.47	2.34
DNR (mg NOx-N/L*hr)	2.21	3.87	2.02	2.02
SNR (mg NOx-N/g MLVSS*hr)	1.33	1.22	1.29	1.35
SDNR (mg NOx-N/g MLVSS*hr)	1.15	1.69	1.06	1.17

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.37	11.00	0.68	11.68	16.7
10		10.16	1.56	11.72	
15		9.40	1.86	11.26	
20		8.84	2.28	11.12	
90	8	7.78	1.64	9.42	26.9
105	7.3	8.42	0.96	9.38	
120	6.18	8.70	0.70	9.40	
135	5.65	9.86	0.70	10.56	18.35
150	4.83	9.98	0.66	10.64	
165	4.13	11.26	0.68	11.94	
180	3.5	11.64	0.69	12.33	15.9
255					11
330	0.097	15.78	0.03	15.81	10.35

NP PCI (B)

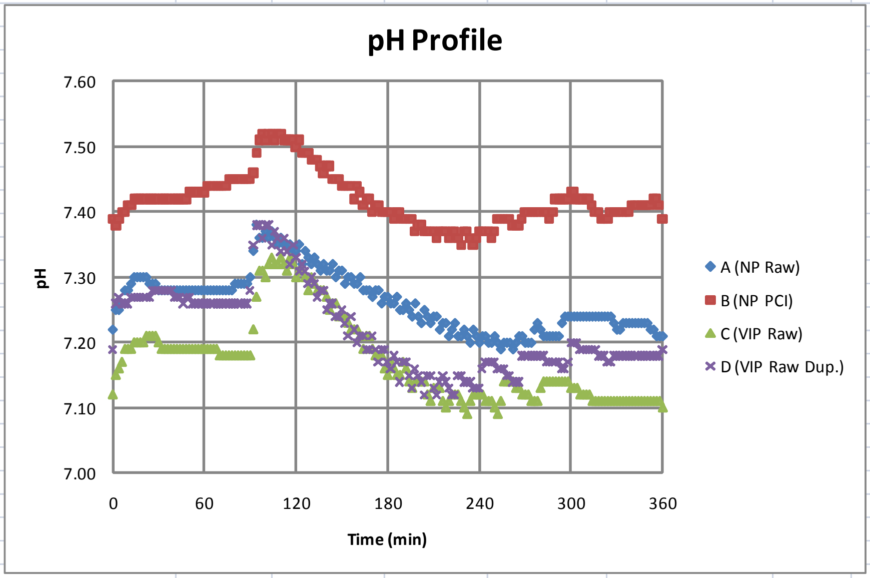
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.72	5.24	0.94	6.18	15.0
10		4.10	1.94	6.04	
15		3.44	2.34	5.78	
20		3.14	1.88	5.02	
90	7.44	1.52	1.58	3.10	29.2
105	6.52	2.32	0.82	3.14	
120	5.54	2.86	0.64	3.50	
135	4.89	3.60	0.68	4.28	17.1
150	4.01	4.22	0.70	4.92	
165	3.45	5.16	0.76	5.92	
180	2.52	5.82	0.74	6.56	12.6
255					7.95
330	0.115	8.20	0.02	8.22	7.22

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.56	5.06	1.24	6.30	5.2
10		4.24	2.00	6.24	
15		3.54	2.28	5.82	
20		3.46	2.34	5.80	
90	6.37	1.76	3.14	4.90	17.7
105	5.53	2.50	1.38	3.88	
120	4.82	3.60	0.86	4.46	
135	4.08	4.32	0.76	5.08	2.6
150	2.93	4.98	0.78	5.76	
165	2.36	5.52	0.80	6.32	
180	1.96	6.32	0.65	6.97	0.16
255					0.15
330	0.099	8.38	0.03	8.41	0.24

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.37	7.10	0.280	7.38	4.9
10		6.62	0.680	7.30	
15		6.26	0.840	7.10	
20		5.90	0.900	6.80	
90	5.88	4.74	1.280	6.02	9.9
105	4.98	5.20	0.760	5.96	
120	4.38	5.90	0.740	6.64	
135	3.55	6.38	0.760	7.14	0.35
150	3.3	7.08	0.700	7.78	
165	2.61	7.66	0.660	8.32	
180	1.67	8.42	0.780	9.20	0.14
255					0.13
330	0.111	9.86	0.024	9.88	0.22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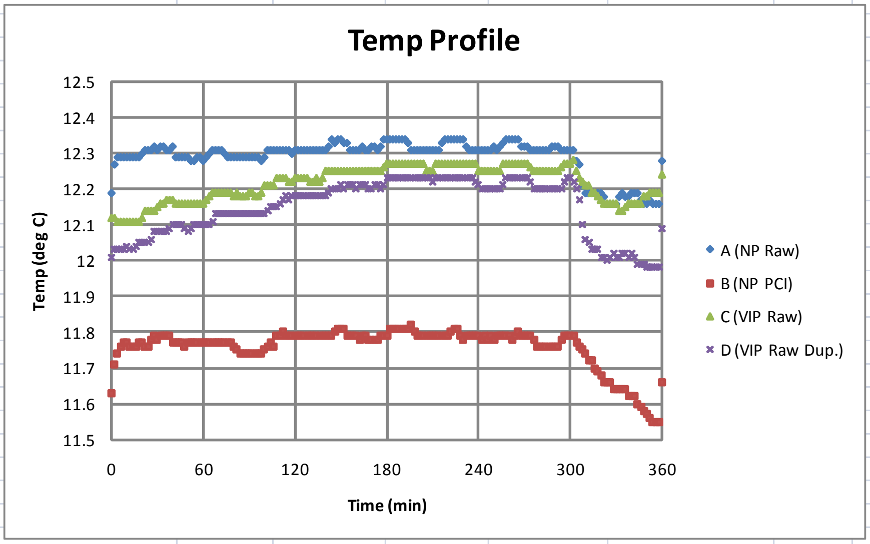
7.50
7.40
7.30
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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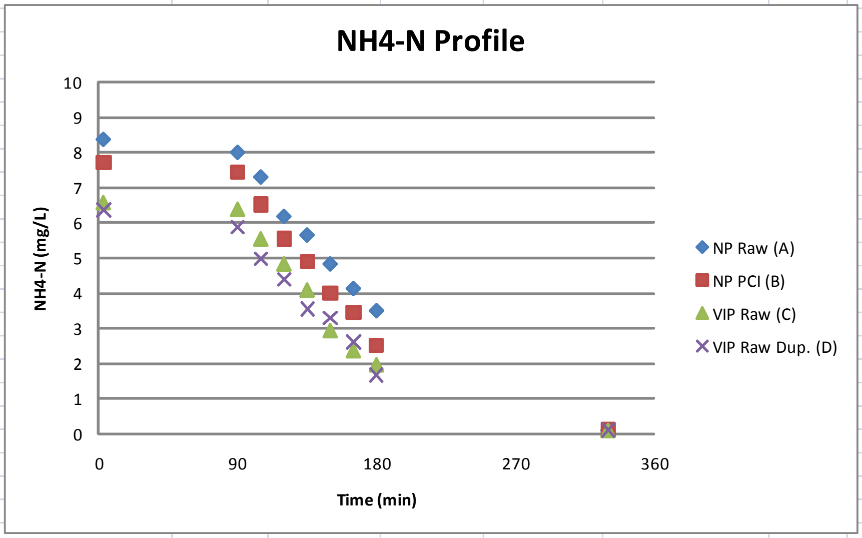
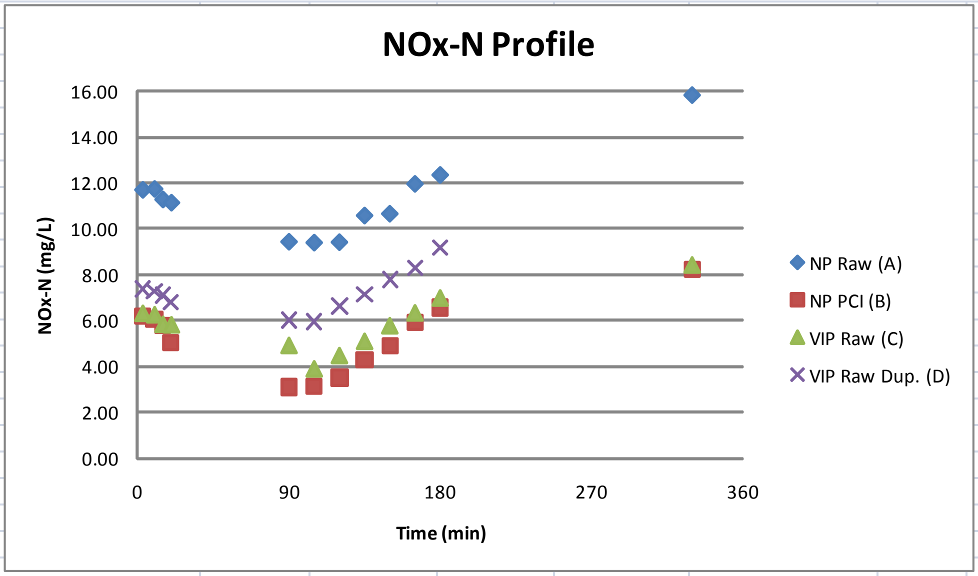
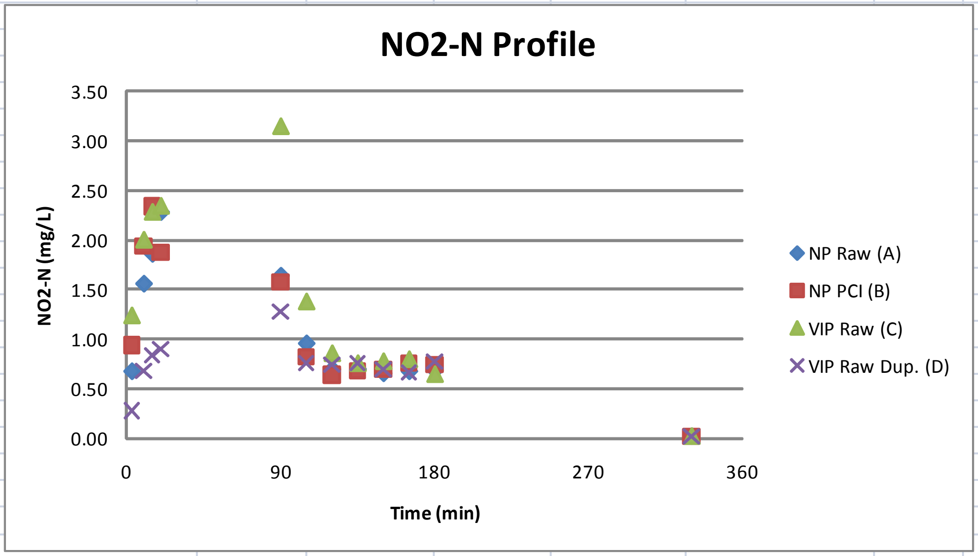
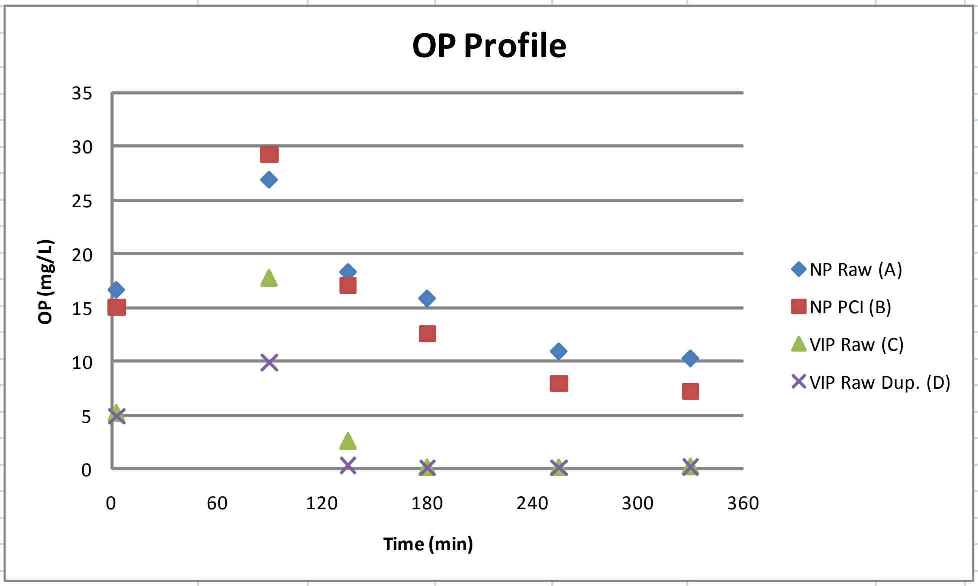
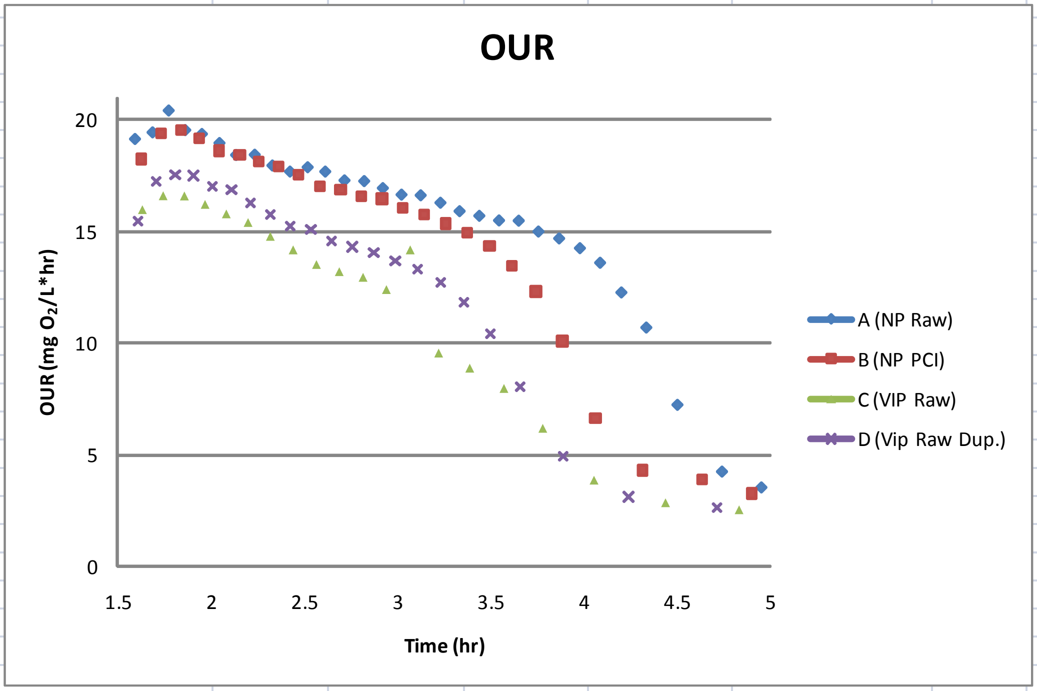
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

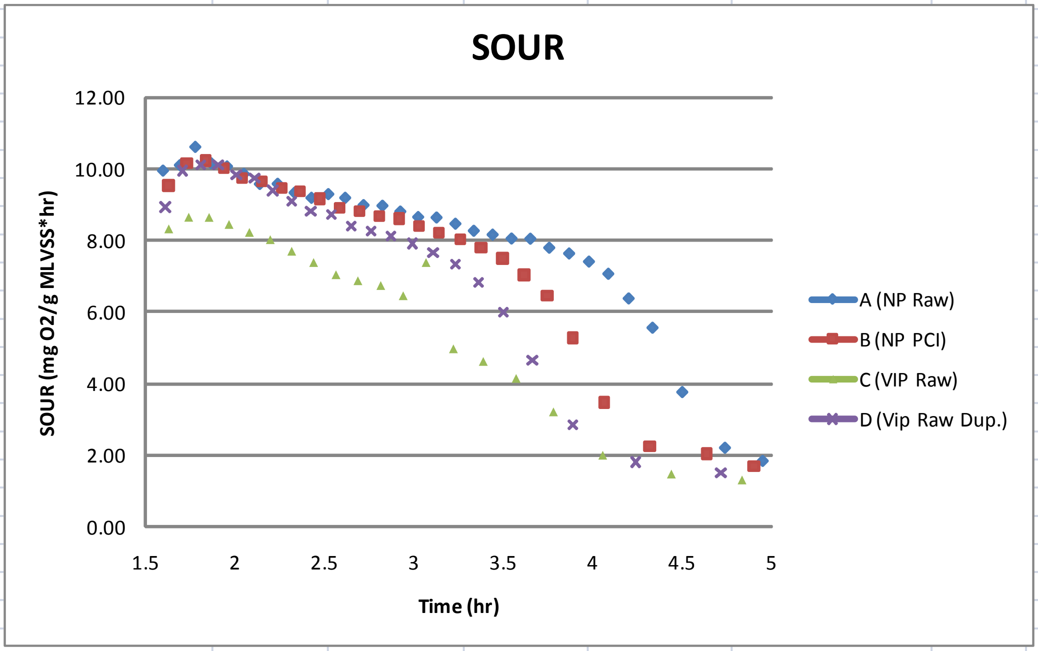

NH4-N Profile
10
9
8
7
6
5
4
3
2
1
0
NH4-N (mg/L)
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCl (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OP Profile
OP (mg/L)
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR
OUR (mg O₂/L*hr)
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

15-Sep-10

Feed

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH4-N	mg/L	34	28.15	24.55	24.1
TSS	mg/L	130	194	124	111
Voltl. Frac.		82%	88%	84%	82%
VSS	mg/L	106.6	170.72	104.16	91.02
COD	mg/L	620	836	593	511
sCOD$_{GF}$	mg/L	216	194	192	196
ffCOD	mg/L	141	128	138	143
cBOD	mg/L	136	142	128	109
cBOD$_{GF}$	mg/L	61	48	63	52
TKN	mg/L	53.6	48.9	38.4	38.4
TKN$_{MF}$	mg/L	42.1	36.3	30.5	30.3
TP	mg/L	8.04	8.14	4.92	5.03
OP	mg/L	19.7	17.2	10.0	10.1

Aerobic Start (0930)

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	8.03	6.59	6.34	5.93
NO3-N	mg/L	6.68	0.40	2.34	3.88
NO2-N	mg/L	1.70	0.72	3.46	2.140

Mixed Liquor

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
MLSS	mg/L	2440	2860	2440	2140
Voltl. Frac.		81%	80%	77%	78%
MLVSS	mg/L	1976.4	2288	1878.8	1669.2
TKN	mg/L	174	203	155	137
TP	mg/L	73.7	96.7	79.8	70.5

Effluent

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	0.095	0.089	0.11	0.101
NO3-N	mg/L	15.00	6.30	9.16	9.82
NO2-N	mg/L	0.03	0.04	0.03	0.052
TSS	mg/L	15	18	13	11
Voltl. Frac.		88%	90%	80%	77%
VSS	mg/L	13.2	16.2	10.4	8.47
COD	mg/L	86	90	84	166
sCOD$_{GF}$	mg/L	52	51	63	65
ffCOD	mg/L	44	39	51	58
cBOD	mg/L	6	8	4	3
cBOD$_{GF}$	mg/L	<2	<2	<2	<2
TKN	mg/L	3.54	3.37	2.03	1.96
TKN$_{MF}$	mg/L	1.92	1.64	1.29	0.96
TP	mg/L	3.74	3.02	0.28	0.34
OP	mg/L	10.6	8.3	0.23	0.25
Turb.	NTU	3.75	11.2	1.86	1.58

Settled Sludge Volume					
		A (NP Raw)	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
@ 5 min	**mL/L**	345	535	245	235
@ 30 min	**mL/L**	190	290	150	145

SVI	**(mL/g)**	77.9	101.4	61.5	67.8

	A (NP Raw)	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
OUR (mg O_2/L*hr)	16.40	14.44	11.75	12.92
MLVSS (g/L)	1.98	2.29	1.88	1.67
SOUR (mg O_2/g MLVSS*hr)	8.30	6.31	6.26	7.74

Avg. Temp. (° C)	
A (NP Raw)	12.39
B (NP PCl)	11.90
C (VIP Raw)	12.30
D (Vip Raw Dup.)	12.27

	A (NP Raw)	**B (NP PCl)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
MLVSS Conc. (g/L MLVSS):	1.98	2.29	1.88	1.67
NR (mg NOx-N/L*hr)	2.55	2.75	1.70	1.61
DNR (mg NOx-N/L*hr)	2.93	1.45	2.52	3.45
SNR (mg NOx-N/g MLVSS*hr)	1.29	1.20	0.91	0.96
SDNR (mg NOx-N/g MLVSS*hr)	1.48	0.63	1.34	2.07

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.5	10.14	0.80	10.94	11.6
10		8.84	1.68	10.52	
15		8.22	2.00	10.22	
20		8.00	2.14	10.14	
90	8.03	6.68	1.70	8.38	25.1
105	7.34	7.62	0.98	8.60	
120	6.42	8.20	0.76	8.96	
135	5.63	8.54	0.72	9.26	18.15
150	4.82	9.52	0.74	10.26	
165	4.29	10.42	0.72	11.14	
180	3.3	10.16	0.63	10.79	13.95
255			0.00		11.15
330	0.095	15.00	0.03	15.03	10.6

NP PCI (B)

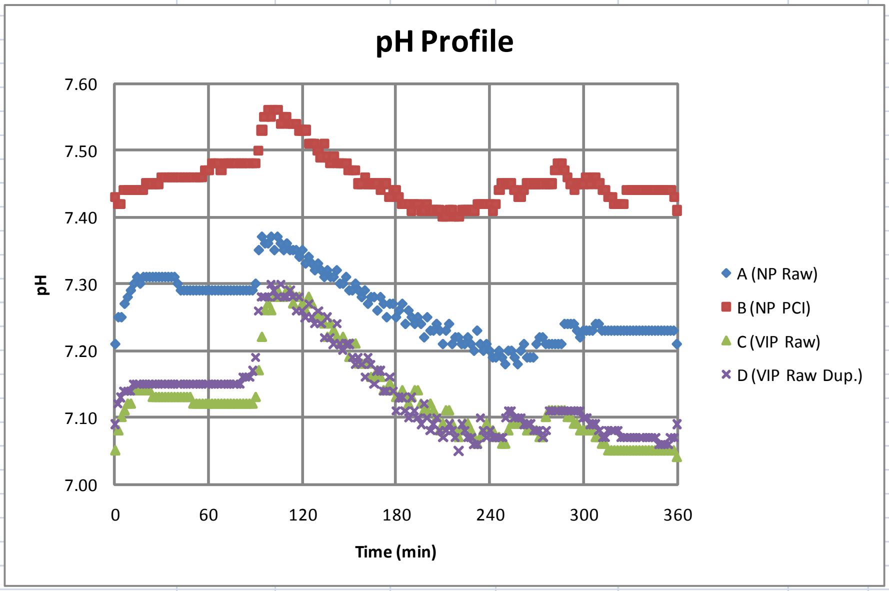
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.29	3.34	0.54	3.88	1.1
10		2.18	1.44	3.62	
15		2.12	1.56	3.68	
20		1.93	1.48	3.41	
90	6.59	0.40	0.72	1.12	20.1
105	5.74	1.11	0.44	1.55	
120	4.91	1.63	0.50	2.13	
135	3.98	2.18	0.56	2.74	12.4
150	3.48	3.06	0.64	3.70	
165	2.55	3.56	0.64	4.20	
180	1.82	4.18	0.61	4.79	9.75
255			0.00		8.45
330	0.089	6.30	0.04	6.34	8.3

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.76	4.82	1.56	6.38	3.3
10		4.40	2.46	6.86	
15		3.98	2.50	6.48	
20		3.80	2.64	6.44	
90	6.34	2.34	3.46	5.80	10.8
105	5.9	3.38	1.72	5.10	
120	5.17	4.24	1.00	5.24	
135	3.94	4.60	0.74	5.34	1.5
150	3.61	5.70	0.72	6.42	
165	2.7	5.98	0.66	6.64	
180	2.17	6.68	0.66	7.34	0.1
255			0.00		0.16
330	0.11	9.16	0.03	9.19	0.23

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.09	6.54	1.180	7.72	3.1
10		5.72	1.720	7.44	
15		5.22	1.740	6.96	
20		4.96	1.840	6.80	
90	5.93	3.88	2.140	6.02	10.0
105	5.3	4.68	1.180	5.86	
120	4.58	5.34	0.900	6.24	
135	3.65	5.64	0.820	6.46	1.7
150	3.17	6.48	0.820	7.30	
165	2.41	6.60	0.740	7.34	
180	1.92	7.70	0.800	8.50	0.14
255			0.000		0.16
330	0.101	9.82	0.052	9.87	0.25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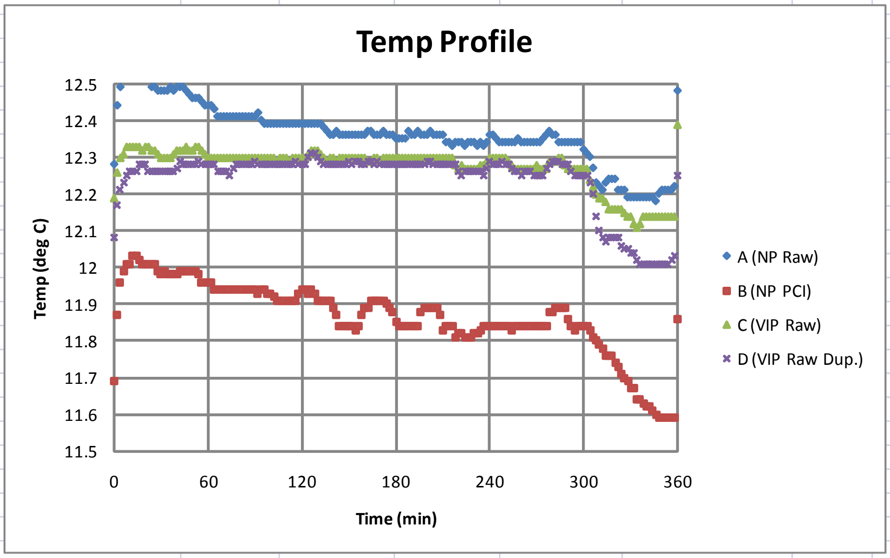
7.60
7.50
7.40
7.30
7.20
7.10
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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Temp (deg C)
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12.3
12.2
12.1
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11.5
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120
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240
300
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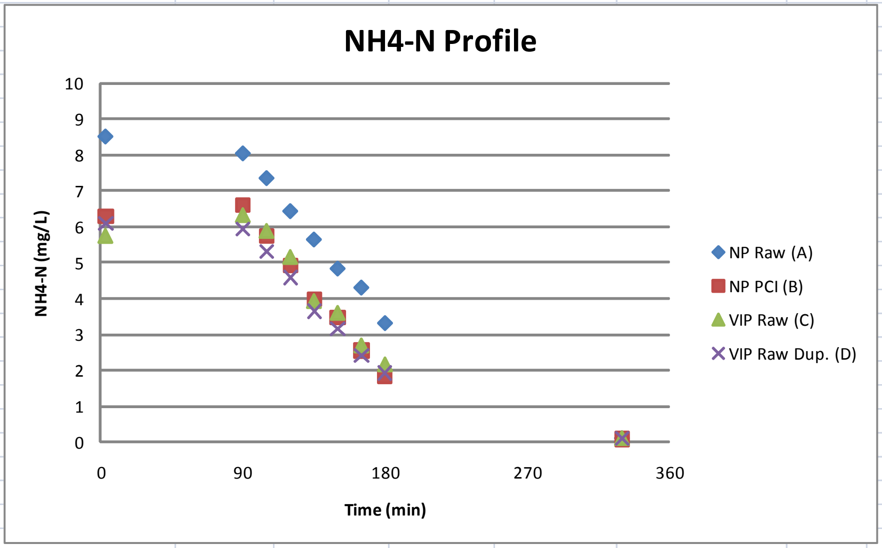
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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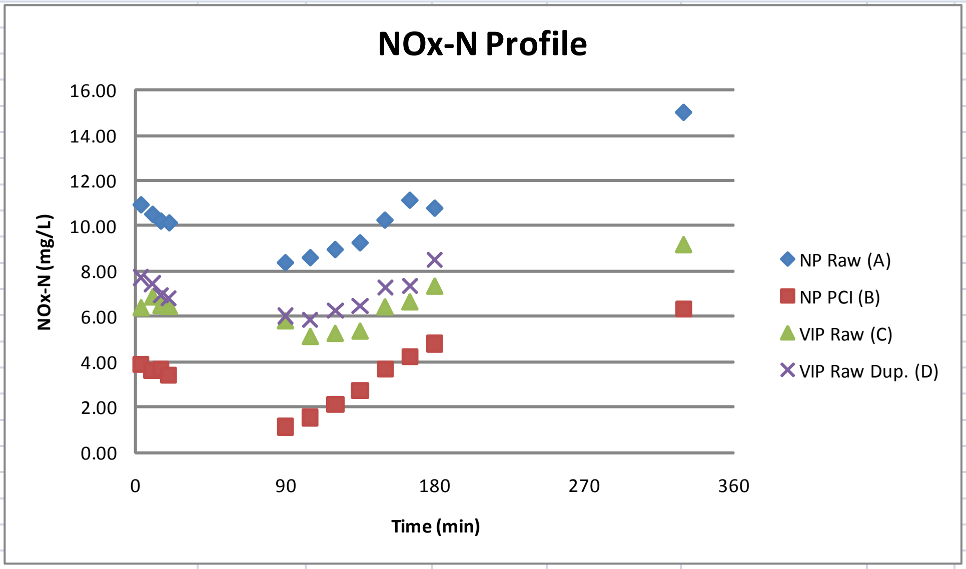
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCl (B)
VIP Raw (C)
VIP Raw Dup. (D)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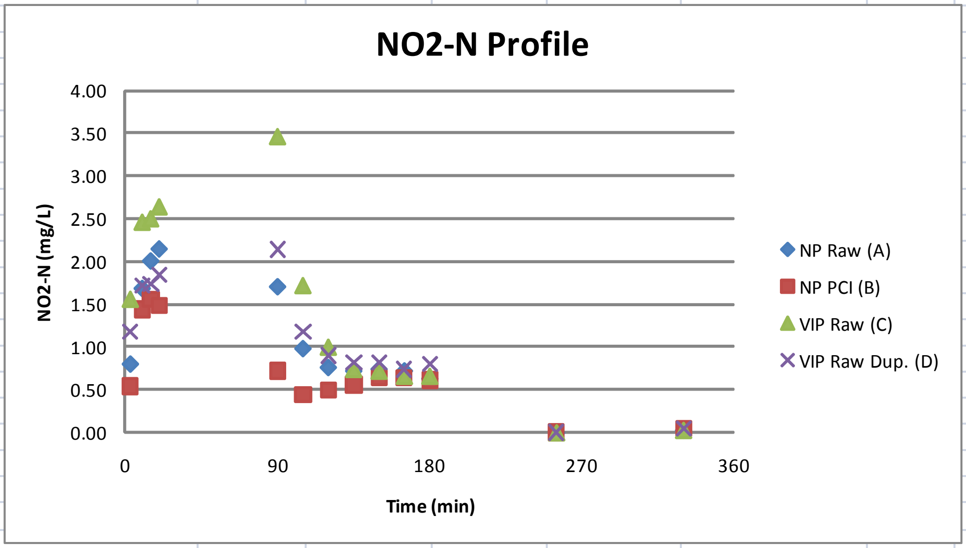
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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NO2-N (mg/L)
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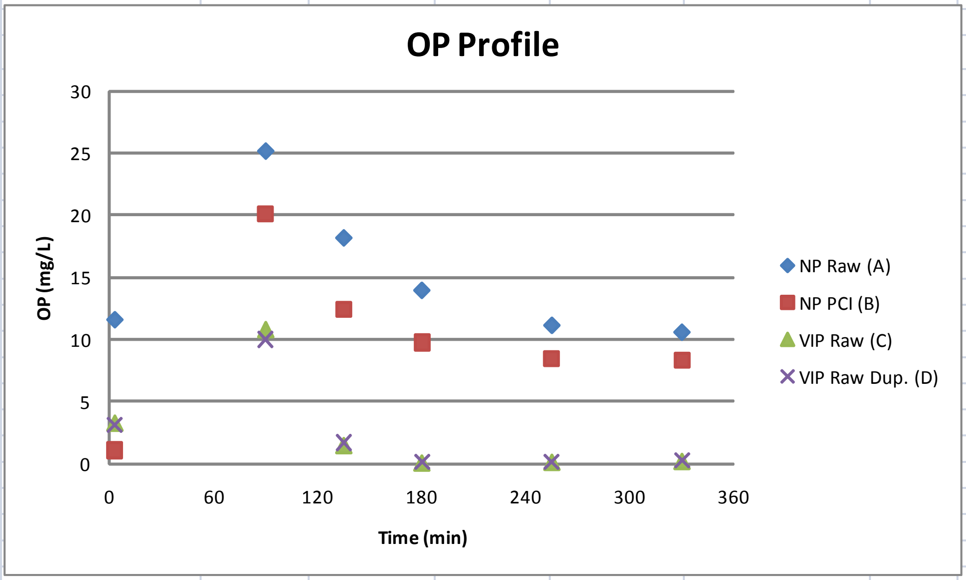
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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OP (mg/L)
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25
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5
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60
120
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300
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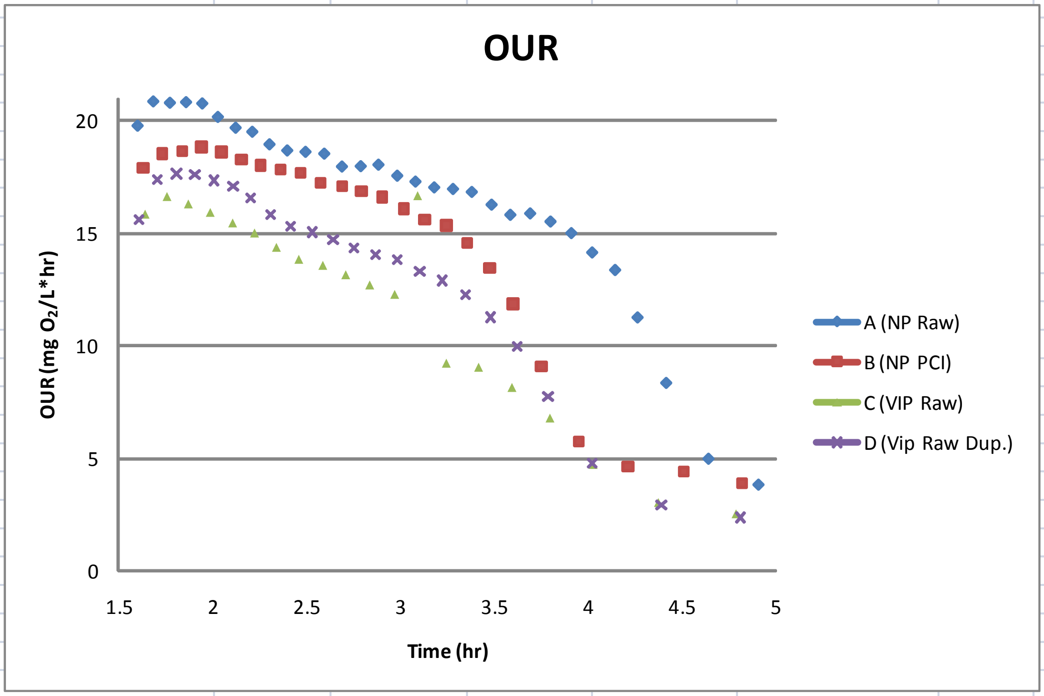
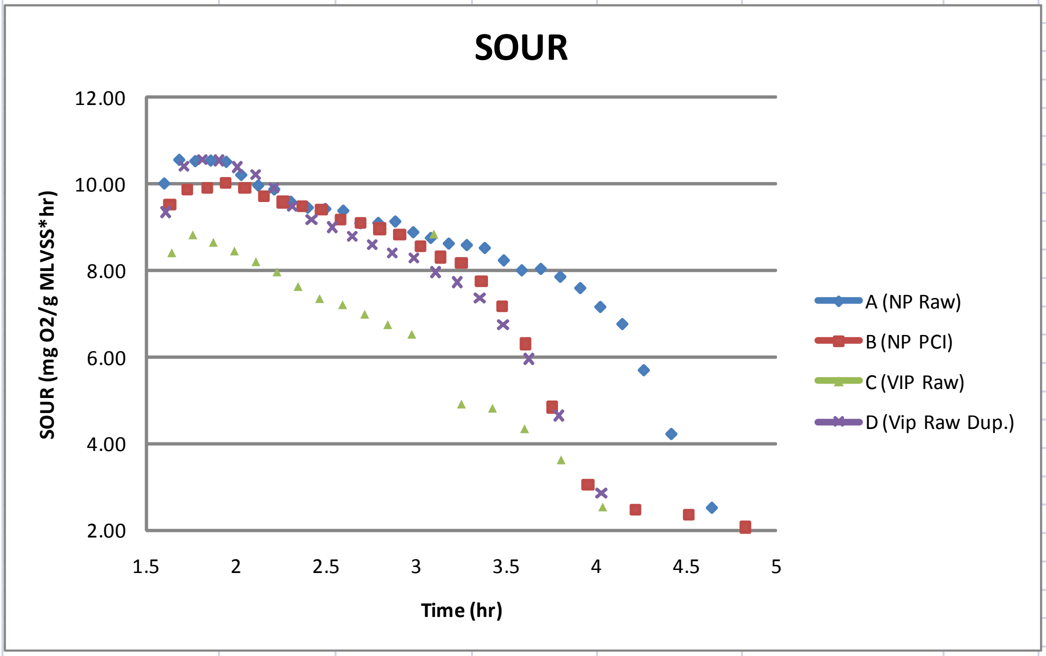
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

17-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	34.9	150	86%	129	589	52.8
B (NP PCI)	32	166	86%	142.76	446	49.9
C (VIP Raw)	28.25	143	81%	115.83	527	40.3
D (Vip Raw Dup.)	28.4	127	79%	100.33	430	39.2

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.73	5.82	1.68
B (NP PCI)	6.70	2.33	1.44
C (VIP Raw)	6.54	1.85	2.82
D (Vip Raw Dup.)	6.10	3.55	1.60

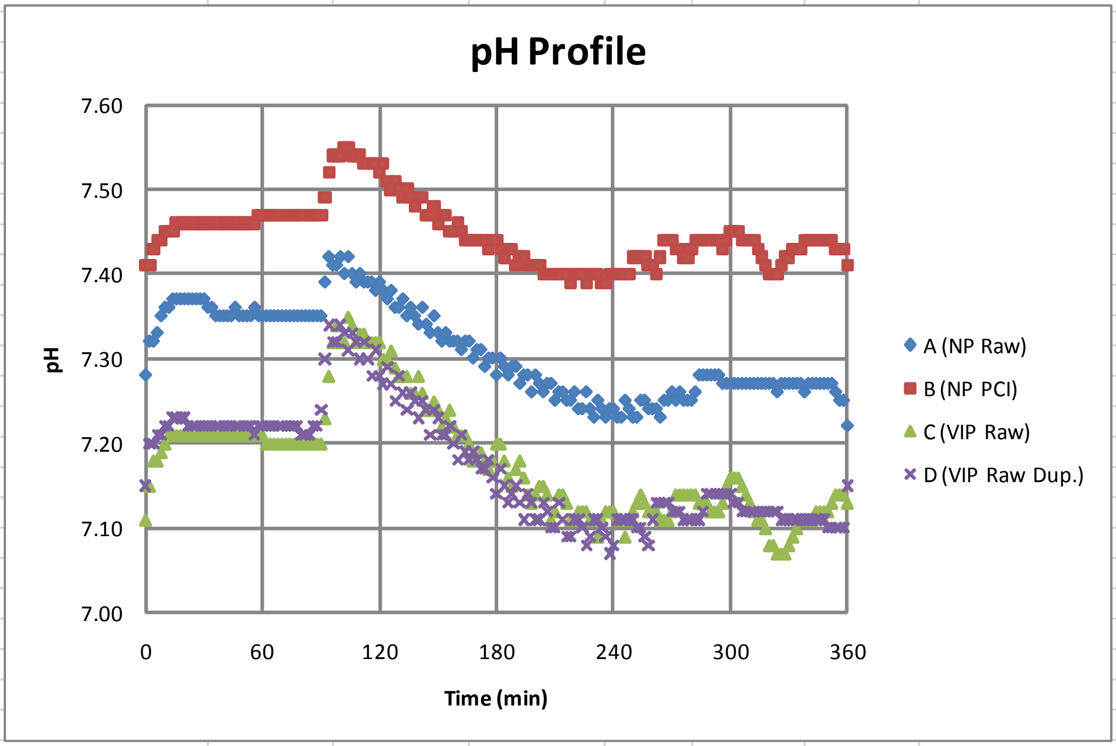
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2640	80%	2112
B (NP PCI)	3040	80%	2432
C (VIP Raw)	2520	79%	1990.8
D (Vip Raw Dup.)	2100	78%	1638

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.091	14.3	0.032	12	6.44
B (NP PCI)	0.084	9.4	0.04	19	18
C (VIP Raw)	0.079	9.2	0.024	13	3.47
D (Vip Raw Dup.)	0.085	9.9	0.024	12	3.46

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	340	195	73.9
B (NP PCI)	540	295	97.0
C (VIP Raw)	240	155	61.5
D (Vip Raw Dup.)	235	150	71.4

	A	B	C	D
OUR (mg O_2/L*hr)	16.42	14.86	11.45	13.01
MLVSS (g/L)	2.11	2.43	1.99	1.64
SOUR (mg O_2/g MLVSS*hr)	7.77	6.11	5.75	7.94

Avg. Temp. (° C)	
A (NP Raw)	12.40
B (NP PCI)	11.92
C (VIP Raw)	12.30
D (Vip Raw Dup.)	12.29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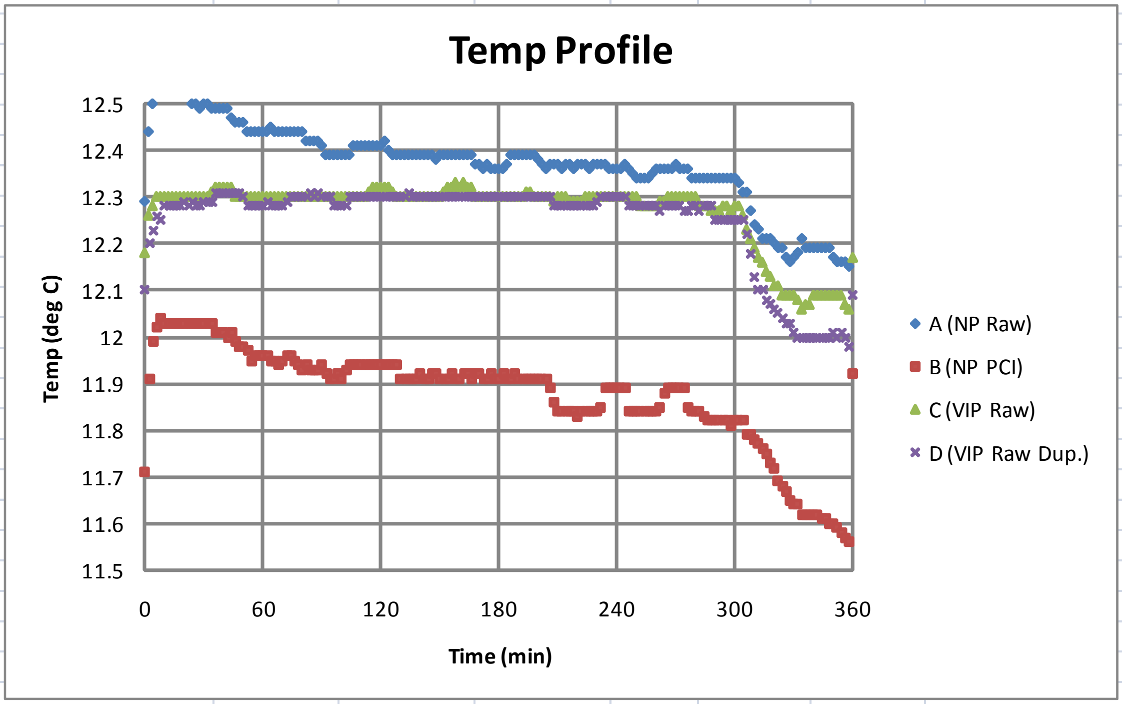
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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12
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11.8
11.7
11.6
11.5
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

20-Sep-10

Feed

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH4-N	mg/L	32.3	29.7	23.9	23.9
TSS	mg/L	118	140	86	88
Voltl. Frac.		83%	94%	88%	86%
VSS	mg/L	97.94	131.6	75.68	75.68
COD	mg/L	558	620	315	323
sCOD$_{GF}$	mg/L	235	181	174	168
ffCOD	mg/L	162	124	125	121
cBOD	mg/L	155	145	98	96
cBOD$_{GF}$	mg/L	72	41	38	39
TKN	mg/L	51.7	54.8	41.8	40.5
TKN$_{MF}$	mg/L	44.9	22.6	32.6	34.3
TP	mg/L	8.7	9.43	4.86	4.95
OP	mg/L	19.4	19.7	9.7	9.7

Aerobic Start (0930)

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	7.29	6.93	5.83	5.24
NO3-N	mg/L	3.67	4.69	4.68	4.69
NO2-N	mg/L	2.08	2.02	1.44	1.000

Mixed Liquor

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
MLSS	mg/L	2500	3140	2500	2140
Voltl. Frac.		81%	82%	80%	78%
MLVSS	mg/L	2025	2574.8	2000	1669.2
TKN	mg/L	180	173	172	150
TP	mg/L	71.6	69.4	79.7	70.3

Effluent

Parameter	units	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	0.119	0.146	0.111	0.124
NO3-N	mg/L	12.94	12.18	11.64	11.10
NO2-N	mg/L	0.04	0.03	0.04	0.032
TSS	mg/L	17	15	14	13
Voltl. Frac.		92%	91%	79%	73%
VSS	mg/L	15.64	13.65	11.06	9.49
COD	mg/L	80	64	68	60
sCOD$_{GF}$	mg/L	58	51	48	48
ffCOD	mg/L	38	40	43	38
cBOD	mg/L	8	9	5	4
cBOD$_{GF}$	mg/L	<2	<2	<2	<2
TKN	mg/L	4	3.44	2.21	2.18
TKN$_{MF}$	mg/L	2.53	2.02	1.15	1.43
TP	mg/L	4.91	5.5	0.41	0.5
OP	mg/L	13	13.4	0.15	0.12
Turb.	NTU	9.47	7.33	3.72	2.67

Settled Sludge Volume					
		A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
@ 5 min	**mL/L**	355	530	255	245
@ 30 min	**mL/L**	200	300	160	150

SVI	**(mL/g)**	80.0	95.5	64.0	70.1

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
OUR (mg O_2/L*hr)	16.24	15.53	10.70	11.84
MLVSS (g/L)	2.03	2.57	2.00	1.67
SOUR (mg O_2/g MLVSS*hr)	8.02	6.03	5.35	7.10

Avg. Temp. (° C)	
A (NP Raw)	12.28
B (NP PCI)	11.79
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.20

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.03	2.57	2.00	1.67
NR (mg NOx-N/L*hr)	2.50	2.39	2.06	1.96
DNR (mg NOx-N/L*hr)	5.58	4.63	3.24	3.58
SNR (mg NOx-N/g MLVSS*hr)	1.23	0.93	1.03	1.17
SDNR (mg NOx-N/g MLVSS*hr)	2.76	1.80	1.62	2.15

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.45	7.92	1.08	9.00	17.65
10		6.56	1.84	8.40	
15		5.80	2.14	7.94	
20		5.27	2.14	7.41	
90	7.29	3.67	2.08	5.75	29.1
105	7.02	4.90	1.18	6.08	
120	6.6	5.85	0.84	6.69	
135	5.68	6.17	0.74	6.91	23.2
150	4.99	6.89	0.68	7.57	
165	4.26	8.09	0.67	8.76	
180	3.35	8.24	0.63	8.87	18.8
255					13.75
330	0.119	12.94	0.04	12.98	13

NP PCI (B)

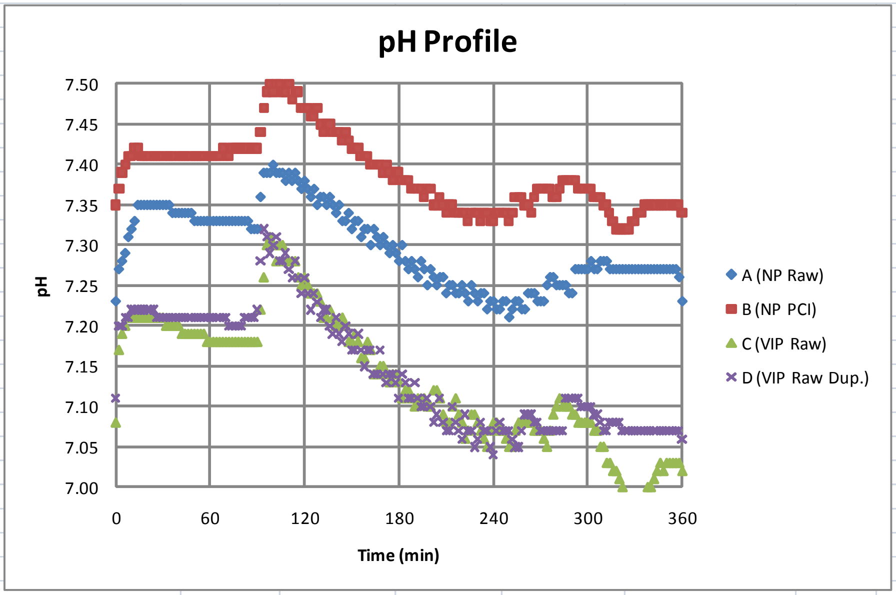
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.76	8.43	0.74	9.17	18.3
10		7.19	1.68	8.87	
15		6.47	1.82	8.29	
20		6.04	1.86	7.90	
90	6.93	4.69	2.02	6.71	24.1
105	6.5	5.70	1.40	7.10	
120	5.89	6.53	1.14	7.67	
135	5.07	7.32	1.06	8.38	19.55
150	4.27	8.07	0.99	9.06	
165	3.52	8.82	0.98	9.80	
180	2.6	9.13	0.95	10.08	16.55
255					15.3
330	0.146	12.18	0.03	12.21	13.4

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.69	7.22	0.76	7.98	3.6
10		6.61	1.10	7.71	
15		5.94	1.06	7.00	
20		5.97	1.20	7.17	
90	5.83	4.68	1.44	6.12	6.2
105	5.87	5.74	0.88	6.62	
120	4.99	6.23	0.72	6.95	
135	4.25	6.72	0.74	7.46	1.2
150	3.3	7.33	0.74	8.07	
165	3	7.90	0.73	8.63	
180	2.3	8.40	0.72	9.12	0.22
255					0.13
330	0.111	11.64	0.04	11.68	0.15

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.34	7.25	0.600	7.85	3.25
10		6.56	0.960	7.52	
15		5.86	0.920	6.78	
20		5.97	1.020	6.99	
90	5.24	4.69	1.000	5.69	6.4
105	5.01	5.47	0.700	6.17	
120	4.7	6.14	0.740	6.88	
135	3.94	6.53	0.760	7.29	2.15
150	3.65	6.33	0.720		
165	2.74	6.71	0.740		
180	2.11	7.94	0.750	8.69	0.9
255					0.19
330	0.124	11.10	0.032	11.13	0.12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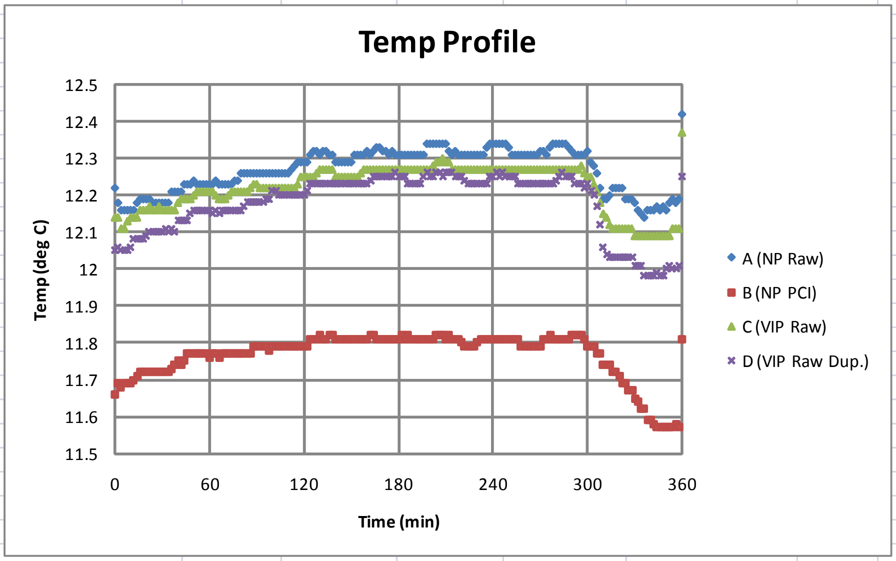
7.10
7.05
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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11.6
11.5
Temp (deg C)
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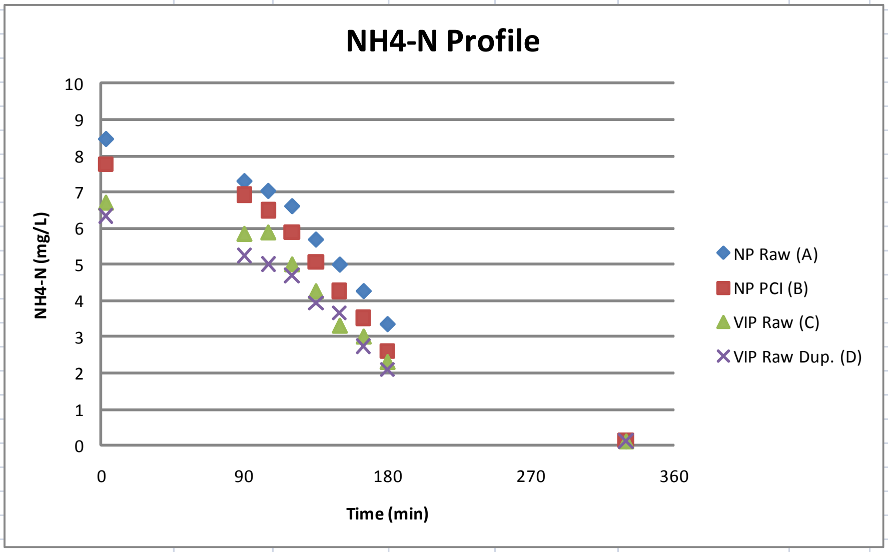
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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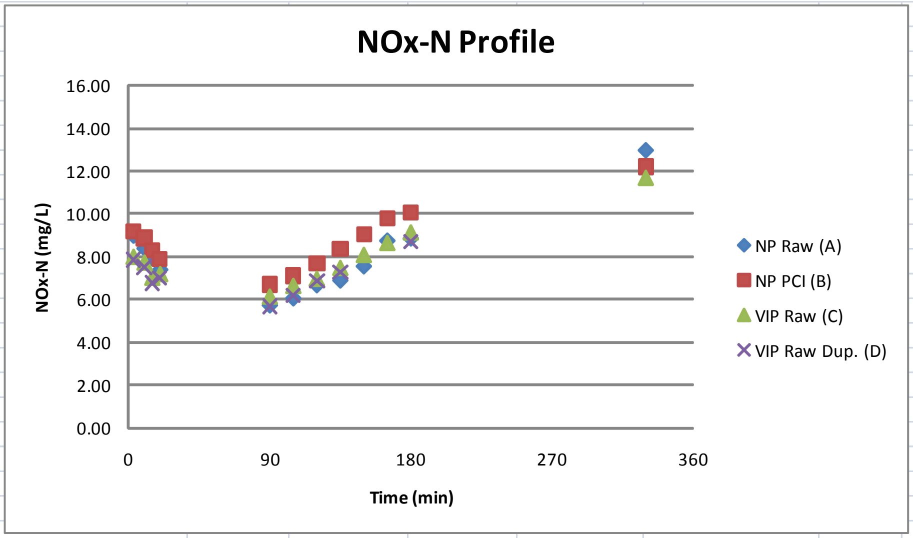
10
9
8
7
6
5
4
3
2
1
0
NH4-N (mg/L)
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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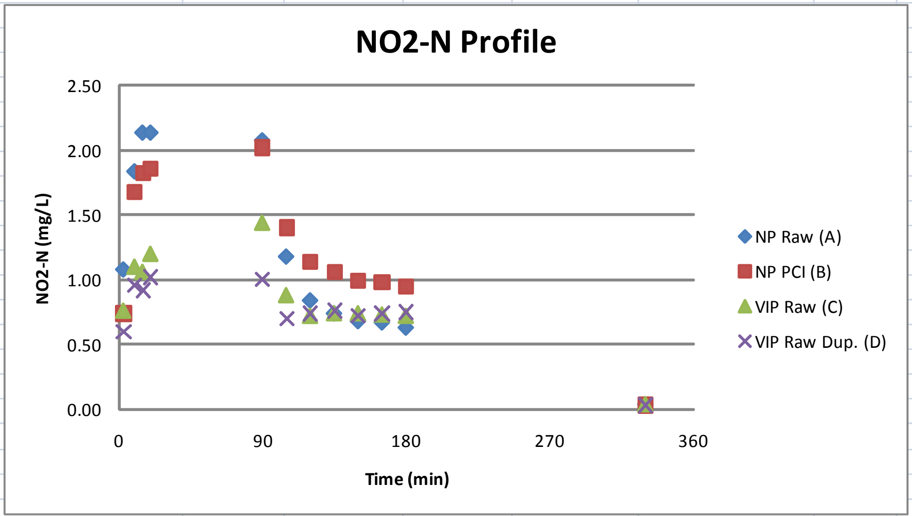
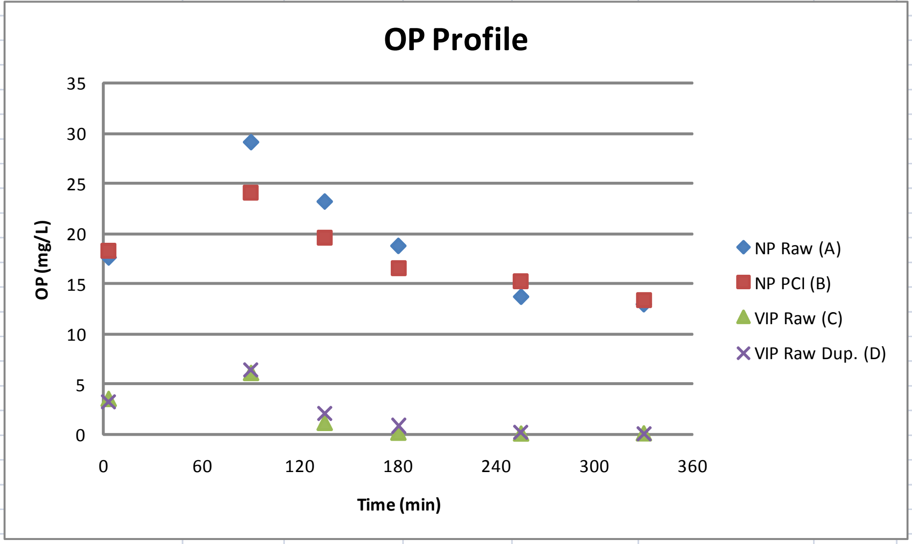
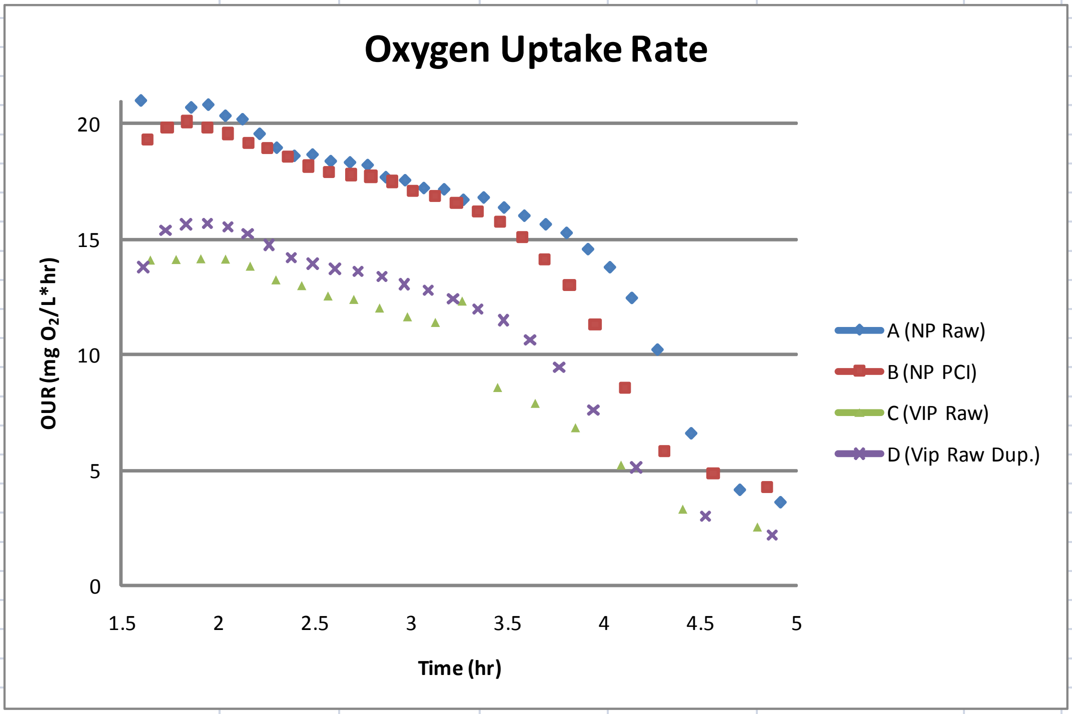
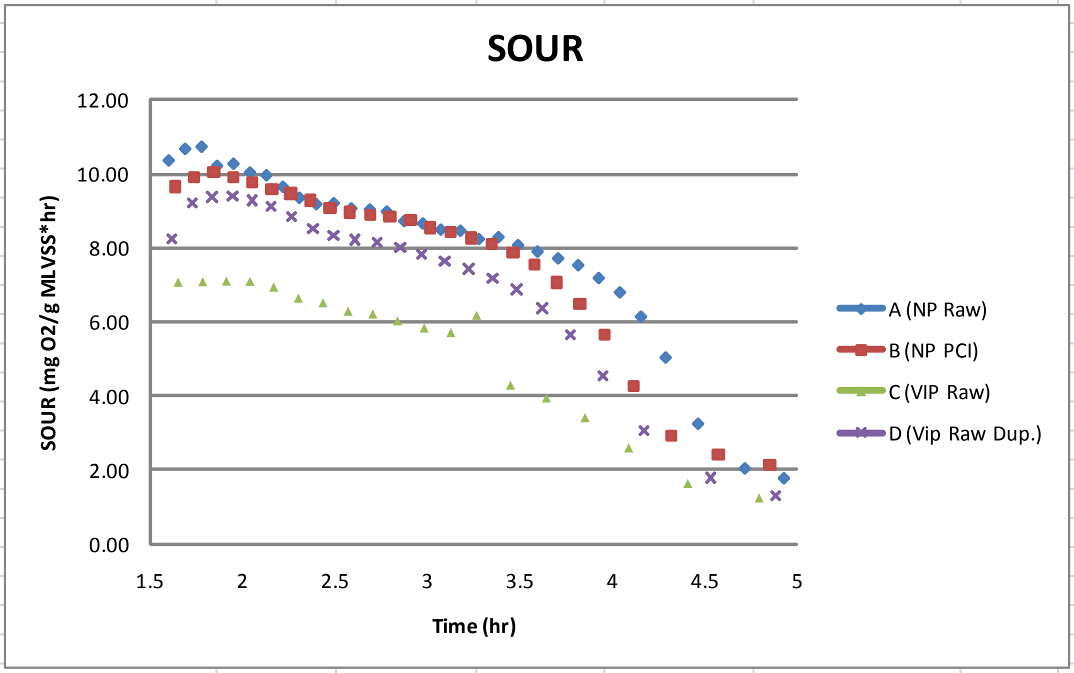

NO2-N Profile


OP Profile


Oxygen Uptake Rate
OUR (mg O_2/L*hr)
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

22-Sep-10

Feed

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH4-N	mg/L	34.4	33.45	25.55	25.55
TSS	mg/L	106	236	83	84
Voltl. Frac.		87%	88%	80%	79%
VSS	mg/L	92.22	207.68	66.4	66.36
COD	mg/L	547	478	302	365
$sCOD_{GF}$	mg/L	220	175	188	204
ffCOD	mg/L	148	106	119	134
cBOD	mg/L	178	143	101	111
$cBOD_{GF}$	mg/L	73	49	71	70
TKN	mg/L	57.1	77.2	41.3	44.2
TKN_{MF}	mg/L	41.3	39.1	34.1	37.1
TP	mg/L	10.1	13.6	4.69	4.91
OP	mg/L	18.9	20.2	10.3	10.3

Aerobic Start (0930)

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	7.72	7.35	6.68	6.58
NO3-N	mg/L	5.00	6.77	4.14	4.46
NO2-N	mg/L	2.24	1.70	2.26	1.72

Mixed Liquor

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLSS	mg/L	2340	3100	2260	2080
Voltl. Frac.		82%	83%	77%	77%
MLVSS	mg/L	1918.8	2573	1740.2	1601.6
TKN	mg/L	182	237	173	192
TP	mg/L	68.7	91.1	79.7	70.2

Effluent

Parameter	units	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
NH3-N	mg/L	0.123	0.096	0.108	0.104
NO3-N	mg/L	14.20	15.60	12.10	11.80
NO2-N	mg/L	0.04	0.03	0.04	0.03
TSS	mg/L	17	12	15	11
Voltl. Frac.		90%	92%	77%	79%
VSS	mg/L	15.3	11.04	11.55	8.69
COD	mg/L	68	68	67	58
$sCOD_{GF}$	mg/L	46	50	55	48
ffCOD	mg/L	37	38	43	44
cBOD	mg/L	7	7	4	3
$cBOD_{GF}$	mg/L	<2	<2	<2	<2
TKN	mg/L	4.48	3.76	2.52	2.5
TKN_{MF}	mg/L	2.22	2.2	1.27	1.43
TP	mg/L	5.65	6.87	0.42	0.49
OP	mg/L	15.55	20.2	0.25	0.21
Turb.	NTU	9.75	9.64	2.68	2.71

Settled Sludge Volume					
		A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
@ 5 min	**mL/L**	390	600	270	285
@ 30 min	**mL/L**	210	305	165	160

SVI	**(mL/g)**	89.7	98.4	73.0	76.9

	A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
OUR (mg O_2/L*hr)	16.43	15.94	10.73	12.60
MLVSS (g/L)	1.92	2.57	1.74	1.60
SOUR (mg O_2/g MLVSS*hr)	8.56	6.20	6.17	7.87

Avg. Temp. (° C)	
A (NP Raw)	12.36
B (NP PCI)	11.90
C (VIP Raw)	12.27
D (Vip Raw Dup.)	12.25

	A (NP Raw)	**B (NP PCI)**	**C (VIP Raw)**	**D (Vip Raw Dup.)**
MLVSS Conc. (g/L MLVSS):	1.92	2.57	1.74	1.60
NR (mg NOx-N/L*hr)	1.34	1.90	1.95	2.37
DNR (mg NOx-N/L*hr)	5.57	3.21	2.34	2.69
SNR (mg NOx-N/g MLVSS*hr)	0.70	0.74	1.12	1.48
SDNR (mg NOx-N/g MLVSS*hr)	2.90	1.25	1.34	1.68

NP Raw (A)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	8.06	8.60	1.14	9.74	18.65
10		7.24	1.86	9.10	
15		6.59	2.02	8.61	
20		6.13	2.04	8.17	
90	7.72	5.00	2.24	7.24	29.3
105		5.93	1.26	7.19	
120	6.11	6.54	0.82	7.36	
135	5.34	6.64	0.74	7.38	24
150	4.49	7.70	0.70	8.40	
165		7.66	0.68	8.34	
180		8.81	0.66	9.47	18.35
255					15.3
330	0.123	14.20	0.04	14.24	15.55

NP PCI (B)

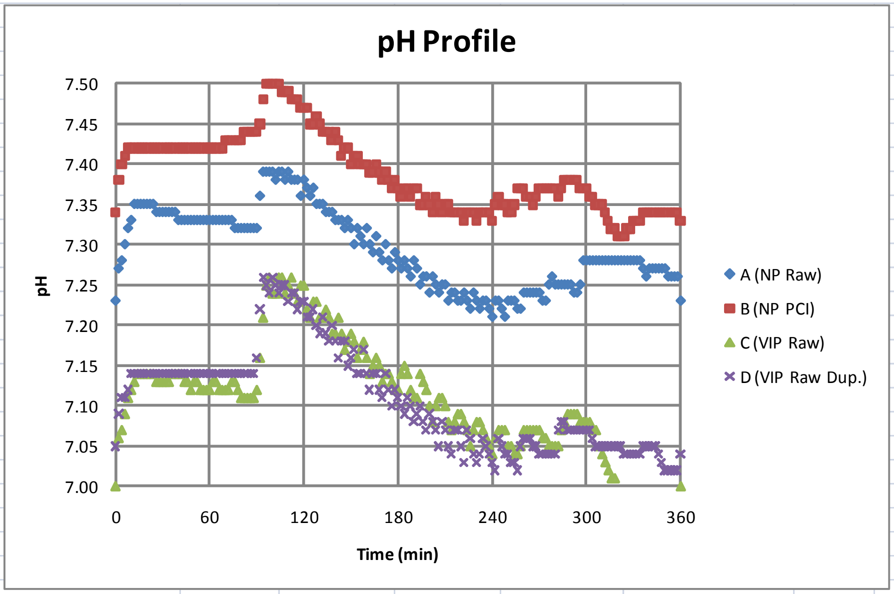
	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	7.34	9.85	0.62	10.47	22.0
10		8.84	1.42	10.26	
15		8.54	1.56	10.10	
20		7.90	1.60	9.50	
90	7.35	6.77	1.70	8.47	26.4
105		7.63	1.22	8.85	
120	5.55	7.44	0.98		
135	4.7	8.75	0.92	9.67	21.6
150	4.05	9.55	0.88	10.43	
165		9.52	0.88	10.40	
180		9.95	0.86	10.81	20.05
255					18.2
330	0.096	15.60	0.03	15.63	20.2

VIP Raw (C)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	6.93	6.92	0.94	7.86	3.75
10		6.14	1.64	7.78	
15		5.73	1.82	7.55	
20		5.37	2.02	7.39	
90	6.68	4.14	2.26	6.40	11.2
105		5.03	1.14	6.17	
120	5.35	4.87	0.98	5.85	
135	4.44	6.04	0.96	7.00	3.9
150	3.89	6.30	0.96	7.26	
165		6.96	0.94	7.90	
180		6.87	0.94	7.81	0.82
255					0.07
330	0.108	12.10	0.04	12.14	0.25

VIP Raw Dup. (D)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	6.51	7.17	0.82	7.99	3.45
10		6.24	1.38	7.62	
15		5.94	1.44	7.38	
20		5.74	1.50	7.24	
90	6.58	4.46	1.72	6.18	11.5
105		4.56	0.96	5.52	
120	4.56	4.49	0.76		
135	4.21	5.74	0.74	6.48	4.75
150	3.5	6.54	0.72	7.26	
165		7.22	0.74	7.96	
180		7.64	0.72	8.36	2.16
255					0.66
330	0.104	11.80	0.03	11.83	0.21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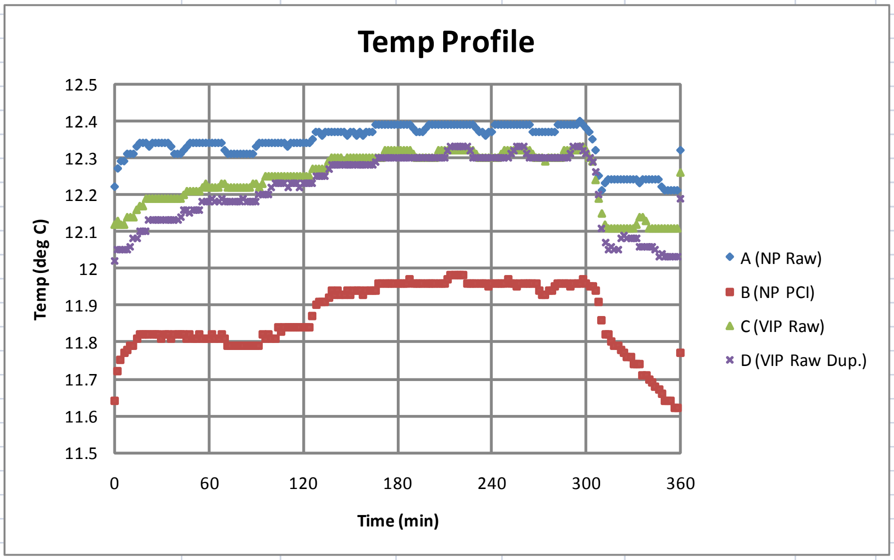
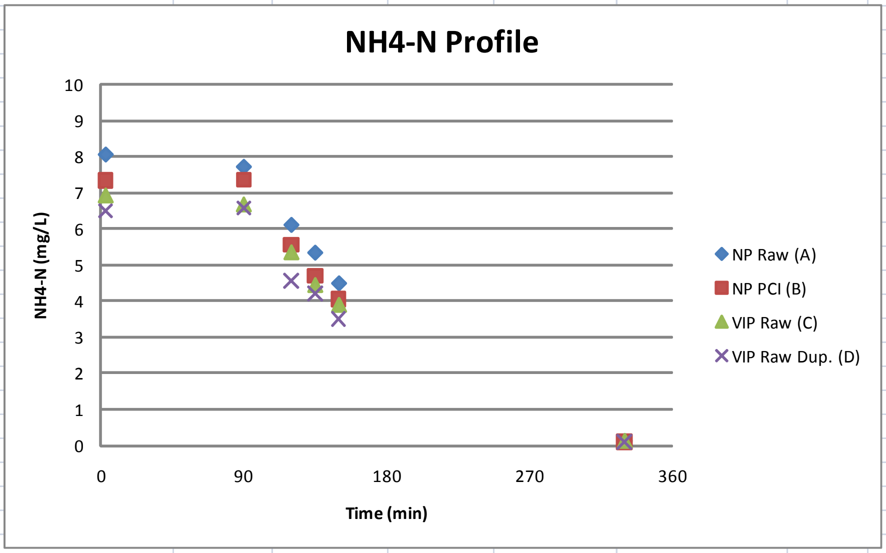
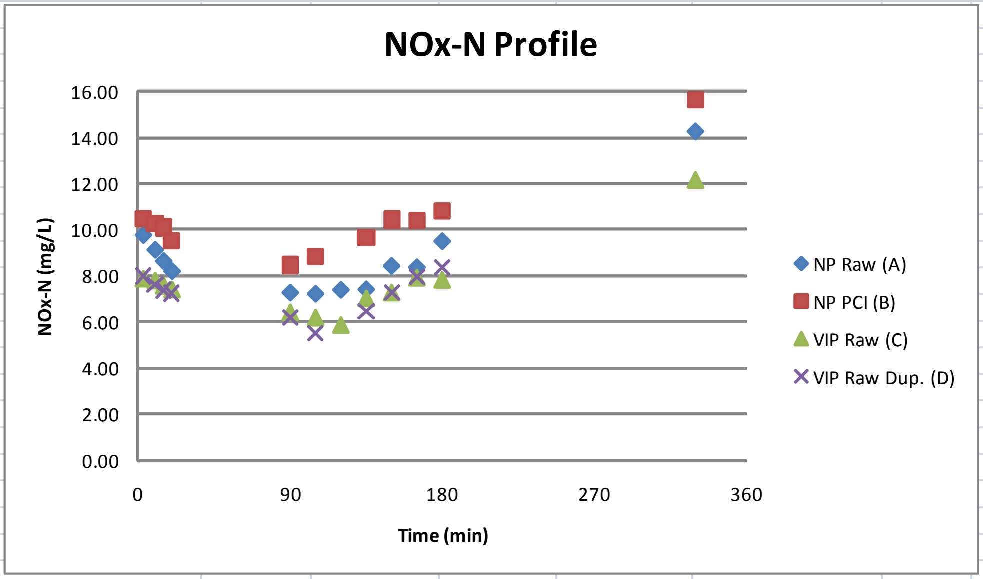
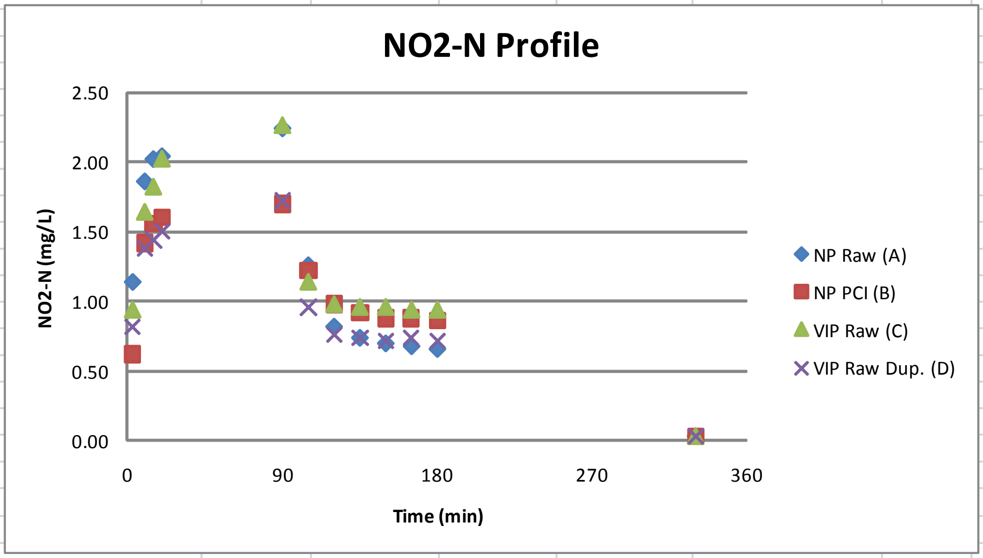
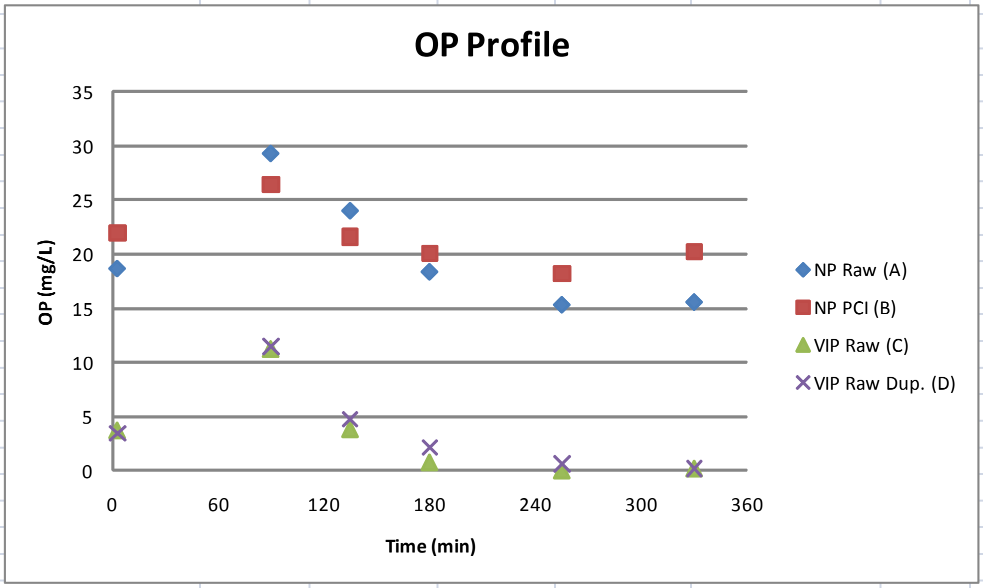
pH
7.50
7.45
7.40
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

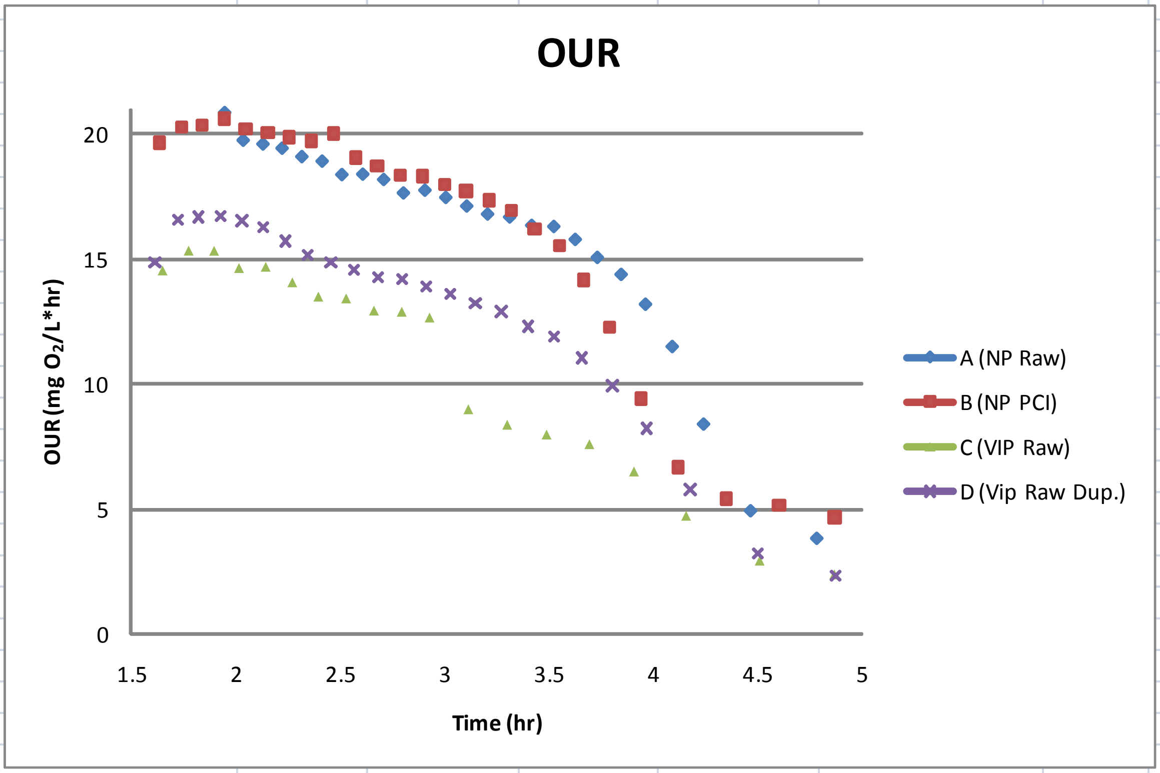

Temp Profile
Temp (deg C)
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

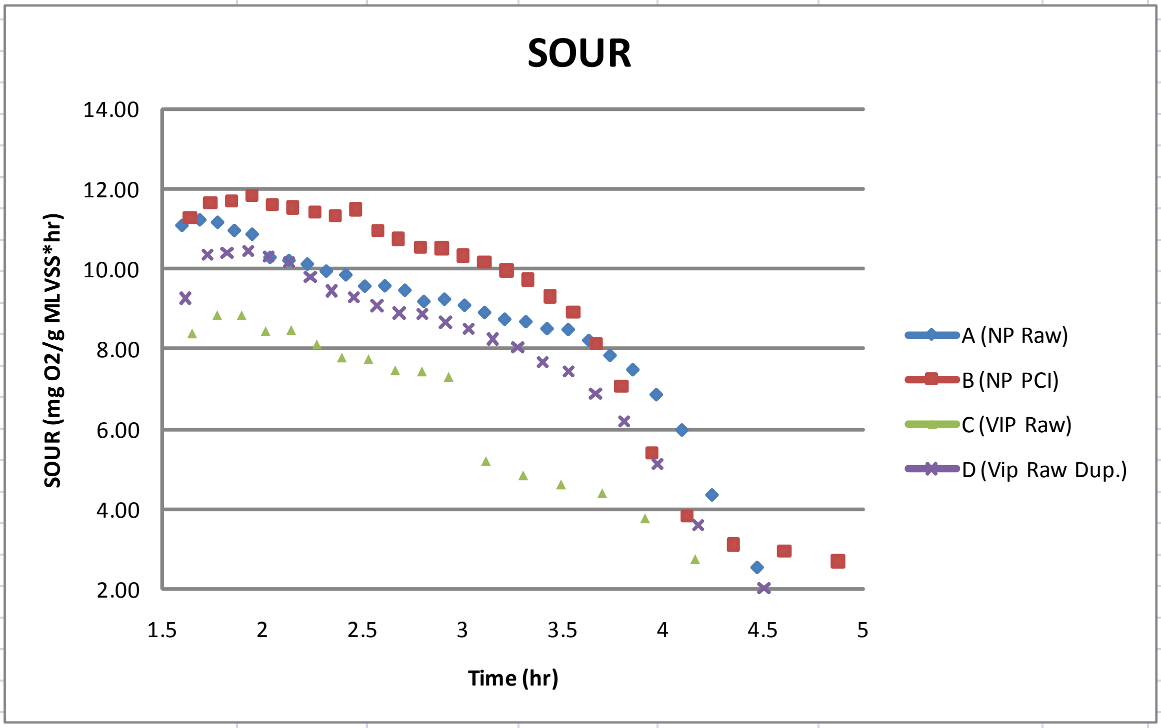

NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCl (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile


NO2-N Profile


OP Profile


OUR
OUR (mg O_2/L*hr)
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

24-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.7	102	86%	87.72	646	50
B (NP PCI)	30.25	146	86%	125.56	935	50.4
C (VIP Raw)	27.2	142	80%	113.6	831	42.6
D (Vip Raw Dup.)	27.2	140	81%	113.4	685	43.3
	27.2	141	0.805	113.5	758	42.95

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.37	5.78	1.92
B (NP PCI)	6.97	5.98	1.82
C (VIP Raw)	6.32	4.93	1.84
D (Vip Raw Dup.)	6.31	4.87	1.62

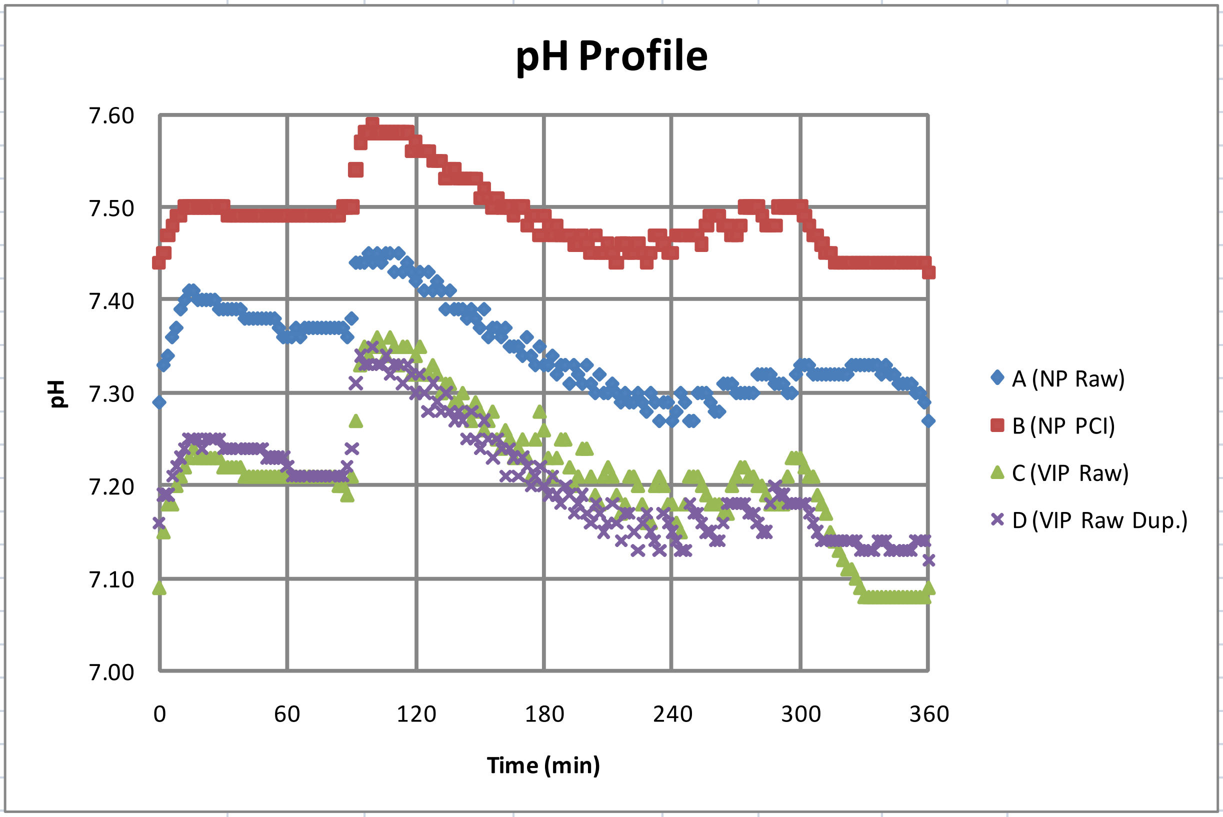
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2460	80%	1968.0
B (NP PCI)	3080	81%	2494.8
C (VIP Raw)	2300	79%	1817.0
D (Vip Raw Dup.)	2380	78%	1856.4

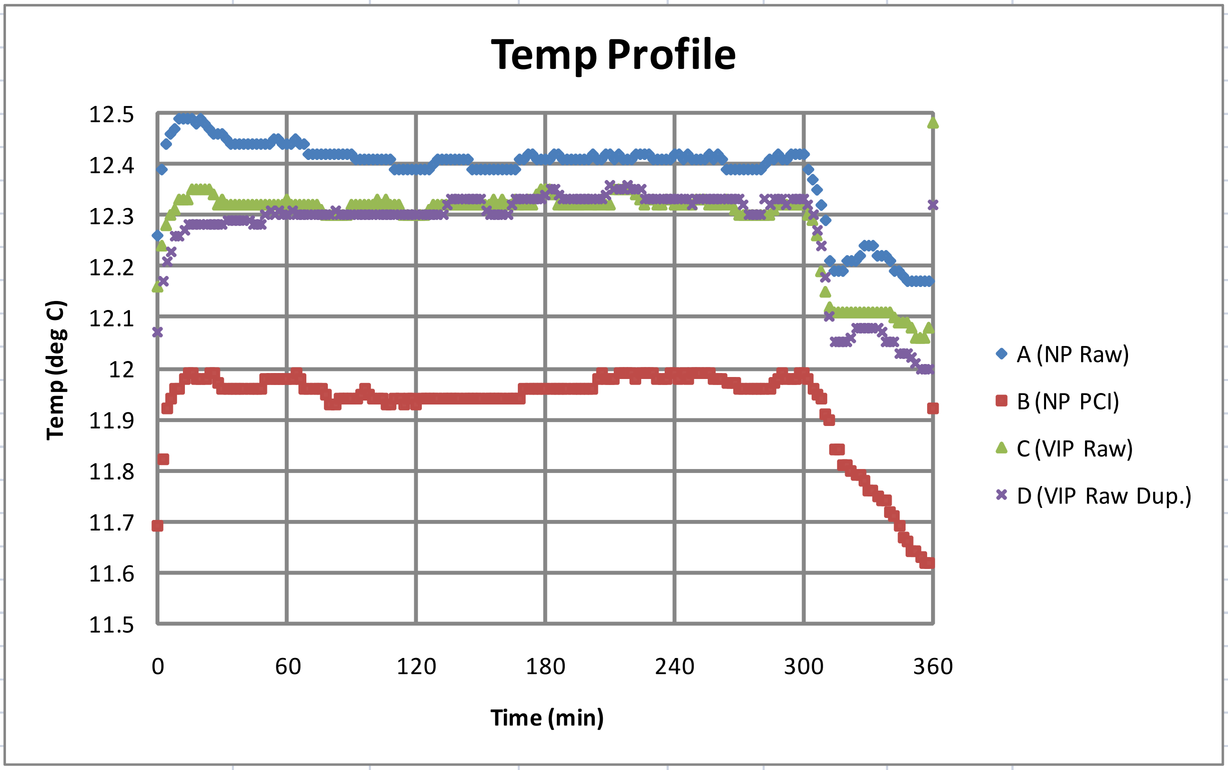
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.097	14.6	0.034	17	9.62
B (NP PCI)	0.105	14.3	0.038	12	9.23
C (VIP Raw)	0.890	12.7	0.032	11	2.97
D (Vip Raw Dup.)	0.093	11.6	0.036	10	2.79

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	410	220	89.4
B (NP PCI)	590	300	97.4
C (VIP Raw)	270	160	69.6
D (Vip Raw Dup.)	300	165	69.3

	A	B	C	D
OUR (mg O_2/L*hr)	17.89	16.64	11.20	13.87
MLVSS (g/L)	1.97	2.49	1.82	1.86
SOUR (mg O_2/g MLVSS*hr)	9.09	6.67	6.16	7.47

Avg. Temp. (° C)	
A (NP Raw)	12.42
B (NP PCI)	11.96
C (VIP Raw)	12.32
D (Vip Raw Dup.)	12.31


pH Profile
7.60
7.50
7.40
7.30
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

27-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	32.4	108	88%	95.04	487	53.6
B (NP PCI)	31.5	163	88%	143.44	504	51.5
C (VIP Raw)	25.9	109	84%	91.56	369	42.9
D (Vip Raw Dup.)	25.9	116	81%	93.96	372	40.7
	25.9	112.5	0.825	92.76	370.5	41.8

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.56	5.92	1.78
B (NP PCI)	7.05	6.07	2.18
C (VIP Raw)	6.11	5.65	1.46
D (Vip Raw Dup.)	6.12	5.06	1.24

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2340	80%	1872.0
B (NP PCI)	2600	81%	2106.0
C (VIP Raw)	1960	80%	1568.0
D (Vip Raw Dup.)	1820	78%	1419.6

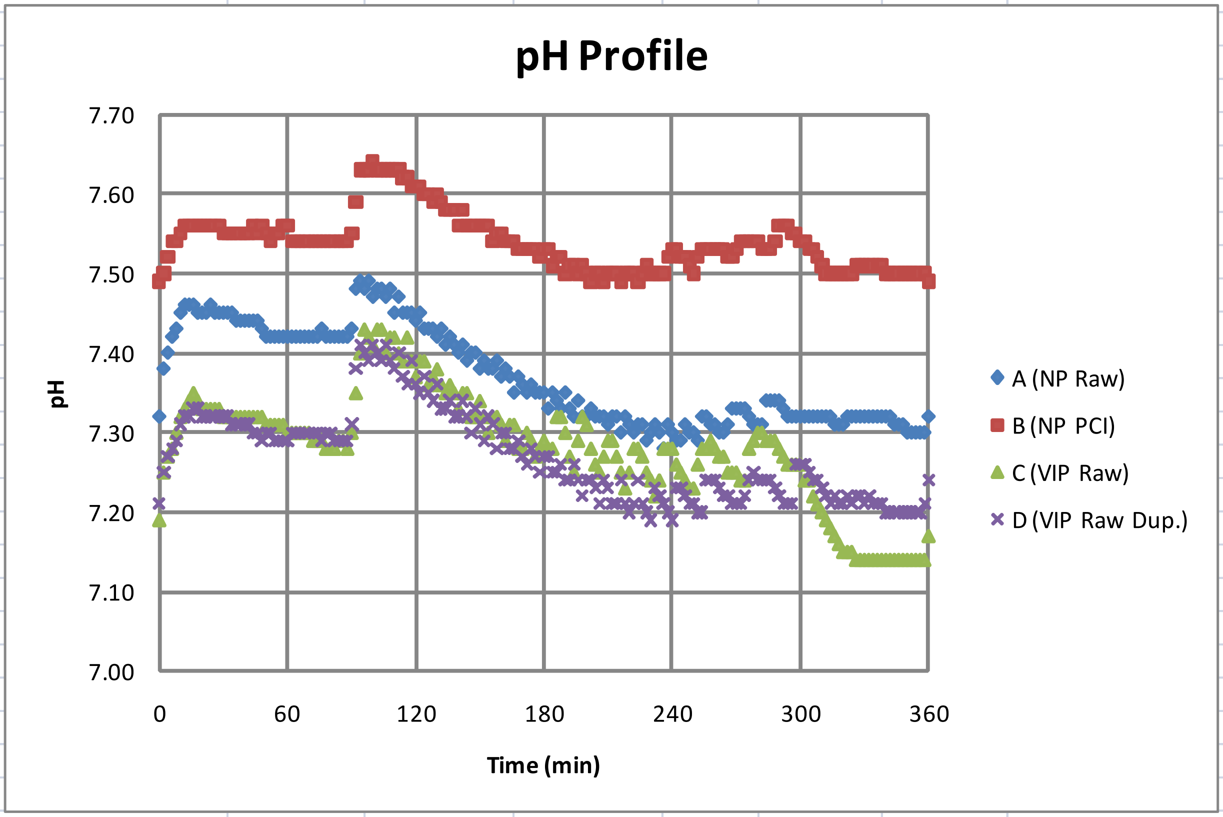
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.083	14.7	0.038	13	8.3
B (NP PCI)	0.073	13.2	0.034	13	10.3
C (VIP Raw)	0.630	13.2	0.024	13	3.52
D (Vip Raw Dup.)	0.072	12.3	0.032	8	2.36

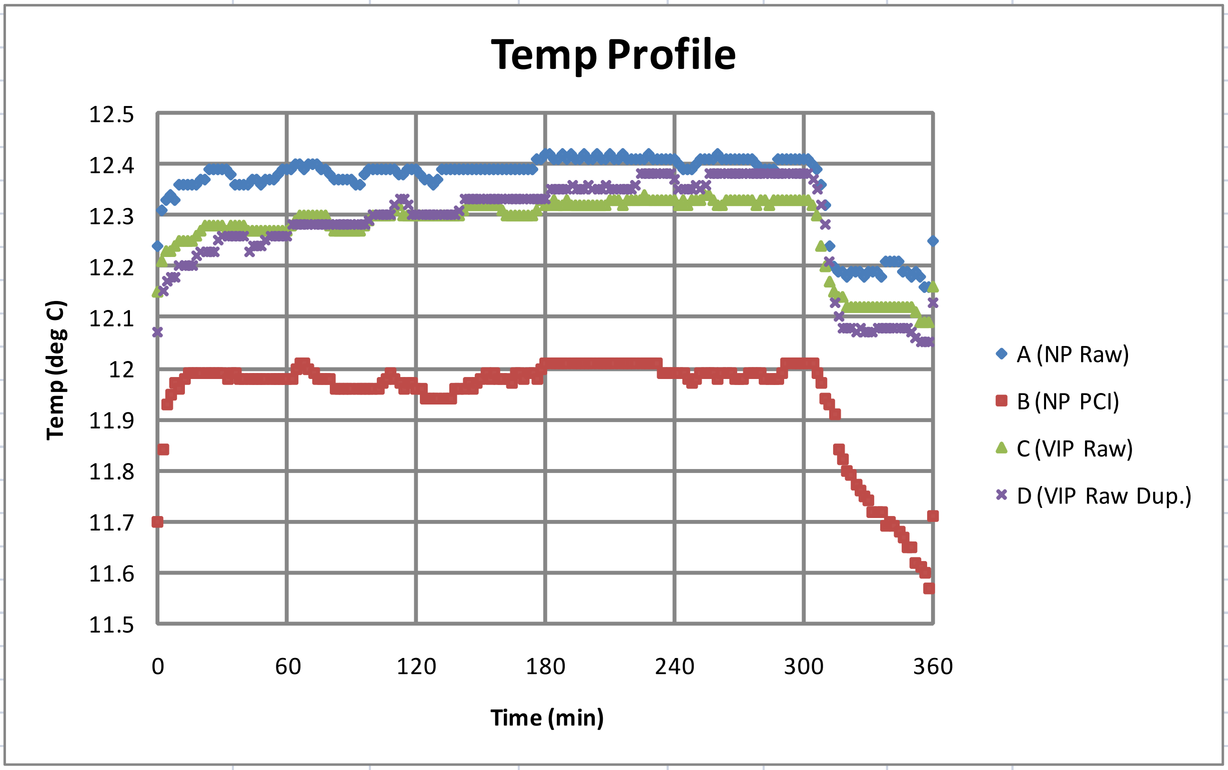
Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	425	215
B (NP PCI)	555	285
C (VIP Raw)	265	155
D (Vip Raw Dup.)	300	160

SVI (mL/g)
91.9
109.6
79.1
87.9

	A	B	C	D
OUR (mg O_2/L*hr)	17.46	16.61	11.62	13.58
MLVSS (g/L)	1.87	2.11	1.57	1.42
SOUR (mg O_2/g MLVSS*hr)	9.32	7.89	7.41	9.56

Avg. Temp. (° C)	
A (NP Raw)	12.39
B (NP PCI)	11.98
C (VIP Raw)	12.31
D (Vip Raw Dup.)	12.32


pH Profile
pH
7.70
7.60
7.50
7.40
7.30
7.20
7.10
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

29-Sep-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.9	124	87%	107.88	574	52.9
B (NP PCI)	32.5	196	83%	162.68	837	53.9
C (VIP Raw)	25	46	84%	38.64	314	38.5
D (Vip Raw Dup.)	25	53	79%	41.87	347	35.8
	25	49.5	0.815	40.255	330.5	37.15

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	7.18	4.46	1.440
B (NP PCI)	7.19	2.96	3.180
C (VIP Raw)	5.92	6.08	0.880
D (Vip Raw Dup.)	5.90	5.43	0.680

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2160	81%	1749.6
B (NP PCI)	2760	80%	2208
C (VIP Raw)	2120	77%	1632.4
D (Vip Raw Dup.)	1960	78%	1529

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.050	14.2	0.032	16	8.9
B (NP PCI)	0.029	12.8	0.048	16	10.9
C (VIP Raw)	0.029	13.7	0.04	9	1.98
D (Vip Raw Dup.)	0.062	12.2	0.04	7	2.35

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	440	220	101.9
B (NP PCI)	540	280	101.4
C (VIP Raw)	270	160	75.5
D (Vip Raw Dup.)	320	165	84.2

	A	B	C	D
OUR (mg O_2/L*hr)	18.08	17.02	8.90	11.98
MLVSS (g/L)	1.75	2.21	1.63	1.53
SOUR (mg O_2/g MLVSS*hr)	10.33	7.71	5.45	7.83

Avg. Temp. (° C)	
A (NP Raw)	12.36
B (NP PCI)	11.87
C (VIP Raw)	12.26
D (Vip Raw Dup.)	12.23

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.75	2.21	1.63	1.53
NR (mg NOx-N/L*hr)	2.87	2.54	2.43	2.47
DNR (mg NOx-N/L*hr)	8.21	3.05	3.33	7.55
SNR (mg NOx-N/g MLVSS*hr)	1.64	1.15	1.49	1.62
SDNR (mg NOx-N/g MLVSS*hr)	4.69	1.38	2.04	4.94

NP Raw (A)

	NH3-N	NO3-N	NO2-N	NOx-N
Time	mg/L	mg/L	mg/L	mg/L
3	8.06	8.83	1.14	9.97
10		7.32	1.82	9.14
15		6.36	1.72	8.08
20		6.03	1.74	7.77
90	7.18	4.46	1.44	5.90
105	6.77	5.51	0.82	6.33
120	6.11	6.56	0.72	7.28
135	5.19	7.10	0.70	7.80
150	4.46	7.55	0.72	8.27
165	3.43	8.33	0.70	9.03
180	2.86	9.67	0.80	10.47
330	0.05	14.20	0.03	14.23

NP PCI (B)

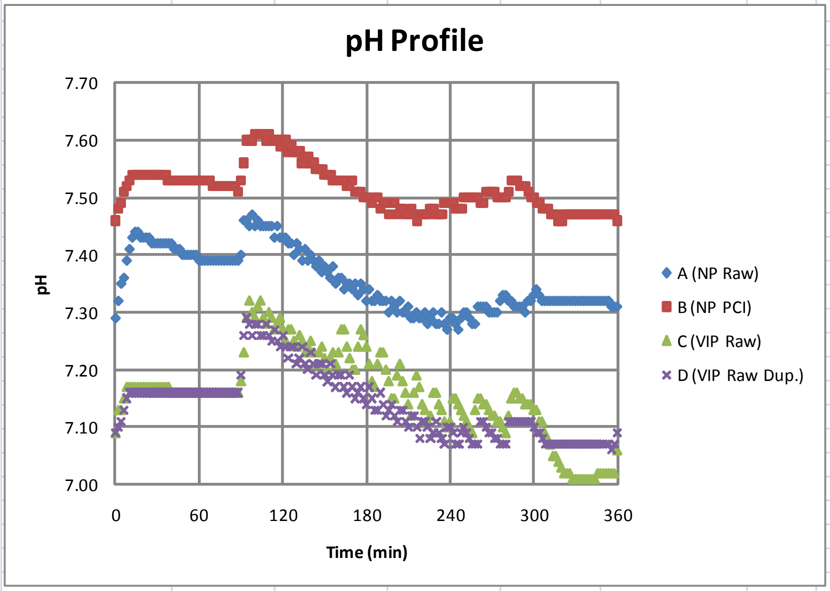
	NH3-N	NO3-N	NO2-N	NOx-N
Time	mg/L	mg/L	mg/L	mg/L
3	7.27	7.16	1.32	8.48
10		6.28	2.44	8.72
15		5.07	2.84	7.91
20		4.79	2.96	7.75
90	7.19	2.96	3.18	6.14
105	6.58	4.19	1.98	6.17
120	5.54	5.22	1.34	6.56
135	4.66	6.42	1.04	7.46
150	3.95	7.10	0.90	8.00
165	3.01	8.06	0.89	8.95
180	2.11	8.87	0.86	9.73
330	0.029	12.80	0.05	12.85

VIP Raw (C)

	NH3-N	NO3-N	NO2-N	NOx-N
Time	mg/L	mg/L	mg/L	mg/L
3	6.78	8.31	0.72	9.03
10		7.51	0.98	8.49
15		7.29	0.94	8.23
20		7.06	1.04	8.10
90	5.92	6.08	0.88	
105	5.77	6.50	0.60	7.10
120	5.14	7.37	0.66	8.03
135	4.19	7.60	0.70	8.30
150	3.83	8.48	0.72	9.20
165	2.97	8.87	0.72	9.59
180	2.35	9.51	0.72	10.23
330	0.029	13.70	0.04	13.74

VIP Raw Dup. (D)

	NH3-N	NO3-N	NO2-N	NOx-N
Time	mg/L	mg/L	mg/L	mg/L
3	6.09	8.30	0.600	8.90
10		6.51	0.820	7.33
15		6.77	0.800	7.57
20		5.70	0.820	6.52
90	5.9	5.43	0.680	
105	5.61	5.82	0.580	6.40
120	4.71	6.11	0.660	6.77
135	4.15	6.82	0.720	7.54
150	3.68	7.23	0.740	7.97
165	2.97	7.25	0.750	
180	2.39	8.68	0.780	9.46
330	0.062	12.20	0.040	12.24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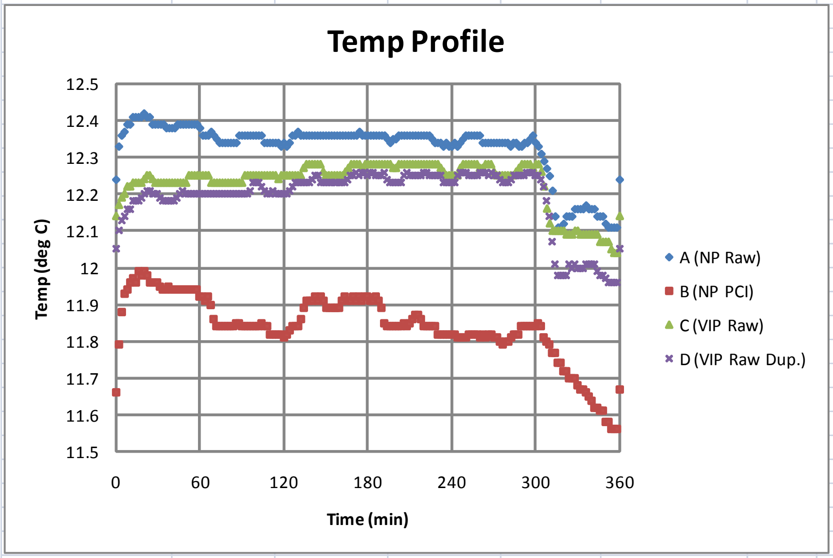
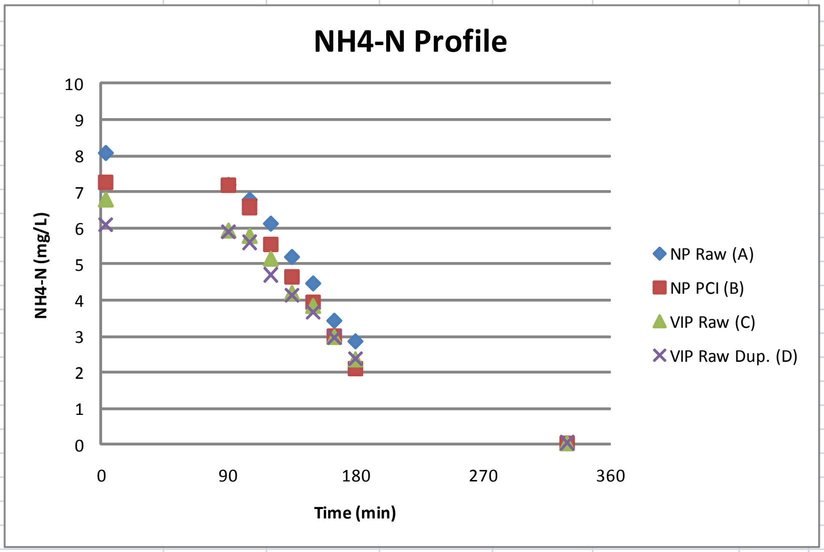
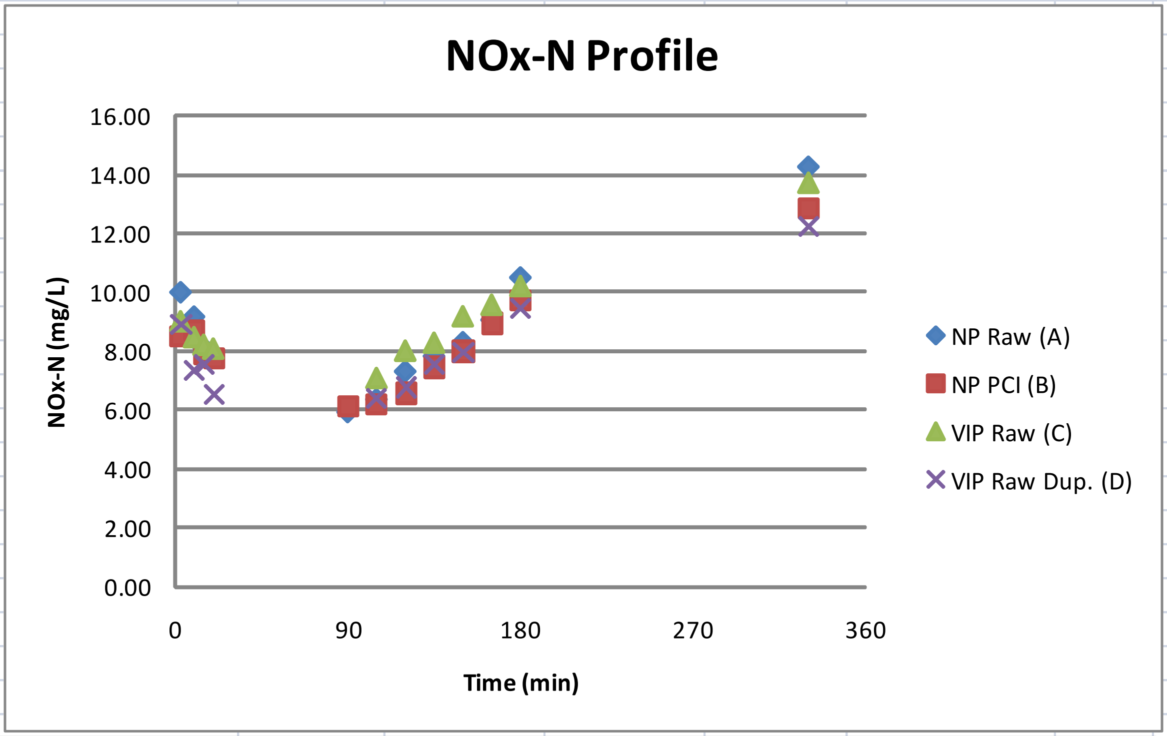
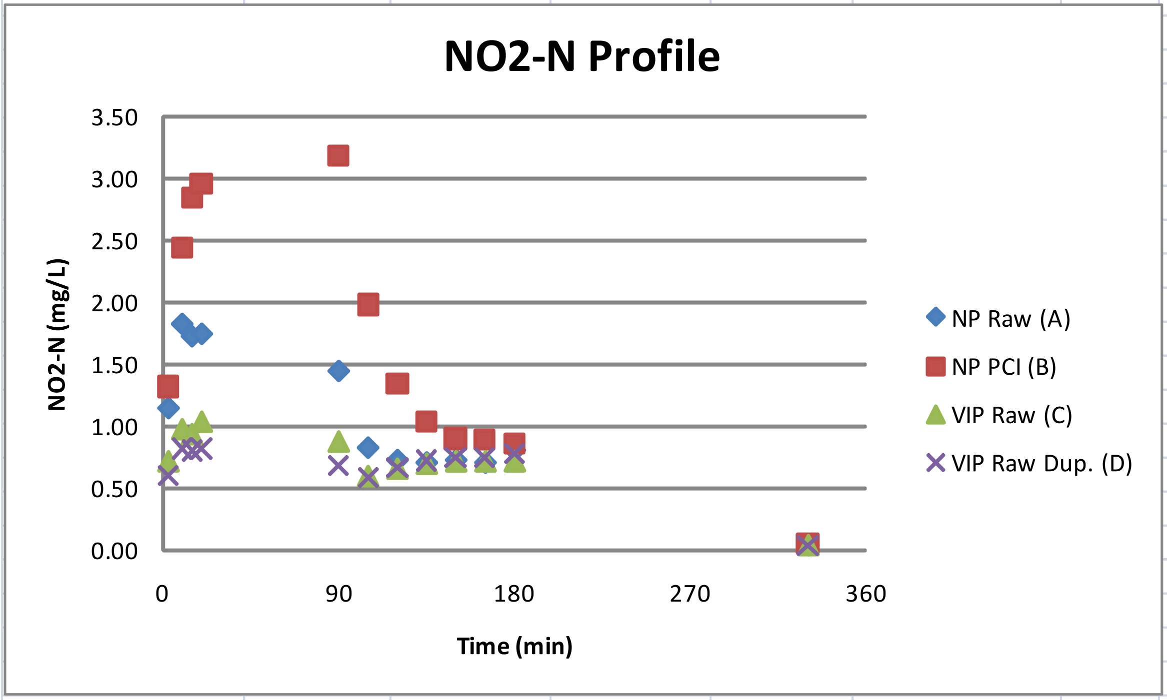
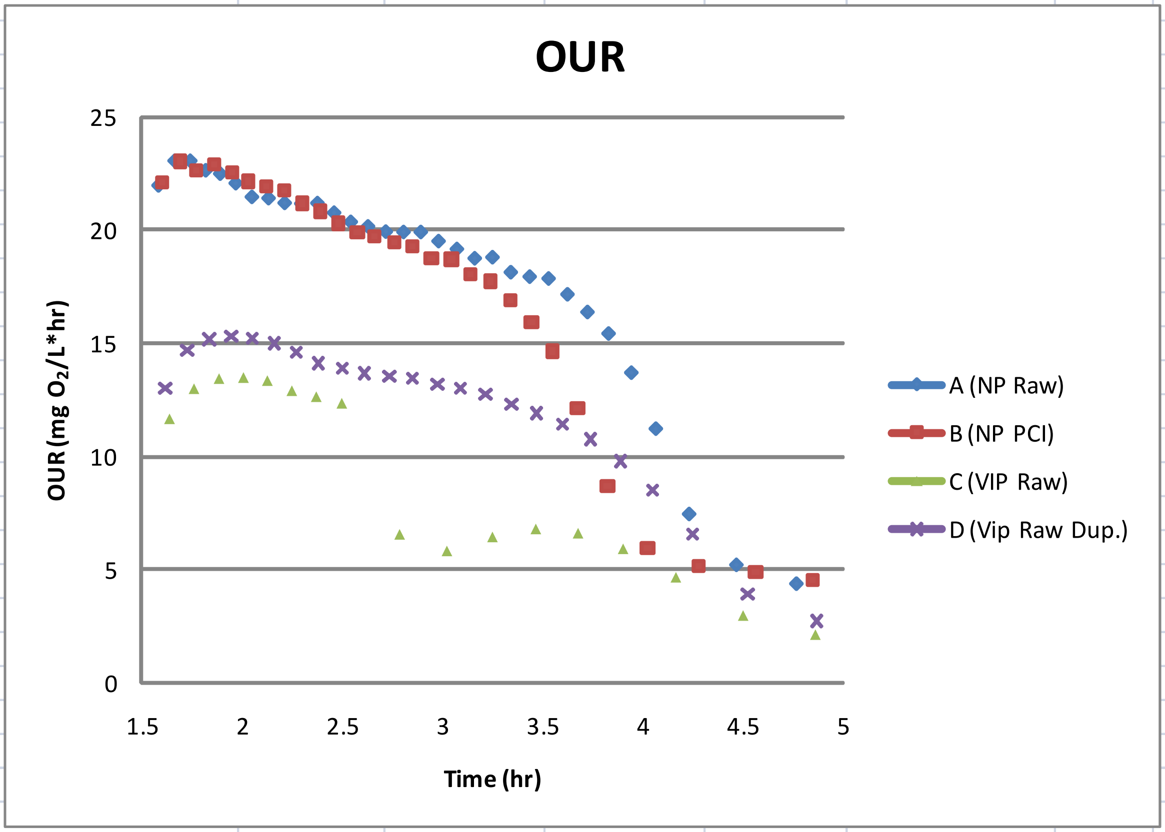
pH
7.70
7.60
7.50
7.40
7.30
7.20
7.10
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

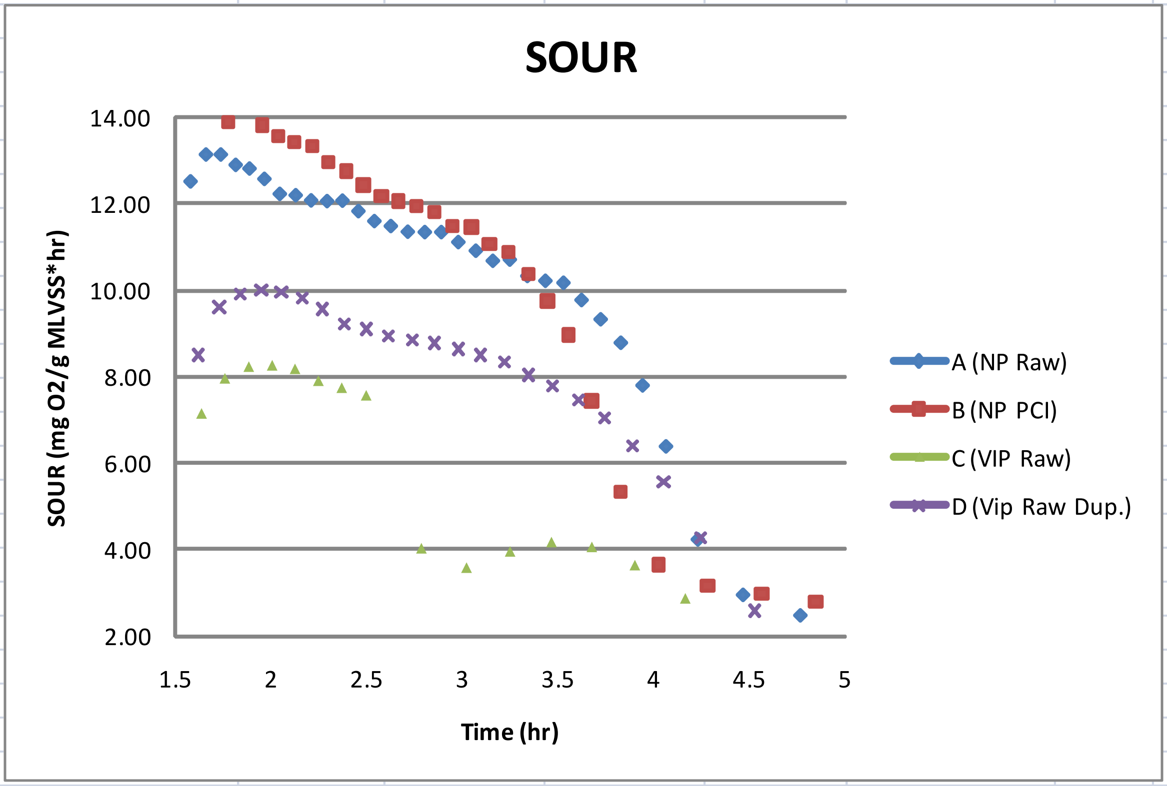

Temp Profile
Temp (deg C)
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCl (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NOx-N Profile
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NOx-N (mg/L)
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
NO2-N (mg/L)
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

1-Oct-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	27.75	110	84%	92.4	557	44.2
B (NP PCI)	25.55	154	86%	132.44	608	41.1
C (VIP Raw)	22	134	75%	100.5	482	33.7
D (Vip Raw Dup.)	22	136	75%	102	531	34.9
	22	135	0.75	101.25	506.5	34.3

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.03	6.51	0.82
B (NP PCI)	5.63	2.29	2.66
C (VIP Raw)	5.01	2.66	0.96
D (Vip Raw Dup.)	4.80	1.88	0.64

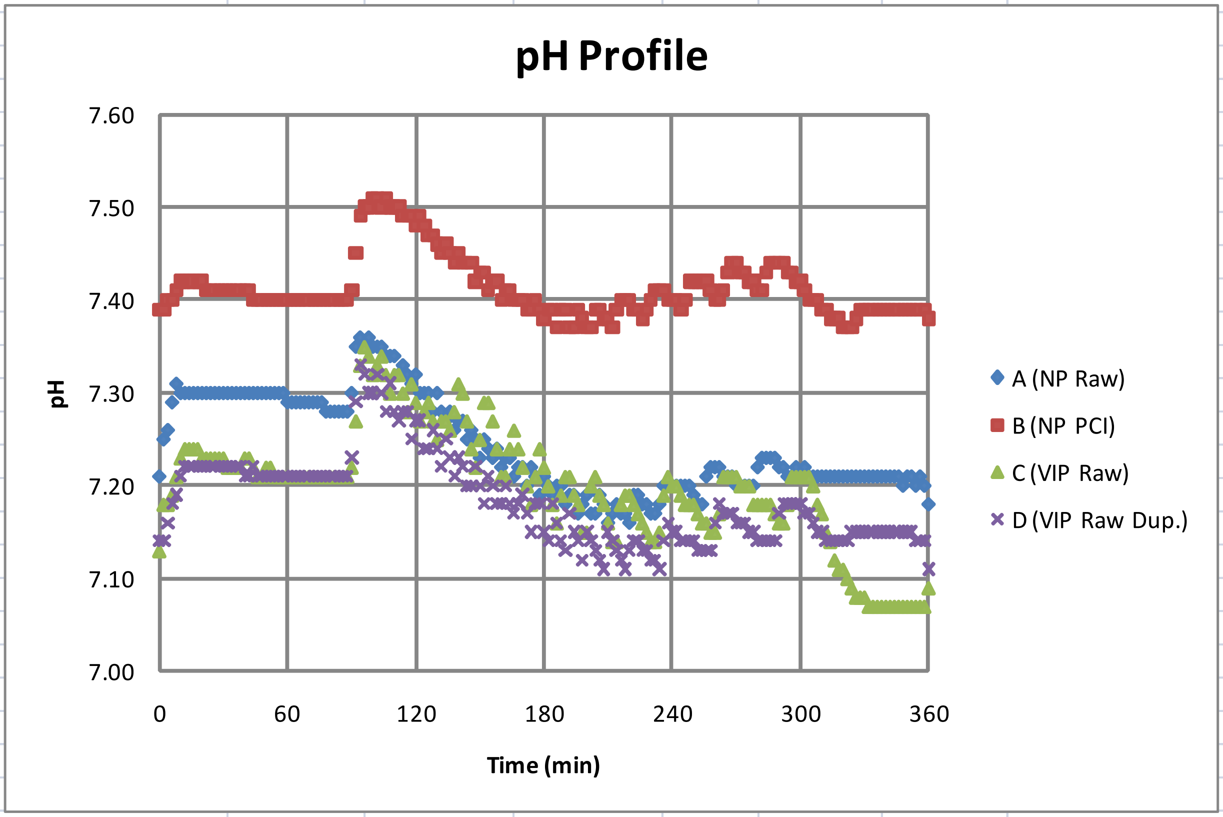
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2320	81%	1879.2
B (NP PCI)	2720	81%	2203.2
C (VIP Raw)	2080	78%	1622.4
D (Vip Raw Dup.)	1960	79%	1548.4

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.069	15.9	0.028	12	
B (NP PCI)	0.081	11.6	0.056	15	
C (VIP Raw)	0.075	10.7	0.024	10	
D (Vip Raw Dup.)	0.093	9.5	0.02	7	

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	410	220	94.8
B (NP PCI)	500	290	106.6
C (VIP Raw)	270	165	79.3
D (Vip Raw Dup.)	320	170	86.7

	A	B	C	D
OUR (mg O_2/L*hr)	15.30	14.55	8.19	11.15
MLVSS (g/L)	1.88	2.20	1.62	1.55
SOUR (mg O_2/g MLVSS*hr)	8.14	6.60	5.05	7.20

Avg. Temp. (° C)	
A (NP Raw)	12.39
B (NP PCI)	11.94
C (VIP Raw)	12.30
D (Vip Raw Dup.)	12.30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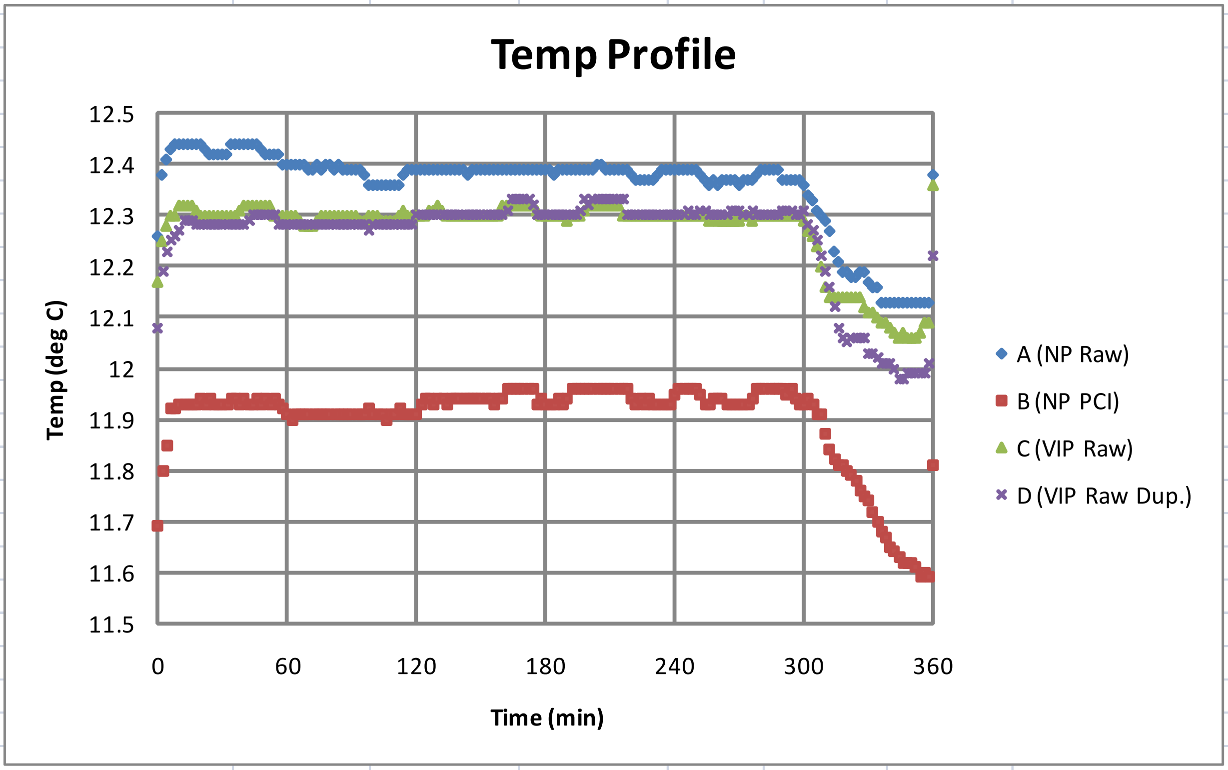
7.10
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

4-Oct-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	19.65	61	79%	48.19	282	31.5
B (NP PCI)	15.85	136	79%	107.44	554	31.7
C (VIP Raw)	12.75	47	74%	34.78	285	19.9
D (Vip Raw Dup.)	12.75	48	77%	36.96	185	20.5
	12.75	47.5	0.755	35.87	235	20.2

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	3.77	6.56	0.24
B (NP PCI)	3.47	4.63	0.66
C (VIP Raw)	2.55	5.60	0.26
D (Vip Raw Dup.)	2.60	4.70	0.20

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2180	81%	1765.8
B (NP PCI)	2500	78%	1950.0
C (VIP Raw)	2000	79%	1580.0
D (Vip Raw Dup.)	1880	78%	1466.4

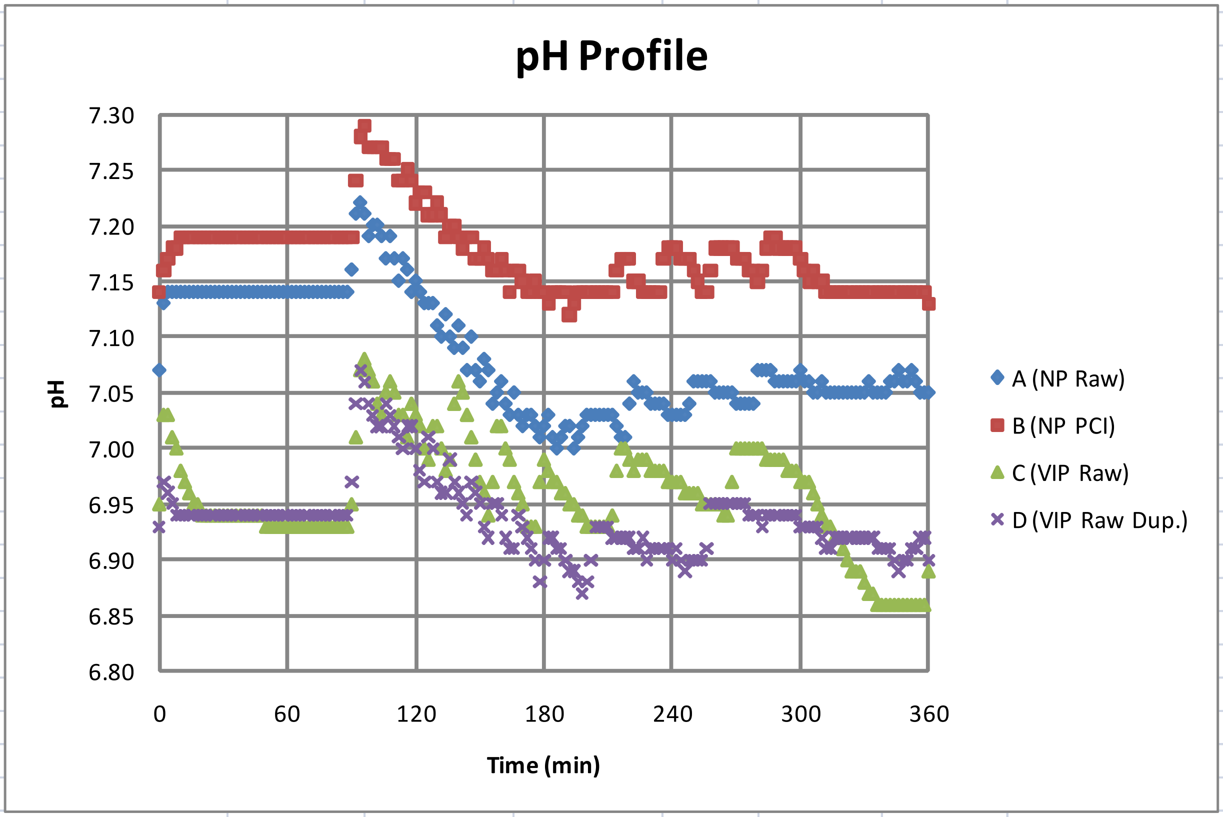
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.055	0.0	0.024	9	
B (NP PCI)	0.056	0.0	0.024	15	
C (VIP Raw)	0.053	0.0	0.028	8	
D (Vip Raw Dup.)	0.055	0.0	0.024	3	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	450	220
B (NP PCI)	530	260
C (VIP Raw)	260	150
D (Vip Raw Dup.)	330	170

SVI (mL/g)
100.9
104.0
75.0
90.4

	A	B	C	D
OUR (mg O_2/L*hr)	11.45	9.92	4.44	6.38
MLVSS (g/L)	1.77	1.95	1.58	1.47
SOUR (mg O_2/g MLVSS*hr)	6.49	5.08	2.81	4.35

Avg. Temp. (° C)	
A (NP Raw)	12.35
B (NP PCI)	11.82
C (VIP Raw)	12.27
D (Vip Raw Dup.)	12.24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7.00
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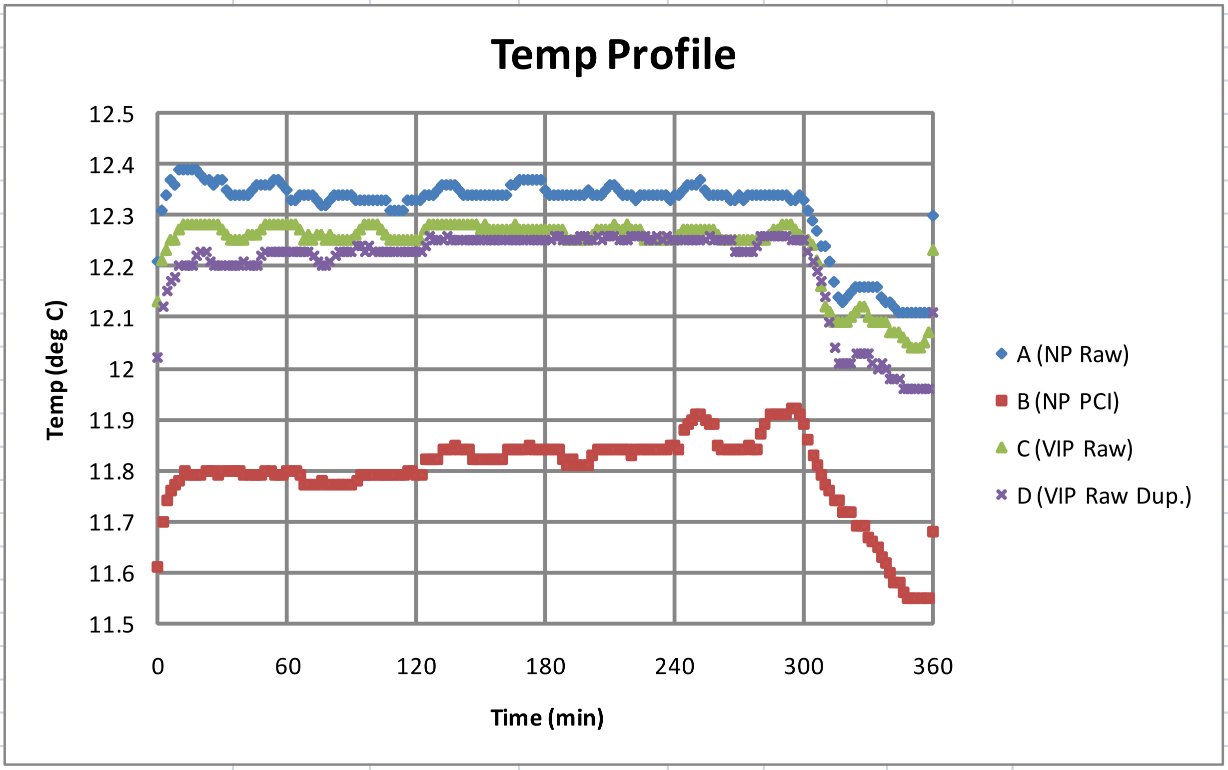
6.90
6.85
6.80
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

6-Oct-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	16.08	136	74%	100.64	393	28.1
B (NP PCI)	18.04	106	80%	84.8	394	29.2
C (VIP Raw)	8.4	39	68%	26.52	133	13.2
D (Vip Raw Dup.)	8.4	37	71%	26.27	125	13.25
	8.4	38	0.695	26.395	129	13.225

Aerobic Start (0930)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	3.74	6.32	0.300
B (NP PCI)	4.06	7.69	0.420
C (VIP Raw)	1.77	6.31	0.200
D (Vip Raw Dup.)	1.65	5.92	0.180

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2020	83%	1676.6
B (NP PCI)	2340	81%	1895.4
C (VIP Raw)	1800	80%	1440
D (Vip Raw Dup.)	1660	82%	1361

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.025	12.2	0.02	11	
B (NP PCI)	0.022	13.7	0.028	16	
C (VIP Raw)	0.020	8.66	0.024	12	
D (Vip Raw Dup.)	0.029	8.64	0.024	4	

Settled Sludge Volume (mL/L)

	5 min	30 min
A (NP Raw)	490	230
B (NP PCI)	495	240
C (VIP Raw)	235	145
D (Vip Raw Dup.)	305	155

SVI (mL/g)
113.9
102.6
80.6
93.4

	A	B	C	D
OUR (mg O_2/L*hr)	10.85	9.92	3.41	3.80
MLVSS (g/L)	1.68	1.90	1.44	1.36
SOUR (mg O_2/g MLVSS*hr)	6.47	5.23	2.37	2.79

Avg. Temp. (° C)	
A (NP Raw)	12.33
B (NP PCI)	11.80
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.16

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.68	1.90	1.44	1.36
NR (mg NOx-N/L*hr)	2.49	2.54	1.10	1.48
DNR (mg NOx-N/L*hr)	3.95	5.94	-2.04	0.36
SNR (mg NOx-N/g MLVSS*hr)	1.48	1.34	0.76	1.09
SDNR (mg NOx-N/g MLVSS*hr)	2.36	3.14	-1.42	0.27

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	3.95	7.87	0.18	8.05	
10		7.14	0.26	7.40	
15		6.77	0.26	7.03	
20		6.71	0.26	6.97	
90	3.74	6.32	0.30	6.62	
105	3.36	6.47	0.38	6.85	
120	2.71	6.84	0.54	7.38	
150	1.48	8.13	0.74	8.87	
165	0.895	8.83	0.76	9.59	
180	0.458	9.58	0.72	10.30	
195	0.166	10.40	0.35	10.75	
330	0.025	12.20	0.02	12.22	

NP PCI (B)

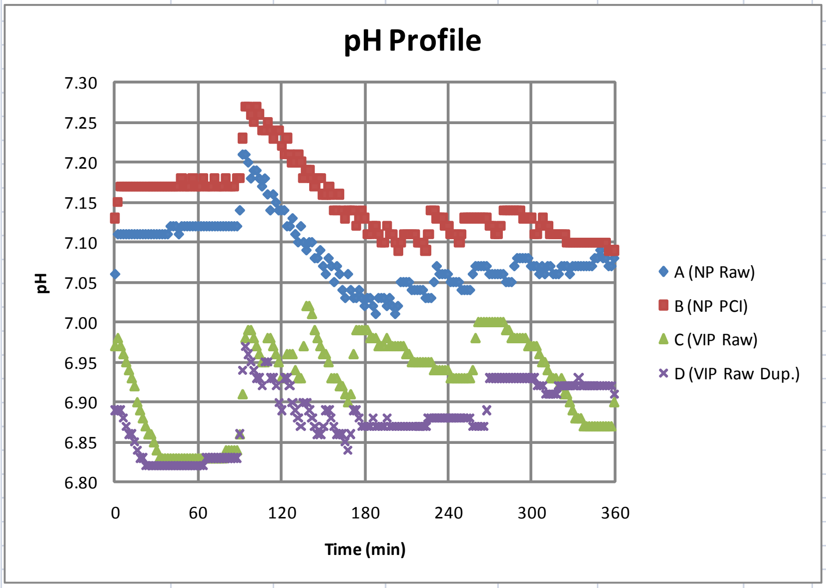
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	3.98	9.62	0.24	9.86	
10		8.57	0.36	8.93	
15		7.79	0.34	8.13	
20		7.98	0.34	8.32	
90	4.06	7.69	0.42	8.11	
105	3.62	8.20	0.50	8.70	
120	2.89	8.68	0.60	9.28	
150	1.83	10.30	0.72	11.02	
165	1.2	10.30	0.72	11.02	
180	0.732	11.10	0.62	11.72	
195	0.37	12.30	0.46	12.76	
330	0.022	13.70	0.03	13.73	

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	1.97	5.71	0.14	5.85	
10		6.29	0.20	6.49	
15		6.10	0.26	6.36	
20		6.19	0.30	6.49	
90	1.77	6.31	0.20	6.51	
105	1.35	6.39	0.30	6.69	
120	1.04	6.70	0.36	7.06	
150	0.404	7.36	0.36	7.72	
165	0.171	7.93	0.28	8.21	
180	0.13	7.69	0.18	7.87	
195	0.152	8.25	0.06	8.31	
330	0.02	8.66	0.02	8.68	

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	1.79	5.92	0.100	6.02	
10		6.36	0.180	6.54	
15		5.96	0.220	6.18	
20		5.71	0.260	5.97	
90	1.65	5.92	0.180	6.10	
105	1.31	6.13	0.300	6.43	
120	1.06	6.46	0.380	6.84	
150	0.428	7.12	0.380	7.50	
165	0.246	7.46	0.300	7.76	
180	0.139	7.32	0.180	7.50	
195	0.177	7.76	0.060	7.82	
330	0.029	8.64	0.024	8.66	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6.85
6.80
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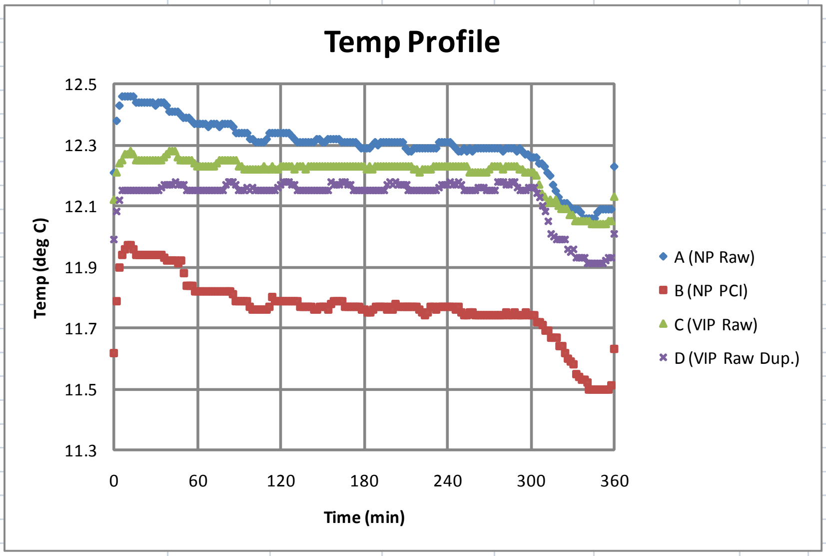
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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11.9
11.7
11.5
11.3
Temp (deg C)
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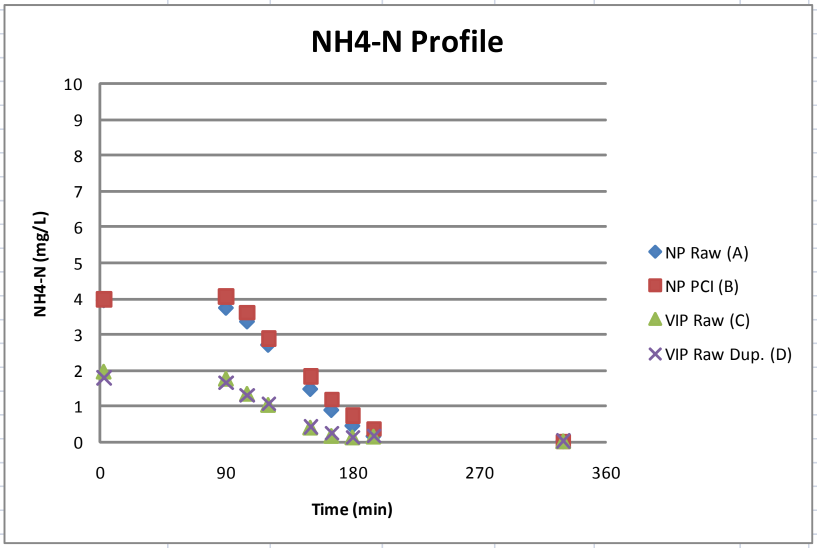
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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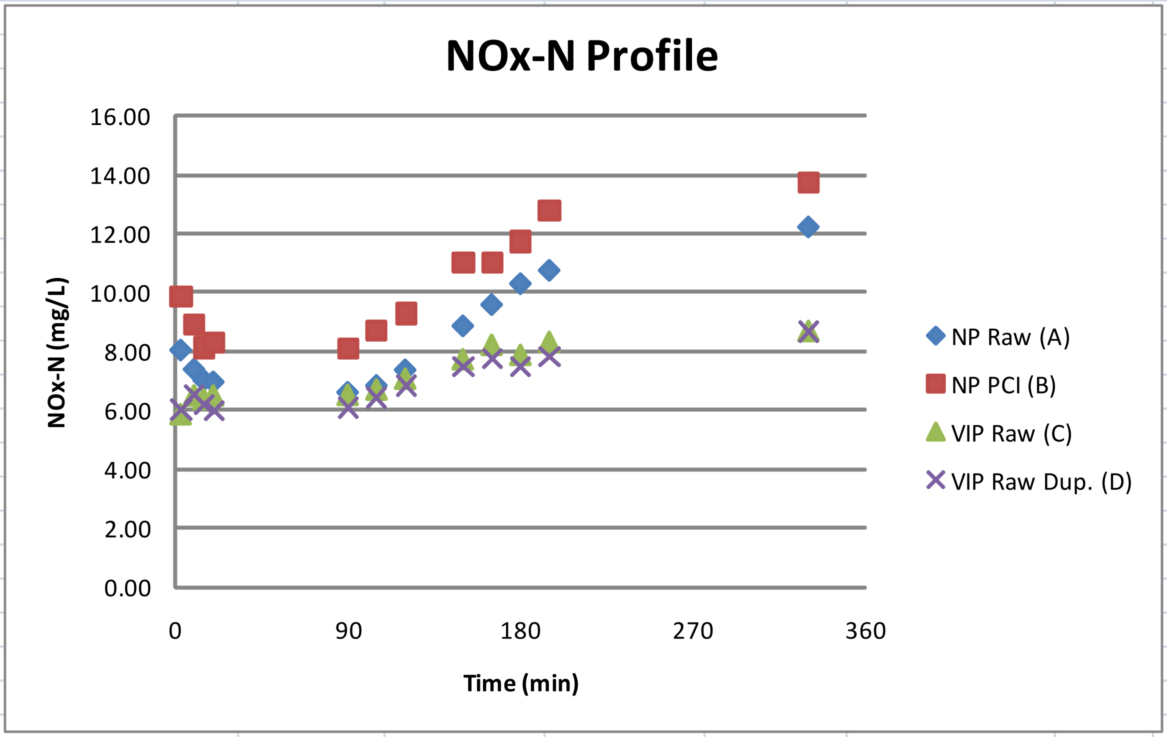
10
9
8
7
6
5
4
3
2
1
0
NH4-N (mg/L)
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCl (B)
VIP Raw (C)
VIP Raw Dup. (D)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NOx-N (mg/L)
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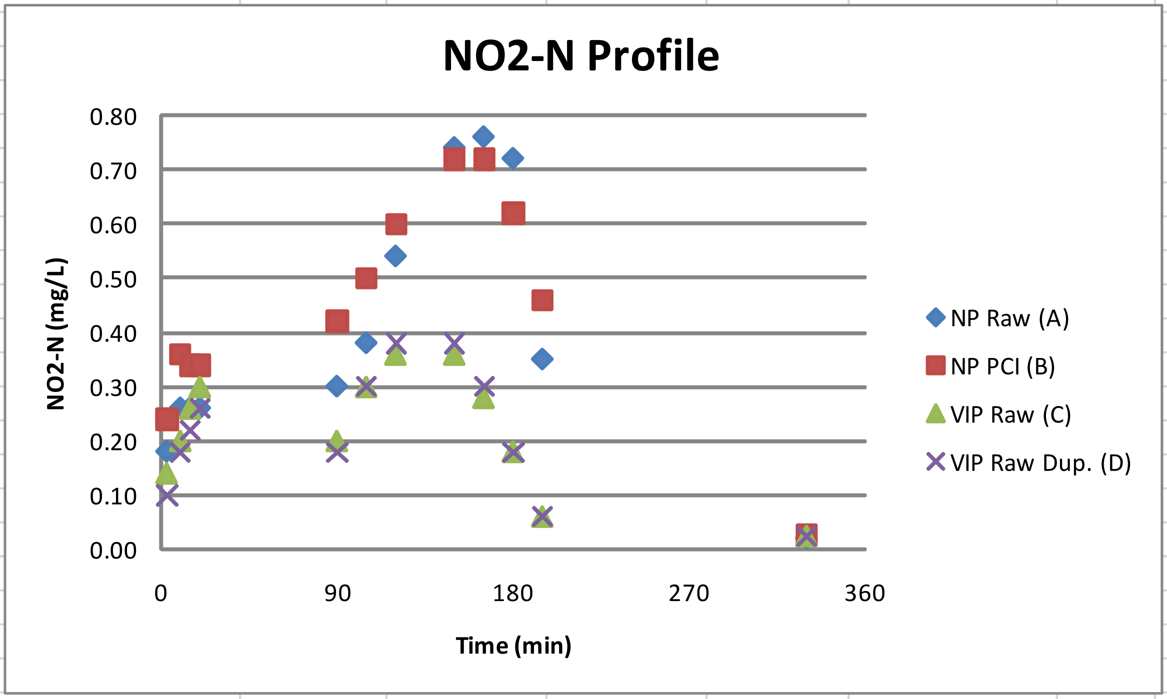
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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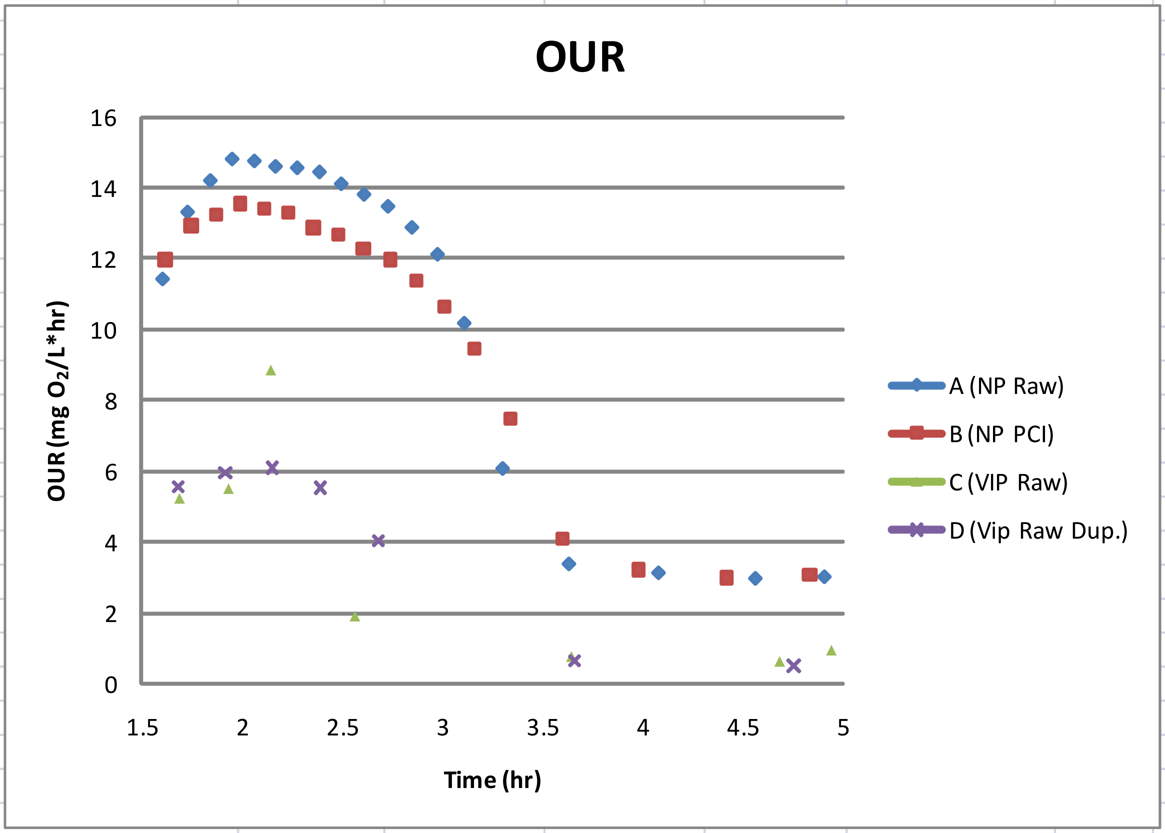
NO2-N (mg/L)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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14
12
10
8
6
4
2
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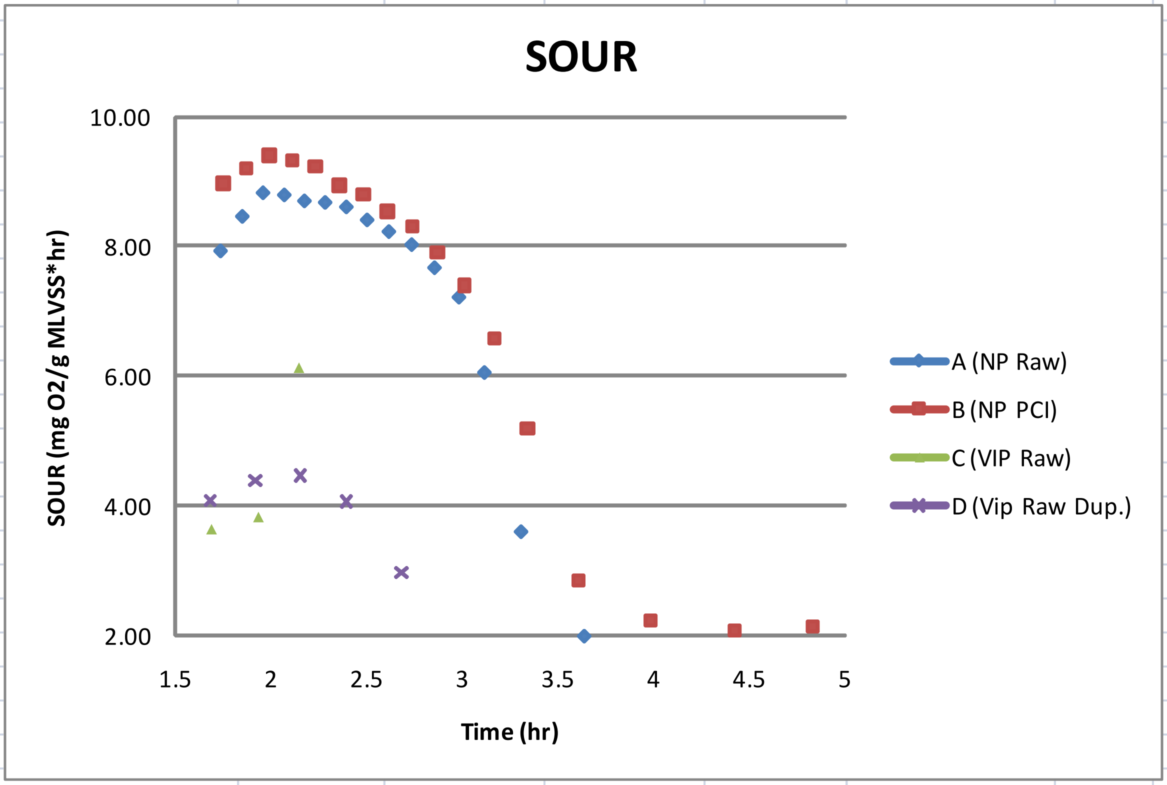
OUR (mg O_2/L*hr)
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
10.00
8.00
6.00
4.00
2.00
SOUR (mg O2/g MLVSS*hr)
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

8-Oct-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	20.2	155	81%	125.55	554	35
B (NP PCI)	22	185	78%	144.3	374	37.9
C (VIP Raw)	10.6	104	71%	73.84	648	18.1
D (Vip Raw Dup.)	10.6	104	69%	71.76	305	18.6
	10.6	104	0.7	72.8	305	18.35

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	4.48	3.90	0.82
B (NP PCI)	5.08	8.42	0.58
C (VIP Raw)	2.13	6.27	0.25
D (Vip Raw Dup.)	2.35	6.20	0.15

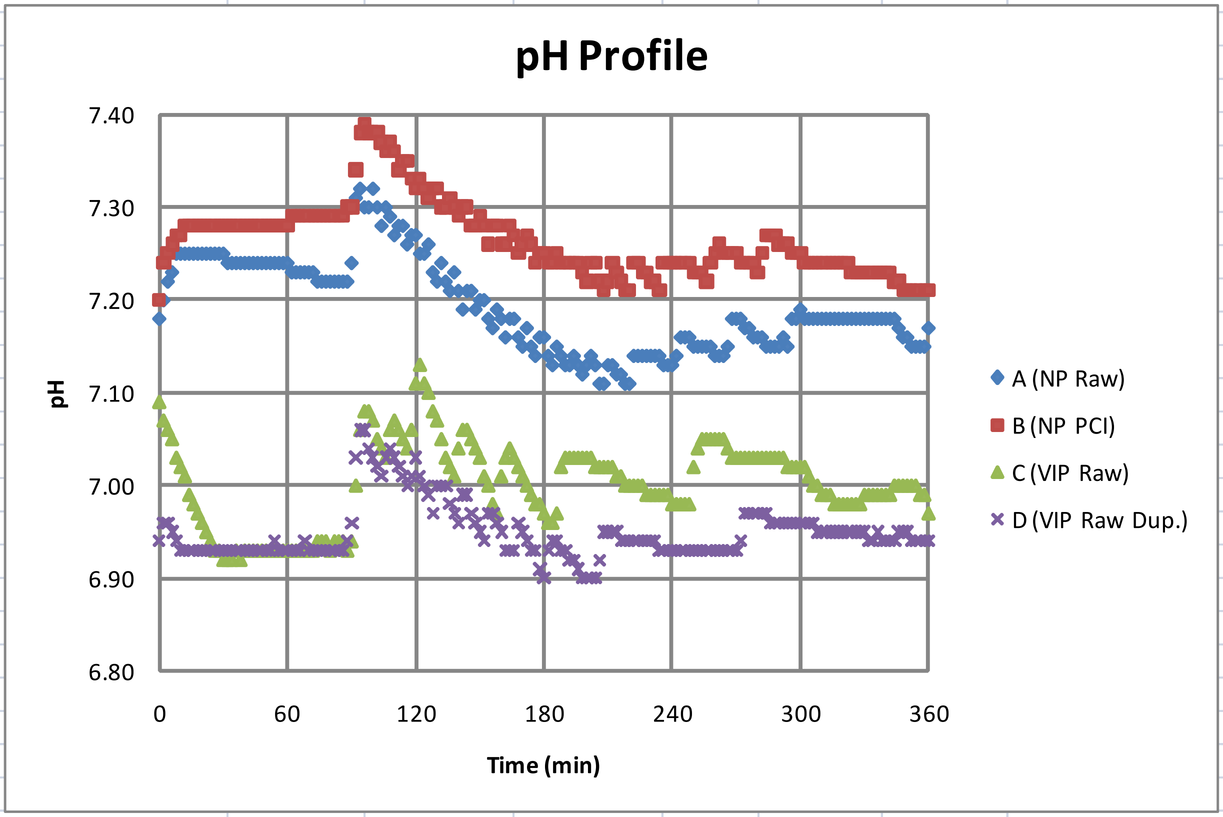
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2400	79%	1896.0
B (NP PCI)	2400	79%	1896.0
C (VIP Raw)	1820	76%	1383.2
D (Vip Raw Dup.)	1720	74%	1272.8

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.074	9.2	0.02	10	
B (NP PCI)	0.084	14.2	0.024	18	
C (VIP Raw)	0.069	8.9	0.02	7	
D (Vip Raw Dup.)	0.071	8.6	0.02	5	

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	510	240	100.0
B (NP PCI)	450	225	93.8
C (VIP Raw)	230	140	76.9
D (Vip Raw Dup.)	300	150	87.2

	A	B	C	D
OUR (mg O_2/L*hr)	12.18	11.26	3.20	5.15
MLVSS (g/L)	1.90	1.90	1.38	1.27
SOUR (mg O_2/g MLVSS*hr)	6.42	5.94	2.32	4.05

Avg. Temp. (° C)	
A (NP Raw)	12.32
B (NP PCI)	11.78
C (VIP Raw)	12.21
D (Vip Raw Dup.)	12.14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6.80
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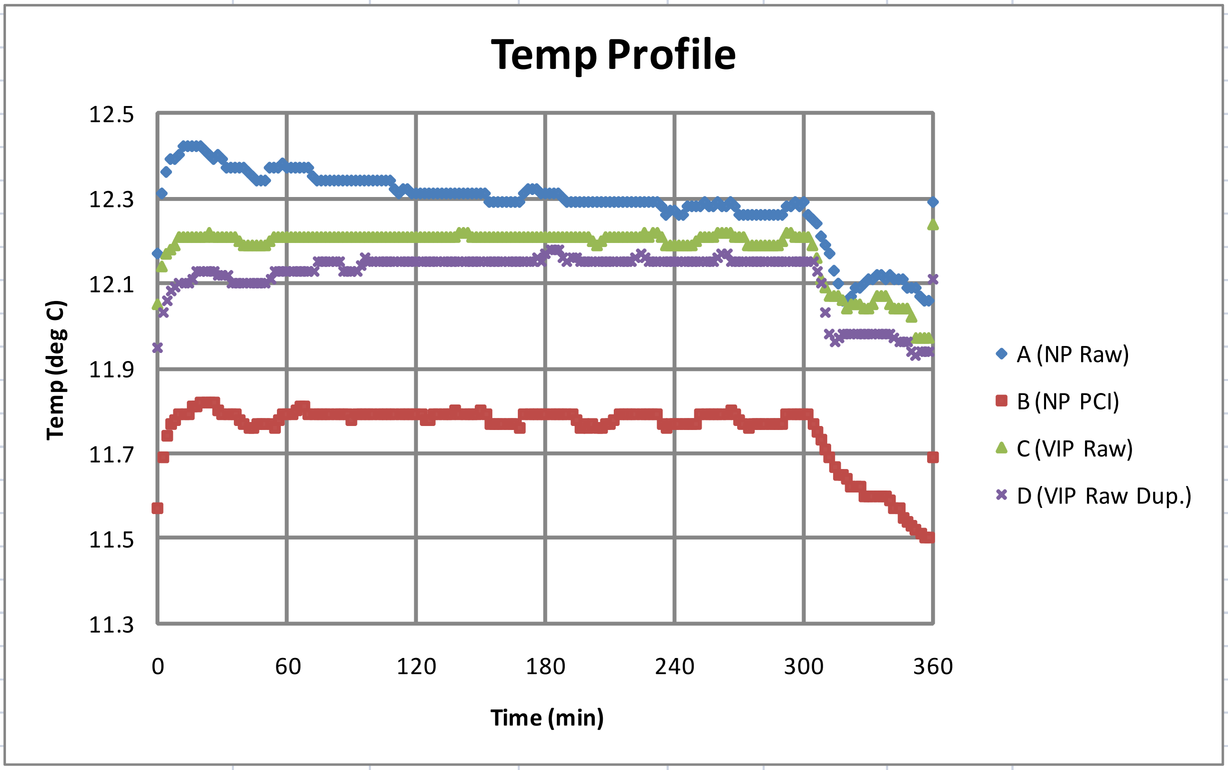
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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Temp (deg C)
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12.1
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11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

11-Oct-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	29.45	122	84%	102.48	408	36.3
B (NP PCI)	31.95	120	83%	99.6	485	39.7
C (VIP Raw)	15.2	136	67%	91.12	317	20.6
D (Vip Raw Dup.)		136	66%	89.76	390	21
	15.2	136	0.665	90.44	353.5	20.8

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	5.13	1.96	1.06
B (NP PCI)	5.57	7.47	0.92
C (VIP Raw)	2.83	5.21	0.38
D (Vip Raw Dup.)	2.79	4.31	0.42

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2300	79%	1817.0
B (NP PCI)	2040	79%	1611.6
C (VIP Raw)	1780	75%	1335.0
D (Vip Raw Dup.)	1460	77%	1124.2

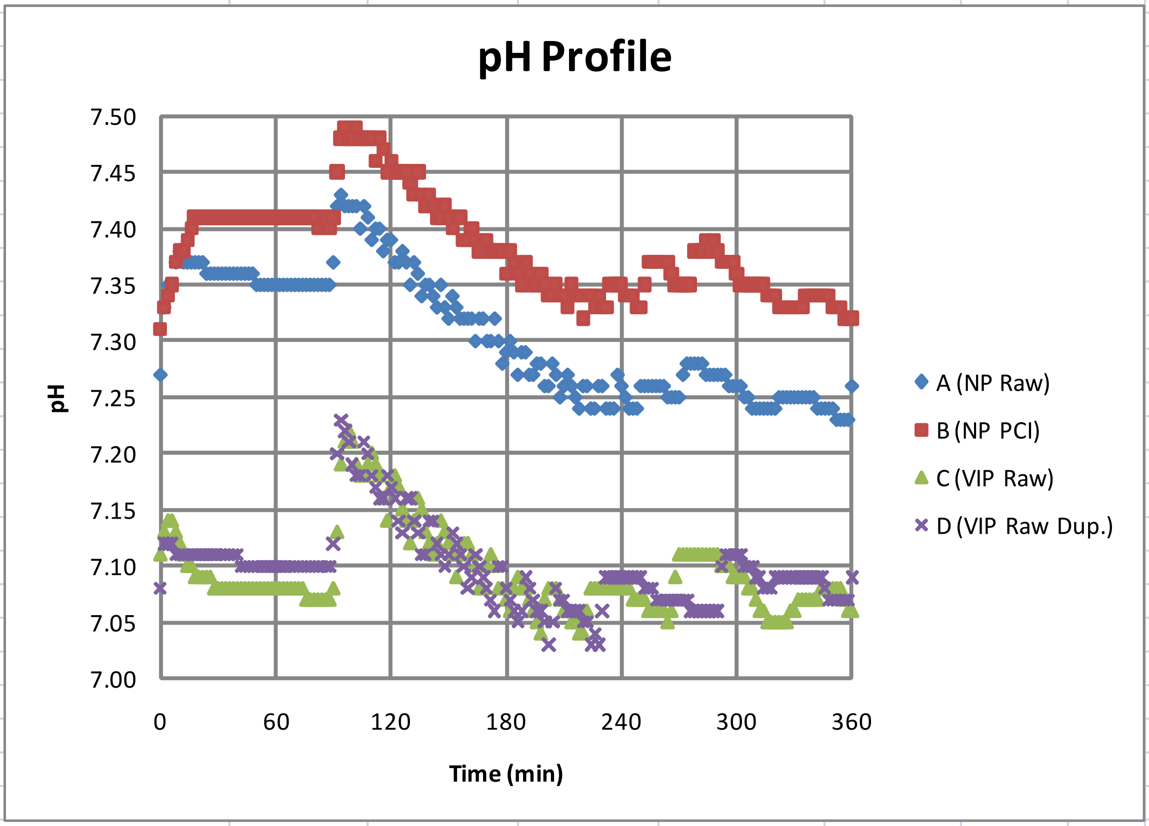
Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.066	11.8	0.028	11	
B (NP PCI)	0.070	13.6	0.032	22	
C (VIP Raw)	0.148	8.7	0.04	8	
D (Vip Raw Dup.)	0.054	7.8	0.02	5	

Settled Sludge Volume (mL/L)	5 min	30 min
A (NP Raw)	540	250
B (NP PCI)	420	215
C (VIP Raw)	225	135
D (Vip Raw Dup.)	300	145

SVI (mL/g)
108.7
105.4
75.8
99.3

	A	B	C	D
OUR (mg O_2/L*hr)	12.05	12.06	5.01	6.05
MLVSS (g/L)	1.82	1.61	1.34	1.12
SOUR (mg O_2/g MLVSS*hr)	6.63	7.48	3.75	5.38

Avg. Temp. (° C)	
A (NP Raw)	12.25
B (NP PCI)	11.71
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.10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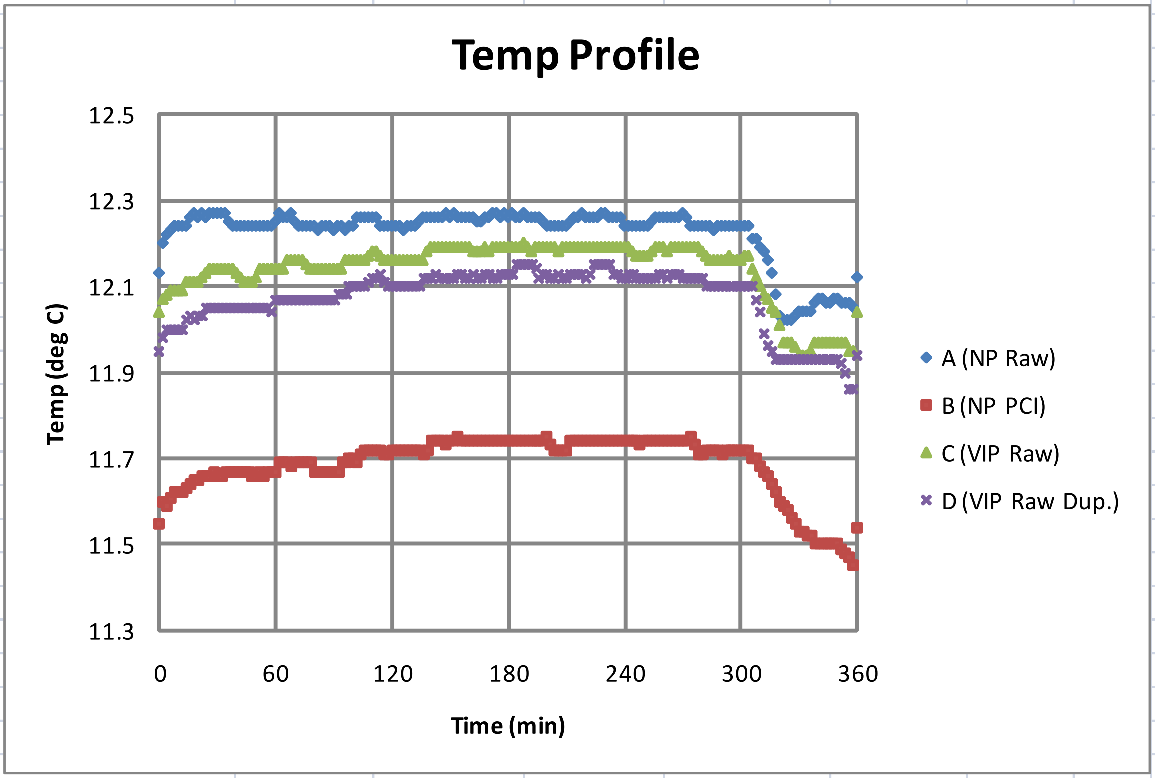
7.05
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

13-Oct-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	30.45	90	87%	78.3	354	39.8
B (NP PCl)	30.45	122	82%	100.04	406	44.7
C (VIP Raw)	15.4	56	82%	45.92	223	21.8
D (Vip Raw Dup.)		54	81%	43.74	209	21.1
	15.4	55	0.815	44.83	216	21.45

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	5.72	0.93	1.28
B (NP PCl)	6.11	6.97	1.26
C (VIP Raw)	3.22	4.59	0.58
D (Vip Raw Dup.)	3.07	3.36	0.62

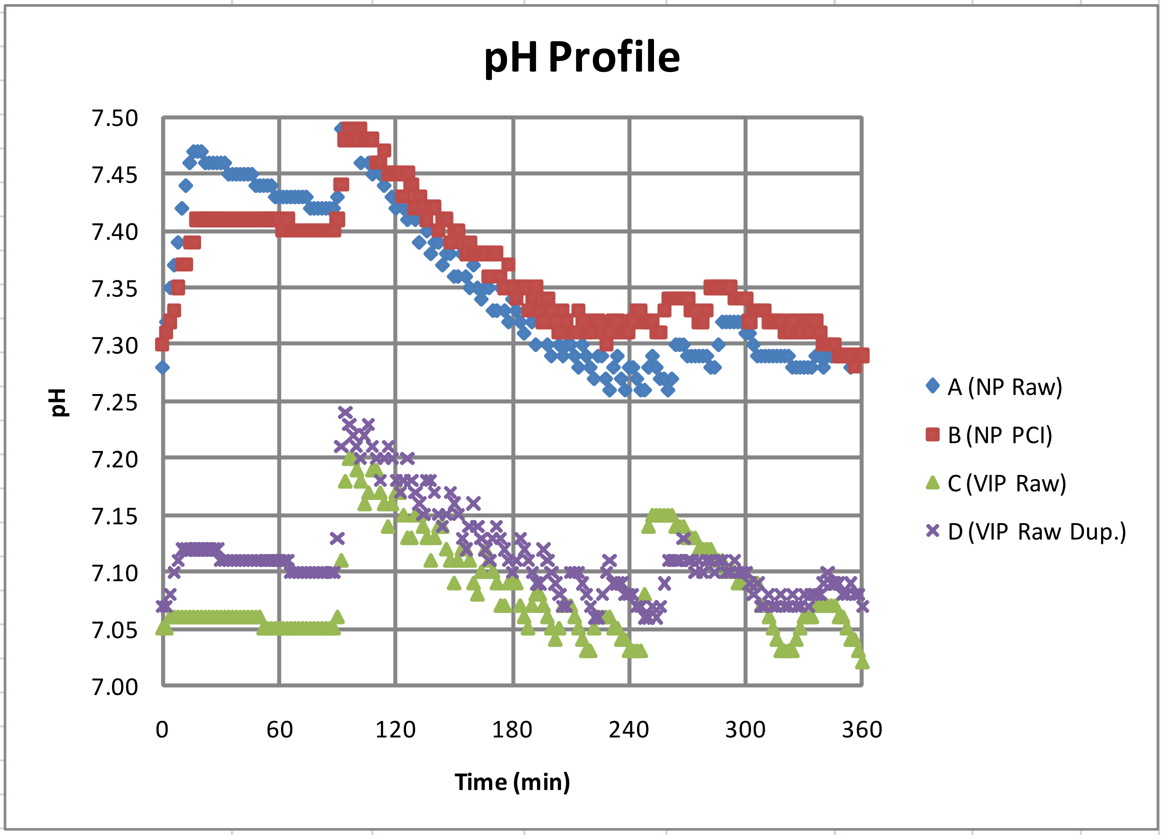
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2140	78%	1669.2
B (NP PCl)	2100	79%	1659.0
C (VIP Raw)	1480	74%	1095.2
D (Vip Raw Dup.)	1440	83%	1195.2

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.072	7.2	0.04	14	
B (NP PCl)	0.076	14.0	0.048	25	
C (VIP Raw)	0.057	8.2	0.056	8	
D (Vip Raw Dup.)	0.057	6.9	0.048	5	

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	560	255	119.2
B (NP PCl)	405	210	100.0
C (VIP Raw)	215	135	91.2
D (Vip Raw Dup.)	300	145	100.7

	A	B	C	D
OUR (mg O_2/L*hr)	13.03	13.02	5.67	6.32
MLVSS (g/L)	1.67	1.66	1.10	1.20
SOUR (mg O_2/g MLVSS*hr)	7.81	7.85	5.18	5.29

Avg. Temp. (° C)	
A (NP Raw)	12.41
B (NP PCl)	11.91
C (VIP Raw)	12.30
D (Vip Raw Dup.)	12.28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7.10
7.05
7.00
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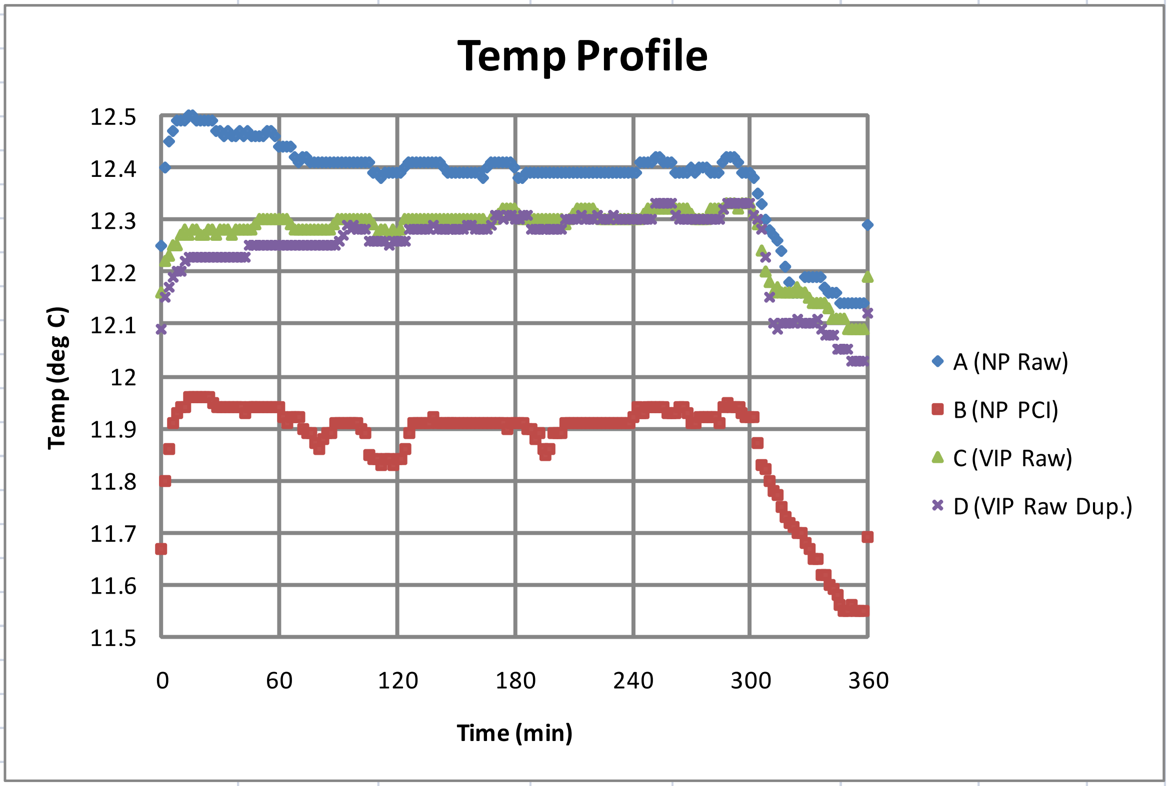
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

15-Oct-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	30	110	87%	95.7	627	46.1
B (NP PCI)	30.3	130	88%	114.4	425	46.3
C (VIP Raw)	17	76	84%	63.84	320	26.2
D (Vip Raw Dup.)		71	87%	61.77	289	24
	17	73.5	0.855	62.805	304.5	25.1

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.35	0.30	0.50
B (NP PCI)	6.64	6.80	1.54
C (VIP Raw)	3.88	3.24	0.42
D (Vip Raw Dup.)	3.74	2.68	0.42

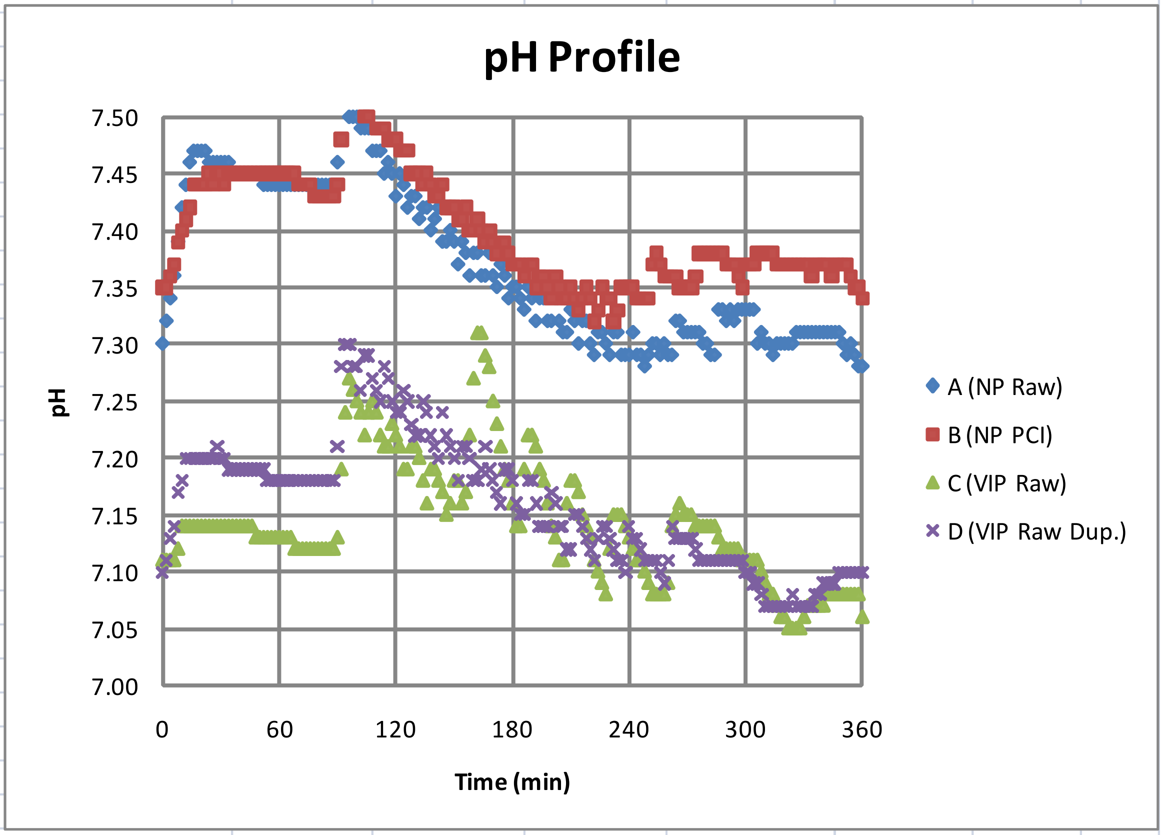
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1980	81%	1603.8
B (NP PCI)	2360	81%	1911.6
C (VIP Raw)	1650	78%	1287.0
D (Vip Raw Dup.)	1520	79%	1200.8

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.092	7.2	0.024	15	
B (NP PCI)	0.069	13.8	0.02	19	
C (VIP Raw)	0.065	7.2	0.02	7	
D (Vip Raw Dup.)	0.074	6.5	0.024	4	

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	520	250	126.3
B (NP PCI)	410	210	89.0
C (VIP Raw)	220	135	81.8
D (Vip Raw Dup.)	300	145	95.4

	A	B	C	D
OUR (mg O_2/L*hr)	13.09	13.81	5.79	7.14
MLVSS (g/L)	1.60	1.91	1.29	1.20
SOUR (mg O_2/g MLVSS*hr)	8.16	7.22	4.50	5.94

Avg. Temp. (° C)	
A (NP Raw)	12.32
B (NP PCI)	11.74
C (VIP Raw)	12.19
D (Vip Raw Dup.)	12.10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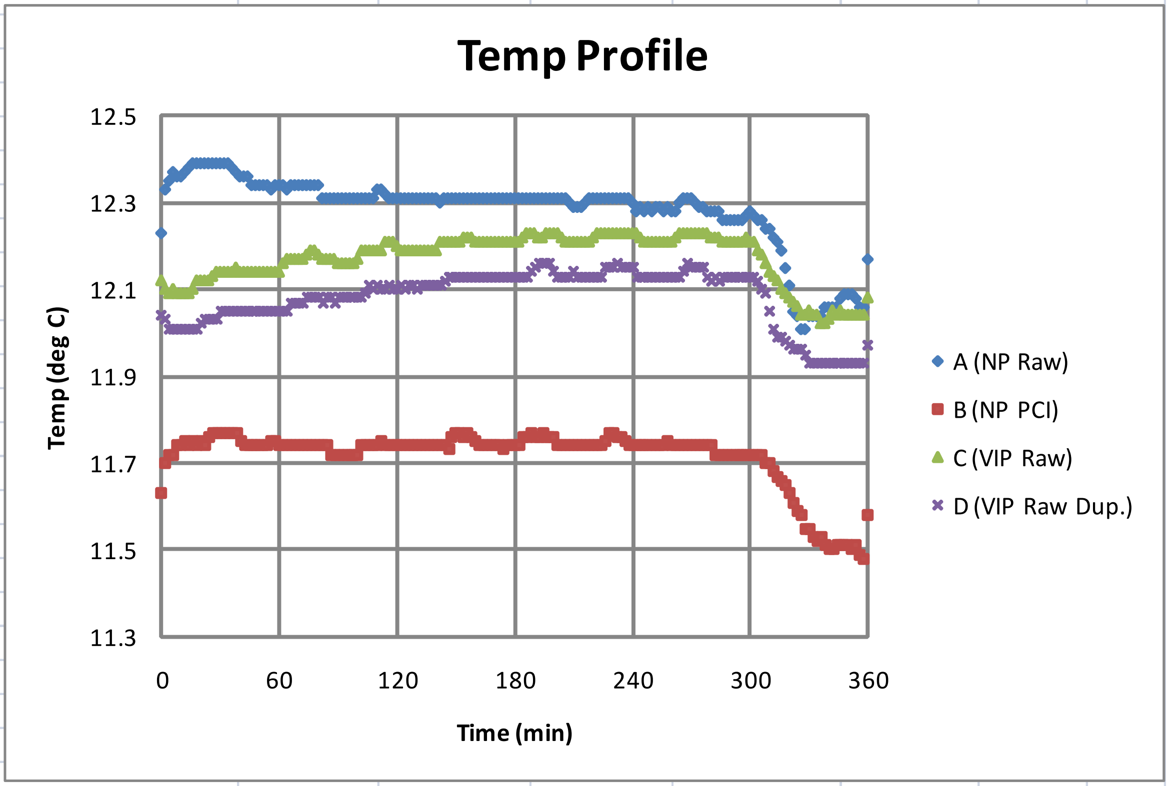
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
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12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

18-Oct-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	28.65	96	87%	83.52	598	43.2	6
B (NP PCI)	30.55	126	87%	109.62	516	47.8	7
C (VIP Raw)	16.75	83	77%	63.91	281	26.9	2
D (Vip Raw Dup.)		100	74%	74	276	28	
	16.75	91.5	0.755	68.955	278.5	27.45	2

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.47	0.60	1.020
B (NP PCI)	7.32	6.20	1.640
C (VIP Raw)	3.89	5.14	0.210
D (Vip Raw Dup.)	3.91	4.24	0.290

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1820	85%	1547
B (NP PCI)	2240	79%	1769.6
C (VIP Raw)	1580	77%	1216.6
D (Vip Raw Dup.)	1540	79%	1217

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.122	7.26	0.027	9		4.6
B (NP PCI)	0.072	14.7	0.027	19		4.95
C (VIP Raw)	0.049	9.49	0.033	7		1.26
D (Vip Raw Dup.)	0.068	8.64	0.033	4		0.88

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	500	235	129.1
B (NP PCI)	435	215	96.0
C (VIP Raw)	225	140	88.6
D (Vip Raw Dup.)	310	145	94.2

	A	B	C	D
OUR (mg O_2/L*hr)	12.76	14.62	2.86	6.92
MLVSS (g/L)	1.55	1.77	1.22	1.22
SOUR (mg O_2/g MLVSS*hr)	8.25	8.26	2.35	5.69

Avg. Temp. (° C)	
A (NP Raw)	12.38
B (NP PCI)	11.86
C (VIP Raw)	12.35
D (Vip Raw Dup.)	12.29

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.55	1.77	1.22	1.22
NR (mg NOx-N/L*hr)	1.48	2.59	1.16	1.18
DNR (mg NOx-N/L*hr)	7.30	5.20	5.61	4.51
SNR (mg NOx-N/g MLVSS*hr)	0.96	1.47	0.95	0.97
SDNR (mg NOx-N/g MLVSS*hr)	4.72	2.94	4.61	3.70

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.93	4.27	0.98	5.25	5.2
10		2.70	1.28	3.98	
15		2.22	1.33	3.55	
20		1.90	1.27	3.17	
90	6.47	0.60	1.02	1.62	6.6
105	5.68	1.10	0.45	1.55	
120	5.25	1.68	0.41	2.09	
150	4.5	2.12	0.39	2.51	5.15
165	3.76	2.58	0.49	3.07	
180	3.5	3.18	0.48	3.66	
195	2.82	3.53	0.59	4.12	4.9
330	0.122	7.26	0.03	7.29	4.6

NP PCI (B)

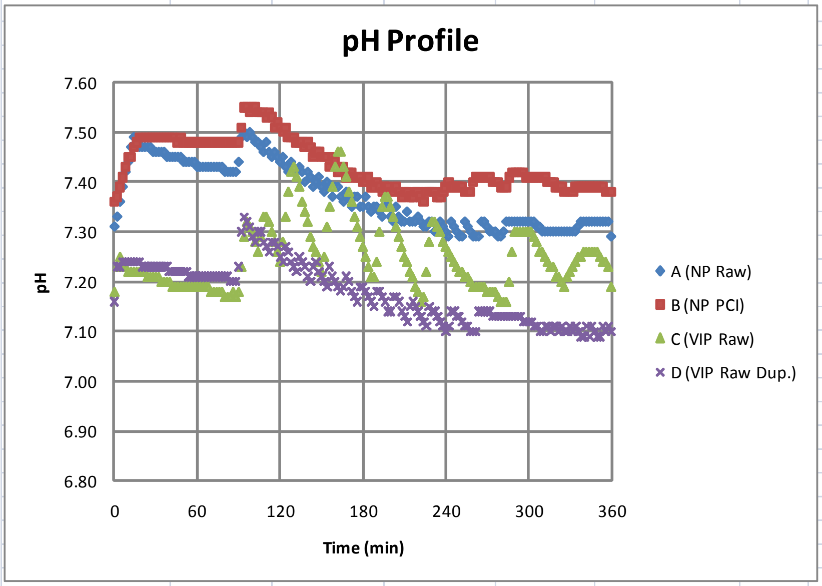
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.32	9.70	0.86	10.56	5.35
10		8.28	1.38	9.66	
15		7.82	1.60	9.42	
20		7.44	1.61	9.05	
90	7.32	6.20	1.64	7.84	7.45
105	6.07	6.64	1.07	7.71	
120	5.36	7.60	1.00	8.60	
150	4.67	8.50	1.06	9.56	5.95
165	3.45	8.46	1.03		
180	3	10.40	1.10	11.50	
195	2.11	10.90	1.11	12.01	5.25
330	0.072	14.70	0.03	14.73	4.6

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	3.93	6.98	0.14	7.12	1.4
10		5.68	0.14		
15		5.84	0.19	6.03	
20		5.40	0.12	5.52	
90	3.89	5.14	0.21	5.35	1.5
105	3.43	5.18	0.33	5.51	
120	3.12	5.66	0.44	6.10	
150	2.64	5.82	0.45	6.27	1.15
165	2.38	6.20	0.44	6.64	
180	1.93	7.16	0.51		
195	1.46	6.99	0.50	7.49	1.04
330	0.049	9.49	0.03	9.52	1.26

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	3.06	6.09	0.180	6.27	0.7
10		5.00	0.270		
15		5.16	0.250	5.41	
20		4.76	0.220	4.98	
90	3.91	4.24	0.290	4.53	1.4
105	3.47	4.30	0.270	4.57	
120	3.16	4.70	0.360	5.06	
150	2.87	5.18	0.400	5.58	1
165	2.44	5.30	0.387	5.69	
180	2.13	6.00	0.413	6.41	
195	1.72	6.03	0.407	6.44	0.88
330	0.068	8.64	0.033	8.67	0.88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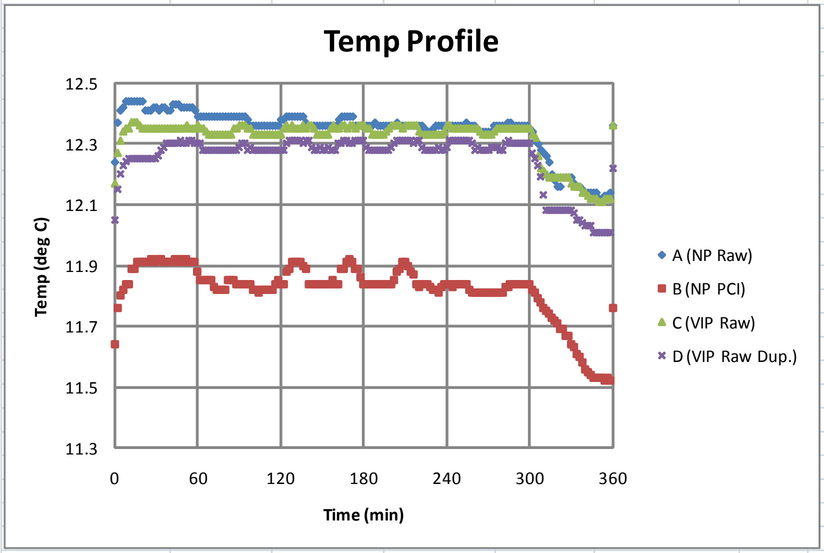
7.60
7.50
7.40
7.30
7.20
7.10
7.00
6.90
6.80
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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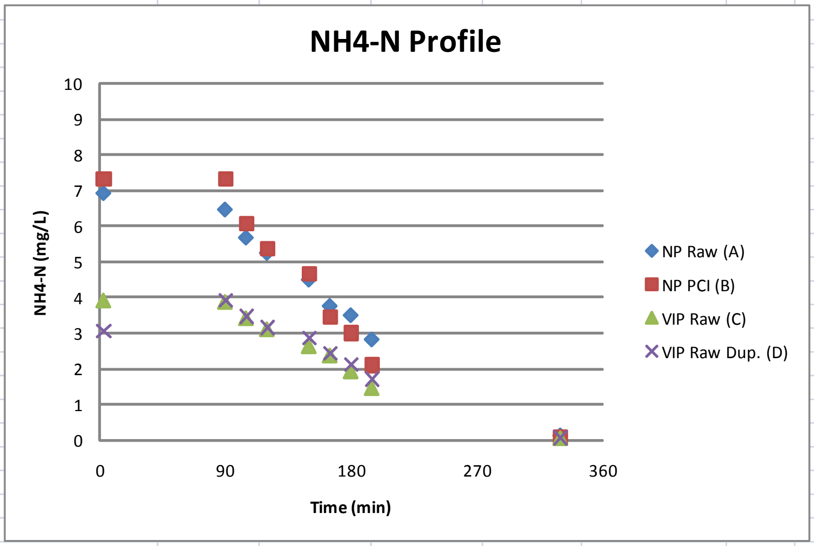
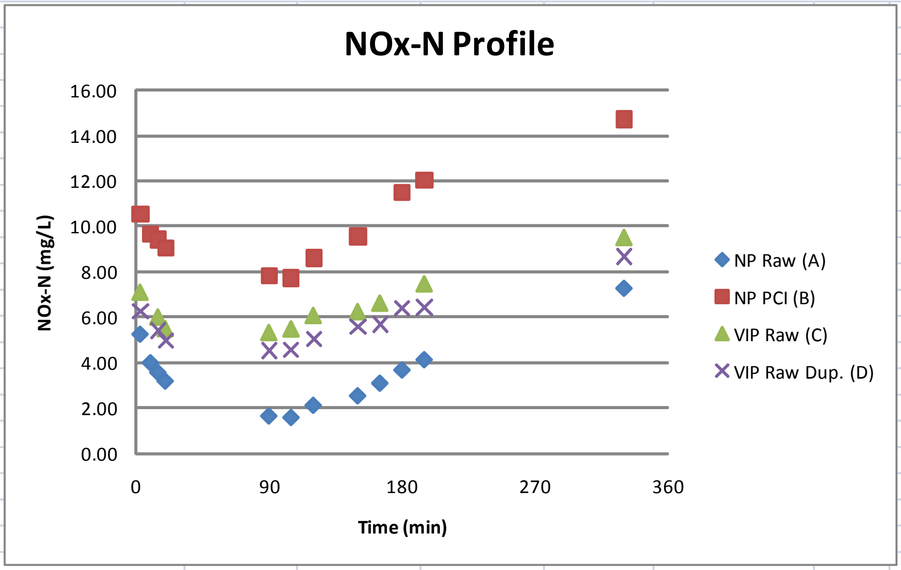
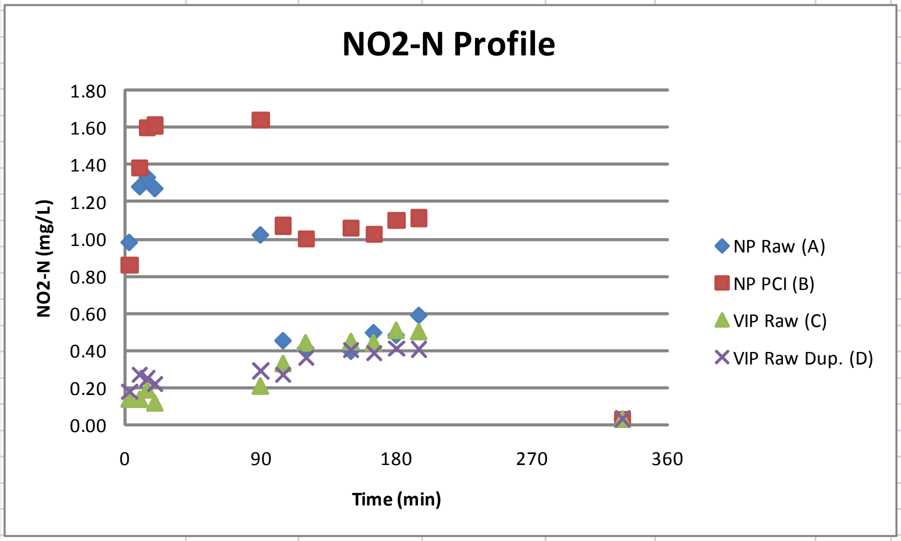
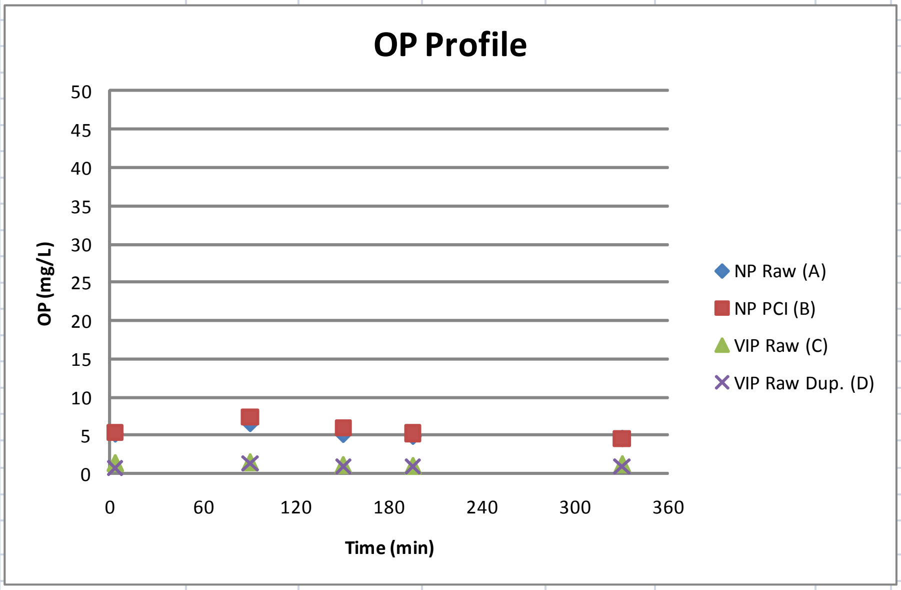
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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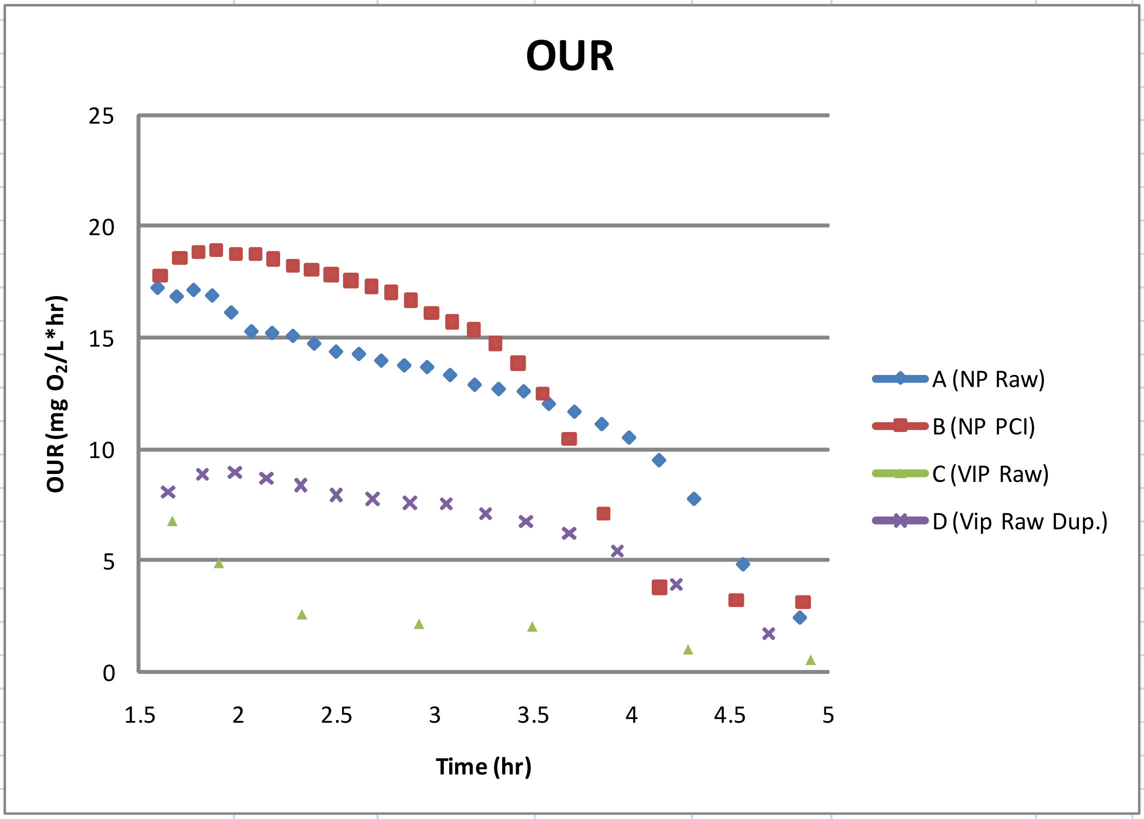
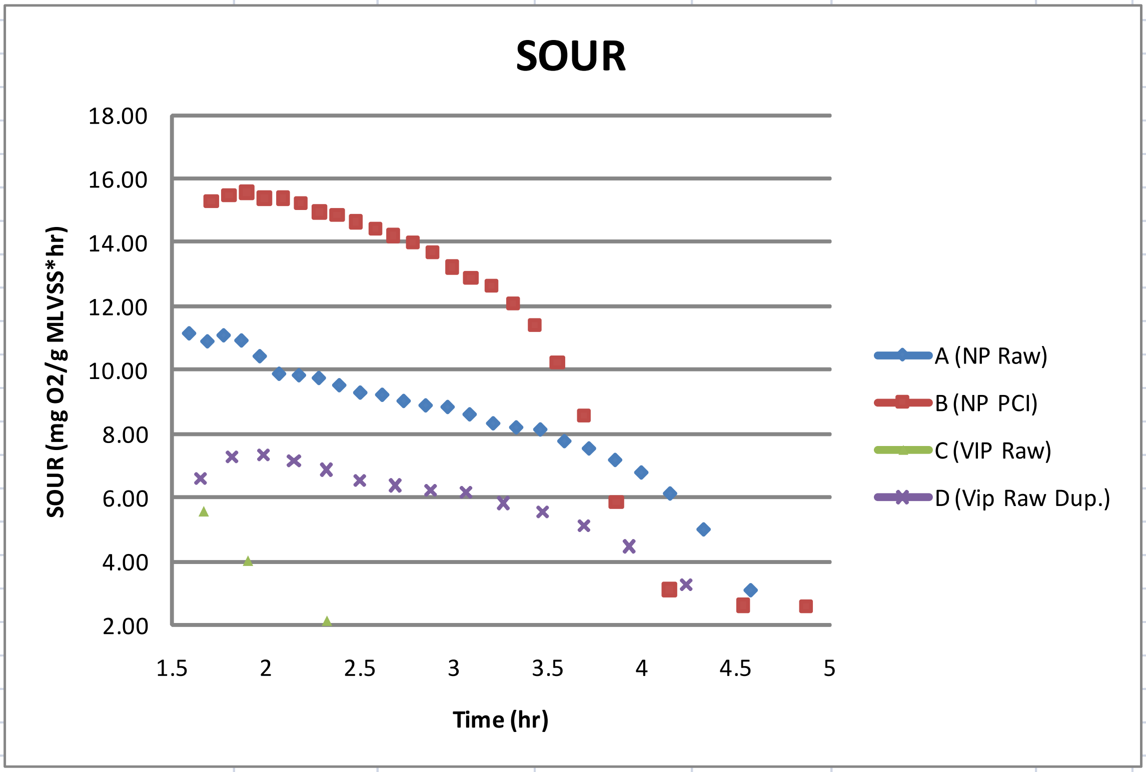
OP (mg/L)
50
45
40
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)

20-Aug-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	30.15	129	85%	109.65	617	45.1	6.7
B (NP PCI)	33.55	155	82%	127.1	459	54.1	8.5
C (VIP Raw)	19.5	55	86%	47.3	261	26.5	3.3
D (Vip Raw Dup.)		55	79%	43.45	277	25.6	
	19.5	55	0.825	45.375	269	26.05	3.3

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.25	0.17	0.040
B (NP PCI)	6.88	6.34	1.360
C (VIP Raw)	3.98	4.32	0.280
D (Vip Raw Dup.)	4.08	3.76	0.320

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2080	79%	1643.2
B (NP PCI)	2420	78%	1887.6
C (VIP Raw)	1760	76%	1337.6
D (Vip Raw Dup.)	1640	76%	1246

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.061	6.78	0.016	8	4.42	5.6
B (NP PCI)	0.059	15.4	0.020	17	8.58	6.6
C (VIP Raw)	0.068	9.55	0.032	8	4.59	1.24
D (Vip Raw Dup.)	0.062	8.59	0.032	7	2.42	0.92

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	510	240
B (NP PCI)	440	225
C (VIP Raw)	220	140
D (Vip Raw Dup.)	315	145

SVI (mL/g)
115.4
93.0
79.5
88.4

	A	B	C	D
OUR (mg O_2/L*hr)	14.12	14.87	7.45	7.30
MLVSS (g/L)	1.64	1.89	1.34	1.25
SOUR (mg O_2/g MLVSS*hr)	8.59	7.88	5.57	5.86

Avg. Temp. (° C)	
A (NP Raw)	12.37
B (NP PCI)	11.79
C (VIP Raw)	12.28
D (Vip Raw Dup.)	12.22

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.64	1.89	1.34	1.25
NR (mg NOx-N/L*hr)	1.89	3.19	1.74	1.57
DNR (mg NOx-N/L*hr)	6.97	6.92	4.57	5.96
SNR (mg NOx-N/g MLVSS*hr)	1.15	1.69	1.30	1.26
SDNR (mg NOx-N/g MLVSS*hr)	4.24	3.66	3.42	4.78

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.78	2.54	1.28	3.82	6.25
10		1.14	1.60	2.74	
15		0.46	1.48	1.94	
20		0.54	1.42	1.96	
90	6.25	0.17	0.04	0.21	7.3
105	5.81	0.54	0.22	0.76	
120	4.97	1.10	0.34	1.44	
150	4.51	1.70	0.42	2.12	6.35
165	3.59	2.31	0.44	2.75	
180	3.1	2.87	0.49	3.36	
195	2.49	2.90	0.50	3.40	6
330	0.061	6.78	0.02	6.80	5.6

NP PCI (B)

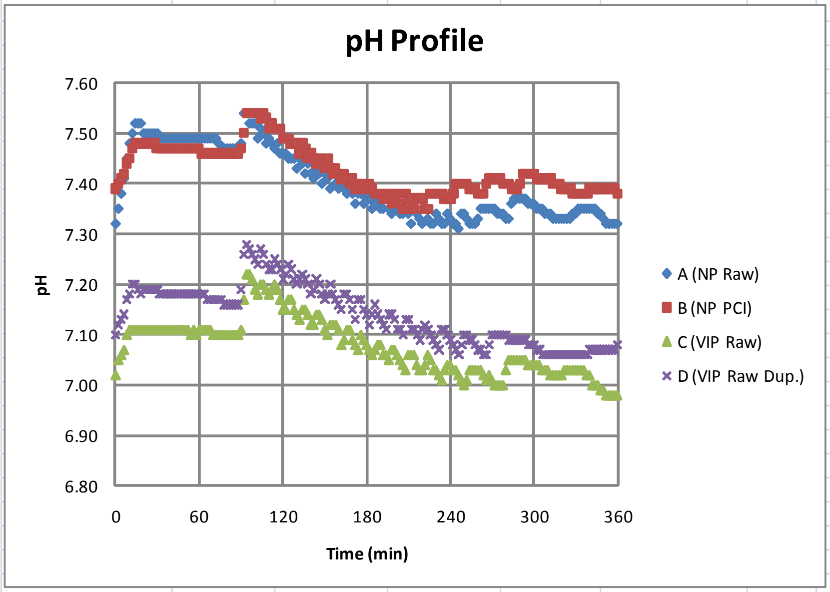
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.56	10.20	0.76	10.96	7.35
10		8.97	1.50	10.47	
15		7.79	1.44	9.23	
20		7.71	1.50	9.21	
90	6.88	6.34	1.36	7.70	7.9
105	6.37	7.21	0.98	8.19	
120	5.24	8.14	1.00	9.14	
150	4.41	9.04	1.08	10.12	7.15
165	3.37	9.53	1.08		
180	2.43	10.90	1.12	12.02	
195	1.62	12.40	1.12	13.52	6.8
330	0.059	15.40	0.02	15.42	6.6

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.97	6.11	0.40	6.51	2.8
10		5.51	0.58		
15		4.72	0.48	5.20	
20		4.90	0.44	5.34	
90	3.98	4.32	0.28	4.60	2.85
105	3.81	4.40	0.28	4.68	
120	3.22	4.80	0.36	5.16	
150	2.92	5.46	0.42	5.88	2.55
165	2.46	5.62	0.42	6.04	
180	1.97	6.13	0.42		
195	1.67	7.36	0.44	7.80	1.32
330	0.068	9.55	0.03	9.58	1.24

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.66	5.58	0.380	5.96	2.6
10		4.94	0.500		
15		4.16	0.420	4.58	
20		3.91	0.420	4.33	
90	4.08	3.76	0.320	4.08	2.9
105	3.84	3.78	0.280	4.06	
120	3.49	3.98	0.310	4.29	
150	2.93	4.56	0.360	4.92	2.35
165	2.52	4.99	0.410	5.40	
180	2.11	5.40	0.370	5.77	
195	1.83	6.73	0.360	7.09	1.06
330	0.062	8.59	0.032	8.62	0.92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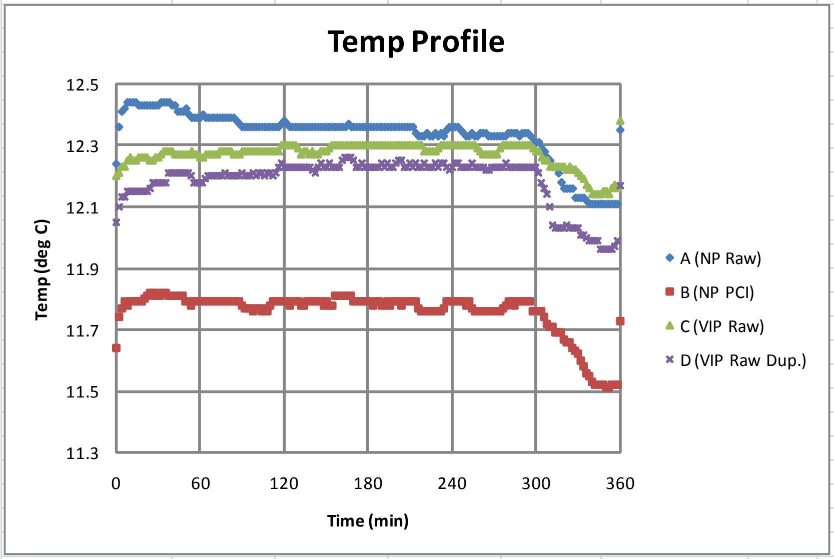
7.40
7.30
7.20
7.10
7.00
6.90
6.80
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.3
12.1
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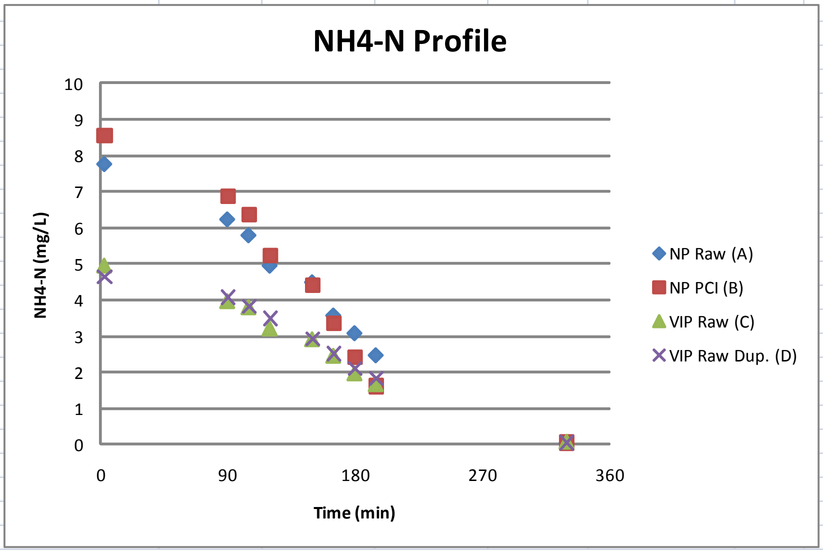
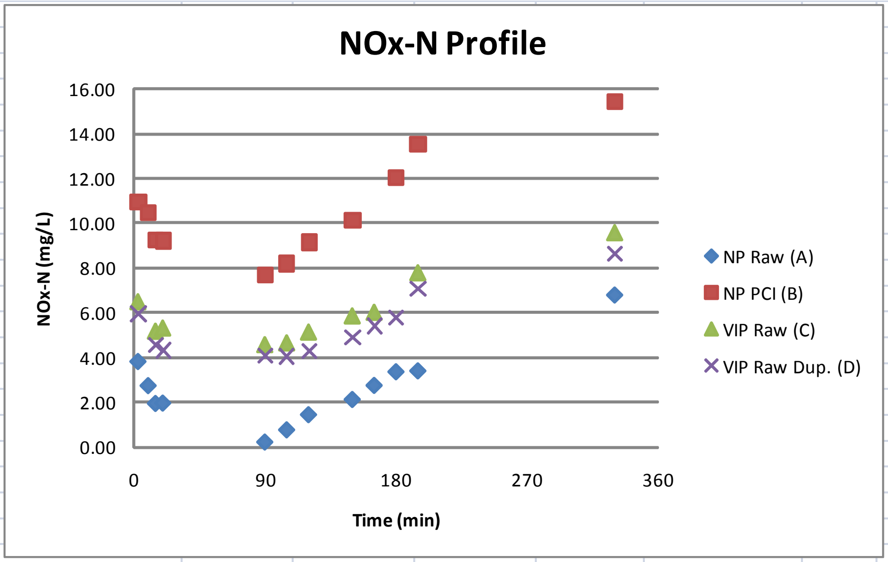
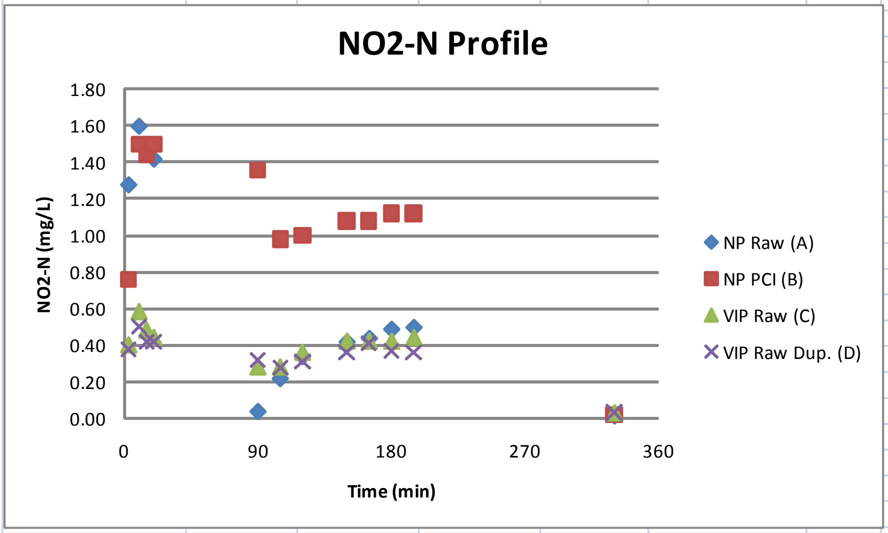
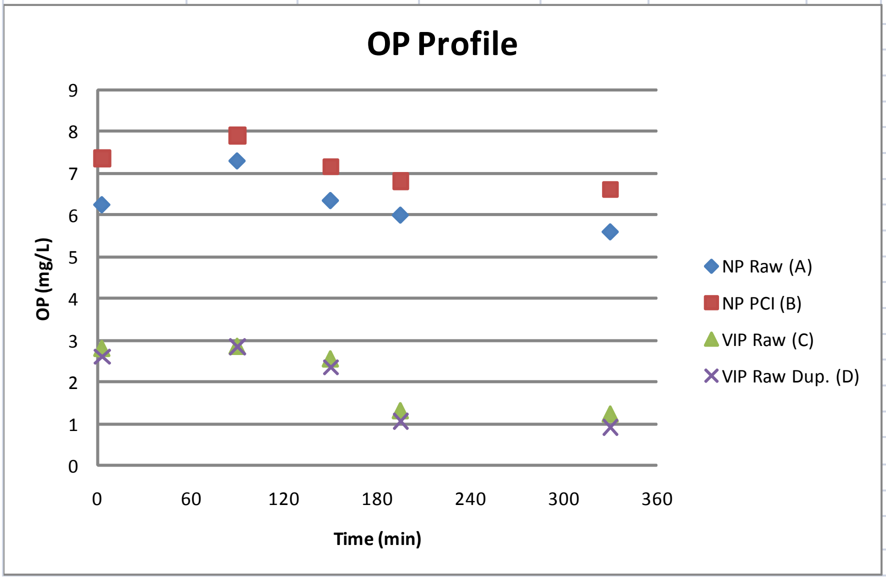
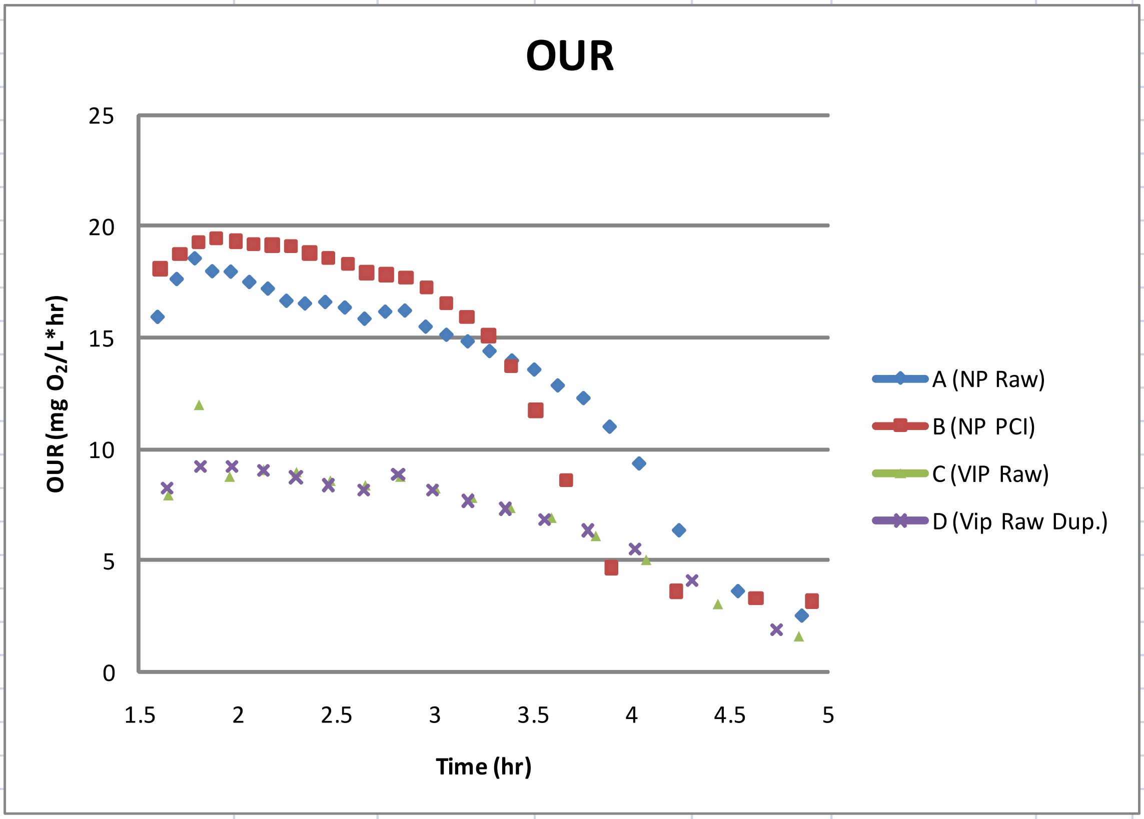
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

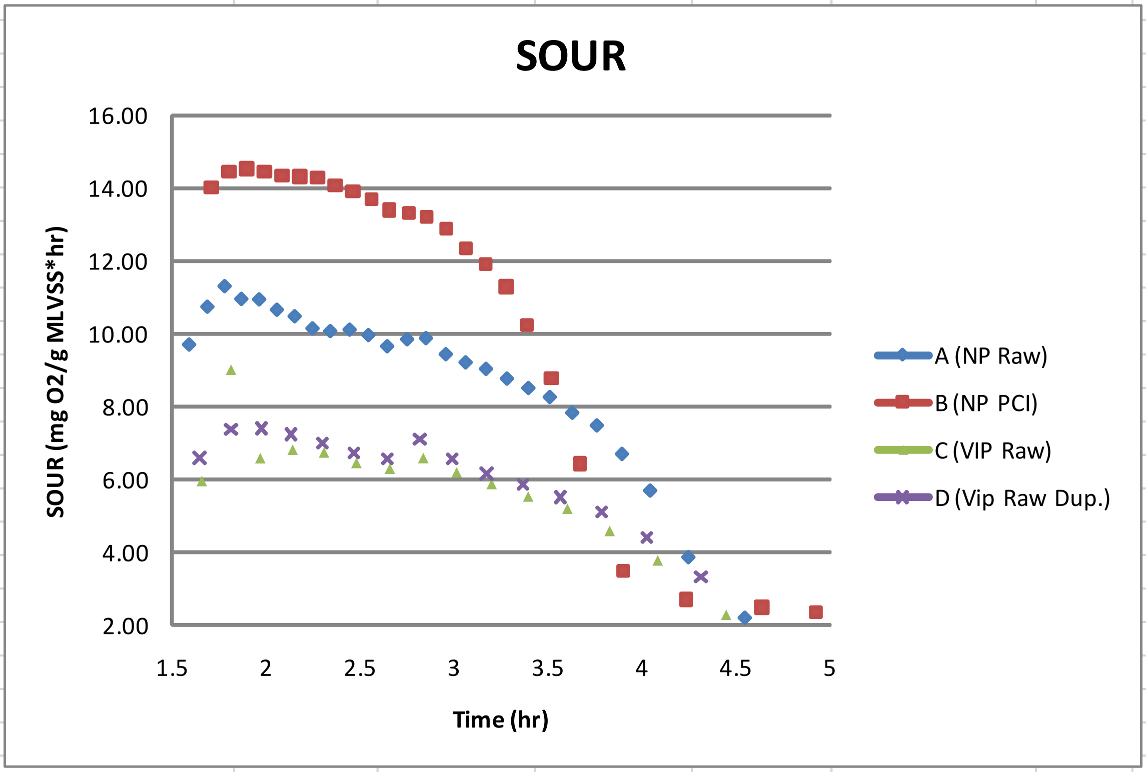

NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCl (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OP Profile
OP (mg/L)
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

22-Oct-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	29.3	110	95%	104.5	412	43.4
B (NP PCI)	30.75	132	92%	121.44	394	44.1
C (VIP Raw)	20.8	68	91%	61.88	279	28.1
D (Vip Raw Dup.)		74	95%	70.3	288	28.8
	20.8	71	0.93	66.09	283.5	28.45

Aerobic Start (0930)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.57	0.98	1.40
B (NP PCI)	7.39	8.17	1.14
C (VIP Raw)	4.61	1.66	0.32
D (Vip Raw Dup.)	4.44	1.97	0.34

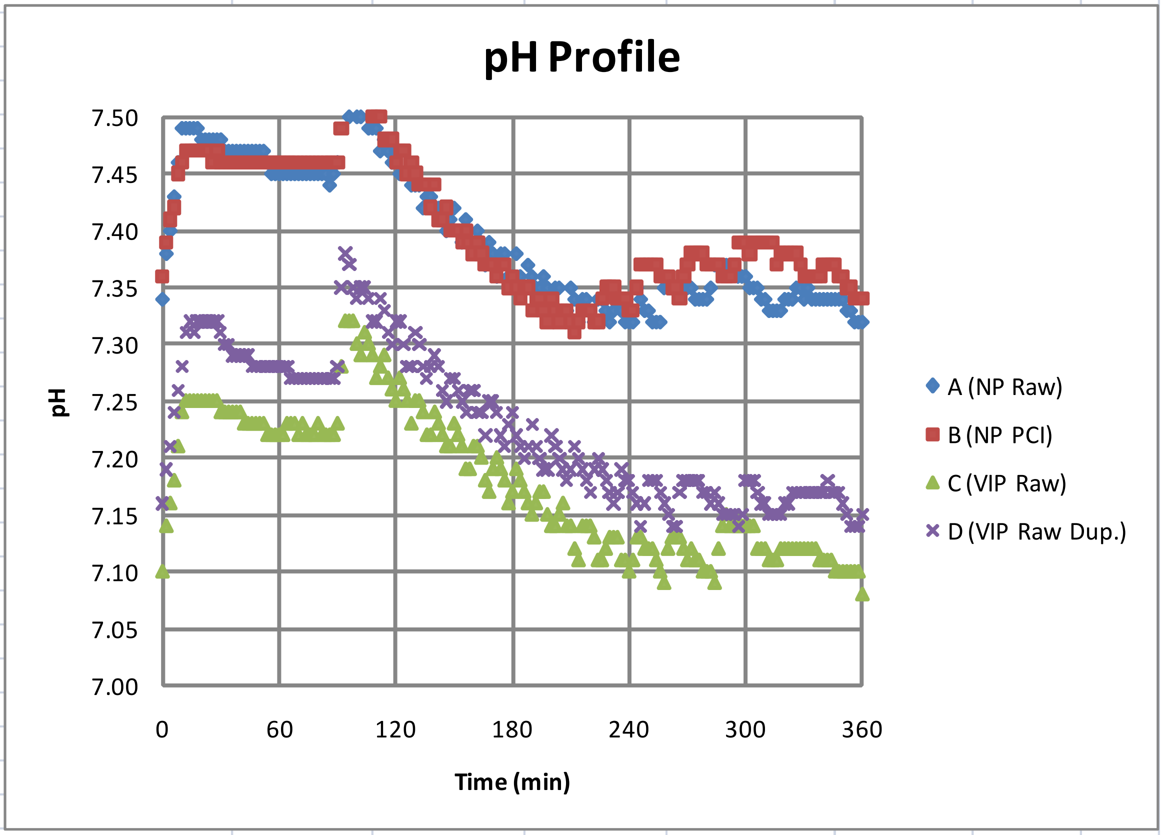
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1820	85%	1547.0
B (NP PCI)	2320	81%	1879.2
C (VIP Raw)	1440	81%	1166.4
D (Vip Raw Dup.)	1340	81%	1085.4

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.089	7.6	0.02	7	4.18
B (NP PCI)	0.088	15.8	0.02	14	7.76
C (VIP Raw)	0.089	5.8	0.032	7	3.77
D (Vip Raw Dup.)	0.069	6.1	0.024	5	2.15

Settled Sludge Volume (mL/L)	5 min	30 min		SVI (mL/g)
A (NP Raw)				0.0
B (NP PCI)				0.0
C (VIP Raw)				0.0
D (Vip Raw Dup.)				0.0

	A	B	C	D
OUR (mg O_2/L*hr)	13.89	15.50	7.54	8.00
MLVSS (g/L)	1.55	1.88	1.17	1.09
SOUR (mg O_2/g MLVSS*hr)	8.98	8.25	6.46	7.37

Avg. Temp. (° C)	
A (NP Raw)	12.31
B (NP PCI)	11.74
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.14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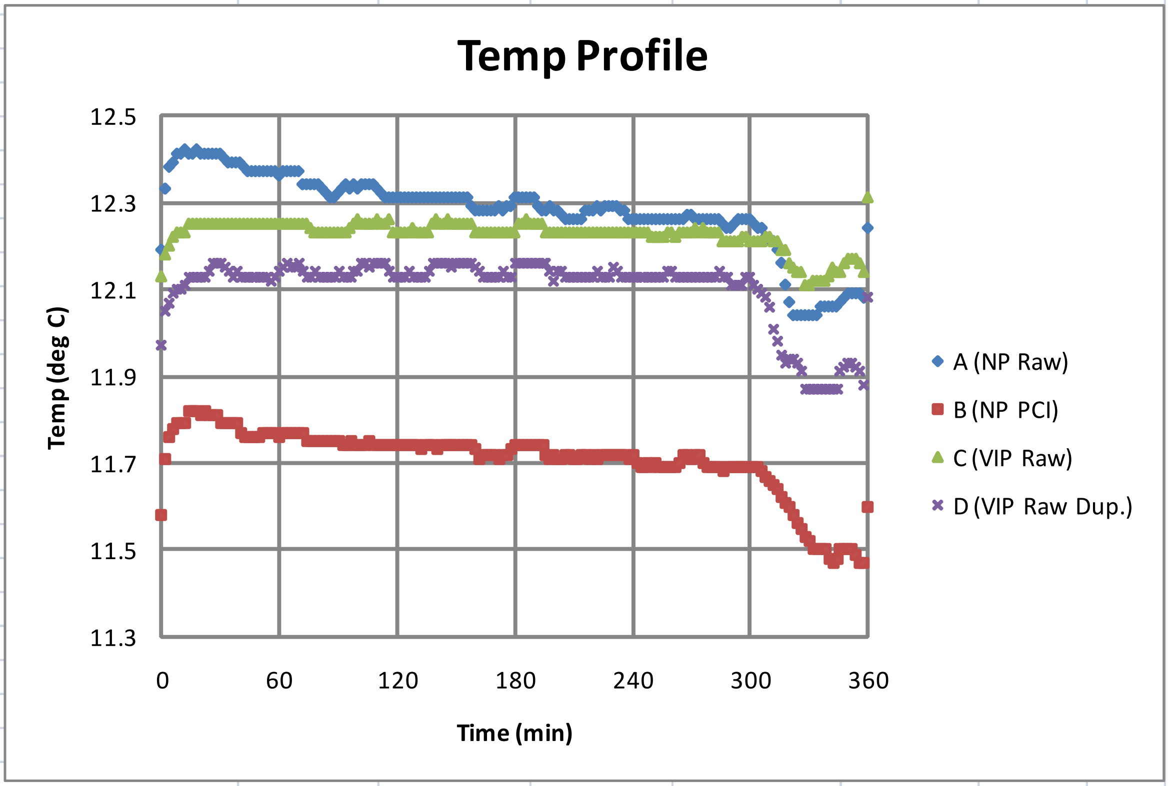
7.40
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

25-Oct-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	29.3	101	87%	87.87	373	48.6	6.1
B (NP PCI)	30.65	129	87%	112.23	389	48	7
C (VIP Raw)	21	69	82%	56.58	288	28.5	2.6
D (Vip Raw Dup.)		76	81%	61.56	282	30.1	
	21	72.5	0.815	59.07	285	29.3	2.6

Aerobic Start (0930)			
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.58	1.77	1.080
B (NP PCI)	6.99	6.31	1.540
C (VIP Raw)	4.67	2.19	0.240
D (Vip Raw Dup.)	4.58	2.49	0.260

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1860	82%	1525.2
B (NP PCI)	2200	80%	1760
C (VIP Raw)	1480	81%	1198.8
D (Vip Raw Dup.)	1480	80%	1184

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.053	8.97	0.020	8	5.28	5.3
B (NP PCI)	0.052	14.5	0.024	14	8.14	5.5
C (VIP Raw)	0.064	6.9	0.052	10	5.29	1.54
D (Vip Raw Dup.)	0.050	7.16	0.032	9	3.98	1.26

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	540	250
B (NP PCI)	475	240
C (VIP Raw)	225	140
D (Vip Raw Dup.)	330	150

SVI (mL/g)
134.4
109.1
94.6
101.4

	A	B	C	D
OUR (mg O_2/L*hr)	13.90	15.36	7.97	8.19
MLVSS (g/L)	1.53	1.76	1.20	1.18
SOUR (mg O_2/g MLVSS*hr)	9.11	8.73	6.65	6.92

Avg. Temp. (° C)	
A (NP Raw)	12.39
B (NP PCI)	11.82
C (VIP Raw)	12.30
D (Vip Raw Dup.)	12.24

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.53	1.76	1.20	1.18
NR (mg NOx-N/L*hr)	2.55	3.36	1.42	1.48
DNR (mg NOx-N/L*hr)	10.26	6.41	7.32	5.72
SNR (mg NOx-N/g MLVSS*hr)	1.67	1.91	1.19	1.25
SDNR (mg NOx-N/g MLVSS*hr)	6.73	3.64	6.11	4.83

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.09	5.37	1.28	6.65	5.7
10		3.43	1.44	4.87	
15		3.14	1.26	4.40	
20		2.41	1.26	3.67	
90	6.58	1.77	1.08	2.85	6.3
120	4.85	3.09	0.54	3.63	
150	4.22	3.84	0.58	4.42	
165	3.27	4.29	0.64	4.93	5.15
180	2.63	5.76	0.66	6.42	
195	2.15	6.41	0.66	7.07	
210	1.49	7.16	0.66	7.82	5.4
330	0.053	8.97	0.02	8.99	5.3

NP PCI (B)

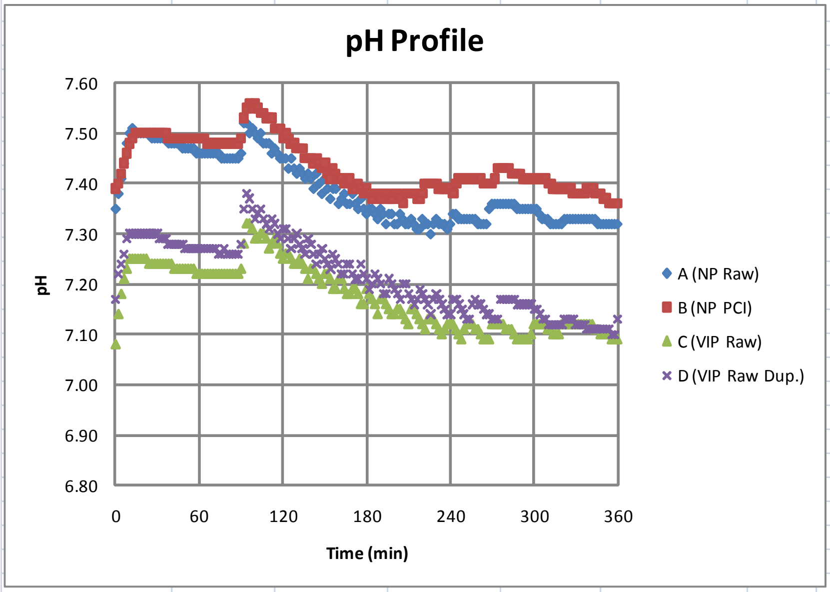
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.59	10.30	1.40	11.70	6.2
10		8.95	1.56	10.51	
15		8.37	1.34	9.71	
20		8.66	1.38	10.04	
90	6.99	6.31	1.54	7.85	6.9
120	4.7	8.40	1.14	9.54	
150	3.91	9.61	1.18	10.79	
165	3.06	10.40	1.32	11.72	5.85
180	2.01	11.70	1.36		
195	1.14	12.30	1.28	13.58	
210	0.558	13.70	1.02	14.72	5.65
330	0.052	14.50	0.02	14.52	5.5

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.26	4.83	0.44	5.27	1.9
10		3.43	0.60		
15		3.02	0.46	3.48	
20		2.88	0.42	3.30	
90	4.67	2.19	0.24	2.43	2.15
120	3.68	2.85	0.34	3.19	
150	3.29	3.23	0.36	3.59	
165	2.73	3.15	0.36	3.51	1.6
180	2.49	3.83	0.37	4.20	
195	2.11	4.07	0.38		
210	1.73	5.25	0.37	5.62	1.56
330	0.064	6.90	0.05	6.95	1.54

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.03	4.61	0.380	4.99	1.7
10		3.84	0.560		
15		2.93	0.440	3.37	
20		3.12	0.400	3.52	
90	4.58	2.49	0.260	2.75	2.0
120	3.84	3.06	0.360	3.42	
150	3.36	3.42	0.340	3.76	
165	2.79	3.89	0.350	4.24	1.45
180	2.47	4.24	0.380	4.62	
195	2.07	5.18	0.390	5.57	
210	1.74	5.21	0.380	5.59	1.36
330	0.05	7.16	0.032	7.19	1.26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7.30
7.20
7.10
7.00
6.90
6.80
pH
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60
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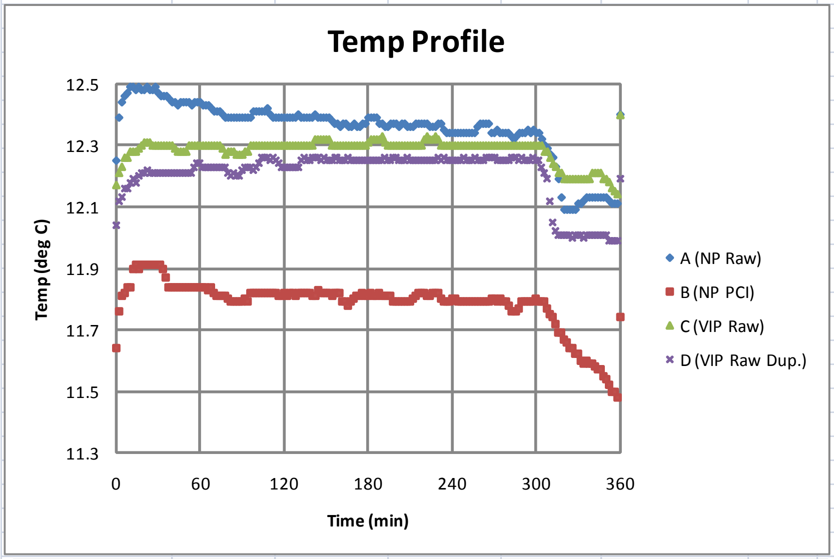
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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11.9
11.7
11.5
11.3
Temp (deg C)
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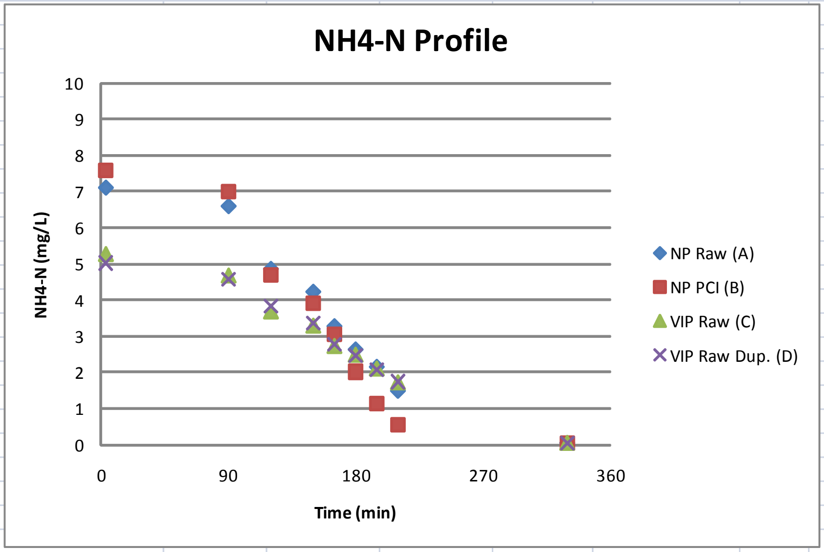
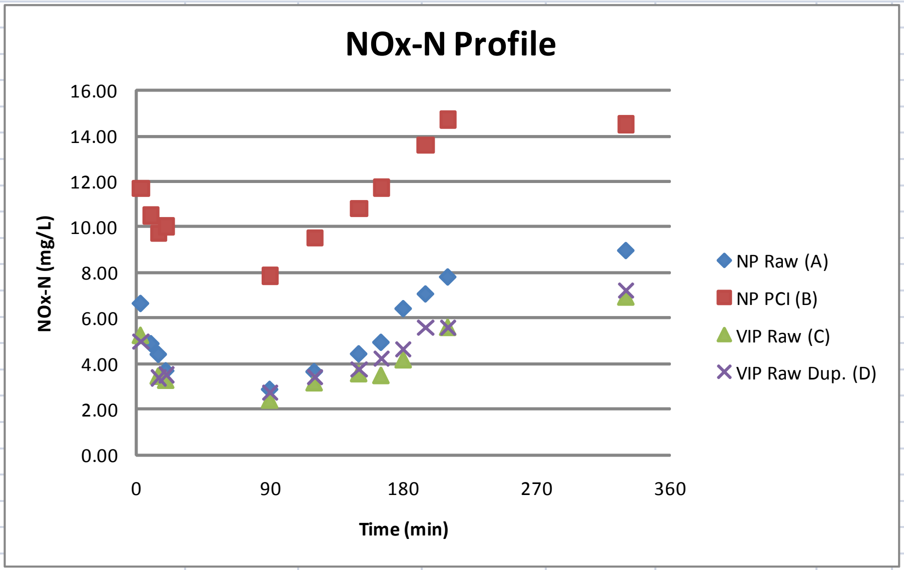
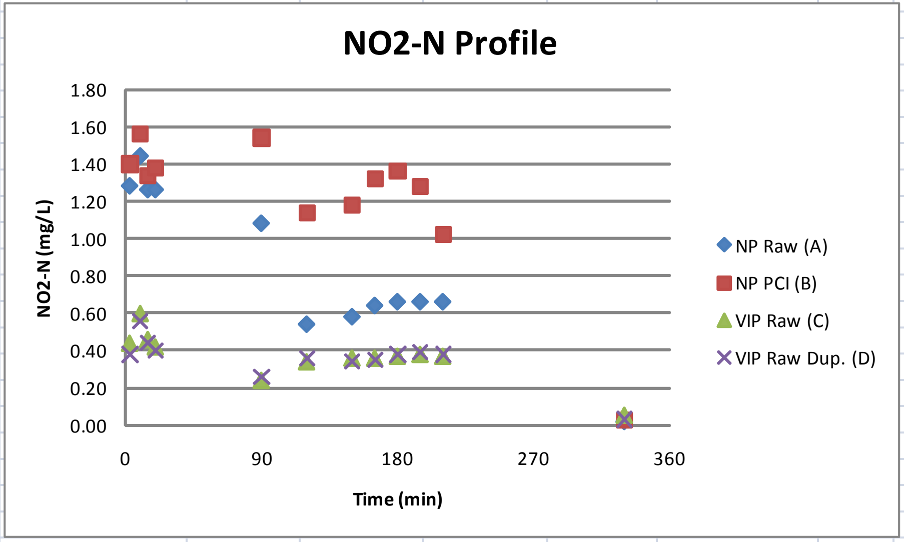
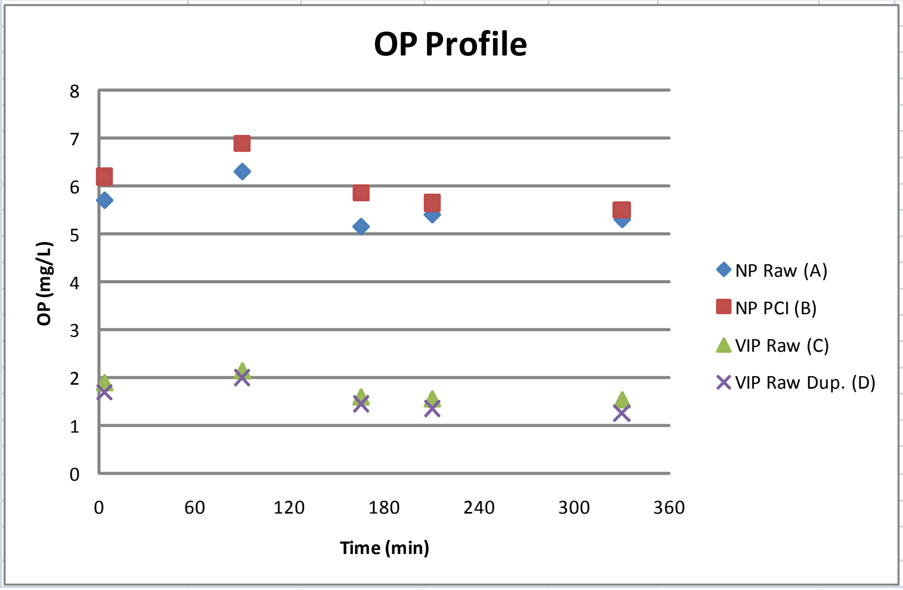
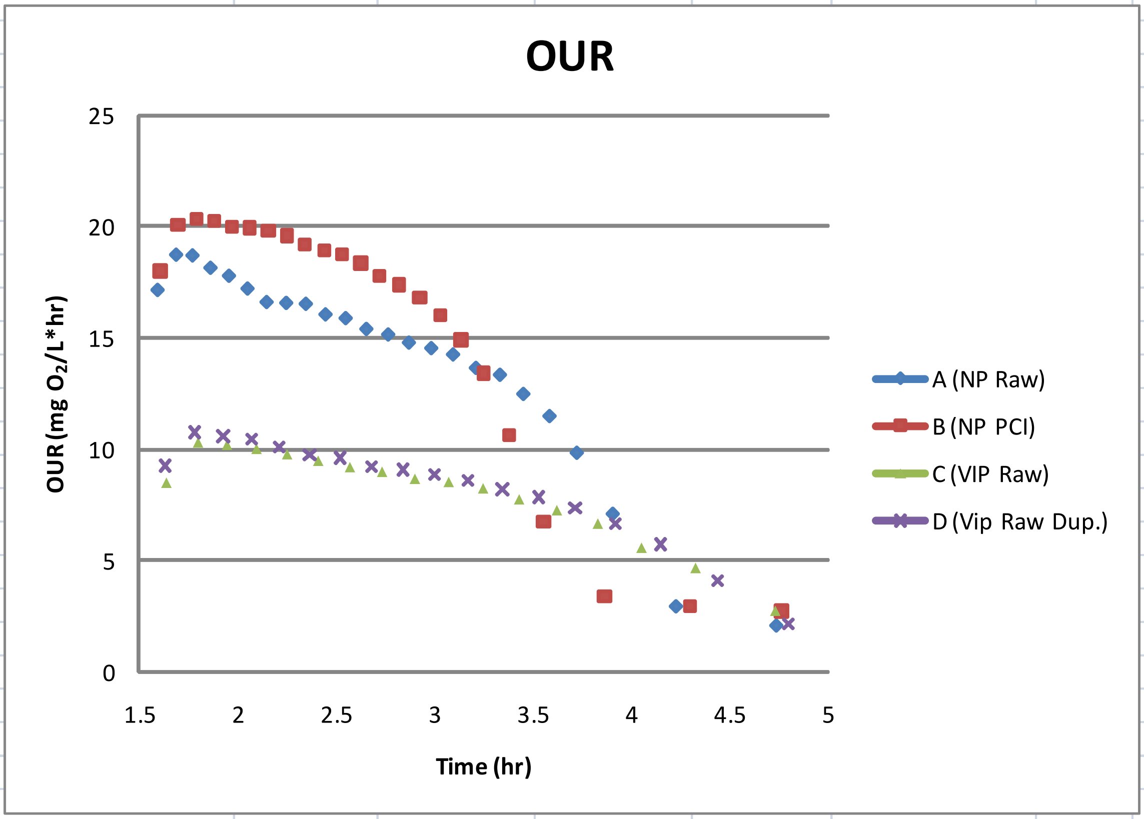
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

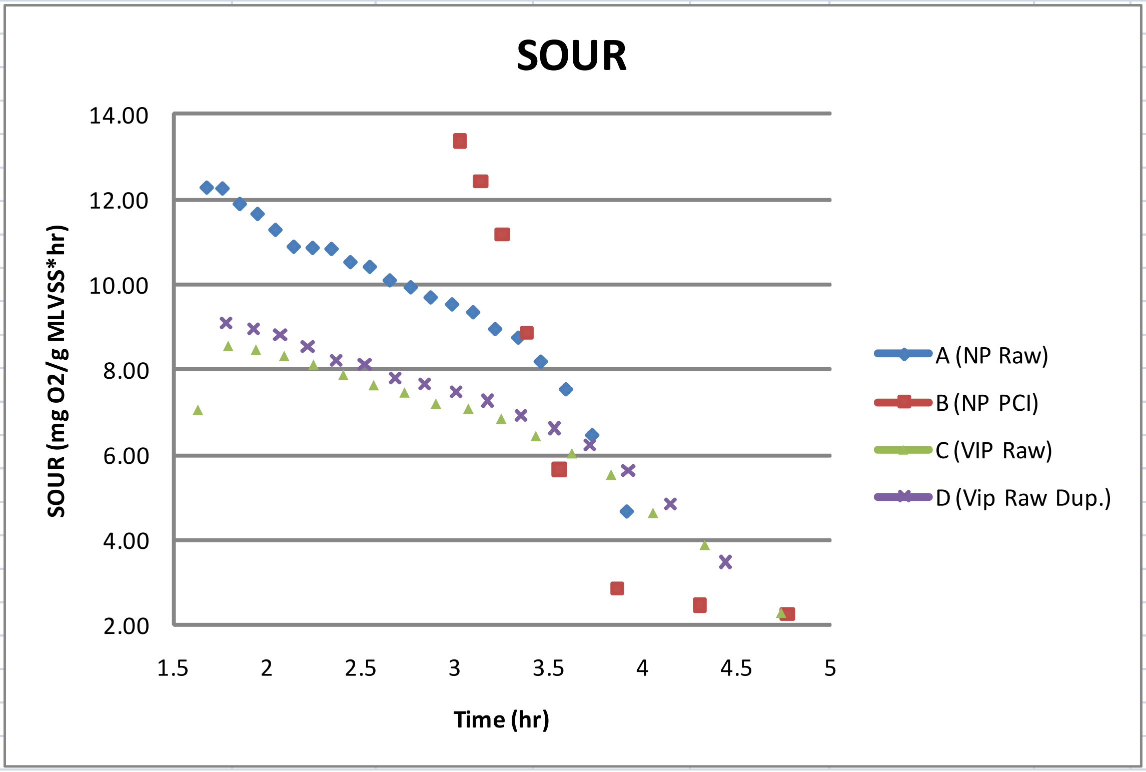

NH4-N Profile
10
9
8
7
6
5
4
3
2
1
0
NH4-N (mg/L)
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

27-Oct-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	28.1	121	87%	105.27	518	44.1	5.7
B (NP PCI)	29.15	126	88%	110.88	466	43.1	6.7
C (VIP Raw)	21.25	186	78%	145.08	569	33.9	2.7
D (Vip Raw Dup.)		165	80%	132	744	34.7	
	21.25	175.5	0.79	138.54	656.5	34.3	2.7

Aerobic Start (0930)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L
A (NP Raw)	6.12	0.29	0.060
B (NP PCI)	6.65	5.33	1.780
C (VIP Raw)	4.76	0.19	0.040
D (Vip Raw Dup.)	4.79	0.16	0.020

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1860	82%	1525.2
B (NP PCI)	2240	79%	1769.6
C (VIP Raw)	1620	81%	1312.2
D (Vip Raw Dup.)	1540	83%	1278

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.065	6.42	0.020	9	5.25	5.05
B (NP PCI)	0.074	13.3	0.028	12	5.77	5.25
C (VIP Raw)	0.066	4.42	0.024	7	4.42	1.35
D (Vip Raw Dup.)	0.064	4.32	0.024	7	3.71	1.05

Settled Sludge Volume (mL/L)

	5 min	30 min
A (NP Raw)	545	250
B (NP PCI)	470	240
C (VIP Raw)	225	140
D (Vip Raw Dup.)	335	150

SVI (mL/g)
134.4
107.1
86.4
97.4

	A	B	C	D
OUR (mg O_2/L*hr)	14.69	16.24	9.30	9.78
MLVSS (g/L)	1.53	1.77	1.31	1.28
SOUR (mg O_2/g MLVSS*hr)	9.63	9.18	7.08	7.65

Avg. Temp. (° C)

A (NP Raw)	12.45
B (NP PCI)	11.95
C (VIP Raw)	12.39
D (Vip Raw Dup.)	12.32

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.53	1.77	1.31	1.28
NR (mg NOx-N/L*hr)	2.01	3.04	1.47	2.07
DNR (mg NOx-N/L*hr)	8.73	6.34	3.91	5.22
SNR (mg NOx-N/g MLVSS*hr)	1.32	1.72	1.12	1.62
SDNR (mg NOx-N/g MLVSS*hr)	5.73	3.58	2.98	4.08

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.53	4.10	1.16	5.26	6.25
10		2.50	1.46	3.96	
15		2.10	1.24	3.34	
20		1.60	1.18	2.78	
90	6.12	0.29	0.06	0.35	7.3
105	5.63	1.50	0.24	1.74	
120	4.87	2.30	0.34	2.64	
150	4.02	2.90	0.36	3.26	6.35
165	3.15	2.80	0.46	3.26	
180	2.51	3.60	0.50	4.10	
195	1.85	3.80	0.52	4.32	6
330	0.065	6.42	0.02	6.44	5.6

NP PCI (B)

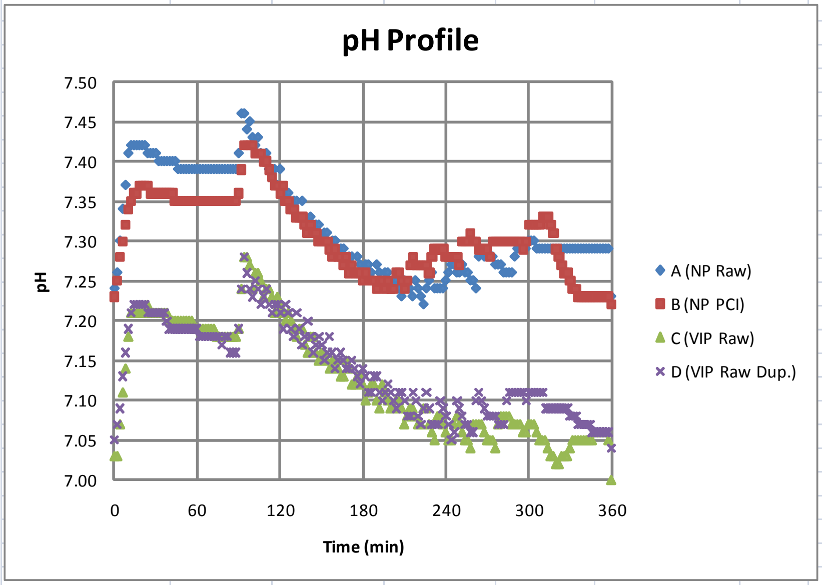
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.79	10.30	1.04	11.34	7.35
10		7.90	1.50	9.40	
15		7.30	1.50	8.80	
20		8.20	1.52	9.72	
90	6.65	5.33	1.78	7.11	7.9
105	5.74	7.30	1.26	8.56	
120	4.65	8.00	1.09	9.09	
150	3.86	10.00	1.16	11.16	7.15
165	2.73	9.60	1.20		
180	1.74	10.10	1.23	11.33	
195	1.05	12.00	1.10	13.10	6.8
330	0.074	13.30	0.03	13.33	6.6

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.12	2.80	0.74	3.54	2.8
10		2.00	0.74		
15		1.90	0.58	2.48	
20		2.00	0.52	2.52	
90	4.76	0.19	0.04	0.23	2.85
105	4.17	1.30	0.20	1.50	
120	3.88	1.40	0.25	1.65	
150	3.47	1.70	0.30	2.00	2.55
165	2.9	1.80	0.31	2.11	
180	2.44	2.80	0.34		
195	2.08	3.10	0.33	3.43	1.32
330	0.066	4.42	0.02	4.44	1.24

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.98	2.80	0.580	3.38	2.6
10		2.40	0.620		
15		2.20	0.520	2.72	
20		1.30	0.480	1.78	
90	4.79	0.16	0.020	0.18	2.9
105	4.46	0.70	0.180	0.88	
120	3.74	0.60	0.248	0.85	
150	3.34	1.50	0.280	1.78	2.35
165	2.87	2.40	0.288	2.69	
180	2.44	3.20	0.304	3.50	
195	2.08	3.40	0.320	3.72	1.06
330	0.064	4.32	0.024	4.34	0.92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7.10
7.05
7.00
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60
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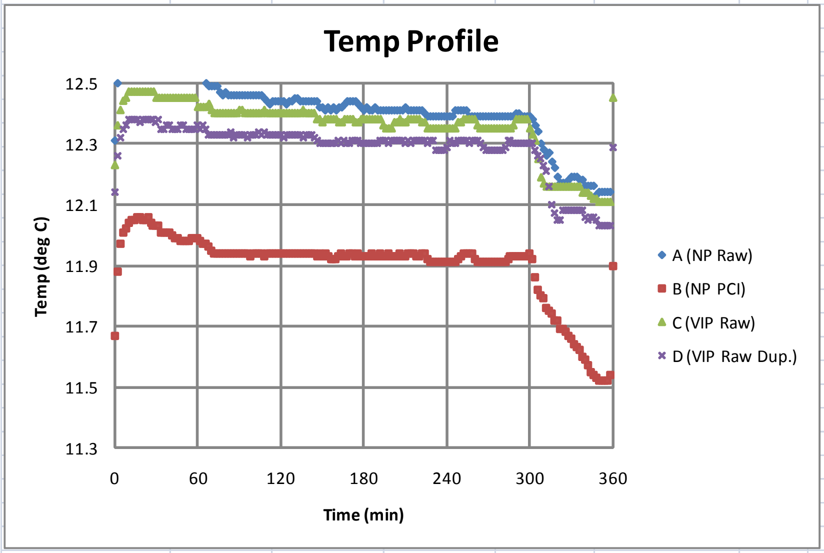
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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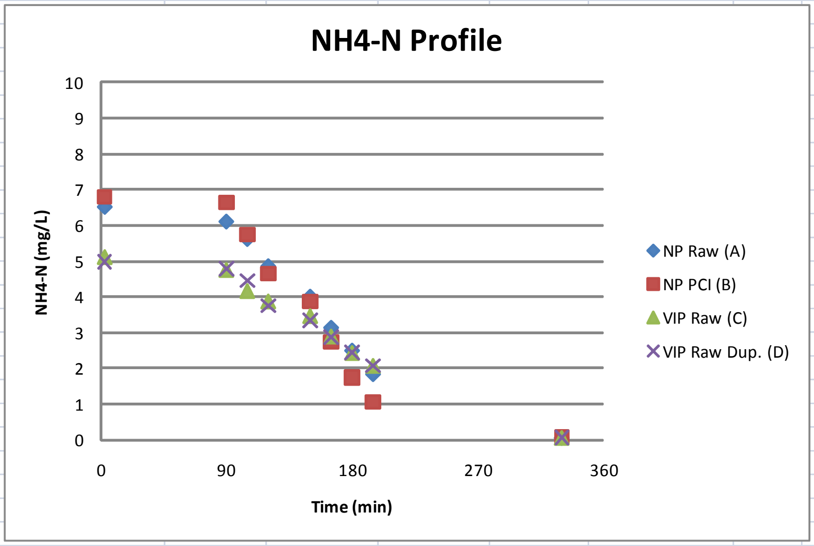
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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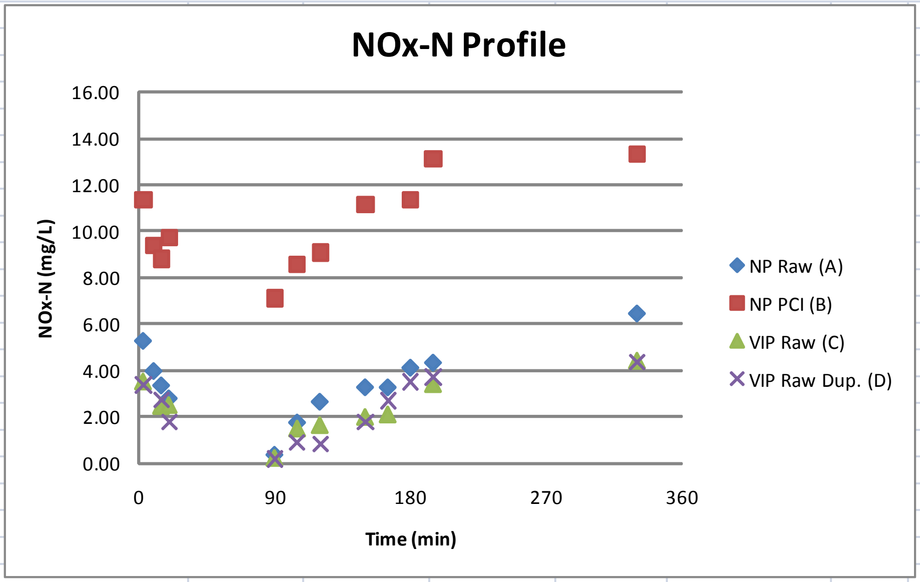
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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NOx-N (mg/L)
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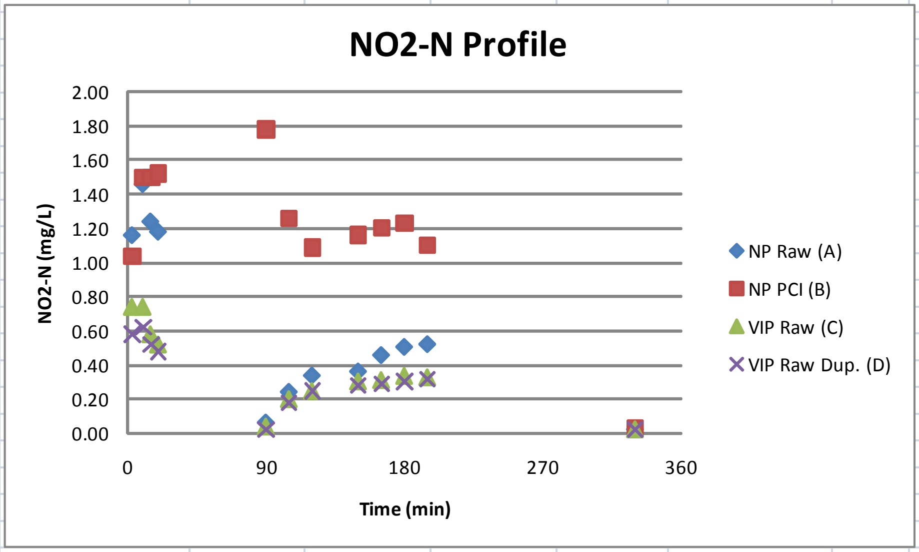
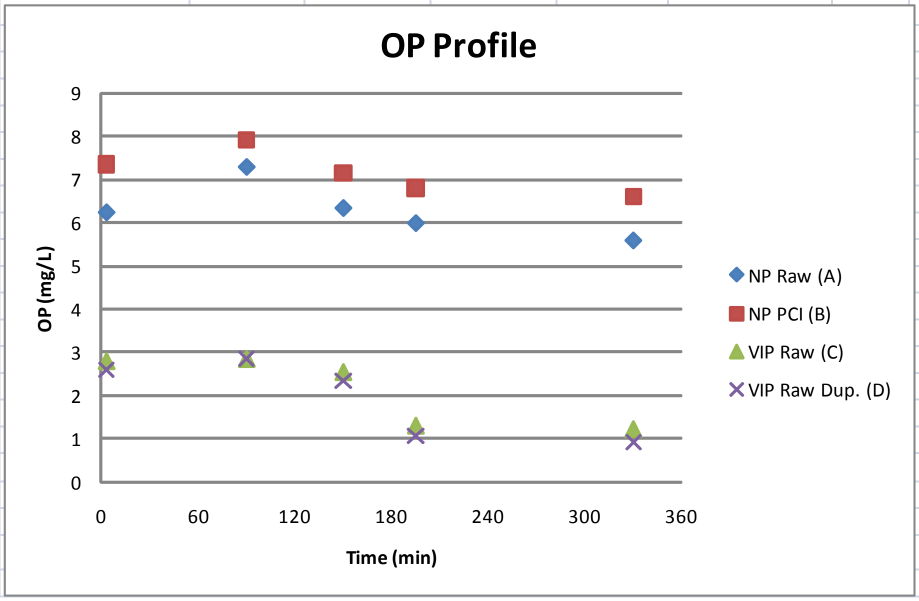
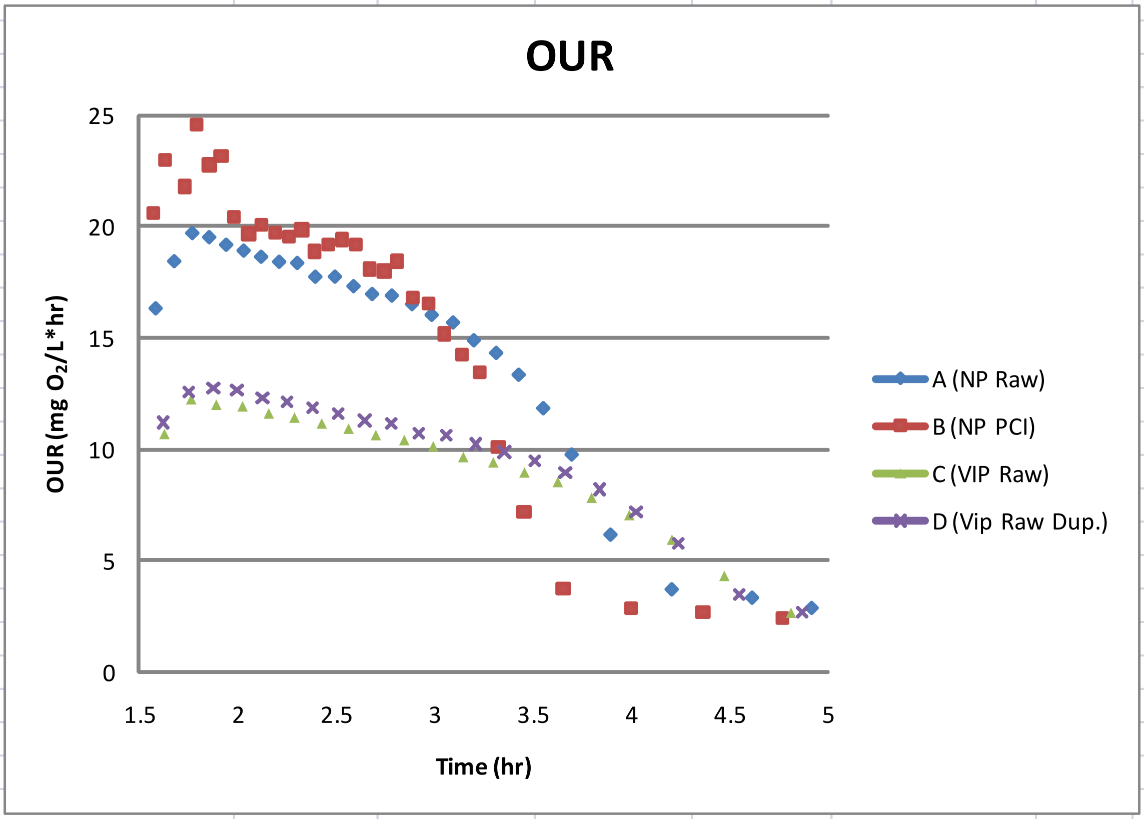
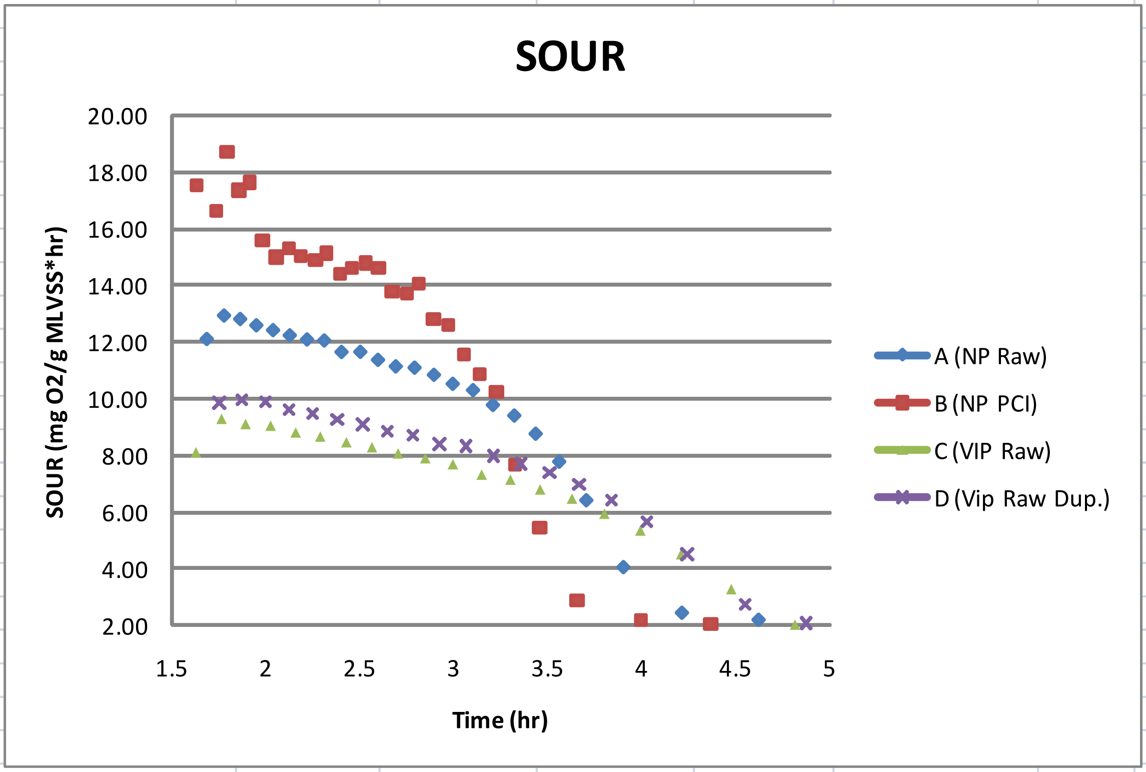
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OP Profile
OP (mg/L)
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

29-Oct-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	32.2	121	87%	105.27	436	44.1
B (NP PCI)	34.05	125	84%	105	384	47
C (VIP Raw)	23.85	99	86%	85.14	352	32.6
D (Vip Raw Dup.)		93	89%	82.77	401	31.3
	23.85	96	88%	83.955	376.5	31.95

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1860	83%	1543.8
B (NP PCI)	2140	81%	1733.4
C (VIP Raw)	1560	79%	1232.4
D (Vip Raw Dup.)	1420	82%	1164.4

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.074	7.1	0.02	7	
B (NP PCI)	0.067	13.9	0.024	9	
C (VIP Raw)	0.059	4.5	0.028	6	
D (Vip Raw Dup.)	0.063	4.4	0.028	7	

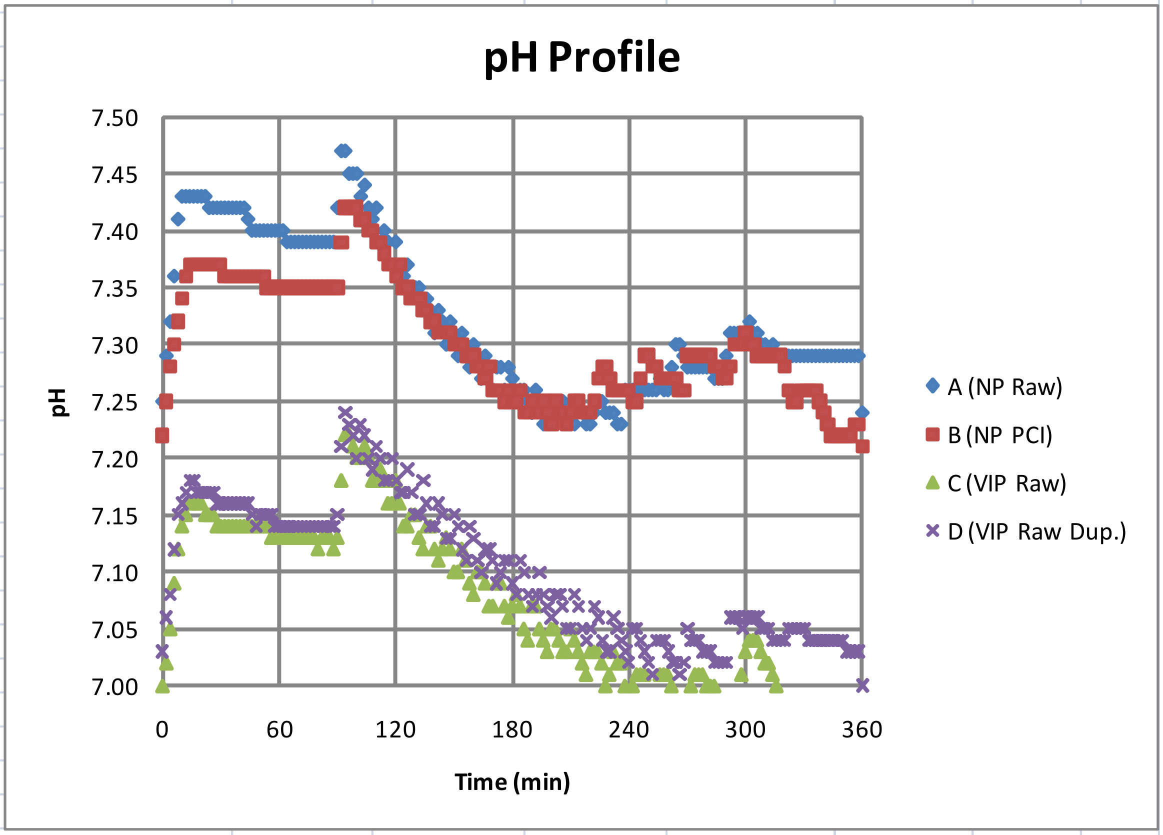
Settled Sludge Volume (mL/L)

	5 min	30 min
A (NP Raw)	620	290
B (NP PCI)	560	270
C (VIP Raw)	270	160
D (Vip Raw Dup.)	390	170

SVI (mL/g)
155.9
126.2
102.6
119.7

	A	B	C	D
OUR (mg O_2/L*hr)	14.19	15.36	8.76	9.27
MLVSS (g/L)	1.54	1.73	1.23	1.16
SOUR (mg O_2/g MLVSS*hr)	9.19	8.86	7.11	7.96

Avg. Temp. (° C)	
A (NP Raw)	12.29
B (NP PCI)	11.69
C (VIP Raw)	12.22
D (Vip Raw Dup.)	12.10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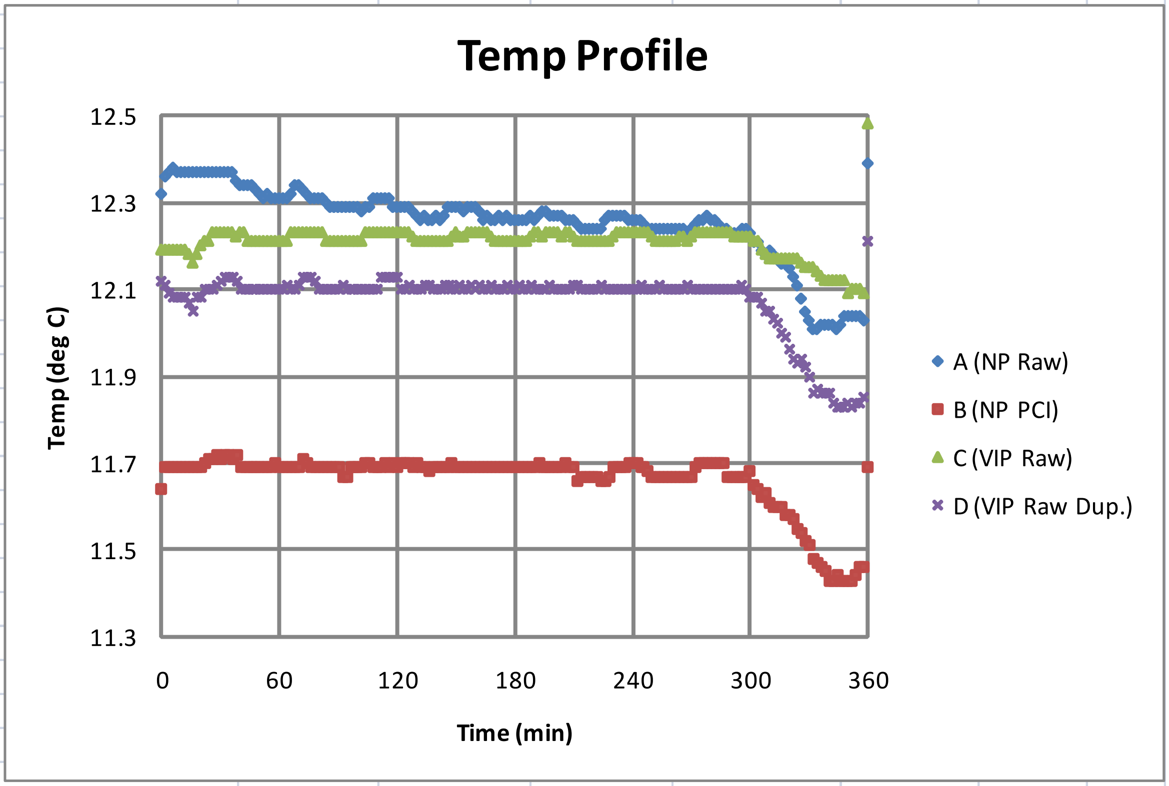
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.3
12.1
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11.7
11.5
11.3
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60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

1-Nov-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	29.15	113	88%	99.44	604	43.1
B (NP PCI)	29.3	128	89%	113.92	363	45.3
C (VIP Raw)	20.1	110	89%	97.9	452	31
D (Vip Raw Dup.)		128	83%	106.24	526	31.1
	20.1	119	0.86	102.07	489	31.05

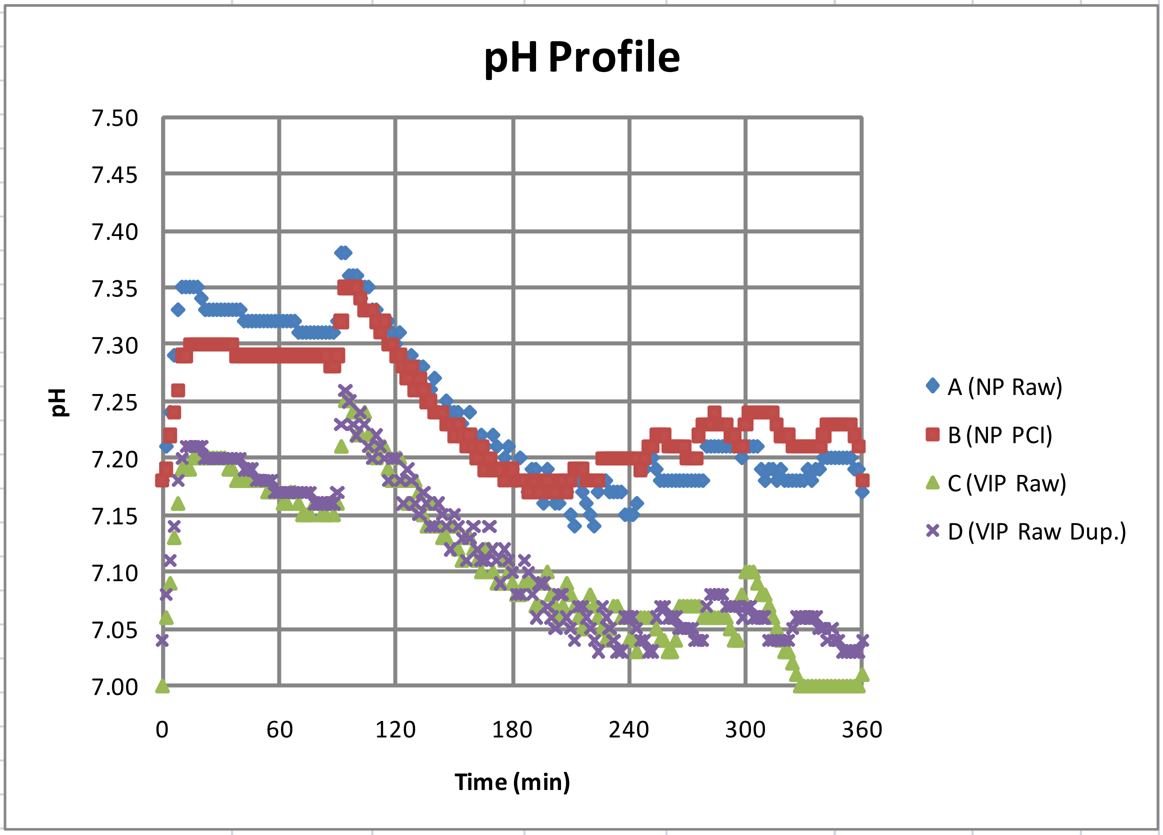
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1720	87%	1496.4
B (NP PCI)	2000	85%	1700.0
C (VIP Raw)	1500	89%	1335.0
D (Vip Raw Dup.)	1480	84%	1243.2

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.072	9.1	0.02	9	
B (NP PCI)	0.074	15.1	0.028	8	
C (VIP Raw)	0.055	4.3	0.024	6	
D (Vip Raw Dup.)	0.053	4.3	0.02	7	

Settled Sludge Volume (mL/L)			SVI (mL/g)
	5 min	30 min	
A (NP Raw)	600	280	162.8
B (NP PCI)	540	265	132.5
C (VIP Raw)	265	160	106.7
D (Vip Raw Dup.)	380	170	114.9

	A	B	C	D
OUR (mg O_2/L*hr)	13.51	13.83	8.06	9.08
MLVSS (g/L)	1.50	1.70	1.34	1.24
SOUR (mg O_2/g MLVSS*hr)	9.03	8.14	6.04	7.31

Avg. Temp. (° C)	
A (NP Raw)	12.29
B (NP PCI)	11.73
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.11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7.10
7.05
7.00
pH
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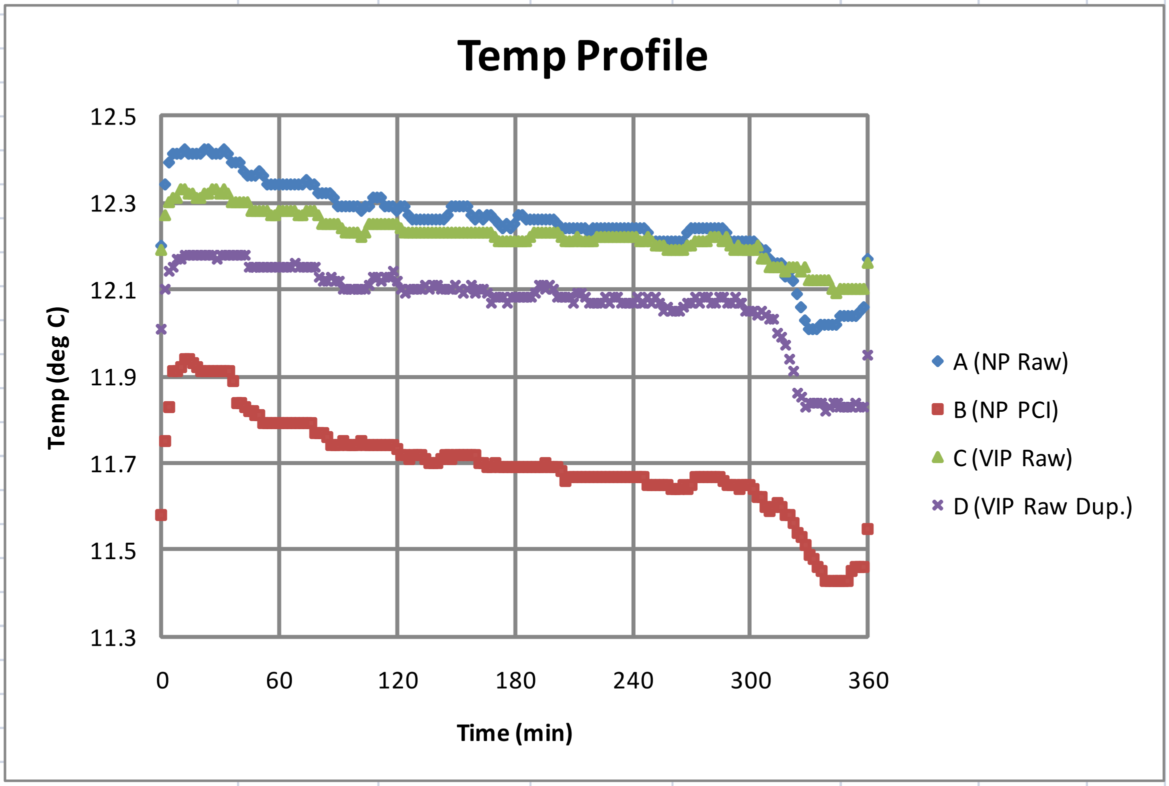
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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11.7
11.5
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Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

3-Nov-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	30.65	148	84%	124.32	554	46.4	6
B (NP PCI)	31.35	118	83%	97.94	571	45.1	7
C (VIP Raw)	19.6	96	85%	81.6	435	28.7	2.1
D (Vip Raw Dup.)		100	84%	84	405	30	
	19.6	98	0.845	82.8	420	29.35	2.1

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1900	82%	1558
B (NP PCI)	2080	80%	1664
C (VIP Raw)	1640	82%	1344.8
D (Vip Raw Dup.)	1640	79%	1295.6

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.084	12.6	0.072	11	7.17	5.05
B (NP PCI)	0.048	17.7	0.024	9	5.42	5.6
C (VIP Raw)	3.330	7.14	0.548	7	4.36	1.35
D (Vip Raw Dup.)	9.050	0.568	0.024	9	4.62	1

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	620	270	142.1
B (NP PCI)	520	250	120.2
C (VIP Raw)	300	160	97.6
D (Vip Raw Dup.)	440	170	103.7

	A	B	C	D
OUR (mg O_2/L*hr)	15.98	15.49	9.02	3.72
MLVSS (g/L)	1.56	1.66	1.34	1.30
SOUR (mg O_2/g MLVSS*hr)	10.26	9.31	6.70	2.87

Avg. Temp. (° C)	
A (NP Raw)	12.30
B (NP PCI)	11.75
C (VIP Raw)	12.21
D (Vip Raw Dup.)	12.10

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.56	1.66	1.34	1.30
NR (mg NOx-N/L*hr)	3.23	3.62	1.25	0.07
DNR (mg NOx-N/L*hr)	9.06	6.73	3.53	0.66
SNR (mg NOx-N/g MLVSS*hr)	2.07	2.18	0.93	0.06
SDNR (mg NOx-N/g MLVSS*hr)	5.82	4.04	2.63	0.51

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.97	5.94	1.00	6.94	5.6
10		4.32	1.06	5.38	
15		3.66	0.82	4.48	
20		3.77	0.72	4.49	
105	9.3	3.25	0.38	3.63	5.75
120	7.99	3.78	0.48	4.26	
135	7.51	4.58	0.62	5.20	
150	6.29	5.30	0.60	5.90	5.05
165	5.67	6.30	0.72	7.02	
180	4.95	6.55	0.74	7.29	
195	4.18	7.74	0.80	8.54	5
330	0.084	12.60	0.07	12.67	5.05

NP PCI (B)

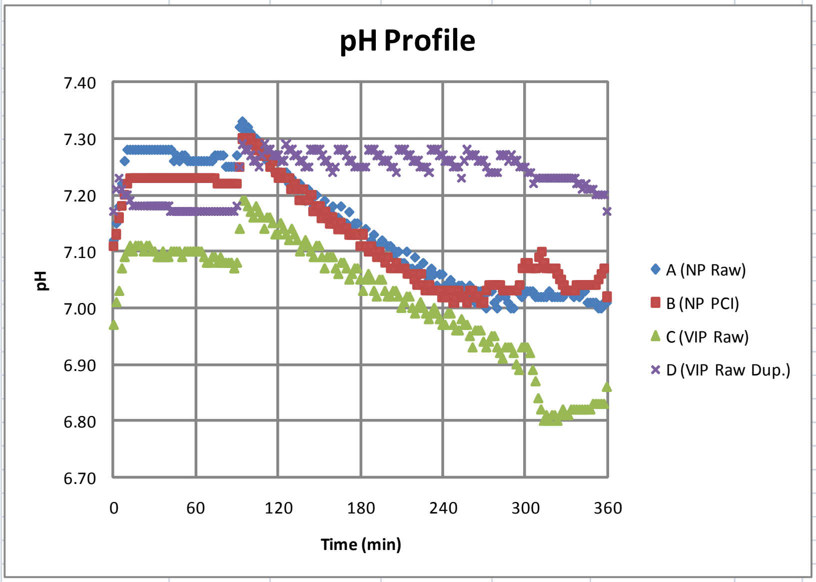
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.26	10.40	0.80	11.20	14.25
10		8.99	1.02	10.01	
15		8.83	0.98	9.81	
20		8.21	1.00	9.21	
105	8.8	8.32	0.82	9.14	6.35
120	7.53	8.92	1.00	9.92	
135	6.76	10.00	1.14	11.14	
150	5.72	10.90	1.24	12.14	5.75
165	4.9	11.90	1.32	13.22	
180	3.93	12.10	1.32	13.42	
195	3.08	13.20	1.36	14.56	5.65
330	0.048	17.70	0.02	17.72	5.6

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.96	3.18	0.34	3.52	2
10		2.36	0.46	2.82	
15		2.28	0.34	2.62	
20		2.24	0.28	2.52	
105	9.14	1.61	0.22	1.83	1.75
120	8.46	1.86	0.30	2.16	
150	8.16	2.18	0.36	2.54	
165	7.67	2.26	0.42	2.68	1.45
180	7.25	2.92	0.44	3.36	
195	6.8	3.24	0.44	3.68	
210	6.34	3.58	0.48	4.06	0.52
330	3.33	7.14	0.55	7.69	0.54

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.95	0.58	0.060	0.64	1.65
10		0.51	0.040	0.55	
15		0.47	0.060	0.53	
20		0.40	0.040	0.44	
105	9.33	0.15	0.040	0.19	1.4
120	9.5	0.18	0.040	0.22	
150	9.39	0.19	0.040	0.23	
165	9.02	0.19	0.040	0.23	1.1
180	8.81	0.28	0.040	0.32	
195	9.2	0.30	0.040	0.34	
210	9.11	0.25	0.040	0.29	1.2
330	9.05	0.57	0.024	0.59	1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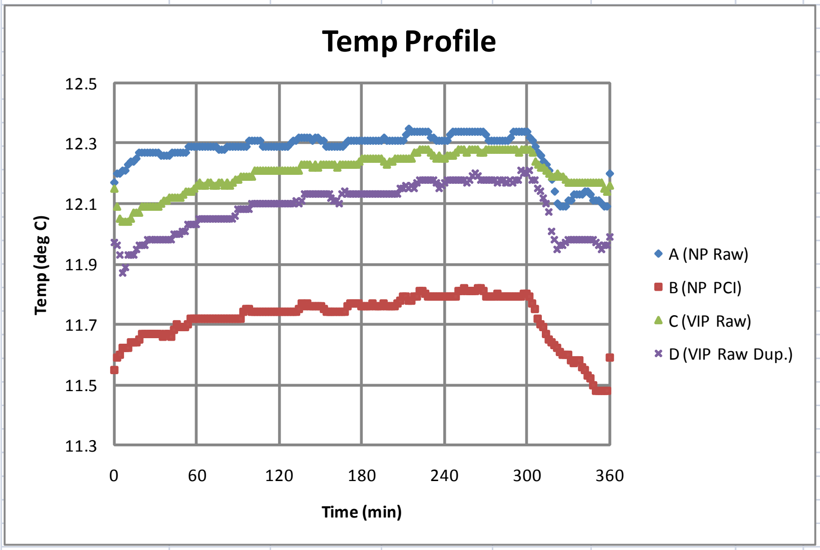
7.10
7.00
6.90
6.80
6.70
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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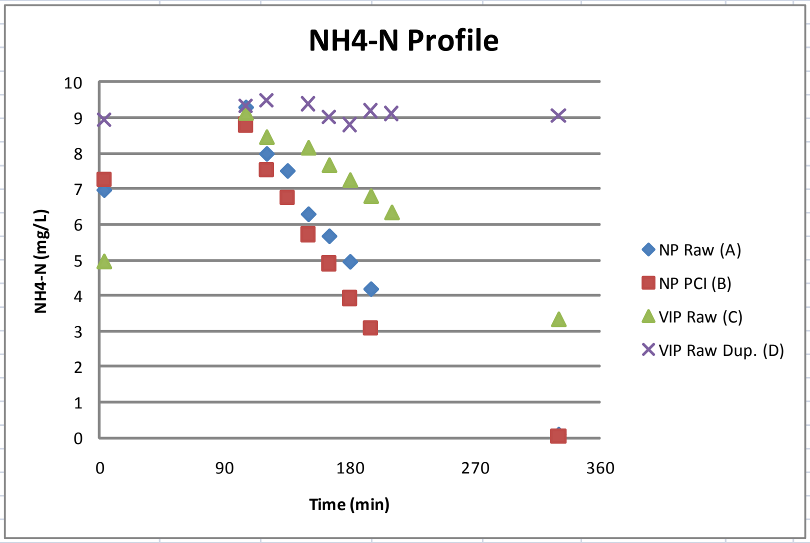
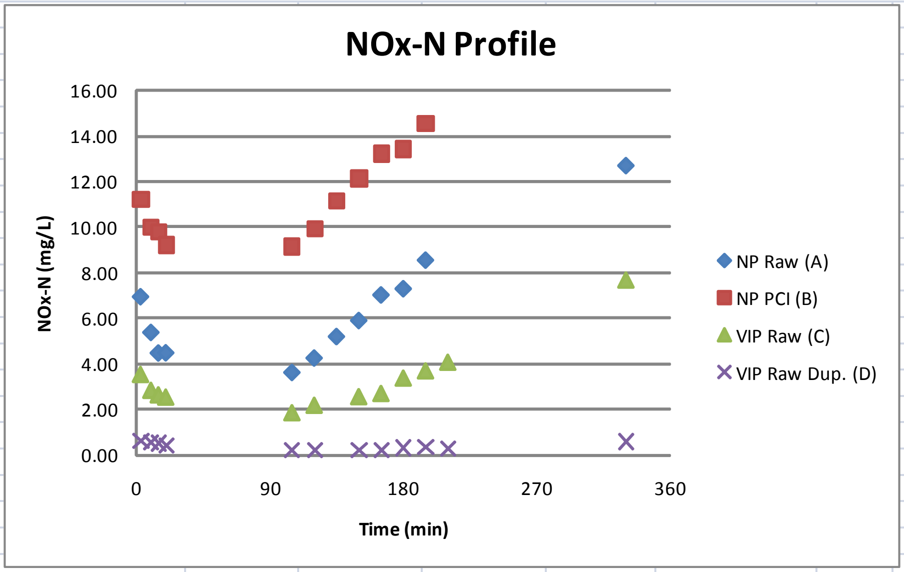
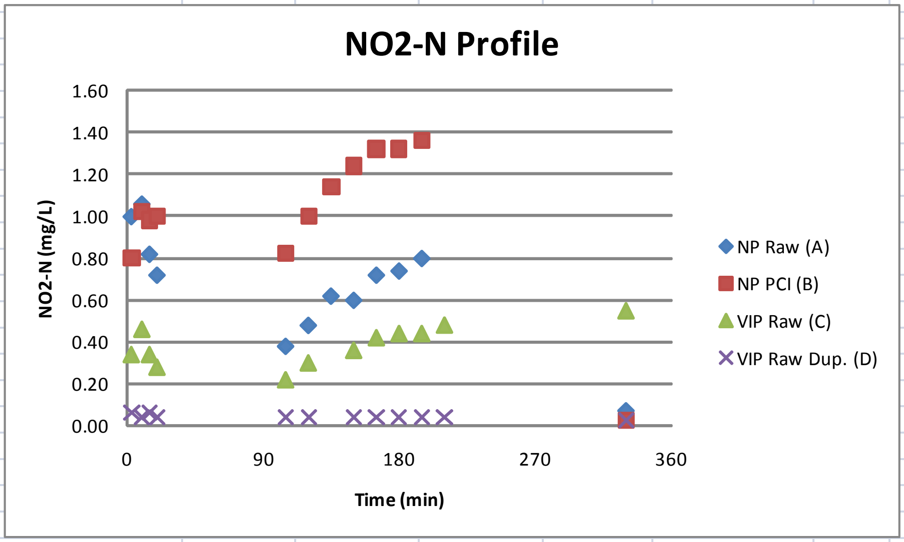
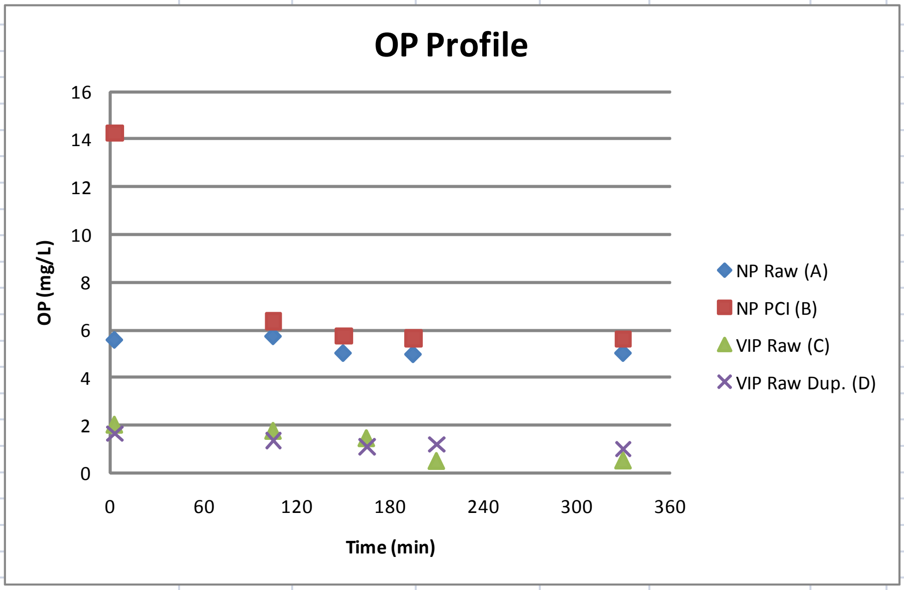
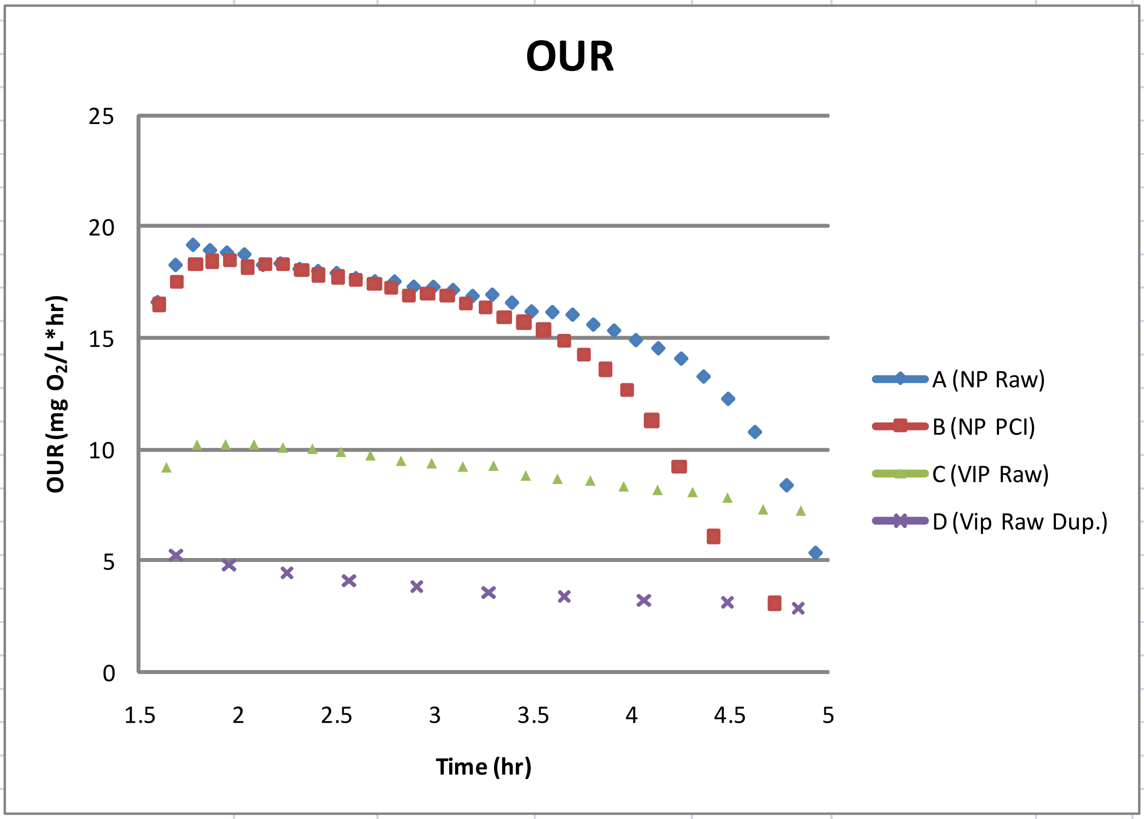
11.5
11.3
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

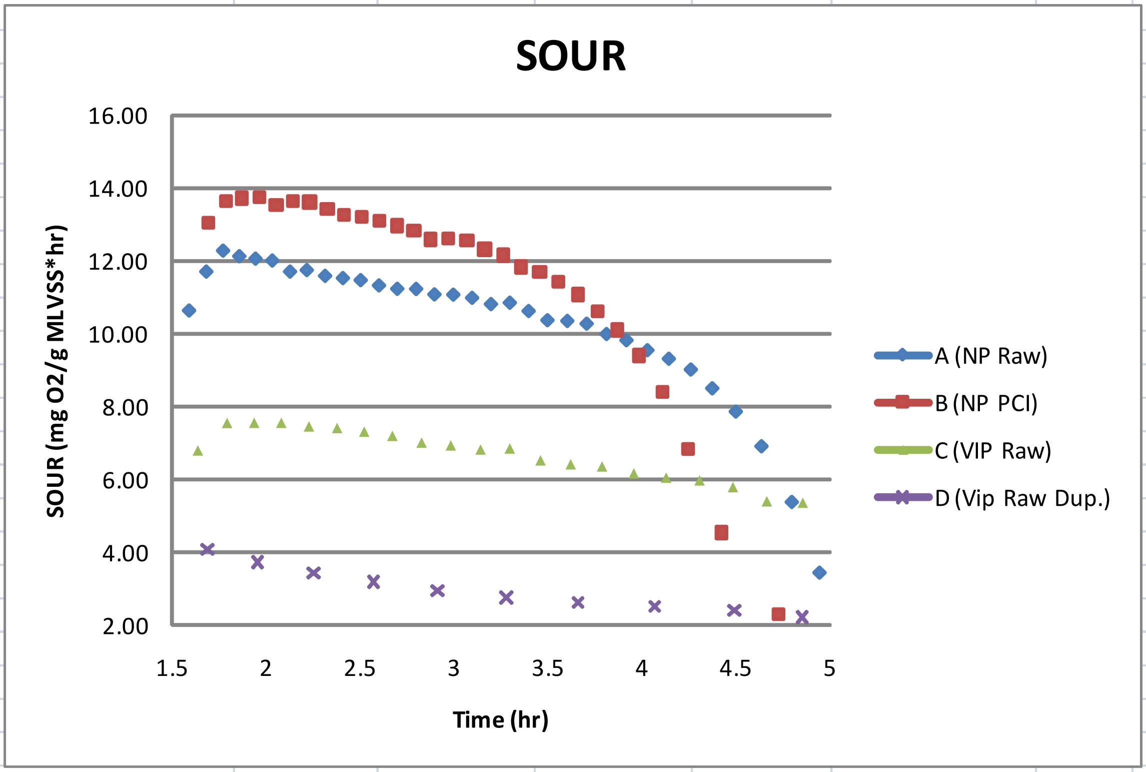

NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCl (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
16
14
12
10
8
6
4
2
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)

5-Nov-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	32.05	124	87%	107.88	412	47.1
B (NP PCl)	31.75	82	90%	73.8	347	47.5
C (VIP Raw)	22.85	110	87%	95.7	345	33.9
D (Vip Raw Dup.)		114	86%	98.04	358	33.5
	22.85	112	0.865	96.87	351.5	33.7

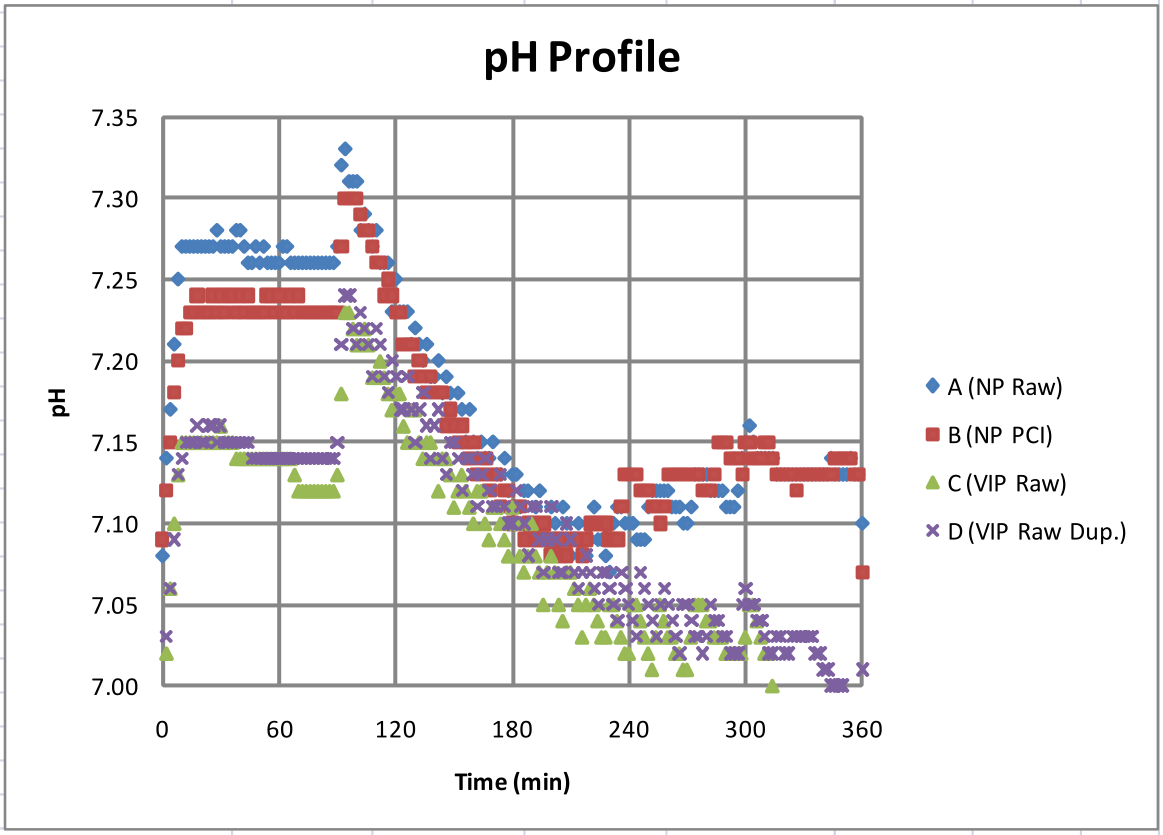
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1760	86%	1513.6
B (NP PCl)	1780	83%	1477.4
C (VIP Raw)	1580	82%	1295.6
D (Vip Raw Dup.)	1330	80%	1064.0

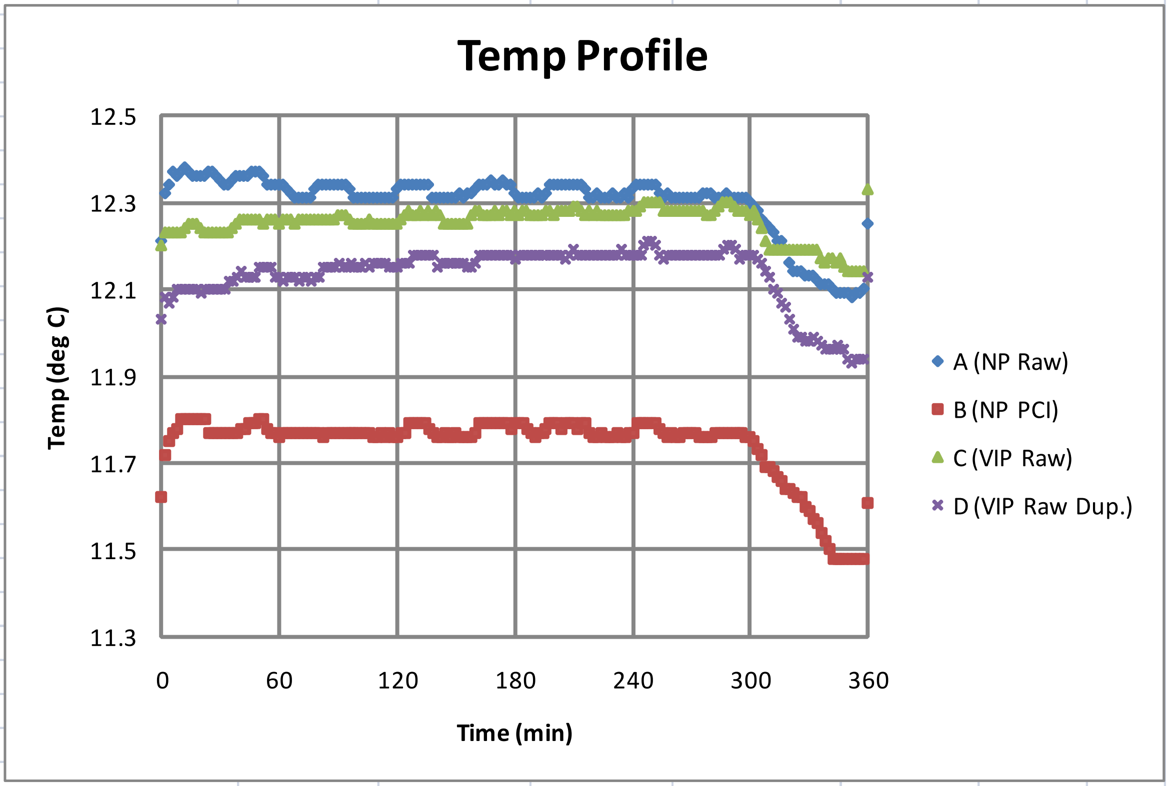
Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.138	9.3	0.016	8	
B (NP PCl)	0.071	15.5	0.02	5	
C (VIP Raw)	0.085	5.5	0.028	7	
D (Vip Raw Dup.)	0.162	6.2	0.096	9	

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)			0.0
B (NP PCl)			0.0
C (VIP Raw)			0.0
D (Vip Raw Dup.)			0.0

	A	B	C	D
OUR (mg O_2/L*hr)	15.42	14.16	8.83	10.07
MLVSS (g/L)	1.51	1.48	1.30	1.06
SOUR (mg O_2/g MLVSS*hr)	10.18	9.58	6.81	9.46

Avg. Temp. (° C)	
A (NP Raw)	12.33
B (NP PCl)	11.77
C (VIP Raw)	12.27
D (Vip Raw Dup.)	12.16


pH Profile
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
12.5
12.3
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

8-Nov-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	30.85	132	89%	117.48	518	45.7
B (NP PCI)	32.8	116	88%	102.08	465	49.9
C (VIP Raw)	20.8	132	82%	108.24	379	34.6
D (Vip Raw Dup.)		138	83%	114.54	500	34
	20.8	135	0.825	111.39	439.5	34.3

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1700	86%	1462.0
B (NP PCI)	1660	86%	1427.6
C (VIP Raw)	1560	85%	1326.0
D (Vip Raw Dup.)	1430	83%	1186.9

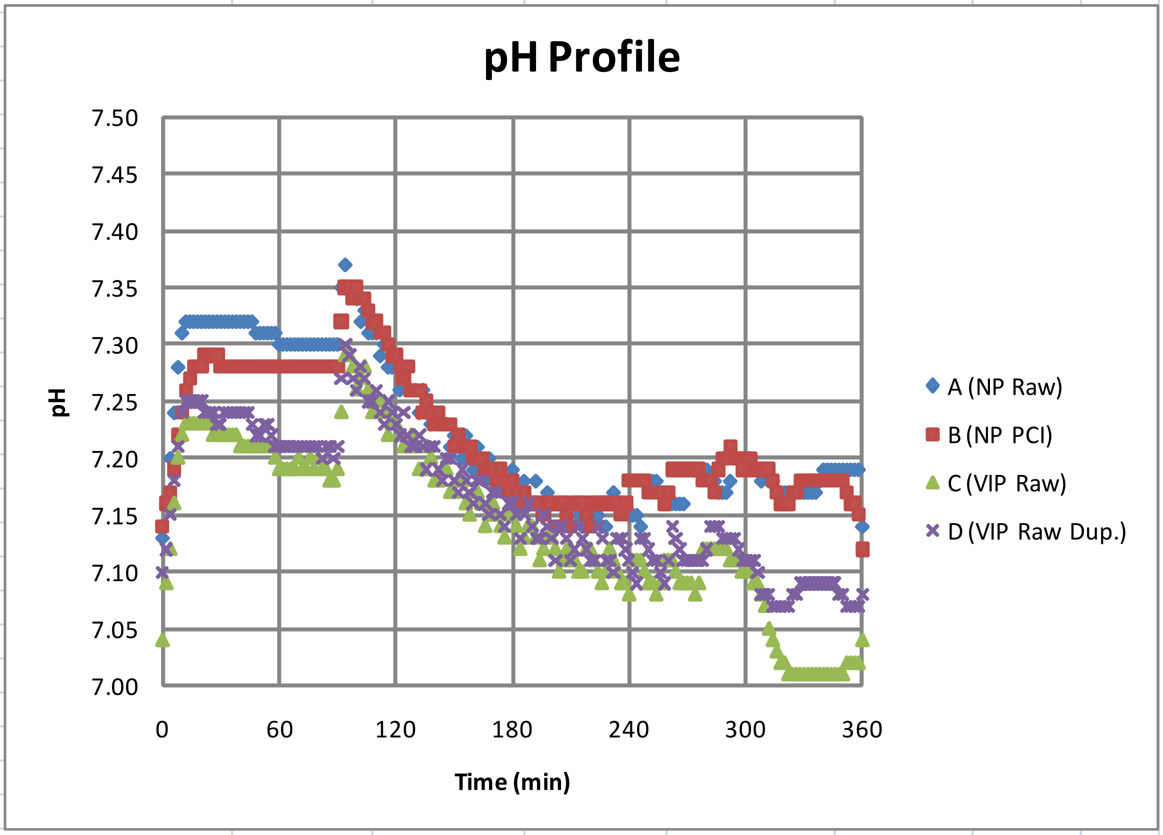
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.078	6.3	0.02	7	
B (NP PCI)	0.063	12.6	0.028	5	
C (VIP Raw)	0.069	4.3	0.044	5	
D (Vip Raw Dup.)	0.072	4.4	0.04	8	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	15.71	14.51	8.78	10.03
MLVSS (g/L)	1.46	1.43	1.33	1.19
SOUR (mg O_2/g MLVSS*hr)	10.74	10.16	6.62	8.45

Avg. Temp. (° C)	
A (NP Raw)	12.35
B (NP PCI)	11.77
C (VIP Raw)	12.26
D (Vip Raw Dup.)	12.13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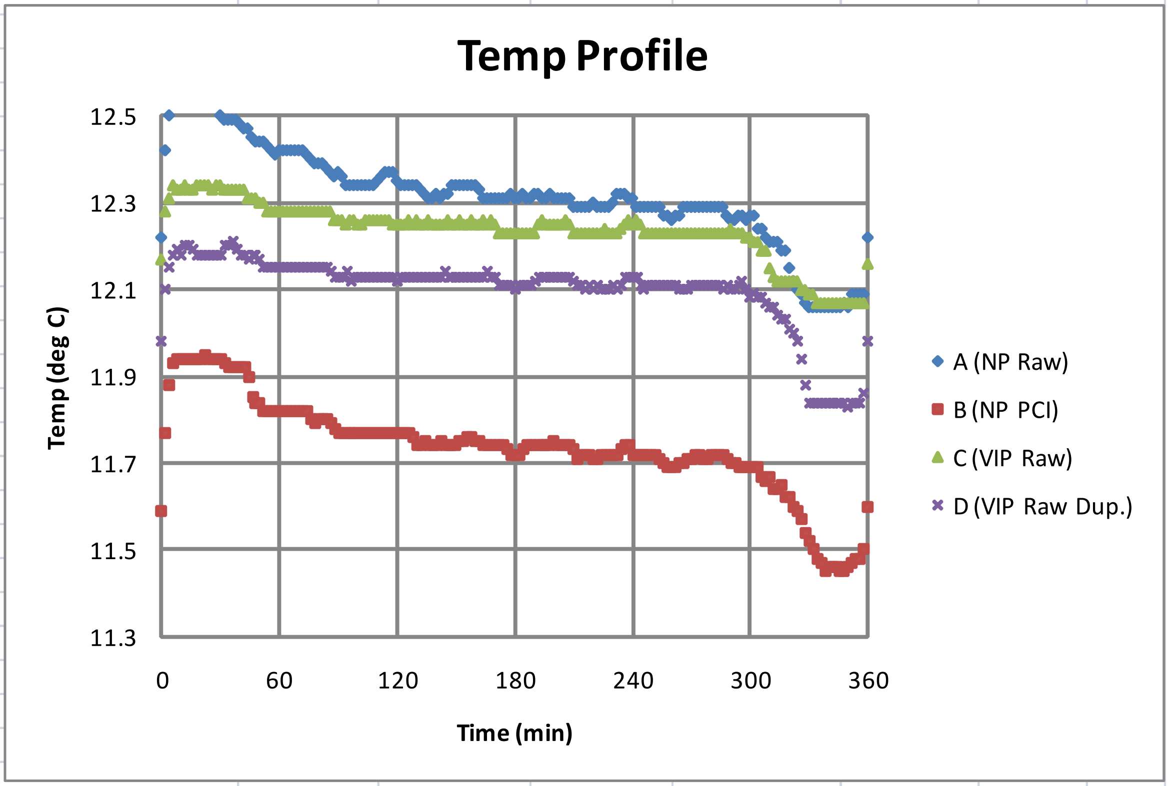
pH
7.50
7.45
7.40
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

10-Nov-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	30.2	94	91%	85.54	361	43.4	6.7
B (NP PCI)	32.65	134	90%	120.6	507	48	7.6
C (VIP Raw)	20.3	116	84%	97.44	332	32.6	2.7
D (Vip Raw Dup.)		116	86%	99.76	341	30.9	
	20.3	116	0.85	98.6	336.5	31.75	2.7

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1900	82%	1558
B (NP PCI)	2120	80%	1696
C (VIP Raw)	1700	81%	1377
D (Vip Raw Dup.)	1840	79%	1453.6

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.055	10.1	0.040	5	6.43	5.35
B (NP PCI)	0.047	14.6	0.028	5	6.96	5.85
C (VIP Raw)	2.500	7.22	0.632	7	4.45	1.65
D (Vip Raw Dup.)	2.230	6.92	0.568	9	4.43	1.65

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	16.64	16.16	10.66	12.10
MLVSS (g/L)	1.56	1.70	1.38	1.45
SOUR (mg O_2/g MLVSS*hr)	10.68	9.53	7.74	8.32

Avg. Temp. (° C)	
A (NP Raw)	12.30
B (NP PCI)	11.75
C (VIP Raw)	12.21
D (Vip Raw Dup.)	12.10

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.56	1.70	1.38	1.45
NR (mg NOx-N/L*hr)	2.84	4.36	1.78	1.81
DNR (mg NOx-N/L*hr)	6.73	6.32	4.42	5.12
SNR (mg NOx-N/g MLVSS*hr)	1.83	2.57	1.29	1.25
SDNR (mg NOx-N/g MLVSS*hr)	4.32	3.72	3.21	3.52

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.83	3.72	0.80	4.52	5.6
10		2.29	1.02	3.31	
15		1.93	0.86	2.79	
20		1.89	0.76	2.65	
105	8.75	1.65	0.22	1.87	5.75
120	8.15	1.71	0.34	2.05	
135	6.91	2.89	0.38	3.27	
150	6.33	3.34	0.42	3.76	5.05
165	5.49	3.85	0.46	4.31	
180	4.73	4.77	0.52	5.29	
195	3.91	5.46	0.54	6.00	5
330	0.055	10.10	0.04	10.14	5.05

NP PCI (B)

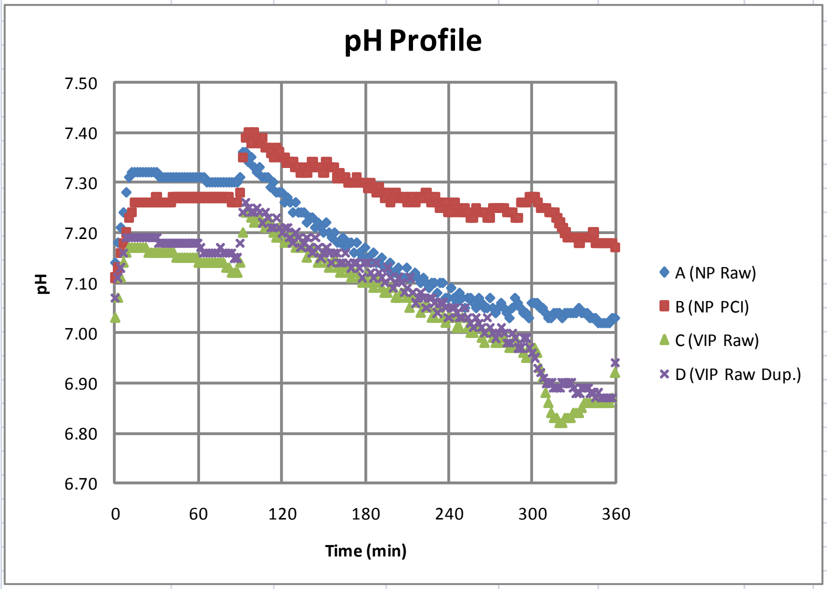
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.27	7.83	0.74	8.57	14.25
10		6.65	1.12	7.77	
15		6.08	1.00	7.08	
20		5.95	0.90	6.85	
105	8.77	5.29	0.64	5.93	6.35
120	7.69	6.05	0.84	6.89	
135	6.58	6.89	0.94	7.83	
150	5.49	7.55	1.08	8.63	5.75
165	4.65	9.14	1.14	10.28	
180	3.84	10.00	1.28	11.28	
195	2.87	11.10	1.26	12.36	5.65
330	0.047	14.60	0.03	14.63	5.6

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.71	2.54	0.60	3.14	2
10		1.88	0.46	2.34	
15		1.64	0.42	2.06	
20		1.51	0.38	1.89	
105	9.07	0.92	0.34	1.26	1.75
120	8.41	1.32	0.38	1.70	
135	7.86	1.72	0.40	2.12	
150	7.21	2.12	0.42	2.54	1.45
165	6.88	2.53	0.48	3.01	
180	6.37	3.00	0.48	3.48	
195	5.78	3.43	0.50	3.93	0.52
330	2.5	7.22	0.63	7.85	0.54

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	4.89	2.23	0.780	3.01	1.65
10		1.37	0.580	1.95	
15		1.20	0.500	1.70	
20		1.11	0.440	1.55	
105	8.69	0.52	0.220	0.74	1.4
120	8.13	0.94	0.300	1.24	
135	7.44	1.35	0.340	1.69	
150	6.9	1.69	0.360	2.05	1.1
165	6.48	2.18	0.400	2.58	
180	6.05	2.59	0.420	3.01	
195	5.5	3.03	0.460	3.49	1.2
330	2.23	6.92	0.568	7.49	1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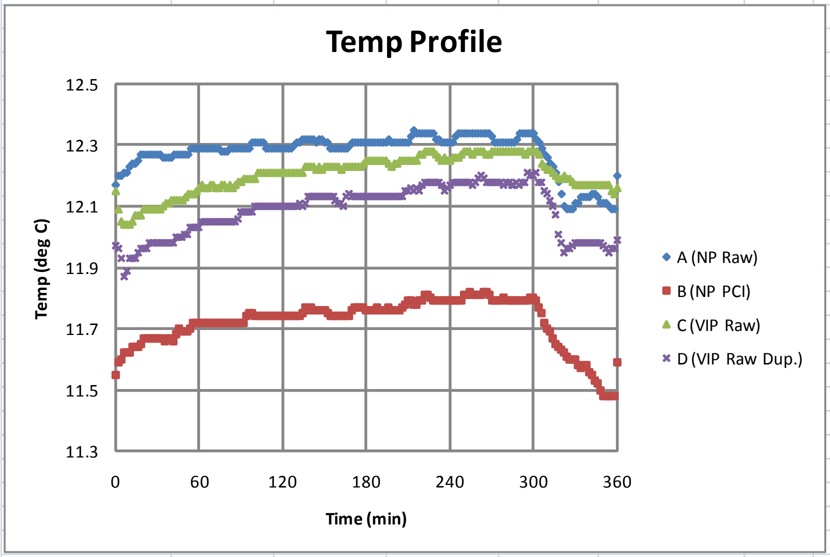
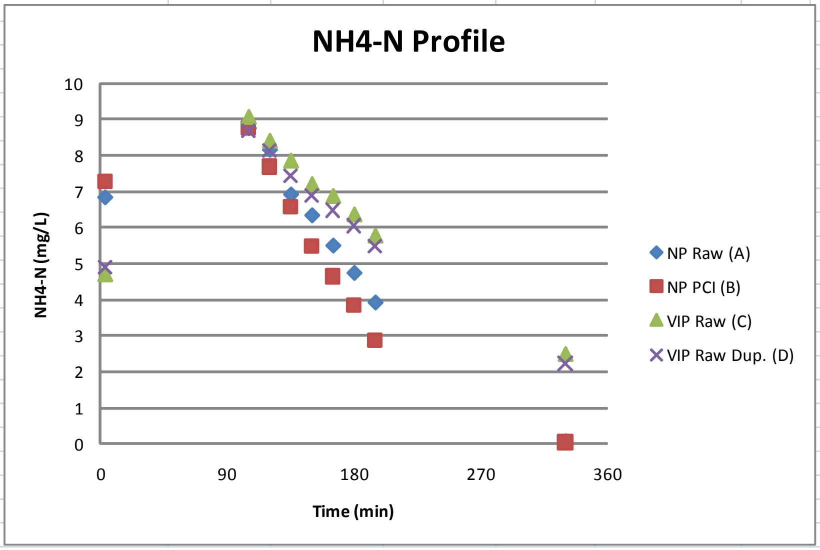
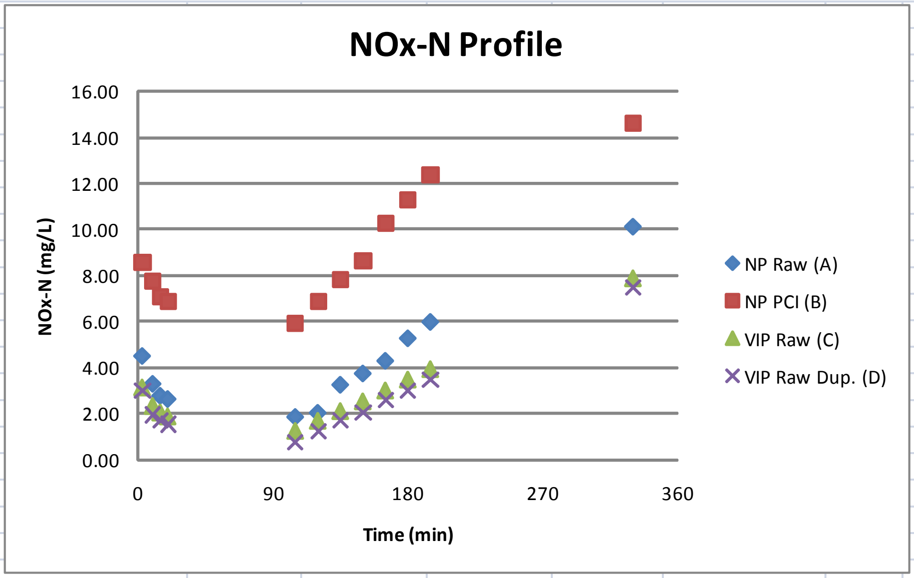
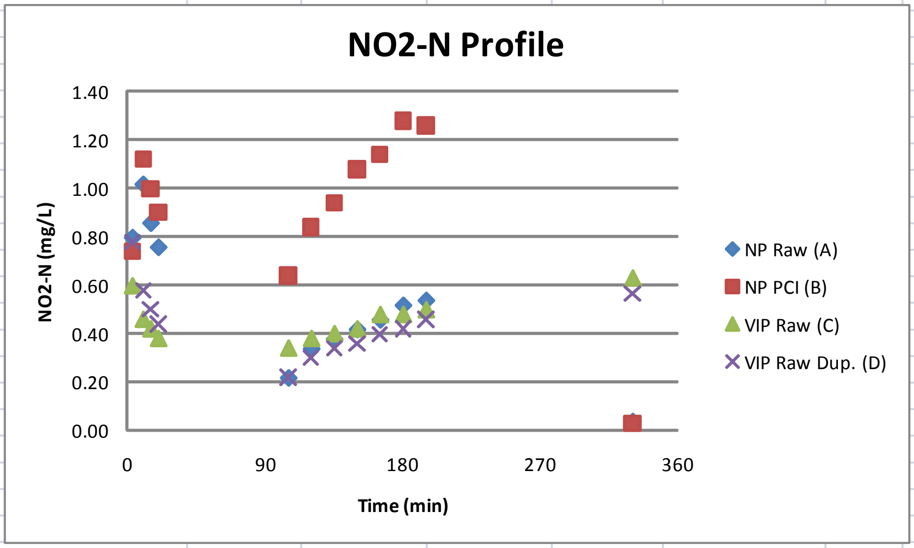
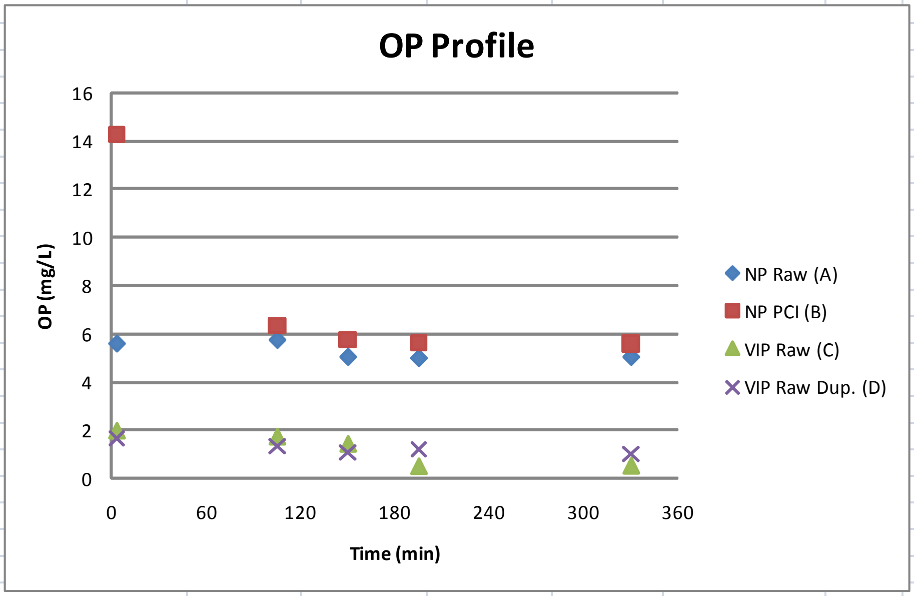
pH
7.50
7.40
7.30
7.20
7.10
7.00
6.90
6.80
6.70
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

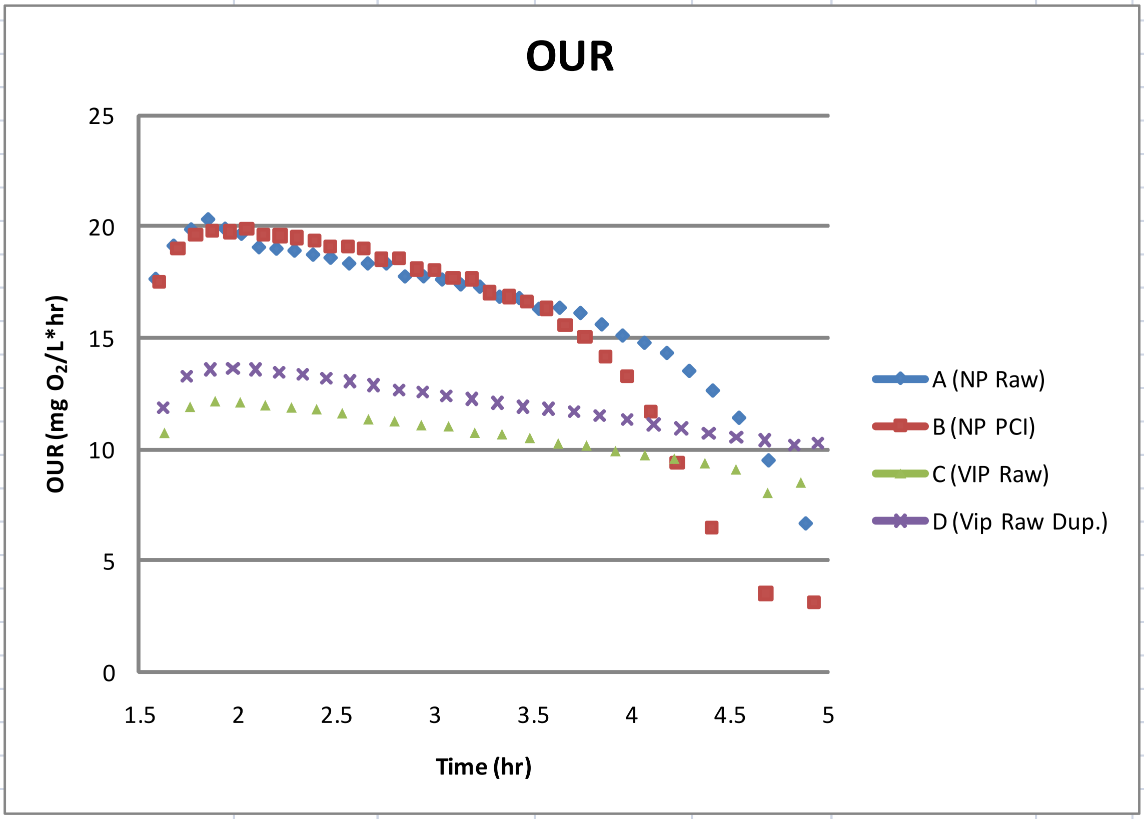

Temp Profile
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

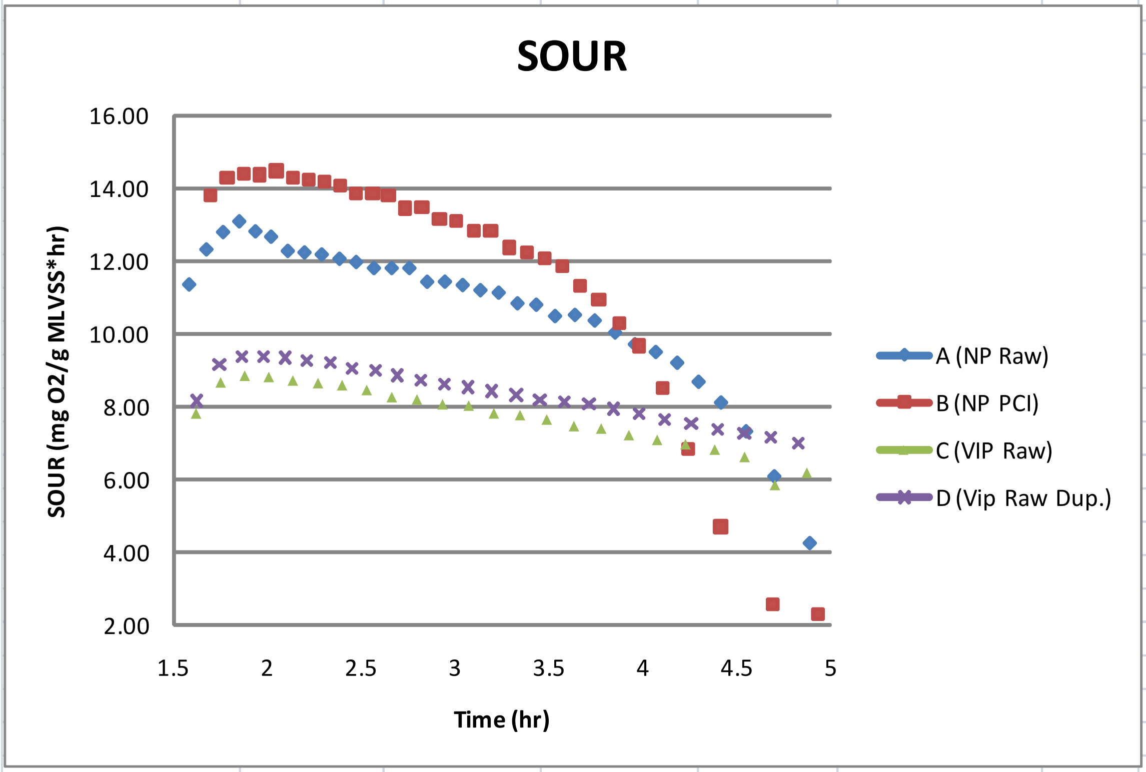

NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
16
14
12
10
8
6
4
2
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O₂/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)

12-Nov-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	31.05	104	90%	93.6	407	42.8	
B (NP PCI)	28.8	132	89%	117.48	606	48.1	
C (VIP Raw)	21.8	106	87%	92.22	495	34.6	
D (Vip Raw Dup.)		104	85%	88.4	453	35.2	
	21.8	105	0.86	90.31	474	34.9	#DIV/0!

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1880	86%	1616.8
B (NP PCI)	2200	83%	1826
C (VIP Raw)	1720	81%	1393.2
D (Vip Raw Dup.)	1760	82%	1443.2

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.100	7.41	0.020	4	
B (NP PCI)	0.106	12.1	0.020	3	
C (VIP Raw)	2.930	10.9	0.640	7	
D (Vip Raw Dup.)	3.250	17.8	0.604	8	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	725	315
B (NP PCI)	530	255
C (VIP Raw)	500	195
D (Vip Raw Dup.)	560	205

SVI (mL/g)
167.6
115.9
113.4
116.5

	A	B	C	D
OUR (mg O_2/L*hr)	15.13	14.85	10.45	10.47
MLVSS (g/L)	1.62	1.83	1.39	1.44
SOUR (mg O_2/g MLVSS*hr)	9.36	8.13	7.50	7.25

Avg. Temp. (° C)	
A (NP Raw)	12.40
B (NP PCI)	11.85
C (VIP Raw)	12.32
D (Vip Raw Dup.)	12.24

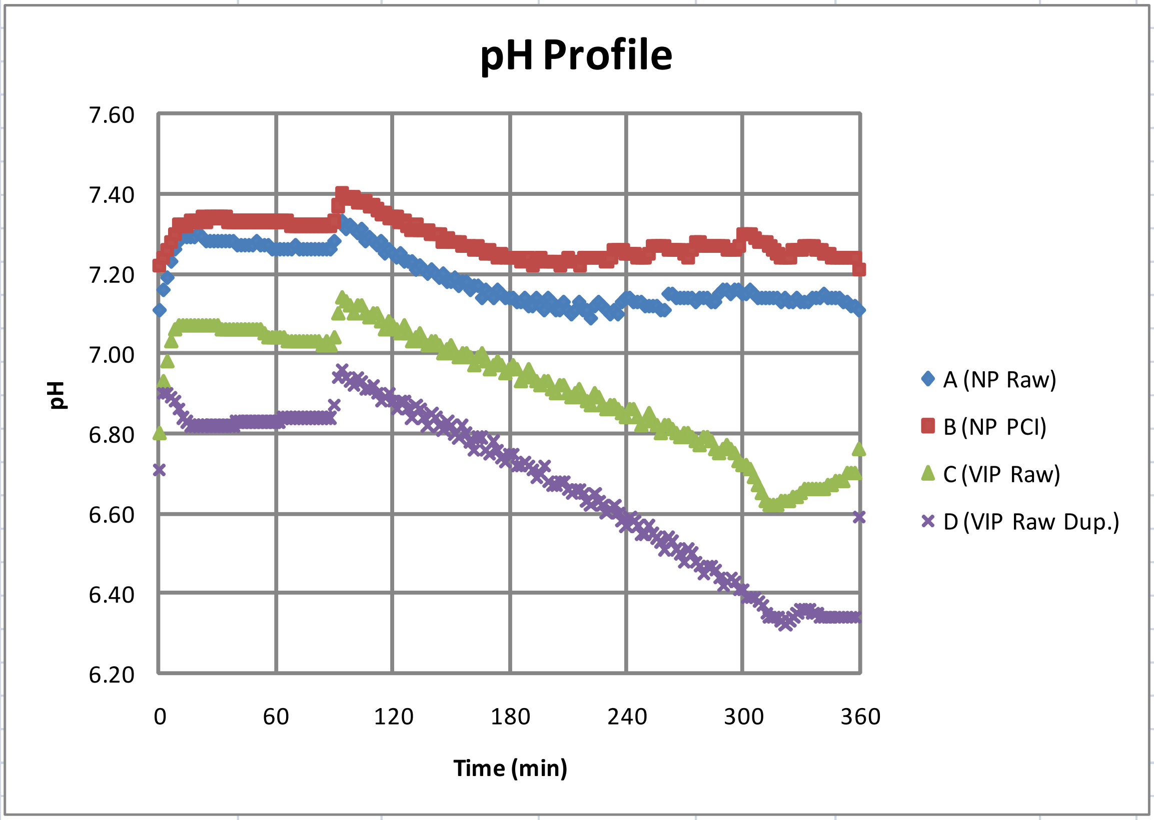
	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.62	1.83	1.39	1.44
NR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	2.20	1.93
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	4.50	-1.59
SNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	1.58	1.33
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	3.23	-1.11

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.23	6.20	0.64	6.84
10		5.62	0.34	5.96
15		5.52	0.22	5.74
20		5.35	0.20	5.55
105	9.14	5.06	0.34	5.40
120	8.58	5.53	0.50	6.03
135	8.1	6.05	0.24	6.29
150	7.55	6.72	0.62	7.34
165	6.89	6.96	0.66	7.62
180	6.51	7.45	0.70	8.15
195	6.03	7.96	0.72	8.68
330	2.93	10.90	0.32	11.22

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L
3	4.47	10.70	0.380	11.08
10		11.00	0.460	11.46
15		10.90	0.500	11.40
20		11.10	0.480	11.58
105	8.64	11.90	0.600	12.50
120	8.2	12.70	0.760	13.46
135	7.65	12.80	0.780	13.58
150	7.06	13.20	0.860	14.06
165	6.57	13.50	0.880	14.38
180	6.14	14.20	0.920	15.12
195	5.8	14.70	0.920	15.62
330	3.25	17.80	0.302	18.10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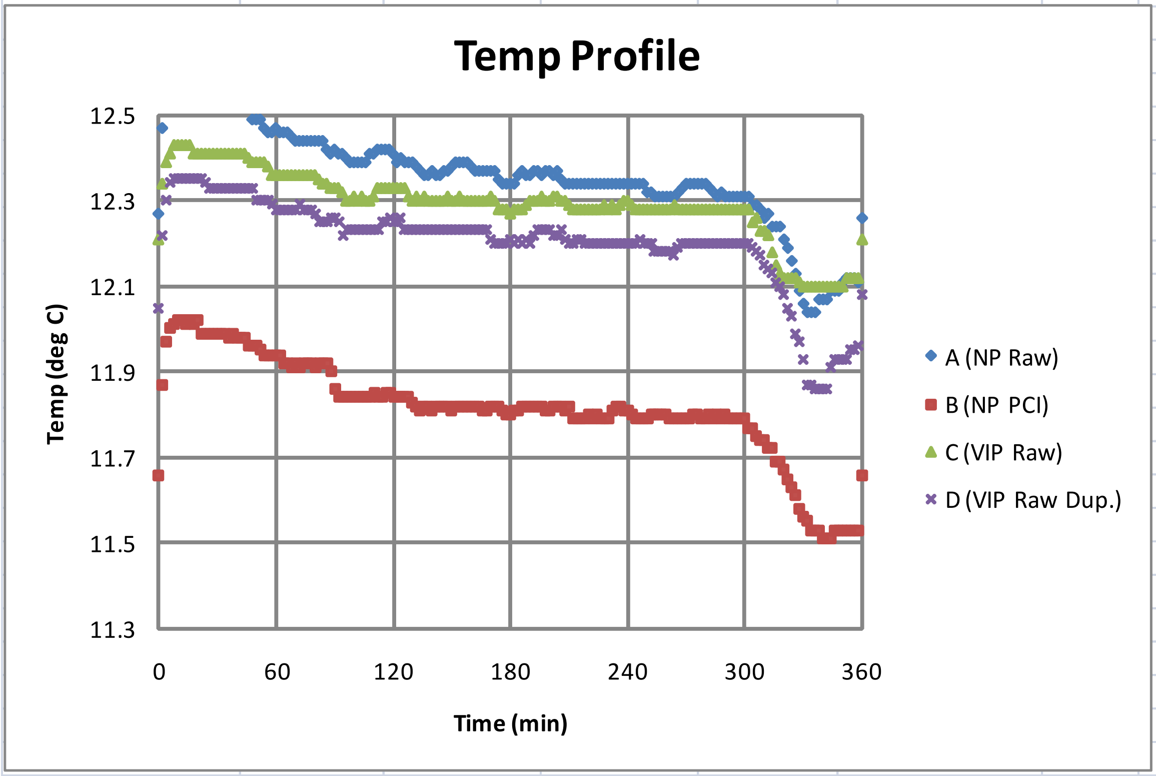
7.40
7.20
7.00
6.80
6.60
6.40
6.20
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
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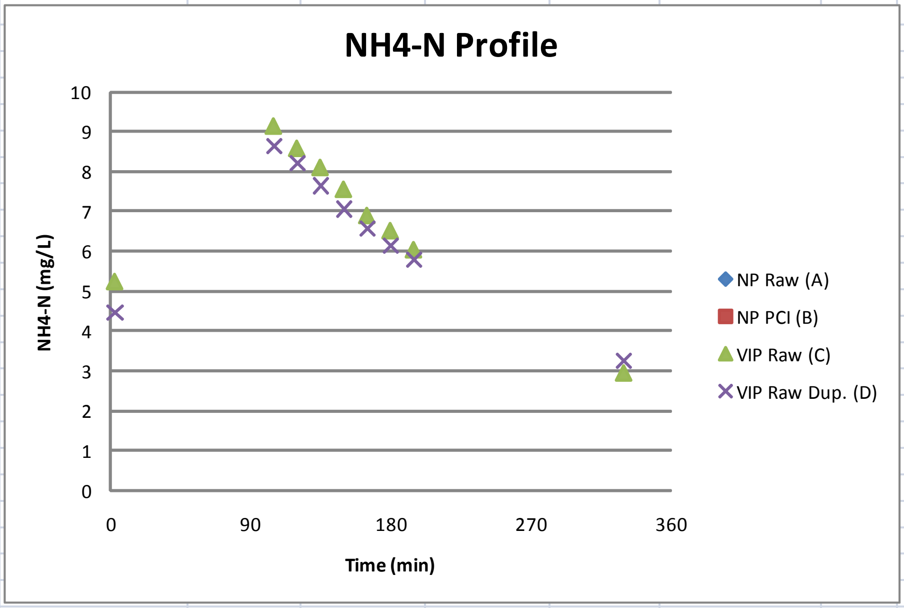
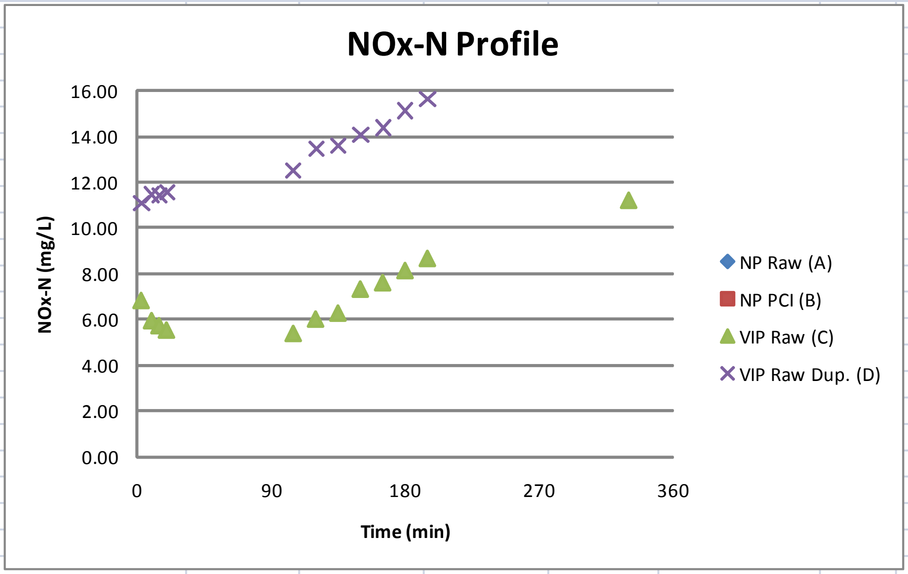
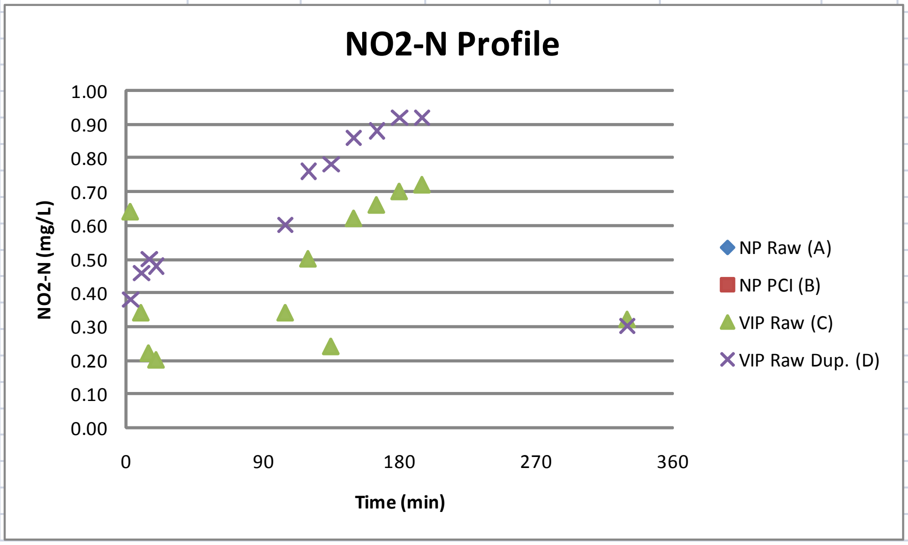
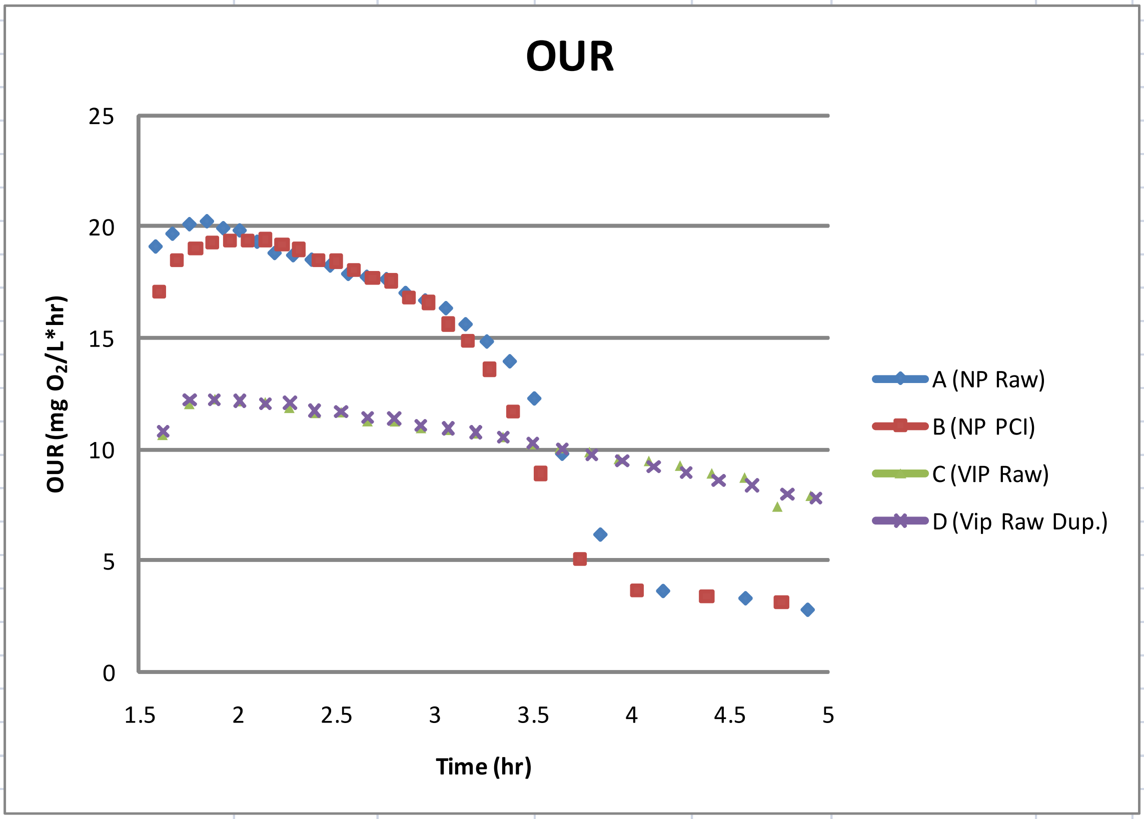
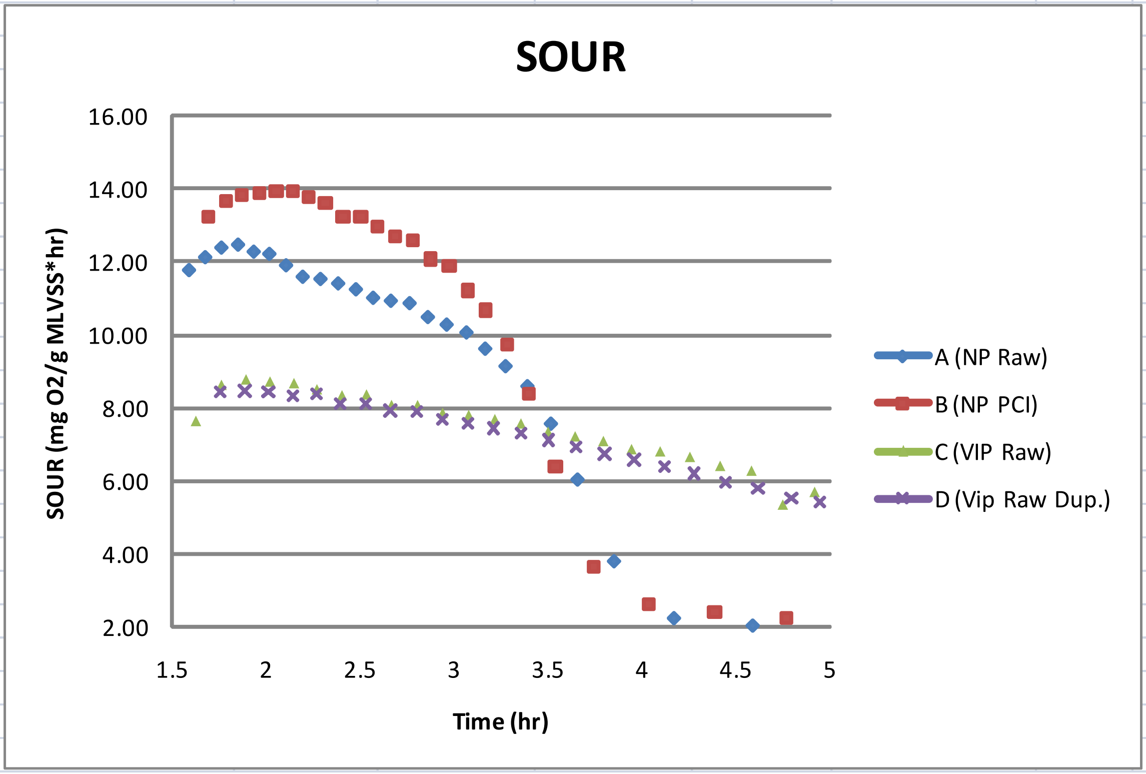
12.3
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
25
20
15
10
5
0
OUR (mg O_2/L*hr)
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
SOUR (mg O2/g MLVSS*hr)
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

15-Nov-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	31.8	96	83%	79.68	459	49.4	
B (NP PCl)	31.75	118	90%	106.2	514	51.6	
C (VIP Raw)	21.1	76	84%	63.84	337	33.9	
D (Vip Raw Dup.)		72	92%	66.24	362	33.4	
	21.1	74	0.88	65.04	349.5	33.65	#DIV/0!

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1560	86%	1341.6
B (NP PCl)	1940	81%	1571.4
C (VIP Raw)	1500	83%	1245
D (Vip Raw Dup.)	1380	83%	1145.4

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU
A (NP Raw)	0.051	7.37	0.020	5	
B (NP PCl)	0.053	10.9	0.020	4	
C (VIP Raw)	1.850	6.01	0.604	7	
D (Vip Raw Dup.)	1.390	11.9	0.740	4	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	720	325
B (NP PCl)	495	245
C (VIP Raw)	485	195
D (Vip Raw Dup.)	495	200

SVI (mL/g)
208.3
126.3
130.0
144.9

	A	B	C	D
OUR (mg O_2/L*hr)	15.01	15.17	10.86	12.56
MLVSS (g/L)	1.34	1.57	1.25	1.15
SOUR (mg O_2/g MLVSS*hr)	11.19	9.65	8.72	10.97

Avg. Temp. (° C)	
A (NP Raw)	12.42
B (NP PCl)	11.94
C (VIP Raw)	12.33
D (Vip Raw Dup.)	12.27

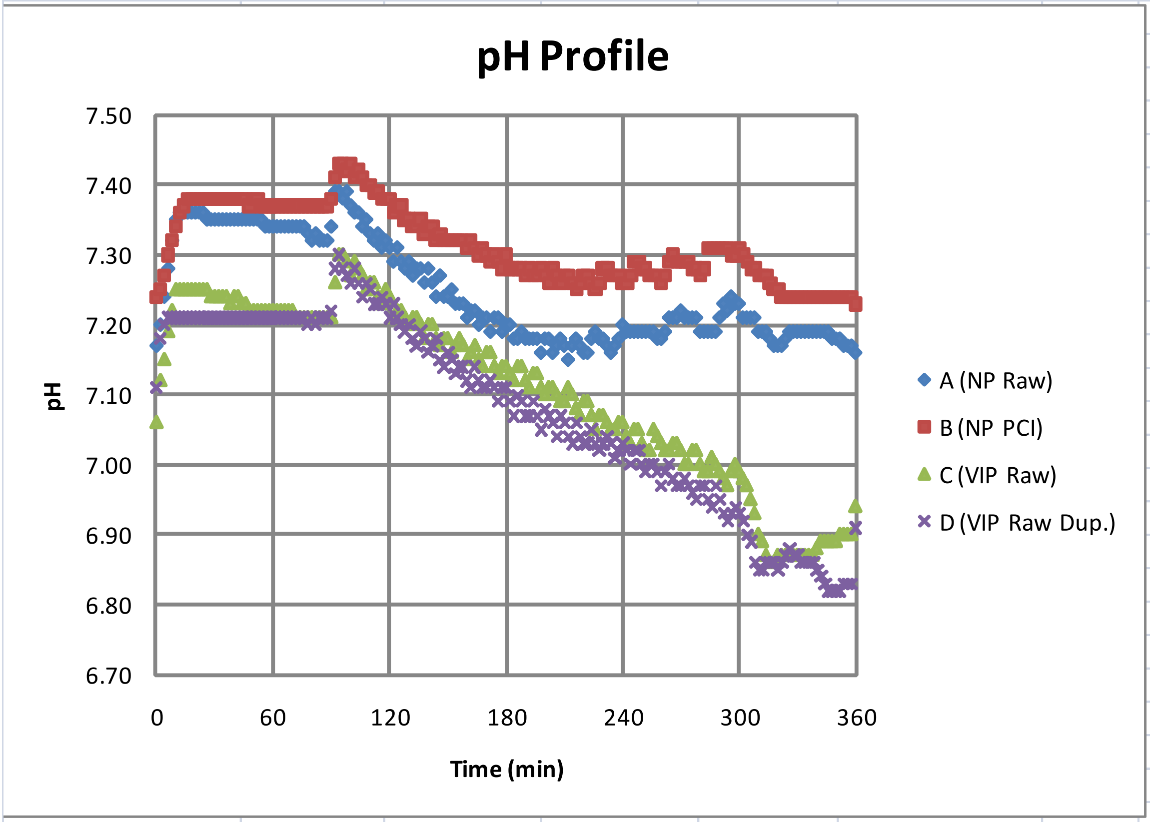
	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.34	1.57	1.25	1.15
NR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	1.99	2.21
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	6.92	9.22
SNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	1.60	1.93
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	5.56	8.05

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.08	2.79	0.32	3.11
6		1.90	0.52	2.42
9		1.55	0.44	1.99
12		1.40	0.54	1.94
15		1.24	0.38	1.62
18		1.25	0.42	1.67
105	8.34	0.39	0.26	0.65
120	7.67	0.70	0.40	1.10
135	7.64	1.18	0.50	1.68
150	6.96	1.59	0.56	2.15
165	6.4	2.12	0.58	2.70
180	5.9	2.50	0.60	3.10
195	5.39	2.99	0.62	3.61
330	1.85	6.01	0.30	6.31

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L
3	4.82	6.13	0.160	6.29
6		5.50	0.260	5.76
9		5.45	0.180	5.63
12		4.55	0.220	4.77
15		4.34	0.140	4.48
18		4.32	0.120	4.44
105	8.49	3.58	0.380	3.96
120	7.67	3.82	0.540	4.36
135	7.48	4.43	0.660	5.09
150	6.81	4.66	0.740	5.40
165	6.3	5.44	0.760	6.20
180	5.74	7.14	0.820	7.96
195	5.24	7.49	0.840	8.33
330	1.39	11.90	0.370	12.27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7.50
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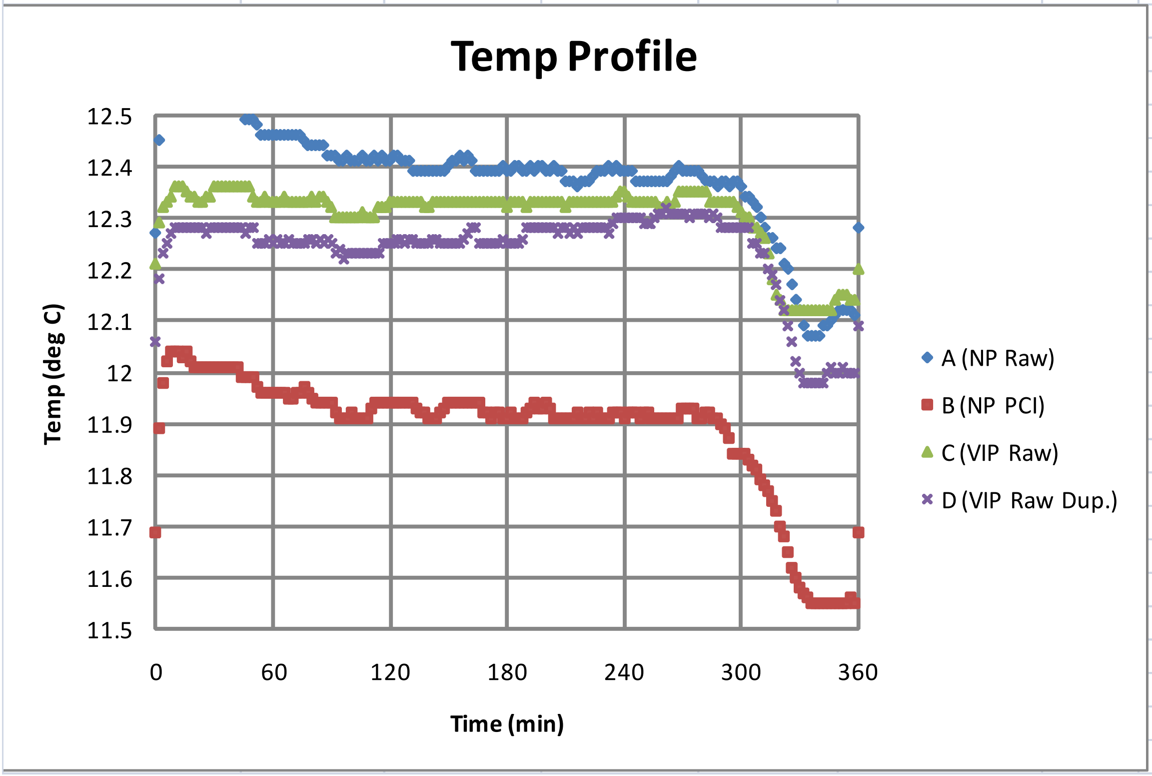
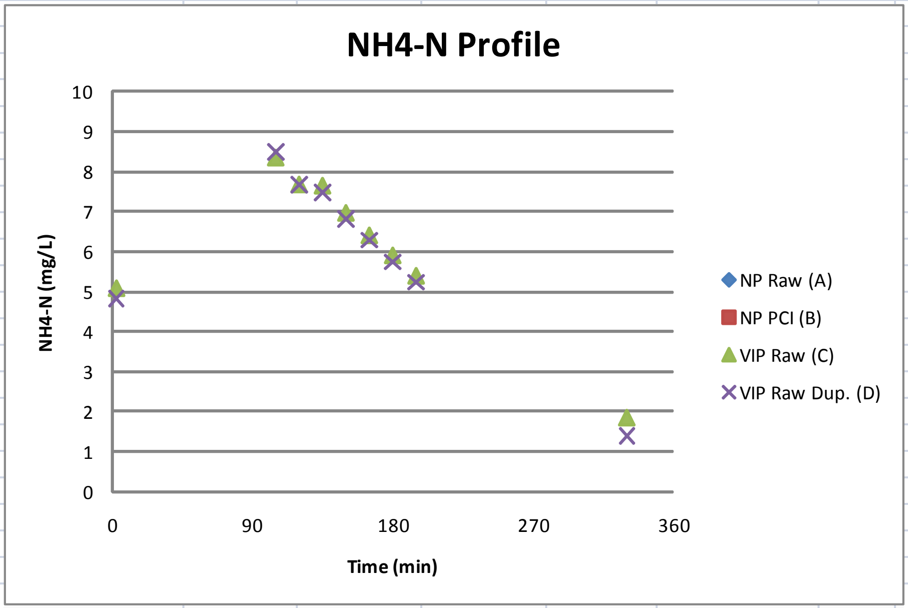
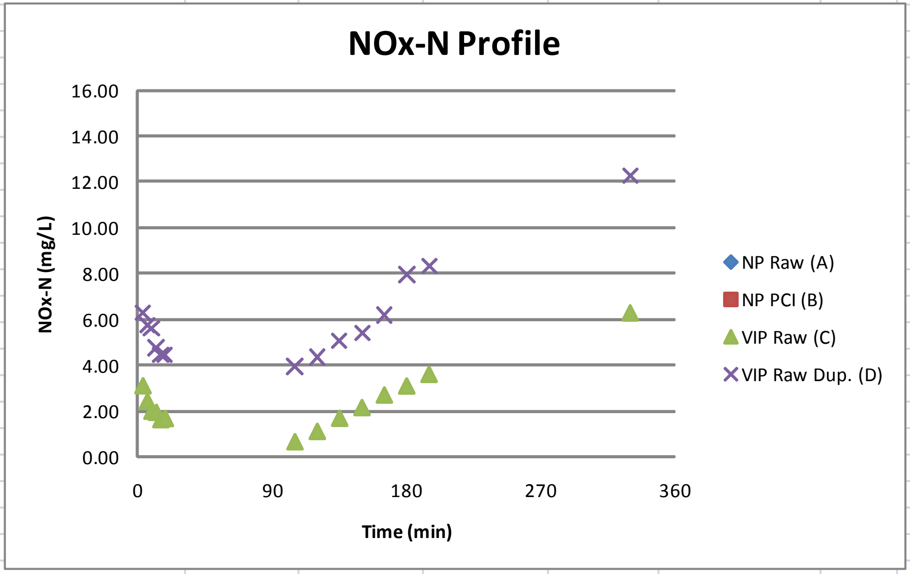
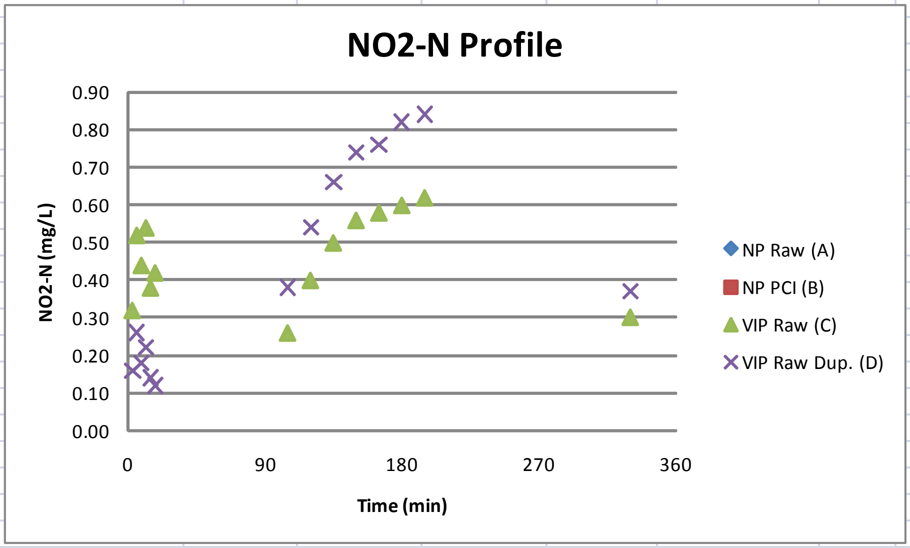
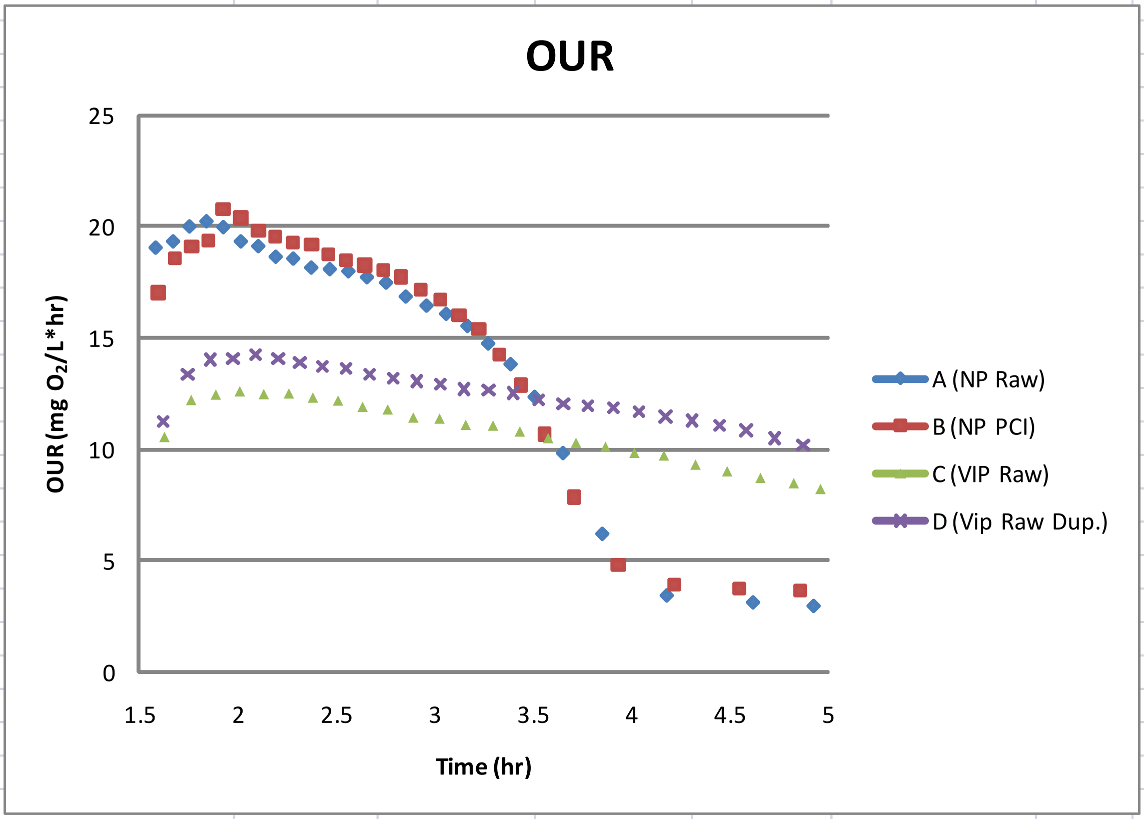
7.30
7.20
7.10
7.00
6.90
6.80
6.70
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
✕ D (VIP Raw Dup.)

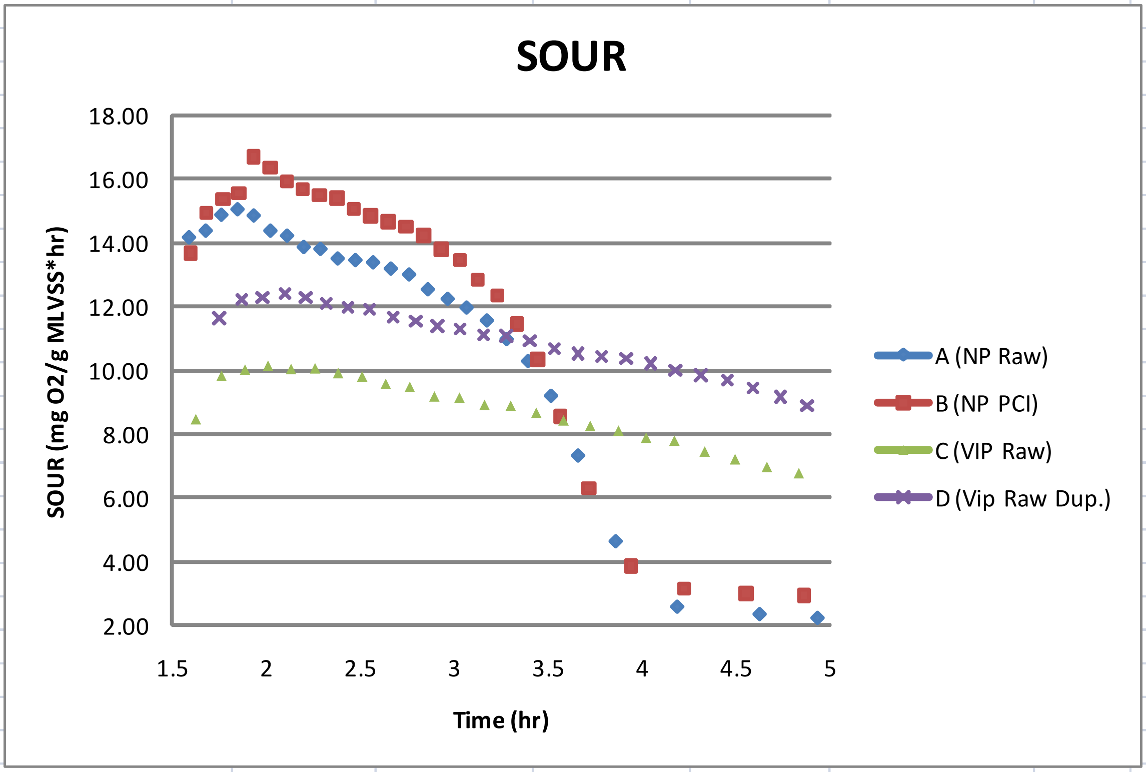

Temp Profile
12.5
12.4
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
11.5
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
✕ D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (Vip Raw Dup.)

17-Nov-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.25	150	87%	130.5	608	50.2
B (NP PCI)	30.15	134	85%	113.9	414	49.7
C (VIP Raw)	20.35	120	85%	102	553	32.6
D (Vip Raw Dup.)		126	84%	105.84	427	34.6
	20.35	123	0.845	103.92	490	33.6

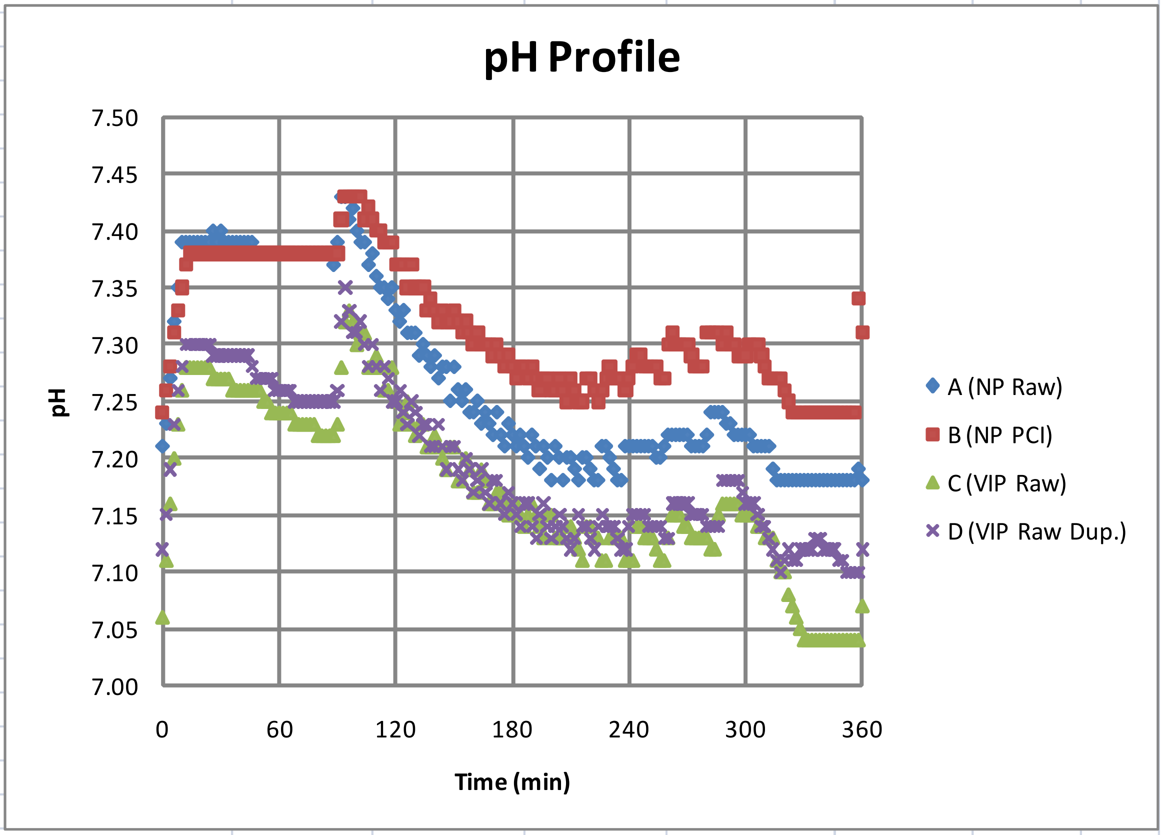
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1780	85%	1513.0
B (NP PCI)	1800	86%	1548.0
C (VIP Raw)	1500	87%	1305.0
D (Vip Raw Dup.)	1560	86%	1341.6

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.059	6.9	0.02	5	
B (NP PCI)	0.061	10.2	0.024	4	
C (VIP Raw)	0.050	3.6	0.024	7	
D (Vip Raw Dup.)	0.058	3.6	0.02	5	

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	710	320	179.8
B (NP PCI)	490	240	133.3
C (VIP Raw)	550	205	136.7
D (Vip Raw Dup.)	560	215	137.8

	A	B	C	D
OUR (mg O_2/L*hr)	16.03	14.61	9.49	10.74
MLVSS (g/L)	1.51	1.55	1.31	1.34
SOUR (mg O_2/g MLVSS*hr)	10.59	9.44	7.27	8.01

Avg. Temp. (° C)	
A (NP Raw)	12.23
B (NP PCI)	11.68
C (VIP Raw)	12.15
D (Vip Raw Dup.)	12.05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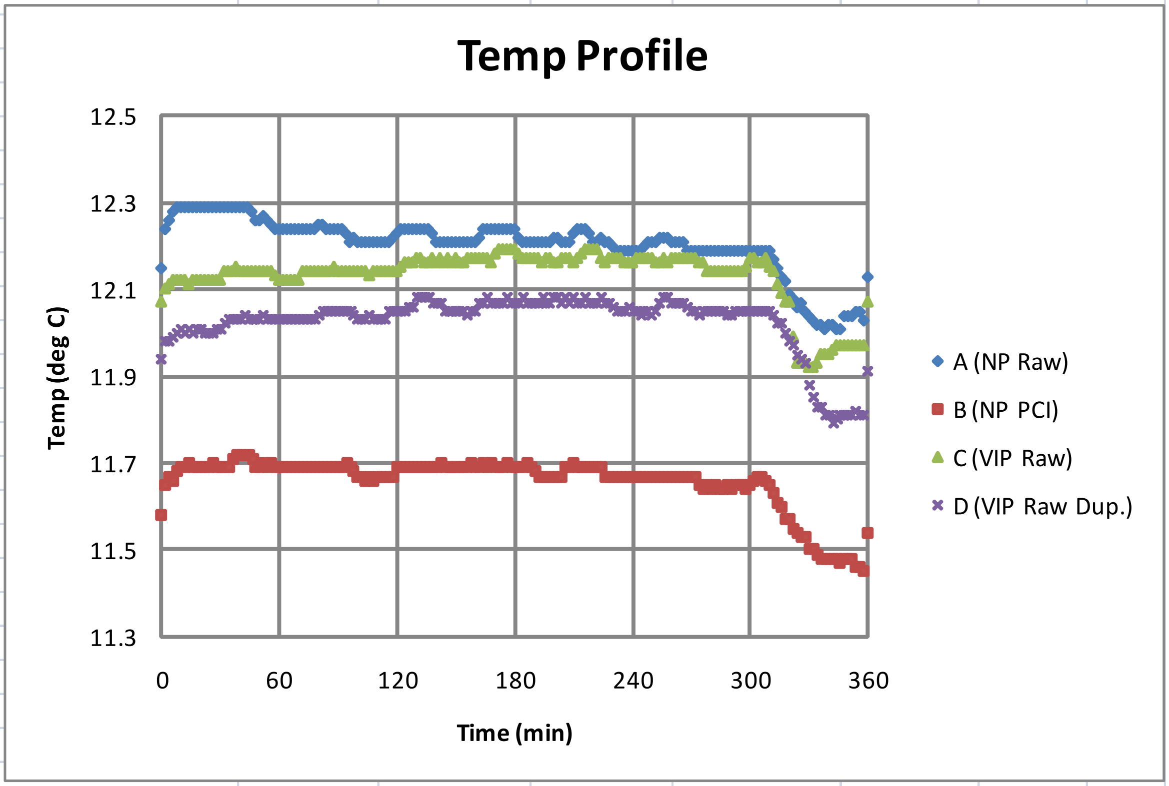
7.25
7.20
7.15
7.10
7.05
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
12.5
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12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

19-Nov-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	32.15	108	88%	95.04	390	48.2
B (NP PCI)	33	110	87%	95.7	405	49.3
C (VIP Raw)	23.8	136	88%	119.68	414	38.4
D (Vip Raw Dup.)		126	90%	113.4	393	38.2
	23.8	131	0.89	116.54	403.5	38.3

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1740	85%	1479.0
B (NP PCI)	1600	85%	1360.0
C (VIP Raw)	1800	86%	1548.0
D (Vip Raw Dup.)	1540	84%	1293.6

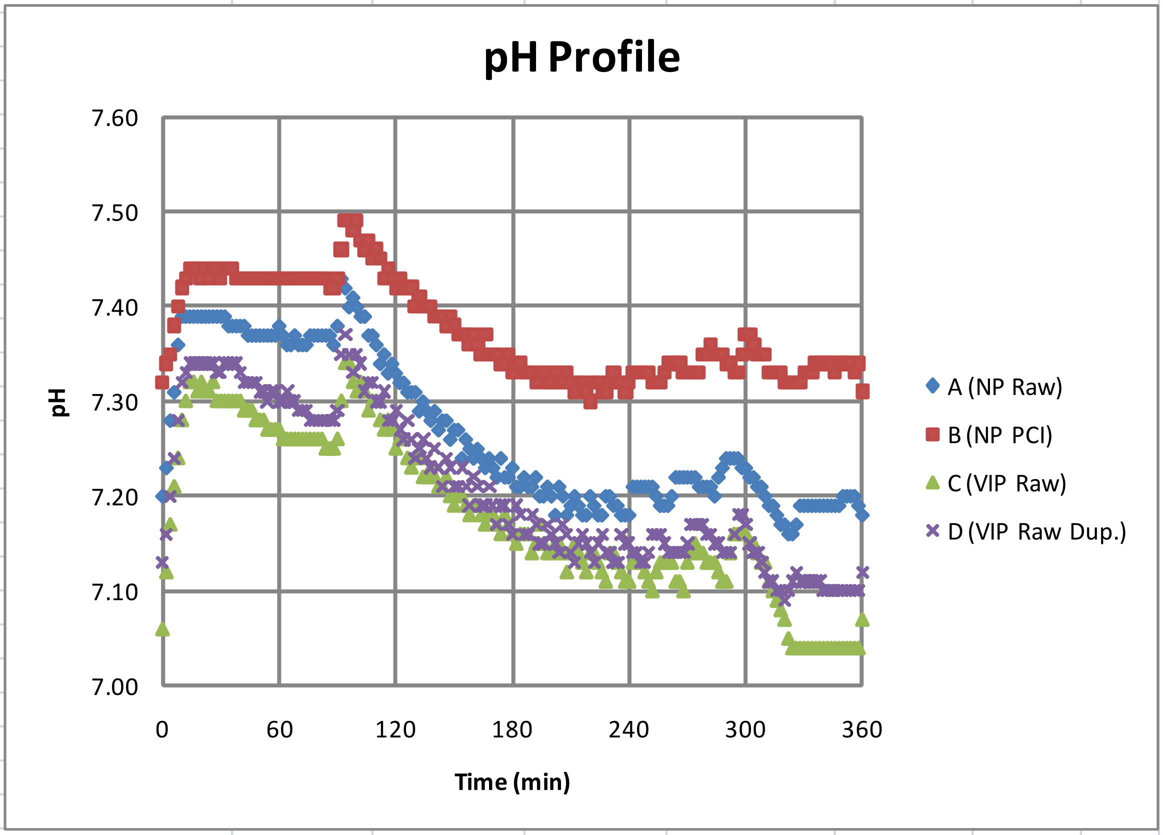
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.109	7.4	0.02	5	
B (NP PCI)	0.151	11.5	0.024	4	
C (VIP Raw)	0.109	4.2	0.036	8	
D (Vip Raw Dup.)	0.111	4.2	0.024	4	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	15.57	14.85	10.00	11.35
MLVSS (g/L)	1.48	1.36	1.55	1.29
SOUR (mg O_2/g MLVSS*hr)	10.53	10.92	6.46	8.78

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCI)	11.67
C (VIP Raw)	12.19
D (Vip Raw Dup.)	12.04


pH Profile
7.60
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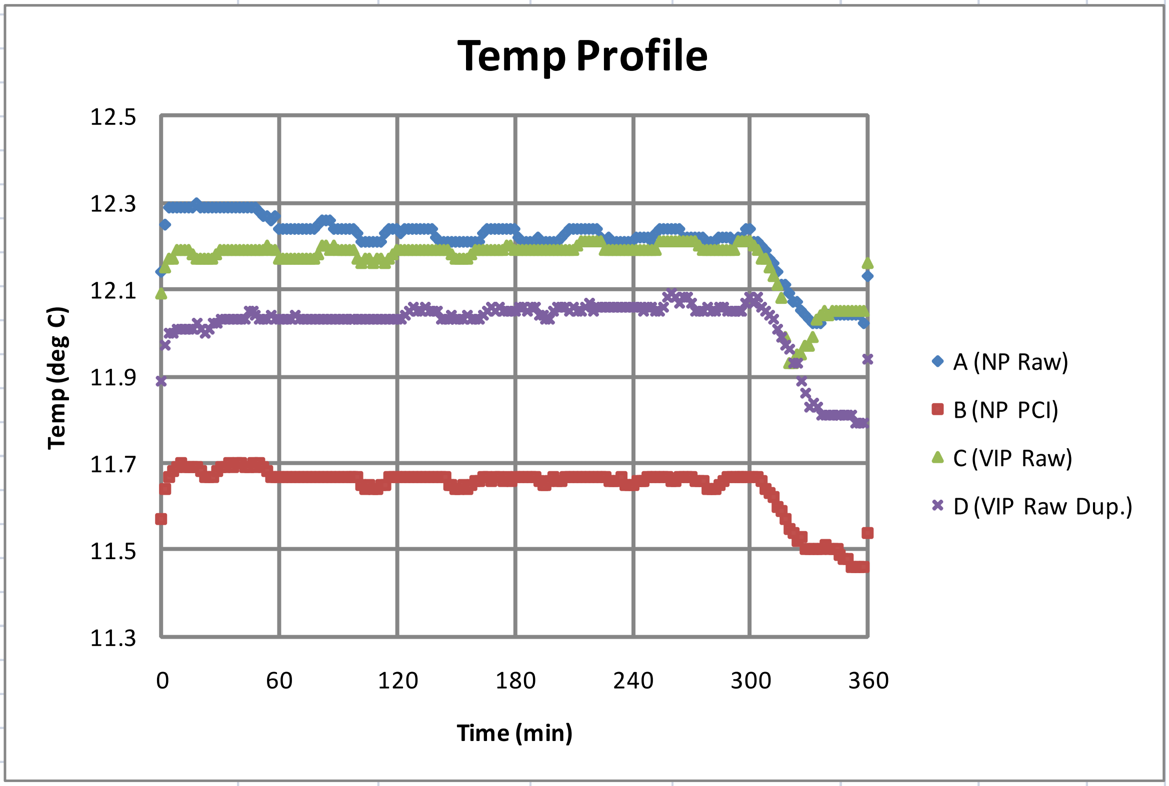
7.30
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
12.5
12.3
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

22-Nov-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	33.5	126	86%	108.36	409	49.4	7.2
B (NP PCI)	31.2	144	86%	123.84	421	49.6	7.2
C (VIP Raw)	23.4	86	93%	79.98	336	35.4	3.4
D (Vip Raw Dup.)		90	84%	75.6	322	33.8	
	23.4	88	0.885	77.79	329	34.6	3.4

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1800	88%	1584
B (NP PCI)	1620	84%	1360.8
C (VIP Raw)	1580	85%	1343
D (Vip Raw Dup.)	1330	82%	1090.6

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.600	7.59	0.016	6		5.8
B (NP PCI)	0.069	12.7	0.024	4		5.75
C (VIP Raw)	0.099	5.24	0.052	6		2.45
D (Vip Raw Dup.)	0.073	5.08	0.024	3		2.4

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	680	270
B (NP PCI)	540	250
C (VIP Raw)	615	235
D (Vip Raw Dup.)	650	270

SVI (mL/g)
150.0
154.3
148.7
203.0

	A	B	C	D
OUR (mg O_2/L*hr)	15.42	14.89	9.43	10.46
MLVSS (g/L)	1.58	1.36	1.34	1.09
SOUR (mg O_2/g MLVSS*hr)	9.73	10.94	7.02	9.60

Avg. Temp. (° C)	
A (NP Raw)	12.30
B (NP PCI)	11.75
C (VIP Raw)	12.21
D (Vip Raw Dup.)	12.10

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.58	1.36	1.34	1.09
NR (mg NOx-N/L*hr)	2.93	3.52	1.58	1.71
DNR (mg NOx-N/L*hr)	5.70	6.61	5.56	5.68
SNR (mg NOx-N/g MLVSS*hr)	1.85	2.59	1.18	1.57
SDNR (mg NOx-N/g MLVSS*hr)	3.60	4.86	4.14	5.21

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.26	3.03	1.12	4.15	6.35
10		2.15	1.02	3.17	
15		1.91	0.88	2.79	
20		1.74	0.80	2.54	
105	6.03	1.06	0.26	1.32	6.1
120	4.91	1.78	0.36	2.14	
135	4.25	2.58	0.42	3.00	
150	3.45	3.34	0.50	3.84	5.85
165	2.66	4.11	0.50	4.61	
180	1.94	4.88	0.52	5.40	
195	1.23	4.90	0.54	5.44	5.7
330	0.06	7.59	0.02	7.61	5.8

NP PCI (B)

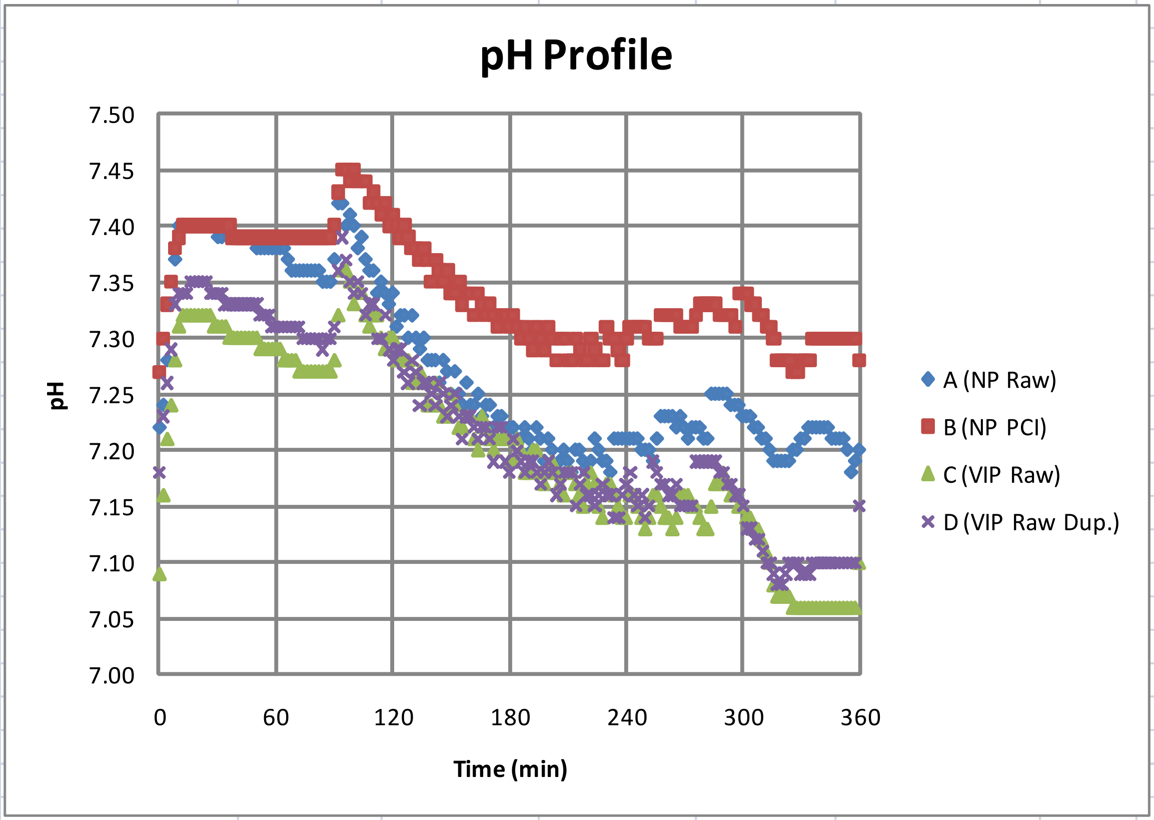
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.23	7.96	0.82	8.78	6.4
10		6.22	1.10	7.32	
15		6.43	1.04	7.47	
20		5.77	0.96	6.73	
105	6.04	5.60	0.48	6.08	6.25
120	5.04	5.55	0.74	6.29	
135	4.26	7.55	0.84	8.39	
150	3.45	7.94	0.90	8.84	5.75
165	2.64	8.67	0.92	9.59	
180	2	9.72	0.94	10.66	
195	1.23	10.10	0.88	10.98	5.7
330	0.069	12.70	0.02	12.72	5.75

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.5	2.73	0.36	3.09	2.65
10		1.54	0.64	2.18	
15		1.32	0.44	1.76	
20		1.21	0.32	1.53	
105	4.6	0.42	0.22	0.64	2.6
120	3.84	0.77	0.30	1.07	
135	3.57	1.22	0.36	1.58	
150	2.98	1.60	0.40	2.00	2.5
165	2.58	1.98	0.38	2.36	
180	2.21	2.45	0.42	2.87	
195	1.71	2.44	0.42	2.86	2.35
330	0.099	5.24	0.05	5.29	2.45

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.46	2.79	0.340	3.13	2.7
10		1.54	0.620	2.16	
15		1.35	0.440	1.79	
20		1.24	0.280	1.52	
105	4.51	0.43	0.240	0.67	2.9
120	3.76	0.81	0.340	1.15	
135	3.24	1.28	0.400	1.68	
150	2.72	1.71	0.420	2.13	2.35
165	2.3	2.14	0.440	2.58	
180	1.81	2.62	0.460	3.08	
195	1.23	2.64	0.440	3.08	2.4
330	0.073	5.08	0.024	5.10	2.4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7.35
7.30
7.25
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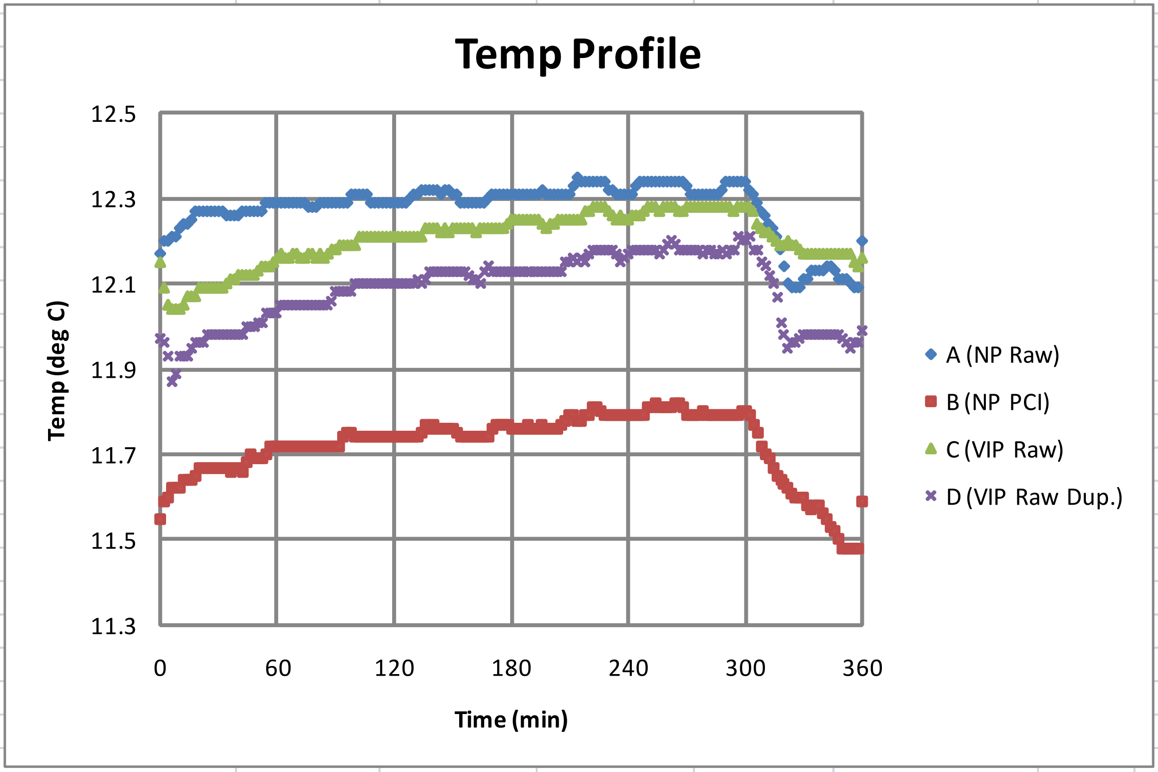
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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12.1
11.9
11.7
11.5
11.3
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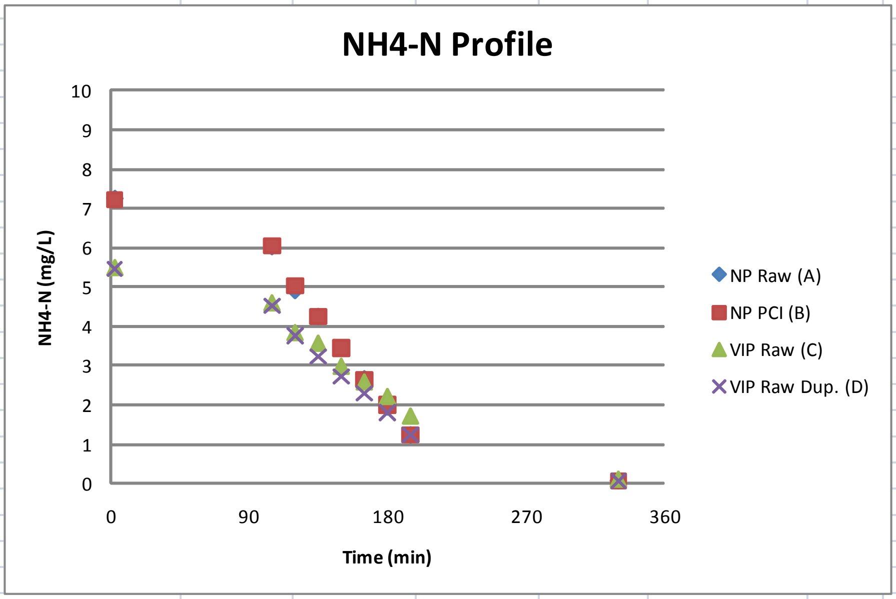
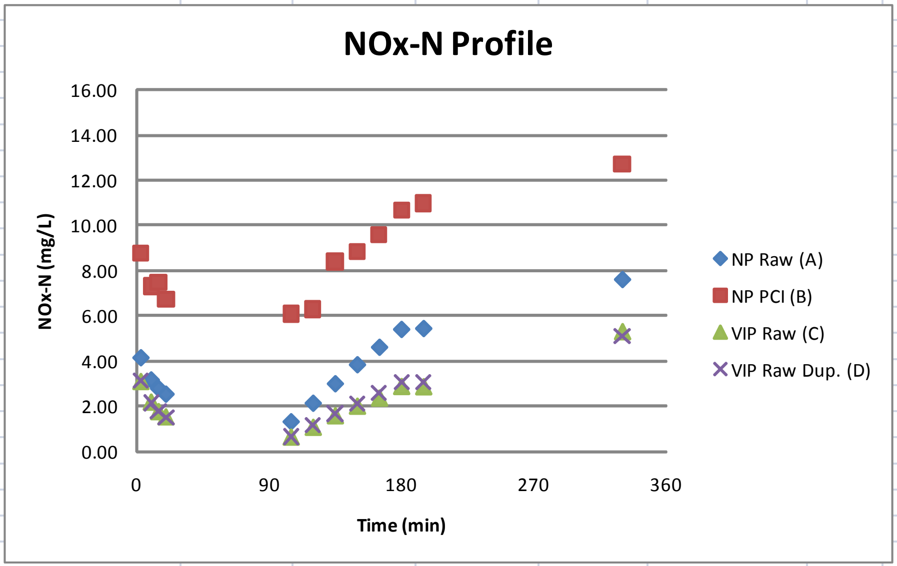
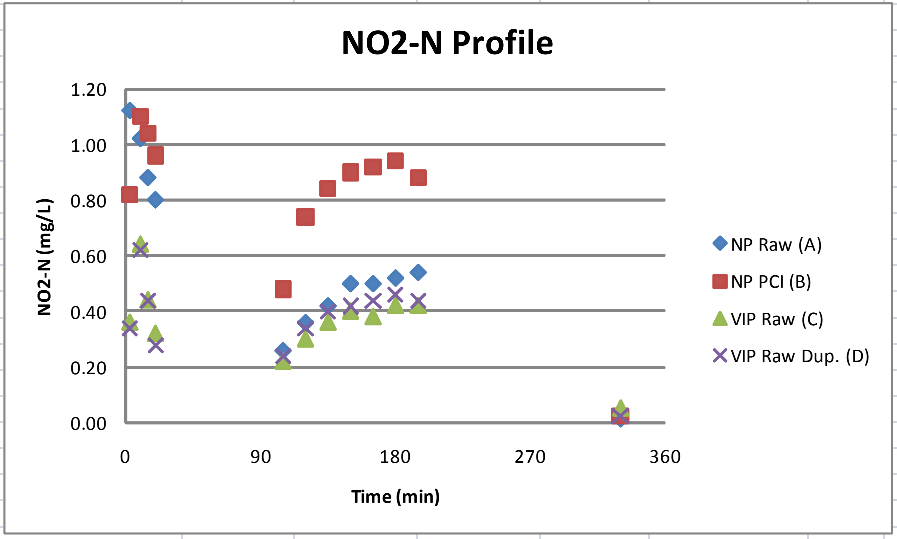
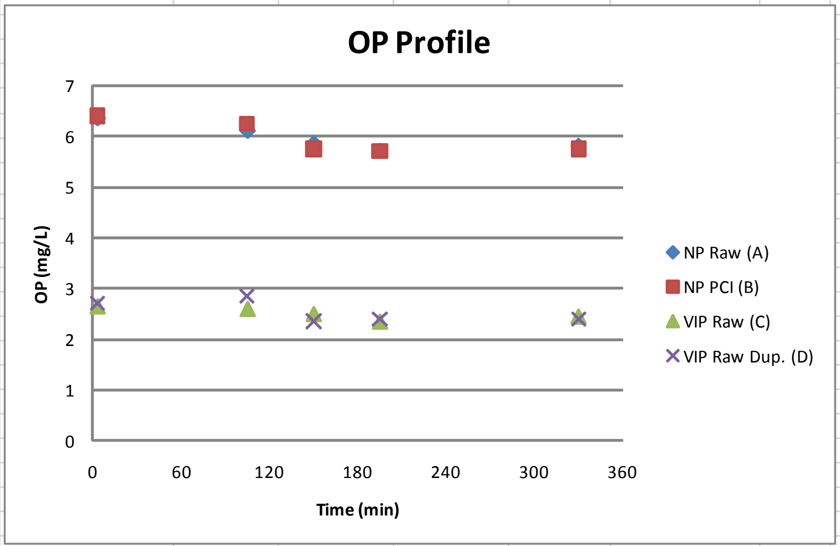
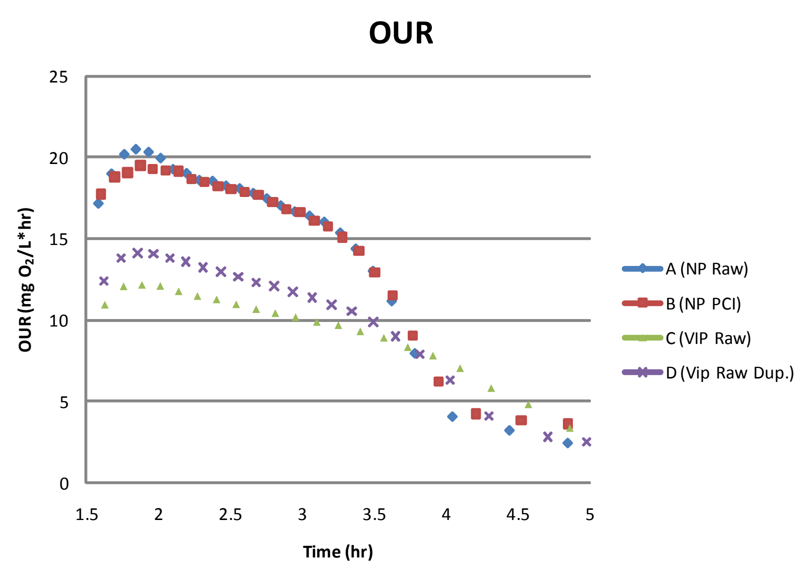
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

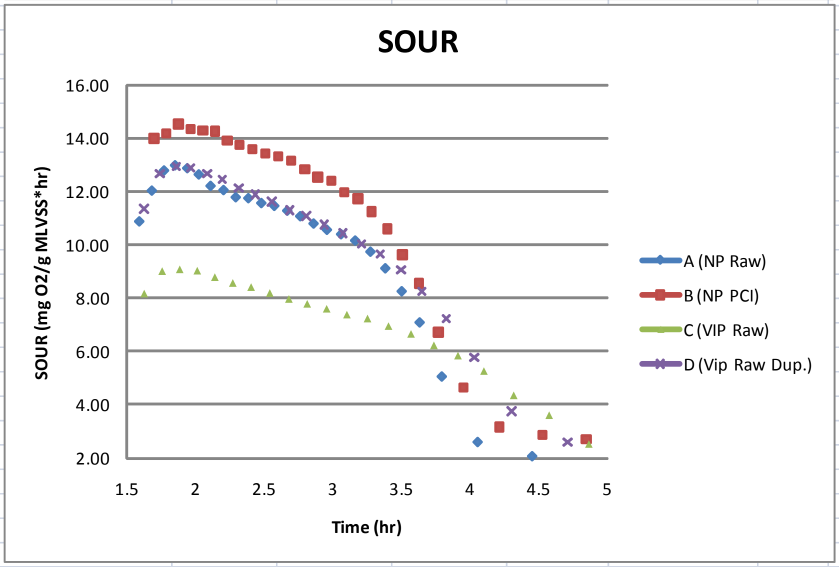

NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

24-Nov-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	36.2	74	89%	65.86	387	49.1
B (NP PCI)	33.45	83	89%	73.87	413	49.5
C (VIP Raw)	25.6	52	96%	49.92	327	34.3
D (Vip Raw Dup.)		64	97%	62.08	390	36.4
	25.6	58	0.965	56	358.5	35.35

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1780	88%	1566.4
B (NP PCI)	2040	85%	1734.0
C (VIP Raw)	1580	89%	1406.2
D (Vip Raw Dup.)	1560	87%	1357.2

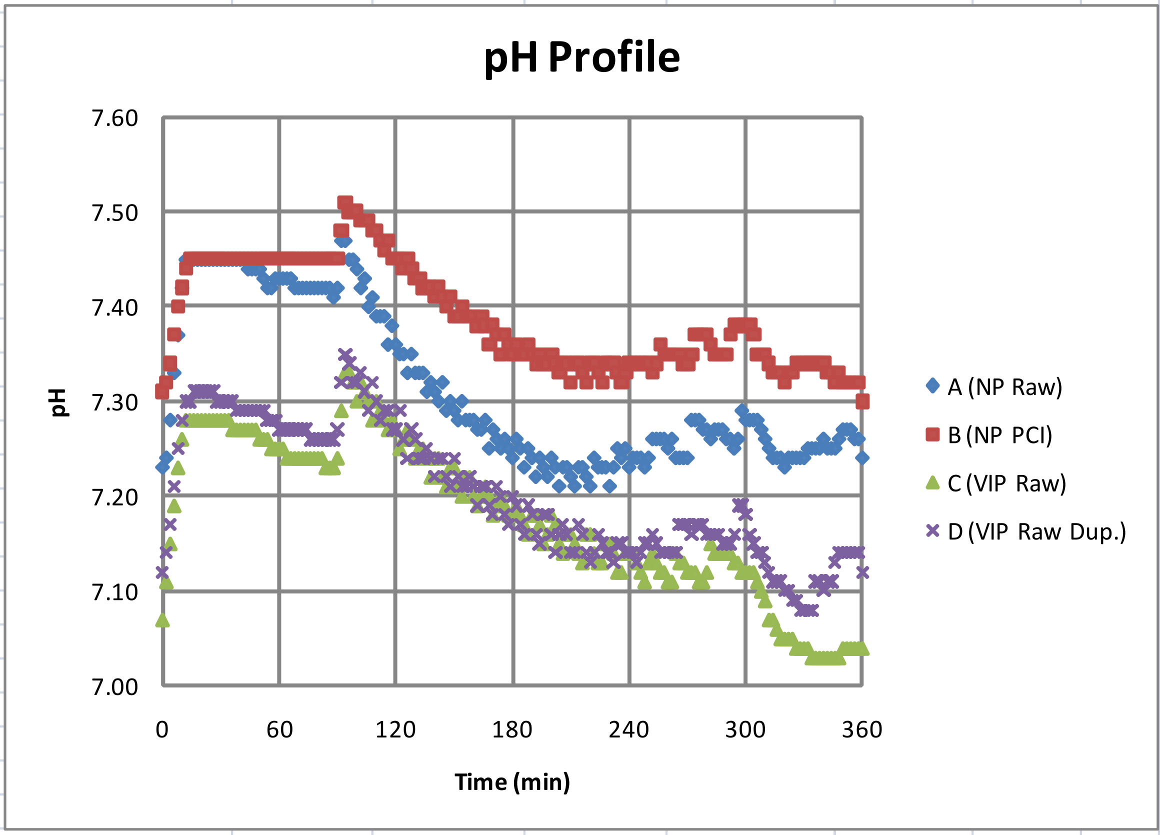
Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.077	6.5	0.016	6	
B (NP PCI)	0.090	8.4	0.032	5	
C (VIP Raw)	0.118	5.0	0.044	3	
D (Vip Raw Dup.)	0.124	4.6	0.02	2	

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	640	265	148.9
B (NP PCI)	525	260	127.5
C (VIP Raw)	610	240	151.9
D (Vip Raw Dup.)	665	280	179.5

	A	B	C	D
OUR (mg O_2/L*hr)	17.25	0.14	-3.99	-1.85
MLVSS (g/L)	1.57	1.73	1.41	1.36
SOUR (mg O_2/g MLVSS*hr)	11.01	0.08	-2.84	-1.36

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCI)	11.70
C (VIP Raw)	12.18
D (Vip Raw Dup.)	12.05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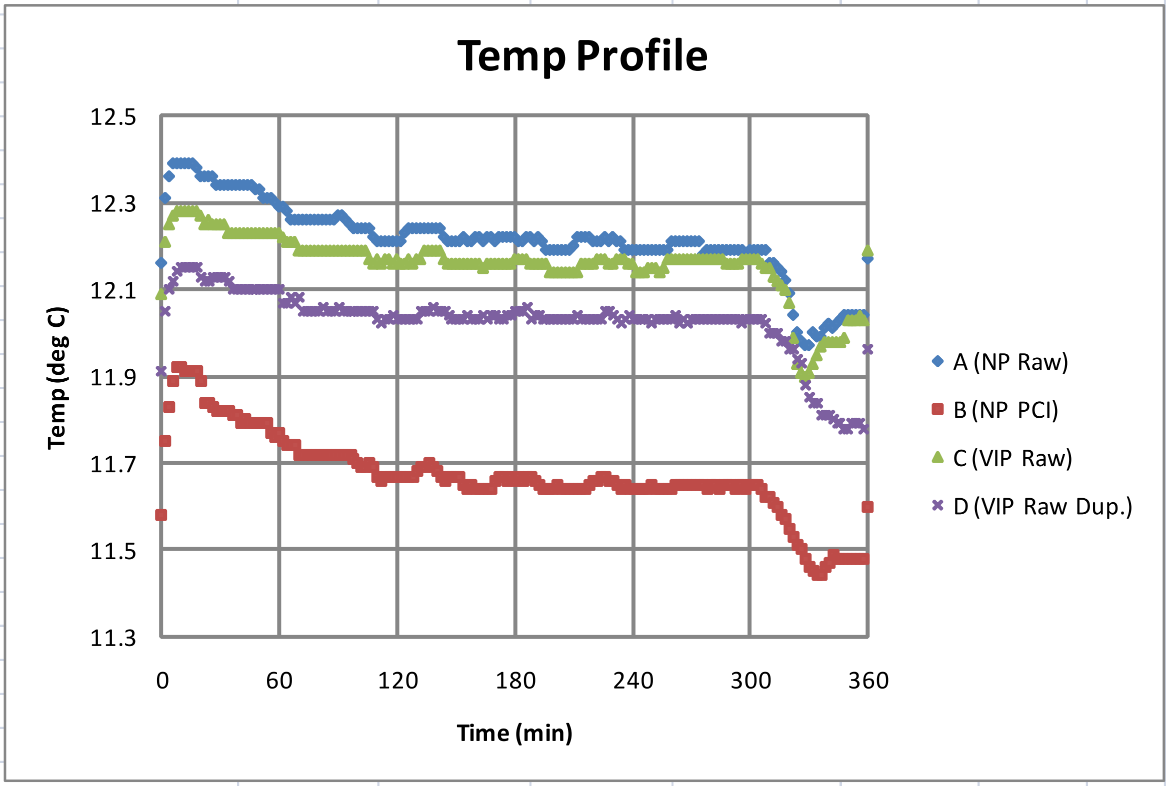
7.60
7.50
7.40
7.30
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
12.5
12.3
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

29-Nov-10

Feed						
	NH3-N mg/L	**TSS mg/L**	**Voltl. Frac. %**	**VSS mg/L**	**COD mg/L**	**TKN mg/L**
A (NP Raw)	32.7	136	90%	122.4	462	47.3
B (NP PCI)	31.05	150	84%	126	484	47.5
C (VIP Raw)	22.75	162	79%	127.98	444	36.3
D (Vip Raw Dup.)		164	79%	129.56	451	37.4
	22.75	163	0.79	128.77	447.5	36.85

Mixed Liquor			
	MLSS mg/L	**Voltl. Frac. %**	**MLVSS mg/L**
A (NP Raw)	1800	86%	1548.0
B (NP PCI)	1960	85%	1666.0
C (VIP Raw)	1540	86%	1324.4
D (Vip Raw Dup.)	1640	84%	1377.6

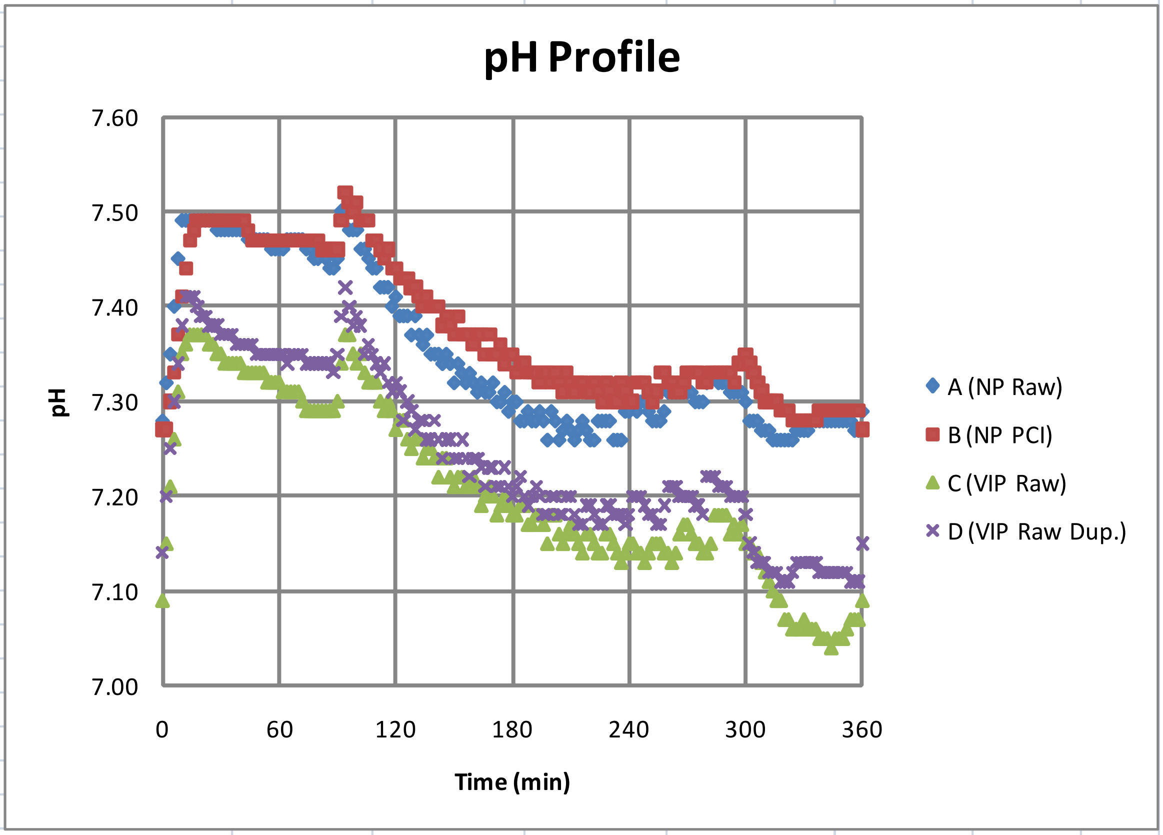
Effluent (1330)					
	NH3-N mg/L	**NO3-N mg/L**	**NO2-N mg/L**	**TSS mg/L**	**Turb. NTU**
A (NP Raw)	0.052	7.2	0.032	8	
B (NP PCI)	0.045	7.8	0.048	4	
C (VIP Raw)	0.047	4.7	0.028	5	
D (Vip Raw Dup.)	0.042	4.7	0.028	2	

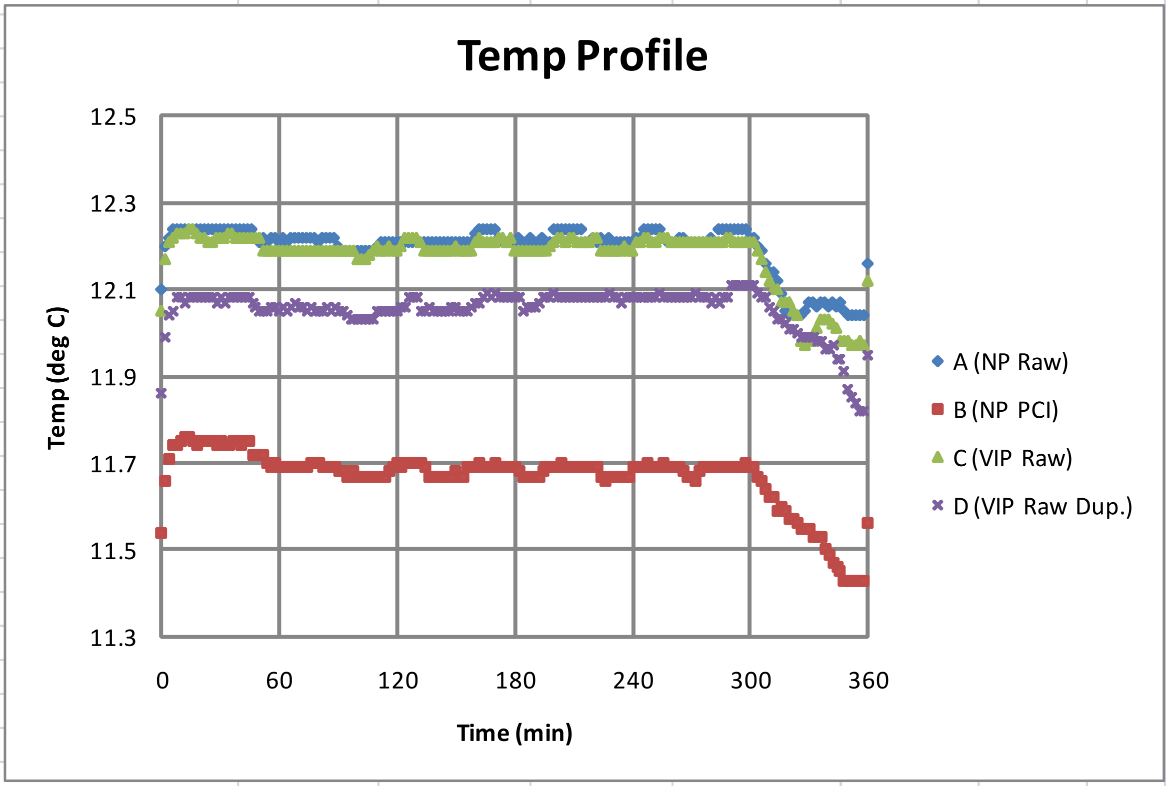
Settled Sludge Volume (mL/L)		
	5 min	**30 min**
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	**B**	**C**	**D**
OUR (mg O_2/L*hr)	1.55	-2.10	6.75	7.85
MLVSS (g/L)	1.55	1.67	1.32	1.38
SOUR (mg O_2/g MLVSS*hr)	1.00	-1.26	5.10	5.70

Avg. Temp. (° C)	
A (NP Raw)	12.22
B (NP PCI)	11.69
C (VIP Raw)	12.20
D (Vip Raw Dup.)	12.07


pH Profile
7.60
7.50
7.40
7.30
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
12.5
12.3
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

1-Dec-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	34	168	89%	149.52	519	55.8	
B (NP PCI)	34.4	136	88%	119.68	450	53.5	
C (VIP Raw)	24.5	128	89%	113.92	395	39.4	
D (Vip Raw Dup.)		138	88%	121.44	418	39.2	
	24.5	133	0.885	117.68	406.5	39.3	#DIV/0!

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1880	90%	1692
B (NP PCI)	1800	86%	1548
C (VIP Raw)	1540	88%	1355.2
D (Vip Raw Dup.)	1560	85%	1326

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.061	8.59	0.020	6		
B (NP PCI)	0.053	11.9	0.048	5		
C (VIP Raw)	1.860	7	0.524	9		
D (Vip Raw Dup.)	1.050	7.67	0.540	2		

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)	565	235
B (NP PCI)	565	265
C (VIP Raw)	730	285
D (Vip Raw Dup.)	850	375

SVI (mL/g)
125.0
147.2
185.1
240.4

	A	B	C	D
OUR (mg O_2/L*hr)	2.58	0.10	-0.78	0.14
MLVSS (g/L)	1.69	1.55	1.36	1.33
SOUR (mg O_2/g MLVSS*hr)	1.52	0.06	-0.58	0.11

Avg. Temp. (° C)	
A (NP Raw)	12.39
B (NP PCI)	11.88
C (VIP Raw)	12.32
D (Vip Raw Dup.)	12.29

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.69	1.55	1.36	1.33
NR (mg NOx-N/L*hr)	3.58	3.84	1.94	2.12
DNR (mg NOx-N/L*hr)	9.75	8.39	7.10	7.34
SNR (mg NOx-N/g MLVSS*hr)	2.11	2.48	1.43	1.60
SDNR (mg NOx-N/g MLVSS*hr)	5.76	5.42	5.24	5.53

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	7.94	3.39	1.24	4.63
10		1.58	1.46	3.04
15		1.11	1.06	2.17
20		0.83	1.12	1.95
105	8.35	0.67	0.28	0.95
120	7.39	1.43	0.38	1.81
135	6.31	2.10	0.50	2.60
150	5.47	2.99	0.50	3.49
165	4.6	3.77	0.54	4.31
180	3.89	4.52	0.58	5.10
195	2.88	5.89	0.64	6.53
330	0.061	8.59	0.02	8.61

NP PCI (B)

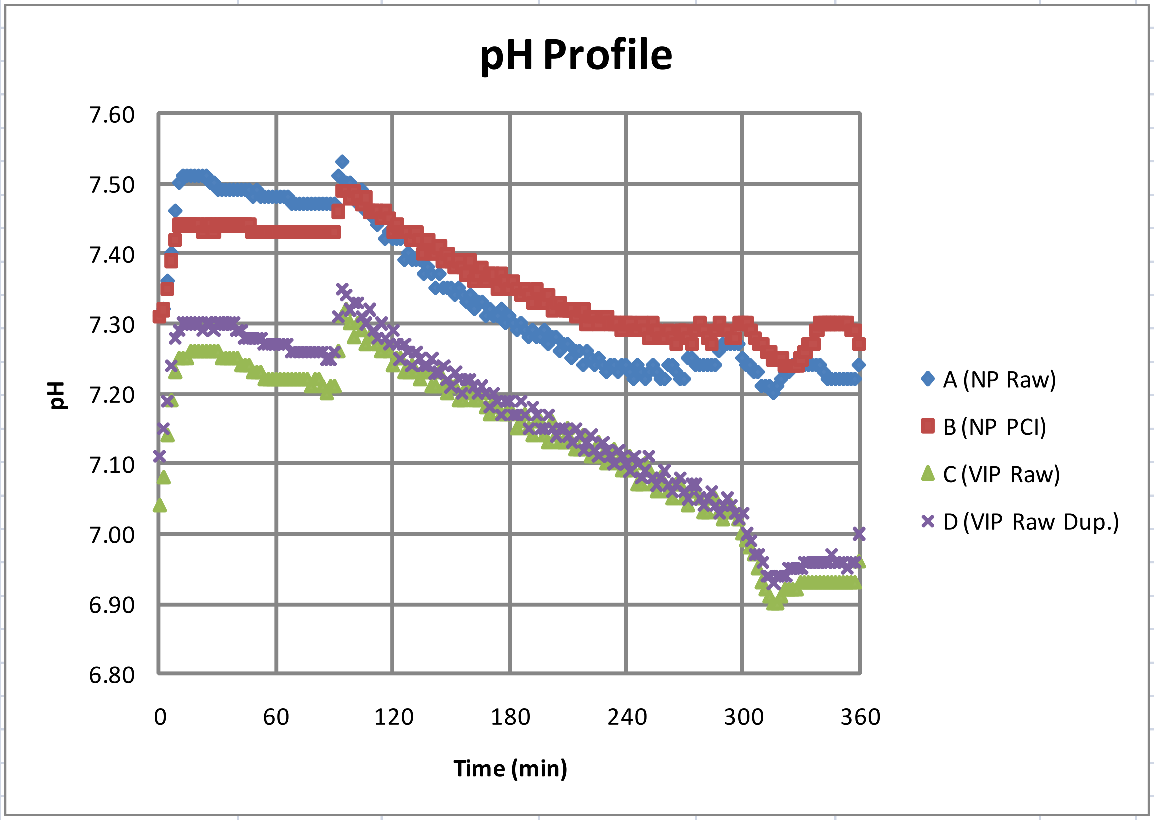
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	8.29	6.14	0.92	7.06
10		4.40	1.34	5.74
15		3.91	1.28	5.19
20		3.81	0.86	4.67
105	8.25	2.70	0.42	3.12
120	7.2	2.78	0.50	3.28
135	6.37	3.82	0.68	4.50
150	5.53	4.85	0.68	5.53
165	4.78	5.89	0.74	6.63
180	4.19	6.71	0.72	7.43
195	3.29	7.26	0.76	8.02
330	0.053	11.90	0.05	11.95

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.9	2.24	1.00	3.24
10		0.97	0.86	1.83
15		0.89	0.66	1.55
20		0.63	0.56	1.19
105	8.48	0.40	0.32	0.72
120	7.74	0.76	0.40	1.16
135	7.12	1.22	0.44	1.66
150	6.64	1.66	0.50	2.16
165	6	2.08	0.50	2.58
180	5.72	2.58	0.50	3.08
195	5.19	3.09	0.58	3.67
330	1.86	7.00	0.52	7.52

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.84	2.12	1.140	3.26
10		1.01	1.160	2.17
15		0.75	0.740	1.49
20		0.54	0.700	1.24
105	8.3	0.42	0.260	0.68
120	7.36	0.92	0.460	1.38
135	6.79	1.32	0.540	1.86
150	6.24	1.53	0.620	2.15
165	5.79	2.20	0.520	2.72
180	5.24	2.78	0.600	3.38
195	4.66	3.33	0.680	4.01
330	1.05	7.67	0.540	8.21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7.10
7.00
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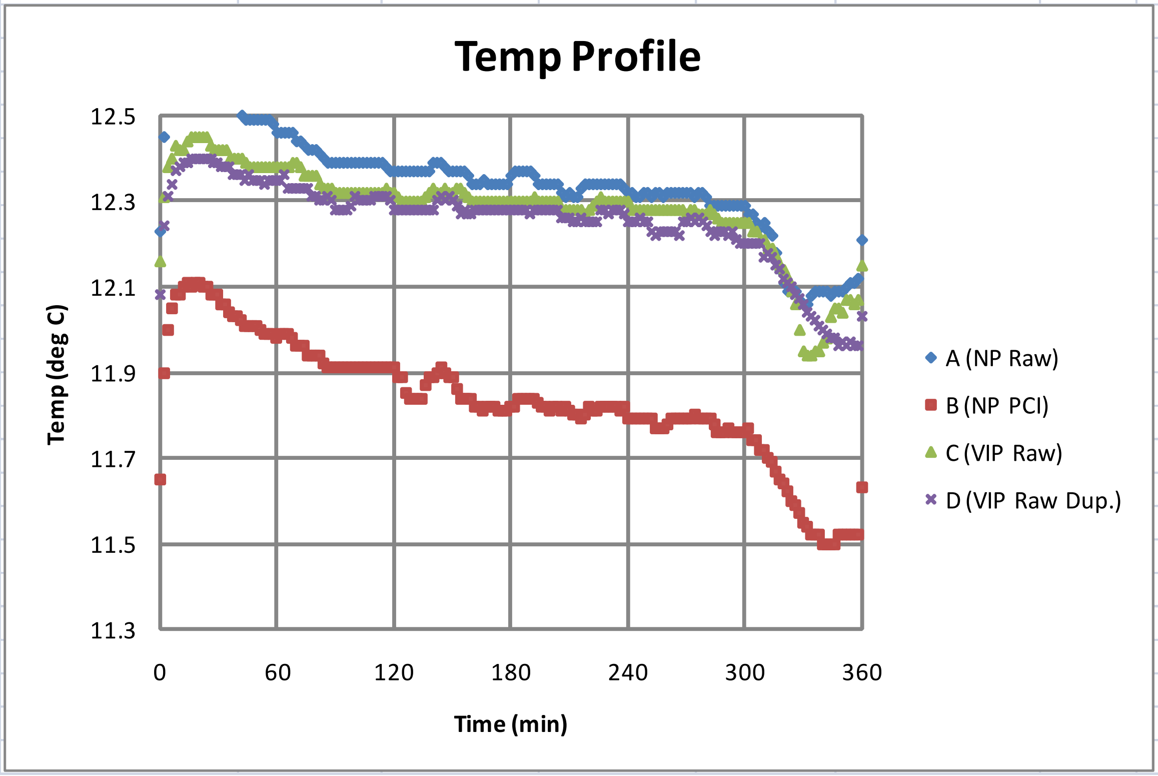
6.80
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
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12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

3-Dec-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	33.65	156	94%	146.64	461	54.9
B (NP PCl)	33.75	178	84%	149.52	473	56
C (VIP Raw)	25.1	116	91%	105.56	362	40
D (Vip Raw Dup.)		116	90%	104.4	366	42.1
	25.1	116	0.905	104.98	364	41.05

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	1820	90%	1638.0
B (NP PCl)	2020	85%	1717.0
C (VIP Raw)	1560	88%	1372.8
D (Vip Raw Dup.)	1440	88%	1267.2

Effluent (1330)

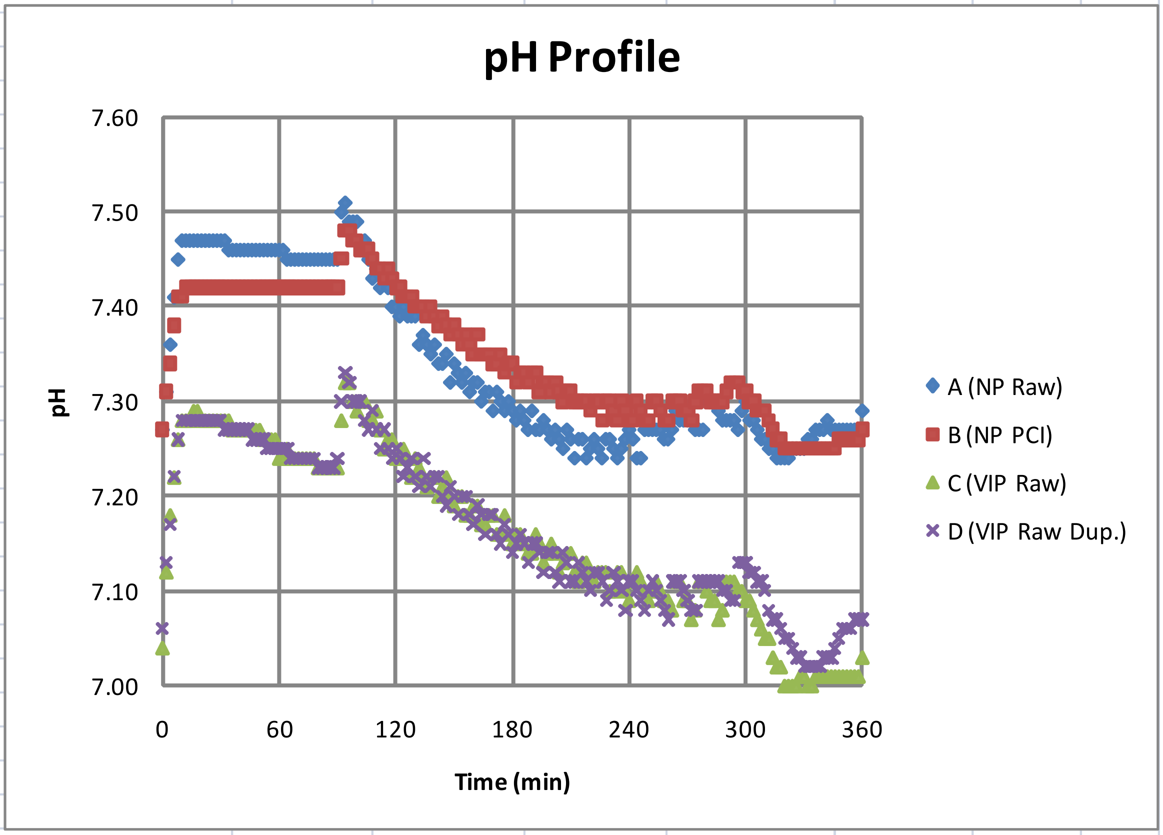
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.080	7.7	0.028	9	
B (NP PCl)	0.058	12.0	0.032	7	
C (VIP Raw)	0.059	5.7	0.076	4	
D (Vip Raw Dup.)	0.055	5.8	0.036	2	

Settled Sludge Volume (mL/L)	5 min	30 min
A (NP Raw)	620	235
B (NP PCl)	580	270
C (VIP Raw)	790	320
D (Vip Raw Dup.)	820	365

SVI (mL/g)
129.1
133.7
205.1
253.5

	A	B	C	D
OUR (mg O_2/L*hr)	8.43	7.58	5.52	6.16
MLVSS (g/L)	1.64	1.72	1.37	1.27
SOUR (mg O_2/g MLVSS*hr)	5.15	4.41	4.02	4.86

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCl)	11.65
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.03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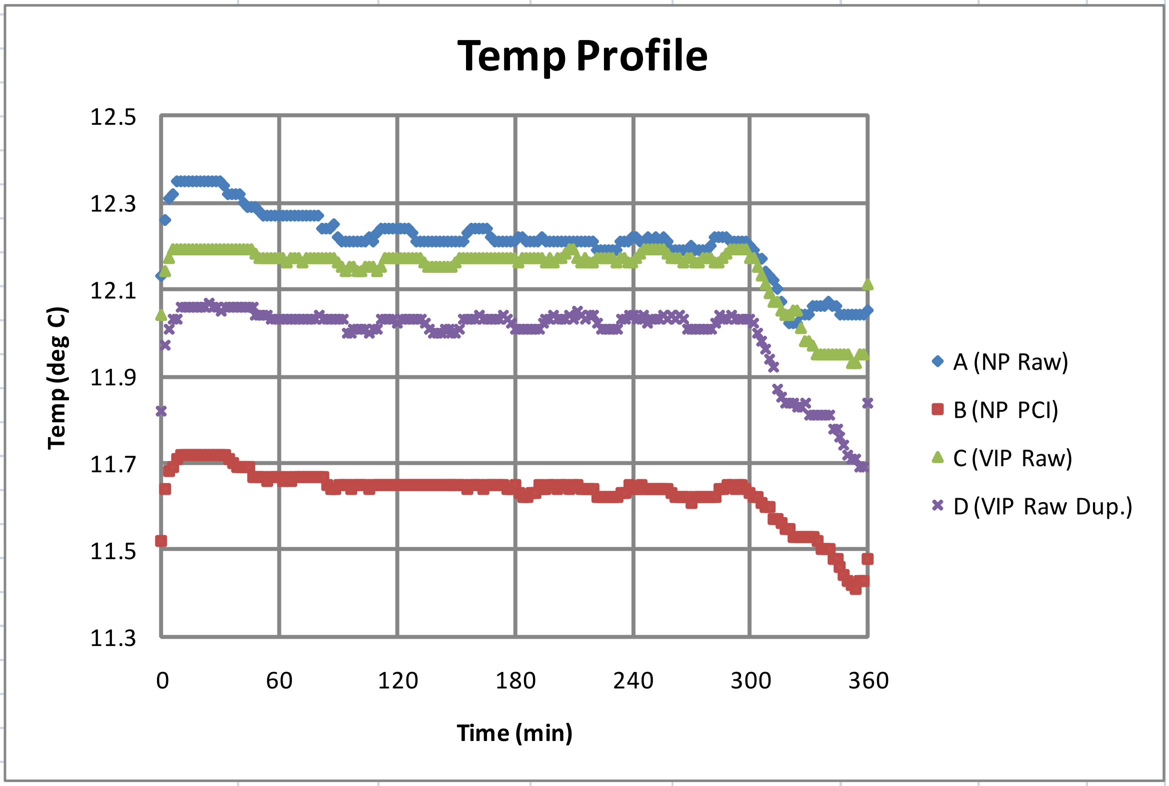
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

6-Dec-10

Feed						
	NH3-N mg/L	**TSS mg/L**	**Voltl. Frac. %**	**VSS mg/L**	**COD mg/L**	**TKN mg/L**
A (NP Raw)	30.5	152	91%	138.32	455	55.2
B (NP PCI)	32.65	118	92%	108.56	409	54.7
C (VIP Raw)	25	124	84%	104.16	382	40.7
D (Vip Raw Dup.)		132	79%	104.28	385	42
	25	128	0.815	104.22	383.5	41.35

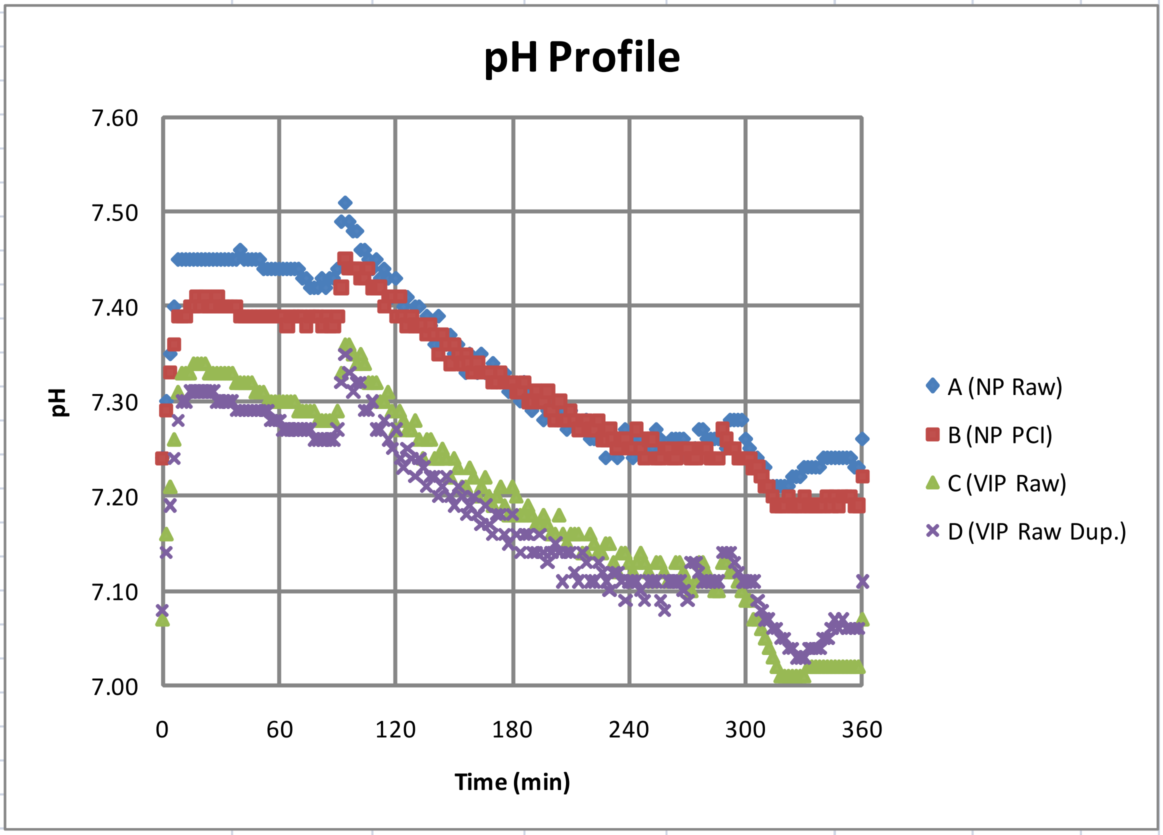
Mixed Liquor			
	MLSS mg/L	**Voltl. Frac. %**	**MLVSS mg/L**
A (NP Raw)	1680	89%	1495.2
B (NP PCI)	1840	83%	1527.2
C (VIP Raw)	1560	79%	1232.4
D (Vip Raw Dup.)	1620	75%	1215.0

Effluent (1330)					
	NH3-N mg/L	**NO3-N mg/L**	**NO2-N mg/L**	**TSS mg/L**	**Turb. NTU**
A (NP Raw)	0.074	8.9	0.028	12	
B (NP PCI)	0.146	15.2	0.048	5	
C (VIP Raw)	0.097	6.3	0.144	7	
D (Vip Raw Dup.)	0.063	6.2	0.096	3	

Settled Sludge Volume (mL/L)			**SVI**
	5 min	**30 min**	**(mL/g)**
A (NP Raw)	525	225	133.9
B (NP PCI)	520	250	135.9
C (VIP Raw)	740	290	185.9
D (Vip Raw Dup.)	710	305	188.3

	A	**B**	**C**	**D**
OUR (mg O_2/L*hr)	0.14	1.97	1.83	3.86
MLVSS (g/L)	1.50	1.53	1.23	1.22
SOUR (mg O_2/g MLVSS*hr)	0.10	1.29	1.49	3.18

Avg. Temp. (° C)	
A (NP Raw)	12.19
B (NP PCI)	11.61
C (VIP Raw)	12.14
D (Vip Raw Dup.)	11.98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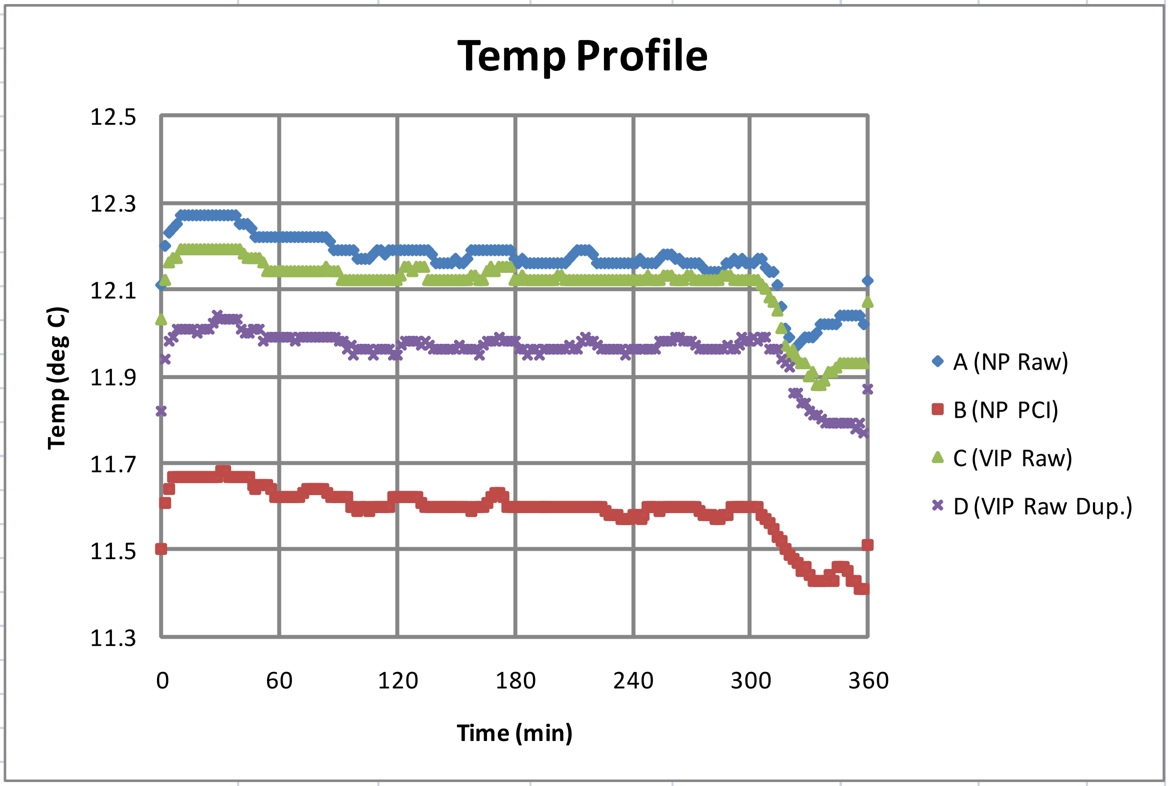
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

8-Dec-10

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	31.95	214	88%	188.32	628	54.3
B (NP PCl)	32.35	170	89%	151.3	534	56.1
C (VIP Raw)	24.9	134	90%	120.6	525	40
D (Vip Raw Dup.)		140	90%	126	540	38.2
	24.9	137	0.9	123.3	532.5	39.1

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2140	88%	1883.2
B (NP PCl)	2240	86%	1926.4
C (VIP Raw)	1880	86%	1616.8
D (Vip Raw Dup.)	1440	86%	1238.4

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.088	8.1	0.14	10	
B (NP PCl)	0.102	13.4	0.196	4	
C (VIP Raw)	0.081	2.9	0.072	3	
D (Vip Raw Dup.)	0.080	3.0	0.044	2	

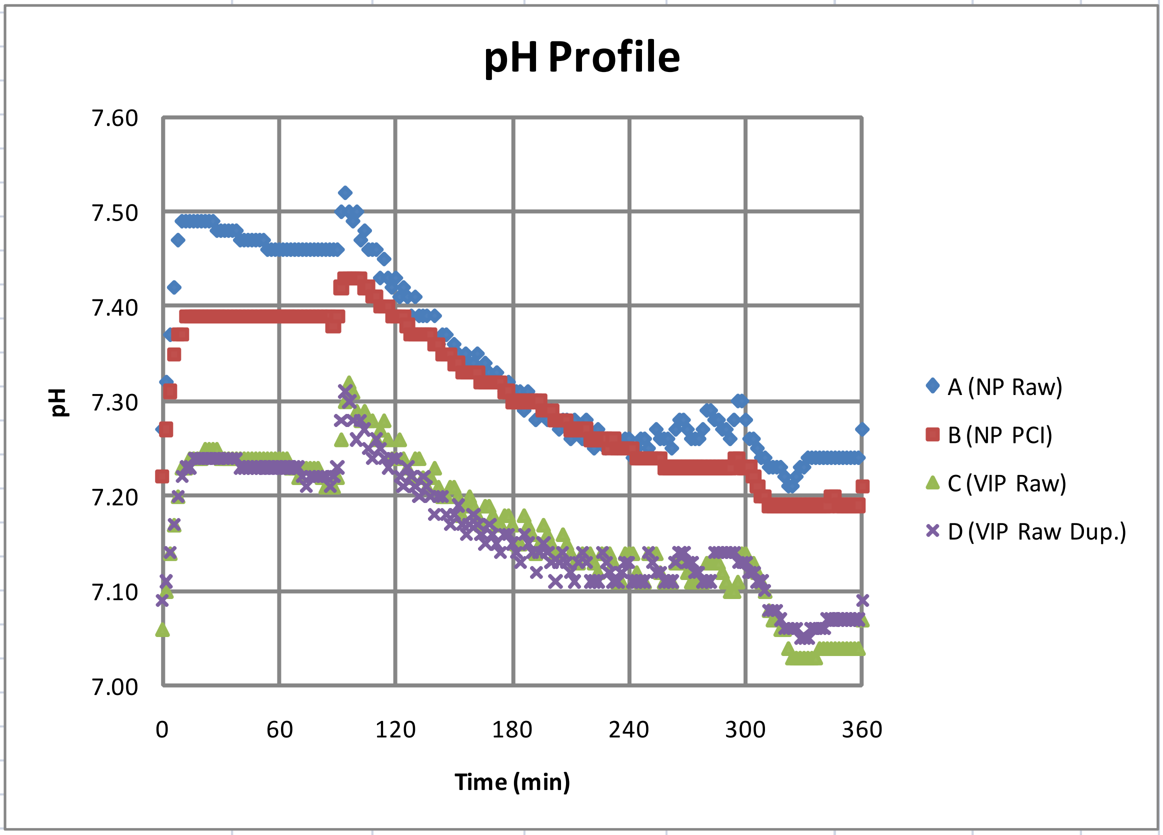
Settled Sludge Volume (mL/L)

	5 min	30 min
A (NP Raw)	550	240
B (NP PCl)	540	260
C (VIP Raw)	795	325
D (Vip Raw Dup.)	615	260

SVI (mL/g)
112.1
116.1
172.9
180.6

	A	B	C	D
OUR (mg O_2/L*hr)	6.13	-0.25	-2.65	0.62
MLVSS (g/L)	1.88	1.93	1.62	1.24
SOUR (mg O_2/g MLVSS*hr)	3.25	-0.13	-1.64	0.50

Avg. Temp. (° C)	
A (NP Raw)	12.20
B (NP PCl)	11.60
C (VIP Raw)	12.24
D (Vip Raw Dup.)	12.04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60
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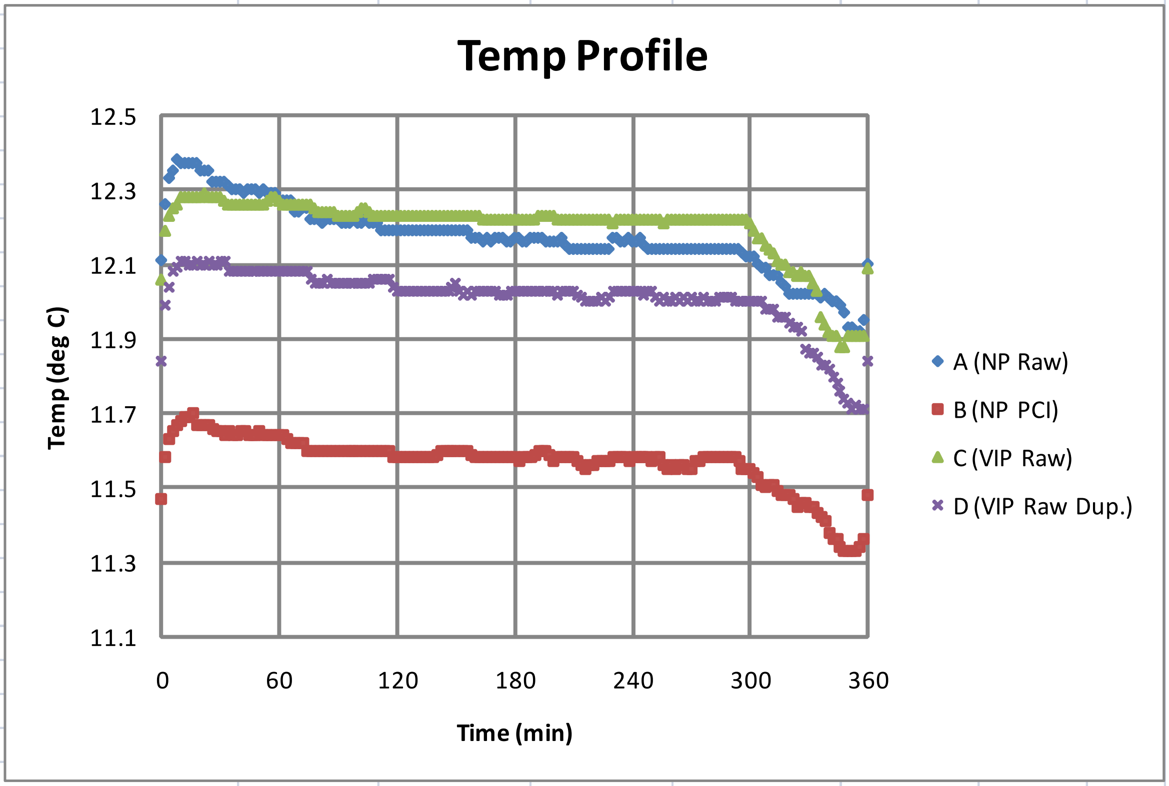
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

10-Dec-10

Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	34.55	192	91%	174.72	931	56.4
B (NP PCl)	33.95	166	88%	146.08	630	54
C (VIP Raw)	26.4	104	88%	91.52	600	43.3
D (Vip Raw Dup.)		112	88%	98.56	578	38.1
	26.4	108	0.88	95.04	589	40.7

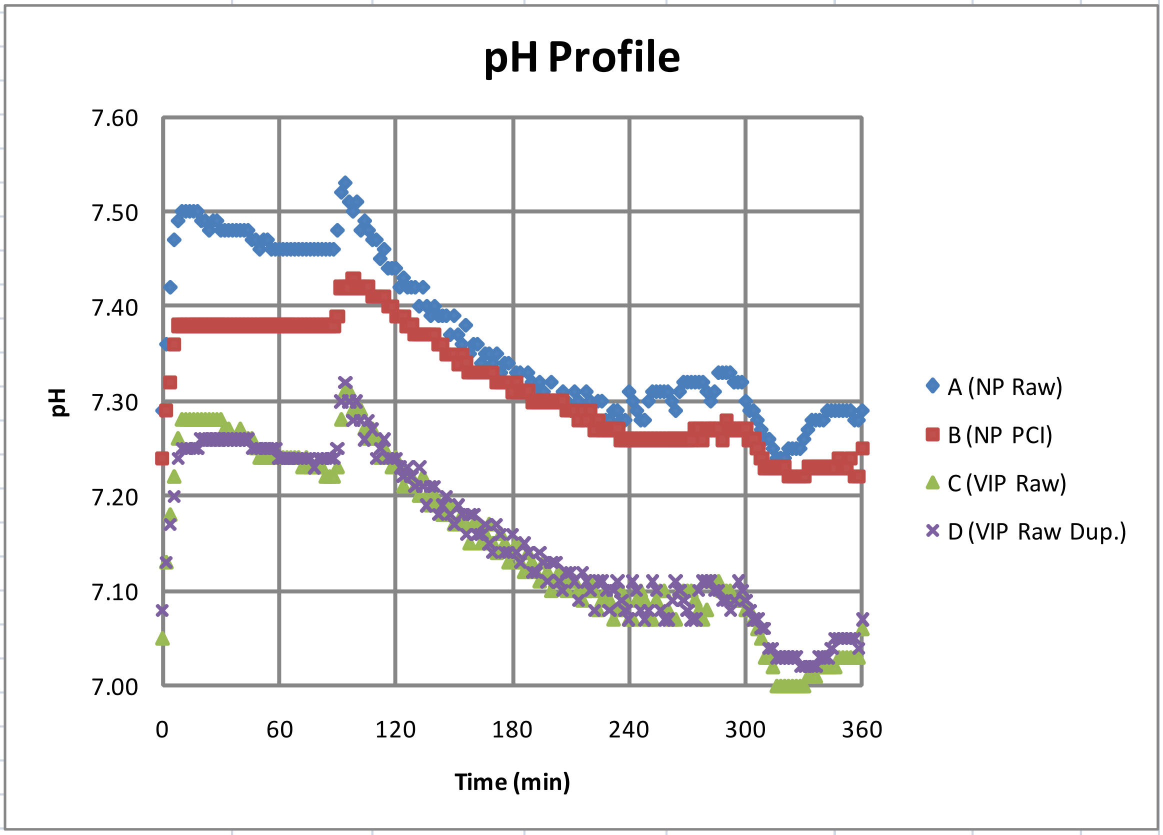
Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2160	86%	1857.6
B (NP PCl)	2120	86%	1823.2
C (VIP Raw)	1880	83%	1560.4
D (Vip Raw Dup.)	1780	87%	1548.6

Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.033	8.4	0.032	8	
B (NP PCl)	0.038	13.1	0.06	4	
C (VIP Raw)	0.036	6.3	0.036	5	
D (Vip Raw Dup.)	0.034	5.6	0.044	3	

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	540	245	113.4
B (NP PCl)	540	270	127.4
C (VIP Raw)	670	305	162.2
D (Vip Raw Dup.)	580	265	148.9

	A	B	C	D
OUR (mg O_2/L*hr)	7.07	0.96	0.28	2.75
MLVSS (g/L)	1.86	1.82	1.56	1.55
SOUR (mg O_2/g MLVSS*hr)	3.80	0.52	0.18	1.78

Avg. Temp. (° C)	
A (NP Raw)	12.27
B (NP PCl)	11.69
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.06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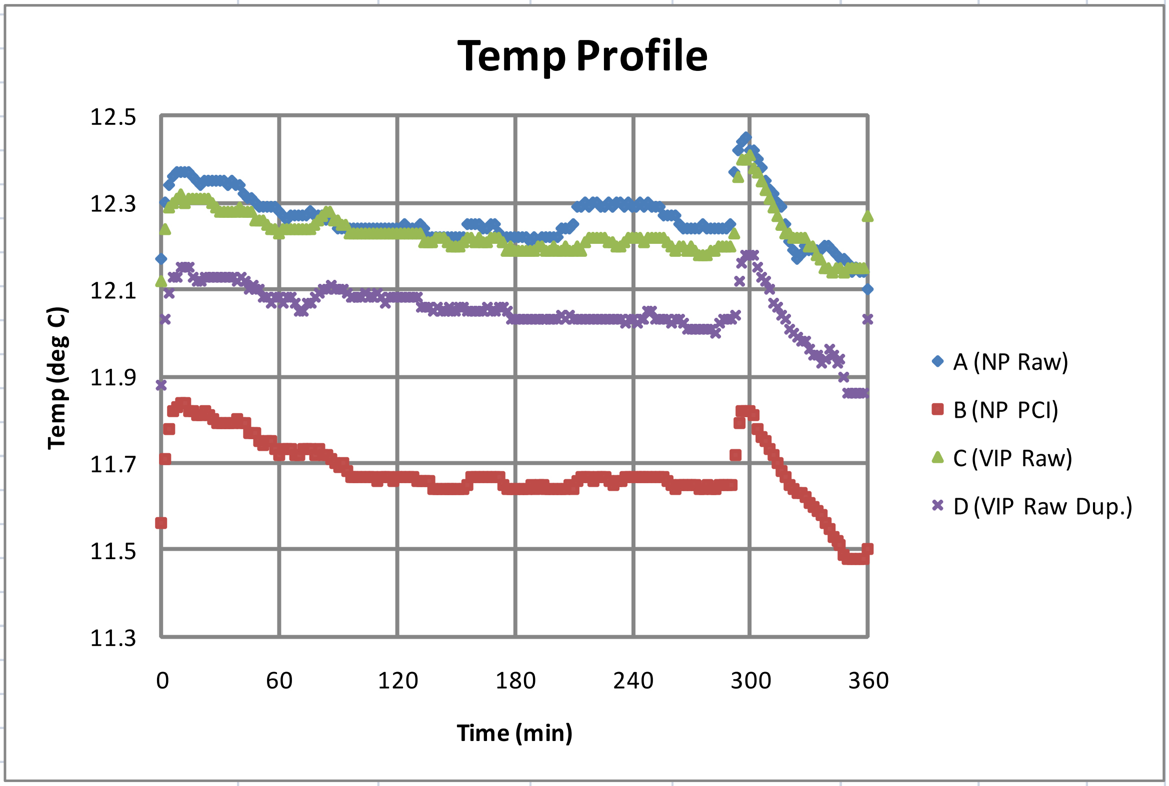
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

13-Dec-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	35.6	102	84%	85.68	510	55.1	8
B (NP PCl)	37.15	178	88%	156.64	501	54.5	11.3
C (VIP Raw)	24.65	158	87%	137.46	402	43.5	2.8
D (Vip Raw Dup.)		154	86%	132.44	407	42	
	24.65	156	0.865	134.95	404.5	42.75	2.8

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2160	87%	1879.2
B (NP PCl)	2220	87%	1931.4
C (VIP Raw)	1820	87%	1583.4
D (Vip Raw Dup.)	1780	85%	1513

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.032	10.4	0.028	6		6.6
B (NP PCl)	0.672	9.1	0.304	6		9.2
C (VIP Raw)	0.887	8.52	0.532	8		2.45
D (Vip Raw Dup.)	1.030	8.32	0.540	6		2.55

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	700	285	131.9
B (NP PCl)	700	315	141.9
C (VIP Raw)	790	325	178.6
D (Vip Raw Dup.)	725	295	165.7

	A	B	C	D
OUR (mg O_2/L*hr)	18.90	16.12	1.31	-2.34
MLVSS (g/L)	1.88	1.93	1.58	1.51
SOUR (mg O_2/g MLVSS*hr)	10.06	8.35	0.83	-1.55

Avg. Temp. (° C)	
A (NP Raw)	12.28
B (NP PCl)	11.71
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.10

	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.88	1.93	1.58	1.51
NR (mg NOx-N/L*hr)	3.43	2.46	2.44	2.29
DNR (mg NOx-N/L*hr)	7.73	8.16	5.72	5.42
SNR (mg NOx-N/g MLVSS*hr)	1.82	1.27	1.54	1.51
SDNR (mg NOx-N/g MLVSS*hr)	4.11	4.23	3.61	3.58

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.53	3.27	1.58	4.85	6.9
10		1.89	1.32	3.21	
15		1.57	1.32	2.89	
20		1.43	1.20	2.63	
105	8.61	0.81	0.28	1.09	6.95
120	7.76	1.55	0.36	1.91	
135	6.74	2.38	0.46	2.84	
150	5.93	3.20	0.54	3.74	6.75
165	5.06	4.03	0.58	4.61	
180	4.19	4.85	0.60	5.45	
195	3.26	5.50	0.64	6.14	6.7
330	0.032	10.40	0.03	10.43	6.6

NP PCI (B)

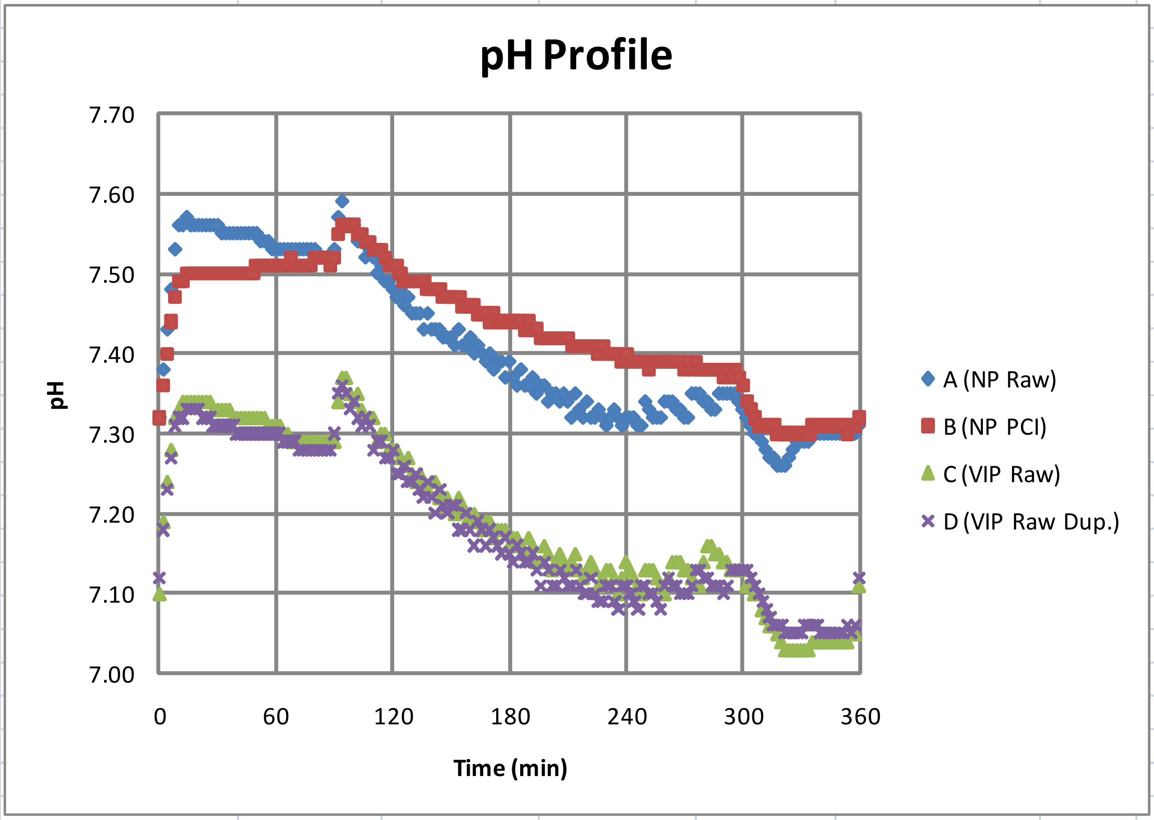
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	9.19	3.41	2.00	5.41	10.2
10		2.19	1.46	3.65	
15		1.71	1.52	3.23	
20		1.60	1.50	3.10	
105	8.87	0.73	0.22	0.95	10
120	7.82	1.30	0.34	1.64	
135	7.2	1.74	0.32	2.06	
150	6.51	2.12	0.32	2.44	9.55
165	5.92	2.98	0.36	3.34	
180	5.36	3.64	0.36	4.00	
195	4.64	4.22	0.38	4.60	9.35
330	0.672	9.10	0.30	9.40	9.2

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.36	2.88	0.38	3.26	2.7
10		1.83	0.42	2.25	
15		1.75	0.24	1.99	
20		1.32	0.28	1.60	
105	8.64	0.42	0.32	0.74	2.8
120	7.92	0.89	0.52	1.41	
135	7.32	1.42	0.58	2.00	
150	6.72	1.73	0.62	2.35	2.55
165	5.99	2.60	0.62	3.22	
180	5.54	3.23	0.66	3.89	
195	4.71	3.68	0.70	4.38	2.55
330	0.887	8.52	0.53	9.05	2.45

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	6.08	3.00	0.380	3.38	2.8
10		2.04	0.540	2.58	
15		1.94	0.260	2.20	
20		1.68	0.160	1.84	
105	8.43	0.45	0.280	0.73	2.8
120	7.9	0.96	0.520	1.48	
135	7.22	1.01	0.600	1.61	
150	6.66	2.04	0.600	2.64	2.65
165	6.05	2.59	0.620	3.21	
180	5.49	2.85	0.660	3.51	
195	4.71	3.52	0.660	4.18	2.7
330	1.03	8.32	0.540	8.86	2.55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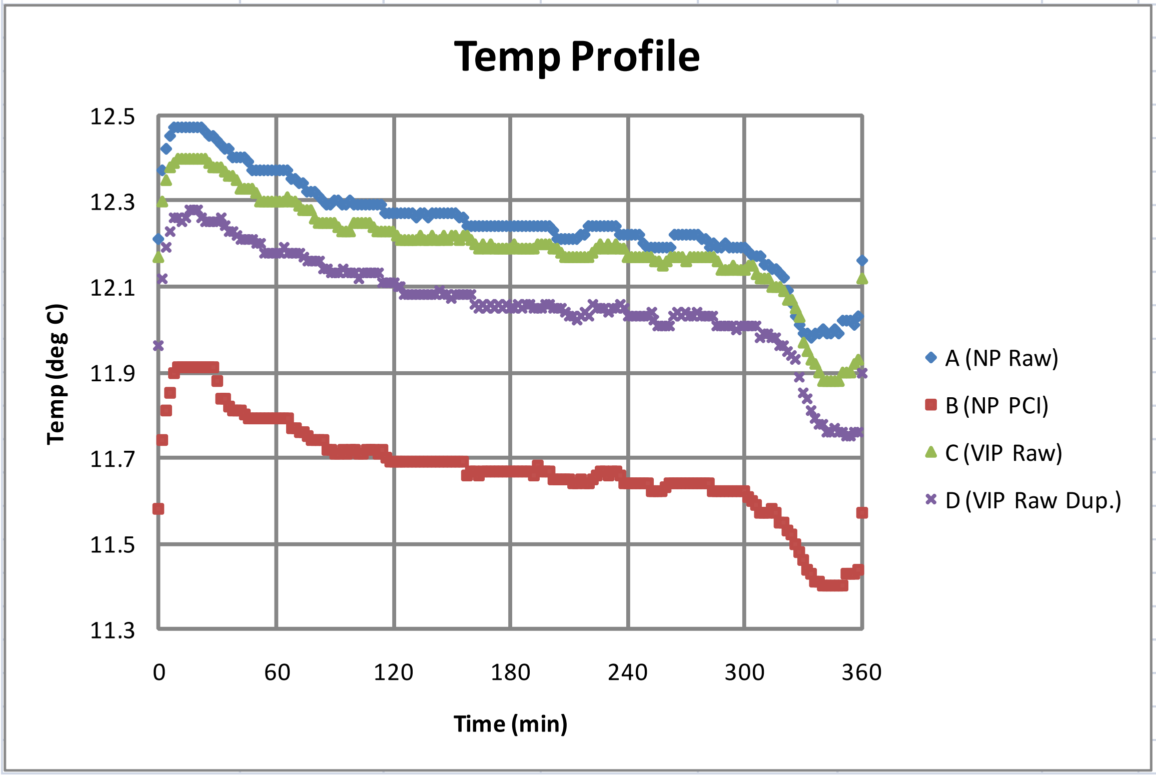
C (VIP Raw)
D (VIP Raw Dup.)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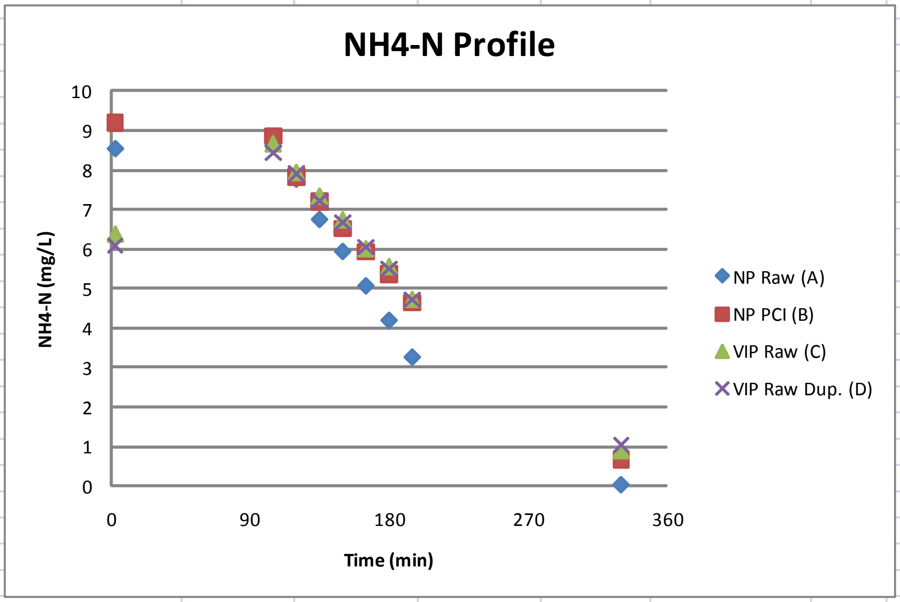
C (VIP Raw)
D (VIP Raw Dup.)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8
7
6
5
4
3
2
1
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360
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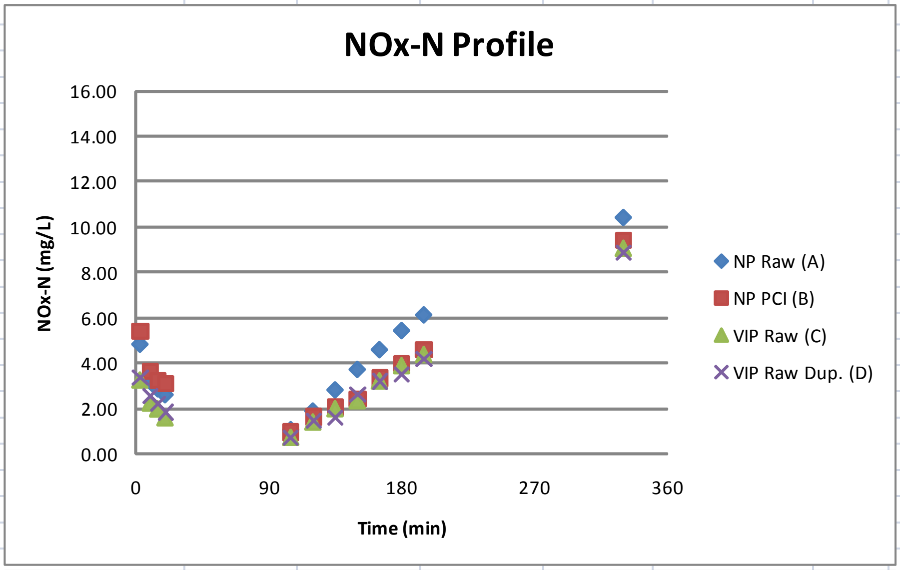
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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180
270
360
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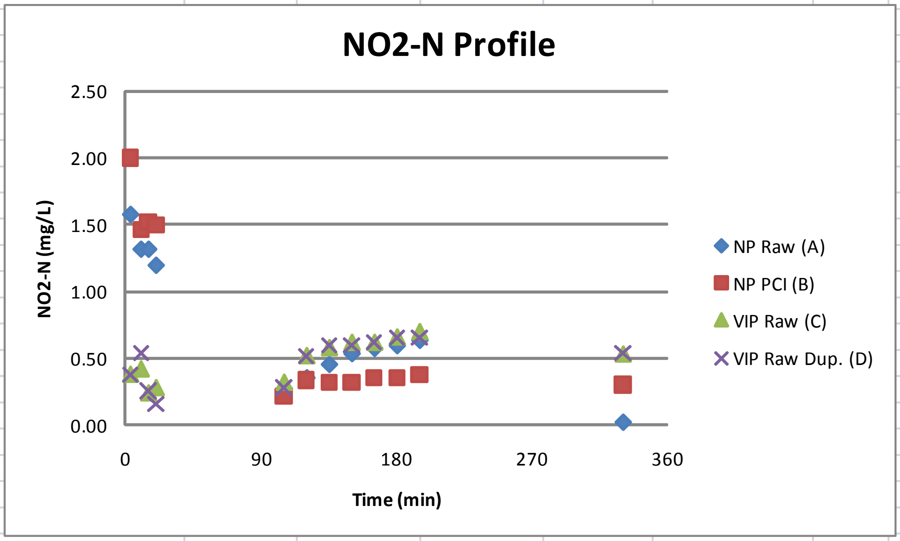
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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1.00
0.50
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

15-Dec-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	32.3	163	92%	149.96	602	51.8	7.5
B (NP PCl)	33.45	283	92%	260.36	729	55.5	8.8
C (VIP Raw)	22.95	150	83%	124.5	562	39.3	2.4
D (Vip Raw Dup.)	24.1	130	91%	118.3	695	40.8	

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2360	87%	2053.2
B (NP PCl)	2300	85%	1955
C (VIP Raw)	1780	88%	1566.4
D (Vip Raw Dup.)	1940	87%	1687.8

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.035	7.89	0.028	9		6.1
B (NP PCl)	0.039	7.34	0.096	7		7
C (VIP Raw)	0.650	8.02	0.492	7		2
D (Vip Raw Dup.)	0.680	8.32	0.512	4		2.15

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	660	285	120.8
B (NP PCl)	740	325	141.3
C (VIP Raw)	725	305	171.3
D (Vip Raw Dup.)	725	315	162.4

	A	B	C	D
OUR (mg O_2/L*hr)	1.86	-1.18	-0.35	0.07
MLVSS (g/L)	2.05	1.96	1.57	1.69
SOUR (mg O_2/g MLVSS*hr)	0.91	-0.60	-0.22	0.04

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCl)	11.65
C (VIP Raw)	12.13
D (Vip Raw Dup.)	11.98

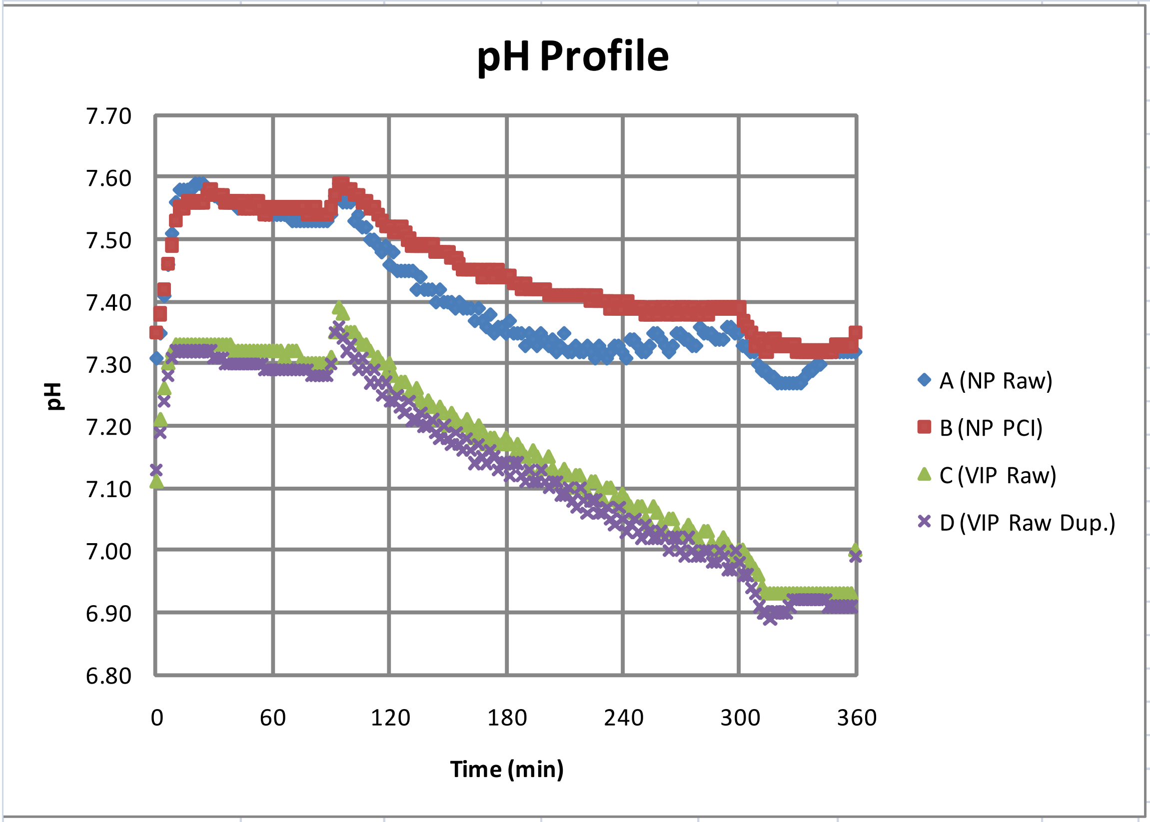
	A (NP Raw)	B (NP PCl)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.05	1.96	1.57	1.69
NR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	2.45	2.47
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	6.94	7.56
SNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	1.57	1.47
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	4.43	4.48

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.86	3.20	0.14	3.34
6		2.64	0.54	3.18
9		2.18	0.48	2.66
12		1.97	0.32	2.29
15		1.83	0.22	2.05
18		1.74	0.14	1.88
105	8.79	0.53	0.26	0.79
120	8.02	0.99	0.44	1.43
135	7.34	1.55	0.54	2.09
150	6.68	2.11	0.58	2.69
165	6.04	2.67	0.66	3.33
180	5.34	3.15	0.66	3.81
195	4.72	3.83	0.68	4.51
330	0.65	8.02	0.49	8.51

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L
3	5.62	2.92	0.260	3.18
6		2.30	0.580	2.88
9		2.00	0.580	2.58
12		1.72	0.420	2.14
15		1.36	0.300	1.66
18		1.27	0.180	1.45
105	8.57	0.50	0.280	0.78
120	7.82	0.99	0.440	1.43
135	7.23	1.53	0.540	2.07
150	6.33	2.01	0.580	2.59
165	5.92	2.65	0.640	3.29
180	5.2	3.17	0.700	3.87
195	4.64	3.74	0.700	4.44
330	0.68	8.32	0.512	8.83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7.30
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6.90
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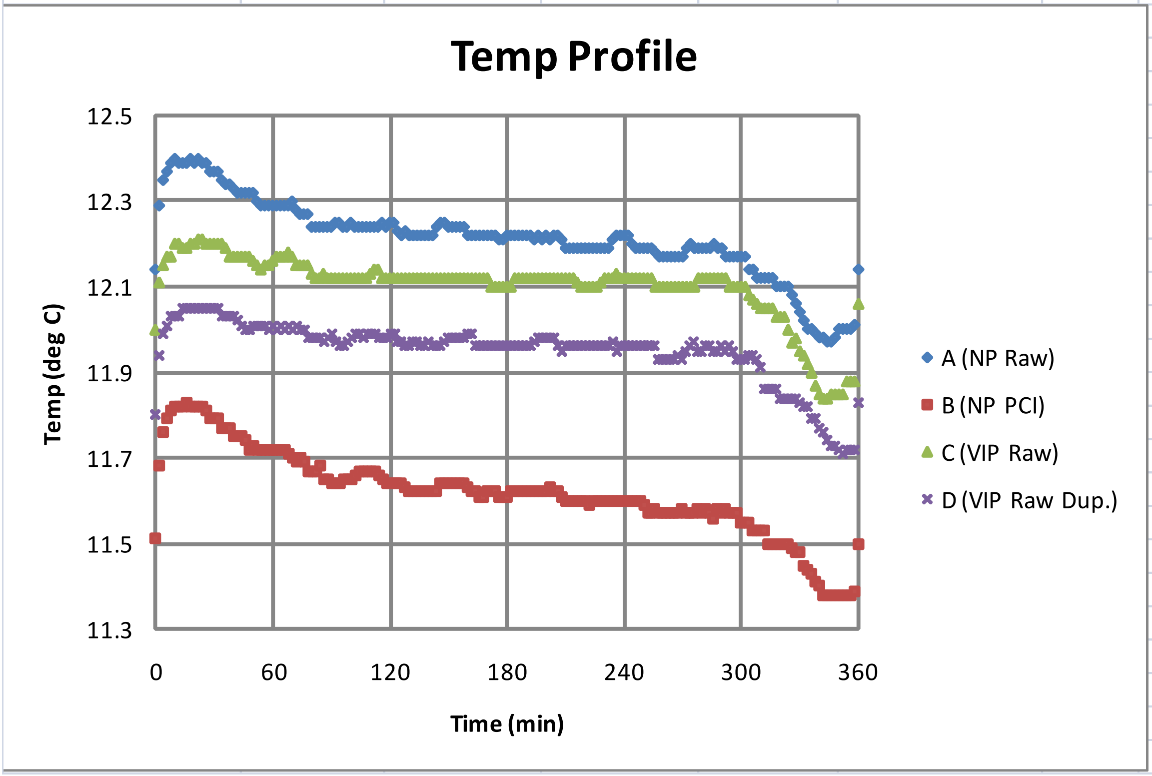
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
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12.3
12.1
11.9
11.7
11.5
11.3
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180
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300
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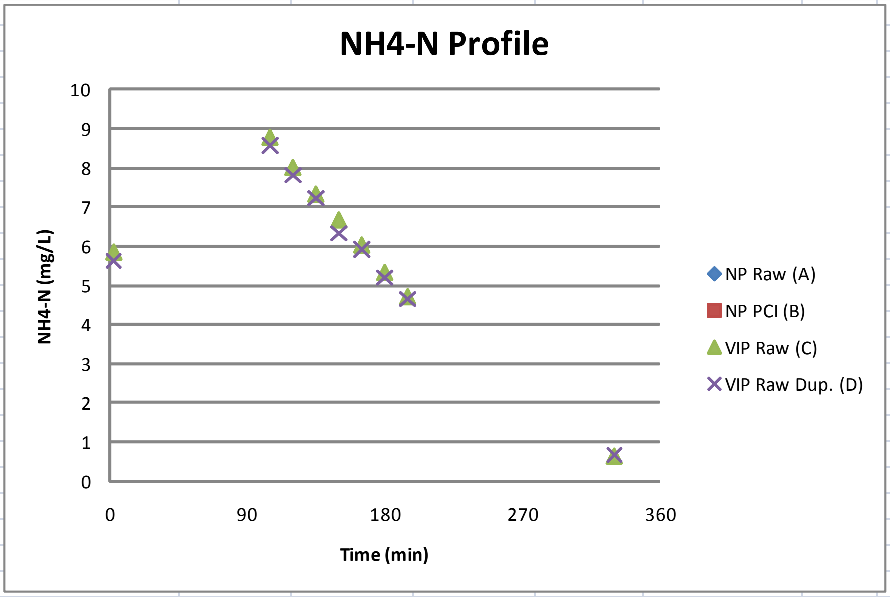
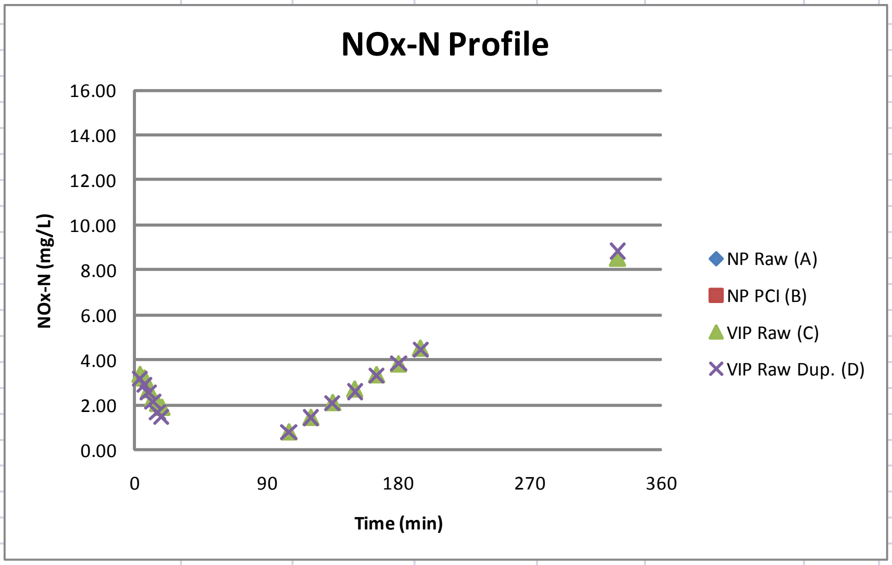
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NOx-N Profile
NOx-N (mg/L)
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14.00
12.00
10.00
8.00
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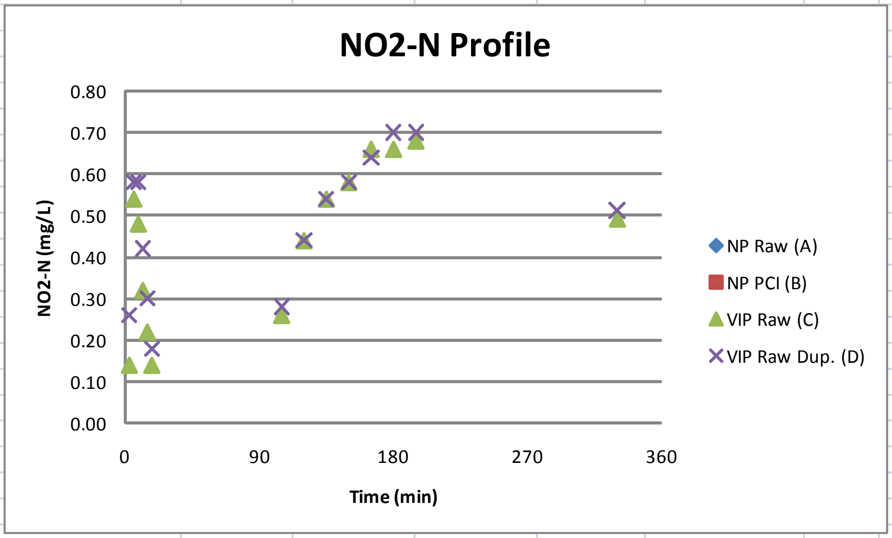
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
0.80
0.70
0.60
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0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)

17-Dec-10

Feed							
	NH3-N	TSS	Voltl. Frac.	VSS	COD	TKN	OP
	mg/L	mg/L	%	mg/L	mg/L	mg/L	mg/L P
A (NP Raw)	32.45	186	89%	165.54	924	50.3	6.3
B (NP PCI)	35.75	236	88%	207.68	840	55.3	9.1
C (VIP Raw)	23.5	156	84%	131.04	761	34.7	2.6
D (Vip Raw Dup.)	24.25	136	90%	122.4	624	36.4	3.5

Mixed Liquor			
	MLSS	Voltl. Frac.	MLVSS
	mg/L	%	mg/L
A (NP Raw)	2260	88%	1988.8
B (NP PCI)	2600	85%	2210
C (VIP Raw)	1780	90%	1602
D (Vip Raw Dup.)	2000	86%	1720

Effluent (1330)						
	NH3-N	NO3-N	NO2-N	TSS	Turbidity	OP
	mg/L	mg/L	mg/L	mg/L	NTU	mg/L P
A (NP Raw)	0.042	9.51	0.028	10		4.95
B (NP PCI)	0.670	8.16	0.376	6		6.65
C (VIP Raw)	0.618	8.99	0.496	8		2.25
D (Vip Raw Dup.)	0.628	8.54	0.500	8		2.4

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	765	320	141.6
B (NP PCI)	775	370	142.3
C (VIP Raw)	770	320	179.8
D (Vip Raw Dup.)	770	325	162.5

	A	B	C	D
OUR (mg O_2/L*hr)	0.93	-1.02	-2.36	-0.61
MLVSS (g/L)	1.99	2.21	1.60	1.72
SOUR (mg O_2/g MLVSS*hr)	0.47	-0.46	-1.47	-0.35

Avg. Temp. (° C)	
A (NP Raw)	12.25
B (NP PCI)	11.65
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.00

	A	B	C	D
	(NP Raw)	(NP PCI)	(VIP Raw)	(Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.99	2.21	1.60	1.72
NR (mg NOx-N/L*hr)	2.79	2.08	2.37	2.25
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	4.92	7.59
SNR (mg NOx-N/g MLVSS*hr)	1.40	0.94	1.48	1.31
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	3.07	4.41

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.63	3.00	1.22	4.22	5.4
6					
9					
12					
15					
18					
105	8.53	0.76	0.22	0.98	5.3
120	7.73	1.46	0.32	1.78	
135	6.64	2.17	0.38	2.55	
150	5.8	2.37	0.42	2.79	5.1
165	5.05	3.81	0.44	4.25	
180	4.25	3.80	0.48	4.28	
195	3.49	4.75	0.50	5.25	5
330	0.042	9.51	0.03	9.54	4.95

NP PCI (B)

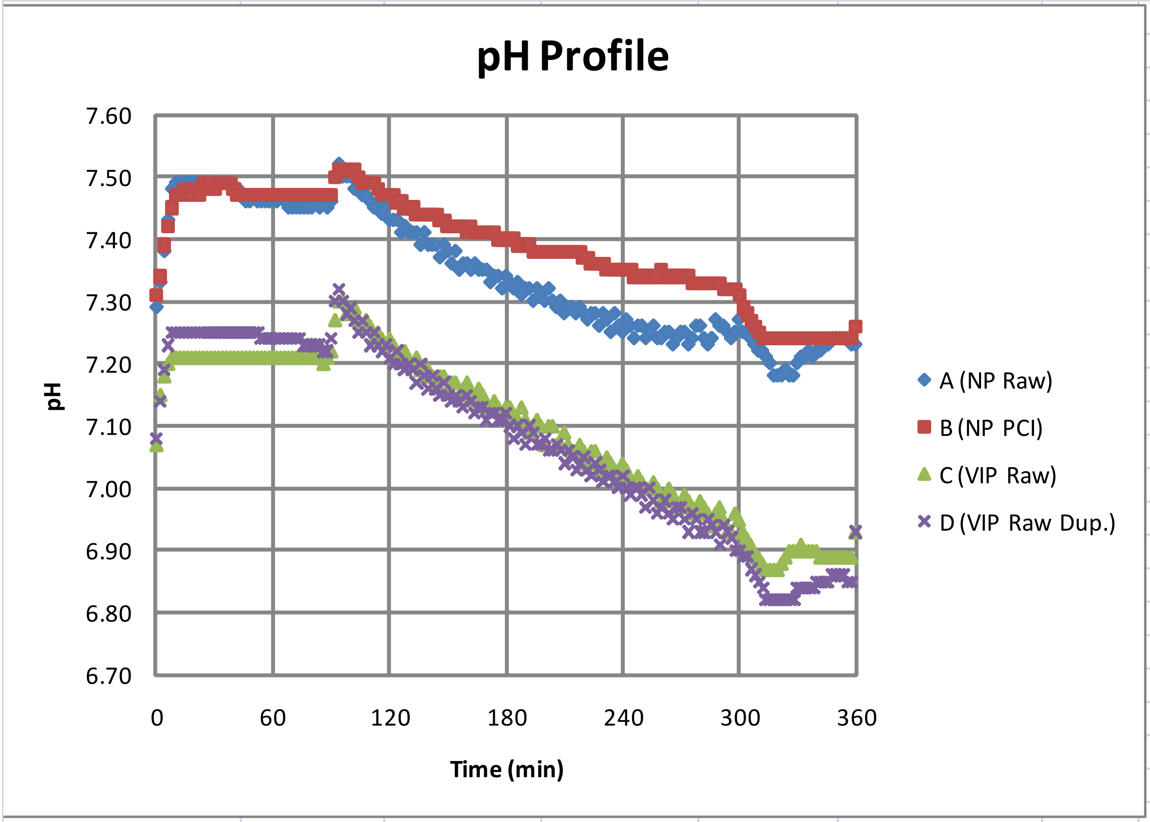
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.06	2.52	1.60	4.12	7.7
6					
9					
12					
15					
18					
105	8.38	0.68	0.18	0.86	7.75
120	7.8	1.17	0.24	1.41	
135	7.18	1.69	0.26	1.95	
150	6.72	2.28	0.28	2.56	7.15
165	5.98	2.91	0.30	3.21	
180	5.31	3.29	0.30	3.59	
195	4.65	3.49	0.34	3.83	6.9
330	0.67	8.16	0.38	8.54	6.65

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.77	3.22	0.14	3.36	2.45
6		3.04	0.26	3.30	
9		2.76	0.14	2.90	
12		2.52	0.08	2.60	
15		2.42	0.06	2.48	
18		2.32	0.06	2.38	
105	8.37	0.74	0.30	1.04	2.35
120	7.88	1.22	0.46	1.68	
135	7.14	1.79	0.58	2.37	
150	6.55	2.28	0.58	2.86	2.15
165	5.92	2.95	0.66	3.61	
180	5.32	3.12	0.64	3.76	
195	4.63	4.08	0.70	4.78	2.2
330	0.618	8.99	0.50	9.49	2.25

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L	OP mg/L P
3	5.55	2.82	0.320	3.14	2.8
6		2.24	0.480	2.72	
9		1.85	0.440	2.29	
12		1.64	0.280	1.92	
15		1.48	0.160	1.64	
18		1.32	0.120	1.44	
105	8.6	0.50	0.320	0.82	2.7
120	7.69	1.00	0.460	1.46	
135	7.07	1.45	0.580	2.03	
150	6.67	2.11	0.620	2.73	2.5
165	5.84	2.36	0.640	3.00	
180	5.35	2.98	0.700	3.68	
195	4.54	3.37	0.720	4.09	2.35
330	0.628	8.54	0.500	9.04	2.4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7.00
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6.80
6.70
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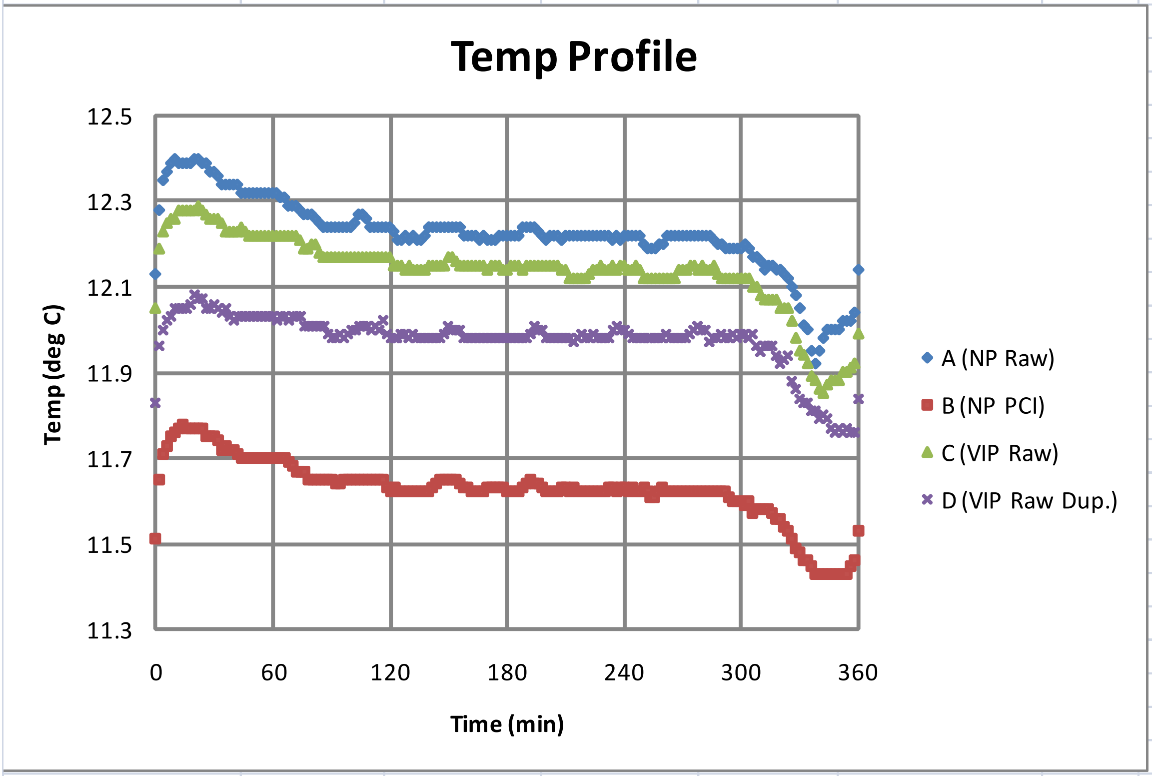
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
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12.3
12.1
11.9
11.7
11.5
11.3
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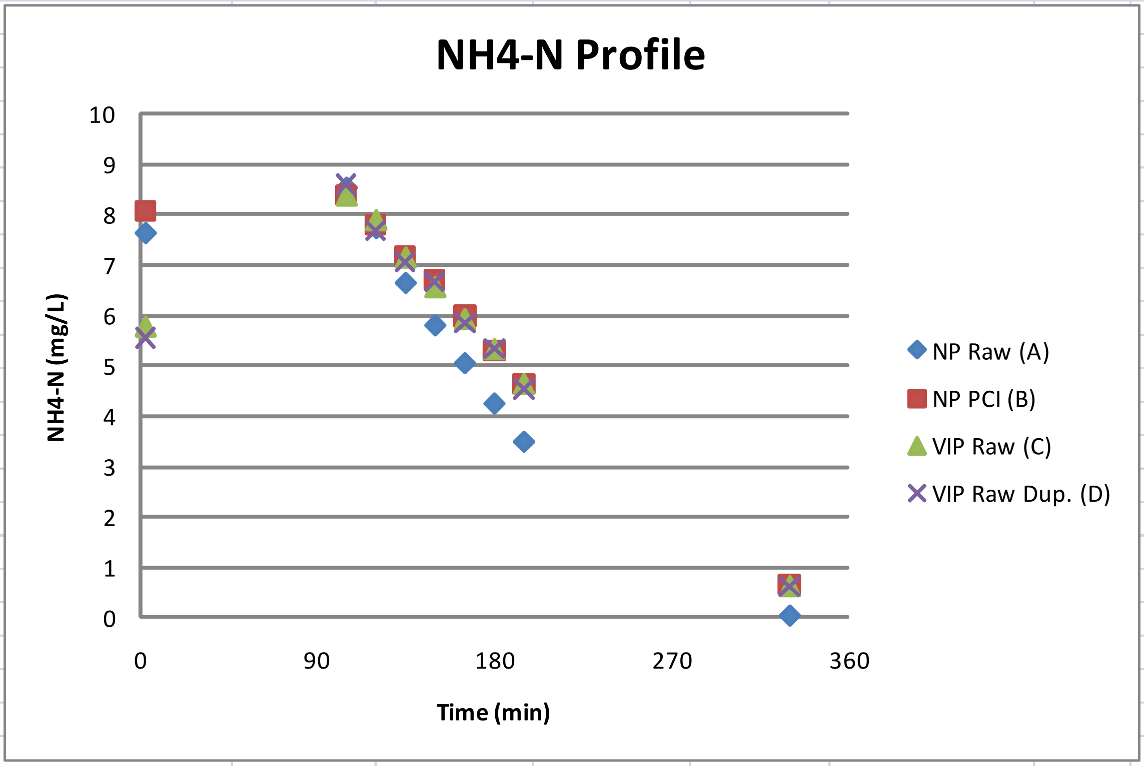
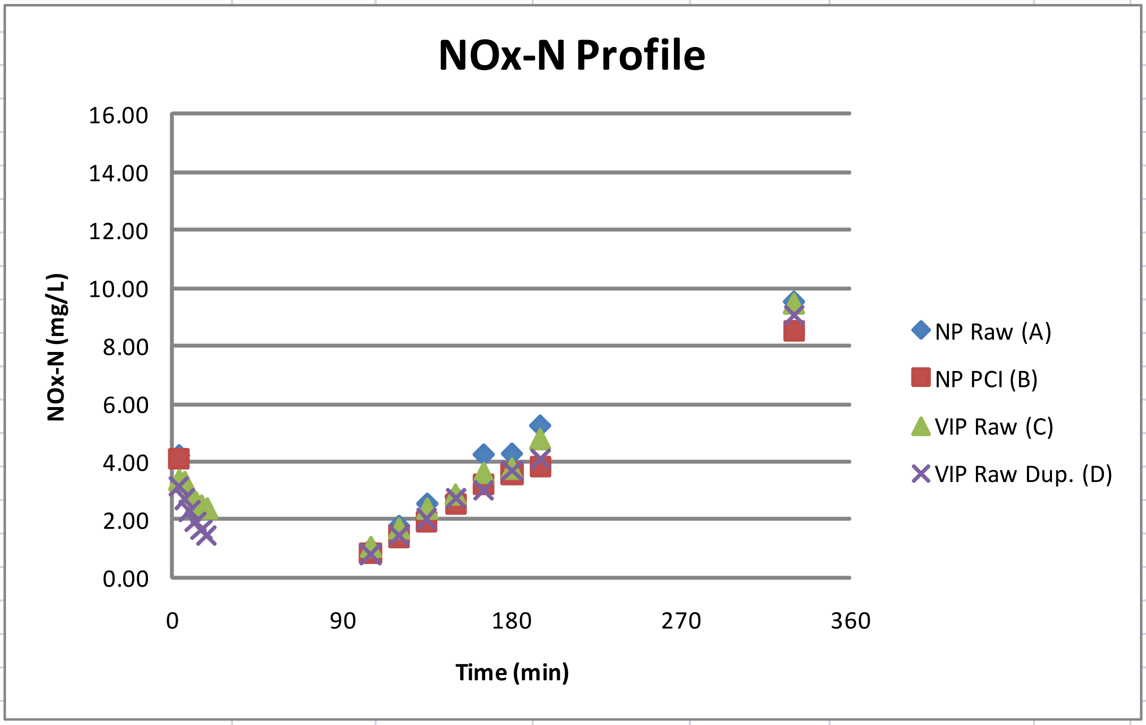
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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NOx-N (mg/L)
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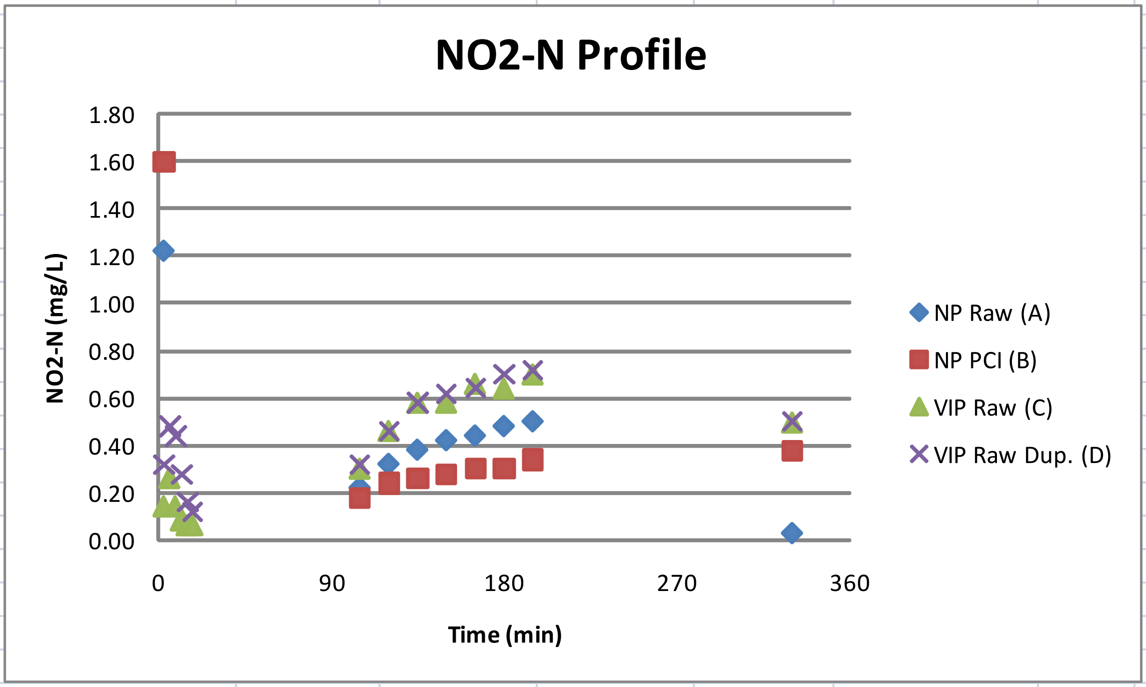
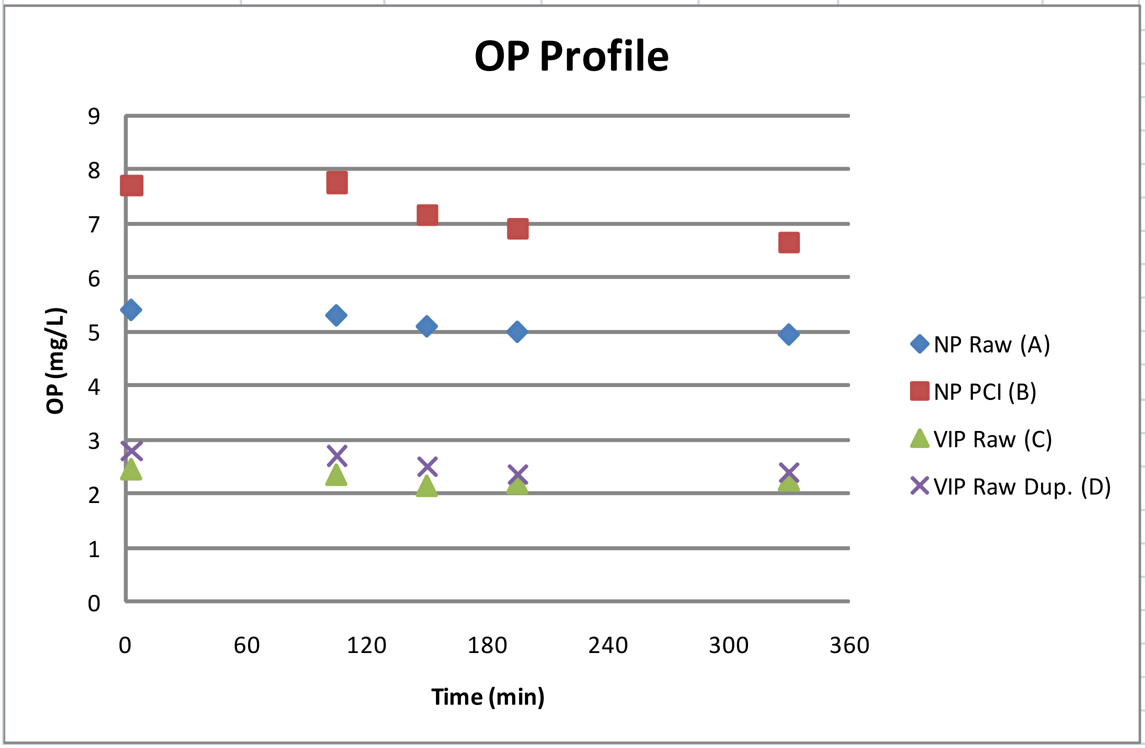
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OP Profile
OP (mg/L)
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

20-Dec-10

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	33.8	136	96%	130.56	804	47.3	6.4
B (NP PCI)	33.85	126	87%	109.62	686	49.5	8.1
C (VIP Raw)	21.4	163	80%	130.4	772	36.5	2.2
D (Vip Raw Dup.)	23.35	117	87%	101.79	715	35.3	3.2

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2080	87%	1809.6
B (NP PCI)	2260	89%	2011.4
C (VIP Raw)	1720	88%	1513.6
D (Vip Raw Dup.)	1600	89%	1424

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.078	9.23	0.060	9		5.2
B (NP PCI)	0.424	8.35	0.208	5		6.65
C (VIP Raw)	0.058	9.4	0.068	8		2.2
D (Vip Raw Dup.)	0.046	6.69	0.036	7		2.26

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	840	405	194.7
B (NP PCI)	760	360	159.3
C (VIP Raw)	695	300	174.4
D (Vip Raw Dup.)	730	315	196.9

	A	B	C	D
OUR (mg O_2/L*hr)	4.25	0.24	-2.28	-3.25
MLVSS (g/L)	1.81	2.01	1.51	1.42
SOUR (mg O_2/g MLVSS*hr)	2.35	0.12	-1.50	-2.28

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCI)	11.61
C (VIP Raw)	12.13
D (Vip Raw Dup.)	11.97

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.81	2.01	1.51	1.42
NR (mg NOx-N/L*hr)	2.82	2.34	2.71	2.50
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	0.48	7.57
SNR (mg NOx-N/g MLVSS*hr)	1.56	1.17	1.79	1.76
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	0.32	5.32

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.83	3.10	1.540	4.64	5.75
6					
9					
12					
15					
18					
105	7.72	0.74	0.200	0.94	5.5
120	7.19	1.39	0.280	1.67	
135	6.33	2.03	0.360	2.39	
150	5.64	2.68	0.360	3.04	5.3
165	4.87	3.23	0.380	3.61	
180	4.18	3.96	0.420	4.38	
195	3.32	4.88	0.420	5.30	5.15
330	0.078	9.23	0.060	9.29	5.2

NP PCI (B)

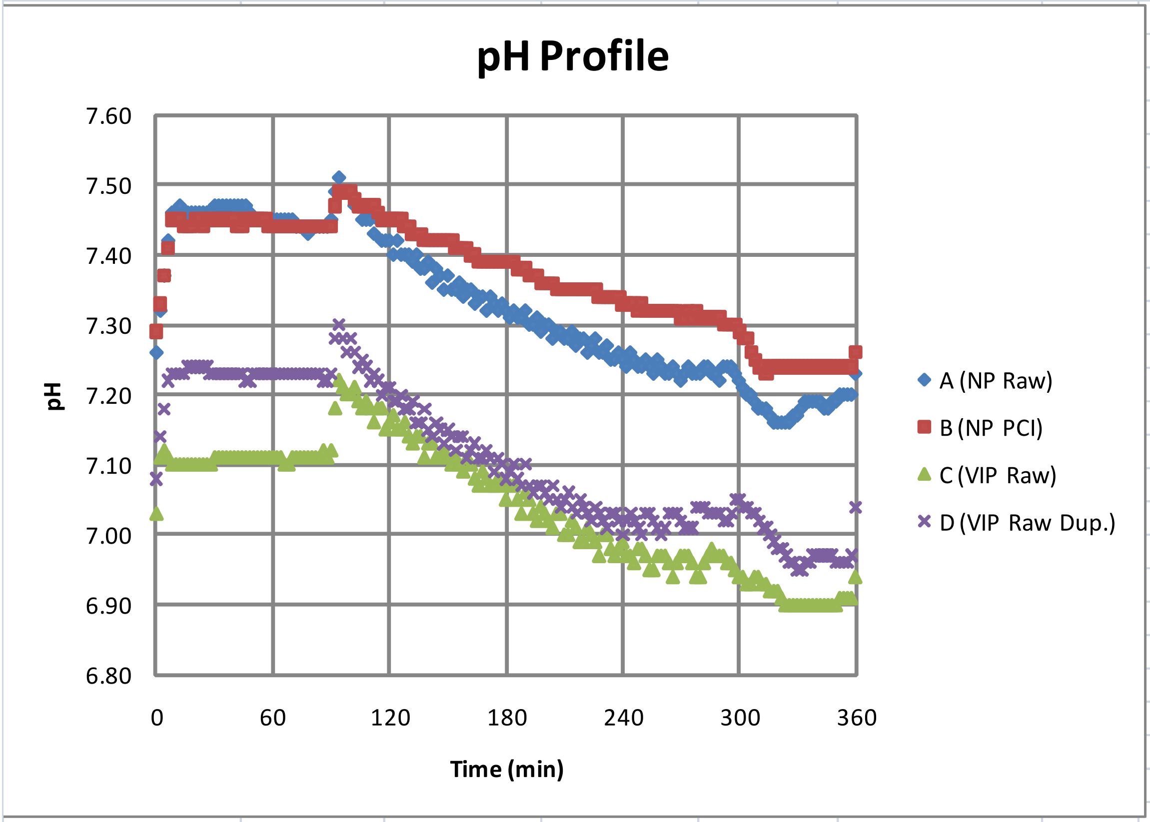
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.89	2.70	1.360	4.06	7.3
6					
9					
12					
15					
18					
105	7.82	0.71	0.160	0.87	7.25
120	7.35	1.25	0.240	1.49	
135	6.44	1.79	0.240	2.03	
150	5.95	2.19	0.300	2.49	6.85
165	5.31	2.60	0.280	2.88	
180	4.65	3.61	0.320	3.93	
195	4.1	4.11	0.320	4.43	6.75
330	0.424	8.35	0.208	8.56	6.65

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.39	4.00	0.200	4.20	2.5
6		4.06	0.220	4.28	
9		4.00	0.240	4.24	
12		4.00	0.200	4.20	
15		3.92	0.200	4.12	
18		3.72	0.180	3.90	
105	6.02	2.22	0.540	2.76	2.35
120	5.58	2.81	0.620	3.43	
135	4.85	3.39	0.680	4.07	
150	4.28	3.95	0.740	4.69	2.3
165	3.58	4.89	0.760	5.65	
180	2.97	5.40	0.800	6.20	
195	2.34	5.94	0.780	6.72	2.05
330	0.058	9.40	0.068	9.47	2.2

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L	OP mg/L P
3	5.51	2.48	0.400	2.88	2.8
6		2.00	0.520	2.52	
9		1.54	0.420	1.96	
12		1.52	0.280	1.80	
15		1.52	0.200	1.72	
18		1.38	0.140	1.52	
105	5.83	0.44	0.300	0.74	2.5
120	5.29	0.89	0.480	1.37	
135	4.54	1.23	0.580	1.81	
150	3.9	1.73	0.620	2.35	2.5
165	3.31	2.72	0.660	3.38	
180	2.69	3.28	0.660	3.94	
195	2.1	3.78	0.680	4.46	2.25
330	0.046	6.69	0.036	6.73	2.25



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7.20
7.10
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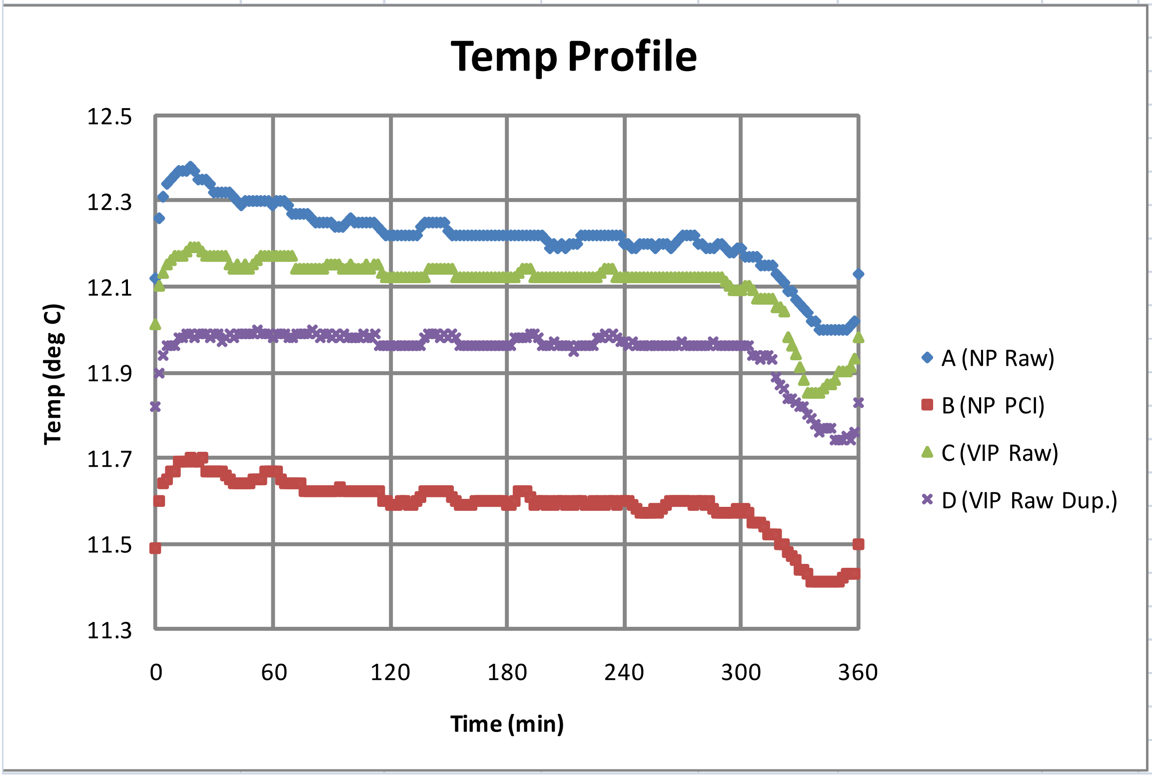
6.90
6.80
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)



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Temp (deg C)
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11.3
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300
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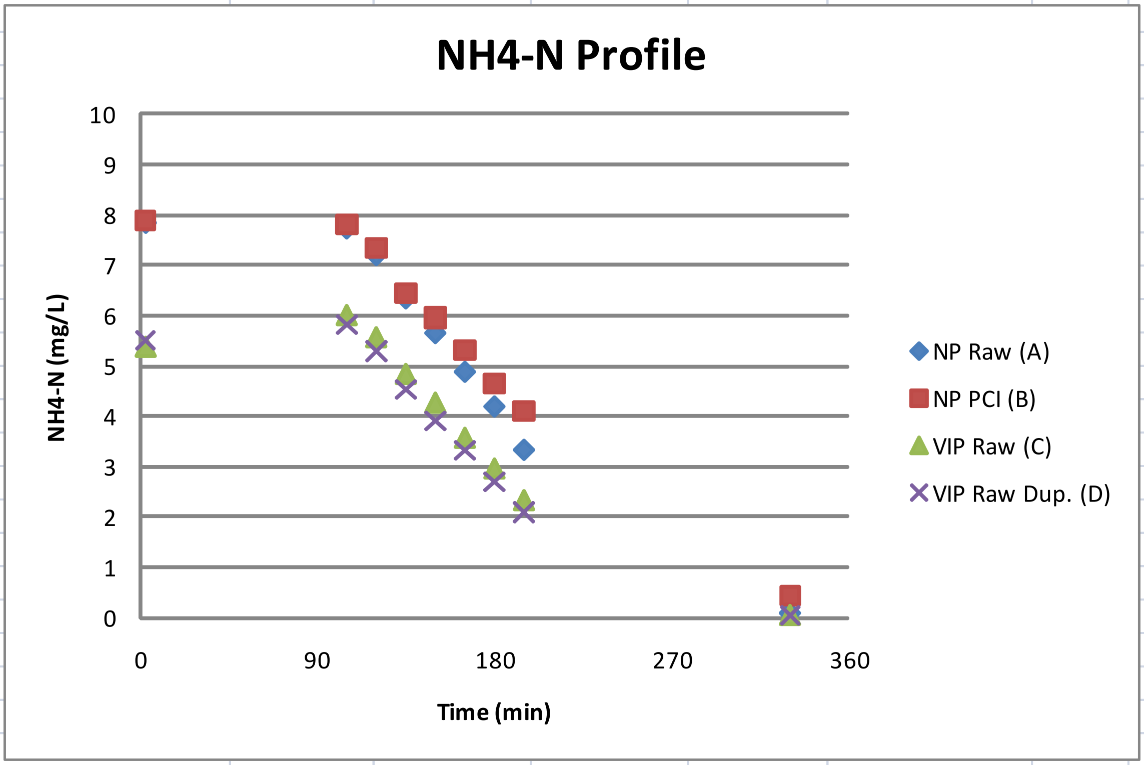
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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9
8
7
6
5
4
3
2
1
0
NH4-N (mg/L)
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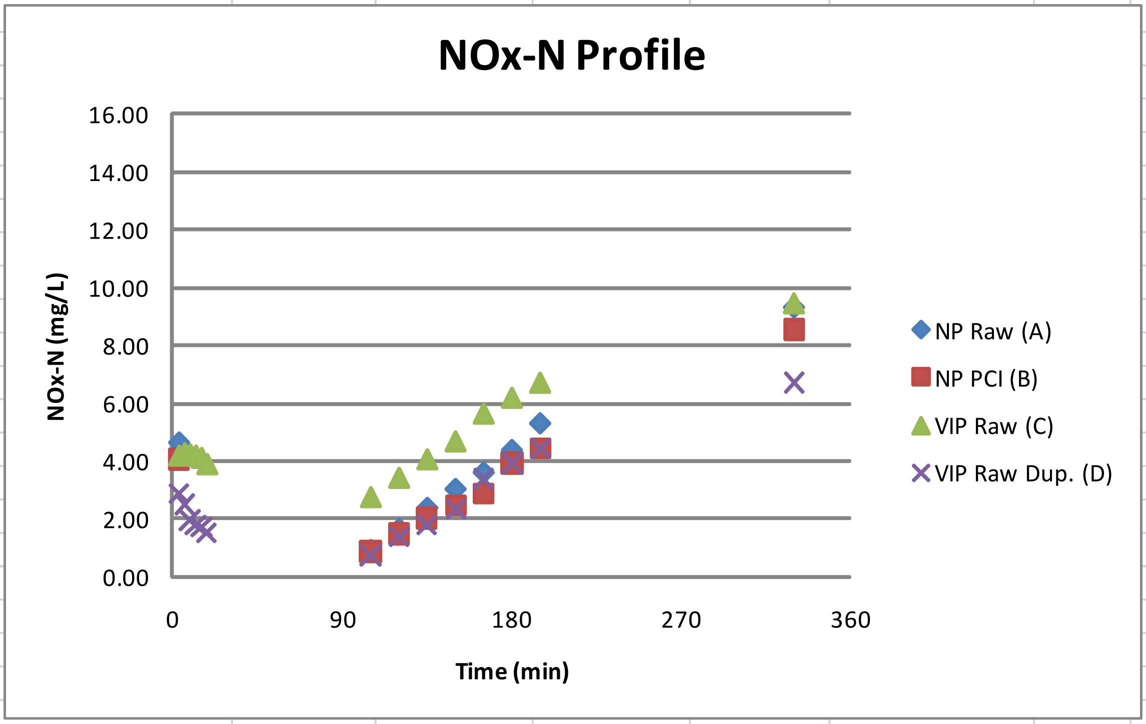
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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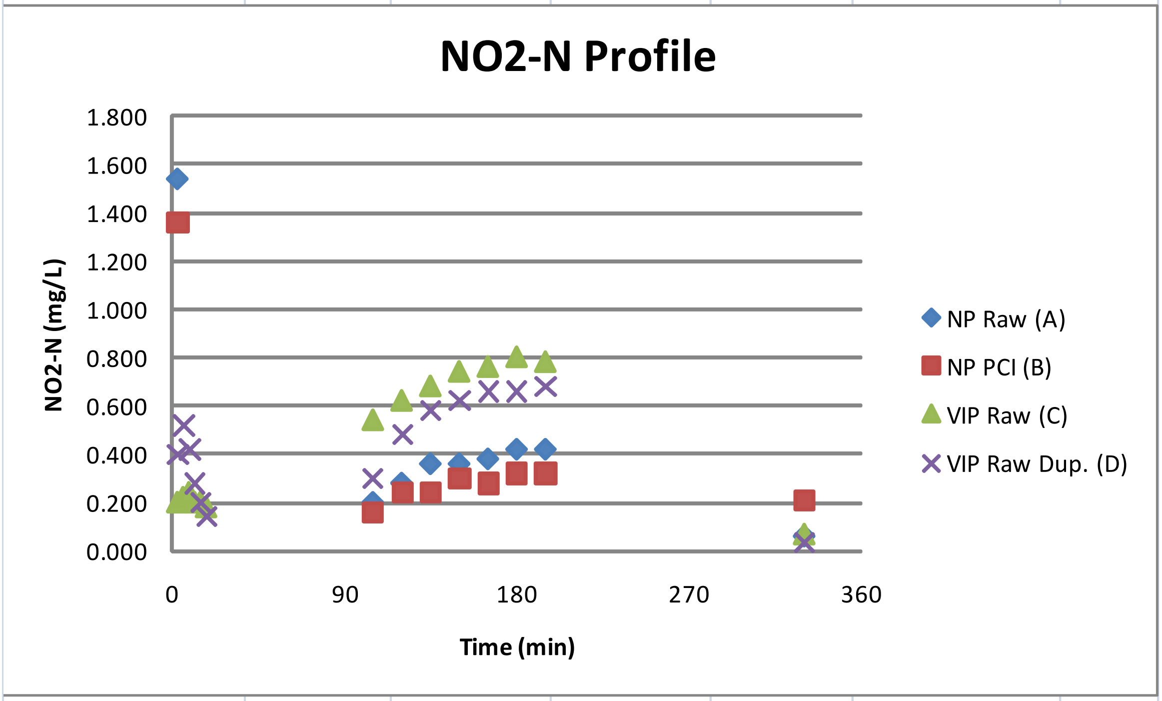
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NOx-N (mg/L)
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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NO2-N (mg/L)
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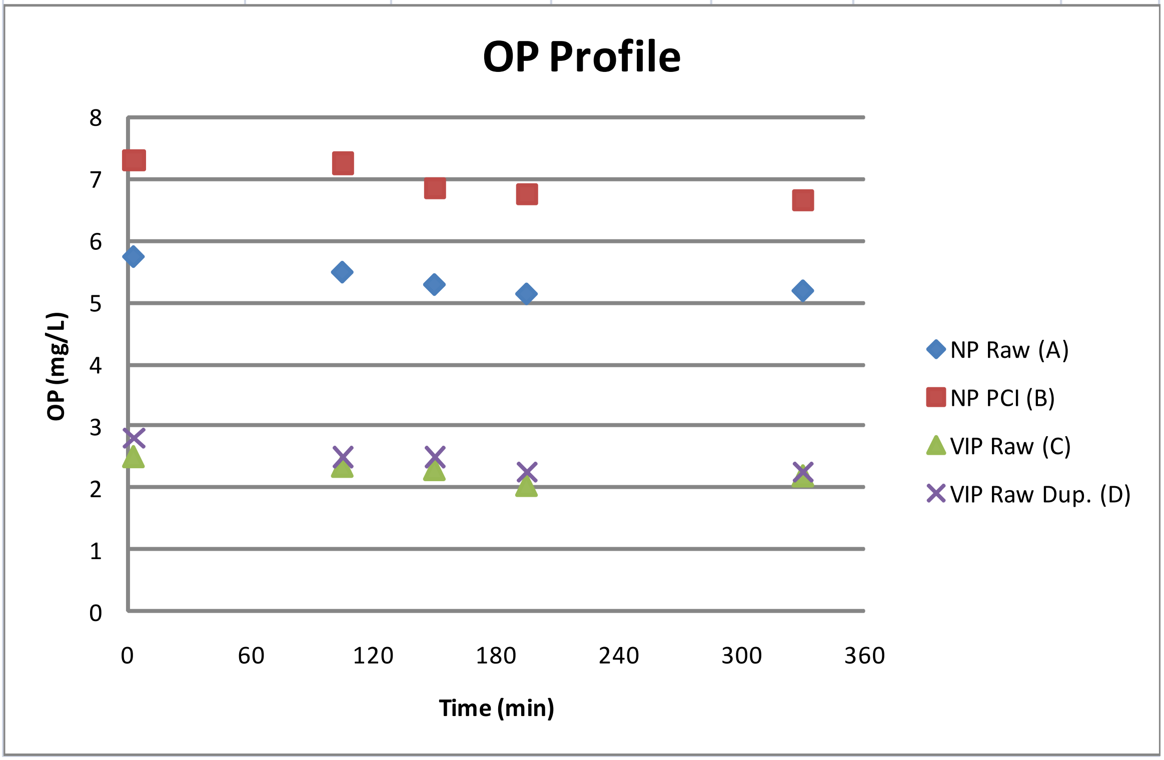
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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0
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60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

22-Dec-10

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	30.45	126	95%	119.7	505	48.1	5.7
B (NP PCI)	31.95	142	89%	126.38	465	47.2	7.6
C (VIP Raw)	20	154	89%	137.06	406	35.5	2.1
D (Vip Raw Dup.)	21.3	108	88%	95.04	367	35.7	3.1

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2160	94%	2030.4
B (NP PCI)	2240	99%	2217.6
C (VIP Raw)	1660	99%	1643.4
D (Vip Raw Dup.)	1620	99%	1603.8

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.087	8.5	0.044	15		4.65
B (NP PCI)	0.302	8.25	0.128	6		5.9
C (VIP Raw)	0.285	8.81	0.424	5		2.1
D (Vip Raw Dup.)	0.270	7.13	0.408	7		2.1

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	850	395	182.9
B (NP PCI)	720	330	147.3
C (VIP Raw)	670	280	168.7
D (Vip Raw Dup.)	735	310	191.4

	A	B	C	D
OUR (mg O_2/L*hr)	4.37	-0.95	-1.07	-1.30
MLVSS (g/L)	2.03	2.22	1.64	1.60
SOUR (mg O_2/g MLVSS*hr)	2.15	-0.43	-0.65	-0.81

Avg. Temp. (° C)	
A (NP Raw)	12.28
B (NP PCI)	11.64
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.02

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.03	2.22	1.64	1.60
NR (mg NOx-N/L*hr)	2.57	2.18	2.44	2.50
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	2.36	7.48
SNR (mg NOx-N/g MLVSS*hr)	1.26	0.99	1.49	1.56
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	1.44	4.66

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.43	2.96	1.44	4.40	5.2
6					
9					
12					
15					
18					
105	7.69	0.66	0.20	0.86	4.95
120	7.03	1.30	0.28	1.58	
135	6.29	1.96	0.34	2.30	
150	5.49	2.46	0.38	2.84	5.05
165	4.82	3.21	0.42	3.63	
180	4.09	3.62	0.50	4.12	
195	3.3	4.29	0.42	4.71	4.6
330	0.087	8.50	0.04	8.54	4.65

NP PCI (B)

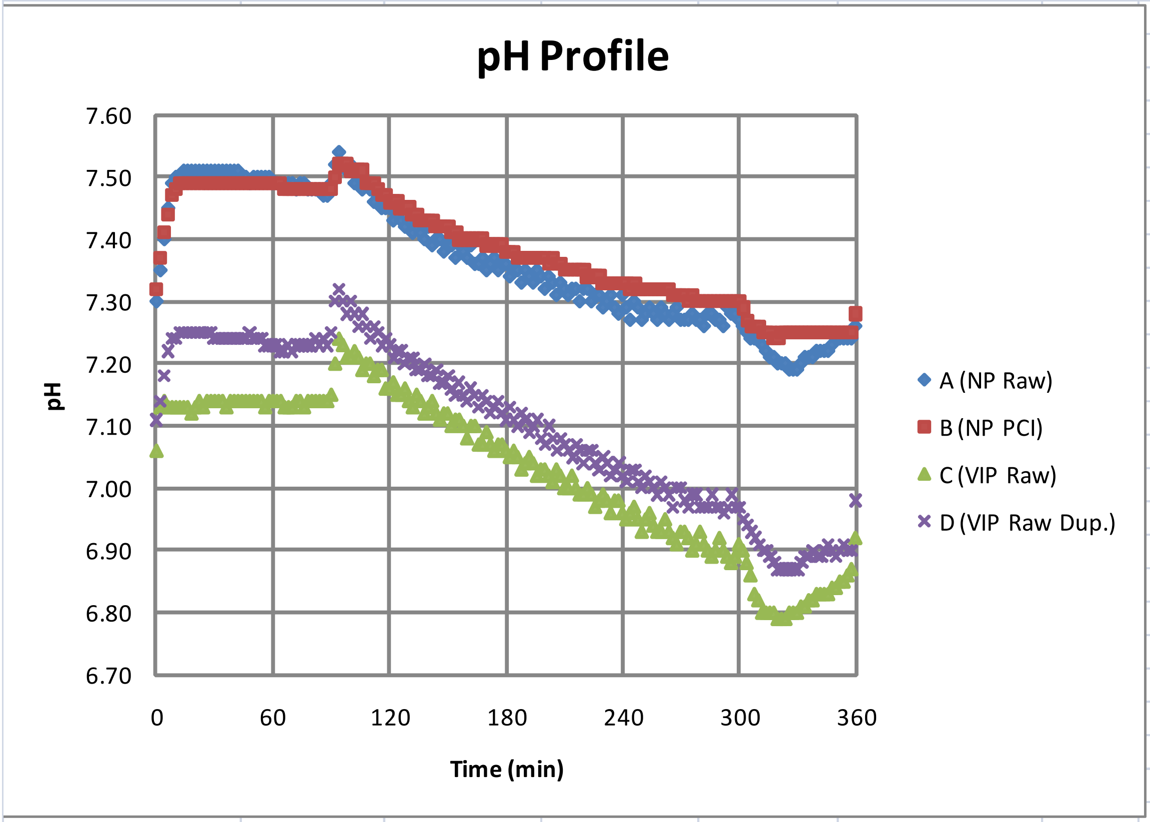
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.31	3.16	1.16	4.32	6.9
6					
9					
12					
15					
18					
105	7.7	0.65	0.16	0.81	6.85
120	7.15	1.24	0.30	1.54	
135	6.44	1.81	0.28	2.09	
150	5.78	2.36	0.30	2.66	6.4
165	5.15	2.74	0.32	3.06	
180	4.64	3.35	0.36	3.71	
195	3.85	3.80	0.34	4.14	6.15
330	0.302	8.25	0.13	8.38	5.9

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.17	3.06	0.18	3.24	2.3
6		3.20	0.22	3.42	
9		3.08	0.18	3.26	
12		2.92	0.12	3.04	
15		2.72	0.12	2.84	
18		2.62	0.08	2.70	
105	7.77	1.06	0.40	1.46	2.25
120	7.13	1.89	0.62	2.51	
135	6.39	2.12	0.66	2.78	
150	5.84	2.57	0.94	3.51	2.15
165	5.16	3.30	0.78	4.08	
180	4.46	3.87	0.80	4.67	
195	3.82	4.45	0.84	5.29	2
330	0.285	8.81	0.42	9.23	2.1

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L	OP mg/L P
3	5.2	2.02	0.560	2.58	2.55
6		1.88	0.560	2.44	
9		1.45	0.480	1.93	
12		1.18	0.320	1.50	
15		1.08	0.220	1.30	
18		0.97	0.140	1.11	
105	7.67	0.37	0.300	0.67	2.35
120	6.94	1.07	0.500	1.57	
135	6.21	1.20	0.620	1.82	
150	5.51	1.89	0.740	2.63	2.35
165	4.89	2.31	0.960	3.27	
180	4.39	2.67	0.740	3.41	
195	3.66	3.33	0.760	4.09	2.15
330	0.27	7.13	0.408	7.54	2.1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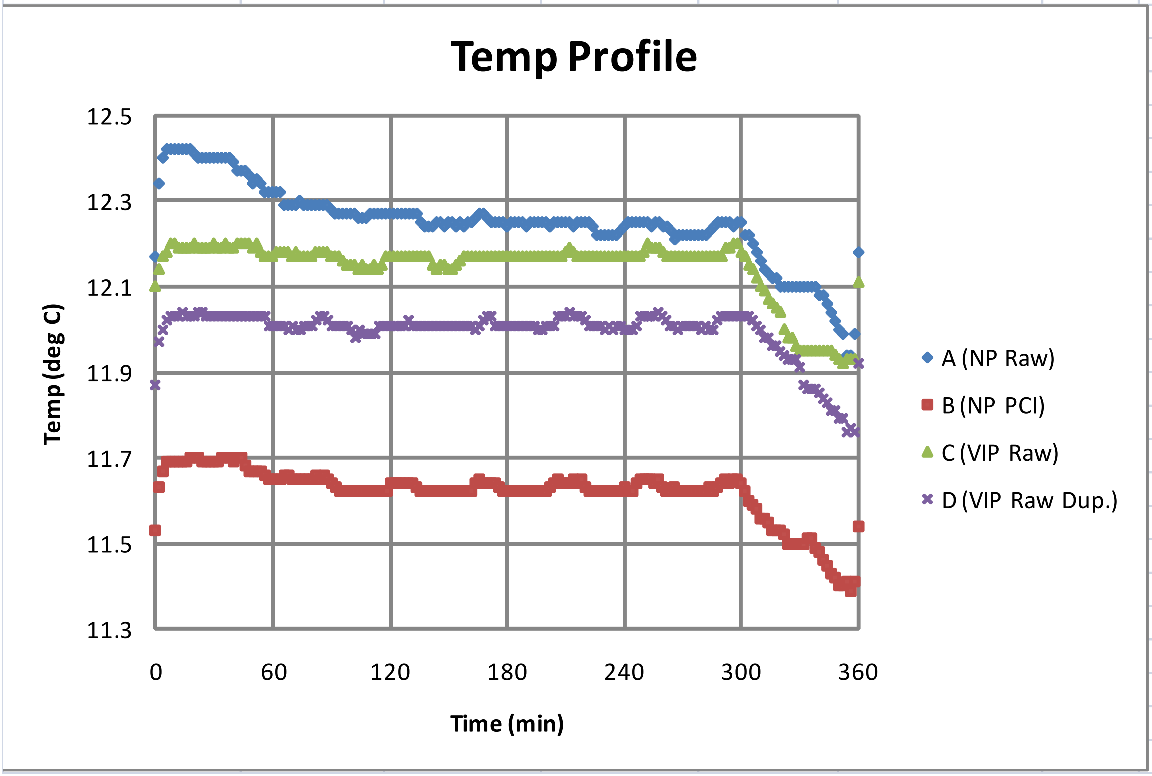
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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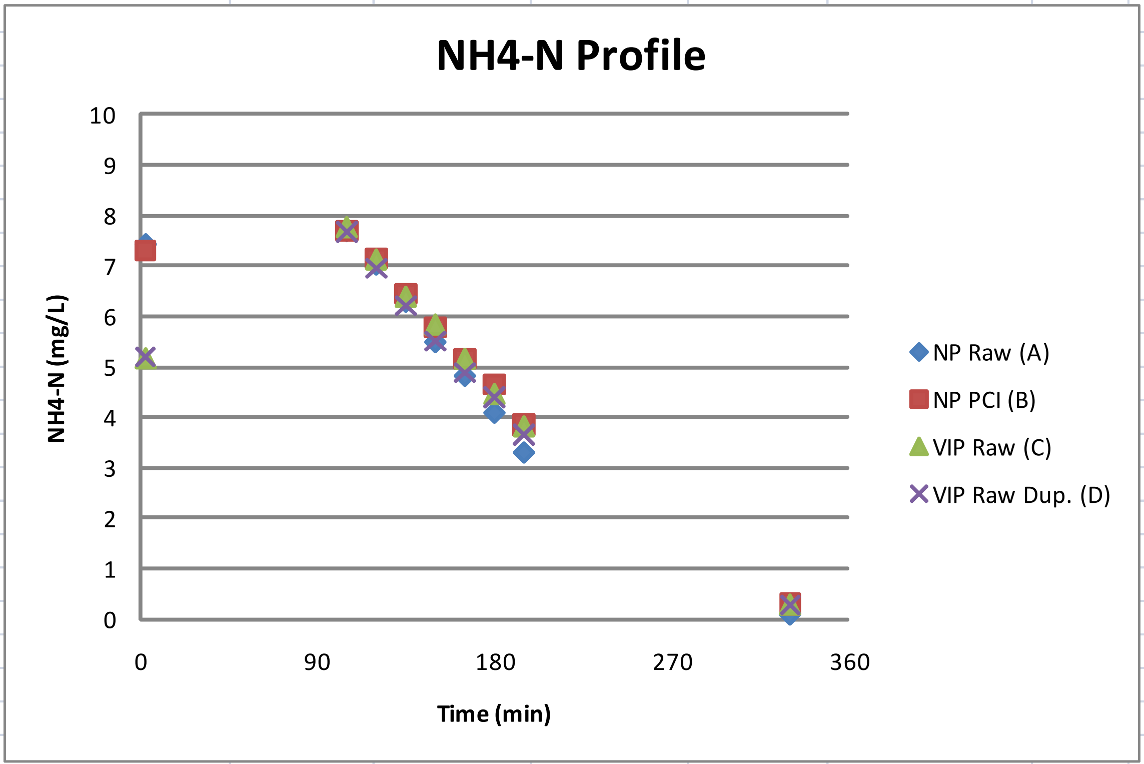
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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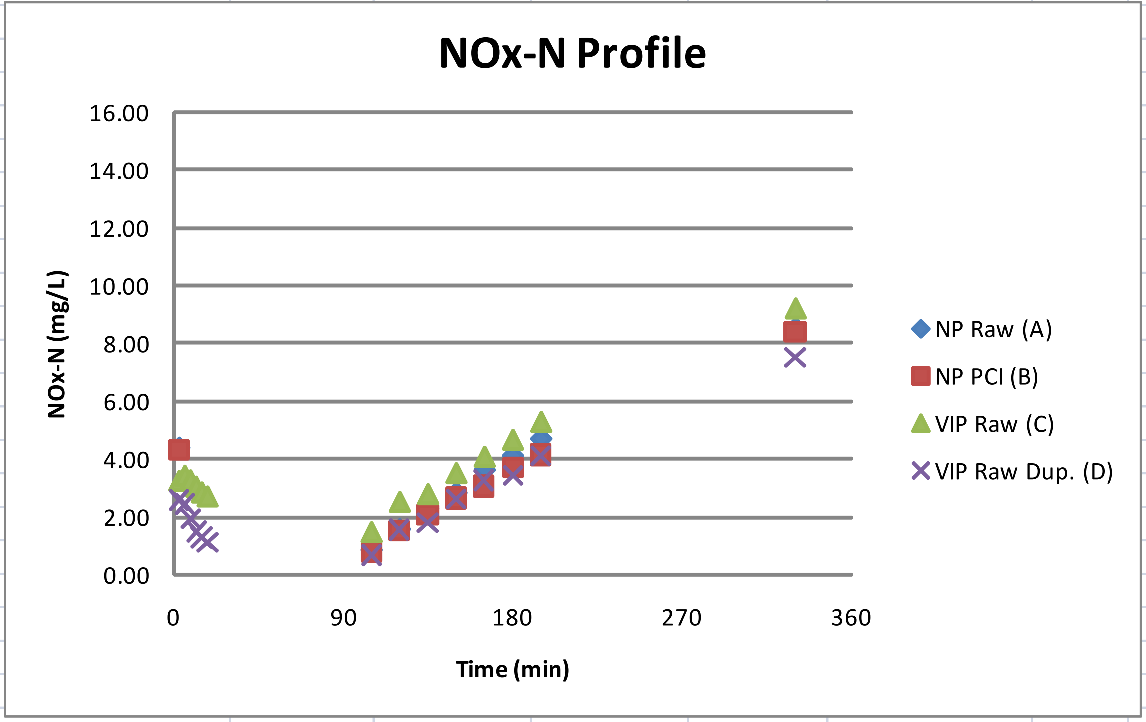
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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6.00
4.00
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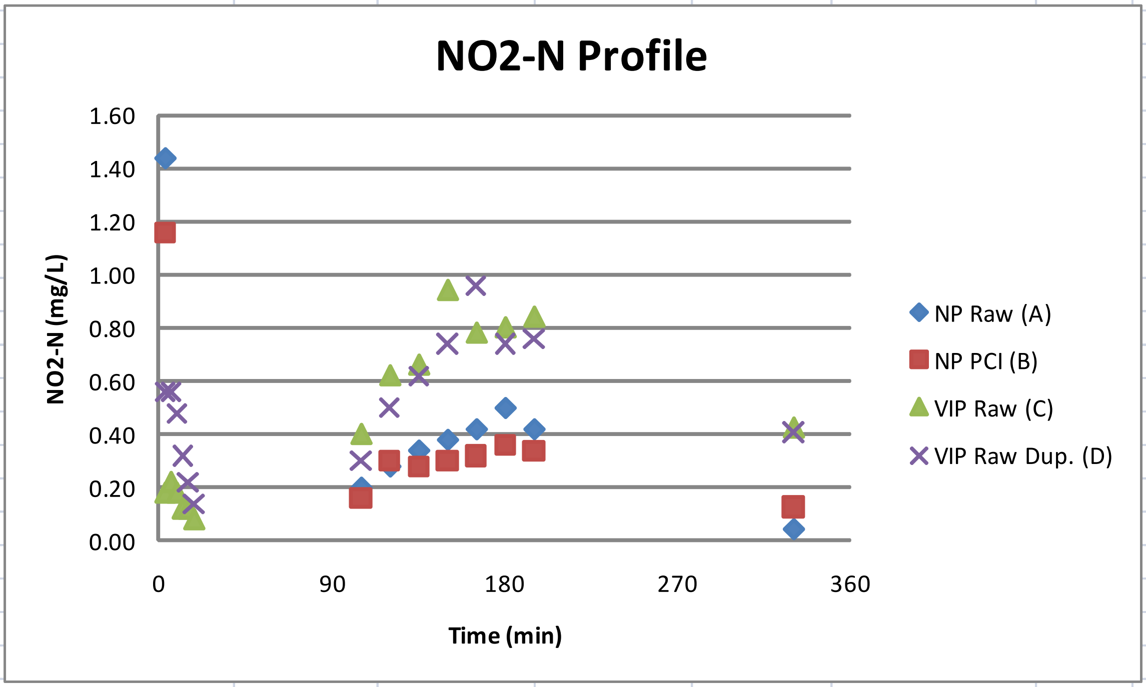
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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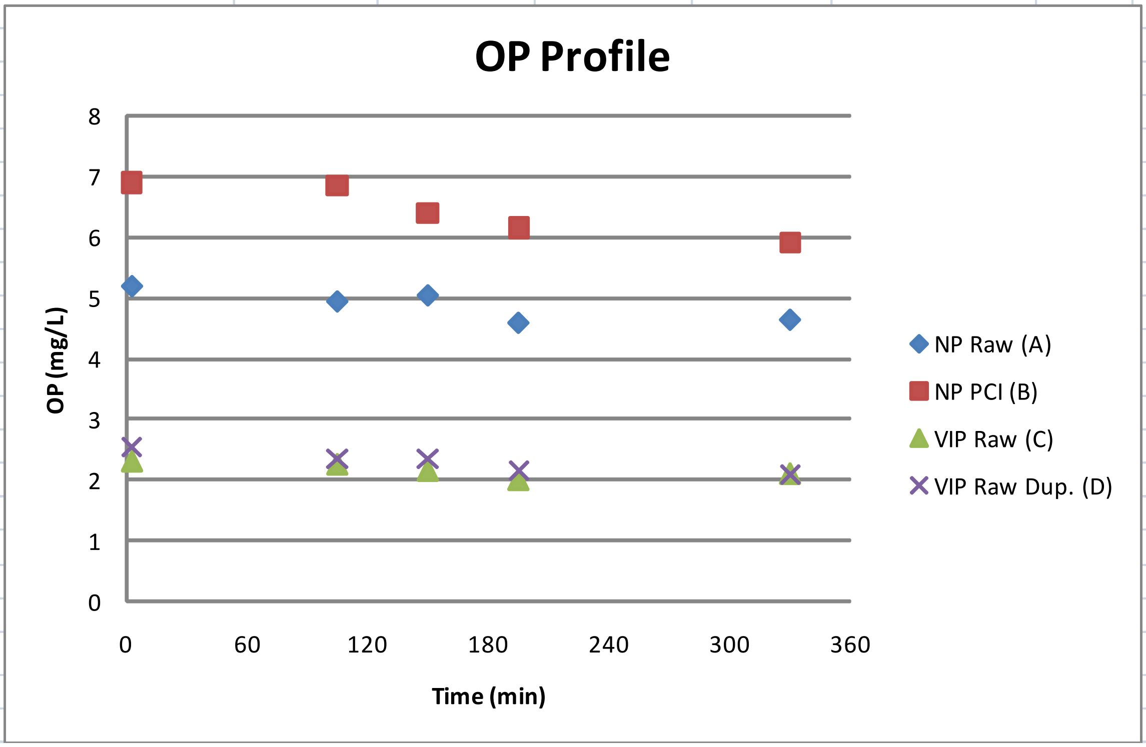
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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OP (mg/L)
0
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120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

29-Dec-10

	Feed						
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	33.7	114	95%	108.3	486	47.8	5.6
B (NP PCI)	34.5	148	91%	134.68	505	51	8.5
C (VIP Raw)	21.05	78	87%	67.86	294	30.1	2.3
D (Vip Raw Dup.)	21.8	61	90%	54.9	306	30.6	2.7

	Mixed Liquor		
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2040	87%	1774.8
B (NP PCI)	2160	88%	1900.8
C (VIP Raw)	1540	87%	1339.8
D (Vip Raw Dup.)	1360	91%	1237.6

	Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	0.856	7.54	0.300	18		4.65
B (NP PCI)	0.037	8.32	0.080	7		5.9
C (VIP Raw)	0.603	12.8	0.720	4		2.1
D (Vip Raw Dup.)	0.551	11.1	0.700	6		2.1

	Settled Sludge Volume (mL/L)		SVI
	5 min	30 min	(mL/g)
A (NP Raw)	820	370	181.4
B (NP PCI)	560	285	131.9
C (VIP Raw)	540	230	149.4
D (Vip Raw Dup.)	525	225	165.4

	A	B	C	D
OUR (mg O_2/L*hr)	-7.35	1.04	-2.01	8.85
MLVSS (g/L)	1.77	1.90	1.34	1.24
SOUR (mg O_2/g MLVSS*hr)	-4.14	0.55	-1.50	7.15

Avg. Temp. (° C)	
A (NP Raw)	12.28
B (NP PCI)	11.68
C (VIP Raw)	12.17
D (Vip Raw Dup.)	12.02

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.77	1.90	1.34	1.24
NR (mg NOx-N/L*hr)	1.91	2.84	2.08	2.10
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	4.36	6.16
SNR (mg NOx-N/g MLVSS*hr)	1.07	1.49	1.55	1.70
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	3.25	4.98

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.7	3.14	0.98	4.12	5.9
6					
9					
12					
15					
18					
105	8.25	0.55	0.18	0.73	5.55
120	7.36	0.98	0.24	1.22	
135	6.86	1.47	0.24	1.71	
150	6.19	1.69	0.28	1.97	5.2
165	5.73	2.48	0.26	2.74	
180	5.12	2.73	0.28	3.01	
195	4.54	3.34	0.30	3.64	5.2
330	0.856	7.54	0.30	7.84	5.1

NP PCI (B)

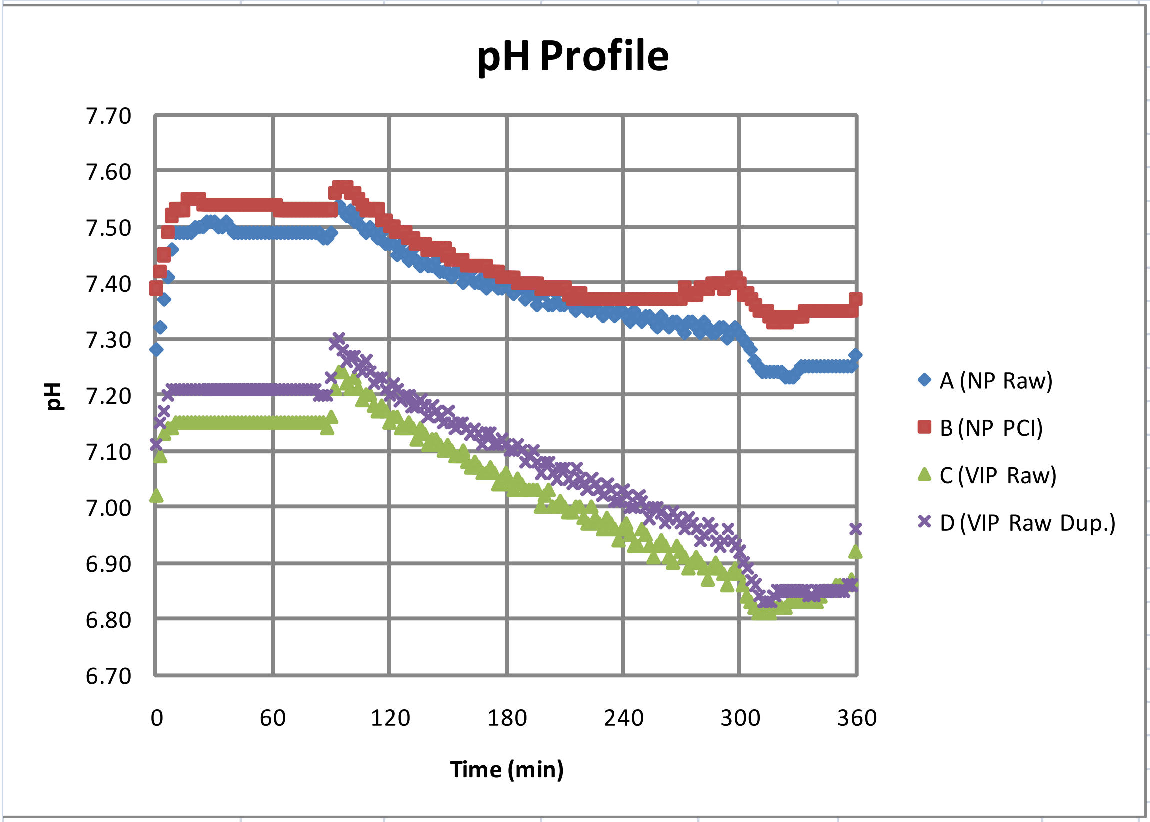
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	8.18	3.86	0.88	4.74	7.8
6					
9					
12					
15					
18					
105	7.78	0.70	0.24	0.94	7.45
120	6.9	1.31	0.34	1.65	
135	5.92	2.15	0.46	2.61	
150	5.06	2.42	0.44	2.86	7.1
165	4.02	3.13	0.46	3.59	
180	3.48	4.00	0.50	4.50	
195	2.66	4.84	0.50	5.34	6.85
330	0.037	8.32	0.08	8.40	6.8

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.27	7.52	0.20	7.72	3.05
6		7.12	0.36	7.48	
9		7.20	0.22	7.42	
12		6.80	0.14	6.94	
15		6.80	0.10	6.90	
18		6.42	0.08	6.50	
105	7.98	5.19	0.44	5.63	2.9
120	7.23	5.11	0.66	5.77	
135	6.62	5.82	0.84	6.66	
150	6	5.66	0.94	6.60	2.8
165	5.56	6.63	1.00	7.63	
180	4.94	6.88	1.06	7.94	
195	4.3	7.63	1.08	8.71	2.65
330	0.603	12.80	0.72	13.52	2.8

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L	OP mg/L P
3	5.12	5.56	0.240	5.80	3.1
6		5.26	0.440	5.70	
9		4.92	0.320	5.24	
12		4.70	0.220	4.92	
15		4.58	0.200	4.78	
18		4.56	0.120	4.68	
105	7.78	2.86	0.400	3.26	2.9
120	7.13	3.18	0.600	3.78	
135	6.51	3.48	0.720	4.20	
150	5.9	3.79	0.820	4.61	2.75
165	5.32	4.61	0.860	5.47	
180	4.64	4.92	0.920	5.84	
195	4.2	5.06	0.940	6.00	2.75
330	0.551	11.10	0.700	11.80	2.7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240
300
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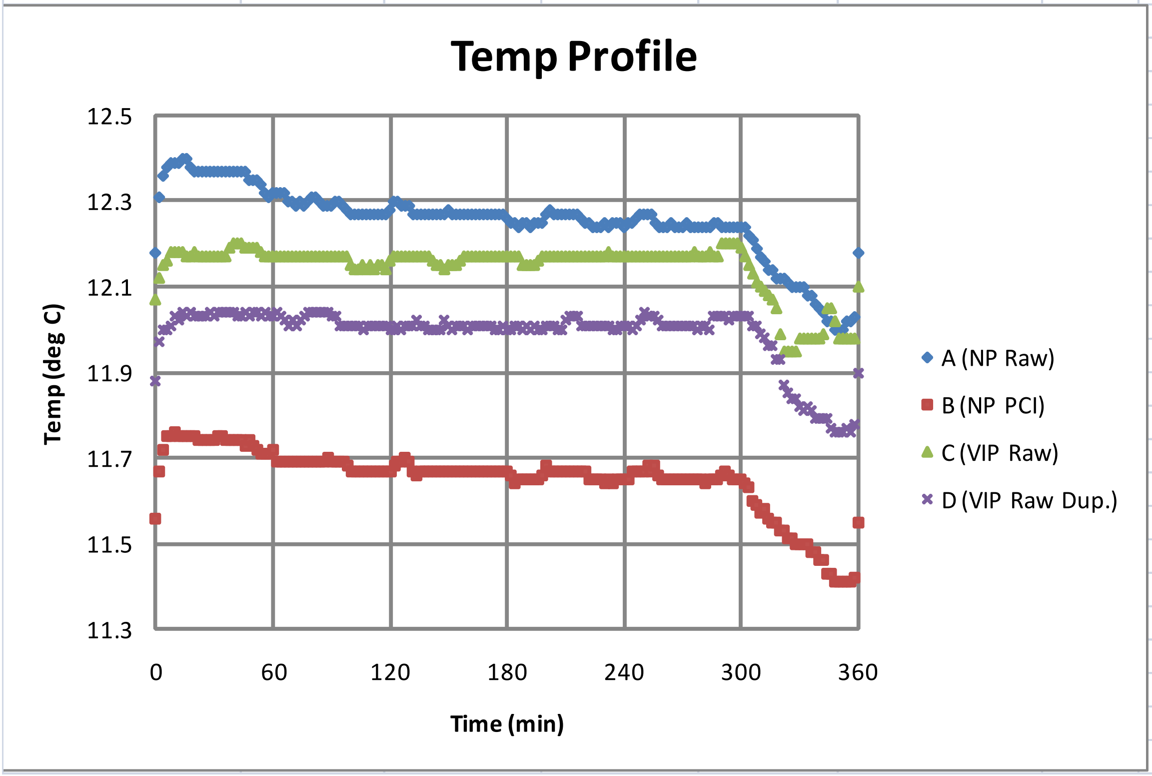
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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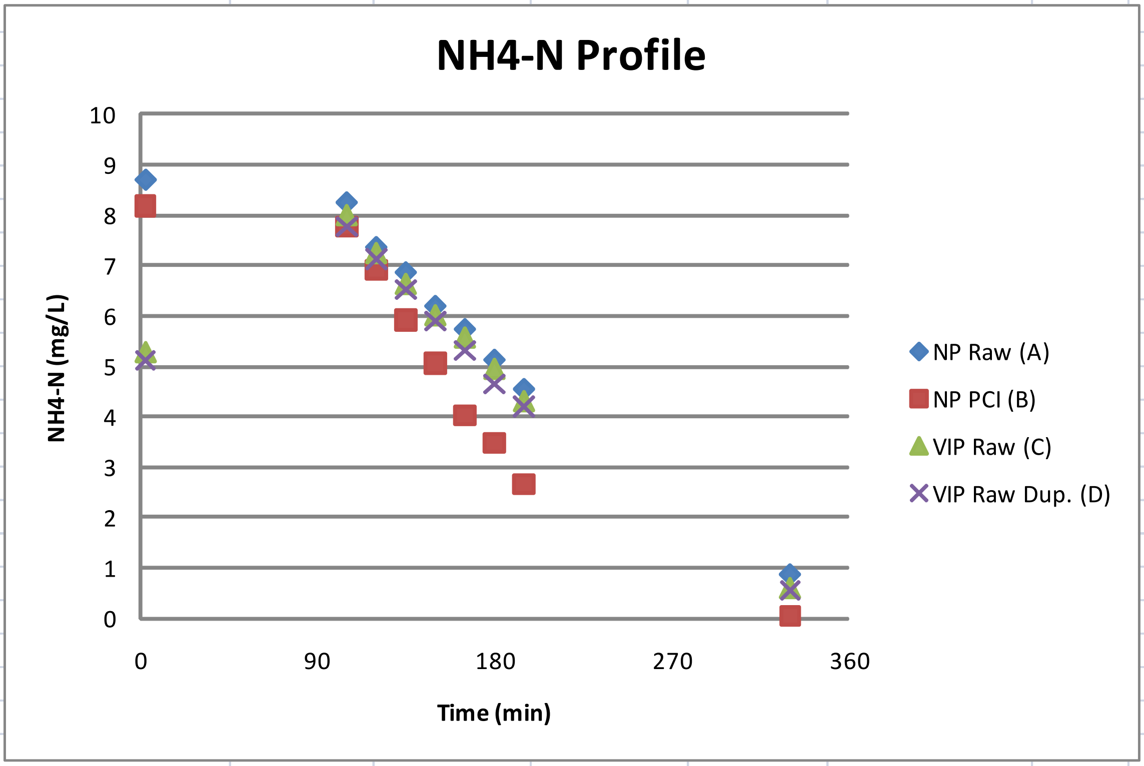
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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9
8
7
6
5
4
3
2
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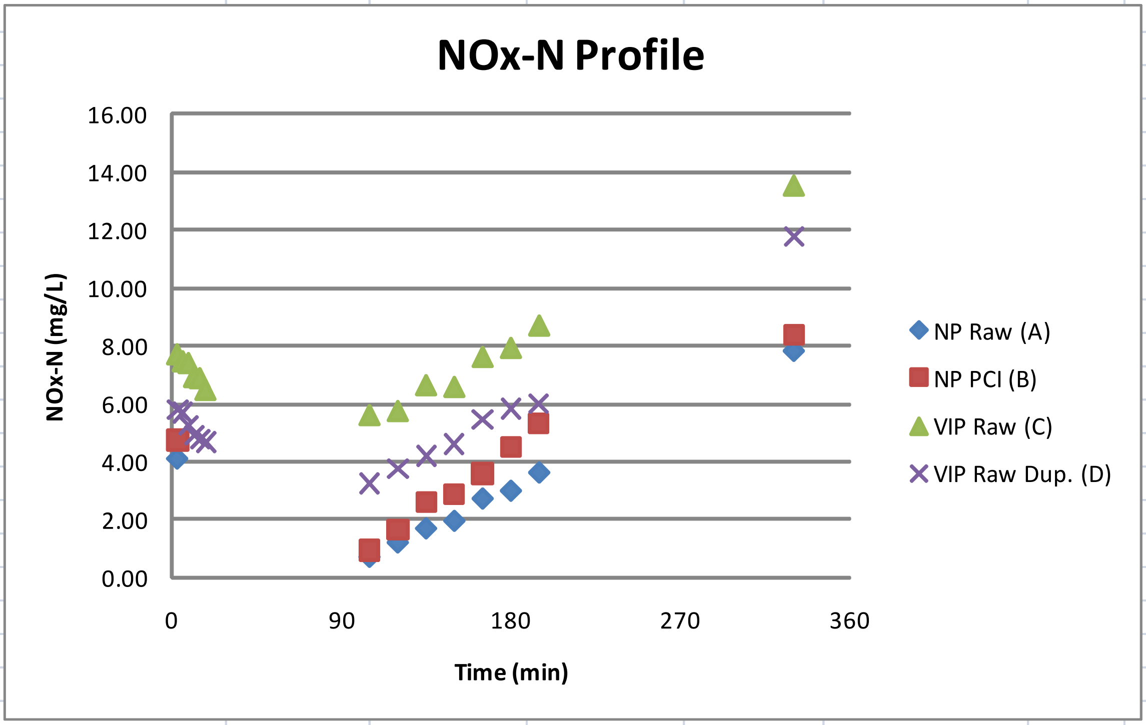
0
NH4-N (mg/L)
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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NOx-N (mg/L)
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180
270
360
Time (min)
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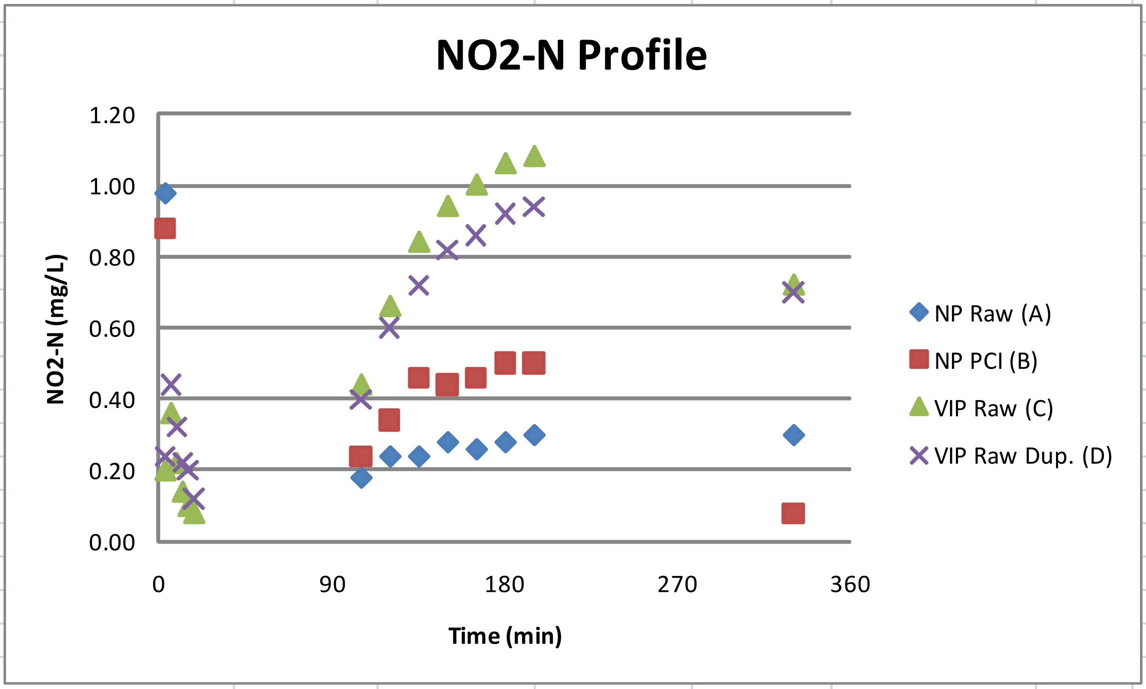
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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360
Time (min)
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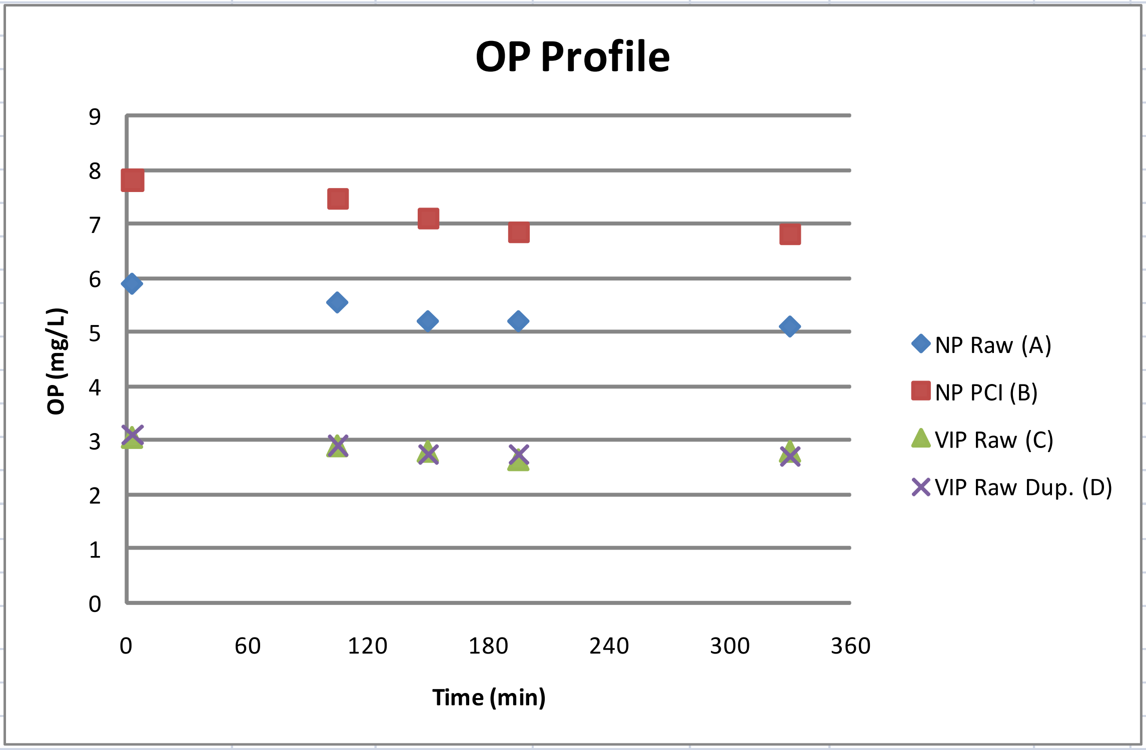
▲ VIP Raw (C)
× VIP Raw Dup. (D)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240
300
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)

31-Dec-10

Feed							
	NH3-N **mg/L**	**TSS** **mg/L**	**Voltl. Frac.** **%**	**VSS** **mg/L**	**COD** **mg/L**	**TKN** **mg/L**	**OP** **mg/L P**
A (NP Raw)	32.65	198	90%	178.2	818	51.2	
B (NP PCI)	33.3	202	87%	175.74	795	53.8	
C (VIP Raw)	18.05	46	88%	40.48	251	30.6	
D (Vip Raw Dup.)	22.45	143	84%	120.12	390	35.4	

Mixed Liquor			
	MLSS **mg/L**	**Voltl. Frac.** **%**	**MLVSS** **mg/L**
A (NP Raw)	2100	86%	1806
B (NP PCI)	2420	84%	2032.8
C (VIP Raw)	1760	85%	1496
D (Vip Raw Dup.)	1820	86%	1565.2

Effluent (1330)						
	NH3-N **mg/L**	**NO3-N** **mg/L**	**NO2-N** **mg/L**	**TSS** **mg/L**	**Turbidity** **NTU**	**OP** **mg/L P**
A (NP Raw)	0.871	6.53	0.196	19		
B (NP PCI)	0.222	6.61	0.028	8		
C (VIP Raw)	0.297	13.8	0.072	8		
D (Vip Raw Dup.)	0.163	4.75	0.028	9		

Settled Sludge Volume (mL/L)			**SVI**
	5 min	**30 min**	**(mL/g)**
A (NP Raw)	735	325	154.8
B (NP PCI)	520	250	103.3
C (VIP Raw)	440	190	108.0
D (Vip Raw Dup.)	465	200	109.9

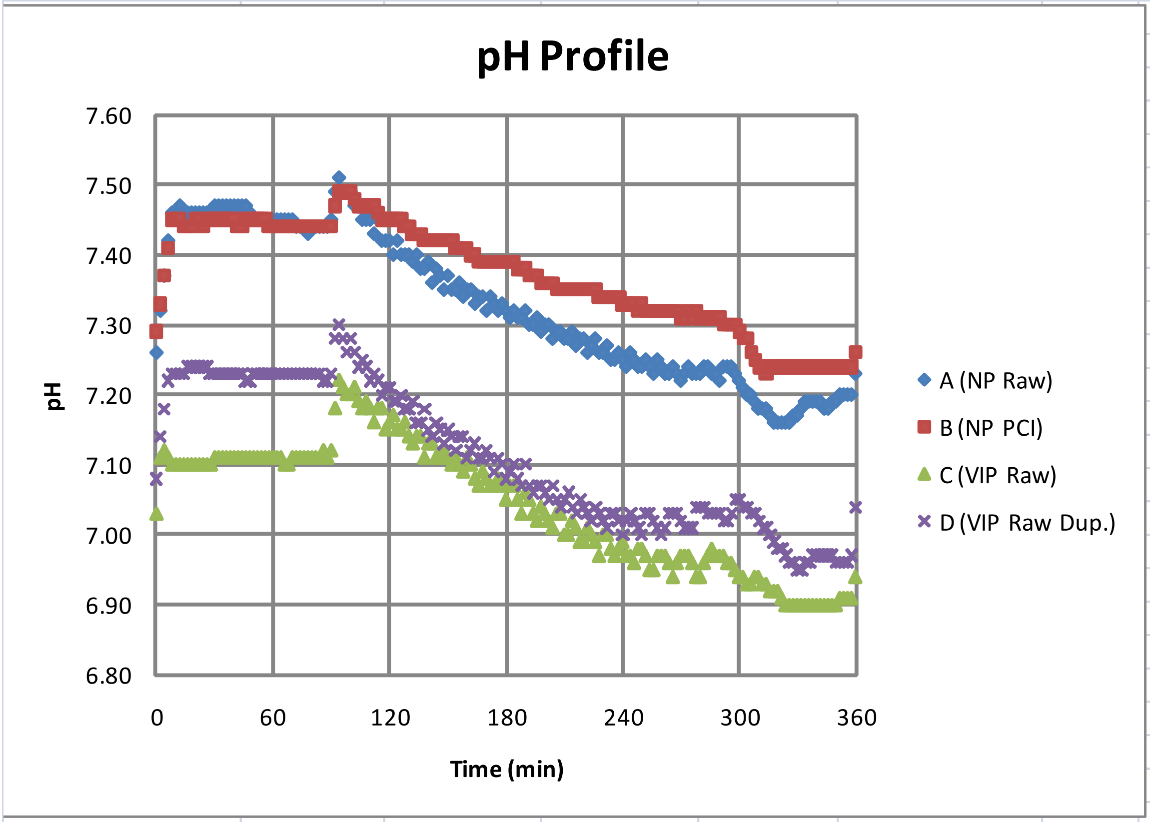
	A	**B**	**C**	**D**
OUR (mg O_2/L*hr)	4.37	-0.95	-1.07	-1.30
MLVSS (g/L)	1.81	2.03	1.50	1.57
SOUR (mg O_2/g MLVSS*hr)	2.42	-0.47	-0.72	-0.83

Avg. Temp. (° C)	
A (NP Raw)	12.24
B (NP PCI)	11.61
C (VIP Raw)	12.13
D (Vip Raw Dup.)	11.97

	A (NP Raw)	**B** (NP PCI)	**C** (VIP Raw)	**D** (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	1.81	2.03	1.50	1.57
NR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	1.62	7.91
SNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	1.08	5.05

VIP Raw (C)		NH3-N	NO3-N	NO2-N	NOx-N	OP
	Time	mg/L	mg/L	mg/L	mg/L	mg/L P
	3	4.88	9.46	0.24	9.70	
	6		9.38	0.28	9.66	
	9		9.34	0.70	10.04	
	12		9.32	0.32	9.64	
	15		8.92	0.36	9.28	
	18		9.12	0.32	9.44	
	105					
	120					
	135					
	150					
	165					
	180					
	195					
	330	0.297	13.80	0.07		

VIP Raw Dup. (D)		NH3-N	NO3-N	NO2-N	NOx-N	OP
	Time	mg/L	mg/L		mg/L	mg/L P
	3	5.41	2.60	0.540	3.14	
	6		2.24	0.540	2.78	
	9		1.59	0.420	2.01	
	12		1.59	0.280	1.87	
	15		1.40	0.220	1.62	
	18		1.37	0.160	1.53	
	105					
	120					
	135					
	150					
	165					
	180					
	195					
	330	0.163	4.75	0.028		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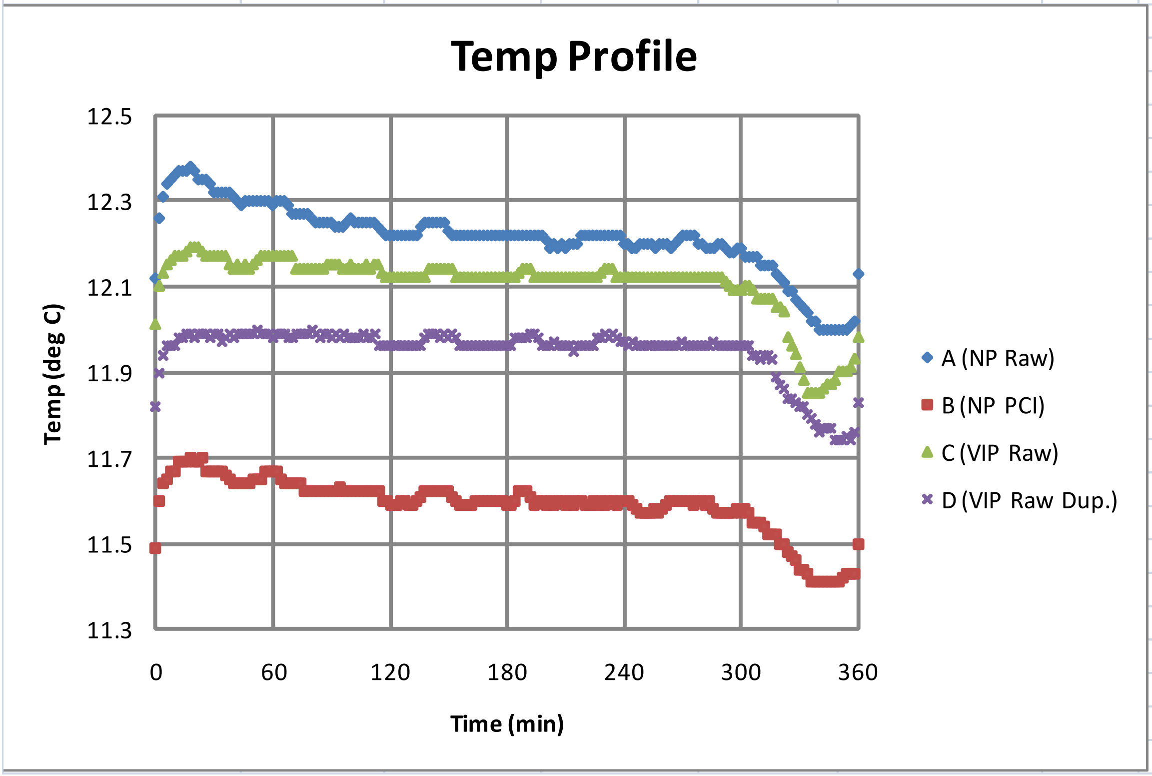
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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Time (min)
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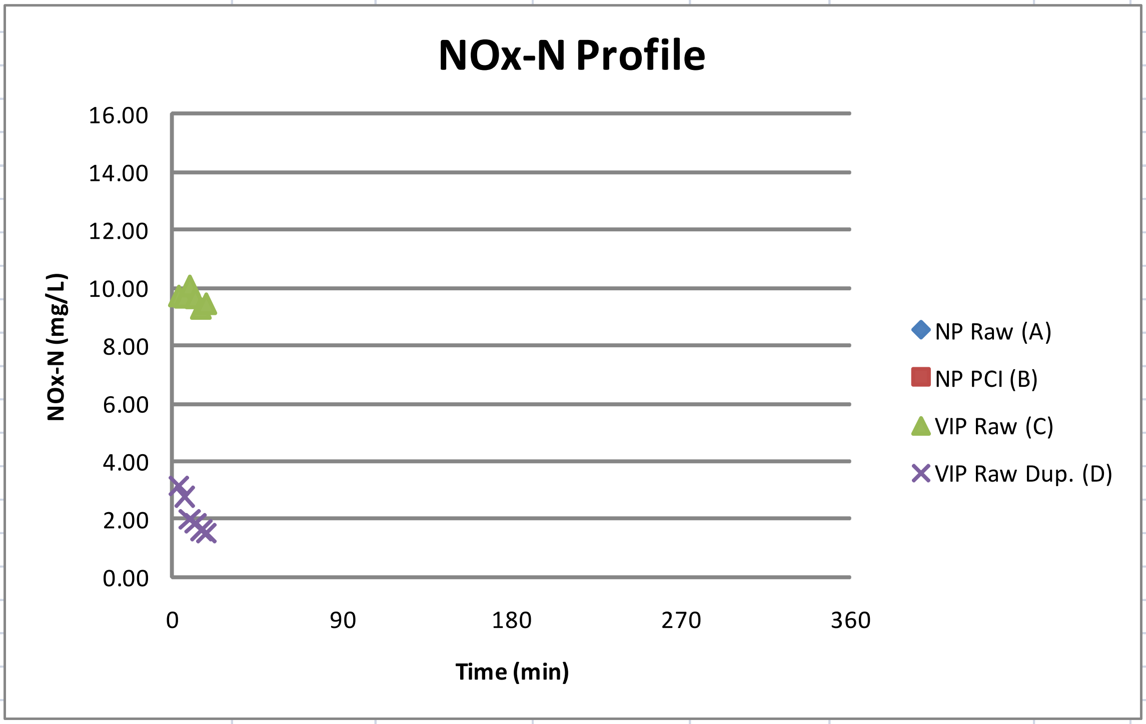
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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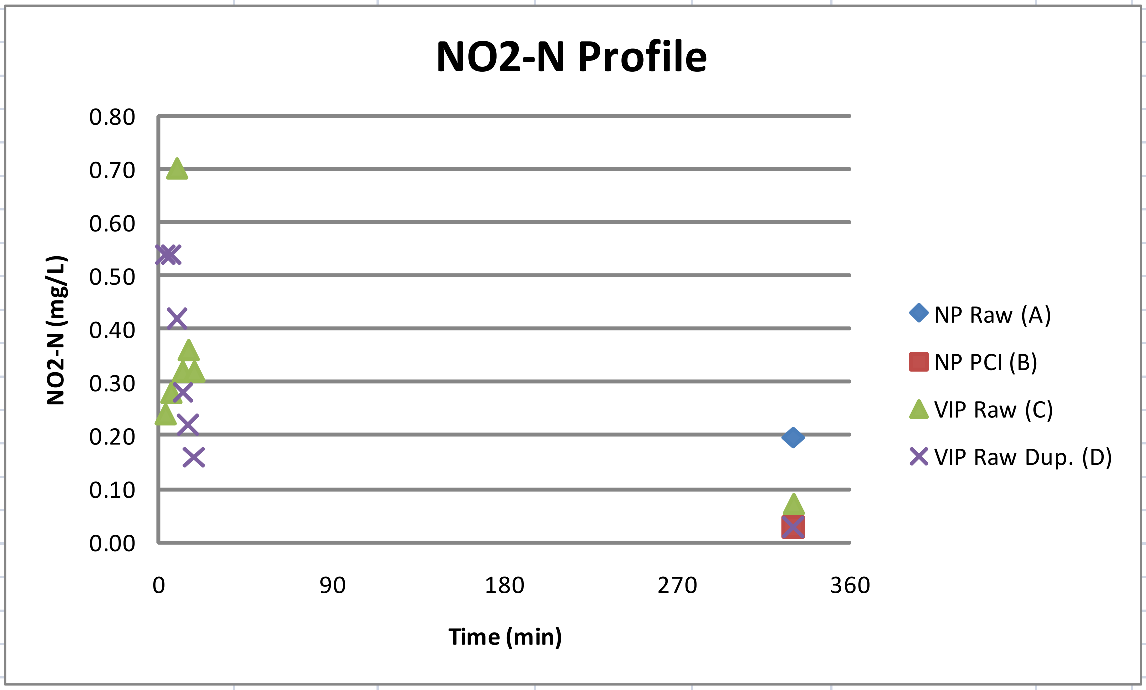
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
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0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

3-Jan-11

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	30.5	174	90%	156.6	648	48.7
B (NP PCI)	35.05	196	88%	172.48	728	53.1
C (VIP Raw)	19.85	108	85%	91.8	400	33
D (Vip Raw Dup.)	20.95	94	87%	81.78	479	30.4

Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2180	86%	1874.8
B (NP PCI)	2320	85%	1972.0
C (VIP Raw)	1640	85%	1394.0
D (Vip Raw Dup.)	1680	86%	1444.8

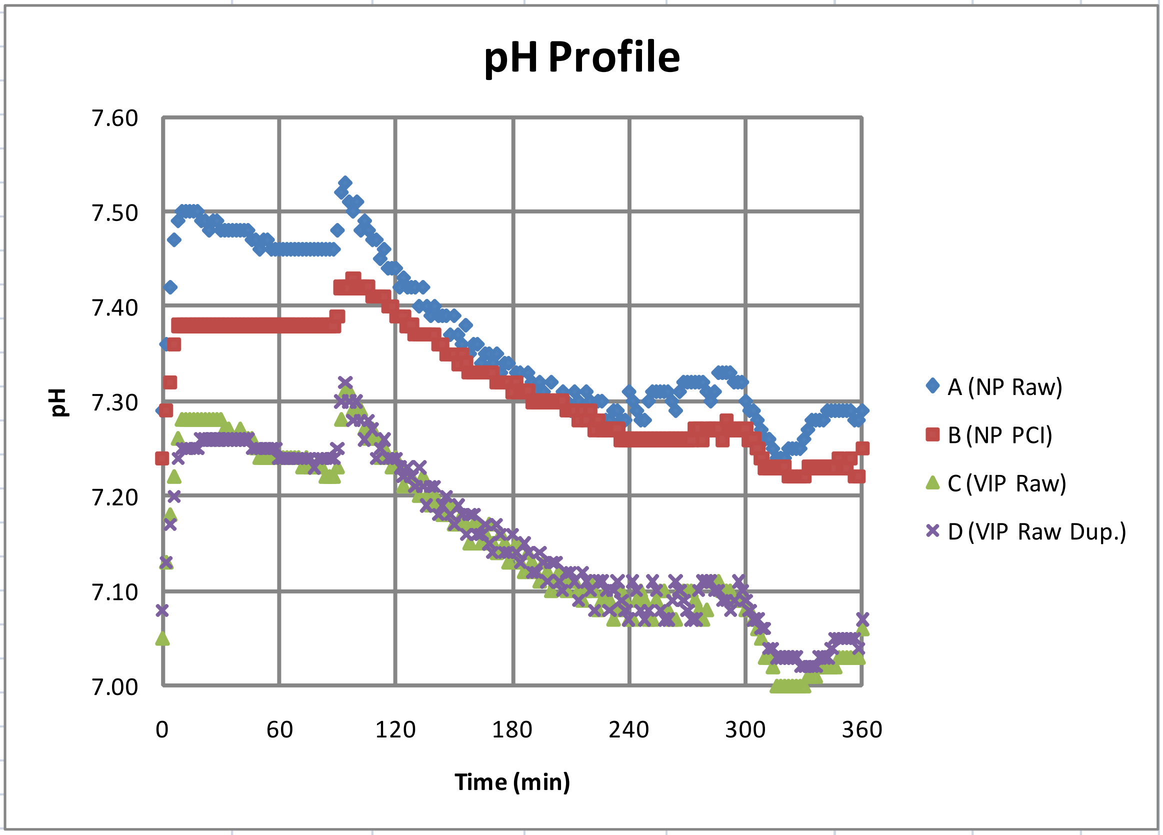
Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	2.490	6.6	0.3	18	
B (NP PCI)	0.075	6.7	0.028	9	
C (VIP Raw)	0.068	10.8	0.036	7	
D (Vip Raw Dup.)	0.109	4.8	0.044	7	

Settled Sludge Volume (mL/L)	5 min	30 min
A (NP Raw)	650	320
B (NP PCI)	410	235
C (VIP Raw)	350	185
D (Vip Raw Dup.)	380	200

SVI (mL/g)
146.8
101.3
112.8
119.0

	A	B	C	D
OUR (mg O_2/L*hr)	7.07	0.96	0.28	2.75
MLVSS (g/L)	1.87	1.97	1.39	1.44
SOUR (mg O_2/g MLVSS*hr)	3.77	0.49	0.20	1.90

Avg. Temp. (° C)	
A (NP Raw)	12.27
B (NP PCI)	11.69
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.06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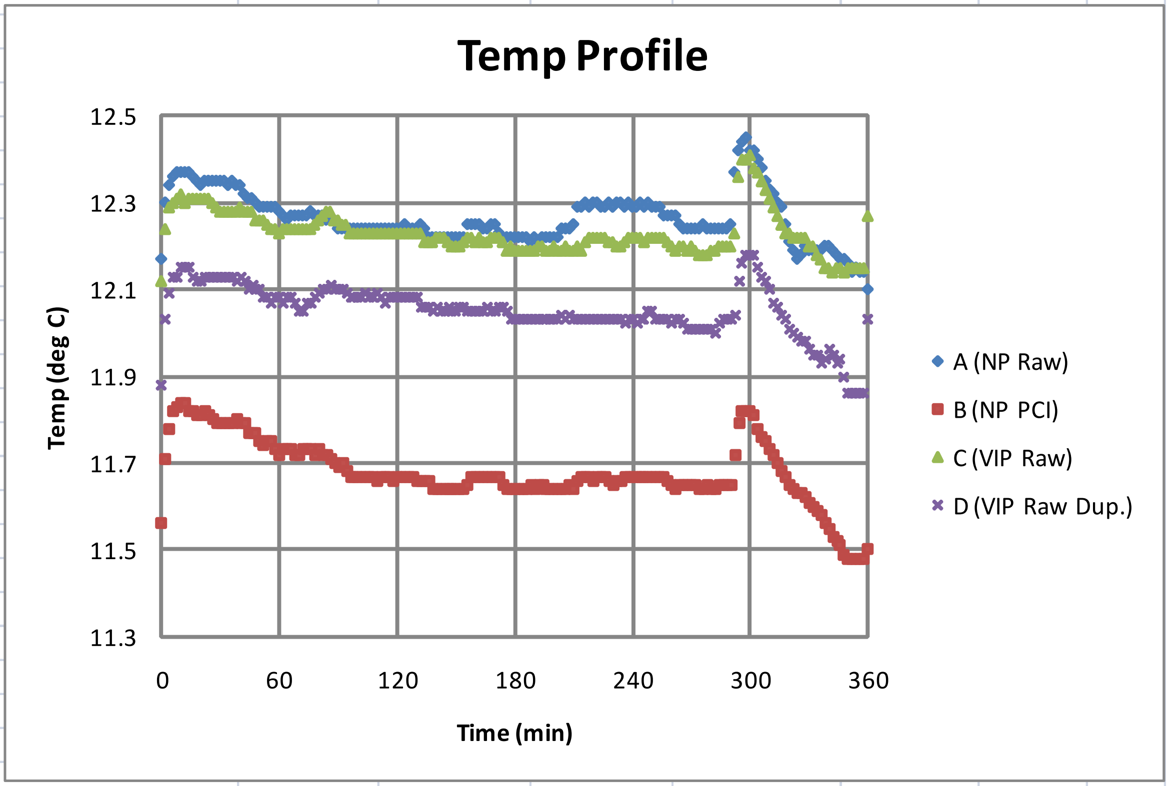
7.30
7.20
7.10
7.00
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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Temp (deg C)
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12.1
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11.5
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0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCI)
▲ C (VIP Raw)
× D (VIP Raw Dup.)

5-Jan-11

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	30.75	193	94%	181.42	741	50.2	4.9
B (NP PCI)	34.55	195	99%	193.05	675	62.5	6.7
C (VIP Raw)	17	316	78%	246.48	528	35.2	1.2
D (Vip Raw Dup.)	19.4	130	94%	122.2	383	31.3	2.4

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2400	93%	2232
B (NP PCI)	2300	94%	2162
C (VIP Raw)	1730	88%	1522.4
D (Vip Raw Dup.)	1580	91%	1437.8

Effluent (1330)						
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turbidity NTU	OP mg/L P
A (NP Raw)	1.248	7.08	0.276	17		3.8
B (NP PCI)	0.072	8.34	0.028	11		5.3
C (VIP Raw)	0.818	9.67	0.592	8		1.4
D (Vip Raw Dup.)	0.888	6.69	0.500	7		1.9

Settled Sludge Volume (mL/L)			SVI
	5 min	30 min	(mL/g)
A (NP Raw)	730	320	133.3
B (NP PCI)	450	230	100.0
C (VIP Raw)	450	220	127.2
D (Vip Raw Dup.)	435	200	126.6

	A	B	C	D
OUR (mg O_2/L*hr)	0.16	19.36	0.35	2.09
MLVSS (g/L)	2.23	2.16	1.52	1.44
SOUR (mg O_2/g MLVSS*hr)	0.07	8.96	0.23	1.46

Avg. Temp. (° C)	
A (NP Raw)	12.31
B (NP PCI)	11.69
C (VIP Raw)	12.18
D (Vip Raw Dup.)	12.08

	A (NP Raw)	B (NP PCI)	C (VIP Raw)	D (Vip Raw Dup.)
MLVSS Conc. (g/L MLVSS):	2.23	2.16	1.52	1.44
NR (mg NOx-N/L*hr)	1.71	3.57	1.67	1.85
DNR (mg NOx-N/L*hr)	#DIV/0!	#DIV/0!	-0.97	9.44
SNR (mg NOx-N/g MLVSS*hr)	0.77	1.65	1.10	1.28
SDNR (mg NOx-N/g MLVSS*hr)	#DIV/0!	#DIV/0!	-0.64	6.57

NP Raw (A)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	7.72	3.14	1.32	4.46	4.25
6					
9					
12					
15					
18					
105	7.22	0.69	0.34	1.03	5.75
120	7.19	0.98	0.26	1.24	
135	6.61	1.28	0.26	1.54	
150	6.15	1.70	0.28	1.98	3.9
165	5.65	2.34	0.30	2.64	
180	5.19	2.52	0.30	2.82	
195	4.58	3.31	0.30	3.61	3.8
330	1.248	7.08	0.28	7.36	3.8

NP PCI (B)

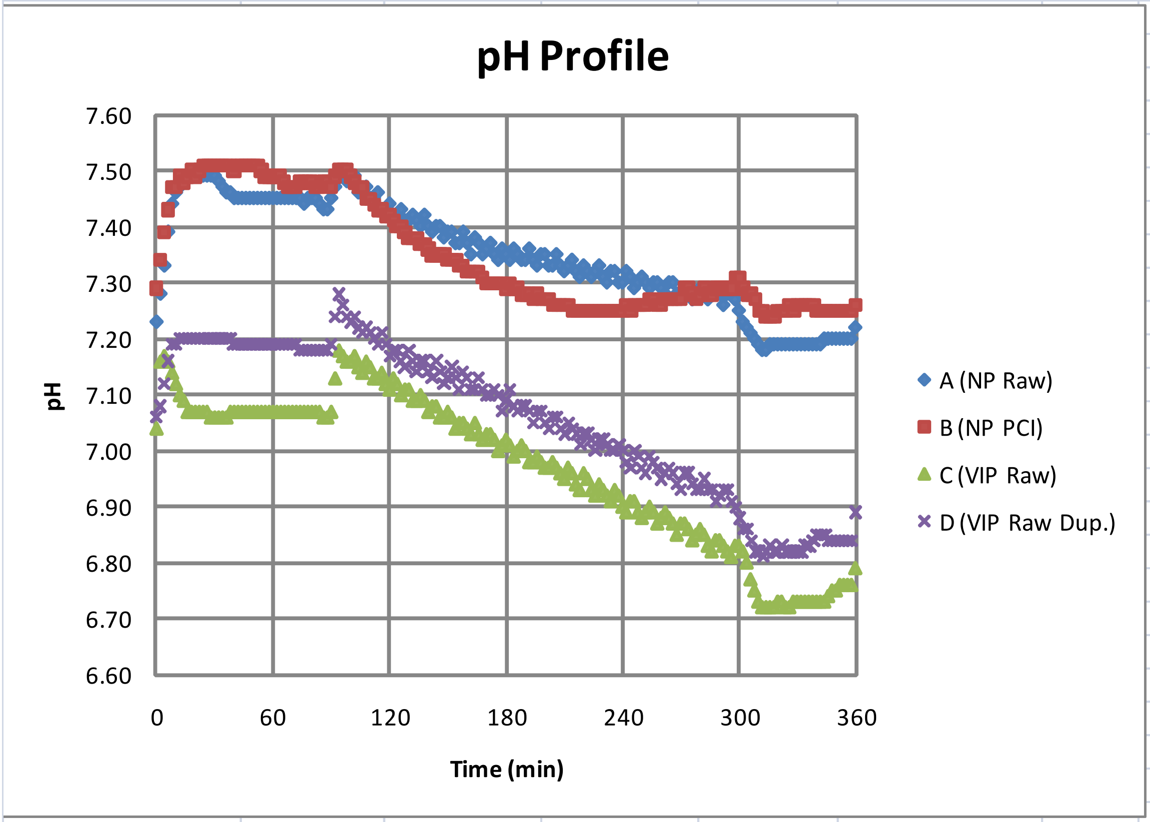
	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	8	3.70	1.14	4.84	5.85
6					
9					
12					
15					
18					
105	8.03	0.45	0.16	0.61	4.15
120	5.53	1.31	0.46	1.77	
135	5.49	1.80	0.54	2.34	
150	4.15	2.51	0.60	3.11	5.4
165	3.83	3.24	0.70	3.94	
180	2.91	4.12	0.68	4.80	
195	2.05	5.72	0.68	6.40	5.2
330	0.072	8.34	0.03	8.37	5.3

VIP Raw (C)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L	mg/L	mg/L	mg/L P
3	4.39	3.60	0.28	3.88	1.6
6		3.52	0.30	3.82	
8		3.54	0.30	3.84	
9		3.70	0.30	4.00	
12		3.68	0.32	4.00	
15		3.66	0.36	4.02	
105	7.25	2.03	0.92	2.95	1.5
120	6.83	2.75	0.76	3.51	
135	6.05	3.10	0.68	3.78	
150	5.59	3.64	0.72	4.36	1.45
165	5.09	3.84	0.76	4.60	
180	4.56	4.36	0.74	5.10	
195	3.97	5.59	0.76	6.35	1.45
330	0.818	9.67	0.59	10.26	1.4

VIP Raw Dup. (D)

	NH3-N	NO3-N	NO2-N	NOx-N	OP
Time	mg/L	mg/L		mg/L	mg/L P
3	4.63	2.52	0.420	2.94	2.15
6		1.87	0.440	2.31	
8		1.53	0.420	1.95	
9		1.46	0.360	1.82	
12		1.30	0.240	1.54	
15		1.11	0.160	1.27	
105	7.62	0.36	0.240	0.60	1.95
120	5.57	0.57	0.400	0.97	
135	6.41	1.00	0.480	1.48	
150	5.7	1.37	0.500	1.87	1.85
165	5.28	1.73	0.560	2.29	
180	4.67	2.40	0.560	2.96	
195	4.15	3.10	0.580	3.68	1.85
330	0.888	6.69	0.500	7.19	1.9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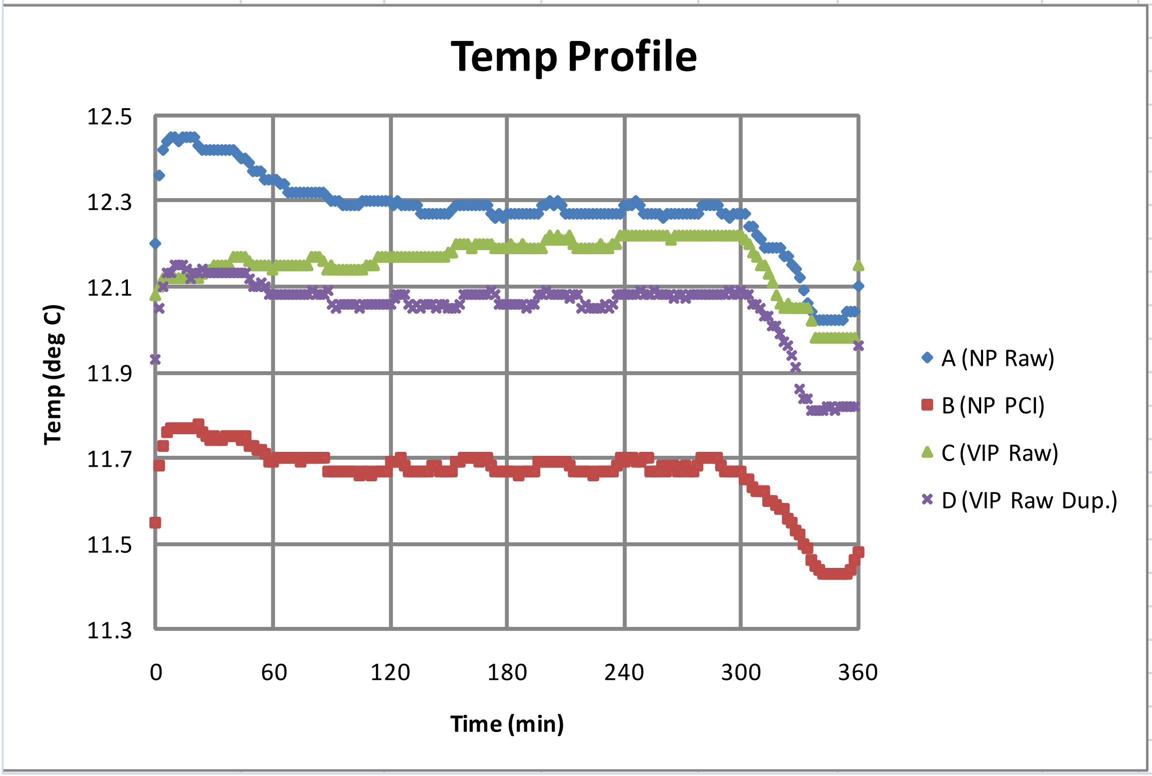
6.90
6.80
6.70
6.60
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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Temp (deg C)
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300
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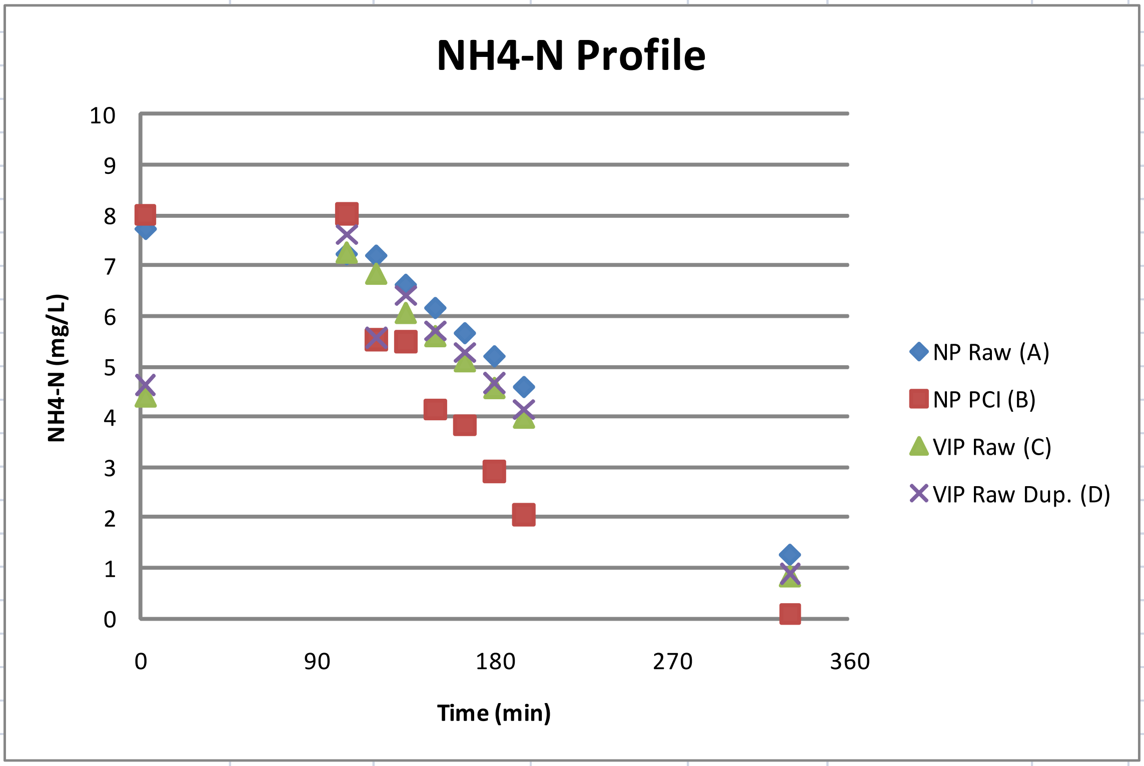
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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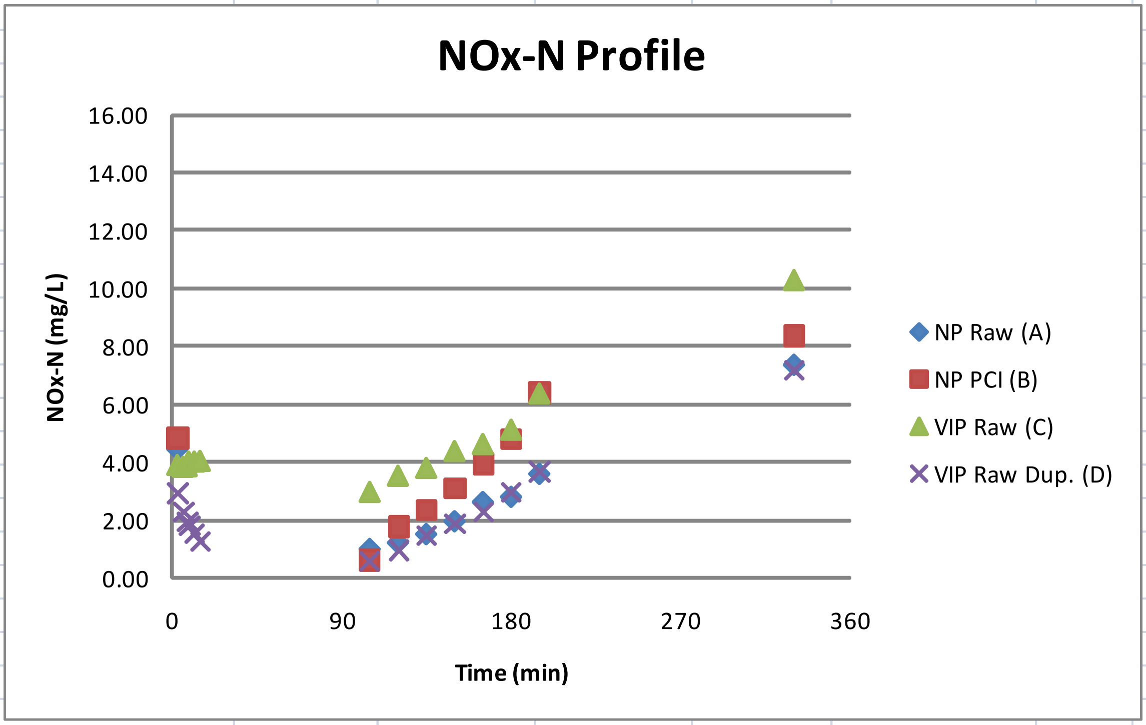
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCl (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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NOx-N (mg/L)
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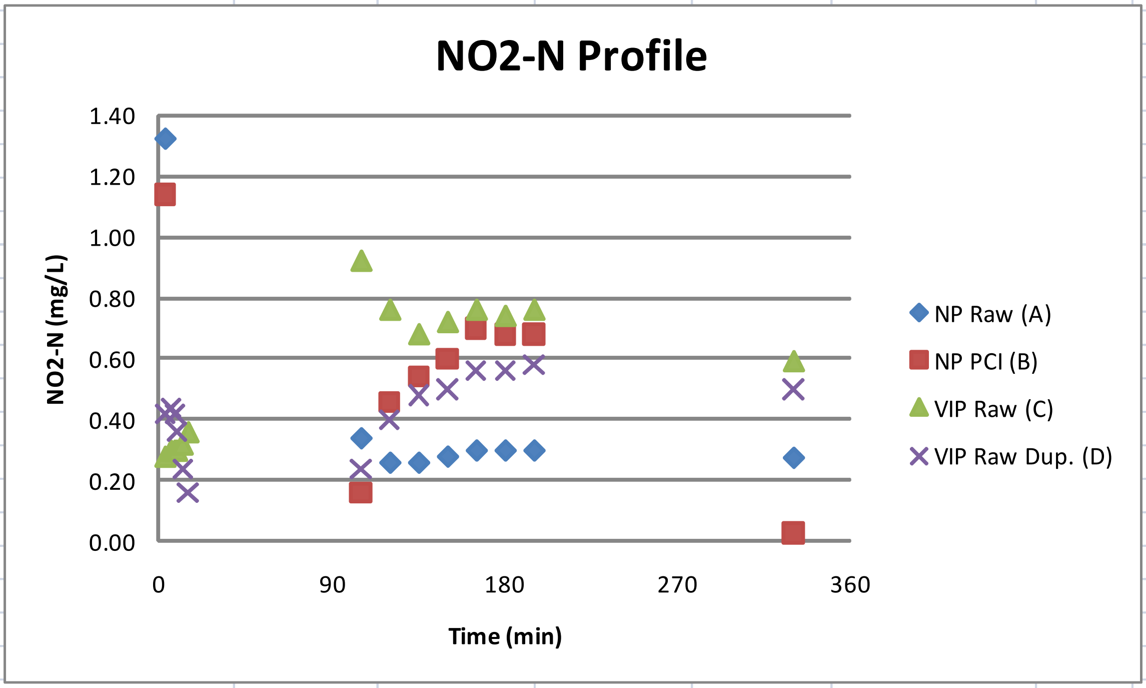
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCl (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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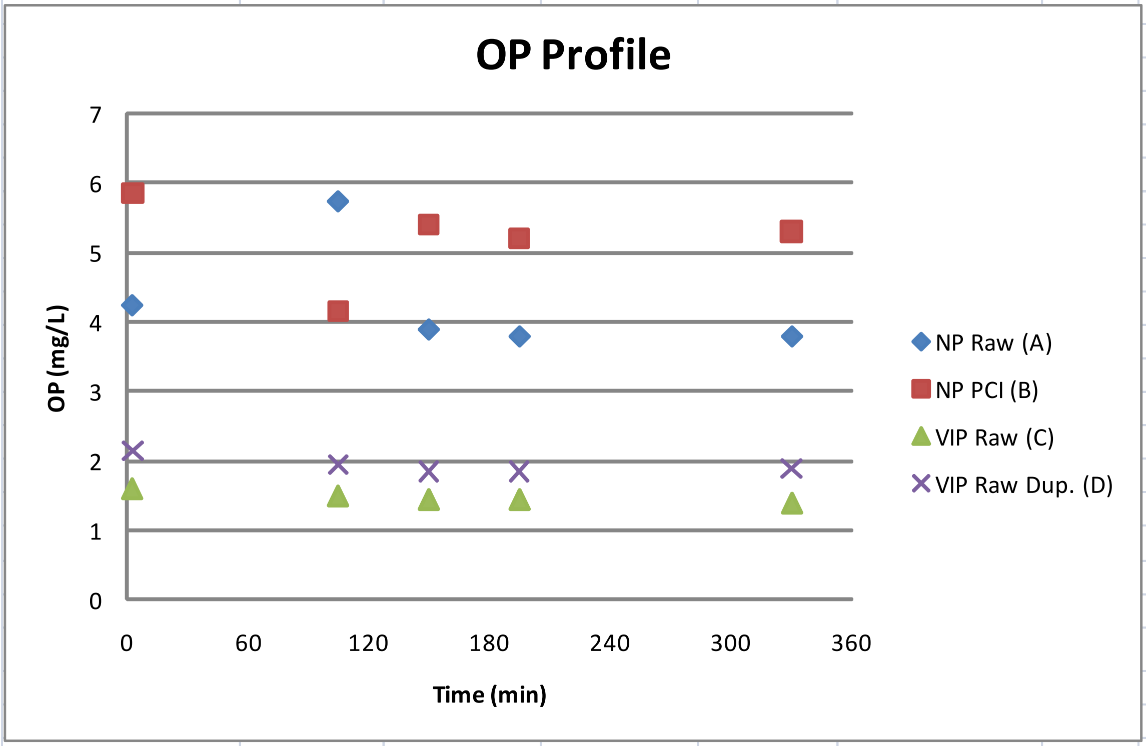
NO2-N (mg/L)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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OP (mg/L)
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6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

7-Jan-11

Feed	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	30.2	94	94%	88.36	644	45.7
B (NP PCI)	32.25	76	92%	69.92	313	48
C (VIP Raw)	18.35	264	84%	221.76	514	31.5
D (Vip Raw Dup.)	19.45	57	88%	50.16	279	30.5

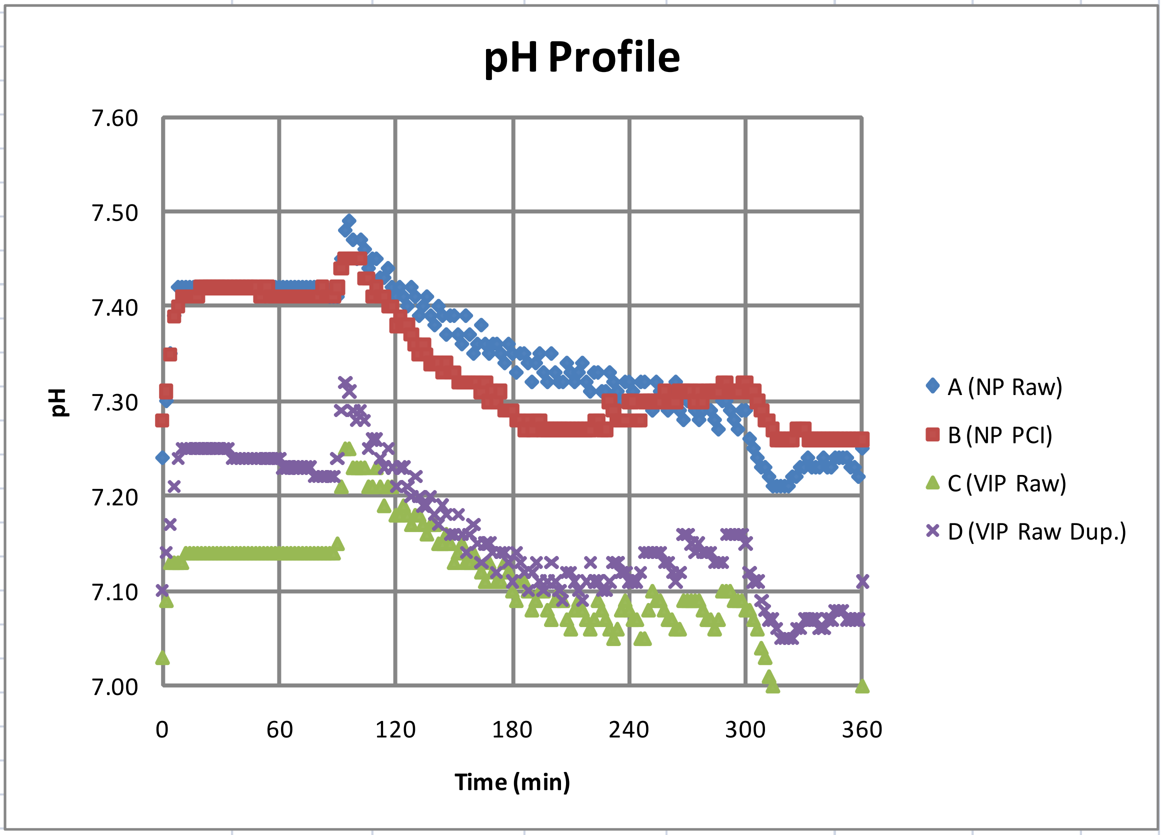
Mixed Liquor	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2300	87%	2001.0
B (NP PCI)	2180	86%	1874.8
C (VIP Raw)	1460	88%	1284.8
D (Vip Raw Dup.)	1420	90%	1278.0

Effluent (1330)	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)	0.303	6.9	0.136	19	
B (NP PCI)	0.053	6.9	0.032	13	
C (VIP Raw)	0.059	4.3	0.032	6	
D (Vip Raw Dup.)	0.082	4.3	0.02	5	

Settled Sludge Volume (mL/L)	5 min	30 min	SVI (mL/g)
A (NP Raw)	710	300	130.4
B (NP PCI)	400	210	96.3
C (VIP Raw)	450	200	137.0
D (Vip Raw Dup.)	430	200	140.8

	A	B	C	D
OUR (mg O_2/L*hr)	-0.42	0.60	7.27	-1.20
MLVSS (g/L)	2.00	1.87	1.28	1.28
SOUR (mg O_2/g MLVSS*hr)	-0.21	0.32	5.66	-0.94

Avg. Temp. (° C)	
A (NP Raw)	12.29
B (NP PCI)	11.63
C (VIP Raw)	12.15
D (Vip Raw Dup.)	12.06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60
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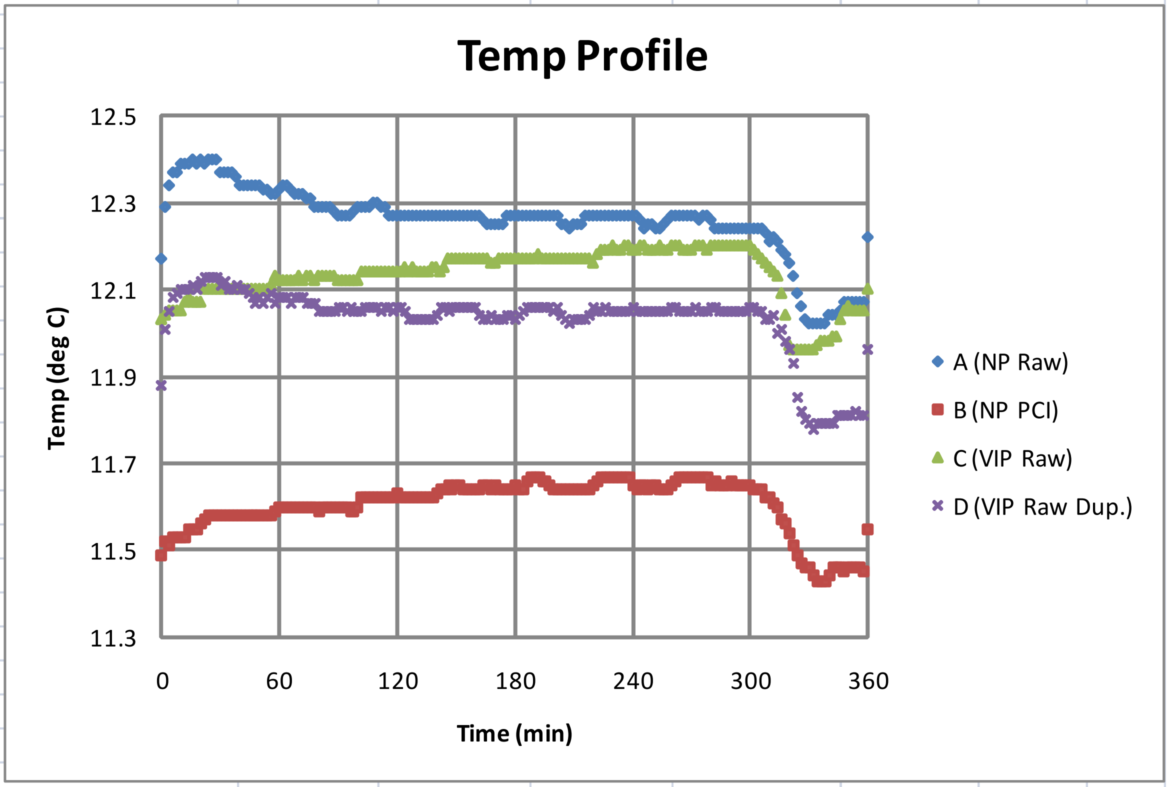
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

10-Jan-11

Feed						
	NH3-N **mg/L**	**TSS** **mg/L**	**Voltl. Frac.** **%**	**VSS** **mg/L**	**COD** **mg/L**	**TKN** **mg/L**
A (NP Raw)	31.9	165	91%	150.15	500	49.7
B (NP PCI)	32.9	44	97%	42.68	292	46.8
C (VIP Raw)	17.9	116	88%	102.08	288	32.7
D (Vip Raw Dup.)	20.45	134	90%	120.6	441	35.9

Mixed Liquor			
	MLSS **mg/L**	**Voltl. Frac.** **%**	**MLVSS** **mg/L**
A (NP Raw)	2280	87%	1983.6
B (NP PCI)	1920	85%	1632.0
C (VIP Raw)	1820	87%	1583.4
D (Vip Raw Dup.)	1780	88%	1566.4

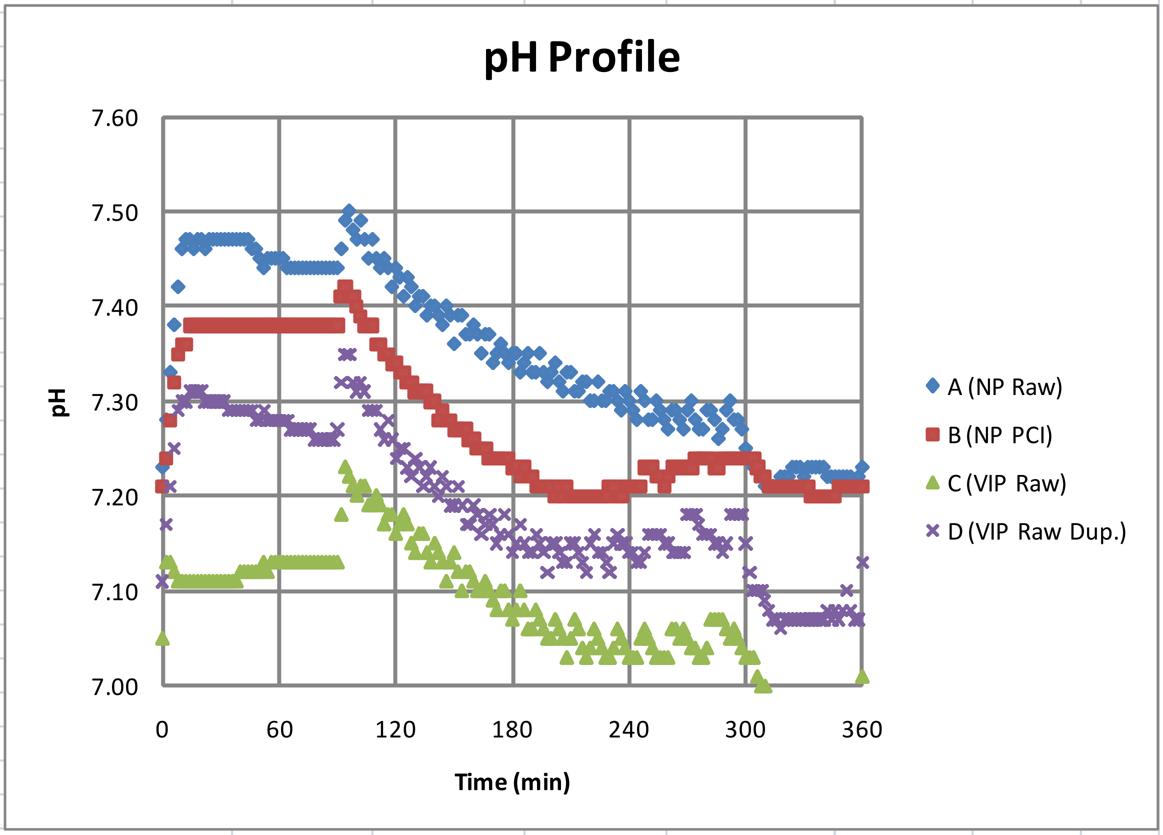
Effluent (1330)					
	NH3-N **mg/L**	**NO3-N** **mg/L**	**NO2-N** **mg/L**	**TSS** **mg/L**	**Turb.** **NTU**
A (NP Raw)	0.108	7.4	0.092	17	
B (NP PCI)	0.044	12.5	0.036	12	
C (VIP Raw)	0.064	7.2	0.044	6	
D (Vip Raw Dup.)	0.042	4.1	0.028	6	

Settled Sludge Volume (mL/L)		
	5 min	**30 min**
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI **(mL/g)**
0.0
0.0
0.0
0.0

	A	**B**	**C**	**D**
OUR (mg O_2/L*hr)	-0.97	0.10	2.10	-1.11
MLVSS (g/L)	1.98	1.63	1.58	1.57
SOUR (mg O_2/g MLVSS*hr)	-0.49	0.06	1.32	-0.71

Avg. Temp. (° C)	
A (NP Raw)	12.31
B (NP PCI)	11.66
C (VIP Raw)	12.23
D (Vip Raw Dup.)	12.06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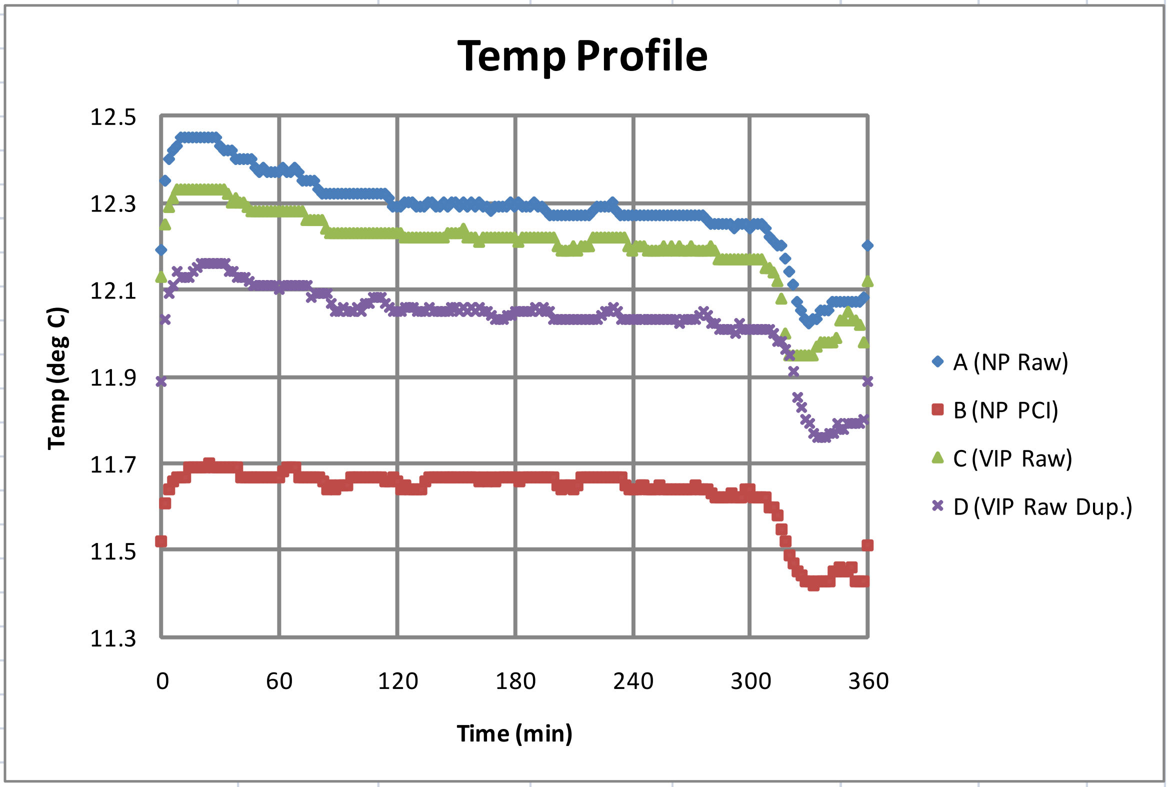
7.10
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)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0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

11-Jan-11

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	7.2	3.62	0.76	4.38
6				
9				
12				
15				
18				
105	8.04	0.67	0.24	0.91
120	7.32	1.14	0.32	1.46
135	6.58	1.45	0.34	1.79
150	6.06	1.91	0.38	2.29
165	5.27	2.54	0.44	2.98
180	4.69	2.98	0.44	3.42
195	4.01	3.74	0.42	4.16
330	0.331	8.84	0.17	9.01

NP PCI (B)

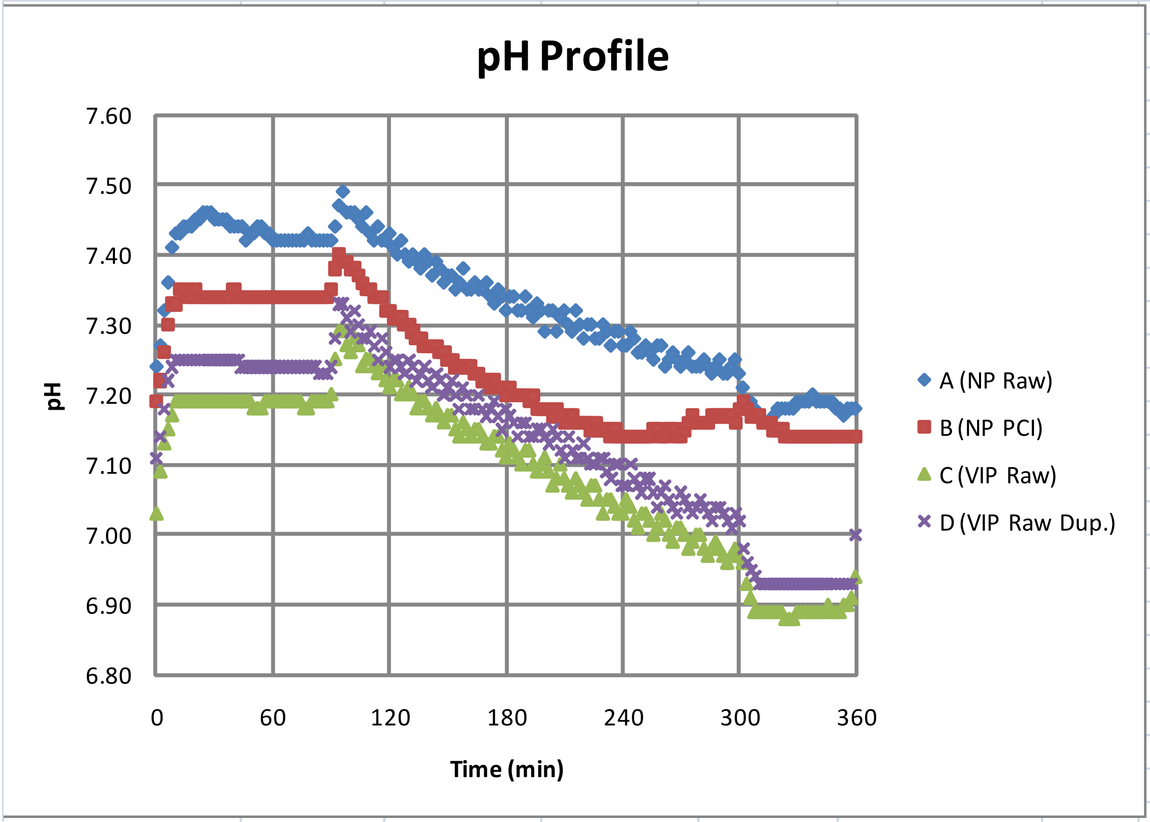
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	7.17	8.66	0.56	9.22
6				
9				
12				
15				
18				
105	7.88	5.09	0.46	5.55
120	7.29	5.84	0.66	6.50
135	6.01	6.79	0.72	7.51
150	5.36	7.29	0.76	8.05
165	4.48	8.13	0.88	9.01
180	3.63	8.94	0.84	9.78
195	2.73	9.85	0.92	10.77
330	0.086	15.10	0.03	15.13

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.26	4.04	0.18	4.22
6		3.76	0.34	4.10
9		3.04	0.32	3.36
12		2.94	0.26	3.20
15		2.72	0.20	2.92
18		2.70	0.18	2.88
21		2.58	0.14	2.72
24		2.44	0.12	2.56
105	7.85	1.03	0.32	1.35
120	7.12	1.12	0.42	1.54
135	6.54	1.74	0.48	2.22
150	6.1	1.96	0.52	2.48
165	5.55	2.35	0.60	2.95
180	5.06	2.76	0.44	3.20
195	4.31	3.30	0.64	3.94
330	0.975	8.01	0.52	8.53

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L
3	5.12	2.40	0.260	2.66
6		1.80	0.420	2.22
9		1.17	0.360	1.53
12		1.04	0.240	1.28
15		0.87	0.140	1.01
18		0.74	0.100	0.84
21		0.61	0.060	0.67
24		0.51	0.060	0.57
105	7.67	0.33	0.260	0.59
120	7.09	0.55	0.420	0.97
135	6.45	1.01	0.500	1.51
150	5.76	1.32	0.540	1.86
165	5.26	1.70	0.620	2.32
180	4.57	2.21	0.600	2.81
195	4.02	2.76	0.660	3.42
330	0.533	6.84	0.428	7.27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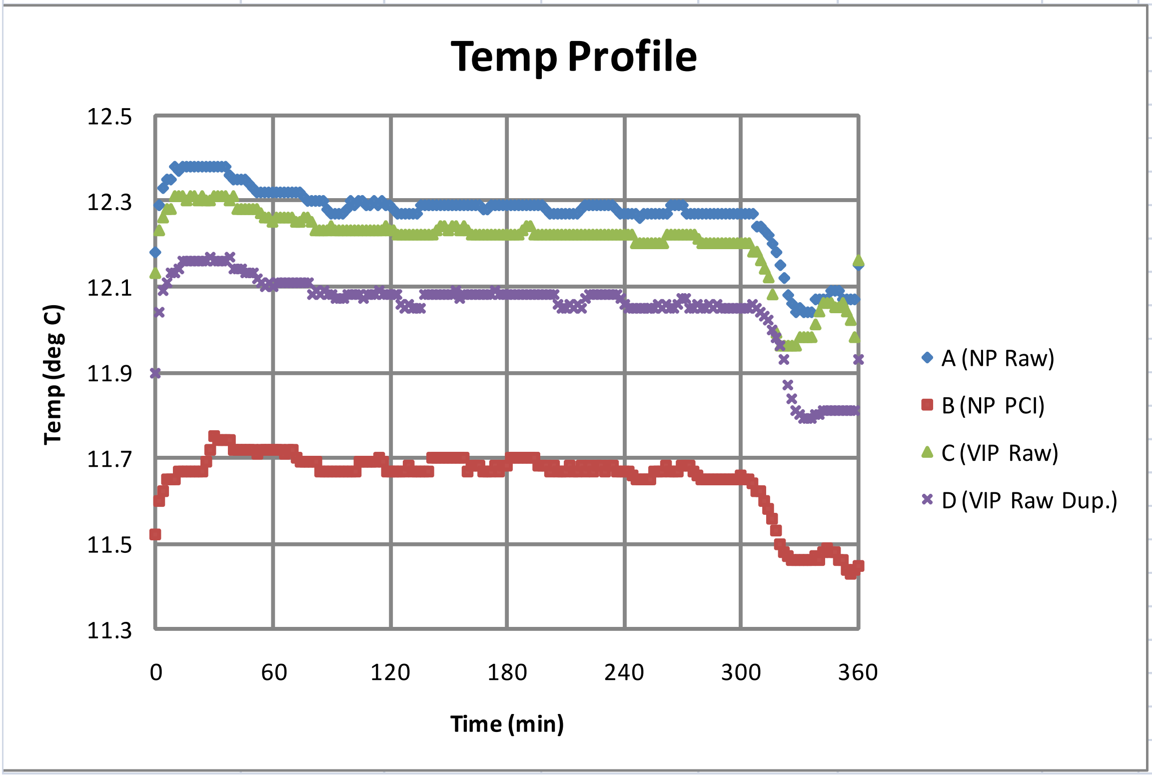
7.20
7.10
7.00
6.90
6.80
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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12.3
12.1
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11.5
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Temp (deg C)
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300
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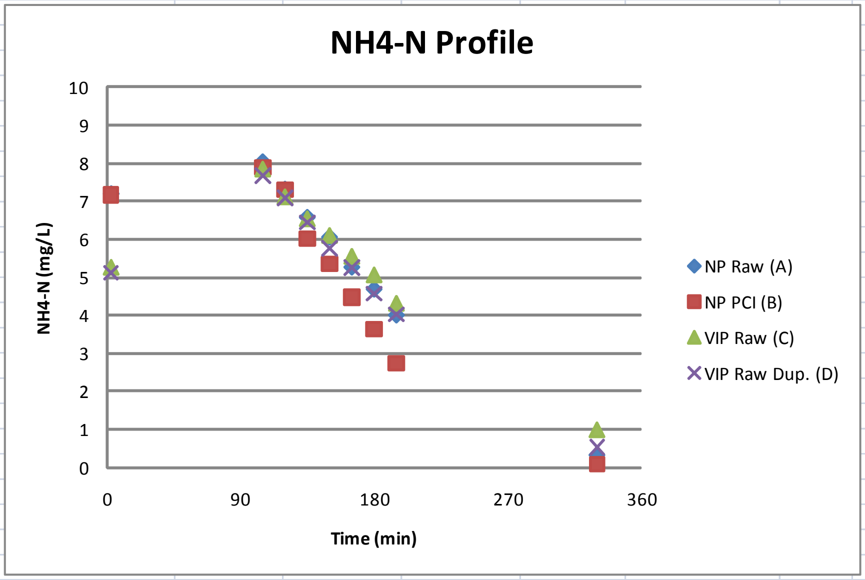
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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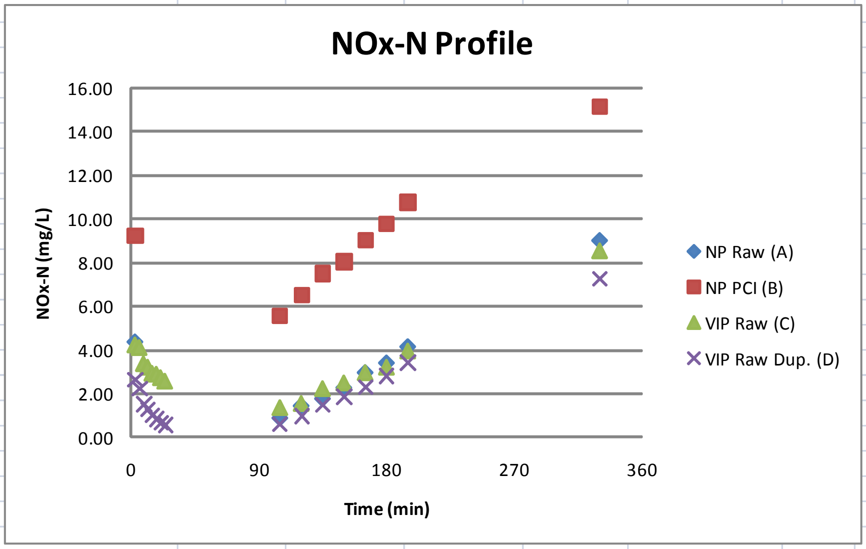
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)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NOx-N (mg/L)
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14.00
12.00
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8.00
6.00
4.00
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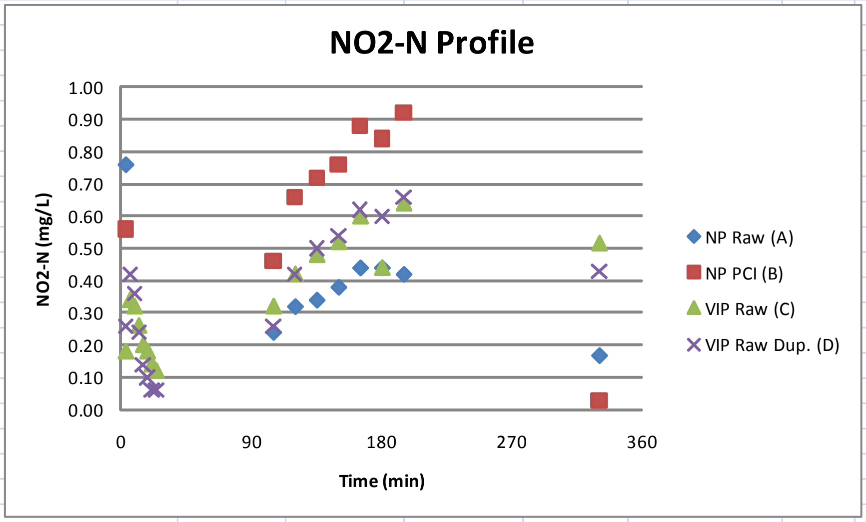
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
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0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)

12-Nov-11

Feed							
	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	29.5	176	92%	161.92	554	52.1	5.4
B (NP PCI)	32.4	31	97%	30.07	423	49.4	8.7
C (VIP Raw)	20.15	318	86%	273.48	699	41.2	2.11
D (Vip Raw Dup.)	20.5	116	91%	105.56	446	34.5	2.5

Mixed Liquor			
	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2380	89%	2118.2
B (NP PCI)	1700	91%	1547.0
C (VIP Raw)	1400	91%	1274.0
D (Vip Raw Dup.)	1660	90%	1494.0

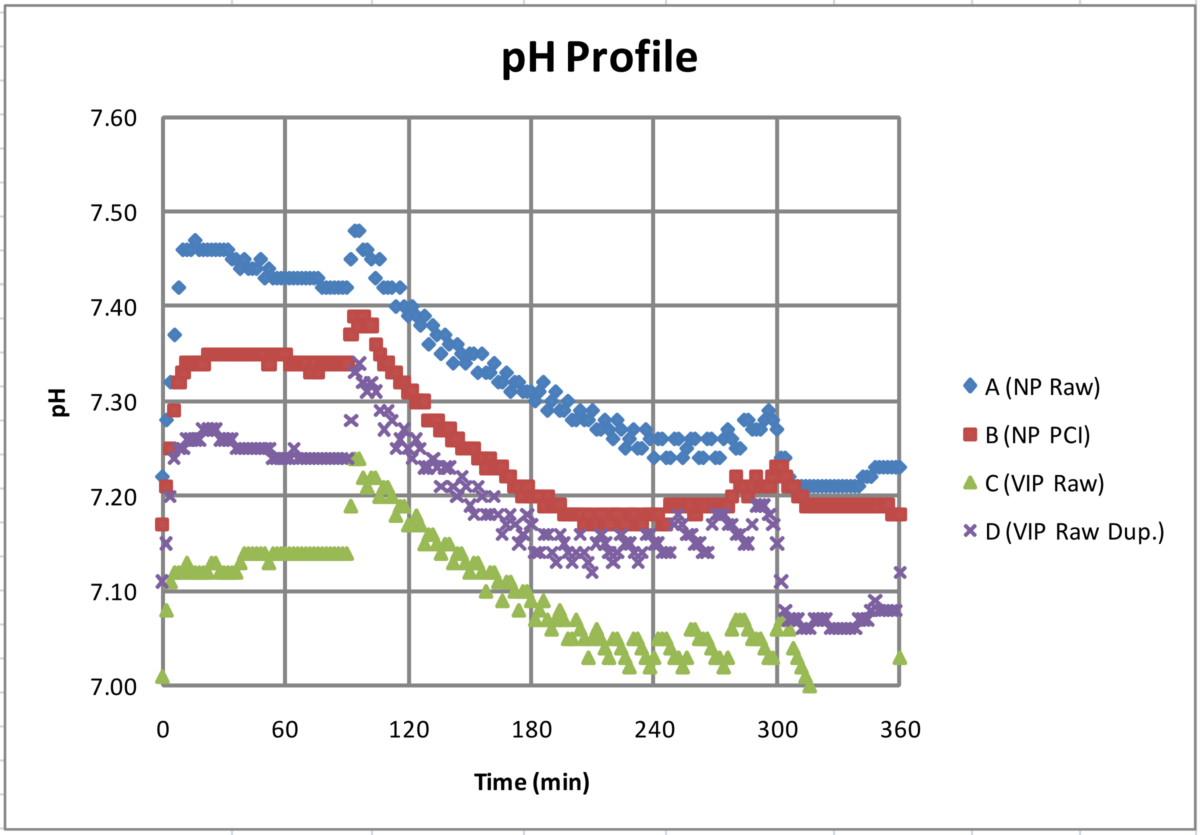
Effluent (1330)					
	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)				15	
B (NP PCI)				7	
C (VIP Raw)				6	
D (Vip Raw Dup.)				4	

Settled Sludge Volume (mL/L)		
	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	-0.81	0.45	9.58	-0.55
MLVSS (g/L)	2.12	1.55	1.27	1.49
SOUR (mg O_2/g MLVSS*hr)	-0.38	0.29	7.52	-0.37

Avg. Temp. (° C)	
A (NP Raw)	12.37
B (NP PCI)	11.70
C (VIP Raw)	12.28
D (Vip Raw Dup.)	12.11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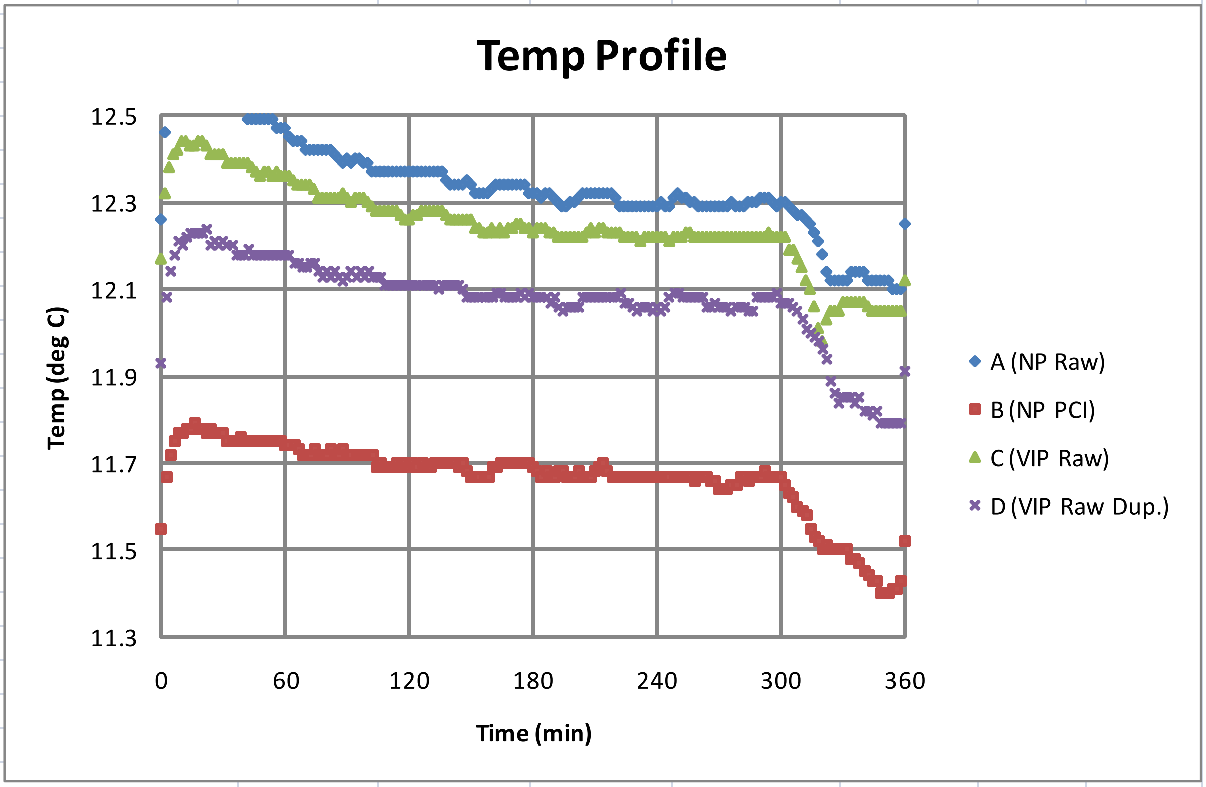
7.20
7.10
7.00
pH
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	7.26	3.40	0.72	4.12
6				
9				
12				
15				
18				
105	7.68	0.76	0.30	1.06
120	6.95	1.05	0.40	1.45
135	6.4	1.28	0.36	1.64
150	5.7	1.85	0.42	2.27
165	5	2.39	0.46	2.85
180	4.43	2.93	0.46	3.39
195	3.7	3.60	0.50	4.10
330	0.079	8.41	0.06	8.47

NP PCI (B)

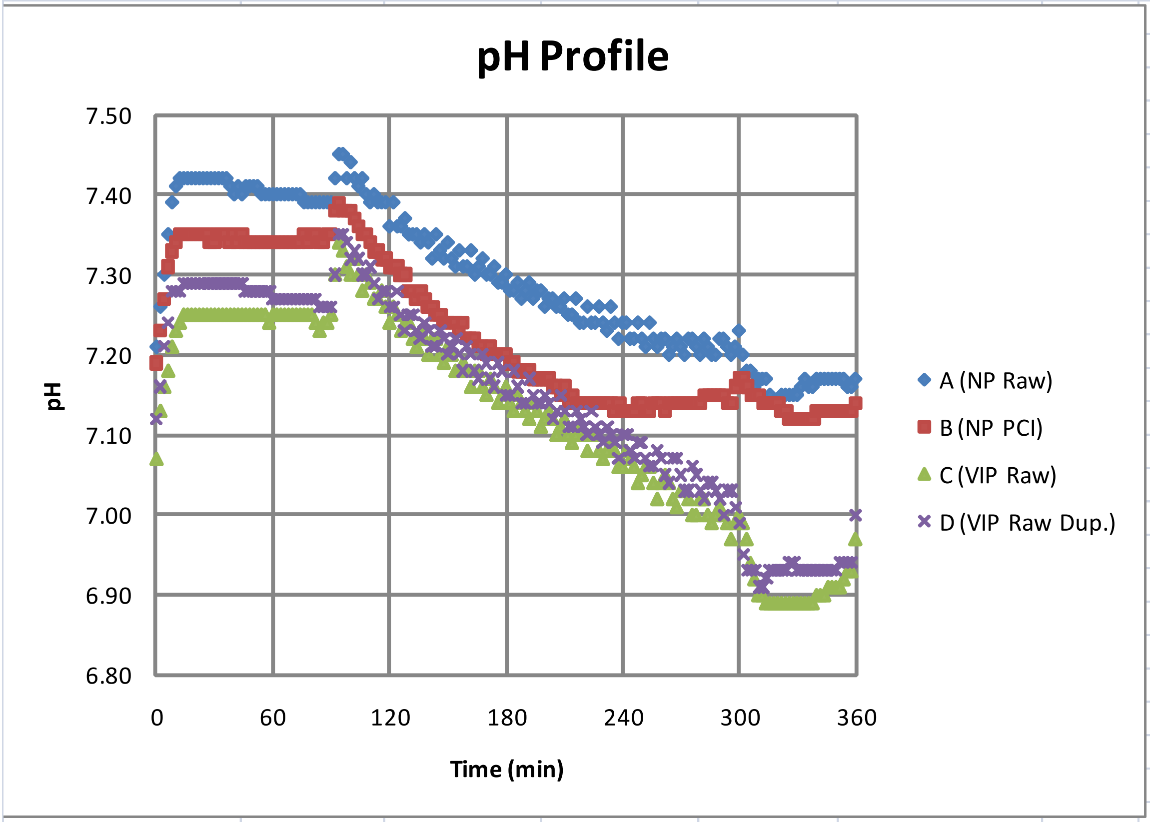
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	7.4	8.32	0.54	8.86
6				
9				
12				
15				
18				
105	7.82	4.95	0.46	5.41
120	6.81	5.58	0.62	6.20
135	5.8	6.15	0.68	6.83
150	5.05	7.30	0.70	8.00
165	4.16	7.88	0.76	8.64
180	3.29	8.47	0.76	9.23
195	2.47	9.54	0.84	10.38
330	0.022	15.50	0.01	15.51

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L
3	5.48	3.42	0.20	3.62
6		3.14	0.38	3.52
9		2.66	0.42	3.08
12		2.26	0.44	2.70
15		2.20	0.30	2.50
18		2.02	0.26	2.28
105	8.81	0.46	0.28	0.74
120	8.11	0.64	0.40	1.04
135	7.62	0.75	0.42	1.17
150	7.03	1.11	0.46	1.57
165	6.45	1.71	0.50	2.21
180	5.91	1.99	0.54	2.53
195	5.3	2.33	0.58	2.91
330	1.2	7.57	0.28	7.85

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L
3	5.43	2.80	0.220	3.02
6		2.18	0.500	2.68
9		1.61	0.560	2.17
12		1.38	0.400	1.78
15		1.16	0.320	1.48
18		1.00	0.220	1.22
105	8.47	0.34	0.300	0.64
120	7.81	0.47	0.440	0.91
135	7.17	0.80	0.600	1.40
150	6.63	1.09	0.540	1.63
165	5.99	1.75	0.580	2.33
180	5.36	1.98	0.600	2.58
195	4.83	2.32	0.660	2.98
330	0.745	7.75	0.254	8.00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6.90
6.80
pH
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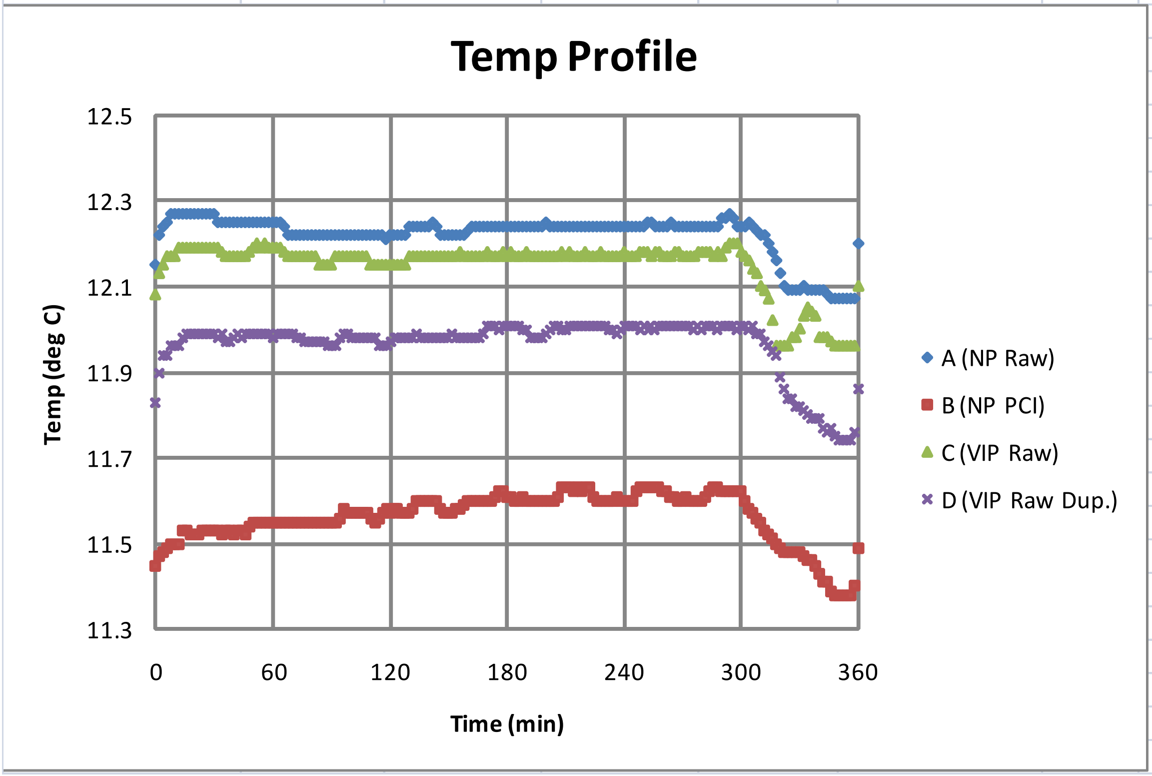
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
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12.1
11.9
11.7
11.5
11.3
Temp (deg C)
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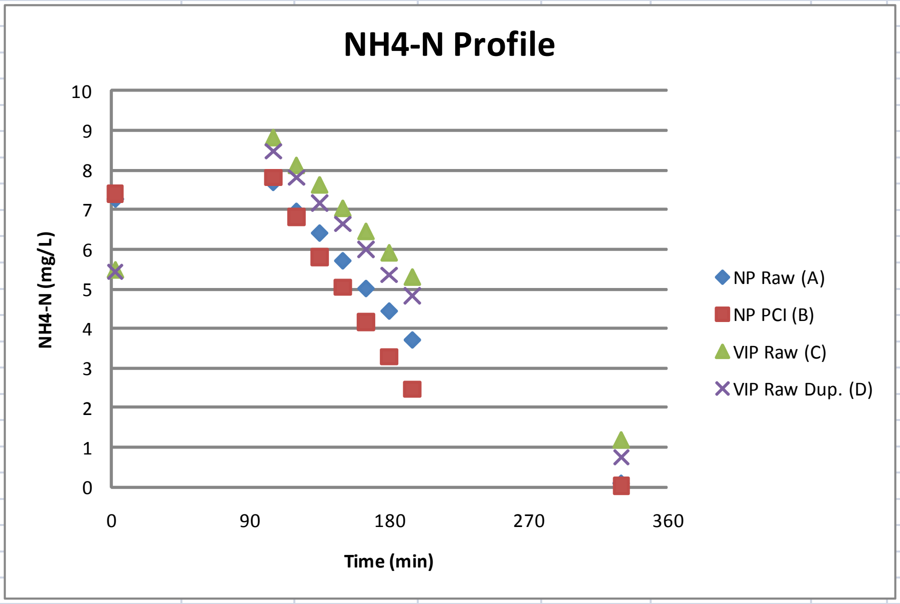
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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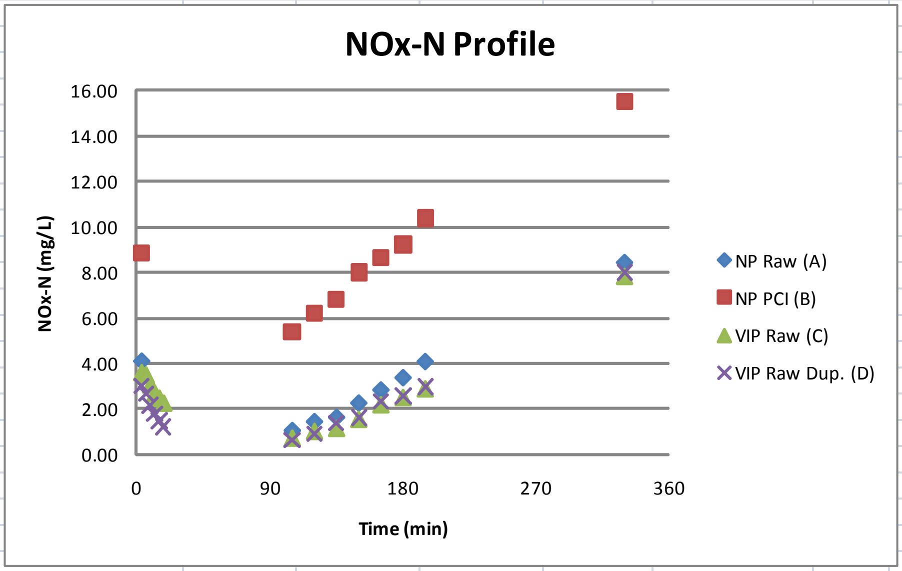
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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NOx-N (mg/L)
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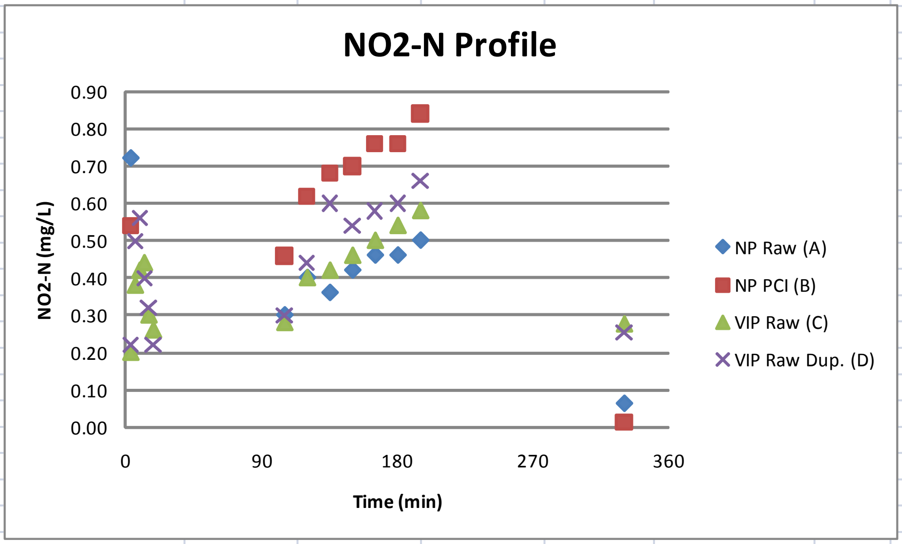
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


NO2-N Profile
NO2-N (mg/L)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)

17-Jan-11

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L	OP mg/L P
A (NP Raw)	31.4	166	88%	146.08	448	46.6	4.6
B (NP PCI)	32	60	90%	54	278	48.6	7.8
C (VIP Raw)	21.25	208	90%	187.2	493	38.4	2.3
D (Vip Raw Dup.)	22.45	114	89%	101.46	402	35.8	2.6

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2260	88%	1988.8
B (NP PCI)	1860	87%	1618.2
C (VIP Raw)	1300	88%	1144.0
D (Vip Raw Dup.)	1960	87%	1705.2

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)				21	
B (NP PCI)				6	
C (VIP Raw)				9	
D (Vip Raw Dup.)				8	

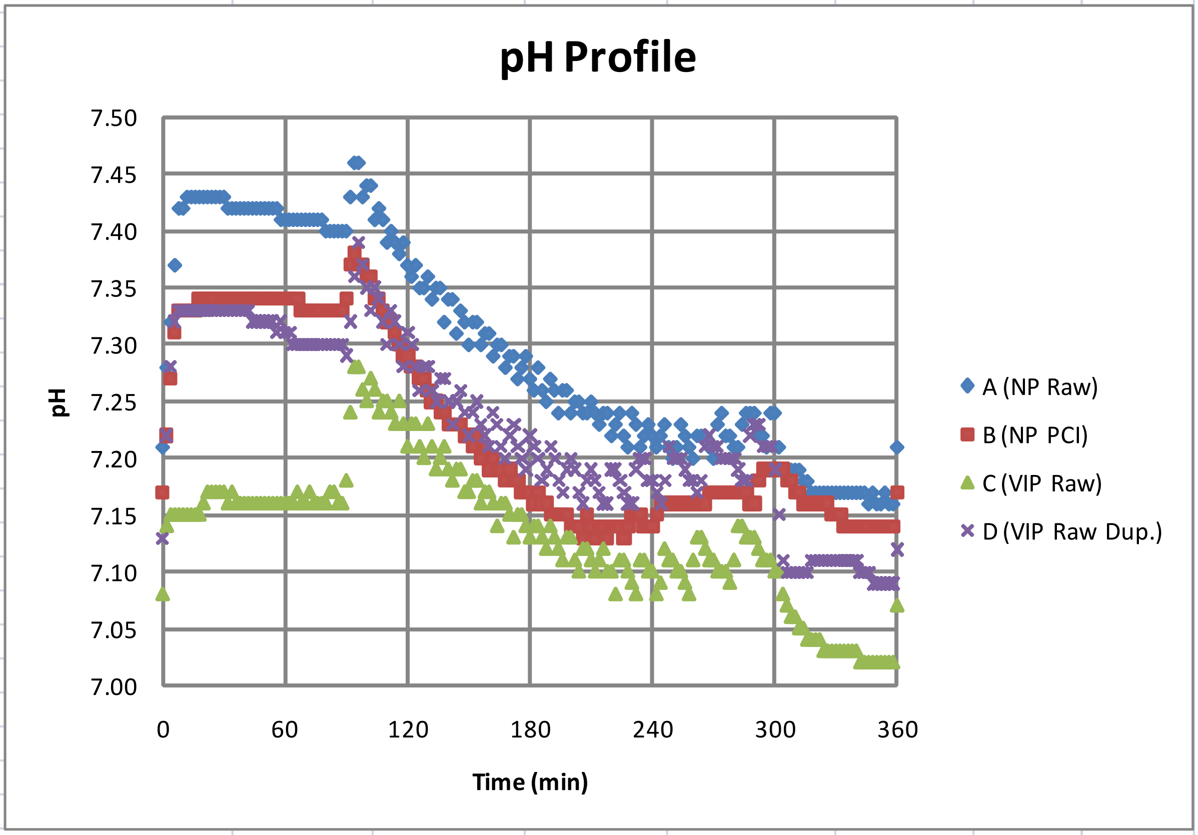
Settled Sludge Volume (mL/L)

	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	16.43	14.23	10.97	0.80
MLVSS (g/L)	1.99	1.62	1.14	1.71
SOUR (mg O_2/g MLVSS*hr)	8.26	8.79	9.59	0.47

Avg. Temp. (° C)	
A (NP Raw)	12.38
B (NP PCI)	11.72
C (VIP Raw)	12.25
D (Vip Raw Dup.)	12.18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7.10
7.05
7.00
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60
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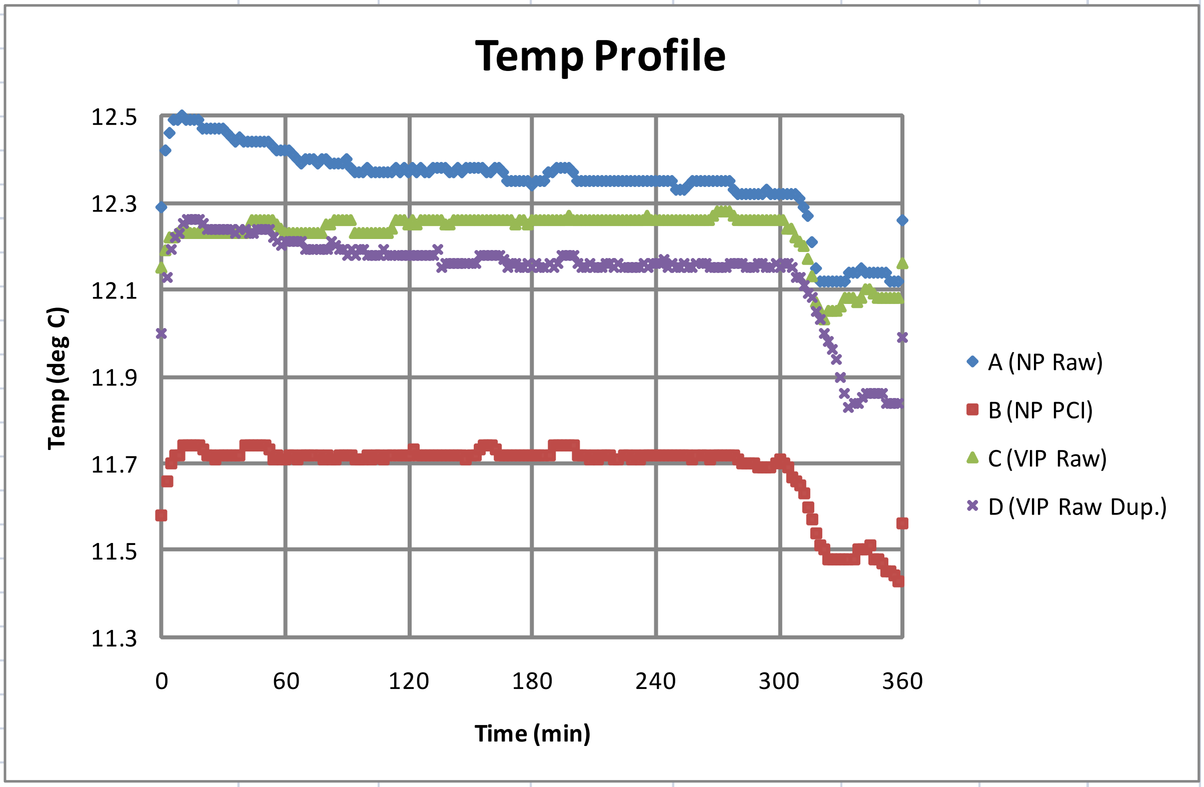
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)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11.5
11.3
Temp (deg C)
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60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (VIP Raw Dup.)

18-Jan-11

NP Raw (A)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.64	3.88	0.41	4.29	4.9
6					
9					
12					
15					
18					
105	8.01	0.82	0.19	1.01	4.7
120	7.34	1.42	0.24	1.66	
135	6.36	2.11	0.28	2.39	
150	5.62	2.80	0.31	3.11	4.7
165	4.81	3.50	0.33	3.83	
180	4.09	4.34	0.35	4.69	
195	3.37	4.86	0.34	5.20	4.2
330	0.118	8.35	0.22	8.57	4.2

NP PCI (B)

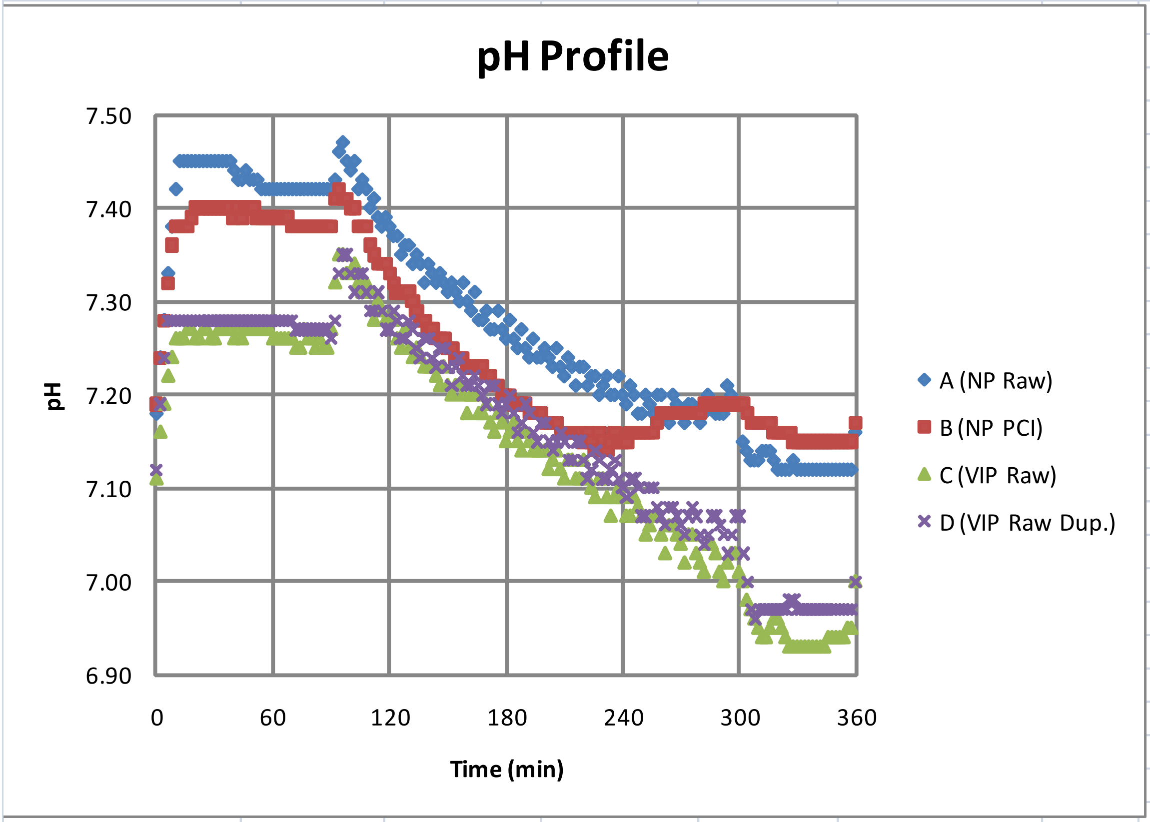
Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	7.96	10.76	0.29	11.05	8.5
6					
9					
12					
15					
18					
105	8.72	7.26	0.27	7.53	8.6
120	6.58	8.09	0.47	8.56	
135	5.54	8.62	0.46	9.08	
150	4.66	9.58	0.50	10.08	8.4
165	3.67	10.60	0.52	11.12	
180	2.79	11.30	0.51	11.81	
195	1.9	12.20	0.49	12.69	8
330	0.104	15.20	0.19	15.39	7.7

VIP Raw (C)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	NOx-N mg/L	OP mg/L P
3	5.51	3.58	0.09	3.67	5.3
6		3.10	0.21	3.31	
9		2.62	0.22	2.84	
12		2.42	0.19	2.61	
15		2.18	0.16	2.34	
18		2.08	0.15	2.23	
105	8.55	0.54	0.15	0.69	14.9
120	6.89	1.04	0.19	1.23	
135	6.32	1.57	0.24	1.81	
150	5.82	2.09	0.28	2.37	2.3
165	5.23	2.65	0.28	2.93	
180	4.62	3.18	0.30	3.48	
195	4.27	3.67	0.30	3.97	2.8
330	0.46	7.27	0.17	7.44	2.4

VIP Raw Dup. (D)

Time	NH3-N mg/L	NO3-N mg/L	NO2-N	NOx-N mg/L	OP mg/L P
3	5.35	2.98	0.140	3.12	25.2
6		2.32	0.300	2.62	
9		1.97	0.280	2.25	
12		1.67	0.220	1.89	
15		1.49	0.180	1.67	
18		1.43	0.170	1.60	
105	8.51	0.51	0.140	0.65	34.7
120	6.82	1.00	0.220	1.22	
135	6.23	1.53	0.270	1.80	
150	5.64	2.10	0.310	2.41	2.4
165	4.95	2.62	0.310	2.93	
180	4.38	3.24	0.330	3.57	
195	3.79	3.73	0.330	4.06	2.2
330	0.23	7.35	0.121	7.47	2.2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7.10
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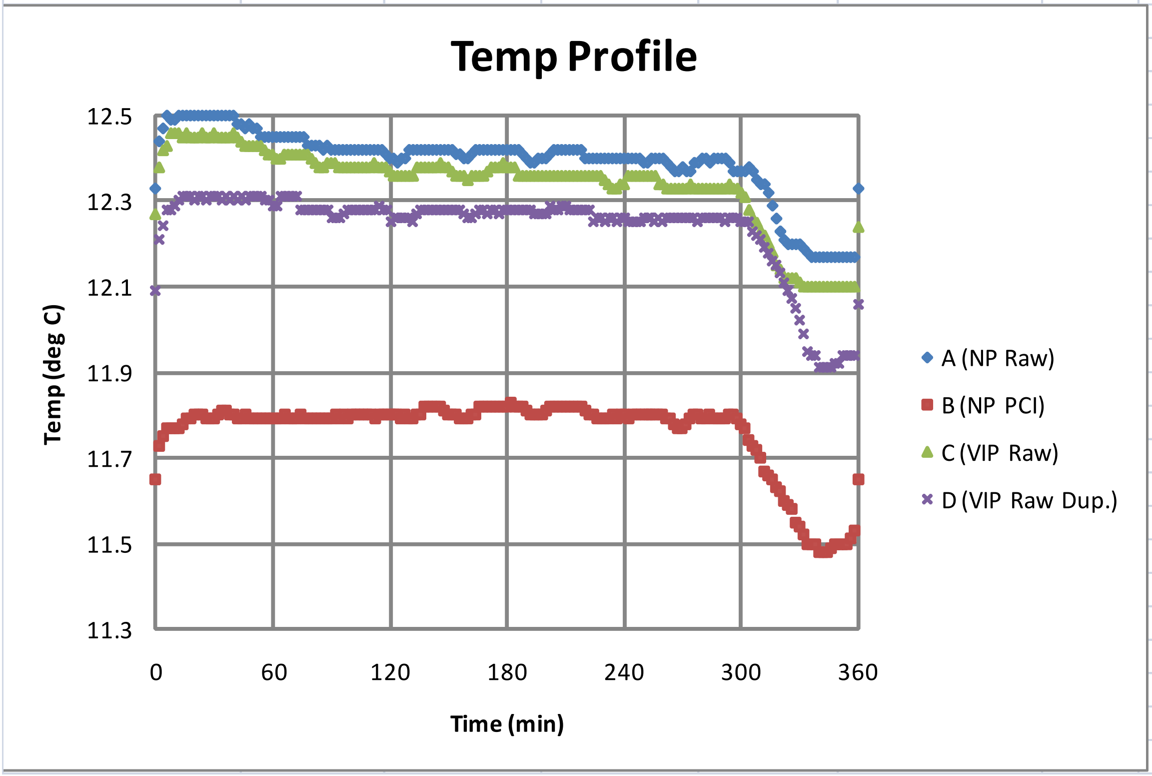
6.90
pH
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)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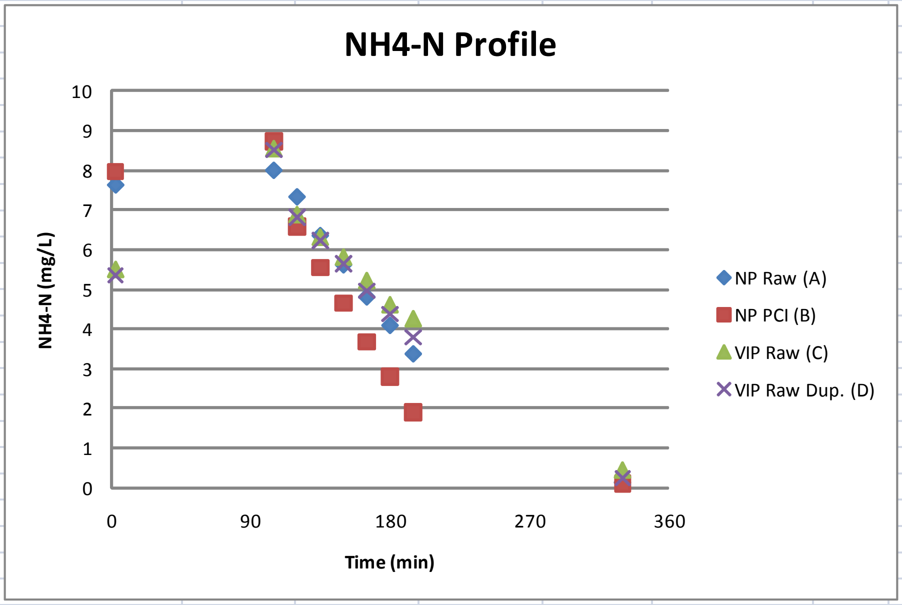
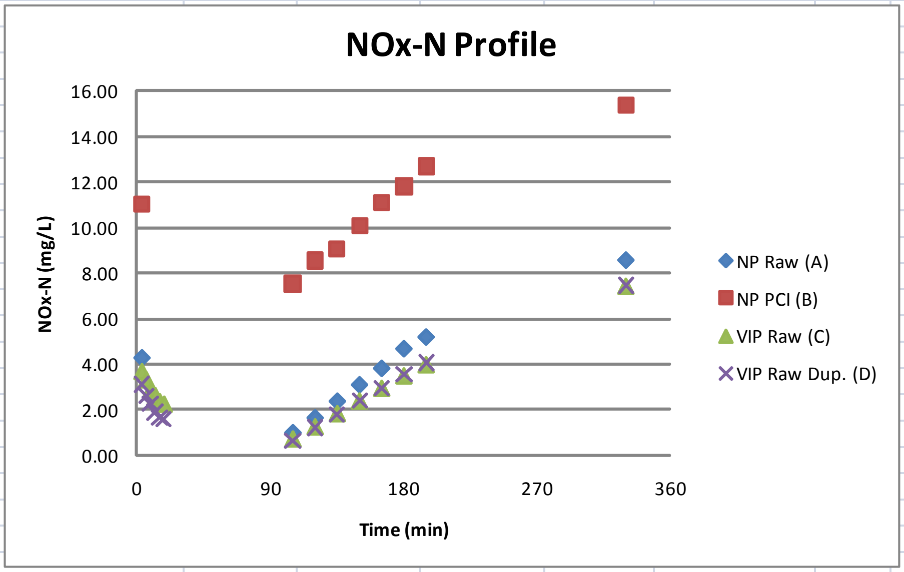
12.1
11.9
11.7
11.5
11.3
Temp (deg C)
0
60
120
180
240
300
360
Time (min)
◆ A (NP Raw)
■ B (NP PCl)
▲ C (VIP Raw)
× D (VIP Raw Dup.)


NH4-N Profile
NH4-N (mg/L)
10
9
8
7
6
5
4
3
2
1
0
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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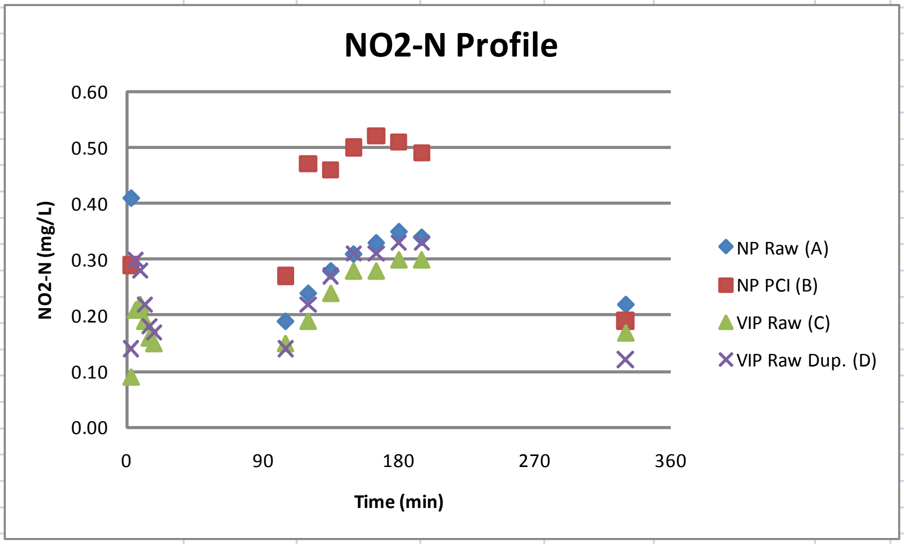
NOx-N (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)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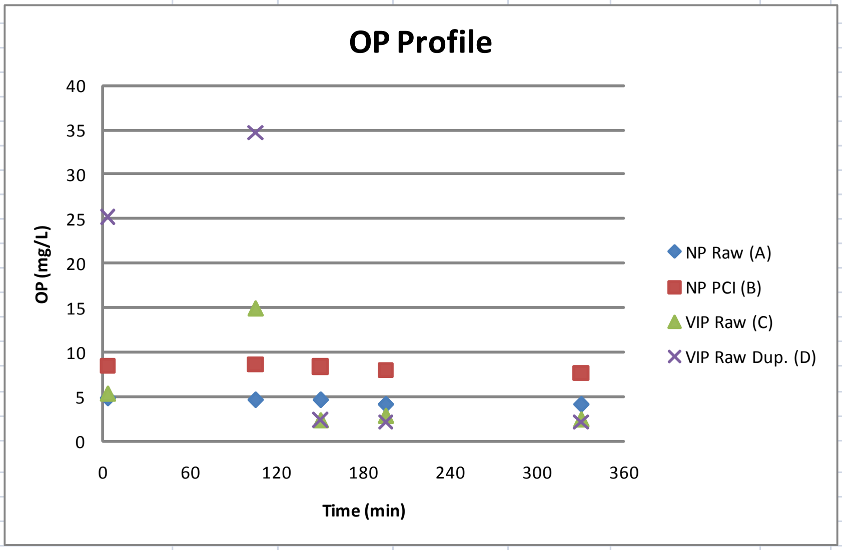
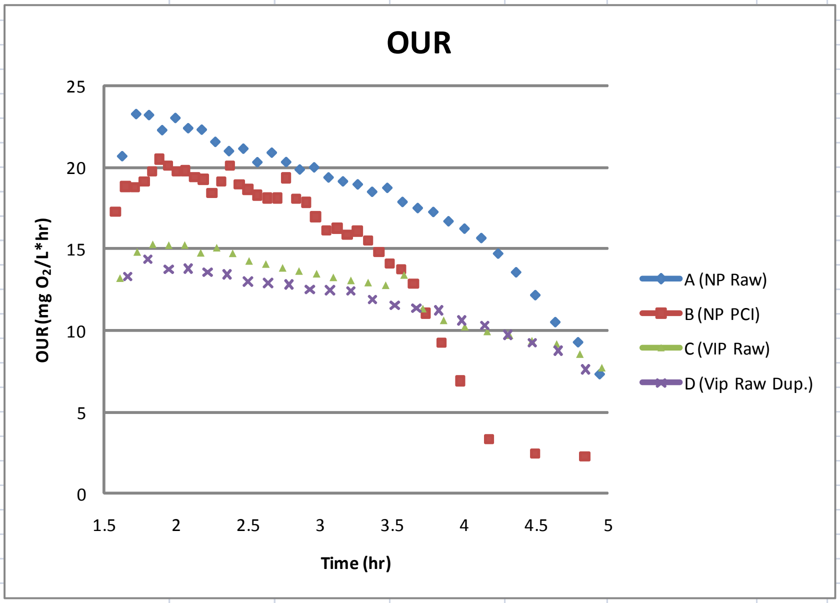
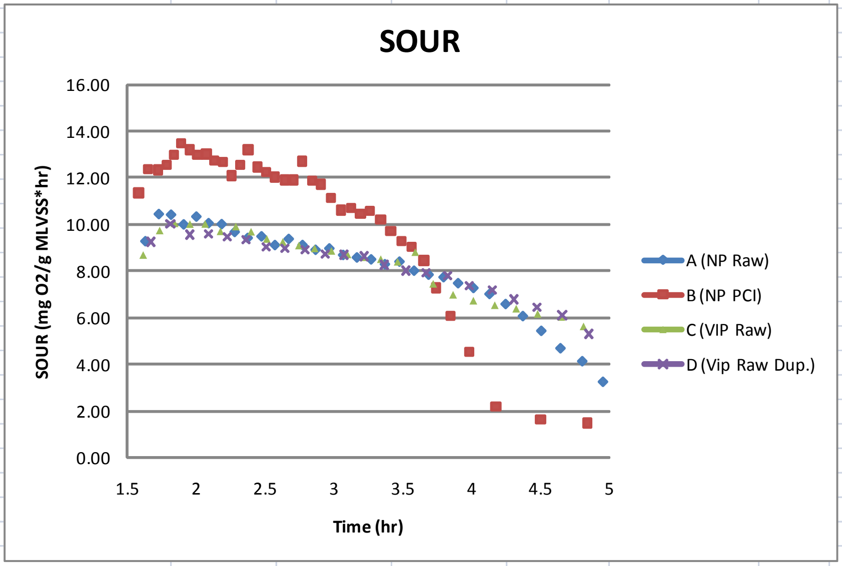
NO2-N (mg/L)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
90
180
270
360
Time (min)
◆ NP Raw (A)
■ NP PCI (B)
▲ VIP Raw (C)
× VIP Raw Dup. (D)


OP Profile
OP (mg/L)
40
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
Time (min)
NP Raw (A)
NP PCI (B)
VIP Raw (C)
VIP Raw Dup. (D)


OUR
OUR (mg O_2/L*hr)
25
20
15
10
5
0
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)


SOUR
SOUR (mg O2/g MLVSS*hr)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.5
2
2.5
3
3.5
4
4.5
5
Time (hr)
A (NP Raw)
B (NP PCI)
C (VIP Raw)
D (Vip Raw Dup.)

19-Jan-11

Feed

	NH3-N mg/L	TSS mg/L	Voltl. Frac. %	VSS mg/L	COD mg/L	TKN mg/L
A (NP Raw)	33.4	170	95%	161.5	550	51.8
B (NP PCI)	32.55	37	97%	35.89	331	47.8
C (VIP Raw)	21	67	96%	64.32	343	32.4
D (Vip Raw Dup.)	22.4	47	93%	43.71	337	32

Mixed Liquor

	MLSS mg/L	Voltl. Frac. %	MLVSS mg/L
A (NP Raw)	2060	94%	1936.4
B (NP PCI)	1500	93%	1395.0
C (VIP Raw)	1540	96%	1478.4
D (Vip Raw Dup.)	1500	93%	1395.0

Effluent (1330)

	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TSS mg/L	Turb. NTU
A (NP Raw)				23	
B (NP PCI)				6	
C (VIP Raw)				9	
D (Vip Raw Dup.)				7	

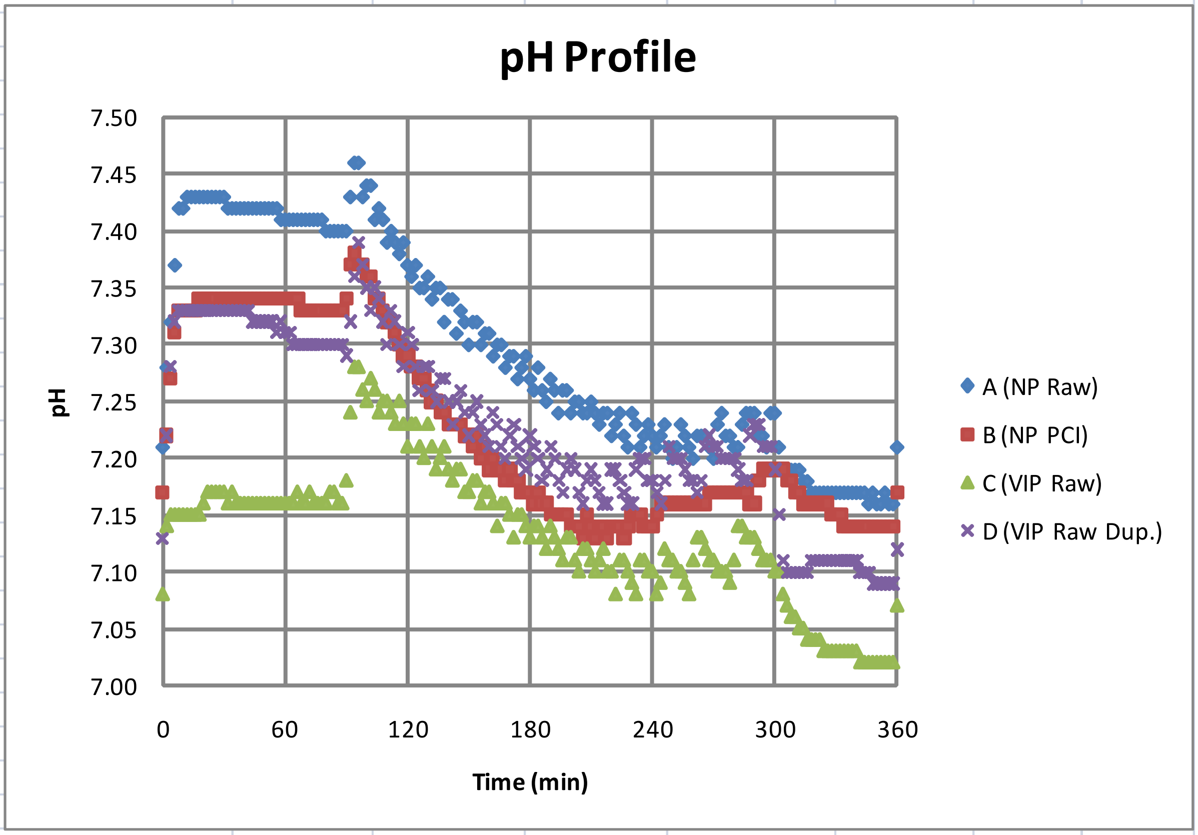
Settled Sludge Volume (mL/L)

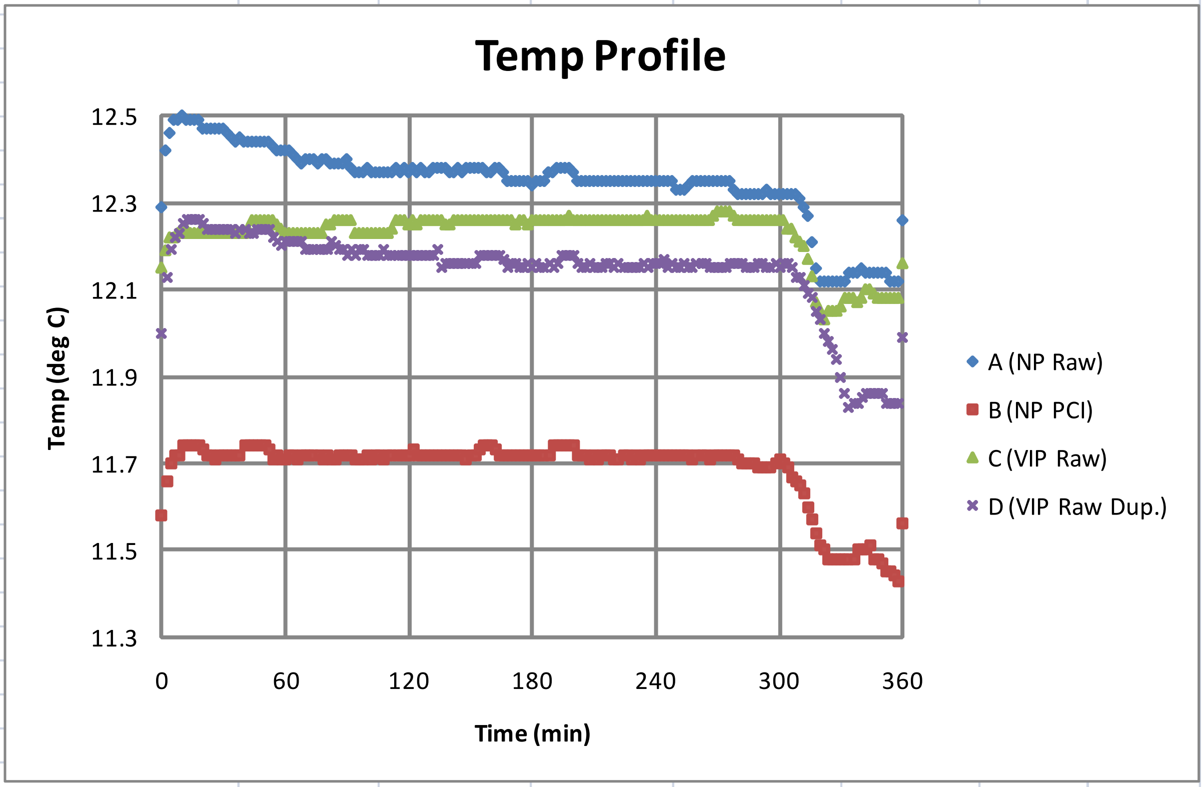
	5 min	30 min
A (NP Raw)		
B (NP PCI)		
C (VIP Raw)		
D (Vip Raw Dup.)		

SVI (mL/g)
0.0
0.0
0.0
0.0

	A	B	C	D
OUR (mg O_2/L*hr)	16.43	14.23	10.97	0.80
MLVSS (g/L)	1.94	1.40	1.48	1.40
SOUR (mg O_2/g MLVSS*hr)	8.49	10.20	7.42	0.57

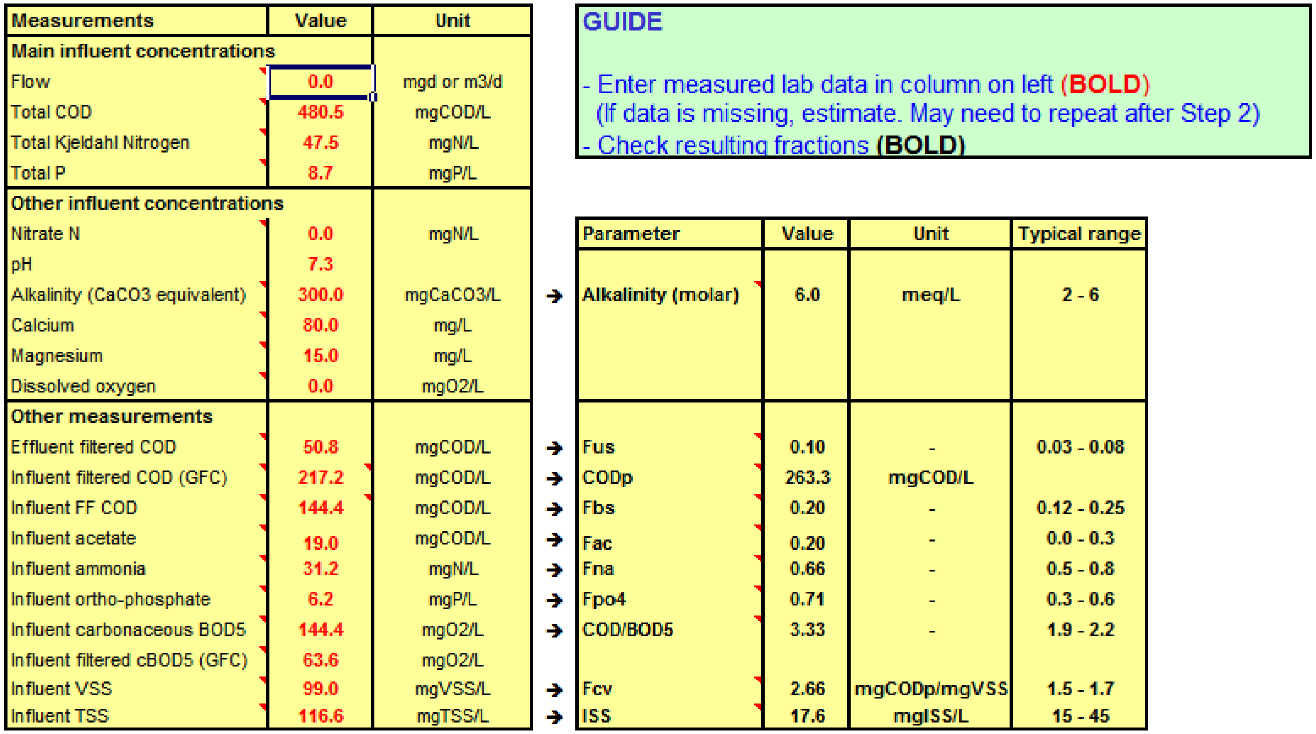
Avg. Temp. (° C)	
A (NP Raw)	12.38
B (NP PCI)	11.72
C (VIP Raw)	12.25
D (Vip Raw Dup.)	12.18


pH Profile
pH
7.50
7.45
7.40
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)


Temp Profile
Temp (deg C)
12.5
12.3
12.1
11.9
11.7
11.5
11.3
0
60
120
180
240
300
360
Time (min)
A (NP Raw)
B (NP PCl)
C (VIP Raw)
D (VIP Raw Dup.)

7.2 Appendix B – Biowin Simulation Input and Wastewater Fractionation

Reactor A – Nansemond RWI

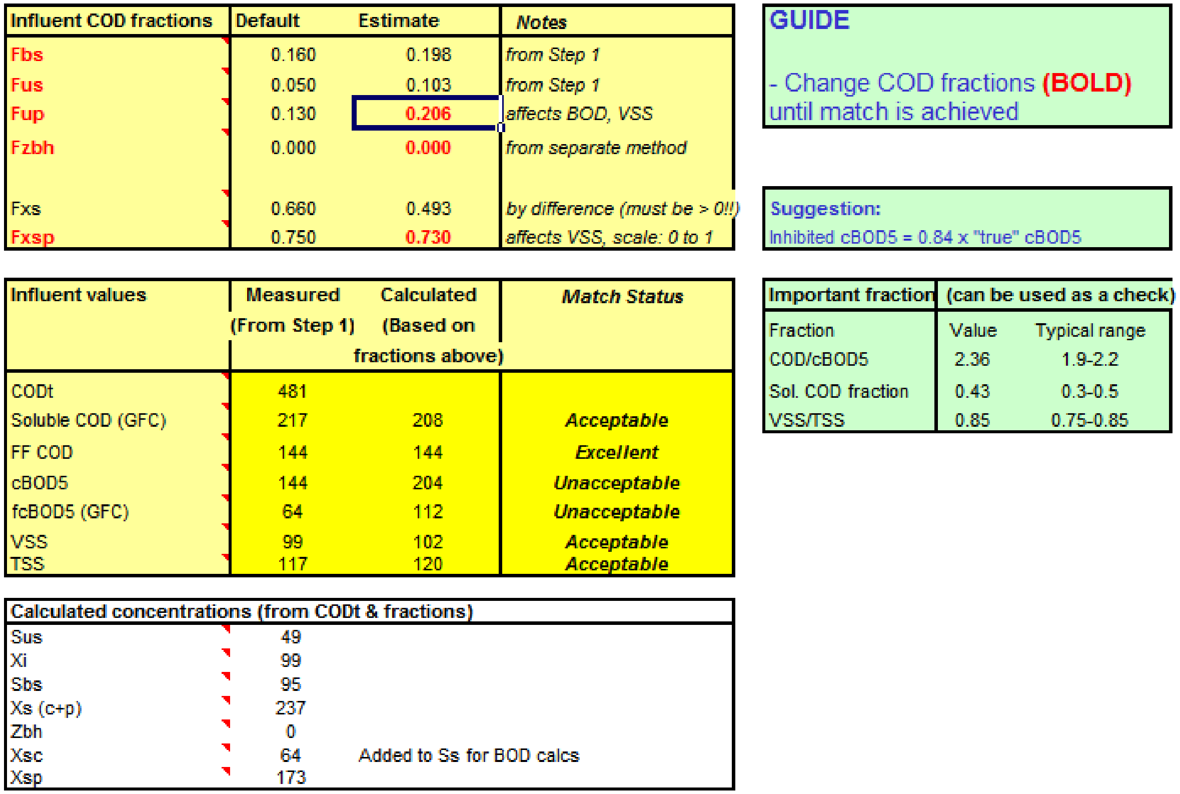


Measurements	Value	Unit
Main influent concentrations		
Flow	0.0	mgd or m3/d
Total COD	480.5	mgCOD/L
Total Kjeldahl Nitrogen	47.5	mgN/L
Total P	8.7	mgP/L
Other influent concentrations		
Nitrate N	0.0	mgN/L
pH	7.3	
Alkalinity (CaCO3 equivalent)	300.0	mgCaCO3/L
Calcium	80.0	mg/L
Magnesium	15.0	mg/L
Dissolved oxygen	0.0	mgO2/L
Other measurements		
Effluent filtered COD	50.8	mgCOD/L
Influent filtered COD (GFC)	217.2	mgCOD/L
Influent FF COD	144.4	mgCOD/L
Influent acetate	19.0	mgCOD/L
Influent ammonia	31.2	mgN/L
Influent ortho-phosphate	6.2	mgP/L
Influent carbonaceous BOD5	144.4	mgO2/L
Influent filtered cBOD5 (GFC)	63.6	mgO2/L
Influent VSS	99.0	mgVSS/L
Influent TSS	116.6	mgTSS/L

GUIDE

- Enter measured lab data in column on left (**BOLD**)
(If data is missing, estimate. May need to repeat after Step 2)
- Check resulting fractions **(BOLD)**

	Parameter	Value	Unit	Typical range
→	**Alkalinity (molar)**	**6.0**	**meq/L**	**2 - 6**
→	**Fus**	**0.10**	-	**0.03 - 0.08**
→	**CODp**	**263.3**	**mgCOD/L**	
→	**Fbs**	**0.20**	-	**0.12 - 0.25**
→	**Fac**	**0.20**	-	**0.0 - 0.3**
→	**Fna**	**0.66**	-	**0.5 - 0.8**
→	**Fpo4**	**0.71**	-	**0.3 - 0.6**
→	**COD/BOD5**	**3.33**	-	**1.9 - 2.2**
→	**Fcv**	**2.66**	**mgCODp/mgVSS**	**1.5 - 1.7**
→	**ISS**	**17.6**	**mgISS/L**	**15 - 45**



Influent COD fractions	Default	Estimate	*Notes*
Fbs	0.160	0.198	*from Step 1*
Fus	0.050	0.103	*from Step 1*
Fup	0.130	**0.206**	*affects BOD, VSS*
Fzbh	0.000	**0.000**	*from separate method*
Fxs	0.660	0.493	*by difference (must be > 0!!)*
Fxsp	0.750	**0.730**	*affects VSS, scale: 0 to 1*

GUIDE

- Change COD fractions **(BOLD)** until match is achieved

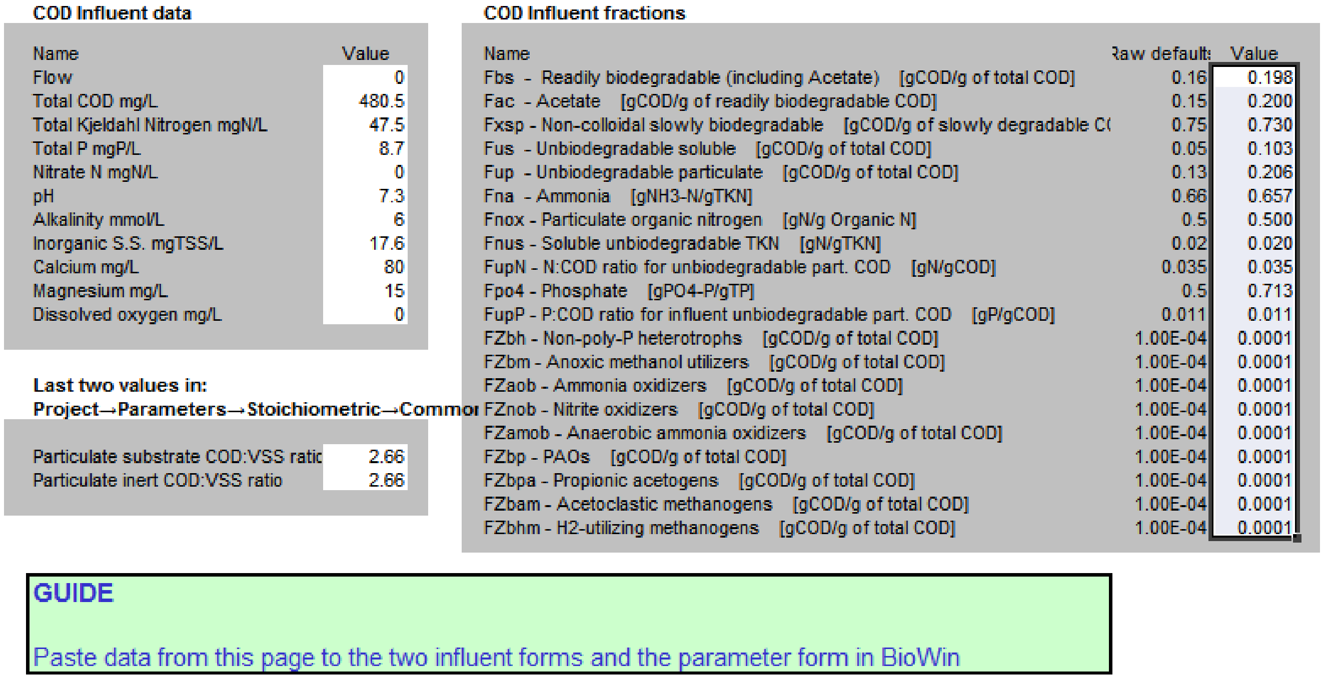
Suggestion:

Inhibited cBOD5 = 0.84 x "true" cBOD5

Influent values	Measured (From Step 1)	Calculated (Based on fractions above)	*Match Status*
CODt	481		
Soluble COD (GFC)	217	208	***Acceptable***
FF COD	144	144	***Excellent***
cBOD5	144	204	***Unacceptable***
fcBOD5 (GFC)	64	112	***Unacceptable***
VSS	99	102	***Acceptable***
TSS	117	120	***Acceptable***

Important fraction	(can be used as a check)	
Fraction	Value	Typical range
COD/cBOD5	2.36	1.9-2.2
Sol. COD fraction	0.43	0.3-0.5
VSS/TSS	0.85	0.75-0.85

Calculated concentrations (from CODt & fractions)		
Sus	49	
Xi	99	
Sbs	95	
Xs (c+p)	237	
Zbh	0	
Xsc	64	Added to Ss for BOD calcs
Xsp	173	



COD Influent data

Name	Value
Flow	0
Total COD mg/L	480.5
Total Kjeldahl Nitrogen mgN/L	47.5
Total P mgP/L	8.7
Nitrate N mgN/L	0
pH	7.3
Alkalinity mmol/L	6
Inorganic S.S. mgTSS/L	17.6
Calcium mg/L	80
Magnesium mg/L	15
Dissolved oxygen mg/L	0

Last two values in:
Project→Parameters→Stoichiometric→Commor

Particulate substrate COD:VSS ratic	2.66
Particulate inert COD:VSS ratio	2.66

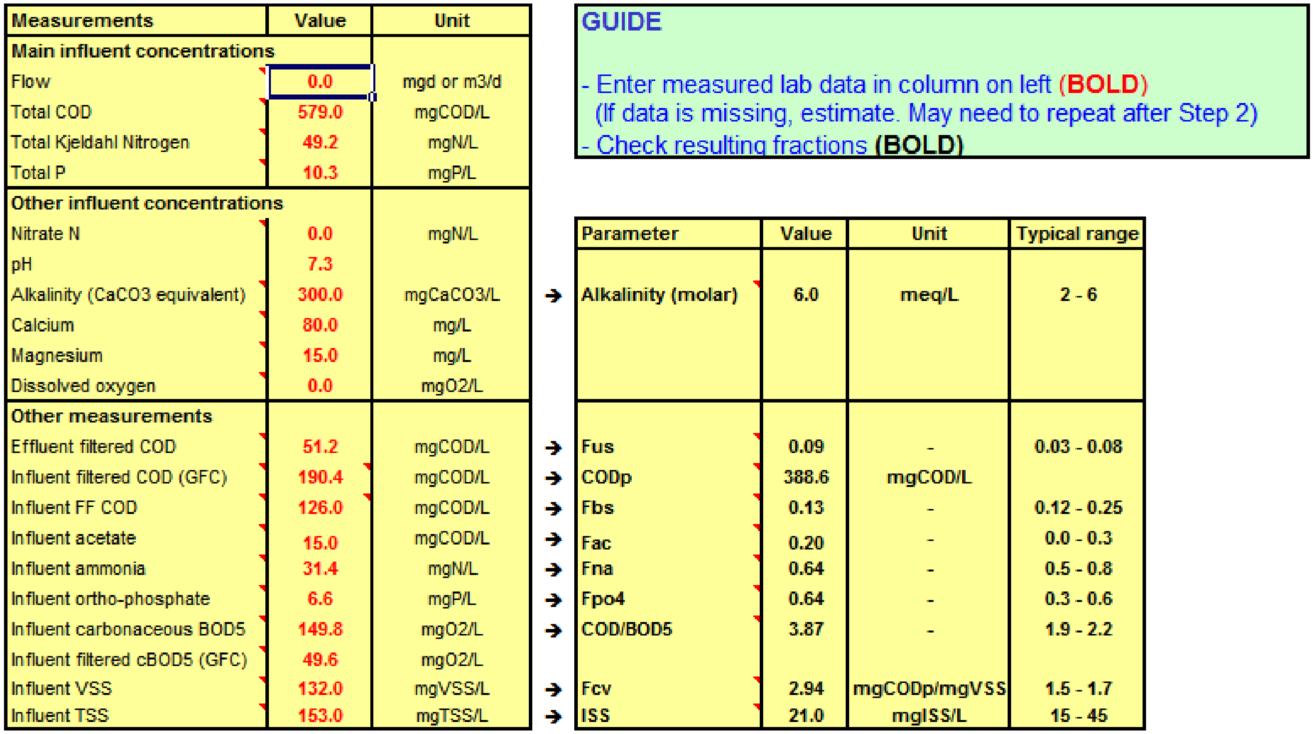
COD Influent fractions

Name	Raw default	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.16	0.198
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.15	0.200
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C(	0.75	0.730
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.05	0.103
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.13	0.206
Fna - Ammonia [gNH3-N/gTKN]	0.66	0.657
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5	0.500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.02	0.020
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.035	0.035
Fpo4 - Phosphate [gPO4-P/gTP]	0.5	0.713
FupP - P:COD ratio for influent unbiodegradable part. COD [gP/gCOD]	0.011	0.011
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.00E-04	0.0001
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.00E-04	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZbp - PAOs [gCOD/g of total COD]	1.00E-04	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	1.00E-04	0.0001

GUIDE

Paste data from this page to the two influent forms and the parameter form in BioWin

Reactor B – Nansemond PCI

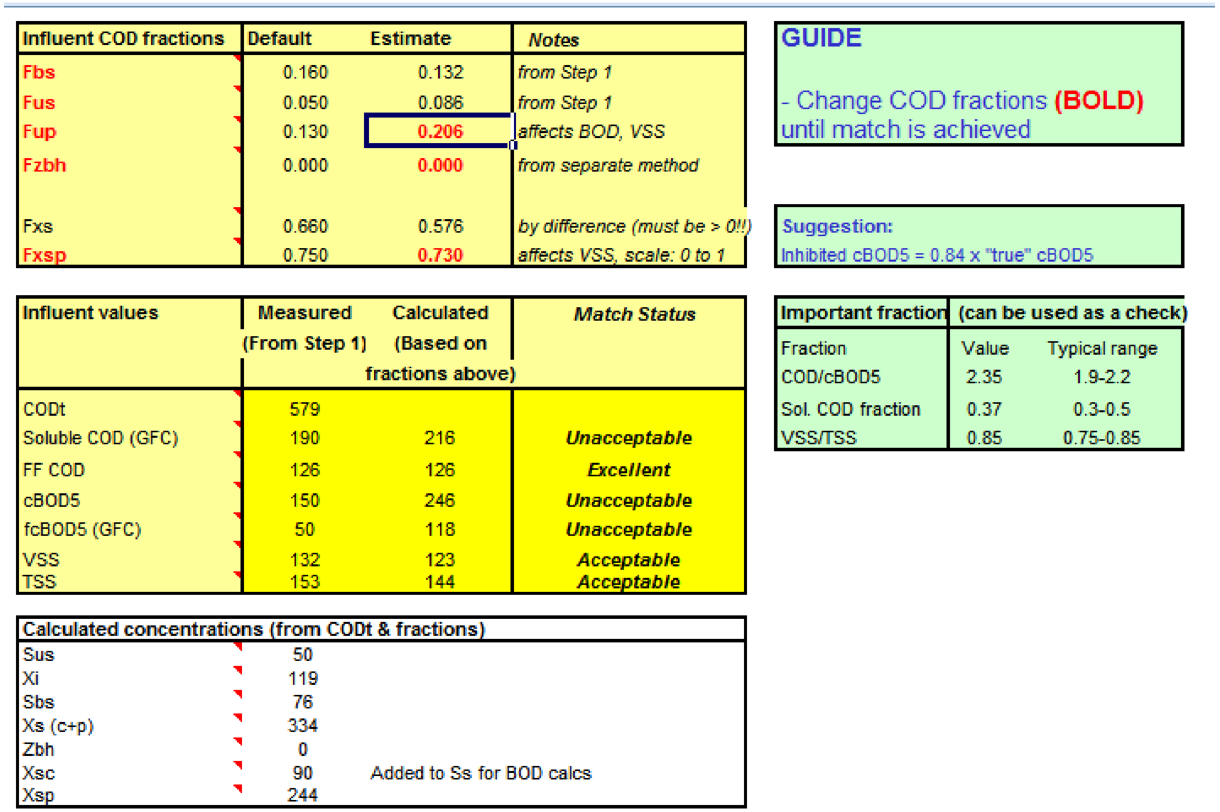


Measurements	Value	Unit
Main influent concentrations		
Flow	0.0	mgd or m3/d
Total COD	579.0	mgCOD/L
Total Kjeldahl Nitrogen	49.2	mgN/L
Total P	10.3	mgP/L
Other influent concentrations		
Nitrate N	0.0	mgN/L
pH	7.3	
Alkalinity (CaCO3 equivalent)	300.0	mgCaCO3/L
Calcium	80.0	mg/L
Magnesium	15.0	mg/L
Dissolved oxygen	0.0	mgO2/L
Other measurements		
Effluent filtered COD	51.2	mgCOD/L
Influent filtered COD (GFC)	190.4	mgCOD/L
Influent FF COD	126.0	mgCOD/L
Influent acetate	15.0	mgCOD/L
Influent ammonia	31.4	mgN/L
Influent ortho-phosphate	6.6	mgP/L
Influent carbonaceous BOD5	149.8	mgO2/L
Influent filtered cBOD5 (GFC)	49.6	mgO2/L
Influent VSS	132.0	mgVSS/L
Influent TSS	153.0	mgTSS/L

GUIDE

- Enter measured lab data in column on left (**BOLD**)
  (If data is missing, estimate. May need to repeat after Step 2)
- Check resulting fractions **(BOLD)**

	Parameter	Value	Unit	Typical range
→	**Alkalinity (molar)**	**6.0**	**meq/L**	**2 - 6**
→	**Fus**	**0.09**	**-**	**0.03 - 0.08**
→	**CODp**	**388.6**	**mgCOD/L**	
→	**Fbs**	**0.13**	**-**	**0.12 - 0.25**
→	**Fac**	**0.20**	**-**	**0.0 - 0.3**
→	**Fna**	**0.64**	**-**	**0.5 - 0.8**
→	**Fpo4**	**0.64**	**-**	**0.3 - 0.6**
→	**COD/BOD5**	**3.87**	**-**	**1.9 - 2.2**
→	**Fcv**	**2.94**	**mgCODp/mgVSS**	**1.5 - 1.7**
→	**ISS**	**21.0**	**mgISS/L**	**15 - 45**



Influent COD fractions	**Default**	**Estimate**	***Notes***
Fbs	0.160	0.132	*from Step 1*
Fus	0.050	0.086	*from Step 1*
Fup	0.130	**0.206**	*affects BOD, VSS*
Fzbh	0.000	**0.000**	*from separate method*
Fxs	0.660	0.576	*by difference (must be > 0!!)*
Fxsp	0.750	**0.730**	*affects VSS, scale: 0 to 1*

GUIDE

- Change COD fractions **(BOLD)** until match is achieved

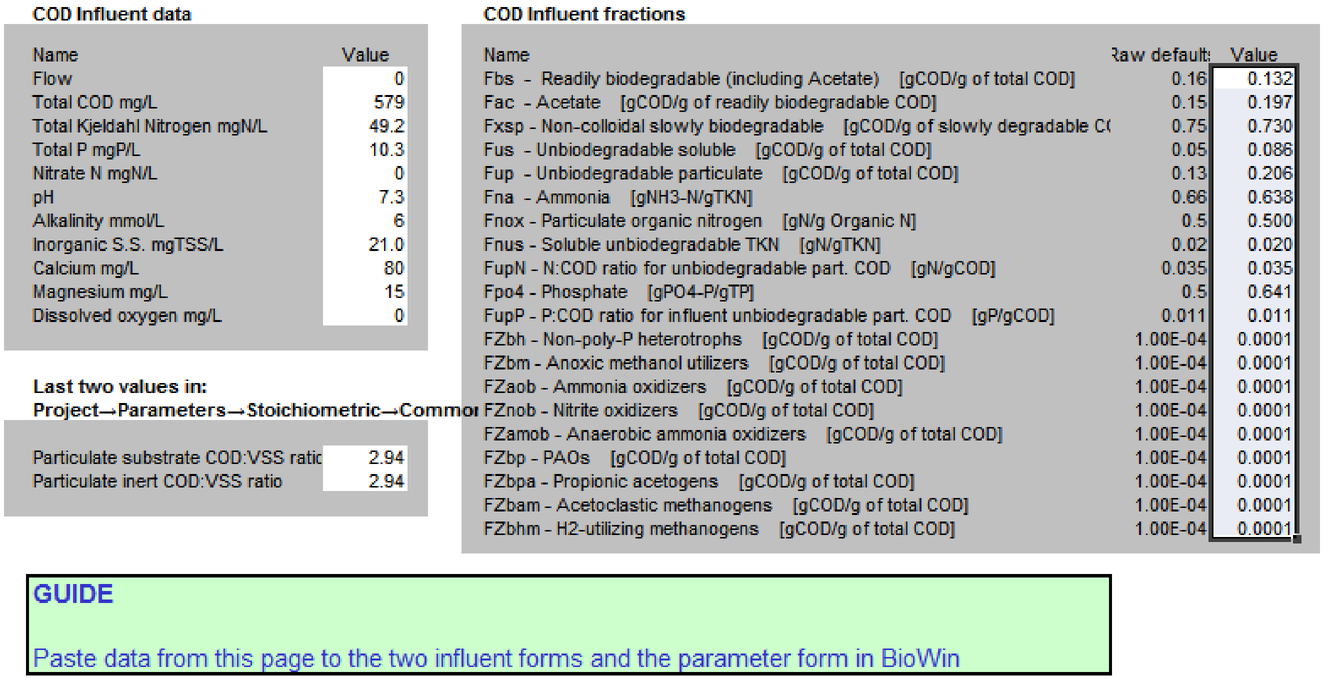
Suggestion:

Inhibited cBOD5 = 0.84 x "true" cBOD5

Influent values	**Measured (From Step 1)**	**Calculated (Based on fractions above)**	***Match Status***
CODt	579		
Soluble COD (GFC)	190	216	***Unacceptable***
FF COD	126	126	***Excellent***
cBOD5	150	246	***Unacceptable***
fcBOD5 (GFC)	50	118	***Unacceptable***
VSS	132	123	***Acceptable***
TSS	153	144	***Acceptable***

Important fraction	**(can be used as a check)**	
Fraction	Value	Typical range
COD/cBOD5	2.35	1.9-2.2
Sol. COD fraction	0.37	0.3-0.5
VSS/TSS	0.85	0.75-0.85

Calculated concentrations (from CODt & fractions)		
Sus	50	
Xi	119	
Sbs	76	
Xs (c+p)	334	
Zbh	0	
Xsc	90	Added to Ss for BOD calcs
Xsp	244	



COD Influent data

Name	Value
Flow	0
Total COD mg/L	579
Total Kjeldahl Nitrogen mgN/L	49.2
Total P mgP/L	10.3
Nitrate N mgN/L	0
pH	7.3
Alkalinity mmol/L	6
Inorganic S.S. mgTSS/L	21.0
Calcium mg/L	80
Magnesium mg/L	15
Dissolved oxygen mg/L	0

Last two values in:
Project→Parameters→Stoichiometric→Commo

Particulate substrate COD:VSS ratic	2.94
Particulate inert COD:VSS ratio	2.94

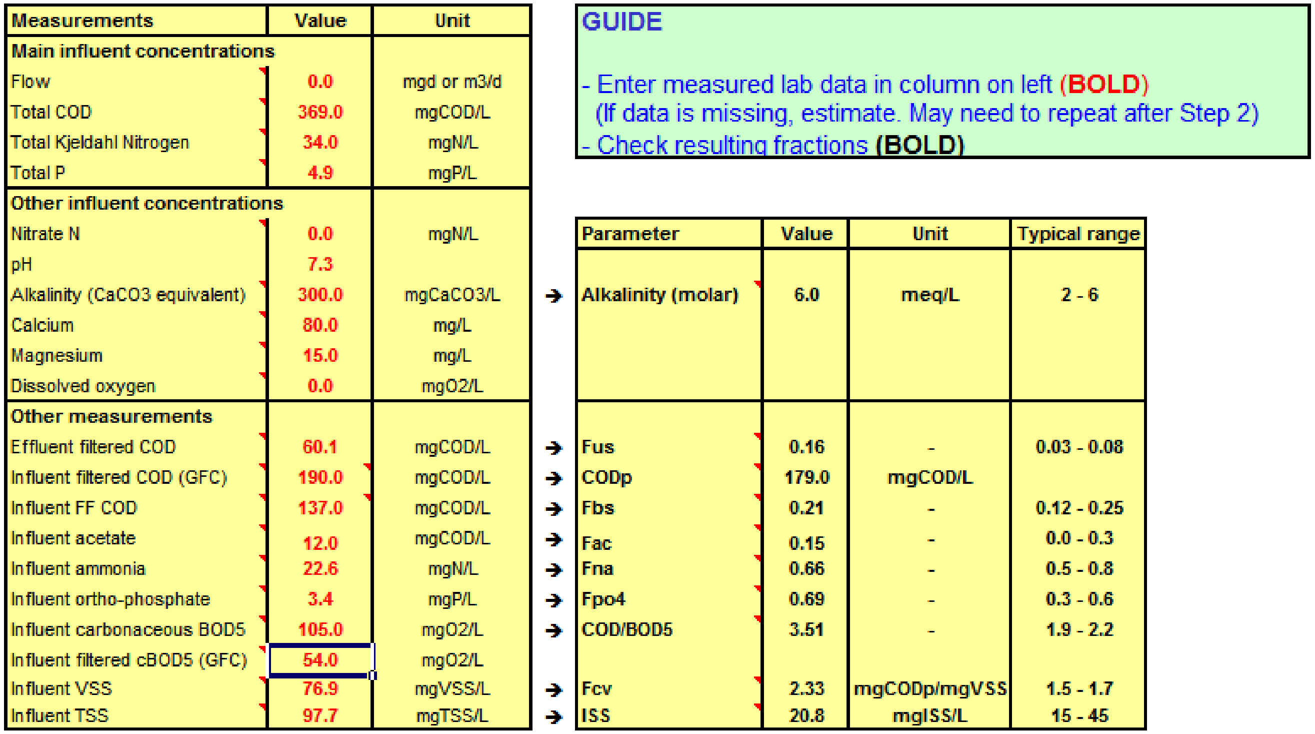
COD Influent fractions

Name	Raw default	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.16	0.132
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.15	0.197
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C	0.75	0.730
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.05	0.086
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.13	0.206
Fna - Ammonia [gNH3-N/gTKN]	0.66	0.638
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5	0.500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.02	0.020
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.035	0.035
Fpo4 - Phosphate [gPO4-P/gTP]	0.5	0.641
FupP - P:COD ratio for influent unbiodegradable part. COD [gP/gCOD]	0.011	0.011
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.00E-04	0.0001
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.00E-04	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZbp - PAOs [gCOD/g of total COD]	1.00E-04	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	1.00E-04	0.0001

GUIDE

Paste data from this page to the two influent forms and the parameter form in BioWin

Reactor C – VIP RWI

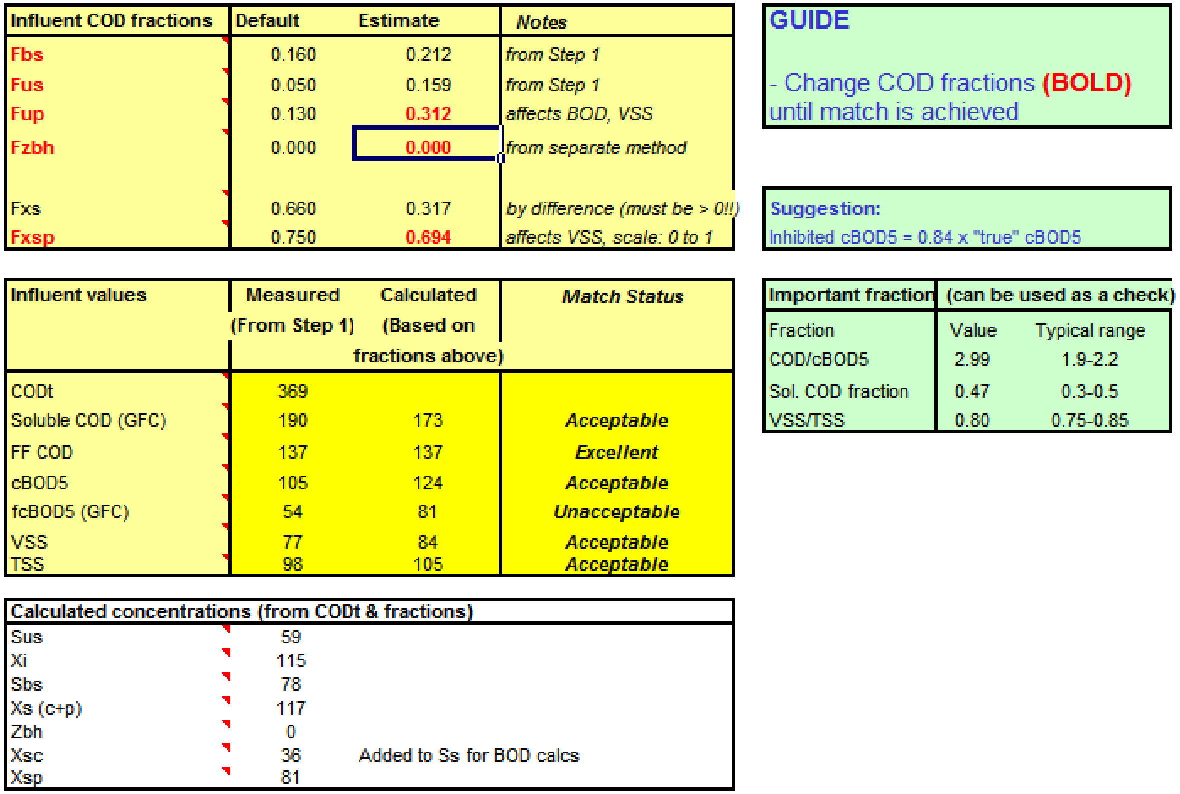


Measurements	**Value**	**Unit**
Main influent concentrations		
Flow	0.0	mgd or m3/d
Total COD	369.0	mgCOD/L
Total Kjeldahl Nitrogen	34.0	mgN/L
Total P	4.9	mgP/L
Other influent concentrations		
Nitrate N	0.0	mgN/L
pH	7.3	
Alkalinity (CaCO3 equivalent)	300.0	mgCaCO3/L
Calcium	80.0	mg/L
Magnesium	15.0	mg/L
Dissolved oxygen	0.0	mgO2/L
Other measurements		
Effluent filtered COD	60.1	mgCOD/L
Influent filtered COD (GFC)	190.0	mgCOD/L
Influent FF COD	137.0	mgCOD/L
Influent acetate	12.0	mgCOD/L
Influent ammonia	22.6	mgN/L
Influent ortho-phosphate	3.4	mgP/L
Influent carbonaceous BOD5	105.0	mgO2/L
Influent filtered cBOD5 (GFC)	54.0	mgO2/L
Influent VSS	76.9	mgVSS/L
Influent TSS	97.7	mgTSS/L

GUIDE

- Enter measured lab data in column on left (**BOLD**)
  (If data is missing, estimate. May need to repeat after Step 2)
- Check resulting fractions **(BOLD)**

Parameter	**Value**	**Unit**	**Typical range**
Alkalinity (molar)	**6.0**	**meq/L**	**2 - 6**
Fus	**0.16**	**-**	**0.03 - 0.08**
CODp	**179.0**	**mgCOD/L**	
Fbs	**0.21**	**-**	**0.12 - 0.25**
Fac	**0.15**	**-**	**0.0 - 0.3**
Fna	**0.66**	**-**	**0.5 - 0.8**
Fpo4	**0.69**	**-**	**0.3 - 0.6**
COD/BOD5	**3.51**	**-**	**1.9 - 2.2**
Fcv	**2.33**	**mgCODp/mgVSS**	**1.5 - 1.7**
ISS	**20.8**	**mgISS/L**	**15 - 45**



Influent COD fractions	Default	Estimate	Notes
Fbs	0.160	0.212	*from Step 1*
Fus	0.050	0.159	*from Step 1*
Fup	0.130	**0.312**	*affects BOD, VSS*
Fzbh	0.000	**0.000**	*from separate method*
Fxs	0.660	0.317	*by difference (must be > 0!!)*
Fxsp	0.750	**0.694**	*affects VSS, scale: 0 to 1*

GUIDE

- Change COD fractions **(BOLD)** until match is achieved

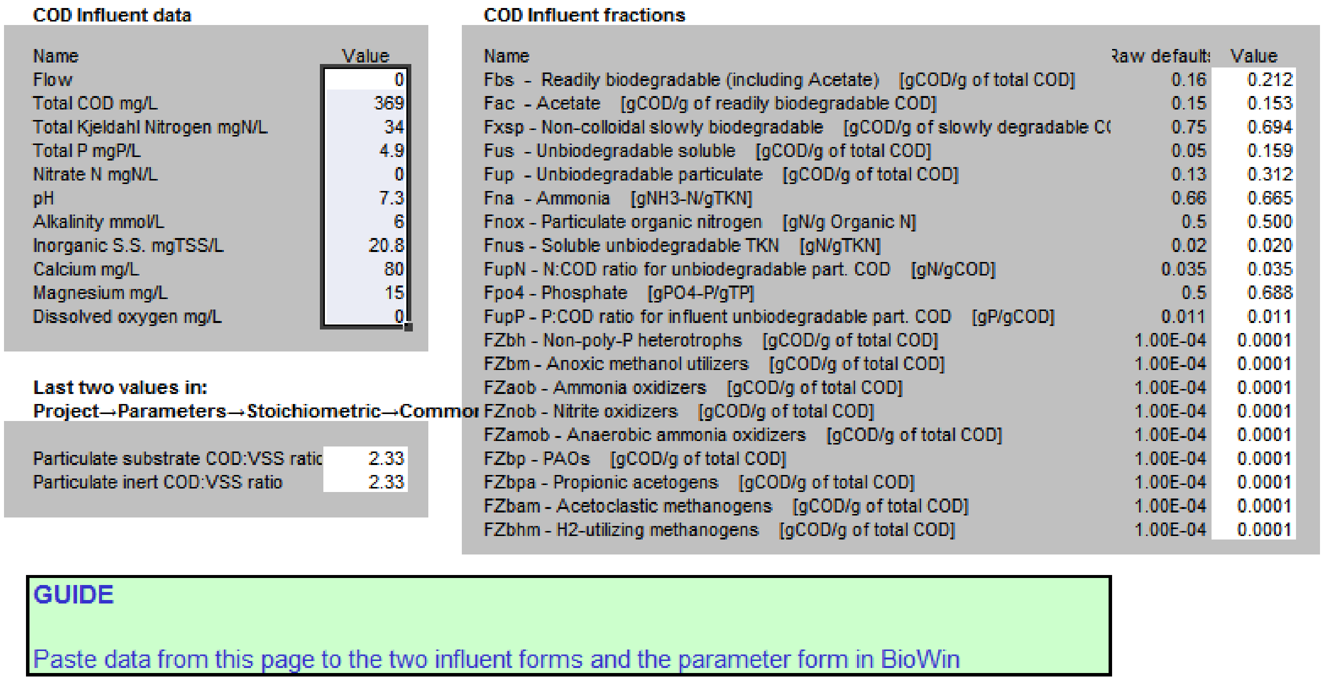
Suggestion:

Inhibited cBOD5 = 0.84 x "true" cBOD5

Influent values	Measured (From Step 1)	Calculated (Based on fractions above)	Match Status
CODt	369		
Soluble COD (GFC)	190	173	***Acceptable***
FF COD	137	137	***Excellent***
cBOD5	105	124	***Acceptable***
fcBOD5 (GFC)	54	81	***Unacceptable***
VSS	77	84	***Acceptable***
TSS	98	105	***Acceptable***

Important fraction	(can be used as a check)	
Fraction	Value	Typical range
COD/cBOD5	2.99	1.9-2.2
Sol. COD fraction	0.47	0.3-0.5
VSS/TSS	0.80	0.75-0.85

Calculated concentrations (from CODt & fractions)		
Sus	59	
Xi	115	
Sbs	78	
Xs (c+p)	117	
Zbh	0	
Xsc	36	Added to Ss for BOD calcs
Xsp	81	



COD Influent data

Name	Value
Flow	0
Total COD mg/L	369
Total Kjeldahl Nitrogen mgN/L	34
Total P mgP/L	4.9
Nitrate N mgN/L	0
pH	7.3
Alkalinity mmol/L	6
Inorganic S.S. mgTSS/L	20.8
Calcium mg/L	80
Magnesium mg/L	15
Dissolved oxygen mg/L	0

Last two values in:
Project→Parameters→Stoichiometric→Commor

Particulate substrate COD:VSS ratic	2.33
Particulate inert COD:VSS ratio	2.33

COD Influent fractions

Name	law default:	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.16	0.212
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.15	0.153
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C(	0.75	0.694
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.05	0.159
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.13	0.312
Fna - Ammonia [gNH3-N/gTKN]	0.66	0.665
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5	0.500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.02	0.020
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.035	0.035
Fpo4 - Phosphate [gPO4-P/gTP]	0.5	0.688
FupP - P:COD ratio for influent unbiodegradable part. COD [gP/gCOD]	0.011	0.011
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.00E-04	0.0001
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.00E-04	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.00E-04	0.0001
FZbp - PAOs [gCOD/g of total COD]	1.00E-04	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	1.00E-04	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	1.00E-04	0.0001

GUIDE

Paste data from this page to the two influent forms and the parameter form in BioWin